WOUNDS OF THE
SKULL & BRAIN

C. CHATELIN & T. DE MARTEL
EDITED BY
F. F. BURGHARD
WOUNDS OF THE SKULL AND BRAIN
WOUNDS OF THE SKULL AND BRAIN
THEIR CLINICAL FORMS AND MEDICAL AND SURGICAL TREATMENT

BY

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WITH A PREFACE BY

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WITH 99 ILLUSTRATIONS AND 2 PLATES

UNIVERSITY OF LONDON PRESS LTD.
18 WARWICK SQUARE, LONDON, E.C. 4
PARIS: MASSON ET CIE, 120 BOULEVARD SAINT-GERMAIN
1918
GENERAL INTRODUCTION

The infinite variety of injuries which any war presents to the surgeon gives to military surgery a special interest and importance. The special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, for if we read the older writers we find little in the moderns that is new in this respect but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist, and indeed of every form of scientific assistance, in the solution of their respective problems. The clinician entered upon the great war armed with all the resources which the advances of fifty years had made available. If the surgical problems of modern war can be said not to differ sensibly from the campaigns of the past, the form in which they have been presented is certainly as different as are the methods of their solution. The achievements in the field of discovery of the chemist, the physicist and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements, it would be wrong to assume that modern scientific knowledge was, on the outbreak
of the war, immediately useful to those to whom the wounded were to be confided. Fixed principles existed in all the sciences auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements—indeed, the requirements were not fully foreseen; the workers in the various fields were isolated, or isolated themselves, pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be—and that they have been of surpassing splendour no one will be found to deny—experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the "Horizon" Collection, which has been appropriately named after the uniform of the French soldier.

The authors, who are all well-known specialists in the subjects which they represent, have given a concise but eminently readable account of the recent acquisitions to the medicine and surgery of war which had hitherto been disseminated in periodical literature.

No higher praise can be given to the Editors than to say that the clearness of exposition characteristic of the French original has not been lost in the rendering into English.

MEDICAL SERIES

The medical volumes which have been translated for this series may be divided into two main groups, the first dealing with certain epidemic diseases, including syphilis, which are most liable to attack soldiers, and the second with various aspects of the
neurology of war. The last word on *Typhoid Fever*, hitherto “the greatest scourge of armies in time of war,” as it has been truly called, will be found in the monograph by MM. Vincent and Muratet, which contains a full account of recent progress in bacteriology and epidemiology as well as the clinical features of typhoid and paratyphoid fevers. The writers combat a belief in the comparatively harmless nature of paratyphoid and state that in the present war haemorrhage and perforation have been as frequent in paratyphoid, as in typhoid fever. In their chapter on diagnosis they show that the serum test is of no value in the case of those who have undergone anti-typhoid or anti-paratyphoid vaccination, and that precise information can be gained by blood cultures only. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum-therapy and vaccine-therapy and the general management of the patient.

Considerable space is devoted to the important question of the carrier of infection. A special chapter is devoted to the prophylaxis of typhoid fever in the army. The work concludes with a chapter on preventive inoculation, in which its value is conclusively proved by the statistics of all countries in which it has been employed.

MM. Vincent and Muratet have also contributed to the series a work on *Dysentery, Cholera and Typhus* which will be of special interest to those whose duties take them to the Eastern Mediterranean or Mesopotamia. The carrier problem in relation to dysentery and cholera is fully discussed, and special stress is laid on the epidemiological importance of mild or abortive cases of these two diseases.

In their monograph on *The Abnormal Forms of Tetanus*, MM. Courtois-Suffit and Giroux treat of those varieties of the disease in which the spasm is confined to a limited group of muscles, *e.g.* those of the head, or one or more limbs, or of the abdomino-
thoracic muscles. The constitutional symptoms are less severe than in the generalized form of the disease, and the prognosis is more favourable.

The volume by Dr G. Thibierge on *Syphilis in the Army* is intended as a *vade mecum* for medical officers in the army.

Turning now to the works of neurological interest, we have two volumes dealing with lesions of the peripheral nerves by Mme. Athanassio-Benisty, who has been for several years assistant to Professor Pierre Marie at La Salpêtrière. The first volume contains an account of the anatomy and physiology of the peripheral nerves, together with the symptomatology of their lesions. The second volume is devoted to the prognosis and treatment of nerve lesions.

The monograph of MM. Babinski and Froment on *Hysteria or Pithiatism and Nervous Disorders of a Reflex Character* next claims attention. In the first part the old conception of hysteria, especially as it was built up by Charcot, is set forth, and is followed by a description of the modern conception of hysteria due to Babinski, who has suggested the substitution of the term "Pithiatism," *i.e.* a state curable by persuasion, for the old name hysteria. The second part deals with nervous disorders of a reflex character, consisting of contractures or paralysis following traumatism, which are frequently found in the neurology of war, and a variety of minor symptoms, such as muscular atrophy, exaggeration of the tendon reflexes, vasomotor, thermal and secretory changes, etc. An important section discusses the future of such men, especially as regards their disposal by medical boards.

An instructive companion volume to the above is to be found in the monograph of MM. Roussy and Lhermitte, which embodies a description of the psychoneuroses met with in war, starting with elementary motor disorders and concluding with the most complex represented by pure psychoses.
When the present war began, surgeons, under the influence of the immortal work of Lister, had for more than a quarter of a century concerned themselves almost exclusively with elaborations of technique designed to shorten the time occupied in or to improve the results obtained by the many complex operations that the genius of Lister had rendered possible. The good behaviour of the wound was taken for granted whenever it was made, as it nearly always was, through unbroken skin, and hence the study of the treatment of wounds had become largely restricted to the study of the aseptic variety. Septic wounds were rarely seen, and antiseptic surgery had been almost forgotten. Very few of those who were called upon to treat the wounded in the early autumn of 1914 were familiar with the treatment of grossly septic compound fractures and wounded joints, and none had any wide experience. To these men the conditions of the wounds came as a sinister and disheartening revelation. They were suddenly confronted with a state of affairs, as far as the physical conditions in the wounds were concerned, for which it was necessary to go back a hundred years or more to find a parallel.

Hence the early period of the war was one of earnest search after the correct principles that should be applied to the removal of the unusual difficulties with which surgeons and physicians were faced. It was necessary to discover where and why the treatment that sufficed for affections among the civil population failed when it was applied to military casualties, and then to originate adequate measures for the relief of the latter. For many reasons this was a slow and laborious process, in spite of the multitude of workers and the wealth of scientific resources at their disposal. The ruthlessness of war must necessarily hamper the work of the medical scientist in almost every direction except in that of
providing him with an abundance of material upon which to work. It limits the opportunity for deliberate critical observation and comparison that is so essential to the formation of an accurate estimation of values; it often compels work to be done under such high pressure and such unfavourable conditions that it becomes of little value for educative purposes. In all the armies, and on all the fronts, the pressure caused by the unprecedented number of casualties has necessitated rapid evacuation from the front along lines of communication, often of enormous length, and this means the transfer of cases through many hands, with its consequent division of responsibility, loss of continuity of treatment, and absence of prolonged observation by any one individual.

In addition to all this, it must be remembered that in this war the early conditions at the front were so uncertain that it was impossible to establish there the completely equipped scientific institutions for the treatment of the wounded that are now available under more assured circumstances, and that progress was thereby much hampered until definitive treatment could be undertaken at the early stage that is now possible.

But order has been steadily evolved out of chaos, and many things are now being done at the front that would have been deemed impossible not many months ago. As general principles of treatment are established it is found practicable to give effect to them to their full logical extent, and though there are still many obscure points to be elucidated and many methods in use that still call for improvements, it is now safe to say that the position of the art of military medicine and surgery stands upon a sound foundation, and that its future may be regarded with confidence and sanguine expectation.

The views of great authorities who derive their knowledge from extensive first-hand practical experience gained in the field cannot fail to serve as a
most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great ally, France, to the common cause is this brilliant contribution to our professional knowledge.

A glance at the list of surgical works in the series will show how completely the ground has been covered. Appropriately enough, the series opens with the volume on The Treatment of Infected Wounds, by A. Carrel and G. Dehelly. This is a direct product of the war which, in the opinion of many, bids fair to become epoch-making in the treatment of septic wounds. It is peculiar to the war and derived directly from it, and the work upon which it is based is as fine an example of correlated work on the part of the chemist, the bacteriologist and the clinician as could well be wished for. This volume will show many for the first time what a precise and scientific method the “Carrel treatment” really is.

The two volumes by Professor Leriche on Fractures contain the practical application of the views of the great Lyons school of surgeons with regard to the treatment of injuries of bones and joints. Supported as they are by an appeal to an abundant clinical experience, they cannot fail to interest English surgeons, and to prove of the greatest value. It is only necessary to say the Wounds of the Abdomen are dealt with by Dr Abadie, Wounds of the Vessels by Professor Sencert. Wounds of the Skull
and Brain by MM. Chatelin and De Martel, and Localisation and Extraction of Projectiles by Professor Ombrédanne and R. Ledoux-Lebard, to prove that the subjects have been allotted to very able and experienced exponents.

ALFRED KEOGH.
EDITOR'S PREFACE

A book that is the outcome of the experience gained at the Salpêtrière must always command the respect of those who work at the subject with which it deals. Under the ægis of Dr Pierre Marie, Dr Charles Chatelin here sets out the results that have been obtained from the observation of more than five thousand cases of wounds of the skull and brain. It is unusual for so great a mass of material to come under the observation of any one set of observers, and the value of the investigation is enhanced by the care and minuteness with which the cases have been examined and observed. Working upon these sure foundations, Dr Chatelin is able to present a number of conclusions which will not only be of great interest to neurologists, but also very helpful to those who have to deal with these distressingly frequent cases.

The section upon the surgical treatment of these cases by Dr de Martel contains views and methods of treatment that will be novel to a good many English surgeons. His views upon the question of
early operation in brain wounds, and his advocacy of an osteo-plastic flap, are not in accord with the views and practice of the majority of surgeons in this war, either among the Allies or the Central Powers. This divergence must, however, enhance the interest with which his share of the work will be received, and it is to be hoped that the dissemination of his views will help to test their merits.

F. F. BURGHARD.
PREFACE

Owing to their frequency and importance, wounds of the skull deserve special study. We have therefore, in accordance with the instructions of the chief of the Medical Staff of the fortress of Paris, Principal Medical Officer Marchoux, examined during 1915 and 1916 nearly five thousand such cases under my care at the Salpêtrière.

In compiling this work my assistant, Dr Charles Chatelin, has made use almost exclusively of the records which we have collected and studied together. He has, in particular, described what we have ourselves seen. Dr Charles Chatelin was better fitted to make use of this considerable mass of material than anyone else, because it is chiefly due to his efforts that our out-patient department at the Salpêtrière, of which he has been the moving spirit, has reached such an unexpected and astonishing development.

For more than six years Dr Chatelin has been my constant fellow-worker, both as Intern and as Assistant. We have been so closely associated that I feel some diffidence in expressing my high opinion of him. I can sum up that high opinion briefly in the words: He has no peer as a clinician.

At the beginning of each chapter of this book will be found an "Anatomical and Physiological Introduction," which is not a merely theoretical discourse, but a practical statement which will enable those
who are not versed in neurology to acquire rapidly the theoretical details necessary to a thorough understanding of the phenomena and disorders to be described.

The study of wounds of the skull received in warfare has introduced to us many new ideas. Hitherto our knowledge of human cerebral pathology, especially with reference to localisation, was based upon cases of local lesions due to hæmorrhage or softening. In such lesions, owing to their vascular origin, the white matter of the convolutions is necessarily largely involved, so that it may be said that our former knowledge of cerebral pathology was almost exclusively confined to the pathology of the white matter. The wounds inflicted in war have produced completely different conditions, that is, lesions of the cortex to the more or less complete exclusion of the white matter, and thus this new pathology corresponds more closely to the data of experimental physiology than did the old cerebral pathology. The former, which we may style cerebral leuco-pathology, dealt especially with massive syndromes—hemiplegia, persistent aphasia, hemiopia, etc.; while the cerebral polio-pathology reveals focal symptoms—monoplegia and dissociations which are often very intricate. It is to this that the interest of this research is due.

In dealing with these lesions of cortical character, it was necessary to localise them with sufficient accuracy to determine which of the convolutions were involved. The use of radiographs with the convolutions marked out with lead wire, as first employed by Dr Chatelin, and improved and perfected by my pupils Charles Foix and I. Bertrand, has been found to give results sufficiently exact and practical to be of great service in clinical practice. By their use we have been enabled, while locating the lesions, to study thoroughly all this novel cerebral pathology.
of which we were furnished with such a lamentable plenitude of cases.

There will also be found in this volume an interesting account of disorders of vision due to wounds of the skull, which are more frequent than might be supposed. I would also call special attention to the very lucid description of the symptoms of cerebellar lesions and their localisation.

I am not well qualified to speak of the surgical section, but the name of de Martel is in itself sufficient to guarantee its excellence. One remark, however, I consider it a professional and social duty to make once more: that, at least in the early part of the war, wounds of the skull have been operated upon much too frequently, much too soon, and much too near the front.

I have therefore read with the greatest satisfaction the following statement by de Martel in this book: "In the ordinary way it is not urgent to operate on wounds of the skull, and, in my opinion, those surgeons who consider that they should operate on a skull as they would on an abdomen are mistaken. If the abdomen contained only solid organs, as does the skull, instead of hollow organs full of septic material, it might be treated in the same way. The only cases where surgical intervention is really urgent are those of the digestive tract and of the circulatory system."

This is the exact truth, and could not be put better. In spite of its small size and its modest pretensions as a hand-book, this work of Drs Chatelin and de Martel is not merely a treatise of traumatic affections, but will remain as a guide to the study of local affections of the skull and brain; it is rich in original views and new ideas. The book is really a great achievement; it marks a step forward.

PIERRE MARIE.
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By Charles Chatelin

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### PART II

**WOUNDS OF THE SKULL**

**BY T. DE MARTEL**

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INTRODUCTION

This part of the book will deal only with wounds of the skull which have been cured surgically, and can be subjected to thorough neurological investigation.

The consideration of the wound itself, of the results (loss of consciousness, paralysis, etc.) that supervene immediately on its infliction or several days afterwards, will be dealt with by Dr de Martel. This section will deal only with the later effects—that is, those which persist for some weeks and can be subjected to careful clinical investigation.

In the examination of cases much attention should be devoted to the history of the wound, and to obtaining all the details of their symptoms which the patients can provide, from the moment of its infliction up to the time of examination.

The correct title of this treatise should therefore be: The Later Effects of Wounds of the Skull.

Most of the first part will be devoted to the method of obtaining a history and to the examination of the patient. An exact diagnosis and (as far as it is possible) a correct prognosis depend on a methodically conducted examination.

The second part will be devoted to the study of the various syndromes produced by wounds of the brain according to their site. It will be found that, on certain points, the injuries of warfare have confirmed many of the conclusions derived from civil
WOUNDS OF THE SKULL AND BRAIN

practice; that on others, it has brought to light facts hitherto hardly suspected; but that, speaking generally, it has not, up to now, revealed anything absolutely novel. For example, there have been many cases of monoplegia due to lesions of the cortex or disturbances of sensation of cortical origin; lesions of the occipital lobe have revealed the remarkable systematisation of the visual area, which had been merely suspected; on the other hand, our knowledge of the functions of the frontal lobe obtained from civil practice remains practically unchanged.

From the practical point of view it will be found that a great number of wounds of the skull produce no objective indication of an organic lesion of the nervous system, but are accompanied by very marked subjective disorders. Such symptoms frequently lead to the question: What is the best course to pursue as regards treatment, and also with regard to the military employment of such patients?

In every case, whether we have to deal with indisputable organic lesions or with purely subjective disorders, it will be evident that the greatest caution is required in regard to any surgical action which, except within certain well-defined limits, should be restricted as much as possible.
PART I

WOUNDS OF THE BRAIN

BY CHARLES CHATELIN
CHAPTER I

EXAMINATION OF A PATIENT WITH A WOUND OF THE SKULL

I. Interrogation of the Patient

This interrogation should be carried out as minutely as possible. The scheme here suggested should be modified and, especially, extended according to the site of the wound under consideration.

The exact circumstances in which the wound was inflicted and the earliest symptoms experienced.—The first question will be the exact date of the wound and, approximately, the hour? What was the soldier doing at the time? Was he erect or recumbent? Was he wearing a trench-helmet or a cap? What was the position of his head? By what kind of projectile was he wounded—rifle bullet, machine-gun bullet, shrapnel, shell-splinter, or grenade? Was there violent impact, or mere shock without any apparent wound, which is by no means unusual. The patient is frequently unable to give more than very incomplete details on these points.

What were the sensations of the patient at the moment of being wounded? Did he lose consciousness immediately? If not, what were his sensations? Did he feel a violent blow on the head? Was there numbness or instant paralysis of the whole of one
side of the body? Was there total loss of speech? Was there loss of sight, and was it preceded or not by an appearance as of flames before the eyes? Was there a ringing or a buzzing in the ears? Did the patient lose consciousness at once; if not, when did he do so? How did he fall? Patients who do not immediately become unconscious are able to give fairly exact information as to their sensations in the short period during which they retain consciousness.

*How long did the patient remain unconscious?* Where was he when he recovered consciousness? How long does he think it was before he was picked up?

*What were his sensations in his head on recovering consciousness:* severe headache, vertigo, little diminution of sight or much, even to actual blindness? Was he deaf?

*Could he speak?* Could he find the words to express his meaning? Did he babble so that he could not be understood? Did he understand what was said to him? (It is necessary to be cautious in accepting the statements of patients on this point, as they are frequently mistaken as to their power of comprehension.) How many days elapsed before he recovered the power of speech? Has he any difficulty of utterance at the time of the examination; if so, what is its nature?

*Was the patient paralysed?* Could he use his leg or his arm? What movements could he execute in bed? It is necessary to press this point closely. The patient will often reply that he could not use either arm or leg, and the inference is that there was total hemiplegia. For instance, the patient, while lying in bed, will say that he can move neither arm nor leg. It is necessary to particularise and to ask him if he can move his fingers, take hold of a
glass or a spoon with either hand, whether he can move his toes, bend or stretch out his leg in bed, raise it, etc.

*On which side was the paralysis of the limbs?* On the side opposite to the wound, or on the same side (homolateral paralysis)?

*Were the sensations in the limbs painful or merely unpleasant?* Could he perceive objects taken in the hand, contact with the bed-clothes or with a bowl of warm water?

Has the patient experienced any special awkwardness in the use of his arm or leg? Was there intentional tremor? It is necessary to ascertain by inquiry whether there were paralytic as opposed to ataxic or asynergic phenomena. It is often very difficult to get exact replies on this very important point.

*Was there any disturbance of urination;* if so, was it urgent or difficult?

*Was there any disorder of vision, and of what nature?* Did the patient see double; for instance, two heads on each of the people around him, which is not uncommon in all varieties of wounds of the skull. Was there blindness, or considerable diminution of vision? Was his sight misty, or did everything appear darkened? Did he see flames or sparks before his eyes?

*Could the patient hear well with both ears, or with one only?* Was there singing in the ears?

*Was there difficulty when eating or drinking?*  
*Had he difficulty in swallowing?*

It must be understood that this inquiry is intended to be modified according to the patient’s replies, and must be modified according to the site of the wound; thus in the case of a wound of the occiput, special attention must be given to the visual phenomena.
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Course of the wound and of the nervous symptoms.— How long was it before the patient could stand up? Had he headache or vertigo? Could he walk without help, or only with the aid of crutches or sticks?

Has he had one or more surgical operations: did these take the form of trephining, extraction of the missile, or plastic operations? Did the wound bleed much? Was a dressing kept on for long? Did it suppurate for long? It is frequently impossible to get precise answers as to the treatment, and in such cases the hospital card which the patient often has with him will furnish information in a very brief form, the slightest surgical treatment, such as the enlargement of the wound or the cleansing of it being entered as "trephining." It is especially necessary to be very sceptical in regard to the extraction of the missile. The patient will say that the projectile has been removed, and may even produce it, and the hospital card may bear the entry: "extraction of missile." Nevertheless there should always be a fresh radiographic examination. In many cases which have come under notice this has shown the presence in the brain of a missile which had escaped notice.

The interrogatory will be closed by asking the patient what troubles he complains of at the time of the examination. Stress need not be laid on such evident signs as hemiplegia, monoplegia, disorders of speech, disorders of vision, which will be made the subject of an exhaustive examination later. He should be questioned as to the subjective disturbances which occur in nearly all cases of wounds of the skull, which may exist alone and require to be investigated in detail. This will be fully dealt with later.
II. Objective Condition of the Wound at the time of Examination

As we have already stated, the cases which come under examination are surgically cured, consequently in nearly all of them the cranial wound will have healed.

The scalp wound.—The scar may be smooth, clean, and hard; or thin, with a tendency to hernia of the brain; or depressed, or irregular (especially after crucial incisions), with hair follicles included in the furrow; on the other hand, the wound may be incompletely eicatrised, with an oozing surface, especially in the case of irregular scars; owing to hairs being entangled in the depression there remains a slight superficial cutaneous infection, and there may even be a small persistent sinus, from which a drop of pus exudes. This sinus is usually the result of a subcutaneous fragment, and calls for surgical cleansing of the wound and removal of the piece of bone.

Loss of bone.—There is naturally great variation in size and shape of the defect, and it is advisable to measure both dimensions with a rule or compasses.

Palpation allows one to ascertain fairly clearly whether we have to deal with a superficial wound only involving the soft parts, or with a furrow in the external table, or with a loss of bone of varying size, with or without spontaneous pulsation, and with or without an impulse on coughing. In certain cases it is difficult to detect the pulsation or the impulse on coughing by palpation alone; the patient may then be told to blow his nose violently, or to bend his head forward very forcibly. The neck may also be lightly

1 Care must be taken not to confuse a contraction of the temporal muscle or a movement of the epicranial fascia, which may be produced by coughing or the act of blowing the nose, with a tendency to bulge.
squeezed with the hand so as to produce a temporary cerebral venous congestion, when the cicatrix may be seen to bulge slightly.

There will be cases in which radiography must be employed to ascertain definitely and precisely the extent and depth of the loss of bony substance and the presence of a missile or splinter. This will be fully discussed in the section dealing with the application of radiography to wounds of the skull.

Finally, there remains the question: How can we be sure that a cranial wound involves the brain? Only by determination of the organic symptoms, which are frequently very much obscured. In a whole class of cases where the most minute investigation yields no objective evidence, in which the patient complains of grave subjective disorders, and in which a radiograph shows neither splinters nor a foreign body imbedded in the brain, it is almost impossible to say positively that there is a cerebral lesion. In these cases lumbar puncture and analysis of the cerebro-spinal fluid has been suggested by several authors as a means of settling the question of injury of the brain (see Chapter III.).

**III. Cranio-cerebral Topography**

Having obtained a description of the wound, it is important to localise it.

After measuring its dimensions, it can be approximately localised by the following method:—

The centre of the hole in the bone is situated so many centimetres to the right or to the left of the median line; so many centimetres above and in front of (or behind) the external auditory meatus, or above the root of the nose, or above the external occipital protuberance, according to the site of the wound. Such a localisation, however, is very vague, and of little
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value. It is of much more value to fix the site of the loss of substance definitely, relatively to the subjacent cerebral convolutions; to attempt, in short, to make a cranio-cerebral localisation. To carry out this localisation on the living subject with anything approaching exactitude it is absolutely necessary to

lay down certain datum-points and to measure certain dimensions with a flexible measuring tape. The topography of the wound can be laid down approximately, with only a small margin of error, if it is borne in mind that there are two great types of cranial formation, which we may name respectively Frontal and Occipital (Froriep).

In the frontal type the brain is, as it were, pushed
forward, the fissure of Rolando being far forward and nearly vertical.

In the occipital type the brain seems to have been tipped backwards on an axis passing transversely through the external auditory meatus on each side, the fissure of Rolando is far back, its posterior ex-

tremity being very oblique, and the other fissures are similarly carried backwards and similarly inclined towards the horizontal. In this latter type the whole of the occipital portion of the cranium (the portion of the cranium behind the auditory orifice) is much developed in length, and the external occipital protuberance is very low down. It may be said, generally, that a short skull belongs to the frontal type,
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and a long skull to the occipital. The breadth of the skull is of relatively slight importance in determining the direction of the principal fissures.

These general principles have been stated before dealing with the methods of exact cranio-cerebral topography, because they will prevent grave mistakes being made when there is no time or facility to take exact measurements.

Putting aside any attempt to give a full description of the numerous methods of cranio-cerebral topography, our attention will be confined to the most simple and effective, which can easily be practised on any patient, and we shall then pass on to the most recent methods which are based on radiography.

The metrical system of datum-points applied to the living subject.—The method of obtaining datum-points in cranio-cerebral topography is based on knowing how to find certain datum-points which can be felt upon the skull in the living object.

To find the datum-points.

1. The nasal point.—This is at the bottom of the naso-frontal angle, which is more easily defined than the glabellum (the prominence above the root of the nose and between the eyebrows), which is usually selected for this point. Besides, the measuring tape can be fixed more steadily at the bottom of the naso-frontal angle than on a prominence which it is often difficult to locate precisely.

2. The external occipital protuberance (inion).—This is generally easily found by palpation.

3. The lambda.—This is the point where the sagittal suture meets the two parieto-occipital sutures, and is the only point where the suture lines of the bones of the skull can be used as a datum-point. It is generally marked by a slight depression caused by the boss of the superior angle of the occipital bone. When there is difficulty in locating the lambda, the lambdoid
suture can be found by measuring off 7 centimetres above the external occipital protuberance along the median line.

4. The external auditory meatus and the zygomatic arch, the contours of which can be easily felt, are likewise valuable datum-points, particularly for localising the lower end of the fissure of Rolando.

To map out the fissures.

1. The fissure of Rolando.—The position of the upper end of this fissure can be found by taking half the distance from the naso-frontal angle to the inion measured on the antero-posterior sagittal line and
adding 2 centimetres thereto. In practice the distance from the root of the nose to the inion is measured with the tape, the number of centimetres divided by 2, and 2 centimetres added to the dividend. This can be checked by measuring off 18 centimetres along the sagittal line, starting from the root of the nose. The points found by these two measurements will always be found to correspond very closely.

To ascertain the point on the skull corresponding to the lower end of the fissure of Rolando proceed as follows:—

On the zygomatic arch, immediately in front of the auditory meatus, erect a perpendicular; start from the zygomatic arch and count off 7 centimetres; this point will correspond to the inferior extremity of the fissure of Rolando.

This observation may be checked thus: Produce this perpendicular to the sagittal line; starting from the auditory opening, mark off one-half the length less 1½ centimetres; this will give the lower end of the fissure of Rolando. The points obtained by these two measurements very nearly coincide.

2. The Sylvian fissure.—Starting from the nasofrontal angle, stretch the measuring tape along the lateral aspect of the cranium 6 centimetres above the external auditory orifice to a point 1 centimetre above the lambda; this is the Sylvian line, which follows the Sylvian fissure along nearly its whole extent.

On this line 7 centimetres from the lambda will be found the gyrus angularis, and at 10 centimetres the gyrus supra-marginalis. The anterior end of the Sylvian fissure can be located by erecting a perpendicular from the centre of the zygomatic arch until it touches the Sylvian line. This point also locates the head of the third frontal convolution.

A point on the sagittal line approximately 1 or 2 centimetres above the lambda corresponds to the
upper end, on the convex edge of the hemisphere, of the external perpendicular fissure which divides the external aspect of the occipital lobe from the parietal lobe; the variations are fairly wide. A perpendicular to the sagittal line let drop from this point will give the course of the external perpendicular fissure along the convexity of the hemisphere.

These simple rules for locating the course of the principal fissures by means of a measuring tape will be found amply sufficient, in practice, to locate the site of a wound relatively to the principal fissures and the principal centres of the cortex.

The application of radiography to cranio-cerebral topography.—By means of radiography it is possible to ascertain definitely the relation that the loss of bone bears to the subjacent cerebral convolutions.

We have made use of this method in the study of
wounds of the visual area (see Chapter VIII.). The technique of this method has since been worked out in detail,\(^1\) and applied to the study of the fissures and convolutions of the outer surface of the brain. A description of the method employed would take up too much space, and readers must refer to the works mentioned in the footnote, but it is based essentially on the following procedure: A prepared brain is removed from its cranium, and the convolutions marked out with leaden wires; the brain is then returned to the cranium, and the whole radiographed in accordance with certain stringent rules, which we shall state later on when dealing with the radiography of wounds of the skull. From the radiographs of variously shaped brains marked out thus with the lead wires a normal topographic plan can be mapped out, which can be laid upon the radiograph of any patient’s skull. It can then be seen to which convolution or fissure the loss of bone corresponds. This method can only be employed after constructing a normal plan, and by radiographing in identical positions and at identical distances.

**IV. Neurological Examination**

In this section is described a systematic method of examining the nervous system, stress being laid on the points which must always be looked for, and the manner in which the search should be carried out.

**Examination of the Segmental Muscular Power**

The search for paralyses.—The examination must be carried out on the patient when recumbent, and methodical tests made of the segmental muscular

\(^1\) Pierre Marie, Foix, and Bertrand, “Recherches sur la topographie crânio-cérébrale, etc.,” *Société de Neurologie*, 2nd March 1916; *Revue Neurologique*, No. 3, March 1916, p. 437,
power of the limbs, trunk, and neck—that is, the power of flexion, extension, abduction, adduction, and rotation in each segment of the members must be tested. The procedure is as follows: The patient is told to flex the forearm on the arm, and, when this movement has been completed, to resist an attempt made by the observer to extend it. In this way the patient is made to put forth the maximum of effort required for each movement. It does not suffice to tell the patient to bend his elbow or to extend his leg, and then for the observer to resist the movement before the flexion of the elbow or the extension of the knee has been carried as far as possible, because, in this way, a wrong impression of a diminution in muscular energy might be received by the examiner.

The testing must be systematically carried out. In the upper limbs: Flexion and extension of the fingers, testing separately the flexion of the metacarpophalangeal joints (interossei); flexion of the second and third phalanges (flexors of the fingers). Extension of the first phalanx. Extension of the second and third phalanges. Abduction and adduction of the fingers. Abduction, adduction, and opposition of the thumb. Flexion, extension, and lateral movements of the wrist. Flexion and extension of the elbow. Pronation and supination of the forearm. Raising the arm to the horizontal forwards and laterally; raising it vertically. Adduction of the arm. Rotation of the arm inwards and outwards. Elevation of the shoulder.

The movements must be tested successively on the sound and on the affected side. In order to obtain a standard for comparison it will be necessary in certain cases to test the segmental muscular power simultaneously on both sides; for instance, flexion of the elbow or the abduction or adduction of the arm.
Similar tests are applied to the lower limbs under similar conditions—flexion, extension, adduction and abduction of the toes; flexion, extension, abduction and adduction of the foot; flexion and extension of the leg on the thigh, etc., as in the upper limb and under similar conditions.

Movements of the trunk.—The patient being seated and bent forward, he is pushed backwards with instructions to resist the movement, care being taken to fix his knees. Extension of the trunk is tested by reversing this procedure.

Movements of the head.—Flexion, extension, rotation, and lateral inclination will likewise be tested, care being taken in each case that the movement is completely carried out, and then opposing it. The examination will be concluded by testing the motility of the face: by putting out the tongue; opening the mouth; showing the teeth; whistling or blowing; laughing; shutting both eyes, then each eye separately; frowning and raising the eyebrows. During these movements observation should be made of the contractions of the platysma on each side, care being taken that the neck is completely uncovered, the head erect and not inclined too far backwards.

In the examination of the motility of the face are included the following:

1. Test of the motility of the tongue (hypoglossal nerves), observing whether there is any atrophy or fibrillary tremors. 2. Test of the trigeminal nerve: closure of the jaws by contraction of the temporal and masseter muscles, lateral movements of the jaw by the pterygoids. By palpation the observer will be informed as to the condition of the masseter, and will be able to detect any more or less marked atrophy of the muscle.
Examination of the Reflexes

Reflexes of the bones and tendons.—The reflexes are tested by comparing them on the two sides of the body.

A. Lower limbs.—A beginning will be made with the patellar reflexes. The best method is to make the patient sit on a chair with the knees slightly bent, the feet resting flat on the ground, and to practise percussion on the tendon on the right and left sides alternately, after instructing the patient completely to relax the muscle. This relaxation is not always easy to obtain, and palpation of the quadriceps extensor cruris must be employed to ascertain whether this muscle is in complete relaxation. This method is much to be preferred to the method of testing the reflexes with the leg under examination crossed over the other, or with the legs hanging over the edge of the bed, or with the patient recumbent. Reflex centre, 3rd lumbar segment.

If the reflex is very feeble or imperceptible, test it by Jendrassik’s method, the patient straining on the crooked and interlocked fingers of the two hands while percussion is applied.

The Achilles reflex.—The patient kneels on a low chair and percussion is applied to the tendon Achillis, after seeing that the foot is not fixed by muscular contraction. If no reflex is perceptible, it is advisable to make sure by direct percussion over the belly of the triceps suralis that idiomuscular contraction is present, and that the absence of a tendon reflex is not due to a defect in the technique employed to elicit it. A similar control test should be applied to each one of the tendon reflexes. While the patient is in this position he can be tested for the medio-plantar reflex (Guillain and Barré) by percussion of the median portion of the sole, when the same reflex
action should be obtained as by percussion of the
tendo Achillis. Reflex centre, 1st sacral segment.

B. Upper limbs.—Reflex of the triceps brachialis
or of extension of the forearm. The examiner seats
himself beside the patient, who is made to carry his
arm outwards and backwards, and to place his hand
flat on his thigh. Percussion is then made over the
tendon of the triceps near the olecranon, and note
is made of the muscular shock in the triceps. Reflex
centre, 7th cervical segment.

The forearm flexion reflex or the lower radial reflex.—
This is elicited by percussing the lower end of the
radius, the elbow being partially flexed and the fore-
arm in semi-pronation and supported by the observer’s
left hand; the percussion should give rise to flexion
of the forearm on the upper arm and a flexion of
the fingers. Reflex centre, 5th and 8th cervical
segments.

The ulnar pronation reflex.—While the patient is
in the same position as before, percussion is made
over the postero-inferior portion of the ulna; this
should give rise to pronation of the forearm and
slight flexion of the fingers. Reflex centre, 6th
cervical segment.

These are the five tendon and bone reflexes which
it is essential to test. In particular cases it is advis-
able to test some others, such as the acromial, sub-
spinous, clavicular, masseteric, etc., which will be
indicated when required. In every case it is absolutely
necessary when testing the reflexes to remember that
the patient must be in complete muscular relaxation,
that the test must be made meticulously by comparing
one side with the other, and that it must never be
decided that a reflex is absent until after a prolonged
and minute examination under the best possible
conditions. Normally the reflexes, whether strong or
feeble, are equal on the two sides; it is the absence
or the dissimilarity of the tendon reflexes which is of special pathological significance.

**Cutaneous and mucous reflexes.**—The following cutaneous and mucous reflexes should always be tested:

*Plantar cutaneous reflex.*—This reflex is of the greatest semeiological value. In making the test it is most important that the muscles of the leg and thigh shall not be contracted; the leg should be slightly bent on the thigh and supported by the observer. If the sole of the foot is then excited by passing a pin along its outer border from the heel to the base of the toes there will be produced, normally, a reflex movement of flexion of the toes, or the toes may remain immobile. If there is a lesion of the pyramidal tract, tickling the sole causes extension of the toes, especially of the great toe, abduction of the toes (the fan), contraction of the tensor fasciae femoris, and sometimes flexion of the leg on the thigh. The stimulus necessary to produce this reflex is sometimes strong and sometimes slight, and must be applied alternately to the skin over the inner and outer half of the sole respectively. There are cases in which excitation of the inner half of the sole gives rise to flexion of the toes, while that of the outer half gives rise to extension only.

By repeating the test several times in different positions, and with varying degrees of excitation, while observing the other reflex movements associated with extension of the toes, all sources of error will be eliminated. In some cases reflex extension of the great toe may be produced by slight excitation of the skin of the dorsum of the instep, or of some point on the skin of the lower limb.

Another very important plantar cutaneous reflex on which great stress has rightly been laid by Hirschberg, and more recently by MM. Pierre Marie and Meige, is the *adductor reflex of the foot.*
As in the last case, the test is carried out with the patient seated, or flat on his back with his legs projecting beyond the end of the bed, or on his stomach with both legs raised nearly to a right angle with the thighs. Having ascertained that there is no muscular contraction, the skin of the inner border of the foot is scratched by drawing a pin or bodkin from the base of the great toe to the heel. A reflex adduction of the foot is thus induced by contraction of the tibialis posticus; the foot is adducted, and the sole inverted with elevation of its internal border. In many wounded subjects it is difficult to get a response from the great toe by tickling the sole, while adduction of the foot is easily produced. This reflex is most important as indicating very slight lesions of the pyramidal tract, especially in the cortical region, at the level of the motor centres for the lower limb.

Cremasteric reflex.—This is obtained by excitation of the skin of the inner aspect of the thigh, and shows itself by a sudden raising of the testicle on the side tested through the contraction of the cremaster. This reflex must not be confused with the slow, vermicular, much more lingering contraction produced under the same conditions by contraction of the involuntary muscle of the dartos (serotal reflex).

Abdominal cutaneous reflex.—This may be divided into three groups: upper, middle, and lower. Rapid excitation, upwards, with a bodkin of the skin of the abdomen, at the level of, or below, the umbilicus to one side of the median line, produces reflex contraction of the subjacent muscles. Here also it is necessary to make sure that the abdominal muscles are completely relaxed.

Palate reflex.—The velum palati is lightly touched with a twist of paper to right and left of the median line; a reflex elevation of the velum is produced, which must not be confused with the reflex of nausea.
The corneal reflex.—The cornea is touched lightly with a hair, care being taken not to brush the eyelashes; an instant closing of the eyelids is induced.

Automatic spinal reflexes (Pierre Marie and Foix) or defensive reflexes.—These are complex, co-ordinated, reflex movements, which are provoked by excitation of the deep or of the superficial sensibility, and arise from automatic action of the cord.

We shall describe only the phenomenon of retraction, which are the most frequently observed and the most important of these reflexes.

This consists essentially of a movement of retraction of the lower limb, which is evoked in the following manner: The patient is extended on the bed and in complete muscular relaxation, and his toes are grasped by the observer and progressively and forcibly flexed. This induces a movement of retraction of the entire lower limb, first of the foot towards the leg, then of the leg towards the thigh, and then of the thigh towards the pelvis, the movement being quite involuntary. This reflex may also be obtained by superficial cutaneous excitation by pinching the skin of the foot or the leg (test for plantar cutaneous reflex).

These reflexes are very frequently met with in the course of spasmodic affections of the nervous centres, and especially when there is more or less complete interruption of the conduction paths between the brain and the spinal cord.

Clonus.—Ankle clonus or epileptiform tremor of the foot is tested for by raising with the left hand the patient's leg, which must be in complete muscular relaxation, and with the right hand sharply dorsiflexing the foot without letting go of the leg. This produces a rapid, regular, and rhythmic series of movements of flexion and extension of the foot. This epileptiform tremor is sometimes elicited in testing for the patellar reflex.
This truly pathological clonus must not be confused with the false clonus (Babinski), which can be produced by voluntary contraction of the muscles, but this latter is neither so prolonged nor so regular as the true clonus, and is not in the least pathological.

*Patellar clonus* is produced by pushing the patella sharply downwards, and thus causing oscillations of it by rhythmical contractions of the quadriceps.

The various types of clonus are indications of exaggerated reflex activity (Babinski).

**Examination of Sensation**

*Superficial sensitiveness.*—The patient is laid on the bed, completely uncovered and blindfolded. This examination should be carried out in a well-warmed room, otherwise the patient is liable to shiver and have vasomotor alterations, and therefore to return vague answers.

*Tactile sensation.*—The patient must be told exactly what is going to be done; thus: “I am going to touch you lightly with my finger (or with a brush or pencil), and you must tell me, ‘I feel,’ or you will count, ‘one, two, three, etc.,’ each time you feel anything.” It is generally necessary to make two or three trials, so as to be quite sure that the patient fully understands, before starting the examination. In this way the tactile sensation is tested, care being taken to proceed from one spot to another at random, and lengthening or shortening the intervals between successive contacts. The observer must merely touch, not press or rub, and every now and then should ask the patient to put his finger on the spot touched (sense of localisation), taking note of any error in doing so. The testing of the facial sensation must not be overlooked, particularly in the trigeminal area, for which purpose it is better to use a tuft of cotton-wool or a hair.
If the examination shows modification of sensation in any particular region the zone of the anaesthesia or hypoæsthesia must be carefully and minutely tested, and its extent mapped out by proceeding from the normal towards the affected region, and vice versa.
The first method generally shows a slightly smaller anaesthetic zone than the other. In certain cases

Weber’s compasses may be used to see how far they must be opened before a double contact is no longer felt as a single one (tactile discrimination).

**Fig. 5A.—Diagram of the radicular topography of sensation. (The letters with index figures indicate the nerve roots and the corresponding spinal segments.)** Back view.
Sensibility to pain—thermic sensibility.—The patient remaining under the same conditions, the first of these tests is made with a pin, observing whether there are any zones of hyperalgesia. The thermic sensibility is tested by using two large test-tubes, one filled with hot water at 50° C. (124° F.) and the other with cold. The patient is to say whether what he feels is hot, or cold, or neither.

Deep sensitiveness.—Whether there are any disorders of the superficial sensitiveness or not, examination of the deep sensitiveness must never be neglected, as it is of great importance. The following tests should be carried out:

Osseous sensitiveness to the tuning-fork.—A powerful tuning-fork is struck, and, while it is vibrating, its stem is applied to various superficial bony points, e.g. the malleoli, the articular ends of the long bones, etc.

Sense of segmental attitude, or the sense of position.—The limb under examination is placed in positions of increasing complexity, and the patient is told to reproduce the position with the other limb, or to describe the position in which the limb is.

Sense of passive movements.—Very slow movements of flexion and extension are practised on different parts of the various limbs, and the patient is told to state whether he can follow mentally the movement and the sensation of movement.

Stereognostic sense.—By this term is meant the faculty of recognising the nature of an object by palpation and touch while the eyes are closed. Various objects—a knife, pencil, key, watch, coin, button, pin, etc.—are successively put into one hand of the patient at a time, and he is then asked to say what it is. Each hand must be tested separately.

When the paralysis is too extensive for the patient to finger the object, he must be helped by bending his fingers and placing the object between the palm
and the pulp of the fingers. It is useful to test the stereognostic sense in both the radial and the ulnar halves of each hand separately. Some patients can identify an object between the thumb and the index finger, but not if it is placed between the two last fingers and the palm, or *vice versa*.

All the facts ascertained relative to the disorders of sensation should be recorded on one or more models of the type shown in figs. 5 and 5A.

**Examination of Co-ordination**

*Lower limb.*—While the patient is recumbent he is told to place the heel of one side on the knee of the other, to remain in this position for a moment, then to extend the leg, and repeat the movement four times. Observation must be made how this movement is performed: whether there are tremors while carrying it out; whether the heel can be kept steady on the knee; whether the movement is repeated regularly or at varying speeds, and with an exaggerated sweep of the limb (dysmetry). The patient should be made to go through the same movement with the eyes shut, and note made of any variations thus produced.

The following exercises may also be applied: Bring the heel up to the buttock, and put the foot flat on the bed; extend the leg to its full length, and repeat the movement.

If the patient is able to stand, let him stand upright in front of a low chair, lean with both hands on the back, place the front part of the sole of the foot on the edge of the chair, return the foot to the ground, and repeat the movement four times in succession with each foot, noting whether he catches his foot on the edge of the chair or raises it too high.

*Upper limb.*—The patient is told to put the tip of his index finger on the end of his nose, the arm being
each time extended to its full length; this is to be done first with the eyes-open, and then with them shut.

*Test of diadococinesia* (Babinski).—The patient is made to execute movements of pronation and supination of the forearm in rapid succession with each arm separately, note being taken how the movement is performed.

**Examination of Equilibrium**

The patient is told to stand erect with his heels together, then with his feet and heels together, then to stand on each leg successively. Note will be made of the changes in equilibrium produced when the patient turns his head backwards, or turns it sharply to the right or to the left. The movements must be repeated with the eyes shut (Romberg’s test). If the patient falls, note will be taken whether the direction is always the same, whether he falls in a mass, or makes irregular movements to regain his equilibrium. These simple tests will be supplemented, if possible, by labyrinthine tests, which are described later on.

**Examination of the Gait**

The gait often shows slight alterations which the tests of segmental power or co-ordination have not clearly disclosed. It must be made the subject of protracted study to define the disorders which may be ascertained: Titubation; lateral deviation; swaying forward; late repulsion; bending; stepping as if going up stairs; swinging the arms as in mowing; spasmodic gait, with very short steps; associated movements. It is impossible to exaggerate the importance of attentive study of this function, which must be completed by a study of ordinary walking.
This examination must be made with the patient completely undressed.

The detailed consideration of the disorders of co-ordination, equilibrium, and gait will be gone into in connection with wounds of the cerebellum, when it will be necessary to expand the various clinical tests which we have just described (see Chapter IX.). But in any case the above tests must always be carried out in the routine examination of a neurological injury.

Examination of the Speech

To this subject is devoted a chapter dealing specially with the technique of the examination of a patient suffering from disorders of the speech (Chapter VII.).

Examination of the Sensory Apparatus

Visual apparatus.—It is most necessary that the neurologist should be qualified to make a brief test of the visual functions of the patient whom he is examining. The following are the investigations which it is most important for him to carry out:—

1. Test of the ocular movements.—The first thing to note is whether there is any strabismus. The patient is then told to follow the observer’s finger with one eye, the other being closed, and then with both eyes, the head remaining immobile. Note is made whether the movement of the eye is complete in every direction, and if there is any sign of nystagmus (horizontal, vertical, or rotary), that is, of rhythmic ocular vibrations. The vibration of nystagmus includes both a rapid movement and a slow movement in the opposite direction; it is the direction of the rapid movement which stamps the character of the nystagmus.

The patient is asked if he always sees one or two fingers during the test. If there is diplopia, the test
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is made more definite by making the patient put a piece of red glass before one eye, and, under the same conditions as before, he is told to follow the flame of a lighted candle with his eyes. If he sees two flames, one red and the other white, he is told to describe their relative positions, by which test it will be possible to ascertain the muscle whose paralysis is the cause of the diplopia.

Examination of the pupil.—This examination should be carried out in the dark room by artificial light. Observation is made of the shape and size of the pupil; of inequality of the pupils; the pupil reflex to light both direct and consensual, that is, by observing one pupil while the light is thrown on to the other. The test is completed by testing the pupil reflex for both convergence and accommodation.

Visual acuity.—This test must never be neglected, but before carrying it out it is first necessary to correct any error of refraction. The patient is then placed at a distance of 5 metres (16½ feet) from a sheet of test types, the acuity being indicated by the figure opposite the line of the smallest characters which he can read.

Examination of the ocular media and the fundus oculi. —The examination will be concluded by a test of the ocular media (the cornea, the anterior chamber, and the lens) with a plane mirror or by oblique light, and then of the fundus (the disc and the macula) indirectly by the reversed image, or directly, if necessary, after dilatation of the pupil by homatropin.

The technique of examination by the perimeter will be found in Chapter VIII.

In many cases it will not be possible to carry out the examination in such detail, and then a specialist must be called in; but every neurologist should be qualified to carry out this elementary examination, if only to get a fair idea of the lesions, and to send
the patient to the specialist with some information on the case.

**Auditory apparatus.**—The same thing may be said with regard to examination of the auditory apparatus, at least as far as auditory tests are concerned. As regards the vestibular tests, they concern the neurologist as much as the aurist, and he ought to know the technique. Information will be obtained as to the condition of the hearing by bringing a watch near to the auricle and noting at what distance the ticking can be heard; or by pronouncing in a whisper various numbers (12, 22, 33, 40, 55, 66, 70, etc.) which the patient has to repeat, and measuring the distance at which the words are audible to the patient.

**Tests with the tuning-fork.**—Only an otologist can make a more exact measurement of the auditory acuity, but for the neurologist it is necessary to locate precisely the anatomical site of the lesion by the following tests:

- **Schwabach's test.**—Apply the end of a low-pitched tuning-fork in vibration to the mastoid, and note how long it is heard. (Prolongation of the perception indicates lesion of the apparatus of transmission; abbreviation, lesion of the apparatus of perception.)

- **Weber's test.**—Place the vibrating fork on the top of the skull. (If there is a lesion of the apparatus of transmission on one side, the sound will appear louder on the same side; if there is a lesion of the apparatus of perception, it will appear louder on the other side.)

- **Rinne's test.**—Apply the foot of the fork in vibration to the mastoid; when it can be no longer heard, the still vibrating prongs of the fork are brought near to the auditory meatus, when it is heard again for several seconds. (If the sound is no longer perceptible, the lesion is situated in the apparatus of transmission; Rinne's negative.)
Lombard's test.—If the patient suffers from uni-lateral deafness, the functioning of the sound ear is suppressed by injecting water into the auditory canal, and he is told to read aloud; the pitch of his voice will be considerably increased during the experiment if the deafness is of central labyrinthine origin (apparatus of perception).

By these tests it can be ascertained whether the site of the lesion is located in the apparatus of transmission or of perception. If the results obtained are abnormal, the case must be referred to an aurist.

Vestibular tests.—The tests which concern the vestibular portion of the labyrinth are much more important to the neurologist, because they supply valuable information regarding the functions of the cerebellum, as well as of the condition of the labyrinth itself.

Before applying them the patient must be questioned as to any subjective disorders from which he may be suffering—vertigo, sense of falling or tottering, or displacement of objects, etc.—and note must be carefully taken, by means of the tests already described, whether there is spontaneous nystagmus or static or kinetic disturbance of equilibrium.

Then the following tests will be made: Rotation test, Barany's caloric test, and Babinski's voltaic vertigo test.

Rotation test.—The simplest plan is to seat the patient on a revolving chair with his head erect and his eyes closed. The chair is rotated from left to right twelve times in about thirty seconds. Under normal conditions, when the rotation is stopped there will be horizontal nystagmus to the left, lasting for about half a minute. If the patient's equilibrium is tested, the body will tend to fall to the right, but this will vary according to the position of the head.

After a few minutes the test is repeated by rotating the chair in the opposite direction; the nystagmus
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will then be to the right, and the inclination to fall to the left.

This test is inconclusive, inasmuch as its effect varies greatly in different subjects; it is not sufficiently sensitive, and as the excitation affects both labyrinths at the same time, it is impossible to get accurate results regarding one only. Rotation to the right specially affects the left labyrinth, and *vice versa*.

The pathological modifications observed in the course of these tests will be stated when dealing with lesions of the labyrinth.

**Barany’s caloric test.**—This test is carried out by injecting hot or cold water into the auditory canal at a moderate pressure. We shall confine our attention to the cold-water test, as it is the most rapid and the most certain; but before carrying it out, the condition of the ear must be examined to make sure that the canal is not obstructed by wax. If the tympanum is perforated, the injection should not be made.

If all is well, the procedure is as follows: Water at a temperature of 25° C. (79° F.) is injected from an ear nozzle into the auditory canal by means of a glass irrigator placed about 20 inches above the level of the canal while the patient is seated with the head upright or inclined slightly backwards; he is told to look away from the injected ear, and his eyes are observed while the injection is being made.

Under normal conditions the following phenomena will be observed: 1. In half a minute to a minute there will be lateral nystagmus to the side opposite to the injected ear, at first slight, but becoming very intense. 2. The injection is stopped, and the patient is placed erect, with his feet together and his eyes shut; there will be a tendency for the whole body to fall to the side corresponding to the ear injected. If the patient’s head is now turned 90° to that side, so that the ear is directed backwards, the inclination will be
backwards. If his head is then turned 90° to the opposite side, so that the injected ear is directed forwards, the inclination will be forwards. All these reactions are labyrinthine in character, but vary greatly in intensity in different subjects. 3. In the course of this test there will be found involuntary movements of the limbs, provoked by the cerebellum under the influence of the stimulation of the labyrinth. For instance, if a normal subject is told to shut his eyes and hold out his arms in front of him, he will easily maintain this attitude for some minutes. But if a right lateral nystagmus is produced in the same subject by injecting cold water into his left ear, and he is told to assume the position, his arms will be seen to deviate slowly and insensibly to the left. In a recumbent subject the same results will be obtained in the lower limbs.

All these labyrinthine reactions obtained by the caloric test are accompanied by more or less marked subjective disturbances—vertigo, nausea, etc. Their intensity varies greatly in different subjects, and the tests should be repeated several times.

This chapter deals only with the technique of the normal reactions, their pathological modifications being reserved for another chapter, in which we shall enter into full details of the modification of the involuntary movements, which are of the highest importance in the localisation of wounds of the cerebellum (Chapter IX.).

Voltaic vertigo test (Babinski).—If the poles of a galvanic battery are applied in front of the tragus on both sides of a normal subject and a current of 2 to 5 milliampères is passed, the head is inclined towards the side of the positive pole. The battery should be of twenty-four elements, connected in series, and provided with a rheostat and a milliampère-meter. The electrodes should be pads, about 1 inch in
diameter, which the operator keeps moistened and firmly applied in front of the tragus on each side, the patient being erect with his feet together when the current is turned on. With a current of 1 or 2 milliampères in a normal subject the head inclines to the side of the positive pole, and if the current is increased, the whole body is drawn to the same side, and with this is often associated a rotary nystagmus directed to the negative pole. If the current is suddenly cut off, the head returns to its normal position. This test is accompanied by more or less marked sensations of vertigo. The voltaic vertigo is sometimes produced by a very weak current, but in some cases the resistance to the voltaic vertigo is exaggerated, and the current has to be increased to 15 or 20 milliampères to induce the inclination of the head. The characters of the nystagmus vary greatly, and in healthy subjects it may be absent.

The pathological modifications of the voltaic vertigo (which will be dealt with later on) frequently resemble those of Barany's caloric test, but there is not necessarily any connection between them. With this test, as with Barany's, involuntary movements of the limbs may be observed.

Lumbar Puncture. Radiography

The description of the neurological examination of a patient suffering from a wound of the skull will be concluded by a brief analysis of two complementary procedures which are very important in diagnosis.

1. Lumbar puncture.—As the technique of this operation is well known, it will not be necessary to describe it in detail; it will suffice to state the following points:—

The fluid must always be tested for excess of albumen by adding nitric acid, drop by drop, to a
known quantity of the cold fluid, shaking it meanwhile until the opalescence ceases to increase. After a little practice the quantity of albumen per litre can be fairly accurately estimated. The normal proportion is about 0.20 centigram per litre. Much greater exactitude can be obtained by using the graduated tube introduced by MM. Sicard and Cantaloube. To 4 cubic centimetres of the slightly warmed fluid are added 12 drops of trichloracetic acid solution (1 in 3); the fluid is allowed to stand for four hours, and the height to which the precipitate has risen on the scale is noted. The quantity of albumen per litre corresponding to the division reached can be ascertained by reference to a table prepared by the inventors.

The cytological examination is both qualitative and quantitative. Quantitative test.—Nageotte’s cell is used, and, by a procedure precisely analogous to that employed in a blood-count, the proportion of cellular elements per cubic centimetre of the cerebro-spinal fluid can be ascertained. For the qualitative analysis, 10 cubic centimetres of the cerebro-spinal fluid are centrifugalised for thirty minutes; the sediment is collected, and a slide is prepared; after fixation and staining, the cellular elements are examined with an immersion lens.

There are two definite indications for lumbar puncture, which will be dealt with later on; one, cases of head-wounds which present no objective sign of cerebral lesions and yet complain of subjective disorders; and the other, when a complication, such as meningitis, abscess, or encephalitis, is feared.

2. Radiography.—This is one of the most essential points in the examination of a wound of the skull, and it is important to observe certain rules of procedure which M. Infroit of the Salpêtrière has long urged.

The usual method is to radiograph the subject lying
flat on his belly, with the right or left side of the face on the radiographic plate. This method has many disadvantages; the varying inclination of the head towards the chest and laterally causes considerable distortion of the bony outlines, and renders the interpretation of the radiograph unreliable. To carry out the system suggested above of cranio-cerebral topography based on fixed datum-points, it is necessary to ensure both the complete immobility of the subject and that the position of the head shall always be absolutely identical. The technique, which is too complex to be described in detail, has been worked out by M. Infroit, the head of the Radiographic Laboratory of the Salpêtrière.

Radiographs taken full-face and in profile show the site and dimensions of the bone defect, the line of a fissured fracture, the presence of fragments, or of any foreign metallic body; by comparison of the various plates, the site of these can be ascertained with great accuracy.
CHAPTER II

THE SUBJECTIVE SYMPTOMS, COMMON TO ALL SKULL WOUNDS

The Ordinary Subjective Syndrome

In nearly every case of wound of the skull the patient complains of purely subjective disorders, the explanation of which is frequently extremely difficult. These subjective symptoms are to be found not only in cases in which there has been previously, or still is at the time of the examination, indisputable evidence of organic lesion of the nervous system, but even more frequently perhaps in cases in which the most minute neurological examination has failed to reveal the slightest organic symptom: no variation of the tendon or cutaneous reflexes, no aphasic symptoms, no disturbance of sensibility, and especially no trace of astereognosis, deficiency of the field of vision, or disturbance of equilibrium.

These subjective disorders occur in cases of wounds of the skull with astonishing regularity; their various types have been carefully studied in detail by M. Pierre Marie.¹

HEADACHE

Nearly all the patients who have sustained a wound of the skull suffer from some form of headache. They complain of a feeling of pressure, constriction, and

throbbing all over the head, or in the frontal or the occipital region, and sometimes behind the eyes, extending on to the face. The seat of the headache is often different from the site of the wound, but the headache is always predominantly in either the frontal or the occipital region. Over the scar, whatever may be its characteristics, and in a fairly wide zone around it, there is frequently hyperaesthesia on the slightest touch; this is particularly marked over the cutaneous scar.

The headache is seldom continuous, but generally recurs at regular periods—on awaking in the morning, or on going to bed at night, or before meals, and is induced or increased by a number of circumstances. In the interrogatories of a large number of patients, the following are given as causes of aggravation of the headache: The act of stooping, sneezing or coughing; any physical exertion; walking rather quickly, going upstairs; even mental exertion, as reading or composing a letter; a rather strong light; bright sunshine, or the light of an arc-lamp. The headache is quickly induced by the sight of objects in motion, such as the wheels of a moving coach, or by looking at a cinema film, and it is then frequently accompanied by a sensation of vertigo, which will be dealt with below. Sudden shocks and loud noises, especially reports and explosions, are certain to bring on the headache, which is often associated with hyperacousis. Travelling on the railway (especially underground) or in a tram is very badly borne. The headache is also increased by changes in the external temperature; cold, extreme heat or high wind, all alike tend to increase it.

**Vertigo: Giddiness**

The patient almost always complains of vertigo as well as headache. What the patient calls vertigo
generally starts with giddiness: a cloud spreads over his sight; he feels that he is losing his equilibrium, although he seldom actually falls down; he is obliged to stop and support himself or to sit down; then he regains composure, but for a short time he feels upset and good for nothing, with a feeling of instability and unsteadiness in his walk. The giddiness is not regular in its recurrence; in some cases it occurs several times a day, and in others only at long intervals. Sometimes it is confined to a mere disorder of vision, such as an appearance of muscae volitantes, when the patient looks steadily at an object for a long time, or reads too long, and it is not accompanied by vertigo.

Other subjective disorders.—In addition to the headache and vertigo, which are the most frequent and most evident, the patient suffers from other nervous disorders, which vary in prominence in different subjects. Among these are Insomnia: either the patient cannot get to sleep, or he starts up in the night with nightmare. Changes in character. The patient displays greatly heightened irritability or emotion, accompanied by more or less marked vasomotor phenomena; fits of rage, reddening of the face, and sometimes epistaxis; he perspires on the least exertion and there is frequently tachycardia, which, however, is seldom persistent. Defective memory. The patient will forget what he has been doing during the day, or an errand on which he has been sent. Finally, fatigue will rapidly follow even slight mental effort, and the effort will cause return of the headache and vertigo.

General characters of the ordinary subjective syndrome.—Nearly all patients describe the disorders above set out in almost the same way and in the same words. This is an altogether special and very characteristic syndrome, but its pathogenic explanation is extremely difficult. It is interesting to observe that neither the site, the dimensions, nor the depth of the
wound has any apparent connection with the intensity or type of the headache or vertigo, and patients in whom only the scalp has been cut complain of the same headache and vertigo. These disorders are most frequently associated with splintering of the external table of the skull. On the other hand, it often happens that patients presenting extensive cranial fracture, accompanied by hemiplegia, paraplegia, etc., do not complain of these disorders, and it may be stated that, speaking generally, this syndrome is apparently much less commonly met with among officers than among the rank and file.

**DIFFERENTIAL DIAGNOSIS AND EXAMINATION FOR OBJECTIVE ORGANIC SIGNS**

Under these circumstances the symptoms of which the patient complains should be most minutely analysed, and search should be made for the most trifling organic signs which may give a clue to the cause of the purely subjective symptoms. Care must be taken not to confuse the commonplace symptoms which we have just described with an important symptom which reveals a more or less serious organic lesion of the brain.

The characteristics of the headache are in general so marked as to render it impossible to mistake it for the headache associated with the onset of an attack of meningitis, or with a cerebral abscess, which is, moreover, accompanied by important organic symptoms, which there will be opportunity to describe later. The vertigo and giddiness may, nevertheless, give rise to serious mistakes, but a careful analysis of the symptoms met with will eliminate any chance of confusing this giddiness without falling with the series of indubitably organic disorders which we shall enumerate.
The trifling dizziness experienced by patients suffering from wounds of the skull must not be identified with the scotoma scintillans, accompanied by slight headache, which occurs in cases of wounds of the occipital lobe, and is, moreover, nearly always associated with absolute scotoma of the hemiopic type, often of very small dimensions, and frequently ignored by the patient, but arising from a lesion of the occipital visual area. Again this sensation of vertigo, accompanied by a condition of general discomfort, must not be taken for an attack of petit mal, which may, however, occur at the termination of a crisis of scotoma scintillans. This will show the importance of analysing the symptoms, and making the most minute examination of the field of vision.

This giddiness must likewise be distinguished from the true disorders of the labyrinth, which is often by no means easy. The vestibular functions must always be carefully examined, especially by the application of the voltaic vertigo test. If the vertiginous manifestations are of the trifling character associated with the syndrome with which we are dealing, the reaction to the galvanic current is generally only slightly modified. But, as M. Babinski has pointed out, in whatever part of the skull the site of the wound may be, it is possible that there may have been a perturbation of the labyrinth causing the vertigo of which the patient complains, and an objective examination will then disclose various modifications of the reaction, such as increased resistance to excitation by the current, movements of the head backwards and forwards instead of inclination to one side, etc. To sum up, a complete neurological investigation must be carried out on every patient who presents the syndrome of subjective symptoms which has just been analysed, and special attention must be paid to the apparatus of the two special senses, which may reveal slight
organic lesions, the symptoms of which must be thoroughly inquired into.

**The visual apparatus.**—A thorough examination of the fundus must be made, and will reveal the presence of any lesion due to increased intracranial pressure. The field of vision must also be examined for an unperceived scotoma.

**The auditory apparatus.**—The vestibular function must be tested, and this will sometimes enable the observer to ascertain the actual cause of the vertigo.

When circumstances permit, the cerebro-spinal fluid must always be examined. In many cases lumbar puncture discloses appreciable modifications of the fluid, which indicate organic lesion of the nervous system (Claude, Sicard). One may find an increase in the pressure of the cerebro-spinal fluid measured by the manometer, which seldom exceeds 50 cubic centimetres of water; there is, however, no fixed ratio between the increase of pressure and the intensity of the subjective symptoms. There may also be an increase of albumen in the cerebro-spinal fluid, never considerable, and varying from 30 to 60 centigrams per litre (Sicard).

The use of radiography must never be neglected, as it may disclose the presence of fragments in the neighbourhood of a bone defect, or of a fissured fracture, or even of a missile in the brain that has been overlooked.

**Course and Treatment**

It is very difficult to make an exact prognosis in these cases. They make no perceptible progress, or progress very slowly. Cases have been known where the patient still complained of the same symptoms after several months. In particular, it may be stated here that several patients, who had undergone plastic
operations upon the bone defect on account of the severity of their symptoms, seem to have received no great benefit thereby.

The best treatment for a patient suffering from these subjective disorders appears to be to let him rest by giving him one, two, or three months' convalescent leave, during which he should follow a course of electric treatment if he is near a suitable institution. Hydrotherapy does not seem to give good results. Then, according to his condition, put him on temporary half-pay, or pass him into the auxiliary service.

Speaking generally, no soldier who has sustained a wound of the skull should be sent back near to the firing line, or anywhere in the neighbourhood of gunfire or explosions.

When the patient has a large pulsating defect in the skull he should be invalided out of the service, except in very rare cases.

Pathogenesis

In a very large majority of cases the origin of these subjective disorders must be sought in an organic modification of the nervous system, which, if not manifested by local indications, can be detected by these general indications. The results obtained by lumbar puncture will afford one test. As Professor Pierre Marie states in his report, "All the subjects describe their symptoms in the same way and in the same words. It is quite certain that this is not a case of the repetition of a lesson which has been learnt."

It is only possible to speculate concerning the importance and anatomical nature of the causal lesion, but it is quite possible, as Léri maintained, that these subjective disorders are connected with meningeal adhesions. Examinations in the course of operations
and post-mortems which have been made in some cases support this view. Still it would seem that an important part must be assigned to lesions of the venous sinuses, and especially to the superior longitudinal sinus, at least when the wounds are situated on the median line of the skull, since any obstruction or modification of the circulation in the venous sinuses may cause an important alteration in the entire circulation of the brain. The possibility of a commotion of the labyrinth by the intensity of the shock inflicted on the skull by the impact of the missile must also be taken into consideration.
CHAPTER III

WOUNDS OF THE FRONTAL LOBE

Anatomy

The frontal lobe is that portion of the hemisphere which is situated in front of the fissure of Rolando. This lobe corresponds to the frontal bone, of which it occupies not only the squamous vertical portion, but also the whole of the orbital aspect. Its outer and posterior limits pass considerably beyond the margins of this bone. It is made up of four convolutions; one parallel to the fissure of Rolando, which is the ascending frontal convolution, and three horizontal convolutions, which are named from above downwards the first, second, and third frontal. Each of these joins the ascending frontal convolution at right angles, runs a course parallel to the upper convex border of the hemisphere, and, at the frontal pole, bends down to the under or orbital aspect of the lobe. Each convolution, therefore, has both a superior or external and an inferior or sub-frontal portion. The first frontal convolution has also an internal surface.

The ascending frontal convolution is dealt with in Chapter IV. This convolution is divided from the three horizontal convolutions by the pre-rolandic, or pre-central, fissure, which runs parallel to the fissure of Rolando, and is often divided into two parts by
the junction of the posterior end of the second frontal with the ascending frontal convolution.

The first or superior frontal convolution is situated at the sagittal border of the hemisphere, and comprises an external or dorsal portion, which joins the ascending frontal convolution by three limbs, and is directed forward, becoming gradually thinner; a narrow, rectilinear, sub-frontal, or orbital portion, and an internal portion which occupies all that part of the internal aspect of the hemisphere above the convolution of the corpus callosum (callosal gyrus). The first frontal sulcus divides the first from the second
frontal convolution on the external aspect of the lobe. The orbital aspect of the sulcus is named the olfactory sulcus, and contains the peduncle of the olfactory bulb.

The second, or middle frontal, gyrus comes from the middle part of the ascending frontal. It is the widest of the three convolutions, and is much spread out and sinuous, occupying two-thirds of the orbital aspect of the lobe, and ends at the transverse branch of the \( H \)-shaped transverse orbital sulcus in the middle of the orbital aspect. It is divided from the third frontal convolution by the second frontal and the external orbital sulcus.

The third, or inferior, frontal convolution (also called Broca’s convolution) lies between the second frontal sulcus and the Sylvian fissure. It is divided into three parts by the branches of the Sylvian fissure: the foot, the opercular portion, between the pre-rolandic sulcus and the ascending branch of the Sylvian fissure; the prominence, the triangular part between the ascending and horizontal branches; and the head, the orbital portion, which forms the posterior and external part of the orbital aspect. The white matter of the frontal lobe is made up of numerous association fibres: fibres of intrinsic association, arcuate fibres, occipito-frontal and uncinate fasciculi, and the callosal fibres.

It is not necessary to enlarge on the numerous varieties of cell-structure in the frontal region. The frontal type is characterised mainly by slightly marked development of the various cellular strata, and a deficiency in cellular elements.

**Physiology**

Medical men and psychologists have always devoted much attention to the functions of the frontal lobe, but in spite of the great number of physiological experiments and anatomical and clinical investiga-
tions which have been carried out, it may be said that we know little or nothing about its functions.

A. Physiological experiments have been carried out principally by two methods: electrical stimulation of the cortex, and total or partial extirpation of the frontal lobes.

The theory has long been maintained that the frontal lobes are a very important centre of association and the seat of the highest psychic functions. This purely theoretical assumption, which was based on the increase in size of the frontal lobes in the animal series in proportion as it approximated to man, has never received the slightest experimental confirmation. On the other hand, Munk and Sherrington appear to have shown by electrical stimulation of the frontal lobes that these do play a certain part in the motor functions. (It must be remembered that the ascending frontal is not included in this chapter.) Munk found in the dog a zone of excitability for the muscular system of the trunk and abdomen, and also for the respiratory movements. Sherrington could find in the monkey only one centre, of lateral movement of the eyeballs to the side opposite to the excited hemisphere, in the whole of the frontal lobe (exclusive of the ascending frontal gyrus). Extirpation of the anterior portion of the frontal lobe in the dog and the monkey has given no reliable result, although Munk appears to have observed a paralysis of the muscles of the trunk.

B. Human pathology, and especially the clinical study of tumours of the frontal lobe, has shown the existence of a certain number of symptoms, which some authorities consider characteristic of a frontal localisation. As the result of my personal experience, I have come to the conclusion that, in most cases, it is very difficult to say whether the symptoms are caused by a frontal lesion, or are due to the tumour acting on regions of the brain at a distance.
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1. *Psychic symptoms.*—Important lesions of the frontal lobes are frequently accompanied by profound disorders of intelligence, etc.; a marked tendency to "joviality" on the part of the patient, who jests and indulges in witticisms which are often extremely puerile, has been held to be of pathognomonic significance, contrasting as it does with the slowness of his psychic reactions, the extreme diminution of his attention, and his apathy.

2. *Motor symptoms.*—Oppenheim has called attention to the existence of a permanent contracture of the muscles of the trunk in opisthotonos or emprosthotonos in the course of the development of tumours of the frontal lobe; this may also come on in crises. This approximates to the results of Munk's experiments. Conjugate deviation of the eyes to the side opposite to the lesion has also been noticed. Disorders of equilibrium and of co-ordination in the movements or the gait of patients who are the subjects of a tumour of the frontal lobe have been described under the name of frontal ataxia. These symptoms are by no means of regular occurrence, and many neurologists consider that they indicate action at a distance on the cerebellum. Motor disorders resembling the catatonic phenomena observed in cases of psychosis have been recently described by Kleist, who locates their cause in the frontal lobe (tonic innervation and tonic perseveration of Wilson). These symptoms will be considered under the head of apraxia. The disorders of speech observed in lesions of the left frontal lobe will be fully dealt with in the chapter on aphasia.

Symptoms

Site and characters of the wounds.—Attention must be given to some peculiarities of wounds of the frontal lobe.
A wound which involves only the frontal sinus must not be considered as a wound of the frontal lobe. The dimensions of the frontal sinus, whose cavity extends into the thickness of the frontal bone above the orbit, vary greatly in different individuals, its vertical diameter above the superciliary arch being often an inch or more. It is important to remember this, so as not to take what is really a wound of the frontal sinus for a wound of the frontal lobe, which is not to say that there may not be grave complications.

One striking circumstance which deserves examination is the relative frequency of very extensive injuries of the frontal region. It is usually in this region that the most extensive losses of substance are to be seen, gaps larger than a crown piece, with marked pulsation and impulse on coughing. It would seem from this that wounds of the frontal region are among the least grave, or, at any rate, the best borne; the vague symptoms of these wounds partly explains their relative benignity.

Symptoms.—It is hardly an exaggeration to say that there are no symptoms special to wounds of the frontal lobe. In the numerous cases which have been examined, the symptoms observed arose from complications peculiar to the wounds and not from the damage to the lobe itself. It may be said generally, however, that patients suffering from an important lesion of the frontal lobe present a peculiar mental condition, a kind of torpor and psychic numbness, slowness of ideation and speech, but in many cases the clinical examination shows no disorder definitely caused by the lesion of the frontal lobe (with the exception of the ascending frontal convolution). Except a slight alteration in the tendon reflexes, more marked on the side opposite to the wound (the lesion being in the neighbourhood of the motor convolutions), none of the symptoms enumerated above—contracture
of the muscles of the trunk, deviation of the eyes, ataxia, apraxia, etc.—have ever been observed by us. It is only on account of the disorders of speech which they may bring on that wounds of the left frontal lobe deserve special mention, but these disorders occur equally in wounds of the right lobe, though not so frequently. For instance, anarthria and dysarthria sometimes come on immediately after the wound, but persist only for a few days or weeks, and have generally ceased at the time of the examination, the patient stating that for some time he was unable to speak, or spoke very indistinctly, although he knew well enough what he wished to say. In other cases, of which we have observed several, wherever any part whatever of the left frontal lobe was involved, there was hesitation or slowness of speech or stuttering resembling that met with in disseminated sclerosis, which persisted for several months after the wound. On the other hand, there was no aphasia.

Complications peculiar to Wounds of the Frontal Region

1. Facial paralysis.—This is due to lesions of the superficial structures, and occurs even when there are no osseous lesions. It is caused by division of the branches of the superior ramus of the facial nerve, and is met with in lateral wounds of the temporal fossa far forward, and manifests itself by paralysis of the frontal muscle when it is of the partial peripheral type. In repose, the forehead on the wounded side is smooth and without wrinkles, and the eyebrow is flat. If the patient is told to frown, or to raise the eyebrows, the movement is absent on the paralysed side, while, on the other hand, the eye is usually easily shut. Electrical tests generally show loss of electric excitability of the frontal muscle, with total or partial R. D. This
paralysis must not be confused with total peripheral paralysis arising from a fissured fracture of the base affecting the facial nerve in the petrous bone, with which auditory troubles are often associated, nor with central paralysis, which, however, is generally on the side opposite to the wound.

2. Lesion of the frontal sinus.—When the wound is anterior and low down, that is, very near the upper edge of the orbit, the frontal sinus may be involved; in a number of cases, as has already been stated, it may even be the only part involved. If the posterior wall has been injured, and the dura mater or the brain brought into direct contact with the sinus, it is generally made evident by an escape of cerebro-spinal fluid from the nose, which may be very persistent, and recur intermittently for months, as has been observed in one case. This complication is particularly serious, because it exposes the patient to the risk of the formidable complication of meningeal infection; the subarachnoid cavity being placed in communication with a natural cavity may easily become infected even after the external wound has cicatrised.

3. Ocular lesions.—This is a very common complication in wounds of the frontal region, and presents several important variations which it is important to know. It is always necessary to interrogate the patient as to the condition of the vision of each eye, to examine the fundus, especially the macular region, and to measure the field of vision and the visual acuity.

(1) Lesions of the optic nerve.—Immediately on receiving the slightest wound in the frontal region the patient loses the sight of the eye on the wounded side. The blindness is generally immediate and total, and it is only in rare cases that there remains even a vague perception of light. Examination of the ocular apparatus, and particularly of the fundus, does not
show anything abnormal at this time. The development is as follows: After a few weeks vision returns, but is much enfeebled; the patient is able to distinguish between light and darkness, but visual acuity remains very low, and the improvement does not increase; the power of vision may even disappear altogether. Examination of the fundus will show now a pallor of the disc, with narrowing of the vessels, indicating atrophy of the optic nerve. The pathogenesis of this atrophy is somewhat complex. It appears to be caused by extension of the fracture of the vault to the roof of the orbit and the optic foramen. The consequence is sometimes actual division of the optic nerve, but more frequently hæmorrhage into its sheath, with compression, and consequent atrophy, of the nerve.

(2) Lesion of the oculo-motor nerves.—Damage to the motor nerves of the eye as they pass into the orbit is much less frequently observed, though total or partial paralysis of the third, or the sixth nerve with strabismus or diplopia, may be seen, but these paralyses are not peculiar to wounds of the frontal region. The sixth nerve appears to be especially fragile, as a slight diplopia, arising from paresis of the external rectus muscle, which is innervated by this nerve, is observed in many patients wherever the site of the wound may be.

(3) Lesions of the macula are a very curious result of wounds of the frontal region, and sometimes of regions more distant from the eye. Immediately on receiving the wound the patient loses the sight of the eye on the wounded side. As his condition improves, vision returns in the peripheral portions of the field of vision, but only very slightly, and the visual acuity remains greatly reduced. In some cases the recovery is more complete, but the patient is left with a more or less extensive central scotoma, which
considerably limits the field of vision; its dimensions can be measured exactly with the perimeter. This scotoma, which is caused by an intra-ocular lesion, must not be confused with a macular or para-macular hemiopic scotoma caused by a lesion of the occipital lobe. The essential character of the latter is that it exists in both eyes, and is absolutely, or nearly absolutely, identical in both fields of vision. If there is a scotoma caused by ocular lesion, examination of the fundus will reveal the existence of very definite lesions of the macular region; sometimes simple oedema, sometimes hæmorrhage and lacerations in various stages of their development. This lesion is very interesting, because it is not due to a direct wound of the eye, but to damage at a distance by “contre-coup,” as it were, the lesion being always confined to the macular region or its immediate neighbourhood.

(4) Chorido-retinal lesions are closely analogous to the foregoing as regards pathogenesis, and are marked by the same symptoms, but the modifications of vision are often more persistent, and perimetric examination shows the existence of a more or less extensive irregular scotoma, which is not confined to the macular region, and may not affect it at all. Examination of the fundus will show various lesions, often in the form of broad, straight, or stellate rents, whitish or edged with pigment, which are caused by actual rupture of the choroid, with consequent hæmorrhage.

Auditory lesions.—Unilateral deafness may exist on the wounded side, or even on the opposite side, or there may be bilateral diminution of the acuteness of hearing. Extension of the fracture to the petrous bone may be found (though seldom), when there will generally be total peripheral facial paralysis on the same side as the paralysis of the auditory nerve. Rupture of the tympanum or disorders of the
labyrinth caused by concussion at a distance are the most frequently found. There should always be a most careful examination for these auditory disorders.

Such are the complications of wounds of the frontal region. They are numerous and frequent, and, on the whole, much more important than lesions of the frontal lobe itself.

**Diagnosis**

It is evident from the above that the diagnosis of a direct lesion of the frontal lobe in cases of wounds of the frontal region will often be very difficult. The diagnosis must be based on the characters of the wound itself, the presence of a missile in the brain, and the accepted symptoms described above, which have hitherto been rarely observed except in cases of tumours of the frontal lobe; as already stated, the result of the examination will generally be negative. The examiner must always be careful to search systematically for indications as to whether the frontal sinus is involved, and for ocular lesions especially, and must make careful use of the ophthalmoscope to detect lesions of the macula, and of the perimeter for unilateral central scotoma.

**Treatment**

Wounds of the frontal lobe do not call for any special treatment; the ocular complications belong to the department of ophthalmology. When the loss of bone is extensive, there will always be a question as to whether there should be a plastic operation. When the loss of substance is plainly visible in the anterior frontal region, it may be desirable for the sake of the patient's appearance to cover in the
defect, but that is, in my opinion, the only valid reason. Plastic operations on the anterior wall of the frontal sinus appear to be well borne, and some of them have been perfect from the aesthetic point of view. The discussion of this very important question will be found in Chapter VI. of Part II.
CHAPTER IV

WOUNDS OF THE ROLANDIC AREA

Anatomy and Physiology

The Rolandic Convolutions

In the rolandic area are included the ascending frontal and the ascending parietal convolutions which surround the fissure of Rolando.

A careful study will be made here of:

1. The fissure of Rolando.
2. The ascending frontal convolution which forms the anterior lip of the fissure of Rolando, the three frontal convolutions coming off from its anterior border.
3. The ascending parietal convolution which forms the posterior lip of the fissure of Rolando, the superior and inferior parietal convolutions springing from its posterior border.

The situation and the anatomical and physiological importance of these two convolutions justify their being classed as a distinct cerebral region (the central lobe of Ecker) and being separated from their respective lobes.

The fissure of Rolando starts from the edge of the inter-hemispheric fissure, a little behind the middle of the hemisphere, and is directed obliquely downwards and forwards, the obliquity increasing as the frontal
lobe becomes thicker, and terminates at a variable distance from the Sylvian fissure. In its course, which is not absolutely straight, it describes a superior curve which is convex in front, a median which is concave in front, and an inferior which is convex in front. The superior extremity forms a small notch on the internal aspect of the hemisphere, and is surrounded by the paracentral lobule, which unites the superior extremities of the two rolandic convolutions on the internal aspect of the hemisphere. The inferior extremity terminates above the Sylvian fissure, from which it is separated by the gyrus uniting the inferior convolutions of the frontal and parietal lobes, the rolandic operculum, sometimes very slightly marked, or placed very deeply in the Sylvian fissure. The floor of the fissure is nearly always intersected by deep transverse folds, forming deep annectant gyri, which intimately connect the two large rolandic convolutions which form the borders of the fissure.

The ascending frontal convolution begins on the internal aspect of the hemisphere, and is the largest part of the paracentral lobule. It runs obliquely downwards and forwards, following the curvatures of the fissures of Rolando, of which it forms the anterior lip. It terminates above the Sylvian fissure, passing round below the lower end of the fissure of Rolando to unite with the inferior extremity of the ascending parietal, thus forming the rolandic operculum.

The ascending parietal convolution also follows the curvatures of the fissure of Rolando, of which it forms the posterior lip. Its upper part is much narrower than the corresponding portion of the ascending frontal, with which its lower extremity is united above the Sylvian fissure by bending round the lower end of the fissure of Rolando. This bend forms the rolandic operculum, which covers the deep convolutions of the insula. The upper end of the convolution is bent
round the upper end of the fissure of Rolando, and unites with the upper end of the ascending frontal to form the paracentral lobule. The paracentral lobule is thus mainly made up of a thick frontal portion and a narrow and slender parietal portion. It will be

![Diagram](image)

**Fig. 7.**—External and internal aspects of one hemisphere and inferior aspect of the brain.

The convolutions are marked by a letter with an indicator; F₁, first frontal; Fa, ascending frontal, etc.; Gs, gyrus supramarginalis; Ga, gyrus angularis; R, fissure of Rolando; Sy, Sylvian fissure; Lob. para, paracentral lobule; L. ling, lingual lobule; L. fus, fusiform lobule, etc.

evident that the ascending frontal and parietal convolutions form a true central lobe, which deserves to be studied apart from the respective lobes of which it forms part, because of its intimate union, its anatomical arrangement, and its physiological properties, which will be stated later.

*Central motor and sensory tracts.*—A whole system
of white fibres which form the central motor and sensory tracts is connected with the portion of the cerebral cortex that has just been described.

The central motor tract or centrifugal tract is formed of several sorts of fibres.

1. The fasciculus geniculatus, the fibres of which originate in the lower fourth of the ascending parietal and frontal convolutions and the rolandic operculum, and are directed transversely inwards across the centrum ovale in the middle segment of the corona radiata; they then form the genu of the internal capsule, passing out thence into the inner portion of the foot of the cerebral peduncle, and terminate in the pons and the medulla oblongata.

2. The pyramidal tract arises from the upper three-fourths of the ascending frontal and parietal convolutions and from the paracentral lobule. At their starting-point the fibres form a kind of fan placed transversely in the middle segment of the corona radiata and pass into the internal capsule, of which they occupy the posterior segment immediately behind the fasciculus geniculatus; they then pass into the foot of the middle cerebral peduncle. The whole length of the pyramidal tract thus formed passes through the ventral part of the pons, forms the anterior pyramid in the medulla oblongata, and divides into three groups of fibres at the inferior extremity of the latter structure; the most important of these groups, the crossed pyramidal tract, passes out in one mass to the opposite side; the second group, the direct pyramidal tract, descends in the spinal cord, and the fibres pass singly to the opposite side; the third group forms the homolateral fibres, which do not undergo decussation. All these fibres terminate in connection with the cells of the anterior cornua of the spinal cord.

The central sensory tract has two segments, an
inferior, the median band of Reil, which is a band of fibres which prolong the posterior column of the cord, and extend from the cells of the posterior cornua through the medulla oblongata to the inferior portion of the optic thalamus, and are joined by the sensory fibres from the nuclei of the cranial sensory nerves. The second or superior segment extends from the inferior portion of the optic thalamus to the cortex of the rolandic area, and on leaving the optic thalamus occupies the posterior segment of the internal capsule behind the genu, and is there intimately intermixed with the motor nerves of the pyramidal tract, described above. These fibres then pass straight into the centrum ovale, spread out fanwise in its median portion, and terminate in the two central convolutions, and particularly in the ascending parietal. It is important to state clearly the general arrangement of these white fibres, because wounds of the rolandic region are often deeply penetrating, and involve the white matter underlying the rolandic convolutions to a wide extent.

Histology.—Very important information as to the structure and cellular architecture of the rolandic cortex has been furnished by the researches of Brodmann and Campbell, a summary of which will be of interest.

The fissure of Rolando divides the rolandic region throughout its whole extent into two zones, which differ entirely in their cellular architecture. The anterior zone, which corresponds to the ascending frontal, is mainly characterised by the absence of the internal granular lamina and the presence of large pyramidal cells (cells of Betz), which increase in number in proportion as they come nearer to the paracentral lobule, disappearing altogether in the inferior portion of the ascending frontal. The posterior zone immediately behind the fissure of Rolando presents
various types of nearly similar structure, but no large pyramidal cells. It will be found that these cyto-
ological data have a very important bearing on the physiology of the rolandic region.

**Physiology**

**Motor zone.**—Before the researches of Sherrington it was supposed that the motor zone was situated in the ascending frontal and parietal convolutions and the paracentral lobule. The motor centres of all the muscular groups were supposed to be located around the fissure of Rolando; the centre for the muscles of the lower limb near the paracentral lobule, of the upper limb in the median portion of both convolutions; and the centres for the face, neck, and eyes in the inferior portion of the same convolutions. After laborious experiments on the ape, Sherrington and Grünbaum proved by means of unipolar faradisation that it is only in the ascending frontal and the anterior portion of the paracentral lobule that electrical stimulation of a given point produces a definite motor reaction. The motor zone therefore appears to be entirely pre-rolandic. These authors concluded their experiments with the destruction of very small portions of the cortex of the ascending frontal, thereby producing paralysis limited to a definite muscular group. A material contribution to the physiology of the motor convolutions has been made by Krause by a series of experiments on human beings. He made use of local electrical stimulation, and by this means located definitely the position of the motor centres in the ascending frontal, in front of the fissure of Rolando, to the exclusion of the ascending parietal. In other respects the distribution of the motor centres as stated by the older authors has been confirmed. They are so distributed that the motor centres of the lower limbs
are situated in the paracentral lobule and the superior portion of the ascending frontal, the centre for the arms in the median portion, and the centre for the face in the inferior portion of the same convolution. Without being so positive, Horsley reached similar conclusions, and was of the opinion that while the ascending frontal is mainly motor, it is also to a certain extent sensory, though much less so than the ascending parietal. It may therefore be said that, arguing from histological and experimental data, the ascending frontal, including the greater part of the paracentral lobe, is to be taken as the only motor zone.

**Sensory zone.**—The localisation of sensation in the cortex is at present not so advanced as is the case with the motor centres. Experiments on animals are very difficult to carry out, and their application to man is hardly justifiable. Experiments on human subjects have been carried out, but they are so few, and the results have been so uncertain, that no great reliance can be placed on them. The only data that are of any practical use are those furnished by clinical and anatomical observations. These show that, speaking generally, the sensory functions appear to be connected with the ascending parietal and the neighbouring regions of the parietal lobe, but that it is impossible to mark out more definitely the limits of the sensory area of the cortex. Efforts to locate the different forms of sensation—tactile, muscular, stereognostic, etc.—are quite uncertain and unreliable. The knowledge derived from experience with the wounded does not justify anything more than a general statement that sensory symptoms predominate, or are found alone, when the lesions are situated in the parietal region, and that motor symptoms are predominant, and a minimum of sensory disorders occurs, when the lesions are situated in the pre-rolandic region.
Fig. 8.—Localisation of the cortical motor centres in the ascending frontal convolution in man, according to Krause, by the local electric stimulation method. It will be noticed that there are no motor centres in the ascending parietal convolution.
**Physiology of the internal capsule: central motor and sensory tract.**—Physiologists and clinicians have long been endeavouring to localise the various fibres which arise from the cortex, or travel to it, in the internal capsule.

(a) With reference to the paths of the various fibres of the motor tract, the supporters of the accepted view suppose that the cranial motor fibres (geniculate tract) are in the neighbourhood of the genu of the capsule; and the pyramidal tract properly so called, divided from front to back into several zones (the cortico-cervical, brachial, lumbar, and crural), in the posterior segment; in short, the higher up in the rolandic zone the point from which the nervous fibres originate in the motor cortex, the further are they situated behind the genu in the posterior segment of the internal capsule. If this were so, a slight lesion of a capsular zone should be capable of producing a slight local paralysis in the face or the upper or lower limb. As a matter of fact, the clinical and anatomical researches of Pierre Marie and Guillon have shown that the most trifling lesion involving the posterior segment of the internal capsule always produces in man the syndrome of hemiplegia, and that a paralysis limited to one limb or to the face never arises from a limited lesion of the capsule, and that, in spite of the accepted anatomical diagrams, it is impossible to assign, on clinical grounds, distinct portions of the capsule to the various fibres for the arm, the leg, the foot, etc., at least in man.

(b) With reference to the sensory tract, it was supposed by Charcot and his followers that the various fibres of general and special sensation passed behind the motor fibres which occupy the anterior two-thirds of the posterior segment of the internal capsule (the sensory crossing), and that any lesion of that region would produce a so-called cerebral hemianæsthesia.
The researches of Pierre Marie have shown that, in man, there may be destructive lesions of the so-called sensory zone of the internal capsule without persistent hemianæst esia ensuing, and therefore there are no conduction paths, in detached groups, specialised for the transmission of sensory impressions in the internal capsule.

Site and Characters of the Wounds

The method of defining the defect in the skull in relation to the fissure of Rolando and the adjacent convolutions, either by the ordinary process of craniometry, or by the special system of radiographic datum-points suggested, has been already described.

The anatomical features of the wound do not call for remark, but if the mapping out of the rolandic cortex is practicable, the clinical picture will vary according to the site of the wound, on the one hand, with the distance up the fissure of Rolando that it extends, and, on the other, with its position in front of, or behind, that fissure; provided that the cerebral lesion is limited to the cortex, and that there is little or no destruction of the subjacent fibres of the white matter.

In view of the physiological data given above, it is to be expected that there will be brachial or crural monoplegias without sensory disturbances, or with more or less important sensory disturbances, which may even greatly predominate over the motor troubles. These monoplegias caused by injury to the cerebral cortex which are so rare in civil practice are very common results of war-wounds, which may be confined entirely to the cortex. A particularly interesting form is the double crural monoplegia from a lesion of both paracentral lobules which produces a true paraplegia of cerebral origin.
The syndrome of hemiplegia is the result of extensive lesions of the bone accompanied by destruction of the rolandic cortex and of the subjacent white matter. A wound of small dimensions, if associated with more or less profound injury of the white matter, and with or without penetration of missile, may be accompanied by a complete hemiplegia, and symptoms will often be found which indicate injury of the central grey nuclei or of the deep white nerve fibres. The wound may be quite outside the rolandic region, say in the frontal region, but the radiograph may show that a missile, which is sometimes very small, has traversed the whole of the internal capsule and been arrested in the occipital region. Several such cases have been observed.

Clinical observation is therefore a better guide in judging the importance of the cerebral lesion than the size of the wound, there being no correspondence whatever between osseous lesions and deep cerebral lesions. Monoplegias, or sensory disorders limited to a single limb, indicate a purely cortical lesion which does not penetrate to any great depth; but if there is a hemiplegic syndrome, it can be concluded that there is more or less profound destruction of the white matter underlying the convolutions, and sometimes of the fibres of the internal capsule as well. It only remains to point out that there will sometimes occur lesions of the rolandic region with the hemiplegic or monoplegic syndrome by contusion, without any loss of bone. In the examination of such cases there will be found merely a lesion of the scalp, with some irregularities of the surface of the bone of the external table; probably a hæmorrhage has occurred either superficial or deep to the dura mater leading to compression of the convolution, or even a direct lesion of the rolandic cortex (bruising of the brain, or slight intracortical hæmorrhages). The clinical picture yielded by such cases will be that of a monoplegia.
WOUNDS OF THE ROLANDIC AREA

Clinical Aspects of the Wounds

Monoplegias

In civil practice true monoplegias are comparatively rare, and are seldom seen except at the beginning of the development of cerebral tumours; monoplegia through softening or cerebral haemorrhage is hardly ever observed.

The wound.—Wounds of the skull as seen in actual war practice are frequently accompanied by a monoplegia because the lesion is merely superficial. These monoplegias can be tabulated according to the order of their frequency as, first, those of the upper limb, second, those of the lower limb, and third, those of the face. In each of these classes the site of the wound differs, and corresponds to the position in the cortex of the motor centres of the face, the upper or the lower limb given in the section dealing with the physiology of the rolandic area. In these monoplegias, which are complete, or partial, according to the seriousness of the wound, there will also be observed various disorders of sensation. These may be classified roughly in accord with the site of the wound as follows: motor disorders will be most prominent if the loss of bone is in front of the fissure of Rolando, and sensory disorders will be the most important, or may be found alone, if the lesion is situated in the ascending parietal convolution.

A. Brachial Monoplegia

The symptoms.—Immediately after receiving the wound the patient, if he has not lost consciousness, or when he regains it, realises that the upper limb is completely useless, or nearly so. In some cases the paralytic phenomena are not strictly confined to one limb; there is also more or less loss of power in the lower limb on the same side, which may disappear in
a few hours, or may persist for weeks. Monoplegia limited to the upper limb seems to be remarkably more frequent than crural monoplegia. At the first onset this monoplegia is flaccid, and passes into contracture after a few weeks, which is generally the time when the patient is examined by the neurologist. It is important to observe that this monoplegia is slight, and much less marked than the complete hemiplegia to be described later on.

Fig. 9.—Usual seat of the wound in brachial monoplegias from a cortical lesion.
Motor disorders.—Total loss of the motility of the limb is rarely observed. The power of moving the shoulder is nearly always retained, and, to a certain extent, the patient is able to raise his arm and move it slightly from the thorax. In repose the patient’s forearm is slightly bent on his arm, and in pronation with the wrist slightly bent and the fingers flexed or incompletely extended. In this very accentuated form of monoplegia a test of the segmental power will show a preponderating affection of all the extensors of the fingers, wrist, and forearm, of the external rotators and of the abductors. The flexors, internal rotators, and the adductors will be relatively much more active. In most cases there is also slight impairment of the motor power of the lower limb.\(^1\) The

\[\text{Fig. 10.—Radiographic localisation of wounds in the rolandic area causing a brachial monoplegia. (Method of Pierre Marie, Foix, and Bertrand.) The dotted zone indicates the projection of the loss of bone on the subjacent convolutions.}\]
face presents a slight degree of asymmetry, and the contraction of the superficial muscles is more feeble on the side affected by the monoplegia. We find, in short, limited to the upper limb, the motor disorders observed in a case of complete hemiplegia from a deep wound of the brain.

In another class of cases the paralysis affects equally all the muscles of the upper limb, and the arm hangs useless at the side. As a rule the paralysis is more localised; it assumes a segmental topography, and is apparent only in all the movements of the hand, or more rarely of the shoulder.

In cases of greatly diminished paralysis, or in which the monoplegia has been originally very slight, a still more marked limitation of the motor troubles having a segmental topography may frequently be observed; only certain groups of muscles in the hand, or much more rarely at the root of the limb, continue to be affected. In these cases of partial monoplegia general weakness of all the movements of the fingers may be observed (extension or flexion being performed without energy), or there may be paresis limited to the movements executed by the interossei, or by some of them, to such an extent that the position of the hand resembles that observed in slight paralysis of the ulnar nerve. One case has been observed in which the motor troubles were limited to the movements of the middle finger only. It is therefore always absolutely necessary to test methodically the movements executed by the various portions of the upper limb.

Examination of the tendon reflexes will show changes; there is nearly always increase in all the reflexes on the same side as the monoplegia, which is more marked in the paralysed limb.

With the exception of the plantar, the cutaneous reflexes are often normal. Free flexion of the toes is
seldom found, and the test pretty frequently evokes no response. Attention should be called to the com-parative rarity of the typical Babinski sign; stimula-tion of the sole of the foot does not cause extension of the toe, often a mere suggestion of separation of the toes. On the other hand, the test for adduction, by scratching the inner border of the foot, often gives a positive result, while a similar procedure on the outer border causes flexion of the toes.

**Disorders of sensation.**—Disorders of sensation, either superficial or deep, are almost the rule in the brachial monoplegias which are not purely of the motor type. Sensory disorders in the form of complete or partial hypoæsthesia on the half of the body corresponding to the monoplegia are frequently observed in connection with wounds corresponding to the superior portion of the rolandic region. At the level of the upper limb the disorders of the sensi-bility are very strongly marked, and assume a segmental distribution. They are seldom complete; more often they conform to the accepted cortical sensory syndrome with nearly complete integrity of the osseous and thermic sensibility and of the sensa-tions of touch and pain, but very marked diminution of the tactile sensibility and of the sense of attitude, accompanied by astereognosis. But this syndrome is far from being the rule; very various isolated disorders of sensibility may be observed, especially a diminution, almost exclusively, of the sensations of pain, temperature, and vibration. No explanation of these variations has as yet been arrived at.

These sensory disorders often assume a special topography of a radicular type which had been previously observed, but is frequently met with as a result of wounds of the skull. These sensory failures are arranged in longitudinal bands over each segment (the hand, forearm, and upper arm) which sometimes
WOUNDS OF THE BRAIN

do not correspond in breadth, and are generally more marked at the extremity than at the root of the limb. It is important to know that anaesthesia of cortical origin may thus assume a pseudo-radicular type.

These sensory troubles are sometimes very persistent, and in a certain number of cases, when the motor troubles have entirely disappeared, there is only an improvement of the stereognostic sensibility to be observed. This astereognosis may extend to the whole hand, or may be limited to the radial (thumb and index finger) or the ulnar portion (the three last fingers). This limited loss of the stereognostic sense is the last vestige of an old cortical lesion, originally very slight or in an advanced stage of cure.

The vasomotor and trophic disorders vary greatly in importance. There may be oedema and cyanosis.
of the integuments in strongly marked monoplegias, or merely an alteration in the colour of the affected hand in cases of slight cortical lesions.

B. Crural Monoplegia

Pure, isolated crural monoplegias are more rarely seen than brachial monoplegias. The same peculiarities may be observed as in brachial monoplegias. Sometimes there is a monoplegia affecting the entire limb. Methodical examination of the segmental muscular power will show predominant injury of all the muscles employed in shortening the limb, viz. the extensors of the foot, the flexors of the knee and thigh, and the adductors; in short, the opposite type to that of brachial monoplegia. More often the monoplegia is segmental or partial, variable in type, and frequently limited to the movements of the foot. It conforms to the type of a peripheral paralysis in the area of distribution of the external popliteal nerve with loss of voluntary extension of the toes, which, however, is retained in the automatic motions of walking. This peculiarity will be dealt with later.

The patellar and tendo Achillis reflexes are brisk; there is frequently ankle clonus, and sometimes reflex shortening of the limb.

The cutaneous reflexes are modified. The plantar cutaneous reflex often produces extension of the toes, but in the type of monoplegia limited to the extensors of the foot and toes described above, there is frequently no response at all to the plantar cutaneous excitation. The sign of adduction is very often observed. It is often impossible to obtain the cremasteric reflex on the side of the monoplegia.

The disorders of sensibility assume the segmental or pseudo-radicular type, and the modifications of deep sensibility are often strongly marked.
Trophic disorders.—Edema, cyanosis, and coldness are more marked than in brachial monoplegia. Double crural monoplegia, amounting to a true "cortical paraplegia" from a lesion of the paracentral lobules, is very frequent.

CORTICAL CEREBRAL PARAPLEGIA

The wound.—This clinical form is always dependent upon wounds of the vertex, generally tangential, which reach the two paracentral lobules where the centres for the movements of the lower limb are situated (see Anatomy and Physiology above). As the lesions of the two lobules are seldom symmetrical, a more or less marked predominance of symptoms is generally found in one of the two lower limbs.

Symptoms.—Immediately after the wound there is a complete flaccid paralysis, and the patient often speaks of transitory paralytic phenomena in the upper limbs. Trouble with the sphincters often occurs at first, after which the flaccid paralysis soon becomes spasmodic. Examination of the patient then shows paralysis of the lower limbs; diminution of the segmental muscular power of the retractors of the limb, more marked at the extremity than at the root of the limb; exaggeration of the tendon reflexes in both upper and lower limbs, with ankle and patella clonus and reflex retraction of the limb; the reflex of extensor action of the toes, or reflex adduction of the foot; loss of the cremasteric and abdominal cutaneous reflexes; irregular disorders of sensation, very frequently of deep sensation; alteration in the gait, such as spasmodic action and walking as if ascending a staircase. These are briefly the signs of double crural monoplegia.

This spasmodic paraplegia, which is so special to war-wounds, displays a very striking variety of clinical forms.
1. Spasmodic paraplegia with retention of the spinal automatism of the movements in walking.—In certain cases examination of the segmental muscular power reveals complete inability to execute certain movements voluntarily; this generally takes the form of inability to raise the toes and the foot voluntarily. If the paralytic phenomena are only slight, and the patient can still walk, though with difficulty, it will be found that raising the toes and the foot, though impossible voluntarily and alone, is executed correctly, though unconsciously and involuntarily, while walking. If the patient is too extensively paralysed to walk, this automatic movement can sometimes be produced by telling the patient to bend his leg sharply on his thigh; then on trying to oppose the movement the foot may be seen to become dorsiflexed and the toes to be extended. This phenomenon is very probably a result of spinal automatism, while the loss of the voluntary motor power is caused by lesion of the cerebral cortex.

2. Cortical spasmodic paraplegia with disorders of co-ordination of movement.—This is a particularly interesting form of cortical paraplegia. The clinical picture is that of spasmodic paraplegia with the addition of more or less marked want of co-ordination. If the patient is told to put his heel on the opposite knee, or up to his thigh, or to touch the observer’s finger with his toe, the movements will be carried out comparatively correctly while the eyes are open, but when he shuts his eyes the movements will be executed with wide oscillations and overshooting the mark, as is observed in cases of tabes. The walk will also be profoundly altered, and often very considerable ataxia, as well as spasmodic action, will be apparent. In these cases it is absolutely necessary to make a very careful examination of the deep sensation, which will always show very marked alteration of the sense of
position and of passive movements, and the tuning-fork test will show that the sensibility to vibration is also affected. In short, it is a case of spasmodic paraplegia with ataxia, very probably of cortical origin, through loss of deep sensation.

Marked disorders of co-ordination of an asynergic, and not an ataxic, type are not so frequent. In these cases the disorders of co-ordination are as evident when the eyes are open as when they are shut. The movements are immoderate rather than inco-ordinated, and there is no indication of alteration of deep sensation. These patients totter when they walk, they widen their base of support, and present every sign of injury to the cerebellum. The explanation of this cerebellar form of cortical paraplegia is obscure. It might be assumed that the cerebellum has been injured by the traumatism, by "contre-coup," but there is no definite anatomical evidence of this hypothesis; nevertheless it is important to get an explanation of this special form of paraplegia in cases of wounds of the vertex.

**Facial Paralysis of Cortical Origin**

**The wound.**—In some cases of very small wounds low down in the rolandic area there will be asymmetry of the face due to facial paresis on the side opposite to the wound.

**Symptoms.**—In the most characteristic cases this facial paresis is not accompanied by hemiplegia, and there is only a very slight alteration in the tendon reflexes of the limbs; the reflexes will be stronger on the side of the facial paresis. This paresis is most marked in such acts as speaking or whistling. Shutting the eye is easily done, but the patient finds it either difficult or impossible to shut the eye on the paralysed side alone, though he has no difficulty in shutting
the eye on the sound side. It has appeared to us that the paralysis always affects mainly the lower part of the facial nerve. There is no alteration in the electric reactions of the nerve or of the paralysed muscles.

This type of facial paralysis of cortical origin due to lesion of the facial centre is seldom met with, but it is important to know of it for the purpose of differential diagnosis. It must not be confused with the patchy and peripheral type of paralysis seen in cases of anterior and lateral wounds of the frontal region, which only affect the upper part of the facial nerve; in these cases there is paresis or marked paralysis of the frontal muscle, with inability to raise the eyebrows.

There is also another type of facial paralysis of the peripheral type which is found in wounds of the skull accompanied by fracture spreading to the base. This is a complete facial paralysis of the peripheral type (Bell’s paralysis) sometimes associated with paralysis of the sixth or eighth cranial nerves. As with the last form described, this form of peripheral paralysis is situated on the same side as the wound, and is accompanied by alterations in the electric reactions of the facial and of the muscles innervated by it. It is due to lesion of the facial nerve in the petrous bone.

**Hemiplegia**

**The wound.**—As has been stated above, complete hemiplegia is the result of an extensive wound of the rolandic area, or of a lesion penetrating to a great depth, although it may appear to be trifling. Wounds, the topography of which does not correspond to the rolandic area, may be accompanied by grave hemiplegia. In these cases the radiograph nearly always shows the presence of a missile in the brain, often very small, and frequently far away from the point.
of entry into the skull. The missile in its passage has destroyed the fibres of the corona radiata or of the internal capsule (fig. 12). When there is such a total persistent hemiplegia of the accepted type it may be assumed that the cerebral lesion is not merely superficial and cortical, but that the white matter is

![Fig. 12. Radiograph of the skull (full face and profile) in a case of complete hemiplegia following a wound of the frontal region. The radiograph shows the existence of an intracerebral missile (the small black dot) which has traversed the internal capsule and has been arrested in the occipital lobe near the median line. The orifice of entry is near the lateral frontal region.](image_url)

also more or less deeply involved, although the cortical lesion may be small in extent. This idea of complete syndromes through even a limited lesion of the white matter is most important; established by Pierre Marie and Guillain for cases of small vascular lesions of the internal capsule, it receives further confirmation in cases of traumatic lesions of the brain.

*Symptoms.—* As the clinical picture of hemiplegia
due to a wound does not present any special features, the symptoms need not be described in detail; they are to a great extent the same as those of the common hemiplegia from softening or haemorrhage. Immediately after the wound half the body is completely paralysed, the limbs are limp, and the reflexes are diminished or suppressed, but after a few weeks contracture appears, and the picture becomes the accepted picture of hemiplegia with contracture.

The patient presents the following appearance:—

In the upper limb there is flexion contracture, the fingers are strongly flexed on to the palm, with the thumb turned in or not, the wrist flexed on the forearm, the forearm on the upper arm, the arm applied more or less closely to the body and rotated inwards, while the shoulder droops.

In the lower limb there is contracture in extension of the whole limb; the foot is adducted and inverted.

In the face, contracture is not generally observed; the facial paralysis is more or less strongly marked, but the upper part of the facial is much less involved than the lower. If the patient is told to open his mouth very wide, the platysma on the paralysed side contracts very slightly or not at all (Babinski).

The tongue, when protruded, deviates to the paralysed side.

The above account of the position of the limbs and the facial appearances applies to the general run of cases, but it is not unusual for the contracture to occur in extension, instead of flexion, in some parts of the upper limb, or, much more rarely, in flexion in the lower limb.

The gait is characteristic; the lower limb, being contracted in extension, is brought forward at each step by a movement of circumduction; the patient scrapes his foot, and frequently drags the ends of
the toes along the ground. While walking, the arm remains almost immobile and slightly abducted.

All the tendon reflexes—the Achillis, patellar, radial, and tricipital—are exaggerated on the paralysed side; the contralateral reflex of the adductors is often seen. There is frequently also clonus of the ankle and patella, and sometimes of the hand.

The cutaneous reflexes are modified. In most cases the plantar cutaneous reflex is extensor, but if there is a slight hemiplegia it may be absent and instead there is the adduction reflex, which has been described above. The cremasteric and abdominal cutaneous reflexes are frequently lost or very weak on the paralysed side.

Disorders of sensibility are common, but vary considerably in type and distribution.

Disorders of tactile sensation are usually more marked in the limbs than in the trunk, in which latter the anaesthesia does not extend to the median line but stops at a little distance short of it.

The sensibility to pain is often modified in a peculiar manner; there is not complete anaesthesia; it can hardly even be said that there is hypoanaesthesia, but rather a true hemiagnosis; the patient is sensible of pain, but cannot describe the cause of the painful sensation nor locate it (Pierre Marie). In most cases the disorders of sensation improve more rapidly than do those of motion.

The deep sensation is very often impaired, sometimes to an extent corresponding with the superficial sensation, and sometimes to a greater degree.

The stereognostic test should always be applied in a case of hemiplegia if the paralysis is not too

1 This pathological reflex, which has been described by Pierre Marie, is obtained by percussion of the tendon of the patella on the healthy side; a contraction of the adductor muscles of the thigh on the paralysed side is thus produced, which is visible under the integument, and is made evident by a movement of adduction in the thigh.
profound to allow it; astereognosis is frequently found, and this disorder lingers long afterwards as a sequela in a nearly cured hemiplegia.

The *trophic and vasomotor disorders* vary in intensity. When the hemiplegia and contracture are strongly marked, there will be cædema of the extremity of the limb, with lividity of the skin, and very often a reduction of the local temperature.

Amyotrophia is a peculiar and comparatively rare trophic disorder. This may be very marked, and is undoubtedly connected with anatomical lesions of a particular locality; it is generally complete, but it appears to be most pronounced about the root of the limb. The electrical reactions of the muscles and nerves are usually normal.

The foregoing is a description of the usual clinical picture of hemiplegia from a wound of the cortex and the white matter of the rolandic convolutions, but it may be modified; certain symptoms may become predominant, and new symptoms may arise, according as the seat of the lesion is evidently in front of, or behind, the fissure of Rolando, and especially in proportion to the depth of the cerebral lesion.

**Clinical varieties of hemiplegia.**—By taking the site of the lesion as a basis, it is possible to draw out an approximate plan for distinguishing wounds of the pre-rolandic area from those of the post-rolandic area.

Lesions evidently situated on the ascending frontal are accompanied by a maximum of motor disorders, while the sensory disorders are not usually persistent. These are the cases which conform to the accepted type of complete hemiplegia. In wounds in the post-rolandic area the hemiplegia is less strongly marked, and frequently becomes so nearly cured as to cease to be apparent except by differences in the tendon reflexes and modifications of the cutaneous reflexes; on the other hand, the sensory disorders, especially
astereognosis, are extremely persistent. Patients who have wounds in this locality should always be tested for astereognosis.

Deeply penetrating wounds with extensive destruction of the white matter, or penetration of the missile deep into the brain, are characterised by symptoms in addition to the accepted syndrome of hemiplegia. In certain cases it is possible by these symptoms to estimate exactly the extent of the destruction of cerebral matter and to diagnose the presence of a missile in the brain. Thus, injury of the central grey nuclei is shown by peculiar sensory phenomena; by more or less severe pains all over the paralysed side; very evident disorders of the deep sensation, hemiataxia or hemiasynergia, involuntary movements resembling those of athetosis, and frequently visual disorders consisting of a homonymous lateral hemiopia on the same side as the hemiplegia, or by quadrantic hemiopia.

Penetrating wounds of the rolandic area reaching the peduncle or the pons appear to be quite exceptional, even if they ever occur. The existence of paralysis of the third, sixth, seventh, and eighth cranial nerves is not sufficient evidence on which to base a diagnosis of alternate hemiplegia. These paralyses are much more likely to be caused by fracture of the vault of the skull, extending to the base, associated with lesion of the trunks of the nerves, than by direct lesion of the peduncle or of the pons.

Marked total amyotrophy along the whole side affected by the hemiplegia is good ground for thinking that there is a deeply penetrating wound, perhaps reaching to below the thalamus or to the peduncle (Georges Guillain and Barré); but very strongly pronounced amyotrophy has been observed with extensive superficial wounds which are unmistakably parietal.
Disorders of speech are purposely omitted here, as they will be made the subject of a special chapter (Chapter VII.).

**Diagnosis.**

In all cases of wounds of the rolandic area a complete examination of the motor and sensory functions of the patient is necessary in order to obtain an accurate idea of the extent of the cerebral lesion, and to form a definite opinion that it is a case of organic and not of functional hemiplegia.

**Differential Diagnosis between Organic and Functional Hemiplegia.**—By means of a series of most important clinical researches Babinski has formulated a series of tests which should be methodically applied whenever there is any doubt as to whether the disorders are organic or functional. The first question which arises in dealing with paralysis of hemiplegic or monoplegic character is as to whether it is a case of organic hemiplegia arising from a cranial wound or lesion of the subjacent cerebral region, or whether it is not rather a case of purely functional disorder or, to follow the accepted nomenclature, hysterical.

**Clinical characteristics of functional (hysterical) hemiplegia.**—Hysterical hemiplegia is generally a partial paralysis which remains partial, or the paralysis is spasmodic from the first.

The osseous, tendinous, and cutaneous reflexes are normal and equal on both sides. The gait is characteristic, the patient drags his paralysed leg behind him, he does not scrape the ground with it. There is very frequently hemianæsthesia of the whole of the paralysed portion of the body associated with the hemiplegia; the hemianæsthesia is of every type, and is generally complete. Or there may be anaesthesia affecting a leg-of-mutton or collar-shaped area, as described by Charcot. Double amblyopia is equally common,
or it may be unilateral. In most cases this clinical picture, when it occurs in an evident case of hemiplegia, enables the diagnosis to be made; but when the symptoms of paralysis are not very pronounced, it will be necessary to make the most thorough examination of the patient. The very varied clinical indications pointed out by Babinski which under these conditions enable organic hemiplegia to be distinguished, as certainly as is possible, from hysterical hemiplegia should be methodically looked for as follows:

**In the face.**—The indication of the platysma myoides. If it is a case of organic hemiplegia the platysma contracts well on the healthy side, but feebly or not at all on the paralysed side, in certain acts such as opening the mouth wide, showing the teeth, etc.

**In the upper limbs.**—In partial organic flaccid hemiplegia the degree of passive flexion of the forearm on the upper arm, when carried as far as possible, is greater in the paralysed than on the healthy side. This is called the phenomenon of exaggerated flexion of the forearm.

If both hands of a patient suffering from organic hemiplegia are put passively into the supinated position and are left alone, the paralysed hand involuntarily becomes pronated.

The phenomenon of the interossei (Souques). If the patient the subject of organic hemiplegia is told to raise the paralysed arm, his fingers will spread out fanwise when carrying out the movement.

While walking, the balancing movements of the arms, which are normally performed inversely to the movements of the thighs, are not seen in a case of functional hemiplegia, or the movements may even be made in harmony.

**In the lower limbs.**—In addition to the plantar cutaneous reflex with extension of the toes, the
contralateral reflex of Pierre Marie, and the clonus of the ankle and the patella, already described, which are only seen when there are lesions of the pyramidal tract, there are other clinical symptoms of great value which are only found in organic hemiplegia.

*Combined flexion of the thigh and trunk.*—The patient being extended on a rigid couch is told to cross his arms and try to sit up. If it is a case of organic hemiplegia, the lower limb on the paralysed side will be seen to raise itself, the thigh will bend and the heel will rise from the couch, while on the sound side the heel will remain flat on the couch and the whole limb will be immobile. When the patient succeeds in sitting up, the same movement will be repeated if he falls quickly backwards. This combined flexion of the thigh and trunk is not met with in cases of functional hemiplegia.

Strümpell's phenomenon is an associated movement of adduction and inward rotation of the foot, produced when the patient's paralysed leg is lying on a firm couch and he is told to flex the leg on the thigh while the movement is opposed by the observer.

The phenomena of associated adduction and abduction have also been described (Raimiste). The patient lies extended flat with his legs spread out, and is told to bring the sound leg to the paralysed one; if the observer opposes the movement, the paralysed leg will make a movement of adduction. An analogous phenomenon of abduction associated with the paralysed side will be seen if the observer opposes the movement of abduction of the sound leg.

According to Grasset, a patient who is the subject of organic hemiplegia can raise the paralysed leg by itself, but he cannot raise both legs simultaneously.

Other less important indications have been described, but it is not worth while to specify them, as those given above are amply sufficient to allow of an exact
diagnosis, and to distinguish with certainty between organic and purely functional hemiplegia. These distinctive indications have been set forth in such detail because the problem is constantly arising, and the first necessity for an exact and correct diagnosis is all the evidence procurable.

Course of lesions of the rolandic area.—The course of the hemiplegias or the monoplegias, consequent on wounds of the rolandic area, is infinitely variable, but a distinction must be drawn between purely cortical wounds giving rise to sensory and motor monoplegias, and the hemiplegias which are almost invariably due to deep-seated lesions.

Pure monoplegias, whether total or dissociated, show an evident tendency to improve. Motor disorders generally decrease more rapidly under proper treatment than sensory disorders, whose sequelæ often linger for months as evidence of the lesion of the cortex; astereognosis, for instance, may remain as the sole symptom of a lesion of the rolandic area for several months or years after the wound.

On the other hand, hemiplegias in which the lesion of the white matter and of the central grey nuclei is much more important than the lesion of the cortex generally become spasmodic after a few weeks, and improve only very slowly. For months or years afterwards there is great awkwardness in the more delicate movements, such as those of the hand particularly. The contractures diminish only by degrees, and if the treatment is neglected, articular rigidity supervenes, and even ankyloses may occur, further increasing the awkwardness of the movements due to the spasmodic character of the hemiplegia. The complications of wounds of the rolandic region have nothing special in their character, and will be dealt with later in the chapter on “Complications of Wounds of the Brain.”
Treatment.—Treatment by physiotherapy should be applied as early as possible, and should consist mainly of massage of the limbs on the paralysed side, with movements of the joints, and mechano-therapy. The patient must not be allowed to remain in his bed, but must be made to get up and walk as soon as ever the condition of the wound will allow of it. Caution should be observed in applying electric treatment (static), which is only of secondary utility.
CHAPTER V

WOUNDS OF THE PARIETAL LOBE

Anatomy

The parietal lobe is situated in the superior median portion of the hemisphere, above the Sylvian fissure which divides it from the temporal lobe, behind the fissure of Rolando which divides it from the frontal lobe, and in front of the external occipital fissure which bounds the occipital lobe. The boundaries of the lobe, which are very clear in front (the fissure of Rolando) and at the base (the Sylvian fissure), are not so clear at the back, where the parietal convolutions are united with the temporal and occipital lobes. Above and mesially the parietal lobe forms a good third of the superior convex border of the hemisphere. It is of interest to note that the parietal lobe corresponds to the parietal bone, but that the bone extends beyond the limits of the lobe in every direction; the centre of the parietal eminence corresponds to the point of junction of the two convolutions which make up the inferior parietal convolution.

The parietal lobe includes three convolutions, a vertical anterior (the ascending parietal) and two horizontal (the first or superior, and the second or inferior). These two convolutions are separated by a single sulcus in the shape of a horizontal $T$, which is called the intra-parietal sulcus. The ascending
WOUNDS OF THE PARIETAL LOBE

parietal has already been dealt with in connection with the rolandic area, of which it has been considered a part.

The superior or first parietal convolution springs from the ascending parietal by a broad-based foot; it follows the superior border of the hemisphere, impinging on both its aspects, and describing S-shaped curves, principally in a vertical direction. Posteriorly it narrows into a connecting fold, which turns round the end of the external occipital fissure (the first external parieto-occipital areus or fold of transition of Gratiolet), and is directly continuous with the first occipital convolution. This convolution has two aspects, an external (the superior parietal) and an internal on the inner aspect of the hemisphere, which is termed the quadrate lobule or precuneus, and is bounded in front by the subfrontal fissure, behind by the occipital fissure, and slightly separated below by a shallow sulcus from the corpus callosum.

The second or inferior parietal convolution springs from the foot of the ascending parietal by a single root, which forms part of the rolandic operculum and covers the island of Reil; it then runs up alongside the ascending parietal, turns round the end of the Sylvian fissure and the end of the first temporal sulcus, and then bifurcates, one part being continued into the second temporal convolution, and the other passing by a connecting fold into the second occipital convolution. This convolution has a very complicated appearance; it has two important curves, a bulky one which surrounds the posterior extremity of the Sylvian fissure forming the marginal lobule or gyrus supramarginalis, while the other turns round the posterior extremity of the first temporal sulcus forming the gyrus angularis.

The very deep intra-parietal sulcus which separates the parietal convolutions has the appearance of a T
laid on its side, with its vertical limb parallel to and behind the fissure of Rolando, while the horizontal branch is parallel to the superior border of the hemisphere, and separates the superior from the inferior parietal convolution. This sulcus is continuous with

Fig. 13.—External and internal aspects of one hemisphere and inferior aspect of the brain.

The convolutions are marked by a letter with an indicator; F₁, first frontal; Fa, ascending frontal, etc.; Gs, gyrus supramarginalis; Ga, gyrus angularis; R, fissure of Rolando; Sy, Sylvian fissure; Lob. para, paracentral lobule; L. ling, lingual lobule; L. fus, fusiform lobule, etc.

the first occipital sulaeus on the external aspect of the occipital lobe.

It is interesting to refer to the cellular architecture of these convolutions. According to Brodmann's researches, the parietal region has a homotypical structure in six strata, which are distributed in the first and second parietal convolutions (to the exclusion
of the ascending parietal) and the precuneus. This difference of cellular architecture is a further justification for dealing separately with the ascending parietal convolution.

**Physiology**

All our knowledge of the physiology of the parietal convolutions is derived from anatomical and clinical researches on the sick and wounded, the data founded thereon being very rudimentary, as will be seen later. Founding his theoretical reasoning on comparative anatomy and on researches in myelo-genetics, Flechsig thought that he had located the site of the centres of association of the sensitive and sensory perceptions, which he named "the great posterior association centre," but human pathology has not furnished any confirmation of this purely theoretical conception. The physiology of the parietal lobe will therefore be considered here by the light afforded by the symptomatology of the wounds of this lobe.

**Symptoms**

**The wound.**—Wounds of the parietal lobe are fairly common, especially those of moderate dimensions not exceeding the diameter of a five-shilling piece. They have no special features, and may be superficial, involving only the cortex, or extending, with or without the presence of a foreign body, into the brain.

**I. Absence of symptoms.**—In a certain number of parietal wounds, in which the cortex has probably been injured (as shown by pulsation and impulse on coughing), or certainly injured (according to the history sheet), there are no symptoms apparent. It is impossible to state definitely the reasons why a lesion of the parietal lobe does not show any symptoms. It would seem from the cases we have observed that
the dumb area is in the first parietal, especially its posterior portion, the precuneus. At least this is what has been observed in soldiers several weeks or months after the wound has been inflicted.

II. Disorders of sensibility.—These are the most common disorders found as the result of parietal wounds, and affect almost exclusively the deep-seated sensibility, viz. the idea of position and the perception of passive movements. While the perception of superficial sensibility appears to be located principally in the ascending parietal, the deep-seated (or muscular) sensibility is probably located in the first and second parietal, but it is not possible to lay down its segmental distribution more precisely. The localisation would seem to be analogous to the distribution of the motor functions in the ascending frontal.

Examination of the patient will show more or less marked disorder of the idea of position extending over the whole limb or confined to its distal extremity. If the patient's fingers or toes are slowly moved, he cannot describe the movement or reproduce with his sound hand a position given to his paralysed hand. It is not unusual to find ataxic disorders (cortical ataxia) limited generally to the lower limb, or in rare cases to the upper limb, associated with these disorders of the sensibility. This ataxia, arising from loss of deep-seated sensibility, and limited to the lower limb, may be observed quite apart from any symptoms of lesion of the pyramidal tract. It is generally bilateral, and when associated with a spasmodic paraplegia is the ataxic form of cortical paraplegia previously described. It must be remembered that in these cases we are dealing with wounds of the vertex which the radiograph has shown to be located behind the fissure of Rolando, that is, in the region of the paracentral lobule and the first parietal on both sides.

Examination for deficiency in the stereognostic
sense is very important in these cases. Stereognosis is not merely a form of sensation, but is due to the simultaneous employment of superficial and deep-seated sensation, and it is not necessary that there should be simultaneous lesion of both these to cause its loss, and it is therefore impossible definitely to locate it. It must also be borne in mind that astereognosis may occur in other complaints than lesions affecting the cortex. It is nevertheless the fact that astereognosis in the whole hand, or part of it, may be met with as the sole symptom of a parietal lesion or as its sequela. Even when there is no other indication of nervous lesion astereognosis must always be sought for, since a careful examination of the various forms of sensibility will often show disorders, sometimes very limited but indisputable, of the muscular sense, slighter injury of superficial sensation, and especially of tactile diserimination, and of the sense of localisation in the hand, associated with the astereognosis.

III. Aphasie disorders.—These arise only when the second or inferior parietal on the left side is involved, more especially its posterior part, which constitutes the gyrus supramarginalis and the gyrus angularis. These aphasic disorders, which resemble Wernicke's aphasia in type, will be dealt with in the chapter on "Aphasia and Wounds of the Brain" (Chapter VII).

IV. Apraxie disorders.—It is common knowledge that apraxia, the syndrome of which has been worked out by Liepmann, consists in inability to execute the movements required to carry out a definite action, although there is no paralysis. Several varieties are distinguished, of which the idealogical and the ideomotor are the most important.

Idealogical apraxia is essentially a disorder of the intelligence similar to, if not identical with, that observed in Wernicke's aphasia, and belongs to the
group of intellectual modifications characteristic of aphasia.

Ideomotor apraxia is very peculiar in its manifestation, and is a special motor disorder. While the patient affected with ideological apraxia is unable to picture mentally the succession of movements required to perform a definite, more or less complicated, action, the patient affected with ideomotor apraxia, although he knows quite well the successive movements required, cannot carry them out, or carries them out all wrong, or with the greatest awkwardness. Ideomotor apraxia appears to occur both in association with aphasic disorders and apart from them; it is therefore evident that it is extremely difficult to discriminate how far the disorder is due to aphasia and how far to apraxia.

Apraxia is very probably caused by lesions of the left parietal lobe, the inferior parietal, and more especially the gyrus supramarginalis. Although the lesion may be situated on the left side of the brain, the apraxic phenomena are usually bilateral, and in certain cases are more marked in the homolateral limb.

Tests for apraxia.—Practical evidence of ideomotor apraxia is obtained by causing the patient to perform a series of actions with one hand at a time, or with both hands.

(a) He is told to perform a simple action, such as raising the hand, shutting the eyes, crossing the legs, putting out the tongue, giving a fillip, putting the fingers to the nose and spreading them out ("cocking a snook"), saluting, clapping his hands, wagging his finger at someone, blowing a kiss.

(b) He is told to perform an act connected with an external object by lighting a cigarette, putting on a stamp and sealing up a letter, locking a door, pouring water into a glass, etc.
(c) He is told to describe the actions from memory without performing them, to describe how a postage-stamp is fixed on, how a match is lighted, etc.

(d) He is required to repeat some action just performed in his presence.

(e) He is kept under observation while eating and dressing. It must be understood that these disorders are significant when there is neither paralysis nor aphasia; this rarely occurs, but whenever there is a lesion of the left parietal lobe unassociated with paralysis or aphasia, or sensory disorders, it is necessary to make these tests.

Stress must be laid on the importance of the search for those modifications of the deep-seated sensibility so frequently associated with lesions of the parietal lobe, as they may be the cause of ataxic phenomena, and of awkwardness in the movements, which must not be taken as indications of apraxia.

The above are the symptoms observed in cases of wounds of the parietal lobe, especially on the left side, whether the lesions are purely cortical or affect slightly the subjacent white matter. It must be borne in mind that these disorders do not always occur, and there are cases in which the most thorough clinical examination fails to find any indication of cerebral lesion, especially when the superior parietal convolution only is involved.

Associated symptoms.—Symptoms indicating lesion of the deep white fibres (the corona radiata, internal capsule, and optic radiations) and of the central grey nuclei may be observed when the wound penetrates deeply or there is extensive destruction of the parietal lobe. The most important are hemiplegia and hemiopia.

The hemiplegia is of the central type, that is, complete hemiplegia with contracture, and is often associated with cerebral hemianæsthesia, which is
shown by predominant loss of the deep-seated sensibility and sense of location, but is very seldom persistent.

The hemiopia is of the homonymous lateral type, is total in the early months, and is slowly modified until there only remains a hemiopic diminution of the field of vision, sometimes complemented by hemiachromatopia. It must be understood that the hemiopia may be complete and permanent if the missile has penetrated to a great depth and severed the optic radiations. When the homonymous lateral hemiopia is on the right side, and the left parietal lobe has therefore been injured, it is not unusual to find alexia associated with it. This is a peculiar disorder, which belongs to the aphasis group, and will be dealt with in that connection.

It must be added that in cases of a deep lesion of the parietal convolutions, associated with hemiplegia or hemiparesis, there is always a possibility of hemiatrophy, often very strongly marked, supervening. In these cases it is difficult to say whether this hemiatrophy really arises from the lesion of the parietal convolutions or from concomitant lesion of some portion of the central grey nuclei.

Course

The course and prognosis of wounds of the parietal lobe vary widely according as the lesion affects the right or the left lobe on account of the aphasis associated with the latter. If the wound is superficial there will be little more than disorders of sensibility, which almost always go on to a slow recovery, although the modifications of the stereognostic sense may be very persistent. If the lesion is a deep one, the course of the case is the same as in the spasmodic hemiplegia, already described in connection with wounds of the
rolandic area. Unless the missile has penetrated very deeply, the hemiopia nearly always improves. On the other hand, if there is aphasia, nearly resembling the sensory aphasia of Wernicke, the prognosis of wounds of the left parietal is greatly aggravated. As a rule the patients remain permanent invalids incapable of following any calling.
CHAPTER VI

WOUNDS OF THE TEMPORAL LOBE

Anatomy

The temporal lobe is situated below the parietal lobe, from which it is divided by the Sylvian fissure, and in front of the occipital lobe. It has an external and an internal aspect, an internal border and an anterior pole. Its posterior border is continued without a break into the occipital lobe. Its external aspect includes the three first convolutions; the two others are on the inferior aspect.

It is very important to describe briefly the position of the temporal lobe relatively to the bones of the cranium. The temporal lobe occupies the temporosphenoidal fossa, the middle fossa of the base of the skull, formed by the greater wing of the sphenoid, the internal aspect of the squamous portion of the temporal bone, and the anterior aspect of the petrous portion. The superior border of the petrous makes an indentation on the inferior aspect of this lobe, which marks the boundary between the temporal and the occipital lobes. It is most important to state these anatomical details with exactness, because, when dealing with a living subject, there is always a tendency to locate the temporal lobe too high up and too far back. The temporal pole really lies behind the orbit, and throughout the greater part of their
extent the convolutions on the external aspect of the lobe correspond to the bony wall above the zygomatic arch, and above and in front of the external auditory meatus. It is most necessary to bear these details in mind if it is desired to locate quickly the site of a wound of the temporal lobe without making a serious error.

There are five temporal convolutions:

The first convolution, or superior temporal gyrus, is slightly sinuous and rather thin, forming the inferior lip of the Sylvian fissure, at the superior extremity of which it unites with the second parietal to form the gyrus supramarginalis.

The second convolution, or middle temporal gyrus, is parallel to the first convolution, from which it is divided by the extremely deep first temporal or parallel sulcus. At its posterior extremity this convolution bifurcates, the upper branch uniting with the second parietal to form the angular gyrus, while the lower one is continuous with the third occipital convolution.

The third convolution, or inferior temporal gyrus, forms the inferior border of the external aspect of the lobe. At its posterior extremity it terminates at the pre-occipital notch.

The fourth convolution is situated on the inferior aspect of the lobe. It is narrow at its anterior extremity, but widens gradually till it unites directly with the fourth occipital convolution to form the fusiform lobule.

The fifth convolution, or hippocampal convolution, is divided from the fourth by the deep fourth temporal (collateral) sulcus. It occupies the internal border of the inferior aspect of the lobe. Its tapering posterior extremity unites with the fifth occipital convolution or lingual lobe. The anterior third of this convolution laps over and conceals the optie
tract, which it presses on to the cerebral peduncle (crura cerebri).

Attached to the fifth temporal convolution are a series of anatomical structures: the hippocampus major with its fimbria, the tænia hippocampi, the sulus of the hippocampus, and the amygdaloid nucleus, with which it is not necessary to deal.

It is important to be acquainted with the fibres of the white matter of the temporal lobe. The association-fibres include the arcuate fibres connecting one convolution to another; the superior longitudinal fasciculus; the uncinate fasciculus extending from the frontal to the temporal lobe; the inferior longitudinal fibres which extend from the temporal to the occipital lobe. This bundle covers a most important projection strand—the optic radiation—which starts from the corpus geniculatum externum below and outside the optic thalamus.

**Physiology**

The generally accepted theory supposes the temporal lobe to be essentially the site of the auditory centre.

According to Meynert, the acoustic fibres converge on the insula and on the superior temporal convolution. It is interesting to remember that Wernieke, relying on these data, located the auditory centre in the superior temporal gyrus, and, as Professor Pierre Marie has pointed out, it was by starting with this improved view that Wernicke was led to the discovery of a new type of aphasia arising from lesion of the parieto-temporal lobe. Experimental research has given very contradictory results. Munk, after a long course of experiments on the dog, claimed to have located the auditory centre in the temporal lobe, and described a psychic and a cortical deafness and a localisation of sounds according to their pitch. The
auditory area on each side was supposed to be in relation with the labyrinth on the opposite side. The results of these experiments were entirely contradicted by those of Kalischer on specially prepared dogs, from which he had removed both temporal lobes; these animals proved to be absolutely normal in the perception of sounds, however high their pitch. Therefore nothing, or next to nothing, is known of the functions of the temporal lobe, and there is not the slightest verification of the accepted theory that the auditory centre is located in this lobe.

**Symptoms**

Most of the symptoms described by the classic writers as arising from lesion of the temporal convolutions have no clinical existence. The symptoms actually found do not really arise in the temporal lobe. The real explanation of the clinical picture is that there is either simultaneous lesion of the adjacent regions of the parietal lobe, or a deep-seated injury of the white fibres or of the grey nuclei.

**A. Symptoms of superficial wounds of the temporal lobe.**

—the classic writers describe the following symptoms as occurring in the human subject in consequence of a lesion of the temporal lobe:

1. **Cortical deafness.**—This view is based on the anatomical conclusions of Meynert, mentioned above. According to this theory, there was in the brain in the region of the temporal lobe a general auditory centre lesion which causes an ordinary deafness similar to that produced by disorders of the functions of the peripheral apparatus. Up to now there has not been a single clinicial case with anatomical verification of deafness of cortical origin.

2. **Pure word-deafness.**—The same theory describes a verbal auditory centre in the foot of the first temporal
convolution, where the auditory images of words, syllables, and letters are stored up. Bilateral lesion of this centre, or a lesion of the centre in the left hemisphere alone, was supposed to give a special syndrome: pure word-deafness characterised clinically by the fact that while the patient does not understand a word of what is said to him aloud, he shows no other disorder, and consequently he is unable to repeat what was said to him or to write from dictation. As a matter of fact, as has been shown by Professor Pierre Marie, not a single case of pure word-deafness has been observed clinically, and the
anatomical and pathological descriptions which have been published are extremely misleading; both with regard to cortical deafness and pure word-deafness, not a single case has been observed among the patients wounded in the temporal region which supports the existence of these two syndromes. The clinical picture of pure word-deafness and its anatomical localisation are purely theoretical conceptions.

3. Wernicke’s aphasia or sensory aphasia.—It is quite otherwise with regard to the part which the posterior portion of the two first temporal convolutions in the left hemisphere plays in the human being. This temporal region forms a part of Wernicke’s zone, which also includes the gyrus angularis and the gyrus supramarginalis, with the subjacent white matter in all the convolutions. Lesion of this “zone of Wernicke” causes aphasia of the so-called sensory type or “Wernicke’s aphasia,” a syndrome which appears as soon as there is the slightest lesion of this area, its intensity being in proportion to the extent of the lesion of Wernicke’s zone or of the fibres which proceed from it. This is a typical example of the law established by Professor Pierre Marie regarding the pyramidal tract—that a complete cerebral hemi-syndrome is produced by the lesion of a part only of the zone in which it takes its rise. There is nothing to authorise the breaking up of this “Wernicke’s zone” into separate centres controlling special departments of the function of language as was done by the older authorities. The “zone of Wernicke” has been shown by Professor Pierre Marie to be, above all, the intellectual centre of language controlling the comprehension of speech, of reading and of writing, the lesion of which causes true aphasia, which includes a variety of clinical types, and has the following clinical characters: the patient can speak, indeed he often speaks too much, but indistinctly; he presents
jargonaphasia, or at the least paraphasia; he does not understand well what is said to him, and he is unable to read or write. A special chapter will be devoted to the very important subject of aphasia, and the special clinical aspects of aphasic disorders in cases of wounds of the brain, as shown by the researches of MM. Pierre Marie and Charles Foix, will be described. At present no symptoms are known which prove superficial lesion of the temporal convolutions except the posterior portion of the first and second left temporal convolutions (Wernicke's aphasia of variable intensity).

B. Symptoms of deep wounds of the temporal lobe.—As the result of wounds in the temporal region a whole group of symptoms may be found from which it may be inferred that there is a deeply penetrating lesion of the white matter, which in some cases may extend to the grey central nuclei (the lenticular nucleus and the optic thalamus). It must be stated, however, that such complications are rare, because, owing to the extreme gravity of the wound, which is almost certain to injure the lateral ventricle, or to be associated with lesions of the medulla through concussion or contusion, it is quickly fatal.

1. Lesions of the grey central nuclei (optic thalamus) and of the cerebral peduncles.—The whole of the group of symptoms described in recent years under the names of thalamic or lenticular syndromes are not met with in war-wounds, but merely a few of the symptoms of which they are made up. The only indications which have been observed are hemiataxia, with marked disorders of the deep sensation associated with slight hemiparesis. These symptoms, viz. hemiataxia, hemianæsthesia (involving specially the varieties of deep sensation), and slight hemiplegia, are parts of the thalamic syndrome of Dejerine and Roussy, which also includes intense pain in the whole
WOUNDS OF THE TEMPORAL LOBE

of the side of the body affected by the anaesthesia, and hemichorea with hemiathetosis. No case has ever been observed where there was good reason to suppose, as some writers have done, that there was injury of the cerebral peduncle at its point of contact with the fifth temporal convolution (see Anatomy), which would be manifested by crossed hemiplegia with direct paralysis of the third pair or oculomotor nerves (Weber's syndrome).

As has already been stated, injury of the oculomotor nerves can seldom be used in wounds of the brain as a means of localisation. Total or partial paralysis of the third nerve, as well as paralysis of the sixth, is fairly frequent as a complication of wounds of the temporal region, and is caused, probably, by extension of a fracture to the base of the skull, in the same way as paralysis of the eighth nerve, which is a common complication of wounds in the same region, and will be dealt with later.

2. Lesions of the white fibres (optic radiation and optic tract).—Penetrating wounds of the temporal lobe are frequently accompanied by hemiopic modifications of the field of vision, which are connected with either direct lesion of the optic radiation in the depth of the lobe, or to an affection of these fibres at their point of contact with the seat of traumatic encephalitis. Homonymous lateral hemiopia, such as is produced by deeply penetrating wounds of the external aspect of the occipital lobe, is most frequently observed. In other cases there may be incomplete lateral hemiopia, predominantly in the superior or inferior quadrant of the field of vision, or a lateral homonymous hemiopic diminution thereof, complemented by hemiaehromatopia. This very curious modification of the field of vision will be dealt with in detail, together with the other visual disorders, in the chapter on "Wounds of the Occipital Lobe" (Chapter
VIII.). As a matter of curiosity the case of homonymous lateral hemiopia through lesion of the optic tract, of which the author has published a description in collaboration with Professor Pierre Marie, may be mentioned here.\footnote{A case of traumatic homonymous lateral hemiopia on the left side through lesion of the right optic tract,” by Professor Pierre Marie and Dr Ch. Chatelin. (Revue Neurologique, Nos. 23–24, p. 1230, 1915.)} A very small missile after traversing the anterior portion of the right temporal lobe injured the optic tract at its point of contact with the cerebral peduncle and produced homonymous lateral hemiopia on the left side.

**Complications**

The only important complication, and a very frequent one, of wounds of the temporal region, is lesion of the auditory apparatus on the same side as the wound.

The examination of this organ must never be neglected, though the patient himself will generally call attention to the fact that he can only hear badly, or is quite deaf, in the ear on the wounded side. There may be merely laceration of the tympanum, which is easily proved by examination with the otoscope. Much oftener, however, there is more or less serious lesion of the internal ear, caused either by direct injury of the main body of the petrous process across the temporal lobe, or by extension of a fracture. In such cases, as a rule, there is complete peripheral facial paralysis on the same side as the deafness. It is for the aurist to deal with deafness caused by lesions of the internal ear, but the neurologist ought to be qualified to ascertain definitely, to a certain extent, whether the lesion affects the organ of reception or the organ of transmission. Reference should be
made to the section of Chapter I. dealing with the auditory tests.

Much more important to the neurologist are the lesions of the vestibule of the labyrinth, which may occur alone without any auditory symptoms caused by lesion of the cochlea. The patient has subjective disorders (vertigo, nausea, sense of falling, and lateropulsion) and objective disorders of equilibrium while at rest and while walking, which should be most carefully examined and tested, especially if he has no disorders of hearing, in which case it is necessary to ascertain whether there is a lesion of the cerebellum, the differential diagnosis being often extremely difficult. This subject will be dealt with in detail in the chapter on "Wounds of the Cerebellum" (Chapter IX.). Cases of paralysis of the third and sixth nerves have been dealt with above.

**Course and Prognosis**

The course and prognosis of wounds of the temporal lobe depend on the site of the wound and the complications.

The prognosis of wounds of the posterior third of the first temporal convolution on the left side, accompanied by Wernicke's aphasia, must be very cautious with regard to the intellectual future of the patient (see Chapter VII.), the aphasia being in some degree proportionate to the extent of the cerebral lesion. Complete labyrinthine deafness is generally permanent; on the other hand, the disorders caused by injury of the vestibule of the labyrinth (vertigo, disorders of equilibrium and gait) generally improve gradually, and disappear in less than a year after the infliction of the wound.
CHAPTER VII

APHASIA IN RELATION TO WOUNDS OF THE BRAIN

Introductory remarks on Aphasia

Before entering upon the consideration of the disorders of speech, more especially those of the aphasic type, it will be well to state as concisely and clearly as possible the old accepted theory of aphasia, and Pierre Marie's new conception thereof.

The history of aphasia begins with Broca, who localised the faculty of articulate language in the foot of the third left frontal convolution, and proposed to call the loss of this function aphemia. The name aphasia was given by Trousseau.

Wernicke showed that in aphasia the loss of articulate language was not the only thing, and distinguished aphasic subjects whose motor functions were solely or chiefly affected, from those who were incapable of identifying verbal auditory impressions. In this form of aphasia, called sensory aphasia, the fundamental disorder, according to Wernicke, was that of hearing, which entailed difficulties of reading and writing as a consequence, the patient being unable to understand the words which fell on his ears, while the power of articulate language was retained. Wernicke located this form of aphasia in the first temporal convolution on the left side.
The accepted theory of aphasia.—Under the influence of these psychological ideas the varieties of aphasia increased, and two great classes of aphasics were distinguished: those who suffered from disorders of articulation, and those who suffered from internal derangement of speech and the comprehension of speech. The first class, who were said to suffer from motor aphasia, had lost the motor images of articulation. The second class, who were said to suffer from sensory aphasia, had lost the auditory visual sensory images of words, which are located in various centres on the left side of the brain; the foot of the third frontal convolution for motor images, and the first temporal and gyrus angularis for the sensory images (auditory and visual). These centres might be injured directly or in their channels of transmission, whence they were divided into the cortical and sub-cortical varieties of aphasia.

In practice six forms of aphasia were described:—

1. True motor, or Broca's aphasia.—The patient could not articulate, or did so badly; he had great difficulty in writing, but could copy printed words in his ordinary handwriting; there was also difficulty in the comprehension of spoken language and of written words, but this was not usually great. The anatomical cause was lesion of the cortex of the foot of the third frontal convolution.

2. Sub-cortical, or pure motor aphasia, was distinguished from the others by suppression or diminution of the power of speech, and was attributed to section of the nerve-fibres which proceed from Broca's centre.

3. Sensory, or Wernicke's aphasia.—The patient could speak, and often spoke a great deal, but used one word in mistake for another (paraphasia), or spoke words without meaning (jargonaphasia); he had great difficulty in understanding spoken words (word-deafness) or written words (word-blindness), and he could
not write. This form of aphasia was said to be caused by destruction of the two first temporal convolutions, the gyrus supramarginalis and the gyrus angularis.

4. *Pure word-deafness.* — The patient could not understand words spoken aloud, nor repeat them nor write from dictation; but he could speak perfectly, and the power of reading aloud or silently was unimpaired. This word-deafness was supposed to be due to lesion of the two temporal lobes.

5. *Pure word-blindness.* — The patient could not read (alexia), he could speak perfectly, and writing spontaneously and from dictation were normal, but he could not read what he had written, although his intelligence was unimpaired. This form of aphasia was supposed to be caused by lesion of the gyrus angularis.

6. *Total aphasia* was a combination of motor and sensory aphasia; the patient could neither speak, nor read, nor write, nor understand signs.

**Pierre Marie's theory of aphasia.** — Professor Pierre Marie has enunciated a new theory, and has opposed on anatomical and clinical grounds the specific character of Broca's centre; the distinction between motor and sensory aphasia; the existence of pure forms of aphasia; and the whole idea of images and centres of images. In Pierre Marie's opinion, one fact dominates the whole question of aphasia—the more or less strongly pronounced inability to understand spoken language. Though certain writers claim that the intelligence remains intact, as a matter of fact there is a very marked diminution of the general intellectual capacity in aphasic patients, which is a much more serious matter than the mere loss of the power of understanding words. In fact, if an aphasic subject is methodically examined, it will be found that he has not only lost the power of language, but that there is a considerable deficiency in the stock of knowledge
acquired didactically. It is this intellectual decay, and not the loss of supposed verbal auditory images, or the existence of word-deafness, which is the essence of the aphasia. Again, it is not the mere fact of speaking badly or of not being able to speak at all which constitutes true aphasia. This disorder, which was classically named sub-cortical motor aphasia, must be carefully distinguished from aphasia, and described separately as anarthria or dysarthria. The outstanding characteristic of Pierre Marie’s anarthria is, that while the patient can hardly speak, or does so only with great difficulty, he can understand thoroughly what is said to him, and can read and write perfectly.

Clinically, Broca’s aphasia and Wernicke’s aphasia are real conditions, but they are very analogous, and are only separated by a few degrees from each other. The only difference, which is, however, an essential one, between the two aphasias is, that in Wernicke’s the patient can speak, and often speaks a great deal, and in Broca’s he cannot speak, or speaks very little; in short, Broca’s aphasia differs from Wernicke’s by the addition of anarthria. In Wernicke’s aphasia the patient can speak, but fails to understand what is said to him, and can neither read nor write. In Broca’s aphasia the patient can neither read nor write, he fails to understand what is said to him, but in addition he speaks with great difficulty or not at all; he has both aphasia and anarthria.

With regard to cerebral localisation, there is a whole series of anatomical and clinical observations to support the contention that the third frontal convolution is not the speech centre. On the contrary, in every case of anarthria there is an isolated lesion of the lenticular area of the brain defined by Pierre Marie, which includes the central grey nuclei and the internal and external capsules, the insula, the motor cortex, and some important fibres of the white matter,
while the third frontal convolution is not included. Anarthria is not connected solely with the left side of the brain, but occurs also through lesion of the same lenticular area on the right side.

![Diagram](image)

**Fig. 15.**—Horizontal section of a healthy left hemisphere intended to show the topography of the areas, the lesions of which give rise to troubles of speech, or, on the contrary, have no part in the production of them (after Pierre Marie).

Lesions occurring in the portions of the hemisphere (the frontal lobe, and notably the third frontal convolution) situated in front of the transverse line A, which is drawn from the sulcus separating the third frontal from the convolutions of the insula, produce neither anarthria nor aphasia.

Lesions bearing on the region situated between A and B (Pierre Marie’s lenticular zone) give rise to anarthria. The line B is drawn transversely from the posterior part of the insula and the posterior extremity of the lenticular nucleus. Lesions situated in rear of B cause aphasia.

In W (Wernicke’s zone) is the isthmus of white matter which unites the temporo-parietal lobe to the lenticular nucleus.
As far as aphasia is concerned, since there is only one kind of aphasia, it is located solely in Wernicke’s zone, which includes the gyrus supramarginalis, the gyrus angularis, the foot of the two first temporal convolutions, and the subjacent white matter up to the wall of the sphenoidal horn of the lateral ventricle, which is in direct contact in front with the lenticular area above described (the temporo-parietal isthmus of Pierre Marie). In cases of Wernicke’s aphasia it is a lesion, variable in extent, of this region which is found. In Broca’s aphasia, which is Wernicke’s aphasia plus anarthria, there will therefore be found a lesion of Wernicke’s zone plus a lesion of the lenticular area. It will be seen how infinite may be the clinical varieties according as one zone or the other is the more extensively involved in the lesion.

To sum up. According to Pierre Marie, “the third frontal convolution plays no special part in the function of speech.” The true centre of speech is Wernicke’s zone, which must be considered to be an intellectual centre and not a sensory centre. In proportion to its extent, any lesion of this centre produces, besides the disorder of speech, a falling-off in the understanding of spoken language and of the power of reading and writing, as well as the loss of certain classes of didactic ideas.

Anarthria is clinically characterised by the loss of speech, while the comprehension of words heard is retained, together with the capacity to read and write, and is produced by a lesion situated in the lenticular area, which impedes the co-ordination of the movements required for the production and articulation of words without producing true paralysis of the muscles.

Wernicke’s aphasia is produced by a lesion of Wernicke’s zone. Broca’s aphasia is produced by the combination of the lesion of anarthria in variable
proportion, according to the case, with a lesion of Wernicke’s zone; thus Broca’s aphasia = Wernicke’s aphasia + anarthria.

Pure word-deafness has no clinical existence. Pure word-blindness, or, to be exact, pure alexia, does exist, but is not localised solely in the cortex of the gyrus angularis (see Chapter VIII., “Wounds of the Occipital Lobe”).

This conception, which differs so greatly from the accepted theory, and is founded entirely on direct investigation of the experience of civil practice (namely, of lesions caused by softening of the brain), has been confirmed by the study of wounds of the brain, as will be seen later on.

**Technique of the Examination in a Case of Aphasia**

The following is a concise outline of the method in which the examination of an aphasic patient is carried out by the staff of Professor Marie at the Salpêtrière which will be useful as a guide in carrying out such examinations, which must be done methodically:—

1. **Test for Comprehension of Speech**

   (a) *Tell the patient to perform the following simple actions*: Put out his tongue, shut his eyes, knock at the door, shake hands, seal up a letter, light a cigarette.

   (b) Perform any of these actions which the patient has failed to carry out, and tell him to copy you.

   (c) Give the patient instructions containing the same word but for different actions: To shake hands, clasp hands, raise the hand, open and shut the hand.

   (d) Give him a complicated instruction —

   1. “Here are three pieces of paper on the table, one large, one medium-sized, and one small; pick up the large one and hand it to me, tear up the medium-
sized one and throw the pieees on the ground, and keep the small one in your hand."

2. "Get up, go and knock at the door three times, and return to your seat."

2. Examination of Speech

(a) Spontaneous speech.—Does it exist, and to what extent? Hand the patient some objects, and tell him to name them; tell him to pronounce words in series, as: the days of the week, the months of the year; the alphabet, the numbers from one to twenty; to repeat these series of words backwards. Tell the patient to describe how he was wounded. Tell him to state his profession. Note whether during this examination there is any dysarthria, paraphasia, or jargonaphasia.

(b) Repetition of words.—Speak to the patient in phrases of gradually increasing length and difficulty, and make him repeat them; make him repeat words beginning with the same syllable, as: tart, tartar, tartuffe, tartlet, etc. Make him repeat some lines of poetry.

(c) Singing.—Can the patient sing with or without words? Can he repeat a song? Can he shout, whistle, cough, etc.?

3. Examination for Reading

Make the patient read aloud. Is silent reading possible? Give him a simple written order to execute, such as: shake hands, put out the tongue. Give him a more complex order. If he cannot read words, get him to name single letters and numbers. Hand him a book or paper upside down, and see whether he puts it in the correct position. Make him read words written vertically. Make him state the meaning of a drawing or emblem. Get him to pick out a word
designating one object placed among others, to tell the time by a watch, to set the watch to a given time; to read figures and make elementary calculations; to count money.

4. Examination of Writing

(a) Can he write spontaneously with pen, or pencil, or blocks?
(b) Can he write from dictation?
(c) Can he copy printed letters, in print? in long hand? Can he do the same with figures?
(d) Can he make a simple drawing: a square, triangle, oblong, etc.? Get him to copy them.

5. Power of Mimicry

(a) Spontaneous mimicry of emotions.—Tell the patient to make a gesture indicating dislike, to shake his finger at someone, to throw a kiss.
(b) Spontaneous descriptive mimicry.—To make signs that he wishes to sleep, to imitate the action of leading a horse.
(c) Conventional mimetic signs.—Make the sign of agreement or of disagreement. Does the patient understand the meaning of gestures?

6. Condition of the Memory

General memory.—For dates, facts, the multiplication table.

Visual memory.—For persons, places (sense of location), objects. What does the wind do to the dust? In the branches of trees? In the sails of ships? How many legs has a dog? What is the colour of snow? of grass? of blood?

Auditory memory.—What does the cock do? the cat? the horse? the dog? the railway engine? the
Memory of tastes.—It must be thoroughly understood that this special examination is always to be supplemented by a general examination of the nervous system, particularly of the motor functions for hemiplegia; of sensation for astereognosis; of the auditory functions for labyrinthine deafness; and of the visual functions for hemiopia and hemiaehromatopia. And care must always be taken to ascertain whether the patient is right-handed or left-handed.

Aphasia consequent on Wounds of the Brain

The Wound

The disorders of speech will be dealt with according to the site and extent of the wound. This is the best division of the subject in view of the great number of clinical variations, and it will also demonstrate more clearly the correctness of the new theory of aphasia expounded above.

In a large majority of cases the aphasic disorders, or the disorders of speech, arise from wounds inflicted by a bullet or shell-splinter which have necessitated trephining. In some cases, however, the aphasia has been caused by direct contusion of the left hemisphere through a fall or by shock caused by explosion at a distance.

It is important to note that, in certain cases in which the lesion was in the right temporo-parietal lobe, the disturbances were slight, and were almost entirely confined to dysarthria, associated with some degree of obnubilation, a condition which is of little importance, and may persist for a variable time in any case of a head wound. If the wound affects the left side of the brain, disorders of speech are the rule; at any rate, they persist for a variable time during the course of
the case, and behave differently according to the site of the cerebral lesion.

**Aphasic Troubles in relation to the Site of the Wound**

The following paragraphs are a summary of the clinical and radiographic researches carried out by MM. Pierre Marie and Ch. Foix at the neurological centre at the Salpêtrière, which will be the subject of an important work by these writers.¹

Fig. 16.—Radiographic localisation of wounds of the skull, with the subjacent lesions which cause the different varieties of troubles of speech (Pierre Marie, Ch. Foix, and Bertrand).

A, zone without troubles of speech; B, dysarthria or anarthria; C, complete aphasia; D, aphasia, predominant in denomination of objects; E, predominant alexia.

¹ A communication on this subject has been made to the combined session of the Société National de Chirurgie and the Société de Neurologie de Paris on the 24th May 1916, by M. Ch. Foix, from which the data given in this chapter are borrowed. (*Revue Neurologique*, No. 6, 1916, p. 827.)
Wounds of the central region: the ascending frontal and ascending parietal convolutions.—If the wound is in the superior portion of the convolutions near the paracentral lobule there is usually no trouble with speech; most frequently the patient has a crural monoplegia. Wounds of the median portion of the central convolutions produce, as we have seen, a brachial monoplegia. If there are any disorders of speech, they are slight. A minute examination of the powers of reading, writing, and calculation only shows very slight deficieny, which is more marked when the wound implicates the ascending parietal, in which case there will be sensory disorders associated with monoplegia, and also a certain degree of dysarthria. Syndromes of anarthria, very severe at first, and leaving persistent dysarthria subsequently, are connected with the inferior portion of the central region. The further forward the site of the wound, the more pure is the anæsthesia. If a wound of the rolandic area extends into the centrum ovale or still lower, the aphasia affects the whole range of the functions of language—reading, writing, comprehension of speech, articulation, and calculation. The lower and more deeply penetrating the wound, the more pronounced are these disorders. The syndrome in such cases is that of Broca’s aphasia, which may be of a very severe type, and only capable of very limited cure.

Wounds of the temporo-parietal region.—With the exception of the extreme upper part of the parietal lobe and the anterior part of the temporal, lesions of which cause only slight disorders, wounds of the temporo-parietal lobe give rise to syndromes of true dissociated aphasia. At the outset there is complete inability to speak, which generally continues for some weeks; then the power of speech gradually returns, together with the ability to understand speech; finally, the power of reading and writing is also
recovered to a certain extent. The development of the symptoms generally lasts several months, and the syndrome is generally fixed at the end of six or eight months. At this stage several clinical types can be distinguished:

(a) The syndrome of aphasia (Wernicke's type).—The patient shows little dysarthria, but principally inability, often pronounced, to name objects; the disorders of the intellect are strongly marked, and the power of calculation is always greatly diminished. It is important to note that the most marked and most persistent syndromes of aphasia arise much more frequently from wounds of the middle and posterior temporal regions than from a lesion of the gyrus angularis or the gyrus supramarginalis.

(b) The syndrome of total aphasia.—All the elements of speech are almost equally affected. The anarthric symptoms are as pronounced as the strictly aphasic ones. A mild brachial monoplegia is often associated with this condition. The lesion is situated in the region of the gyrus supramarginalis.

(c) Predominant alexia is observed in wounds of the extreme posterior end of the temporo-parietal region, which, if deep enough, are associated with homonymous lateral hemiopia or quadrantic hemiopia. If the wound is plainly occipital there will be no defect in the power of reading, even though there may be marked diminution of the field of vision, provided that the lesion does not penetrate very deeply, and does not injure the white fibres of the cortex of the temporo-parietal lobe.

(d) Aphasic residuum.—The intellectual defect is principally in the power of calculation and the vocabulary, which is very limited, the patient having to search for a long time for the right word to designate an object. The patient is able to read pretty well, but not to understand what he has read. It is
generally easy to detect these troubles, but they must be methodically sought for, because a knowledge of their existence is important.

Wounds of the posterior frontal region.—When the lesion involves the area including the foot of the left external frontal convolutions and the inferior portion of the ascending frontal it is frequently associated with disorders of speech, especially if the lesion is low down and far back. These disorders are generally absent if the lesion is slight, but present when the lesion is deep, and are then generally associated with hemiplegia. The clinical aspect is as follows: Immediately after the wound there is complete, or nearly complete, anarthria, and a hemiplegia (which disappears in some hours or not for some weeks), and there is difficulty in reading. When speech is regained, as it generally is after a variable period, the disorders diminish rapidly, and there remains only a slight dysarthria, which affects the intonation, the utterance, and the articulation all at the same time, and which gradually disappears. The power of writing is unaffected, but there is often difficulty in reading. Complete, or nearly complete, cure is the rule.

Wounds of the pre-frontal region, whether situated on the right or on the left side, do not give rise to disorders of speech, except that just at first there may be slight and very transient dysarthria, sometimes of a special type (such as faltering or great deliberation of speech).

Course and Prognosis

Wounds of the left anterior frontal region do not cause disorders of speech. Wounds of the left frontal region are associated with transitory anarthria, followed generally by complete cure. Wounds of the rolandic area are associated with monoplegia or
hemiplegia. When the lesion is superficial and affects principally the inferior portion of the ascending frontal there will be anarthria, leaving behind it a rather prolonged dysarthria. When the lesion is deeper there will be Broca’s aphasia, the more strongly marked the lower and more deeply penetrating is the lesion; this aphasia is usually but little susceptible of cure. Wounds of the temporo-parietal region produce an aphasia closely resembling Wernicke’s, and cause grave and lasting diminution of intelligence and of the power of speech. These details of prognosis are of great importance, because most of the patients remain permanent invalids. Although their complaints appear to be trifling, methodical clinical examination will discover a very great diminution of the capacity of these men for useful employment, and the almost complete impossibility of any of them returning to their trades.

**Differential Diagnosis**

The clinical aspect of aphasic disorders is too characteristic for it to be possible to make any error of diagnosis. But it is necessary to observe that there are dysarthric disorders which are not due to lesion of the lenticular area.

*Cerebellar dysarthria* is characterised by a very deliberate, explosive, sometimes wandering or drawling method of speaking.

*Pseudo-bulbar dysarthria* occurs in lesions of the central grey nuclei or of the pons. The patient speaks breathlessly, and his speech is nasal, muffled, and choking. There is a whole range of symptoms that point to the seat of the lesion: bilateral hemiplegia, dysphagia, and spasmodic laughter and weeping.

*Bulbar dysarthria* is due to nuclear paralysis, and is marked by amyotrophia and fibrillar tremors of
the muscles, innervated by the seventh and twelfth pairs of nerves. As far as is known, none of these varieties of dysarthria are caused by a direct blow, but nearly always by "contre-coup" or by concussion, as will be described later.

*Aphonia, mutism, or hysterical deaf-mutism*, which frequently occur in wounded patients, are too easy of diagnosis for it to be necessary to dwell upon them.
CHAPTER VIII

WOUNDS OF THE OCCIPITAL LOBE

The essential characteristic of wounds of the occipital lobe is the existence of visual disorders due to lesion of the visual area of the occipital cortex and of the central optic tracts. This group of results is much more common than could possibly have been supposed. Nimier, in his remarkable work on *Gunshot Wounds of the Skull and Brain*, mentions only about ten cases of visual disorders of the hemiopic type, several of which are drawn from civil practice. Tatsuji Inouye, who has devoted an important work to the special study of the visual disorders due to war wounds of the visual centre of the cortex, has collected only 28 positive cases from among nearly 80,000 wounded in the Russo-Japanese war. On the other hand, out of 1200 wounds of the skull we have examined 300 wounds of the occipital region, and have found 85 cases in which there was alteration in the field of vision, sometimes associated with other symptoms. This will give some idea of the extreme frequency of these disorders, since they appear in 7 per cent. of the cases of wounds of the skull. We shall see that in many patients these alterations in vision are overlooked because they are not associated with persistent subjective disorders.
Anatomy and Physiology

In many cases wounds of the occipital lobe are not accompanied by any appreciable symptoms. The occurrence and character of the visual disorders are closely related to the anatomy of this part of the brain, which is briefly described in the following paragraphs giving the anatomical and physiological data necessary for a clear explanation.

Fig. 17.—The area striata according to Brodmann.

External aspect of the occipital lobe.
O¹, O², O³, occipital convolutions.
T¹, T², T³, temporal convolutions.
P. O. F., parieto-occipital fissure.
P. O. S., parieto-occipital sulcus.

Internal surface of the occipital lobe.
C, cuneus.
Lg, Lingual lobe.

The extent of the area striata round the calcarine fissure is shown by the dotted area.

Anatomy.—The occipital lobe in shape somewhat resembles a pyramid; the base is in front, and is joined on to the rest of the hemisphere; the summit is the posterior extremity of the lobe, or occipital pole, and lies beneath the upper and outer part of the internal occipital protuberance. The external aspect corresponds to the concavity of the occipital bone,
and is made up of three convolutions (the first, second, and third occipital) placed horizontally, and converging towards the point of the lobe. The inferior aspect is slightly concave, and inclined downwards and outwards; it is made up of two convolutions, the fusiform lobule without, and the lingual lobe within. The tentorium cerebelli is interposed between it and the upper surface of the corresponding lobe of the cerebellum. The internal aspect is divided from the lobe on the opposite side by the falx cerebri, and consists entirely of the triangular sixth occipital convolution, the cuneus; its summit is anterior; the superior border is marked by the parieto-occipital or internal perpendicular fissure, and the inferior border by the calcarine fissure. This extremely deep fissure is situated at the lowest part of the internal aspect of the occipital lobe, and extends upwards and forwards from the point of that lobe towards the hinder end of the corpus callosum.

The white matter of the occipital lobe is traversed by the bundle of fibres which form Gratiolet's optic radiations, the lowest and most external portion of which forms the inferior longitudinal fasciculus. This fasciculus extends from the corpus geniculatum externum to the internal aspect of the occipital lobe, and passing above the horn of the lateral ventricle is spread out round the calcarine fissure, and is known as the intra-cerebral optic fasciculus.

Localisation of the visual area.—While some authors
attribute to the visual centre an area covering the whole of the cortex of the occipital lobe, including its external aspect, others confine the function of vision exclusively to the internal aspect of the lobe, and especially to the cortex of the calcarine fissure,

Fig. 19.—Diagram of the optic paths from the calcarine cortex to the retina.

which has indeed a very peculiar type of cellular architecture found nowhere else except in this situation and its immediate neighbourhood. It has received the name of area striata (fig. 17). This area encroaches very slightly on the convex surface of the occipital lobe at the posterior extremity of the calcarine fissure, where it turns round the point of the lobe. This localisation has been confirmed by the
anatomical and clinical researches of Henschen, and seems to be fully justified. Visual disorders in brain injuries are therefore due to injury of this visual centre, or of the fibres which proceed thither. A wound merely involving the external convolutions without penetrating deeply into the lobe will not be marked by any really reliable symptom.

**Physiology of the visual area.**—It is absolutely necessary to bear in mind that the visual centre of each eye receives simultaneously the visual impressions received by the temporal portion of the retina on the same side, and by the nasal portion of the retina on the opposite side; consequently the destruction of the visual centre of a single side causes loss of vision in a vertical half of the field of vision of both eyes, or homonymous lateral hemiopia, left or right. That is to say, there will be total loss of vision in the right half (homonymous) of the field of vision of each eye if the lesion is on the left side, and *vice versa*; while partial destruction of the visual centre on one side only will cause a partial but identical loss of vision in each homonymous half of the field of vision of each eye. Further, Henschen’s researches have shown that the upper part of the visual centre, for instance, the superior lip of the calcarine fissure on one side, corresponds to the superior quadrant of the retina in each eye, and therefore to the homonymous inferior quadrant of the field of vision of each eye; in other words, the cortex of the calcarine fissure receives a projection from the ocular retina.

**Site and Characters of the Wound: Occipital Cranio-cerebral Topography**

The above rather complicated, but important, anatomical and physiological details will explain why wounds of the occipital lobe are not always accom-
panied by symptoms, because nothing is known of the function of the external convolutions. On the other hand, they will lead us to expect that the symptomatology of wounds of the occipital lobe will be an essentially visual symptomatology, and that the variations in the deficiencies in the field of vision will be very numerous.

**Occipital cranio-cerebral topography.**—The relation of the surface of the occipital lobe to the skull can be practically and approximately ascertained as follows: draw a horizontal line passing immediately below the external occipital protuberance and reaching the posterior border of the mastoid on each side. From the two extremities of this line draw lines meeting at the lambda; these will form an isosceles triangle, the centre of the base of which will be the external occipital protuberance. Any penetrating wound of the skull in the area thus marked out will affect the occipital convolutions, but in order to provoke disorders of vision, the more distant the wound is from the occipital protuberance the deeper must it penetrate. Only wounds in the immediate neighbourhood of, and especially above, the external occipital protuberance will cause a disorder of vision if they affect the cortex only. The anatomical and physiological details given above will make it clear that the defects of vision caused by these wounds will, in the great majority
of cases, be situated in the lower half of the field of vision. In fact, in nearly all cases it is the upper half of the visual centre that is affected by such wounds. The inferior lip of the calearine fissure, deeply situated within the inferior portion of the lobe and in immediate contact with the vermi-form process of the cerebellum and the right lateral sinus, cannot be alone affected by wounds, which must nearly always cause simultaneous injury to the cerebellum and the venous sinuses, and will be so grave as to prove fatal. The few cases of injury to the inferior portion of the calearine fissure alone which have been observed have been caused by indirect wounds. Apart from direct lesions, the occipital lobe may be injured indirectly by missiles penetrating the skull from the parietal or temporal regions, for instance, and becoming arrested in the occipital lobe. It is important to remember this; radiography should always be employed in any case showing alterations in the field of vision, as this will frequently bring to light the presence of a hitherto unsuspected foreign body.

**Symptoms**

As we have said in our epitome of the present accepted theory of the physiology of the occipital lobe, nothing is known of the functions of its external convolutions, and the symptomatology of wounds of this lobe is confined entirely to the disorders arising from lesion of the visual centre in the cortex or of the central occipital tracts. In the pre-war neuropathology, lesions of the visual centre were usually associated with softening from local arterial degeneration, and then almost the only symptom observed was homonymous lateral hemiopia; cases of quadrantie hemiopia or hemiopic scotoma were extremely rare (Henschen). This difference of symp-
Wounds of the occipital lobe

Tomatolagy between lesions of the visual area caused by softening and those caused by war-wounds will be easily understood if it be remembered that in softening the deficiency of cells and nerve fibres is widespread, and involves an entire cone of cerebral matter which is destroyed, while in war cases, when the phenomena of disturbance have ceased and the effusions of blood have been absorbed, the lesion is very circumscribed, of clean section, and situated in healthy cerebral tissue, since the brains are nearly always young, with intact vascular systems and considerable power of repair.

Wounds which penetrate the skull and injure the visual fibres of the cortex, on the other hand, give rise to a great variety of disorders: cortical blindness, inferior hemiopia, single and multiple hemiopic scotomata of all forms, and all these modifications must be methodically looked for with the perimeter, because they are frequently unknown to the patient and his doctor.

Examination of a patient with an occipital wound.—Before beginning to study the varieties of hemiopia it will be useful to sketch out a few points to be observed in the examination of these patients.

It is not necessary to dwell upon the examination of the ocular motility and of the condition of the pupil reflexes, which should always be carried out, nor on the measuring of the visual acuity after correction of any errors of refraction that may be present. The examination of the ocular media and of the fundus must never be neglected, in order to eliminate any corneal or crystalline lesions, and to ascertain the condition of the optic nerve, and especially of the macula. It is essential absolutely to eliminate any macular lesion which might tend to produce a central or pericentral scotoma in the field of vision; such macular lesions are found, as a rule, in the field of vision of one eye only.
These indispensable preliminaries having been carried out, the measuring of the field of vision with the perimeter is proceeded with. This examination should be made by natural light, the patient having his back to the light, and if possible in a room with the walls painted black. A disc of white paper about half an inch in diameter attached to a black index-arm should be used. The patient is told to fix one eye steadily on the fixation point of the perimeter, and the index is displaced by slightly moving it, proceeding from the periphery towards the fixation point. The patient must be strictly cautioned not to move his eye from the point on which it is fixed, and to say immediately he sees a white gleam approaching the fixation point. It will be as well to make one or two preliminary trials so as to make sure that the patient understands the instructions, and to cause the index to disappear behind the perimeter several times so as to see whether the patient becomes aware of its disappearance.

Having taken these precautions, the patient’s field of vision is measured by means of the index, which is moved along the circle of the perimeter from the periphery towards the fixation point, changing the inclination of the perimeter round the latter from time to time so as to test a series of meridians. In practice the number of meridians tested should be about ten for each field of vision, and the results should be noted on a diagram made up of concentric circles corresponding to the different degrees of the graduated arc of the perimeter, and crossed with diameters corresponding to the different positions in which the arc of the perimeter can be placed around its zero.

The mapping-out of the limits of the field of vision for colours (red, blue, and green) is conducted in the same way.
It must always be borne in mind that every patient rapidly tires during this examination. The first result of fatigue is an artificial contraction of the field of vision in the sector which has been longest under examination, which is repeated exactly in the other eye. At a first sitting only the principal meridians should be measured, and the patient should be allowed several hours’ rest before proceeding to measure the whole of the meridians of a single eye, leaving the examination of the other eye till the next day whenever possible. The examination must always be stopped if the patient shows the least sign of fatigue. If it can be managed, a second measurement of the field of vision should be made a few days later so as to make sure of the permanence of its limits. If the visual defects are very small and near the fixation point, an index only one-twelfth of an inch square should be used, and Pigeon’s stereoscope, by which a more exact measurement of the limits of the scotoma can be made, should be substituted for the perimeter.

The Types of Modification of the Field of Vision

Homonymous lateral hemiopia.—Lateral hemiopia through a direct wound of the occipital lobe and isolated destruction of the field of vision on one side only appears to be somewhat rare. If the injury is severe the visual lesion is bilateral, and there is either cortical blindness or an inferior hemiopia. If the injury is moderate, there is not complete lateral hemiopia, but a uni- or bilateral hemiopic defect. Complete typical lateral hemiopia is nearly always due to a lesion of the occipital region more or less external relatively to the median line, penetrating very deeply into the white matter of the occipital lobe and injuring the optic radiations. In many cases
the missile enters the skull a long distance away, and reaches the occipital lobe after having severed the radiations, thus causing hemiopia. Homonymous lateral hemiopia from war-wounds does not, as a rule, display any special clinical symptoms. The vertical limit of the blind area passes through the point of fixation itself, or does not touch the macular field on the side of the hemiopia within a radius of 5 to 10 degrees around the fixation point. The hypothesis upon which these variations are accounted for will be dealt with when we speak of macular and para-macular scotomata. In any event, it appears to us that the fact that the limit of the field of vision passes through the fixation point, or does not touch the macular field, does not seem to deserve the importance attributed to it by some writers; a hemiopia passing through the point of fixation would indicate a lesion of the optic tract (see fig. 19).

It is not necessary to enlarge on the symptoms associated with hemiopia in cases of indirect wounding of the occipital lobe by a missile; it is only necessary to mention the possibility of alexia when there is right homonymous lateral hemiopia. In this case the patient loses the capacity of reading, which must not be confused with the difficulty of reading caused by the diminution of the visual acuity. This pure, or almost pure, alexia occurs when the lesion of the occipital lobe extends very deeply to the convolutions on its inferior aspect (the lingual and fusiform lobules) adjacent to the deep portion of the white matter of Wernicke’s zone, or the zone of language. There is then a lesion of the visual area with slight damage to this zone of language, or of the fibres which proceed from it, that causes alexia (Pierre Marie). If the lesion impinges a little further on the zone of language, the alexia will be associated with a series of symptoms of sensory aphasia of varying intensity.
Figs. 21 to 24 show the field of vision in two cases of homonymous lateral hemiopia selected from those we have observed. Fig. 21 is a case of a direct wound of the occipital region, with extensive destruction of the occipital lobe; there was almost pure alexia associated with hemiopia. In the other case there was a deeply penetrating wound of the external
Fig. 23.—Radiographs in profile and full face showing intra-cerebral missile.

Fig. 24.—The wound in the skull showing the orifice of entry.
Left homonymous lateral hemiopia.
aspect of the occipital lobe, with a missile which had severed the optic radiations lodged deep in the lobe near the median line.

Cortical blindness is caused by extensive destruction of both occipital lobes, or, at the very least, of the visual centre; it is very seldom seen, as the injury is generally so grave as to prove fatal. On the other hand, it is quite common to see cortical blindness precede the other forms of visual disorder for a period, often very brief; but there are cases in which the blindness may continue for months, and in these there is reason to suspect a neuritic complication due to anterior cerebral hypertension or infection. The fundus and the condition of the pupil must then be examined in order to eliminate the possibility of a neuritic complication, and to establish the diagnosis of cortical blindness. In the history of cases of occipital wounds there is nearly always found the anamnesis of a cortical blindness, which lasted a few hours or days and passed away, leaving in its place a more or less extensive hemiopic defect. This transitory cortical blindness is caused by inhibition of the visual centre by shock and the compression due to the oedema consequent on the lesion; it is not due to permanent and total lesion of the area. Transitory blindness of this kind does not generally amount to complete amaurosis; some perception of light is generally retained. Vision often returns in the superior portion of the field, and is accompanied by brilliant phosphenes which indicate irritation of the visual area.

Inferior hemiopia.—In the pre-war period the syndrome of inferior horizontal hemiopia was exceptional in neuro-pathology, and was often attributed to lesion of the chiasma. Professor Lapersonne was the first to contend that this type of hemiopia was due to lesion of the occipital lobe. As might be
expected from the arrangement of the calcarine fissure, it is very frequently caused in this way. On the other hand, for the reasons stated above, superior horizontal hemiopia is extremely rare, as any wound which could injure the inferior portion of the visual centre alone must likewise cause lesion of the cerebellum and of the venous sinuses on both sides, and would certainly cause death. This variety of hemiopia is due sometimes to missiles entering transversely above the external occipital protuberance, and sometimes to direct lesions of the occipital bone in the median line. More rarely it is caused by a wound of the parietal region on one side, the missile travelling obliquely into the occipital lobe of the opposite side.

Inferior horizontal hemiopia is nearly always preceded by a period of more or less complete blindness (cortical blindness), which lasts for a few days or weeks; then the superior portion of the field of vision becomes brighter, vision again becomes normal therein, and examination with the perimeter will show an inferior horizontal hemiopia several months after the wound. It is important to observe that this examination will show that the anopic region does not reach right up to the horizontal meridian, as it does to the vertical meridian in the case of homonymous lateral hemiopia. Sometimes there is a more or less extensive field of vision below the horizontal meridian, and sometimes the defect encroaches on the superior portion, but the defect is always nearly perfectly symmetrical in both homonymous quadrants of the two fields of vision. The name "horizontal hemiopia," therefore, appears to be hardly justified; it is rather a case of bilateral scotoma in sector, or bilateral quadrantic hemiopia. Nor is it uncommon to find this hemiopia diminish to an inferior hemiplegic scotoma by the return of vision to the peripheral portion of the field if the wound is not more than a few months old.
In every case which has come under the writer's personal observation the data furnished by the site of the wound, by the direction of the missile, and by radiographs have demonstrated that it was always the superior portion of the visual area that had been injured. Fig. 25 shows a typical example of this form of hemiopia.
Quadrantic hemiopia. — In this form of hemiopia it is almost always one of the inferior quadrants which is affected, and the defect occurs in the homonymous quadrant of each field of vision, but the superior form is not so rare as the other forms of hemiopia.

Inferior quadrantic hemiopia is caused by a direct wound of the external table of the occipital bone above the protuberance, beyond which the depression of the bone does not pass. Indirect wounds appear more frequently to give rise to superior quadrantic hemiopia. In all cases of this variety observed by the writer the site of the wound had been behind the ear, and quite close to the base of the mastoid process; the missile, travelling very obliquely backwards, has
followed the inferior aspect of the occipital lobe, and has been arrested near the median line. This variety

of lesion of the visual centre must be methodically looked for in every patient who has a wound in this position, because, in such cases, the disorder of vision is nearly always unperceived. But inferior quadrant
hemiopia is the most common variety, the blind area in the field often reaching the fixation point, and it is sometimes complicated by hemiachromatopia in the homonymous superior quadrant. In the cases observed by the writer the limits of the defect of vision have continued unchanged after several months. The site of the wound, its direction, and the radiographic localisation of the missile (if it is still present) all show that the injury is confined to one portion only, either superior or inferior according to the case. Sometimes, instead of the wound being limited entirely to one lip of the calcarine fissure it will have slightly touched the other also, which will be shown in the field of vision by a small scotoma being added to the hemiopia in the quadrant affected.

Fig. 27 illustrates a typical case of quadrantic hemiopia by direct wound.

**Hemiopic scotoma.**—This is the most common form of disorder of the vision caused by wounds in the occipital region. The scotoma is always negative, that is, it does not appear as a black patch in the field of vision, and is consequently nearly always unperceived by the patient. It is usually absolute, the loss of vision within its area being complete. Sometimes, but much more rarely, the scotoma is only relative, the visibility of the white index only diminishing instead of disappearing altogether during part of its passage. These scotomata appear in all sorts of shapes, though they may extend over only a few degrees. Their number, as well as their position relatively to the fixation point, is very variable. They can be divided into three classes: (a) macular and paramacular scotomata, (b) pure macular scotomata, and (c) peripheral scotomata. In most cases the site of the wound is in the immediate neighbourhood of the external occipital protuberance, either in the median line or slightly on one side of it. According
to the descriptions of operations or the information obtained by radiography, there is often damage to

Fig. 29.—The wound of the skull. Fig. 30.—Radiograph of the skull in profile showing fracture with depression of the occipital bone.

Right inferior hemiopic scotoma.

the brain by the missile or by splinters of the internal table of the skull. Most frequently there has been total blindness at the moment of wounding, which has
WOUNDS OF THE BRAIN

Persisted for a few hours or days and then disappeared, the restoration of vision appearing to be perfect. If

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![Diagram of wound of the skull and radiograph of the skull in profile showing fracture of the internal table and an intra-cerebral splinter.]

*Fig. 31.* The wound of the skull. *Fig. 32.* Radiograph of the skull in profile showing fracture of the internal table and an intra-cerebral splinter.

*Left superior macular and paramacular hemiopic scotoma.*

The patient is examined several months after the injury, he will be unconscious of any defect in his vision; it is only minutely methodical examination
of the field of vision with the perimeter that will bring it to light. These scotomata are always homonymous, or situated in the same portions of the field of vision on each side; they are almost mathematically identical in the two fields, and they are constant in shape even when they are very small. Repeated examinations of a patient at intervals of several months have yielded identical results.

If the data derived from the site of the wound, from observations made when the patient first came under surgical treatment, and from radiographs are compared with the position occupied by the scotoma in the field of vision, interesting information respecting the localisation of the visual area can be obtained. Thus purely macular scotomata situated within 10 degrees of the centre of the field of vision are always caused by a small wound of the occiput situated immediately above and slightly to the side of the external occipital protuberance, which therefore almost exclusively affects the extreme point of the occipital lobe. Peripheral scotomata, on the other hand, are caused by much more anterior lesions of the visual area. It must be repeated that it is especially necessary in cases of scotoma to measure the visual acuity and carefully to examine the fundus in order to eliminate any lesion of the macula.

Hemiachromatopia.—This type of disorder of the field of vision appears rarely to occur alone, but is pretty frequently associated with quadrantic hemiopia or hemiopic scotoma. This disorder is generally transitory, being the residuum of a hemiopia which has disappeared, and it also disappears in its turn. It does not appear to be caused by lesion of a special visual colour centre, but rather by slight injury of the general visual centre or of the optic radiations, but in every case of wound of the occipital region the perimetric examination for colours must be carried
Fig. 33.—Radiograph of the skull in profile and full face showing an intracerebral missile on the side opposite to the orifice.

Fig. 34.—The wound of the skull.

Complex form of defect of the visual field.
WOUNDS OF THE OCCIPITAL LOBE

out, even if the field of vision appears to be normal for white light.

**Complex defects of the field of vision.**—Besides the classical types of modification of the field of vision which have been described, extremely complex defects of a hemiopic type may be caused by wounds of the occipital lobe. It would take too long to describe these, but their existence will be fully understood if the idea of a projection of the retina on the cortex of the calcarine fissure is borne in mind. If a projectile traverses the occipital lobes from side to side, or if irregular splinters penetrate more or less deeply into the visual centre, there will be found an extremely irregular patch of anopia, which will always have one absolutely constant characteristic—symmetry of the defect in each moiety of the field of vision. In figs. 33 and 34 is shown a case where the missile has entered to the right of the median line near the protuberance and has been arrested deep in the left occipital lobe; there is a lateral hemiopia on the left, and three hemiopic scotomata on the right.

**Course of Disorders of Vision**

The patients do not usually present marked symptoms of disordered vision except at the time of being wounded, when there is immediate blindness (often of brief duration) followed by rapid return of vision; then the visual defect becomes fixed, the patients generally remaining unconscious of it. If the defect is still observed several months after the wound, it has become permanent. Symptoms of irritation of the visual area are frequently added to these symptoms of inhibition or destruction. At the very instant of being wounded, and before the loss of sight, some patients see an appearance as of a huge flame in front of their eyes; later on, the return of the sight
is accompanied by luminous phosphenes (sparkling coruscations of all colours) over all that portion of the field of vision in which the sight is returning. In some cases there are even visual hallucinations, such as persistence of the image of an object which has disappeared, or the appearance of animals of strange shapes in the blind part of the field. At a very late stage the syndrome of characteristic hemiopic migraine, with a scintillating scotoma and lateral hemiopia lasting several hours, has been observed in some patients affected by macular scotomata, the result of a lesion of the apex of the occipital lobe, and even true epileptic fits commencing with a scintillating scotoma.

Everything that we have seen since our first study of occipital wounds goes to confirm the views we have put forward above.

Up to the present time we have seen close upon one hundred and fifty cases of wound of the occipital region with hemiopic visual affections which have all been examined several times.

We wish to lay stress upon the permanence of the defect in the field of vision when the patient is examined more than six months after the injury if no complication has arisen meanwhile. These facts come out particularly when we are dealing with cases presenting a small macular or paramacular scotoma the dimensions of which can be accurately defined.

**Associated Symptoms**

It is not necessary to particularise the subjective symptoms, such as severe headache or vertigo, of which many patients complain, as there is nothing special about them in connection with wounds of the occipital region. It is, however, necessary to see whether there is any *disturbance of the sense of locality,*
such as have frequently been observed by the writer, the patient not being able to recognise his own bed, or being unable to find his way when walking in the street, or to recognise streets through which he has frequently passed. In practice the test can be made by asking the patient to give the route between two places that he knows well, and, if necessary, he may be made to trace out the route on a map.

Alexia has already been described in connection with homonymous right lateral hemiopia.

Complications.—There are no complications peculiar to wounds of the occipital lobe. There may sometimes be an abscess, or encephalitis may occur, and there may be crises of true epilepsy, sometimes associated with the headache of hemiopia. But unilateral or bilateral affections of the labyrinth are especially common, with impairment of hearing and labyrinthine vertigo, and are caused by lesion at a distance of the labyrinth, by “contre-coup,” or by a fracture extending to the petrous bone. The labyrinthine syndrome is dealt with in connection with wounds of the cerebellum.

Radiography.—In the wounds of the occipital lobe radiography will give information of the greatest importance. Besides often showing the presence of an unsuspected missile in the brain, it may, theoretically, take the place, to some extent, of an anatomical investigation, and give fairly accurate indications as to which portion of the lobe has been affected. The following is the method we have adopted for obtaining a control by using a formalin brain hardened in situ and then removed. The calcarine fissure in each hemisphere has a lead wire laid along its whole length; the optic radiations are marked out with small leaden pellets from the cortex to the chiasma. The brain is then replaced in its cranium and radiographed antero-posteriorly and laterally in exactly
Fig. 35.—Radiograph of a brain replaced in the skull, in which the calcarine fissures and the central optic tracts on the right side have been mapped out with threads and fine shot (full face and profile). The two larger-sized shot correspond to the corpus geniculatum externum and the centre of the chiasma.
the same position as the skulls of the patients by means of M. Infroit’s special apparatus. By placing an accurate tracing of this radiograph over a tracing of the radiograph of the patient’s skull the position of the missile and its path in relation to the optic radiations and the calcarine cortex can be very satisfactorily determined, and in every case in which we employed it positive results were obtained. This method is by no means equal in value to a direct anatomical examination, but the conclusions derived from it, together with our own clinical observations, confirm the results obtained by Henschen by combined anatomical and clinical methods, and help to establish the view as to the projection of the retina on the calcarine cortex.

**Surgical intervention.**—The question as to whether there should be surgical intervention in cases of wounds of the occipital lobe requires the most careful consideration. When there are signs of suppuration, caused by splinters at the orifice itself or when symptoms of a deep-seated abscess can be seen, immediate operation is indicated; but it is much less certain that an operation is desirable if there is a foreign body seated deeply in the occipital lobe which does not apparently give rise to any symptoms of inflammatory complication. If the missile has been *in situ* for several months an operation will not effect any improvement in the defect of vision, which has by this time become permanent, but may increase it by dividing or destroying some other portion of the radiations or of the visual cortex, and it is therefore better not to operate,
CHAPTER IX

WOUNDS OF THE CEREBELLUM

Anatomy

The cerebellum is the portion of the brain which occupies the inferior occipital fossae.

Situation and connections.—It is placed below the occipital lobes, from which it is divided by the tentorium cerebelli. It rests on the occipital bone, which is covered externally by the muscles of the neck, and in front is supported laterally by the posterior surfaces of the two petrous bones; in the median line it is separated from the basilar process by the medulla and the pons. The centre of its greater circumference or posterior border corresponds to the external occipital protuberance.

The knowledge of this very low position of the cerebellum is very important, and must be carefully borne in mind; it is a common mistake to suppose that the cerebellum is much higher up and more accessible than it really is. This is dealt with again in connection with the site of wounds of the cerebellum. A wound of the skull does not certainly and directly affect the cerebellum unless it is situated below a line drawn from the external auditory meatus to the external occipital protuberance.

The cerebellum has a superior aspect entirely covered by the cerebrum. In the centre of this
superior aspect, and running from before backwards, is the superior vermiform process of a herring-bone pattern wedged in between the two lateral lobes, the sloping sides formed by the hemispheres of the cerebellum giving rise to an incline like the ridge of a roof. This is important to remember, as the vermiform process may thus be the only part to be affected by a wound of the occipital region.

The inferior aspect is convex, and deeply furrowed in the middle by an antero-posterior sulcus which separates the two hemispheres of the cerebellum, and at the bottom of which is the inferior vermiform process. The circumference of the cerebellum corresponds in front to the superior border of the two petrous bones, is grooved along its middle to receive the medulla and pons, and helps to form the fourth ventricle. The whole of the posterior border of the circumference corresponds to the transverse groove on the occipital bone occupied by the lateral sinus and, in the median line, the torcular Herophili.

Cerebellar tracts.—The cerebellum is united to the cerebrum and the medulla by three pairs of peduncles; the inferior cerebellar peduncles connect the cerebellum with the medulla and the spinal cord by means of the direct cerebellar tract, Gowers' tract, and fibres emerging from the posterior cornua; these are the afferent fibres to the cerebellum, some direct and others crossed. There are also efferent fibres, the descending cerebellar tract. The middle cerebellar peduncle unites the cerebellum to the grey nuclei of the pons. The superior cerebellar peduncles are made up of efferent fibres, which go from the cerebellum to the nuclei of the tegmentum (or red nucleus), and to the optic thalamus on the opposite side.

Morphology.—The cerebellum was formerly divided into three lobes; a median lobe made up of the superior and inferior vermiform processes, and two
lateral lobes or cerebellar hemispheres. The lobes and vermis were cut up into lobules by deep transverse sulci. The lobules and sulci were arranged *en échelon* on each hemisphere thus: On the superior aspect from front to back, the quadrilateral lobe, the great superior fissure, the lobus cacuminis, and the great horizontal fissure. On the inferior aspect from front to rear, the amygdala, the biventral lobe, the lobulus gracilis, the pyramid, and the inferior semilunar lobe bounded by the great horizontal fissure. The vermis was also divided into two parts, the superior and the inferior, and subdivided into differently named lobules, concerning which it is not necessary to enter into detail.

Bolk, as the result of very minute and careful researches in comparative anatomy, proposed an entirely different division. He proposed to abolish the old nomenclature, and to recognise only an anterior and a posterior lobe separated by a primary sulcus. It is the posterior lobe only which undergoes very great modifications of morphology throughout the animal series, and reasoning from these modifications, Bolk drew the following physiological deductions which have been largely confirmed by experiment and clinical observation: That there are in the cortex of the cerebellum (as well as in the cortex of the hemispheres) centres of localised functions which are centres of representation of the muscular groups, some median, and unequal, appropriated to synergic movements, and others unilateral, appropriated to unilateral movements. These results may not appear to have any direct bearing on wounds of the cerebellum, but it may be that in the future this theory of localisation may enable cerebellar lesions to be exactly located and facilitate surgical intervention.
Physiology

Every author who has dealt with the functions of the cerebellum has endeavoured to define precisely its general function. This has resulted in very contradictory theories, because they looked upon the cerebellum as a whole, without making any distinction between the individual functions of the cerebellar cortex, the white fibres, and the grey nuclei.

Experiments on animals.—Reasoning from results obtained by extirpating the cerebellum in animals, various authors in succession have considered the cerebellum to be the central organ for the co-ordination and regulation of movements, the centre for equilibrium, and the centre for static perception. Luciani grouped the symptoms consequent on removal of the cerebellum under three heads: asthenia, or impairment of the normal tonicity of the muscles in action; atonia, or relaxation of the muscles in repose; and astasia, or irregularity in bringing into play the elementary impulses necessary for a contraction, thus causing tremor and staggering. Munk, reasoning also from numerous experiments on animals, made the cerebellum the centre for unconscious, combined, and co-ordinated movements of the trunk and limbs. It is evident that there is a conflict of opinions, and besides, as experiments on different animals fail to give identical results, it is obvious that the results of such experiments cannot be held to apply strictly to man. As a matter of fact, comparative anatomy proves that the anatomical system of the cerebellum is highly complex (Bolk). The cerebellar function is carried out by the activity of the cortex and the grey nuclei, concerning which our knowledge is very scanty. A more reliable theory of the physiology of the cortex of the cerebellum can only be obtained
by methodical study of localisation in the cerebellar cortex and of its relations with other portions of the central nervous system. Our present knowledge of this subject is still trifling. However, we are beginning to be able to distinguish between an injury to the cerebellar hemispheres and an injury to the vermis, and to make out some of the localisations in the cortex itself. Researches instigated by the very careful work of Bolk show that in the animal (monkey and dog) the extirpation of very circumscribed and strictly defined portions of the cortex bring on symptoms of defect in certain well-defined regions of the body, but Sherrington’s experimental lesions of the central grey nuclei gave much less reliable results. The uncertainty of these experiments is greatly enhanced by the fact that rapid repair occurs in the cerebellar cortex after local destruction, especially in the monkey. The experiments of A. Thomas and Rothmann, however, have shown that there are distinct centres in the cortex of the hemispheres for the movements of abduction, adduction, elevation and depression of the homo-lateral limbs, which are not so much motor-centres, properly so-called, as "centres for the direction of movements"; analogous centres for the muscular systems of the head and neck in the cortex of the vermiform process; and in the cerebellar cortex, separate centres for the "interaction" of the agonistic and antagonistic muscles of particular joints. These are facts of the greatest importance, because they coincide most remarkably with the results of Barany’s clinical researches on man. It would be of little use to recount in detail the complicated history of the almost useless experiments on animals carried out in former days, but it is of great interest to record these recent data, which seem to open out a new path for the physiology and pathology of the cerebellum.
Semeiology of the Cerebellum in Man

Technique of Testing the Cerebellar Functions

Instead of repeating the details of the symptomatology of cerebellar lesions in man it will be more useful to describe the procedure to be observed in the examination of the cerebellar functions, which is calculated to facilitate the search for symptoms. It is not necessary to repeat here the method of testing the muscular energy, the reflexes, the sensibility, etc., which should be carried out on the general lines laid down at the beginning of this book.

A. The Classical Tests

Equilibrium in Repose.—Subjective disorders of equilibrium. Interrogatory.—Has the patient vertigo, and if so, in what position? When erect, or when lying on one side, or when lying on his back? Do sudden movements of the head bring on the vertigo? In what direction does he feel himself inclining? Is it always in the same direction? Do objects which he looks at appear to revolve, and in what direction? Does shutting the eyes reduce the vertigo?

The information derived from this interrogatory is valuable, although the subjective sensation of vertigo may arise from many other than cerebellar lesions; nevertheless a permanent sensation of being always drawn in one direction, which is not diminished by closing the eyes, is in favour of its being a cerebellar vertigo. The most difficult question to decide is that of vertigo of labyrinthine origin, which will be dealt with later.

Objective characteristics of equilibrium in repose. Examination for equilibrium.—Is the patient able to
stand up, with his feet together, or with his heels together, or with his legs apart at any distance he pleases? Is the patient’s position perfectly stable in all, or any, of these positions? If there is an inclination to fall over, in what direction? Is it always in the same direction? Let the patient stand on tiptoe or on one leg. Is the equilibrium affected by the position of the head, when turned backwards, or to the right or left? Let the patient make these movements sharply, and note whether this upsets his equilibrium. Make the patient repeat these movements with his eyes shut.

To test the power of resistance to impulsion. While the patient is standing steadily, push him on the back, or chest, or on the side as if you were trying to upset him, telling him to resist the pressure; suddenly stop the pressure and note whether there is a marked disturbance of equilibrium, and if so, in what direction?

Kinetic Equilibrium. Testing the Gait.—The patient is told to stand erect with his feet together and to start walking. As soon as he starts note whether there is a tendency in the trunk to remain behind, causing the patient to fall in that direction (cf. cerebellar asynergia). While he is walking note whether the patient deviates from side to side of the line which he has been told to follow; if he staggers; if there is a tendency to deviate always to the same side. Note whether the patient walks with his legs wide apart; whether in walking he raises one or

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1 Some of Stein’s tests with an inclined plane may be employed. The patient is made to stand on an inclined plane, the inclination of which is varied to different angles, and the test repeated with the patient in different positions; with his face, back, and each side turned towards the upward inclination of the plane, and the conditions under which he falls are noted.

2 If there is a tendency to fall over, the manner of falling must be noted. As a rule, cerebellar subjects fall in a lump without making any effort to prevent it or to preserve their equilibrium (Babinski).
both legs too high, or too sharply; if his feet strike the ground hard as he steps. Tell the patient to make a half-turn or to stop suddenly at any point in his walk, and note the loss of equilibrium so produced.

It is of great importance carefully and minutely to study the walk of a cerebellar subject, as it often brings out very trifling disorders which the most careful analytical examination would not show. All these tests are directed to the static and kinetic equilibrium of a cerebellar patient, and include nearly the whole of the observations which could be made previous to Babinski's work, which is the real foundation of the clinical semiology of cerebellar cases. The series of indications which will now be described must always be methodically looked for in cases where lesion of the cerebellum is suspected, and they will also explain most of the disorders of walking and equilibrium mentioned above.

**B. Examination for Babinski's Cerebellar Syndrome**

1. Exaggerated Movements (Hypermetria).—When a patient has a lesion of the cerebellum it will be observed that "voluntary movements, or at least some of them, and in certain conditions, will be executed in an exaggerated manner" (Babinski). This may be seen in his spontaneous actions, such as walking. In the first group of the motions of walking the flexion of the thigh on the pelvis is exaggerated, and the foot is raised much too high; in the second group the thigh is extended too sharply, and the foot comes down heavily to the ground. But actions to order will show this more clearly.

   (A) **The upper limb.**—(a) The patient is told to put the end of his index finger on his nose, then to extend his arm laterally as far as possible, and repeat
the action four or five times; he is then told to perform the test at varying speeds, first with the right arm and then with the left, and then with the two arms alternately. A healthy patient will hit the mark every time, but a cerebellar subject will overshoot it and touch his cheek or his eye.

(b) The patient is seated and told to place the palm of his hand on his knee on the same side, then to turn the hand over and replace it on the knee with the palm upwards on exactly the same spot, and to repeat these actions rapidly. A healthy subject will carry out these movements easily and correctly, but with a cerebellar patient the hand will slip down between the knees.

(c) The observer draws a vertical line on a piece of paper, and tells the patient to draw another line from any point to the left and to make it touch the vertical line exactly; a cerebellar subject will nearly always go beyond the vertical line.

(B) The lower limb.—(a) While the patient is lying on his back he is told to put the heel of one foot on the knee on the other side, to keep it there a moment, then to extend the leg again, and to repeat the movement four or five times. A cerebellar patient will raise his heel too high, too far, or too much outwards, and will drop it more or less abruptly on his knee.

(b) The patient while lying on his back is told to bring his heel into contact with his buttock, then to extend the leg, and to repeat the movement four or five times. A cerebellar subject will strike the buttock abruptly with his heel and then let it fall suddenly on the bed.

A cerebellar subject can execute these movements fairly correctly if they are carried out slowly, so the tests must be made in quick time. It will frequently be observed that though the first movements are
much exaggerated, the later ones are less so. The disorder only becomes evident towards the close of the movement; the course is correctly followed by the limb till near the end, when the characteristic disorder, dysmetria, will become evident. The fact that closing the eyes does not increase the disorder observed in these tests enables the observer clearly to distinguish hypermetria from ataxia. These dysmetric disorders have an important bearing on the location of the injury, as when they are found on one side only the lesion of the cerebellum will be on the same side, the cerebellar tracts being direct and not crossed.

2. **Adiadococinesia** is "the destruction or the diminution of the power of executing rapidly successive voluntary movements." If a healthy subject is told to place his hand rapidly and alternately in pronation and supination, the movement will be performed more or less rapidly according to the individual, and also according to whether the right or the left hand is used. With a cerebellar subject it will be observed that while either pronation or supination can be performed rapidly and correctly, the alternation of the movements is much slower than in a healthy subject. In carrying out this test it is essential first to make sure that the subject can carry out rapidly the movements of pronation or supination separately, and that there is no associated paresis. Adiadococinesia may be either bilateral or unilateral, and in the latter case the lesion of the cerebellum will be on the same side.

3. **Cerebellar Catalepsy.**—Babinski describes under this name a phenomenon characterised by prolonged voluntary immobilisation of the muscles in certain positions of static equilibrium. The patient is laid on his back and told to raise his legs in the air with his knees slightly bent and his feet apart, and to
maintain this position as long as possible. A cerebellar subject will execute the movement with more or less large oscillations, then the lower limbs become fixed, "and this fixity is remarkable in its completeness, being greater than that which a normal subject is able to produce." It is maintained for several minutes, and does not appear to be accompanied by any sensation of fatigue. It is rare to see the phenomenon in such perfection, and in any event it is important to note that some cerebellar patients who present titubation and asynergia are able to maintain this attitude as well as a normal subject.

4. Cerebellar Asynergia.—According to Babinski, asynergia is characterised by loss of the faculty of association of movements through want of synchronisation; the following examples will show its characteristics and nature more clearly than a mere definition. It can be very plainly observed in the act of walking, for when the patient starts to walk, he bends his thigh and puts his foot forward in a way which is often exaggerated, but the upper part of his body does not follow the movement of translation. His trunk, instead of being inclined slightly forward remains erect or is even inclined slightly backwards, and when the patient tries to take another step the trunk does not follow, and he falls backwards if not supported.

Babinski has provided a series of clinical tests which make the presence of asynergia perfectly clear.

(a) The patient, while standing erect, is told to bend his trunk backwards as far as possible. A healthy subject can do this, more or less, without falling by flexing the leg on the foot and the thigh on the leg, the knees being carried forward and the whole body curved backwards; but a cerebellar subject curves only the upper part of his trunk, his
legs remain immobile and vertical, with his feet fast on the floor, and he thus loses his balance. This is the reverse of what was observed when he started to walk, there being no synergia in the movements of the trunk and lower limbs. As closing the eyes does not affect this test, it cannot be confused with Romberg's test.

(b) If the patient is laid flat on his back, with his arms crossed on his chest, and is told to sit up, he cannot do so, but will raise his legs more or less from the ground, unlike a healthy subject, who will keep his heels firmly on the ground. This must not be confused with the combined flexion of the thigh and trunk, which is produced only on the paralysed side of a hemiplegic subject. If a cerebellar subject is examined, it will be found that the muscular energy is normal; this must be made certain before concluding from this test that it is really a case of asynergia.

(c) During the tests for hypermetria or dysmetria given above it will be observed that when the movements are carried out somewhat slowly they are not only exaggerated but detached, which is the characteristic of asynergia.

These asynergic disorders may occur unilaterally on the same side as the lesion, and this Babinski styles hemi-asynergia.

Intentional tremor.—During the foregoing tests for asynergia the examiner will observe whether there is tremor (the "intentional tremor" of Charcot), which is perhaps only a form of asynergia. When the tests of bringing the finger to the nose and the heel to the thigh are repeated several times the movement may be seen not to be in a direct, but in a waving line, the oscillations increasing gradually as the movement proceeds, and reaching their maximum at the end. The tremor is of great amplitude, extending to the
full length of the limb under test, but the intensity varies greatly in the same subject. It may even extend to the whole body, and especially to the head and trunk, or it may be confined to the limbs on one side only, and may be seen not only during the execution of a movement, but in the mere effort to maintain an attitude; then the tremor is both static and kinetic.

These are what Babinski describes as the essential symptoms to be found in consequence of lesions of the cerebellar apparatus; their relative importance naturally varying according to the subject, they must therefore be methodically looked for by the tests just described. It is not necessary to lay further stress on their great importance. It has been seen that hypermetria, asynergia, and adiadococinesia account for the difficulties of equilibrium and walking, and the combination of them will also explain the disorders of speech and writing found in cerebellar subjects.

DISORDERS OF WRITING.—The following tests should be carried out:—

(a) Tell the patient to make a dot with a pencil on a piece of paper; the patient will overshoot the paper with the pencil several times, but corrects himself, and finally succeeds in reaching the paper, when he will make a line of varying shape, but not a dot. This disorder arises from hypermetria, as in the test already given.

(b) The patient is told to trace a circle or to make a rounded capital letter, such as O or D. He will not make a continuous curve, but a polygon of a broken outline; this is combined asynergia and hypermetria.

(c) The patient is told to draw regular zigzags between two parallel lines; the lines will be irregular, often overshooting the vertical lines, and the angles
WOUNDS OF THE CEREBELLUM

will be rounded instead of being acute. All these disorders will also be observable in the handwriting of a cerebellar subject.

Disorders of Speech.—The speech is jerky, deliberate, explosive, and sometimes drawling or rolling. The explosive character is due to hypermetria, the deliberation rather to adiadochocinesia. The intensity of these modifications varies greatly in different subjects.

C. Examination for Localising Cerebellar Cortical Symptoms

The researches of Bolk, Van Rynbeek, Rothmann, and André Thomas on animals, and of Barany on man, have enabled us to form the following theory of the physiological action of the cortex of the cerebellum:

There are in the cerebellar cortex centres of muscular tonicity which furnish to the groups of muscles of the various joints the tonicity which maintains their attitude in repose by balancing the antagonistic muscles. During the execution of movements these centres supplement voluntary impulses by increasing the tonicity of certain muscles and diminishing that of the antagonistic muscles, which enables the movements to be correctly performed in a definite direction. They are therefore centres for the direction of movement, and in no wise motor centres. In each hemisphere of the cerebellum there is a tonic, and not a motor, representation of the musculature of the limbs and of the half of the trunk on the same side for each direction of movement of each articulation, which is situated in distinct and very limited regions of the cerebellar cortex. According to Barany, four such centres of direction can be distinguished in man: upwards, downwards, to right and to left, and the musculature of each articulation is represented in each
WOUNDS OF THE BRAIN

Fig. 36.—Anterior and inferior aspect of the cerebellum.

Fig. 37.—Posterior aspect of the cerebellum.

Cerebellar localisations.

Pe, Cerebral peduncle. Lga, Anterior quadrilateral lobule.
Po, Pons Varolii. Lgp, Posterior quadrilateral lobule.
Py, Pyramid of the medulla. Lsls, Superior semilunar lobule.
Ldg, Biventral lobule. Lsli, Inferior semilunar lobule.
Lgr, Slender lobule. V, Vermis.

A, Centre for tonicity "inwards" of the hip.
B, " " " " arm.
C, " " " " hand.

(Destruction of these centres gives rise to a deviation of the arm outwards in the test for spontaneous deviation.)

D, Centre for tonicity outwards of the arm.
E, " " for lowering the arm.
F, " " of the muscles of the right half of the back (?).
G, " " of the abdomen (?).

(The localisation of these two last centres is uncertain.)
centre. It is important to observe that this tonic influence of the brain on the musculature is largely of vestibular origin, and that it undergoes important variations under the influence of excitation of the vestibule (see Barany’s tests).

These physiological data furnish a clue to the consequences of destruction of the cortical centres in the cerebellum. Destruction of a limited region of the cortex will cause: first, the suppression or the diminution of the tonicity of the muscles which come into play in the execution of the movement of a limb in a given direction; second, an exaggeration of the tonicity of the opposing muscles; in short, a loss of balance in the action of the antagonistic muscles, which is shown by: first, a modification of the attitude of the limb in repose; second, a modification of the passive movements, that is, exaggeration or diminution of the passive movements of the articulations in certain directions; third, a modification of the voluntary movements; and fourth, a modification of the cerebellar reactions in the limbs, normally provoked by excitation of the labyrinth (Barany’s test). The more strictly the lesion of the cerebellar cortex is localised, the more clearly will these modifications be confined to certain muscular groups.

In practice the symptoms of defects in the cerebellar cortex can be elicited by examining the patient in the following manner:—

I. The Position of the Limbs.—Careful consideration must be given to the position of the patient’s limbs in repose and in muscular relaxation, when erect and when lying on his back, comparing the position of the limb on the sound side with its fellow on the affected side; and the position of the head and trunk will likewise be observed. For instance, it may be seen that pronation of the forearm is more pronounced on the affected than on the sound side, or vice versa;
that the elbow is more markedly abducted or adducted on one side than on the other; that the right lower limb is in more pronounced external rotation than the left; that the head is inclined towards one shoulder, etc.; but the varieties of possible positions, according to the site of the wound, is so great, that it would not be of any interest to enumerate them. They can only be ascertained by a careful examination of the patient, especially when the wound has destroyed only a very small portion of the cortex.

II. Passive Movements.—Examination of the passive movements is of the greatest importance, and should always be carried out in conjunction with the examination of the voluntary active movements.

The passive movement tests (André Thomas) must be varied at discretion to suit the clinical aspect of each case.

1. Take hold of the patient’s body with both hands, pull him sharply backwards and forwards, and note the extent of the oscillations of his upper limbs. This test may also be applied to the other limbs—the hand, the foot, etc.—in various directions.

2. Pull both the patient’s arms from his body, and let them fall back; compare the manner in which the limbs fall back, and note whether there is any rebound when the arms strike the trunk.

3. Produce passive movements of pronation and supination, and compare the resistance to those movements on each side.¹

The object of all these tests is to ascertain whether

¹ A detailed description of these tests as applied to two wounded patients will be found in a communication by André Thomas to the session of the Société de Neurologie on November 4, 1915. (Revue Neurologique, 1915, Nos. 23, 24, p. 1256.) Both these men showed a special modification of the tendon reflex,—“the pendulum type.” That part of the limb affected by the attempt to elicit the reflex on the bad side described a series of oscillations like a pendulum, while that on the sound side rapidly returned to rest without undergoing any such oscillations.
the resistance to passive movements is diminished, normal, or increased in certain groups of muscles, that is, to make clear the deficiency in the tonic action of the cerebellar centres. It is essential that the patient shall be in as complete a state of voluntary muscular relaxation as possible during these tests.

III. Active Movements. Movements to Order.—A series of symptoms which will only become evident in the movements of certain joints in a given direction can be observed in these patients in the voluntary actions of everyday life and in the execution of movements to order. There will be slowness in carrying out movements on the affected side; the effort will not reach its maximum at the first attempt; the movement will be executed less quickly on the affected side. For instance, if the patient is told to place both index fingers on the end of his nose simultaneously, the index of the affected side will reach the nose after that on the healthy side; the speed of the movement will vary at the different stages of its execution; it will be too slow at the beginning and too hurried at the end, when its amplitude will also be exaggerated; there will be difficulty in stopping, and the mark will be overshot. This hypermetria, described above, may become evident only in the movements of a single limb in a single direction.

All these pathological modifications of the voluntary movements have already been described as they occur in various combinations, in the dysmetria, adiadococinesia, and asynergia of Babinski, and appear to be caused by extensive lesion of the cortex of the cerebellum and of the white fibres. But they may also be observed in the execution of isolated movements, such as the movements of a single joint in one definite direction, and then, in all probability, indicate a very limited lesion of the cortex. The
examination for these symptoms must therefore be protracted and minutely careful.

It will be useful to describe two more tests for ascertaining the modifications of the tonic innervation of the muscular groups in consequence of lesion of the cerebellum. (a) Stewart Holmes’ test, or the test of the resistance. The patient is told to execute a movement, say, of flexion of the forearm on the upper arm; the observer resists the movement, and lets go suddenly. In the normal condition the movement of flexion will be completed, and there will be a slight rebound in extension; when there is lesion of the cerebellum, there will be no rebound. The same test can be applied to the resistance to flexion of the knee, the thigh, or the elbow. (b) Lotmar’s test of the estimation of weight. Identical weights are put into the patient’s hands simultaneously, and he is asked to say whether the weights are equal or not; if there is lesion of the cerebellum, the patient will say that the weight on the side of the cerebellar lesion is the lighter of the two. These two tests also show that the innervation of the antagonistic muscles is insufficient.

IV. Tests of the Cerebellar Reflex Movements of Vestibular Origin (Barany).—(a) Spontaneous deviation of the index finger.—If one of the centres in the cortex of the cerebellum has been destroyed, the suppression of the tonic innervation of certain muscular groups and the exaggerated activity of the opposed group can be ascertained by the deviation produced in certain movements to order. This is called the “Index test,” and is carried out as follows: If it is desired to test the shoulder joint the patient is told to extend his arm, to rest it on his knee, on the same side, and then to touch the observer’s index finger, which is placed in front of him; the patient must repeat this test three or four times with his
eyes open, and then continue with his eyes shut. Under these conditions a normal subject will continue the movement correctly, and touch the observer’s finger each time; but if there is destruction of the centre for the tonicity of the inward movement of the arm the patient’s finger, when his eyes are shut, will deviate outwards, and will no longer reach the observer’s index finger. The deviation may be observed in all directions, and in any joint, according to the function of the centre affected.

In many cases this spontaneous deviation will not be observed, or, to speak more accurately, it only occurs when the lesion of the cerebellum is of comparatively recent date. A method has been devised by Barany for exploring the function of the centres of direction in the cerebellar cortex, and estimating their defect by means of the labyrinth if the spontaneous deviation does not occur. This is called the “test for incited deviation.”

(b) Test for incited deviation. Reflex movements of the limbs.—Barany has proved that if stimulation of the vestibular nerve is provoked by injecting cold water into the auditory canal various phenomena are produced, among which are reflex movements of the limbs, which are deviated towards the side of the injected ear. For instance, if cold water is injected into the left ear of a normal subject, and the “index test” is applied to the different joints, it will produce a deviation to the left. Barany’s theory, stated briefly and without the long details given by him, is that the execution of these movements by the brain is modified at the level of the cerebellum under the influence of excitation of the labyrinth; stimulation of the vestibular nerve on one side only provokes loss of equilibrium in the functions of the cerebellar cortical centres for the direction of movements, and deviation of all the movements of all the articulations
in the same direction is thereby produced. If one of these centres is destroyed the stimulus is not transmitted, and the deviation is not produced in one definite joint for one definite direction. By applying this "test for incited deviation" to each of the vestibular nerves in turn, and employing the "index test," or an analogous one, for the lower limb, the absence of deviation in one or several joints will be ascertained, and thereby the particular portion of the cortex which has been destroyed will be known. This delicate test is of the greatest importance, and must be repeated several times to enable a definite opinion to be reached. Its value has been proved by Barany in numerous clinical cases, which have been confirmed by operations or autopsies, and he was thus enabled to localise a certain number of centres for direction of movements of the articulations in man, which are shown in figs. 36 and 37.

It is necessary to apologise for the length of this description of the examination of a cerebellar subject, but it is only the superficial wounds of the cerebellum which enable us to define exactly the cerebellar localisations. Such wounds, therefore, require the profoundest clinical examination, which should be methodically conducted.

**Site and Characters of Wounds of the Cerebellum**

Speaking generally, wounds of the cerebellum are very seldom observed, which is due, we believe, to its being so close to the medulla, which is either injured at the same time, or is so affected as to cause immediate death from cardiac or respiratory failure, and not because such wounds are in themselves accompanied by damage sufficient to destroy life. According to the writer's personal experience, direct wounds of the cerebellum seem to be more rarely
seen than indirect wounds. By an indirect wound is meant damage to the cerebellum by a missile that has entered the skull anywhere except in the cerebellar area. Cases have been observed of wound of a cerebellar hemisphere by a rifle-bullet or shell-splinter which had entered at the vertex or near the fronto-parietal suture, the missiles being detected by radiography. Direct wounds are rare, because the cerebellum is protected by the nearly horizontal occipital bone and covered by thick masses of muscles, and so is not reached if the wound is slight; when the wound is severe and penetrating, it is most often fatal from shock, or from damage to the medulla, or laceration of the venous sinuses. Still, cases of superficial wounds of the cortex of the cerebellar hemispheres have been seen, and such few cases as have been available have been specially and most carefully studied by André Thomas, from whose description the following is taken.

**Symptoms**

**Deep wounds, generally indirect.**—As has been stated above, these are most frequently cases of penetration of a foreign body into a cerebellar hemisphere. The result produced is a cerebellar hemiplegia (Pierre Marie and Foix), with all the essential elements of the cerebellar syndrome: disorders of equilibrium and gait, hemiasynergia, hypermetria, and adiado-cocinesia on the same side as the wound. If the wound is in the occipital region, a deep lesion of a cerebellar hemisphere may sometimes be direct, but this is exceptional on account of the seriousness of the wound. If the patient survives, there will be found associated with the cerebellar hemi-syndrome disorders of vision due to lesion of the occipital visual centre, homonymous lateral hemiopia on the side
opposite to the wound, complete or incomplete hemiopia, and hemiopia in the superior quadrant. It has already been pointed out that the inferior portion of the visual centre receives impressions from the inferior half of the retina of each eye, and therefore its destruction entails defect of vision in the superior half of the field of vision.

**Direct superficial wounds.**—The localising symptoms (described under B, p. 161), which show abnormality of function in the antagonistic muscles, are found to a varying degree in these wounds. These troubles may be very limited, and confined to certain joints and certain directions. Two cases of this kind have been minutely and carefully studied by André Thomas.¹

Recapitulating in general terms the symptomatology of wounds of the cerebellum according to the region of the cerebellum affected, and no longer considering whether the wound is deep or superficial, the following are the syndromes which will be observed:

**Lesions of the vermis**: typical cerebellar gait with abnormal positions of the head; slowness in the movements of the head and face; troubles of speech; cerebellar asynergia in the trunk and, possibly, the lower limbs.

**Lesions of one hemisphere**: unilateral symptoms on the same side as the lesion, hemiasynergia, unilateral adiadochocinesia, hemihypermetria; Barany's "index test" is abnormal for the upper and lower limbs on the side of the lesion, and in all directions if the lesion is important.

**Lesions of the cortex alone**: the preceding symptoms will be found again, but if the lesion is almost purely cortical, the tests for passivity will be found positive for only one limb, or for only one articulation; the test for spontaneous deviation is positive. Barany's "index test" will show sup-

pression of the deviation in one direction of the movement, and only in one joint, according to the region of the cortex affected.

**Lesions of the central grey cerebellar nuclei:** injury of these appears to provoke principally serious vertiginous troubles of equilibrium (lateropulsion), abnormal positions of the head and trunk, catalepsy, and, perhaps, nystagmus.

**Associated symptoms:** injury of the cranial nerves (III., IV., V., VI., VII., and VIII.) do not belong to the symptomatology of lesions of the cerebellum. The nystagmus so often observed is probably not a direct cerebellar symptom, but is most frequently caused by action at a distance on the labyrinth such as is caused by tumours in the cerebellum; neither do the associated ocular paralyses (such as conjugate deviation, or paralysis of the associated lateral movements) properly belong to the symptomatology of the cerebellum.

**Negative symptoms.**—It is important to remember the absence of disorders of sensation and of alterations in the cutaneous and tendon reflexes in purely cerebellar lesions.

**Course of Wounds of the Cerebellum**

In general the symptoms caused by a wound of the cerebellum diminish regularly. The phenomenon of spontaneous deviation of the index only continues to be observable for a short time after the wound; the signs of asynergia and the hypermetria continue longer, but they finally appear only in certain movements, and the patient can make them cease altogether by keeping a watch on himself. The same is true of the disorders of the gait and equilibrium, which will only be observable when he makes an abrupt movement or a rapid half-turn.
The prognosis of wounds of the cerebellum, as seen at the base, is therefore favourable, and improvement appears to us in all cases to take place slowly but surely.

**Differential Diagnosis**

In the case of a direct wound of the cerebellar region the troubles observed are generally easily traceable to their cause. As a consequence of a wound of the vertex, it will be remembered that there will be observed spasmodic paraplegia of cortical origin together with troubles of co-ordination, which in most cases are due to the existence of serious alterations in deep sensation, and are of the ataxic type. There are much rarer cases in which modifications of the sensibility are not seen, but in which there are asynergic phenomena which will be detected in the way described above, and which probably arise from lesion of the cerebellum at a distance by "contre-coup." That essential organ, the labyrinth, is frequently injured in head-wounds, especially in the occipital region, and as the similarity of the symptoms makes the differential diagnosis particularly difficult, it will be useful to describe in detail the labyrinthine syndrome consecutive to wounds of the skull.

**The Labyrinthine Syndrome following Wounds of the Skull**

Lesion of the labyrinth may occur alone or with a lesion of the cerebellum. Injury to the labyrinth is shown by a group of symptoms which, in many points, resembles what is observed in cerebellar lesions, viz. kinetic and static troubles of the equilibrium.

*The wound.*—Lesions of the vestibular labyrinth may be consecutive to a wound of any part of the
WOUNDS OF THE CEREBELLUM

skull, either by labyrinthine concussion at a distance, or more probably by way of a fracture, often very minute, extending from a wound of the vault to the base. On the other hand, direct wounds near the auditory canal, and especially about the mastoid, are accompanied by lesions involving both the cochlear and vestibular labyrinths, and the patients suffer from labyrinthine deafness. Only lesions of the vestibular labyrinth will be dealt with here, as lesions of the cochlear labyrinth, which entail more or less marked deafness, are in the province of the aurist. It may be added that lesions of the two labyrinths are pretty often dissociated.

Symptoms of Lesion of the Vestibular Apparatus

Functional Symptoms.—These begin with vertigo of the most varied degrees of severity from mere obnubilation, provoked or increased by the movements of stooping, turning abruptly, or looking up in the air, up to fits of giddiness, in which the patient sees everything revolving around him, either towards the side of the wounded ear, or towards the opposite side; he sometimes falls, though he never loses consciousness. These almost constant vertiginous symptoms improve spontaneously, and do not last for more than a year.

Objective Symptoms.—Objective static troubles and disorders of locomotion are, in most cases, associated with the subjective sensation of vertigo, and it is most important to define them so as to distinguish them from their cerebellar analogues. Sometimes there is a slight swaying of the body when standing still and when walking, slight lateropulsion towards the side on which is the injured ear, and a broadening of the base of support. Frequently the patient, injured in one labyrinth only, walks en échelon;
when advancing towards a given point he swerves to one side after a few steps, which is repeated in the same direction again and again as he proceeds. Shutting the eyes causes an evident increase of the troubles of static equilibrium (the lateropulsion), which is not generally the case in a cerebellar subject. If the patient is blindfolded, and he is told to walk to a given point, he quickly loses direction, the angle of deviation being, to some extent, an index to the degree of his loss of the sense of direction (Babinski). Besides these symptoms, which can be ascertained by ordinary clinical methods, the condition of the vestibular labyrinth can be examined much more exactly by a series of tests which constitute the technique of the examination of the vestibular apparatus, and which every neurologist should be able to carry out and to interpret.

**Vestibular Tests.—**

*(a) Examination for spontaneous nystagmus.—* Vestibular nystagmus is made up of two movements of the eyeballs, one slow, and the other abrupt. The nystagmus is named according to the direction of the abrupt movement, i.e. left, if the abrupt movement is made towards the left. This nystagmus appears when the eyes look straight forward; if the patient looks towards the direction of the rapid movement the nystagmus is increased, but it will disappear almost completely if he looks in the opposite direction. To elicit the nystagmus, make the patient look fixedly at an object, at least a yard from him, as looking at too near an object diminishes the nystagmus. Irritative lesion of the labyrinth sets up a nystagmus directed towards the affected side, while a destructive lesion sets up a nystagmus directed towards the opposite side. This spontaneous nystagmus is not a lasting sign, and generally disappears within a few weeks after the labyrinthine lesion. Nevertheless, before proceeding
to the tests now to be described, it is essential to observe the presence or absence of nystagmus. It is to be remarked that in some cases a nystagmus of very short duration can be provoked by abrupt movements of the head; by rotation to the right or left, or by turning it backwards, etc.

(b) Rotary test.—The technique of this test, which is only of comparative value, has already been described in Chapter I., where the results in the normal condition were stated. If there is destruction or impairment of function of one labyrinth, the duration of nystagmus of both kinds will be diminished, but to a much greater degree on the affected side. The disorder of equilibrium will also be much less marked on the affected than on the healthy side.

(c) Barany’s caloric test.—The technique of this test has also been already described in Chapter I. When there is destruction of the vestibular apparatus, the caloric test, however long it may be continued, will not provoke reaction of any kind; if there is partial destruction, the reactions will be more or less diminished. Exaggeration of the reactions often occurs in syndromes of intra-cranial hypertension, and is frequently difficult to interpret. It must be understood that the terms exaggeration and diminution of the reactions are used only in reference to a comparison of the reactions of the affected ear with those of the sound one when tested under similar conditions. It must not be forgotten that unless the labyrinth remains excitable the reactional phenomena in the limbs, which have been described in connection with cerebellar semeiology (deviation of the index), will not be seen. The absence of deviation, of inclination of the body, and of nystagmus indicates destruction of the labyrinth, and prevents investigation of the cerebellar function.

(d) Babinski’s voltaic vertigo test.—The technique
of this test has been described in Chapter I. If the vestibular lesion is bilateral, the resistance to the voltaic current is exaggerated (15 to 20 milliamperes instead of 1 to 2), and there is a backward movement of the head instead of inclination and a rotation. If the lesion is unilateral, or predominant on one side, there will be unilateral inclination of the head to the side of the affected ear, whatever may be the direction of the current; more rarely the head is inclined towards the positive pole if it is on the affected side, but if the poles are changed over, the head will incline backwards. Other and less common changes have been observed. The rotation of the head in the voltaic test also undergoes modifications if the labyrinth is injured.

The modifications of the voltaic vertigo often bring to light very slight disturbances of the labyrinthine apparatus before the other tests described above have indicated any pathological change. During the application of this test the reactional movements of the limbs (index test), described in connection with the caloric test, and the lateral deviation of the body while walking, must likewise be observed.

It would occupy too much space to describe all the pathological modifications which may be observed in the course of this test, but they have been described in detail by Babinski and his pupils.

By this group of tests it is possible to ascertain exactly the condition of the vestibular labyrinth, and whether it is injured, even when there are no auditory disturbances, and also to distinguish the disorders which are due to the labyrinth from those which are due to the cerebellum in those which the patient presents. In fact, it is the only important differential diagnosis which can be made in cases of head-wounds presenting disturbances of co-ordination and of equilibrium.
CHAPTER X

ORGANIC LESIONS OF THE BRAIN BY CON-TUSION AND CONCUSSION WITHOUT FRACTURE OF THE SKULL

General observations.—When a projectile strikes the skull it produces a concussion of the brain by a more or less violent disturbance of the whole mass of the brain, and simultaneously contusion of the nervous tissue at the point struck. The relative importance of the concussion and the contusion varies according to the force of the missile and the resistance of the bone. If the force is high, or the resistance of the skull is very low, there will be fracture with penetration of the projectile or of splinters of bone, and a wound of the brain. This latter eventuality is the most frequent in actual war, and the symptoms are those of "wounds of the brain," which have been described in the preceding chapters. Still, cases are often met with in which there are persistent symptoms of damage to the brain as a result of an injury to the skull, although local examination of the skull and radiography both fail to give any indication of fracture. These casualties are due to cerebral contusion. Again, there are cases in which there has been no direct injury, but the patient has been caught within the area of the explosion of a shell of large calibre and, although not struck by any
of the splinters, presents persistent and indisputable signs of an organic lesion of the nerve centres, sometimes very serious. These casualties are due to cerebral concussion.

In the following description only simple and typical cases have been purposely selected; in fact, such pure cases are rather rare, as there is generally both contusion and concussion simultaneously in varying proportions.

**Cerebral Contusion**

**Symptoms**

The symptoms of cerebral contusion are similar to those of any local superficial lesion of the brain, and do not differ essentially from those of direct wounds of the brain. After a period of shock or concussion following immediately on the injury, which only persists for a few hours and then completely disappears, there will be observed a whole series of localising signs which vary according to the seat of the contusion, signs of an organic lesion entailing a hemiplegia, a monoplegia, aphasia, hemiopia, etc. As all these have been described in connection with the wounds of the various regions of the brain it is not necessary to repeat them, but there is one special form of cerebral contusion to which attention must be drawn, contusion by "contre-coup."

**Contusion by "contre-coup."**—In all the cases which we have observed there has been a wound of the head with fracture and more or less extensive loss of bone in the region struck by the missile. In these cases the wound, although direct, had not caused any symptoms of cerebral organic lesion, but there have been indisputable signs of lesion at a distance, often in a region at a considerable distance on the opposite side to the wound.
The following clinical varieties have been observed:—

(a) Wounds of the temporo-parietal region with hemiparesis or homolateral monoparesis.—In these cases there was a hemiplegia or a slight monoplegia, with somewhat marked disorder of sensation, alterations in the tendon reflexes, and crises of partial Jacksonian epilepsy, all on the same side as the cranial wound, and therefore connected with a lesion of the opposite hemisphere.

(b) Wounds of the vertex with spasmodic cortical paraplegia and inco-ordination of a cerebellar nature.—This variety has been described in Chapter IV. (Wounds of the Rolandic Area). They are probably cases of contusion of the cerebellum at a distance.

(c) Wounds of the frontal region with lesions of the fundus.—These complications of wounds of the frontal region have been dealt with in Chapter III. (Wounds of the Frontal Lobe). Besides lesions of the optic nerve by a fracture of the vault extending to the base, there are important lesions of the retina, radiating and irregular lacerations of the choroid and macula due to lesion of the eyeball by "contre-coup."

(d) Wounds of the occipital region with radicular symptoms.—In some cases of wounds of the occipital region there may be observed symptoms of irritation of the roots of the cervical nerves, shown by impaired movements of the upper limbs, especially marked on waking in the morning, a sensation of heaviness in the limbs, and of tingling or of numbness which the patient can provoke or increase at will by bending his head vigorously on his chest. In most cases there is tenderness on pressure over the cords of the brachial plexus, increase in the tendon reflexes, and paræsthesiae, while electrical examination gives normal results. These symptoms can be explained by contusion at a distance of the upper medullary roots at the moment of the occipital injury.
It is important to be aware of the existence of these symptoms of a lesion at a distance by "contre-coup" in cases of head-wounds, and not to consider that the troubles complained of by the wounded man are purely functional. It must also be noted that in cases of wounds of the right temporo-parietal region there may sometimes be observed symptoms of aphasia which, most probably, arise from lesion of the convolutions of the left hemisphere by "contre-coup."

It is not necessary to dwell upon the pathogenesis of contusion by "contre-coup," as it can be explained by Duret's theory that a cone of depression of the cerebro-spinal fluid is formed at the level of the region directly damaged by the projectile, and a compensatory cone of elevation in the opposite region.

**Cerebral Concussion**

**Symptoms**

The type selected for description here is cerebral concussion consecutive to the bursting of a large projectile near the patient, as frequently happens in actual war, with results the gravity of which have not hitherto been suspected. These are cases of very severe indirect injury without any contusion or wound of the brain; in other words, pure concussion.

**Immediate symptoms.**—They may be summarised thus: immediate loss of consciousness (not always present); complete muscular relaxation; relaxation of the sphincters; slowing of pulse and respiration; low arterial tension; dilated or contracted pupils; epistaxis. A careful examination for some organic lesion has shown some observers that during this period there may be increase and inequality of the tendon reflexes, abolition or diminution of the
cutaneous reflexes, and the plantar cutaneous extensor reflex.

As a rule all these apparently grave symptoms rapidly pass off in a few hours and leave no organic trace behind them. But in some cases the organic nerve lesions remain and become localised, so that, when the patient is examined some months after the injury, various syndromes that have attracted the attention of several neurologists may be found.

**Organic cerebral sequelæ of concussion.**—We cannot enumerate them all,¹ and shall only mention the sequelæ that are undoubtedly organic: spasmodic hemiplegia (Guillain, A. Léri); hemiplegia with hemianæsthesia, due probably to a lesion of the optic thalamus (A. Léri); Jacksonian epileptic crises (Guillain, A. Léri); the cerebellar syndrome (Guillain, Rist); hematobulbia (A. Léri); lesions of the internal ear (often unilateral) with labyrinthine deafness, the prognosis of which is always very doubtful; lesions of the eyeball, and especially of the retina. We have also observed completely analogous cases. All these patients presented lesions of varying nature, but the symptoms observed prove them to be indisputably organic.

We shall not go into the question of traumatic general paralysis from concussion. Without wishing absolutely to deny to traumatism any possible influence in the development of general paralysis, we can only say that in the fairly large number of cases that we have met with the part played by traumatism in the production of the symptoms has never been beyond dispute.

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Diagnosis

The first point is, not to overlook the existence of a direct wound of the brain, whether the loss of substance is very small and a very small missile has penetrated very far from its point of entry, or whether the injury has caused a fracture of the base of the skull; radiographs should therefore always be taken and carefully studied. On the other hand, purely functional nervous happenings of an emotional or hysterical nature, or simply simulations of them, are frequently observed after a shell-burst. In these cases there are neuropathic crises, paraplegia, tremors, bilateral deafness, deaf-mutism, and aphonia, these nervous phenomena being much more common than true organic conditions. It is impossible to describe the differential diagnosis in each of these cases in detail; it will suffice to say that generally a methodical neurological examination, and repeated observation of the patient, will nearly always enable those who are really suffering from concussion with organic lesions to be distinguished from the false cases. In cases of organic concussion lumbar puncture will show either hypertension of the fluid, or evident hyperalbuminosis. But the best proof of the functional nature of the troubles will be their rapid improvement and cure under proper treatment.

Pathogenesis

Only the macroscopic lesions actually observed in the course of the present war are dealt with here, although before the war numerous researches had been carried out on the microscopic lesions observed in experimental concussion.

The existence of disseminated hæmorrhages in the meninges, in the cerebral cortex, and even in the
depth of the brain has been ascertained, and much more rarely there have been cases of disseminated foci of softening without haemorrhage.

In the cases of pure concussion which have been selected as types for description (concussion resulting from the explosion of a large projectile), certain authors are of opinion that the gases violently compressed by the explosion ("wind of the explosion") act like a solid projectile on the skull and brain. Others compare these organic accidents consecutive to concussion to the symptoms due to too rapid decompression in "caisson-sickness" (release of the gases of the blood, and gaseous emboli with rupture of the capillaries and haemorrhages). They consider that the decompression of the atmosphere which is produced after the explosion of a large projectile acts on the nervous centres in the same way.

Probably each of these theories contains a part of the truth, and the pathogenesis of nervous lesions due to concussion is not susceptible of a single explanation.

In conclusion, it may be noted that cases of concussion of the spine with organic lesions are much more numerous than those of concussion with cerebral changes.
Complications of Wounds of the Brain

CHAPTER XI

MENINGITIS

We shall not deal with the acute meningitis which is observed for a few days after the wound, but shall consider the meningitis that occurs later: this may occur in various forms.

SYMPTOMS

There is a slight but persistent suppuration about the scar in the scalp, and a radiograph shows the presence of splinters in the immediate neighbourhood of the wound and at a considerable distance below it; the wound continues to suppurate for several weeks, and the infection extends insidiously to the meninges.

CLINICAL FORMS

Encysted meningitis.—In some cases there is not at first a diffuse meningitis. The wound being several months old has produced adhesions between the dura mater, the pia mater, and the superficial soft parts; the damaged area is limited, and an encysted meningitis occurs on the convexity of the hemisphere; all degrees may be observed from encysted serous

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meningitis to a suppurative meningitis constituting a true dural abscess. Local symptoms of irritation are observed, with signs of compression indicated by a moderate increase in the intra-cranial tension. In this variety very careful surgical intervention may yield the best results.

Diffuse meningitis over the convexity and at the base.—This form may follow on after the one just described, but it more usually appears independently, and may come on several months after the wound. The point of entry of the infection may be at the level of the nearly healed wound. It seems, however, that in these varieties of diffuse meningitis the point of entry of the infection should rather be looked for along a fracture of the base which has involved the middle ear or the frontal sinus. This is the classic form of meningitis consecutive to fractures of the base of the skull. It is not necessary to describe in detail the clinical picture of acute diffuse meningitis, as it has no features specially connected with wounds of the brain. But special emphasis must be laid upon the importance of lumbar puncture in the diagnosis, and also as the only means of relieving a patient whom there is but little hope of curing.

Ventricular meningitis.—This somewhat special form is by no means uncommon in wounds of the brain. It may be even said to be the form peculiar to them. It is the culmination, or the almost certainly fatal complication, of abscesses of the brain which have not been operated upon, but it may be seen apparently as a primary affection. It begins with extremely violent headache accompanied by vomiting. The phenomena of excitement observed in meningitis over the convexity are but slightly marked, and the patient very quickly becomes drowsy, and soon afterwards comatose. The modifications of the respiratory and cardiac rhythm are often very marked, and visual
troubles, such as diminution of the visual acuity and optic neuritis, are common. Somewhat intense glycosuria is not uncommon. The temperature rises rapidly, almost without matutinal remission, and the patient survives only a very short time.

In the cases we have observed there was a very small abscess situated near the wall of the ventricle which had given rise to no appreciable symptoms. Either by contiguity or by rupture of the abscess the infection had entered the ventricle, and there was a thick purulent layer attached to the ependyma of the ventricles, more especially the fourth. It is important to be acquainted with this form of meningitis on account of the extreme seriousness of the prognosis and its very rapid development.

The treatment of this delayed form of meningitis calls for no particular remark. In the encysted form surgical intervention is indicated, and may be useful. In the form of meningitis complicating an abscess of the brain which has been diagnosed and localised, surgical treatment of the abscess should be carried out even if lumbar puncture yields a turbid fluid. In meningitis of the ventricles we believe that all treatment is powerless, but lumbar puncture, carefully employed, may relieve the patient.
CHAPTER XII

ABSCESS OF THE BRAIN

Causes

It is the custom to say that any wound of the skull, or even of the scalp, may be the starting point of a cerebral abscess. In actual fact the more or less penetrating and irregular wounds of the skull, which go on suppurating for a long time, are the most common cause of abscesses. It is the small and irregular fractures, much more than the large losses of substance, which get complicated with cerebral abscess. Such fractures are accompanied by little splinters which penetrate more or less deeply into the brain. It is not so much the splinters, nor even the missile, which are chiefly to blame for the formation of an abscess, but the shreds of clothing and hairs carried in by the projectile. The wound often cicatrices very rapidly; the importance of the cerebral lesion is not recognised, and it is thought to be surgically cured.

The abscess develops either very superficially immediately under the bone defect, or else very deeply in the white matter of the hemisphere. In the former case it is most frequently, but not always, an acute abscess; in the second, the abscess develops slowly, a long time after the receipt of the wound.
Symptomatology

I. Acute Superficial Abscess

It is not necessary to dwell at any length on this variety, which is generally observed during the first few weeks after the injury, and is generally superficial, rapid in development, and in the immediate vicinity of the wound.

The symptoms directly due to the abscess are generally masked by the clinical phenomena arising from the head injury, which is itself often complicated by a diffuse meningitis developing at the same time as the abscess. This is especially the case when the abscess develops within a fortnight after the injury.

As a rule the abscess, even when acute, hardly develops before the end of the second or third week, and if the symptoms directly due to the wound have improved, the onset of suppuration shows itself by a group of meningeal symptoms, such as severe headache, pyrexia, vomiting, vertigo, delirium, or prostration, exactly like that at the onset of diffuse meningitis, but distinguishable from it by certain peculiarities, such as the absence of rigidity or Kernig’s sign, the absence of cutaneous hyperæsthesia, a comparatively low temperature, and a slow pulse. The localising signs, however, generally appear rapidly, and become the most prominent, especially if the abscess is forming about the rolандic area. This accentuation of the localising symptoms proceeds somewhat slowly, and often with intervals of remission.

If there is no intervention the general signs become accentuated, as well as the symptoms of increased intra-eranial tension and diffuse meningitis, which foretell a quickly fatal result. This alternation of meningeal and local symptoms and their compara-
Area of encephalitis at the apex of the right occipital lobe after a bullet-wound. Complete left homonymous lateral hemiopia.

Area of encephalitis on the right parietal lobe extending up to the ventricle, simulating a cerebral abscess.
tively slow development sometimes allow the surgeon to make a correct diagnosis, and to appreciate the fact that the case is not merely one of generalised meningitis, and so enable him to intervene in time and open and drain the abscess.

It is, however, the chronic abscess which has the greatest interest for the neurologist.

II. DEEP CHRONIC ABSCESS

The general symptoms become evident after the wound has been cicatrised for several weeks or months, and when the local symptoms due to lesion of the brain have completely disappeared or become stationary. There is first a modification of the general health, shown by emaciation; loss of appetite; slowness of digestion; constipation; disordered condition of the digestive tract; more or less pronounced pallor of the skin and mucous membranes; cold sweats, sometimes accompanied by shivering; and, finally, an occasional slight rise of temperature (a few tenths of a degree only); this, however, is by no means always so, and in the majority of cases there seems to be a tendency for the temperature to be subnormal. Cerebral symptoms due to increased intra-cranial pressure make their appearance simultaneously with these general symptoms. Headache is nearly always present, but its intensity varies greatly; often very slight and periodical during the period of latency, it may become extremely severe when the abscess reaches a certain size, coming on in regular paroxysms, and provoked by anything which increases the vascular pressure in the brain, such as coughing, sneezing, or stooping. As a rule it is generalised, but its maximum intensity is on the same side as the injured hemisphere, and the patient complains of feeling as if his head were bursting or
being crushed. It is quite different from the neuralgic type of headache described above in connection with wounds of the skull without symptoms of cerebral organic lesions. Nothing relieves it, but it seems to become milder as the case develops, and the patient becomes drowsy and dull before the onset of coma. It is not necessary to dwell on the vomiting, the sensations of vertigo, the slowing, and sometimes irregularity, of the pulse, which persists even where there is pyrexia.

Papillary stasis is a very important symptom of increased intra-cranial pressure which may be found in these cases, but not so regularly as in cerebral tumours; it only occurs with very large abscesses which develop extremely slowly, and at an advanced stage.

Psychic troubles, with the exception of aphasia, are nearly always found at some period. The patient cannot follow a conversation, and replies slowly and distractedly as if just waking from a dream; his mental operations are performed extremely slowly, and are accompanied by a sensation of great fatigue; soon the patient passes into a condition of permanent drowsiness, so that he has to be shaken in order to elicit vague replies to the questions put to him, and this drowsiness becomes a continual sleep or true coma towards the end of the illness. Excitement and incoherence in language and gesture are seldom seen except at the beginning of the case. Convulsions are comparatively rare, but they may be observed in the final stages, especially if the abscess bursts on the convexity of the brain or into the ventricles.

In addition to these general symptoms there are localising signs, which vary greatly according to the seat of the abscess, and which it is not necessary to recapitulate, but which sometimes do not appear
Two abscesses on the left temporal lobe consecutive to a supra-mastoid wound; considerable œdema of the whole hemisphere. Syndrome of intracranial hypertension such as is observed in cerebral tumour.

PLATE II.
ABSCESS OF THE BRAIN

at all. These signs may become evident even when the injury may have shown no sign of cerebral lesion, or in spite of any such signs having entirely disappeared. For instance, a patient with a hemiplegia from a wound in the Rolandic area which has left only trifling sequelæ may develop symptoms of a progressive and rapidly increasing hemiplegia or monoplegia; or to the stationary original symptoms there may be added new symptoms, such as sensory disturbances, hemiopia, etc.

There is one very important symptom pointing to the formation of a cerebral abscess which may be found when the abscess is in the occipital lobe if the field of vision has been thoroughly examined. If the patient presented a hemiopic scotoma, or a quadrantic hemiopia before the formation of the abscess, there will be a rapid aggravation of these symptoms, and a complete hemiopia will take the place of the scotoma.

Clinical forms.—We desire to call special attention to two clinical forms of cerebral abscess observed by us which seem to be somewhat opposed in their manner of development. The abscess may develop like a cerebral tumour, without any modification of temperature, or only with signs of slowly progressive increase of intra-cranial tension; persistent headache, vomiting, and marked papillary stasis, accompanied by rapid diminution of visual acuity, culminating in almost total blindness. Plate II. shows a brain with an abscess of this variety.

In another case the patient, who had been apparently well for several months, developed symptoms of acute ventricular hypertension, with pyrexia, retraction of the neck, Kernig’s sign, rapid diminution of the visual acuity without papillary stasis, and rapidly died. In this case there was a small abscess very deeply seated near the ventricle
which had caused intense ventricular meningitis. These two cases are given to show how difficult the diagnosis of a chronic abscess in the brain may be in certain cases.

**Differential Diagnosis**

The practical question to be decided is whether there shall be surgical intervention or not, therefore it is essential to make quite sure whether there is a generalised meningitis or a focus of encephalitis or an abscess. In the first case, intervention is nearly always useless; in the second case (chronic encephalitis), it is fatal; and it is only in the third that immediate operation is justified.

(a) A differential diagnosis between an abscess and meningitis is seldom called for except in the case of the early superficial abscess of acute development; if the wound is several months old it is no longer a question of a differential diagnosis, but of a diagnosis of complications, e.g. whether the abscess is complicated by generalised meningitis. If that is the case, the pyrexia, the rapid pulse, and the replacing of localising symptoms by those of meningeal irritation, together with the results of lumbar puncture, will clear up the diagnosis.

(b) Besides generalised meningitis, an abscess has to be distinguished from certain other less common cerebral lesions, such as traumatic apoplexy, and especially hæmatoma of the dura mater consecutive to a wound. This generally becomes evident during the first few hours after the injury, but there is a variety known as late traumatic apoplexy, which may not appear till several weeks after the wound. The seat of this is fairly characteristic, as it manifests itself by signs of localised lesions of the pons and medulla, and therefore by quadriplegia, dysphagia,
dysarthria, and pretty often by a homolateral hemiplegia. Its course is fatal, and often very rapid.

(c) The last question is whether it is possible to mistake a traumatic abscess of the brain for a purely functional group of symptoms such as those we have described at the beginning of this work. It does not seem possible; the only common symptom is the headache, but the characters of the headaches in the two cases, as well as the organic symptoms accompanying a cerebral abscess, have been so fully described, that there should be no possible doubt in the matter.
CHAPTER XIII

EPILEPSY

Epilepsy from a Wound of the Brain

Epilepsy is neither a constant, nor even a very common, complication of wounds of the skull. The statistics of the cases we have examined show about 8 per cent. of such cases.

True epileptic fits may occur as a sequel to cerebral concussion, without any wound of the skull. Such an occurrence is rare, but it is important to remember.

It generally comes on six to eight months, but sometimes eighteen months or two years, after the wound, which may be entirely cicatrised by that time; in some cases, however, it is observed soon after the injury, or at the time of a surgical operation, such as trephining, performed several months later. The attacks may assume the form of the classical grand mal or any of the varieties of petit mal.

No correlation has been observed between the seat of the wound and the appearance of epileptic attacks; not only wounds of the frontal or rolandic areas (the latter, however, more often give rise to Jacksonian epilepsy, or to true epilepsy beginning as the Jacksonian variety), but also occipital, and even cerebellar, wounds may cause them. Neither has there been observed any peculiarity in the objective characters of the wound, nor the presence of foreign bodies in
the brain, which will explain the appearance of these attacks. Whether there is loss of the substance of the external table only, or a depressed fracture of the inner table, or a deep or a very large wound, the attacks may come on and be of the same type as a generalised fit. It is therefore impossible to say exactly why certain wounds of the skull and brain are accompanied by epileptic fits after an interval of a few months. It is very probable that there is encephalitis with meningeal adhesions, but this is usually found in all the cases of wounds of the brain verified by a post-mortem.

We wish to lay stress on the fact that, in the seventy-five cases in which there was a projectile retained in the skull and which came under our notice, there was no case of epileptiform fits. On the other hand, we have made necropsies on three patients who were the subject of traumatic epilepsy, in which we found areas of encephalitis but no retained foreign body. Similarly, in the numerous radiographs of cases of traumatic epilepsy that we have had taken we have never found a retained projectile in the brain.

The fits come on at varying intervals, once a month or every two or three months. As a rule the intervals are fairly long; but the cases have not yet been long enough under observation for an opinion to be formed as to the course of this complication, and it is impossible to say definitely whether there is a spontaneous tendency to extension of the intervals between the fits, and whether they will finally disappear. It must also be remarked that treatment by bromides does not appear to modify them much.

Surgical treatment does not appear to give any permanent results. In some cases it seemed that the presence of splinters imbedded in the dura mater might have had an important influence in precipi-
tating the fits; after operation we have seen the intervals between the fits (which had been very short—several a week) get manifestly longer, but the fits have not disappeared altogether.

As a military doctor is often called upon to decide whether the fits from which a patient suffers are neuropathic or really epileptic, it will be useful to recapitulate briefly the characters of grand mal as well as the principal aspects of petit mal.

**The Epileptic Fit**

_Prodromata._—The aura is the first symptom of the fit, and is extremely common. Several varieties are distinguished— the sensory aura: a visual, auditory, gustatory, or olfactory hallucination; the sensitive aura: a sensation of cold or burning in some part of the body, precordial pain, headache, epigastric heat, etc.; the motor aura: tremor of one member or paresis, muscular cramps; the vasomotor and secretory aura, and the psychic aura. The aura lasts a few seconds, and is immediately followed by the convulsive stage.

_The convulsive stage._—The patient emits a scream or cry, and immediately collapses on the ground unconscious and helpless; the skin is pale, and the tonic spasms immediately appear. The features are drawn, the head is turned backwards, the eyes are wide open, the pupils dilate and do not react to light, the jaws are clenched, the arms are rigid, the fists are clenched, the lower limbs are extended, and the respiration is arrested. This tonic stage lasts a few seconds, at the most half a minute. Then comes the clonic stage. The pallor of the integuments is succeeded by a more and more marked cyanosis, prolonged rapid and irregular contractions occur in all the muscles, the tongue is protruded between the teeth
and often bitten, the breathing is irregular and laborious; the patient, still unconscious, becomes stertorous, and a more or less abundant and often reddish froth comes from the mouth. The countenance is swelled, and becomes increasingly purple, and the veins of the neck dilate. There is frequently an involuntary emission of urine and faeces. Then after a varying period the spasms become less frequent and less violent, and become localised in certain groups of muscles; the breathing becomes more regular, deep and full, the cyanosis abates, and the skin becomes paler, and is covered with an abundant sweat. Finally the spasms cease, and the patient falls into a profound sleep, with complete muscular relaxation, and snores. The patient remains totally unconscious throughout the fit. On waking he is exhausted, depressed, and bewildered, answers slowly and with difficulty, and presents signs of sensory or muscular exhaustion amounting to paresis of certain groups of muscles, and there may be observed areflexia or exaltation of the tendon reflexes, with or without Babinski’s sign.

"Petit Mal"

The most usual form is epileptic vertigo. After, or without, a short aura the patient turns pale, his gaze becomes fixed, his respiration stops, he abruptly becomes immobile, and allows anything he may be holding to fall out of his hand, and makes some spasmodic movements. Then in a few seconds his breathing returns, his eyes turn to right and left, he continues his conversation where he left off, and resumes his occupation; he remembers absolutely nothing, but feels uneasy, or evinces a desire to sleep. Besides this typical form of petit mal, the most varied forms may be seen, and of the slightest character, such as a mere suggestion of the aura and nothing
more, vertigo, a sudden and brief sensation of oppression, headache of a mild form, various vasomotor troubles, passing dimness of the sight, etc. It is important to know these very mild forms of epilepsy, and to refer them to their true cause.

The Status Epilepticus

It sometimes happens that wounded men who are to all appearances cured suddenly pass into a true status epilepticus, consisting of fits of general epilepsy supervening on a state of apparently perfect health, or preceded only by twenty-four or forty-eight hours of persistent headache. The fits recur at intervals of a few minutes; the patient becomes comatose, bathed in sweat, and with marked pyrexia. The reflexes are exaggerated, and there is often bilateral extension of the toe. Death supervenes in twenty-four to forty-eight hours in spite of treatment. In the three cases we have seen, lumbar puncture showed moderate lymphocytosis with hyperalbuminosis. It is very important to know this form of epilepsy supervening on wounds of the brain which are apparently cured. It may lead to an erroneous diagnosis of diffuse meningitis or of abscess of the brain, and the medical man may be tempted to have recourse to surgical intervention. In all cases which have come under our observation, and in which there has been a post-mortem examination, there has been a focus of traumatic non-suppurative encephalitis, the focus corresponding in area to the whole extent of the loss of bone, and extending in depth to the ventricle. There was neither meningitis nor localised suppuration, and surgical intervention would have been perfectly useless.
**Diagnosis**

The question always arises when a patient says that he has fits whether they are true epileptic or purely neuropathic fits, and sometimes the only possible way to answer it satisfactorily is by personal observation of a fit, as interrogation of the patient will only yield the elements of a diagnosis of probability.

The true epileptic fit has the following essential characteristics: The aura, then unconsciousness throughout the fit, biting the tongue, involuntary emission of urine, a very short duration of the fit itself, which is followed by sleep.

The purely neuropathic fit, on the contrary, is of long duration. The patient cries out, rolls on the ground, speaks, sees the people surrounding him and speaks to them; he frequently remembers the fit, and when it is over he recovers much more quickly.

The picture of the neuropathic fit is much more dramatic than that of true epilepsy. But in spite of these points of distinction it will often be difficult to make a definite diagnosis, and the only sure guide is the observation of a fit by the medical man.

The numerous varieties of petit mal are often very difficult to identify, as patients suffering from wounds of the skull very often complain of subjective troubles, such as headache, giddiness and vertigo, which also occur in the slight forms of petit mal, and in such cases a correct diagnosis can only be made by prolonged observation of the patient.

**Jacksonian Epilepsy**

Jacksonian epilepsy is frequently, but not always, observed in connection with wounds of the rolandic
area. The conditions under which the phenomena appear are the same as in true general epilepsy, and the same patient may have a Jacksonian convulsion which ends in a general epileptic fit with loss of consciousness; or general epileptic fits may succeed the Jacksonian ones, or may alternate with them. There is every intermediate degree between the pure Jacksonian attacks and pure epilepsy.

**Symptoms.**—The attack consists essentially of involuntary clonic spasms limited to certain definite muscular groups which generally come on without an aura or an initial cry, the patient remaining perfectly conscious of what is going on. The distribution of the muscular spasms is more or less limited, their duration is very variable, and their extension is more or less great. They may be strictly localised or may extend progressively, but in each patient they always start in the same group of muscles, and always develop in an order determined by the anatomical arrangement of the motor centres of the cortex. For instance, if the spasms begin in the face, they will spread immediately to the upper limb and then to the lower limb on the same side; if they begin in the upper limb, they will spread simultaneously to the face and to the lower limb on the same side, etc., finally spreading to the other side of the body. This, however, is merely the general rule; the spasms may remain strictly confined to the groups of muscles in which they began.

The clonic spasms rapidly increase in intensity and end in a tonic stage of very short duration, and then the clonic spasms reappear. The fits may be repeated at very short intervals, and their duration is very variable; they are generally almost identical in development. The patient does not lose consciousness in pure Jacksonian epilepsy. There is one very interesting fact which it is important for both the
patient and the medical man to know: the fits are independent of the will, and cannot be voluntarily arrested; but if, as soon as the first spasms appear, the patient or the doctor firmly presses that part of the limb in which the first spasms appear (the forearm, or toes, etc.), the convulsion may be completely aborted.

Sequelæ.—If the fit has been severe it is frequently followed by a paresis of the muscles affected by the spasms, with alterations in the reflexes, and this lasts for some minutes or hours. If the Jacksonian convulsion occurs in muscles already paralysed, it will be followed by an increase in the paralytic phenomena.

Sensory Jacksonian epilepsy.—Besides the pure motor form of Jacksonian epilepsy there is another which has been described as sensory Jacksonian epilepsy. The patient feels a sensation of tingling or numbness in the extremity of a limb, and this may increase to complete anaesthesia, and may extend to the root of the limb and involve the rest of that half of the body, the attack lasting for some minutes. Various modifications of sensation in this part of the body may occur for some hours after the attack.

Differential Diagnosis

There can be no hesitation with regard to the pure Jacksonian epilepsy, but in patients with wounds of the brain certain special spasmodic phenomena may be observed which must, we think, be distinguished from Jacksonian epilepsy. These are the myoclonic or pseudo-myoclonic fits seen in those with wounds of the rolandic area. These myoclonic, or apparently myoclonic, spasms occur in the muscles of the limbs on the side which has been previously paralysed. They are exaggerated or provoked by the
patient putting the affected limb in a state of muscular tension by stretching the arm or leg, for instance, and they persist as long as the attitude is maintained. They occur irregularly in certain groups of muscles, and are strong enough to cause slight movements of the limb. The spasms are increased if the muscles are percussed with the pessor. The pathogenesis of this phenomenon is very obscure. It is possible that the spasms may be due to irritation of the cortex in the region of the wound, and are therefore nearly akin to true Jacksonian epilepsy. There is a somewhat rare form of epilepsy called myoclonic epilepsy, in which the true epileptic fits alternate with periods of persistent and generalised myoclonic spasm.
CHAPTER XIV

FOREIGN BODIES IN THE BRAIN

There may be fragments of the cap, the scalp, the skull, or the missile carried into the brain. The two former are not visible, as they cannot be shown by radiography, but they are, in our opinion, the most important, because they carry infection. The bone fragments come from the whole thickness of the skull when the wounds are penetrating; if they are
tangential, the external table may be almost intact, while the internal table is split into minute fragments which are often carried far into the substance of the brain. These splinters are of all shapes and sizes, and are often only perceived by the aid of a radiograph (and it must be a very good radiograph too).

Out of about 3000 head cases we have found missiles in the brain in 75. In the cases in which the injury was at least several weeks old the skin wound in the great majority had been healed for some time.

The missiles that have come under our notice have been almost exclusively shell- or grenade-fragments
FOREIGN BODIES IN THE BRAIN 211

of varying size and dimensions, some of them measur-

ing on the radiographic plate as much as an inch in diameter. In the 75 cases alluded to above there

Fig. 40.

Figs. 39 and 40.—Radiograph of the skull (full face and profile), showing the loss of bone, with numerous splinters (shaded) in the depth of the left occipital lobe and almost in the right occipital lobe (Author's case).
were only six shrapnel balls and three or four rifle or machine-gun bullets.

In the majority of the cases the projectile, whatever had been its point of entry, was situated in an area that could be marked out in a lateral view of the skull by a vertical line drawn upwards from the external auditory meatus, and a horizontal one joining the latter orifice to the external occipital protuberance.

The foreign body was situated either entirely in the white matter or, fairly frequently, in the median vertical plane close to the falx cerebri, which, in a certain number of cases, seemed to have arrested its progress.

In a large number of cases the diagnosis of a projectile in the interior of the brain was arrived at owing to a want of correspondence between the seat of the opening in the skull and certain localising cerebral symptoms, such, for instance, as a complete hemiplegia of the capsular type coinciding with a wound in the frontal region (fig. 12), or perhaps a hemiopia occurring after a wound of the vertex (Chapter VIII.).

But it is very important to note that in all these patients the symptoms are those actually due to the mechanical damage done by the missile as it passes through the brain matter. Therefore, if the former in its course, which is often a long one, has given rise to symptoms referable to the division of certain groups of fibres, it must not be supposed that these symptoms are in any way related to the prolonged sojourn of the body in the brain substance, nor that it is a question of complications due to its presence there.

All the cases that have come under our notice went about without experiencing the least inconvenience from the presence of the projectile within their brains, so much so that they were quite ignorant of the fact that they had such a condition.

Without the aid of radiography it would have been
impossible to discover the existence of the foreign body. We may here recall attention to the fact that one can only judge of the position of the latter by making use of two radiographs, one antero-posterior and the other lateral. Without this assistance there is always the danger of mistaking for an intra-cerebral projectile one lodged in the thickness of the skull or situated beneath the orbit, or in one of the bony sinuses.

This being so, we are of opinion that, *given the absence of any infection*, an intra-cerebral projectile does not, *per se*, cause any risk to the patient. Therefore we cannot admit the principle that every foreign body in the brain should be removed, in face of the abundant evidence of the innocuousness of non-septic foreign bodies. Even the most careful surgical intervention has led to disasters in several cases in which the projectile had remained absolutely quiet and inoffensive. In any event, operation, by dividing fresh nerve fibres, adds to the damage already existing, and is likely to add to the patient's troubles.

We are of opinion that, in the case of a foreign body in the brain, no surgical interference is required unless this should be called for by some special symptom pointing to infection.

There will always be time to do this if a minute examination of the neurological condition of the patient is frequently carried out. We would go further and say that the presence of a foreign body renders the search for an abscess, should one arise, much more easy, thanks to radiography, and thus avoids damage likely to be caused by blindly groping about for it without the direction that its presence affords.
PART II

WOUNDS OF THE SKULL

BY T. DE MARTEL
CHAPTER I

GENERAL CONSIDERATIONS

Frequency of head-wounds.—Wounds of the skull are common in the present war, as the head is often the only part exposed by men who take the best cover possible, but are obliged to keep an occasional look-out. These wounds are caused by projectiles often travelling at enormous speeds, are sometimes accompanied by a widespread damage, and are often immediately fatal.

Among those who survive, many are hit in the silent areas of the brain, and show few symptoms when the phenomena of shock have disappeared. Others, on the contrary, are struck in the essential functional areas, and often remain permanent invalids, even when they have escaped the various complications which are liable to carry them off.

In view of the frequency of wounds of the skull, everything possible should be done to diminish their number and gravity.

From the beginning of the war the men attempted to protect their heads from the showers of shrapnel with their trenching tool or a pot. Since the adoption of the trench-helmet the number of head-wounds has certainly decreased. The helmet often stops partially spent bullets or shrapnel, it always diminishes the velocity and lessens the penetrating power of missiles,
WOUNDS OF THE SKULL

and it does away with the presence of fragments of the cap in the wound, which is a great source of infection.

The men must cut the hair very short in order to avoid contamination of the wound with long hairs, and to facilitate the shaving and cleansing of the scalp if it becomes wounded. The preparation of the field of operation should be carried out most carefully and as early as possible. It should be done at the aid-post, as it is of the greatest value. A wound in a dirty scalp, covered with long hair and filth, will certainly become infected secondarily, even if it is not infected from the first. Proust, who has been at the front since the beginning of the war, and has therefore been able to make a number of useful observations, attaches the greatest importance to this early toilet of the wounded area. The head should be gone over with the clippers, working always from the wound outwards so as to carry the clippings as far away from it as possible; it is then washed with soap and shaved, and afterwards treated with ether, alcohol, and with double-strength tincture of iodine. Finally a dry dressing should be most carefully applied so as to avoid any fresh contamination during the transport of the patient.

Transport of the wounded.—The wounded man should be transported as gently as possible to where he can be operated upon and admitted to hospital. As I shall explain later, the necessity for operation in head-wounds is generally not urgent, and those who consider it necessary to operate on a skull as one would operate on an abdomen are, I think, mistaken. If the abdomen, like the skull, contained only solid organs instead of containing hollow ones full of septic material, both might be treated alike. The only imperatively urgent surgery is that of the digestive tract and the circulatory apparatus. In-
juries of the bowels or heart or important vessels would justify the presence of ambulances and surgeons not ten miles, but half a mile from the firing line. Men with wounds of the brain will all gain by being transferred directly to a hospital where they can be installed once for all and remain for many months, provided always that the transfer does not mean a journey to a long distance during which the patient does not receive the necessary care and attention. This applies especially to men with wounds of the brain; in them it is important that the surgeon who performs the operation should follow up the case for a long time. If this had always been the practice, many surgeons who say that military cranial surgery yields comparatively good results would form an exactly contrary opinion. If they had followed their cases they would have seen that many of their patients who had, to all appearance, been cured for some weeks, subsequently died. It is only necessary to read the report of the medical conference of the 4th Army on the 18th June 1915 (Presse médicale, 1st July 1915) to be convinced of what I say, and it does not appear that very early operations performed at the front have, under the circumstances, been very successful, nor protected the patients from later complications.

Varieties of head-wounds.—Wounds of the skull by projectiles may be classified as follows:—

1. Tangential wounds in which the missile has grazed the skull, leaving a mere depression in the bone; sometimes, however, the internal table is broken into numerous fragments and the dura mater is injured. With these wounds may be classed those in which an almost spent missile has struck the skull and produced a depression of the external table, with, perhaps, a corresponding fracture of the internal table.
FIG. 1.—The projectile, generally a bullet, has followed a course tangential to the skull and has made a furrow in its thickness. The internal table is probably broken. This wound is the type of those which must be treated with the gouge-forceps. They often do very well.

FIG. 2.—The projectile has penetrated the skull and passed out again, almost immediately, following the arc of a small circle. In these cases the brain and the dura mater are necessarily injured over a large area, but the cerebral lesions are not very deep, and the detached fragments of bone are never projected very far into the interior of the brain. These wounds are often cured if well treated.
FIG. 3.—Here the projectile has struck the skull at right angles without penetrating it; both tables are broken, and the splinters of the internal table have probably been driven very far into the interior of the brain not far from the ventricle. These wounds, which are not very shattering, are amongst the most serious. This wound may be treated by a large osteoplastic flap.

FIG. 4.—The skull has been traversed from side to side. On the side of the orifice of exit there are no cerebral splinters, these having been projected outwards. The orifice of entry is often small. These wounds, if they are not fatal at once, often do well.
FIG. 5.—The skull has been driven in by a piece of shell of low velocity, and resembles the large injuries of civil practice. It is not uncommon to have to treat such fractures after the wrecking of shelters or explosions of mines.

FIG. 6.—In this case the skull and brain had been ploughed up by a shell-fragment for a long distance and to a great depth. There was blindness due to lesion of both occipital lobes. He finally died of meningo-encephalitis.
2. Wounds in which the missile has penetrated the skull and passed out again almost immediately, describing an arc of a small circle. In these wounds the brain and the dura mater are necessarily injured over a fairly large surface, but the cerebral lesions are not very deep, and the detached fragments of bone are never driven very far into the interior of the brain.

3. Non-penetrating wounds.—In these cases both tables of the skull are broken, and the fragments of the internal table are often driven very deep into the brain not far from the ventricle, which, even if it is not opened at once, may be injured in the course of the operation. These cases are particularly serious.

4. Penetrating wounds.—This type is identical with the previous one, except that in this the projectile has penetrated the skull, and then often lies at a deeper level than the splinters which it has driven in.

5. Perforating wounds.—These are cases in which the skull is traversed from side to side by a bullet. The orifice of entry is generally small, and the splinters are also small. If death is not immediate, these wounds often do well without operation.

6. Cases in which the skull is driven in by a large missile, such as the base of a shell travelling at a low velocity; they are marked by fractures of the skull resembling those seen in civil practice.

7. Cases in which the skull and brain are ploughed up widely and deeply by a large piece of a shell which cuts a broad longitudinal or transverse fissure.

This classification is only a rough one. Numbers have multiple wounds of the head of varying gravity and aspect, and others have wounds in other parts of the body which give rise to fresh difficulties in the treatment of the wound of the skull. The treatment will differ according to the variety of the wound.
It will be evident that the same methods of operation cannot be applied to a broad superficial wound of the skull and brain by a shell-fragment as to a deep and narrow penetrating bullet-wound. In the following pages I shall point out the procedure which appears to be most applicable to each particular case.

**Importance of a careful examination before operation.**—This is the only means of estimating the gravity of a case and of its subsequent improvement.

A patient with a head-wound must always be carefully examined. When the patient is comatose this can be done very rapidly, but in other cases it must be carried out most minutely. For this examination the reader should refer to Part I. of this volume written by Dr Chatelin.

It is obviously of interest to distinguish the phenomena due to shock, which disappear spontaneously more or less quickly if the patient does not die, from those connected with increase of intra-cranial tension, which continue to increase after receipt of the injury. These latter symptoms are improved by trephining, but a similar result can be attained equally well by lumbar puncture. Further on we shall see that one ought not to try to reduce the intra-cranial pressure in the early stages, for the increase of pressure luckily opposes extension of the meningitic phenomena that always exist at the level of injury when the wound is a penetrating one. It is also of interest to ascertain, by examining for motor, sensitive, and sensory troubles, to what extent the cerebrum and the cerebellum have been injured, and to what extent a complete cure of the patient may be hoped for. This examination is unfortunately seldom carried out because of its difficulty and length, which make it almost impossible when there is a great rush of wounded. When it can be carried out, it allows the
surgeon: first, to form an opinion as to the extent of the cerebral lesions, although the bulk of the symptoms may disappear and may be due merely to concussion and cerebral oedema; second, to make out how far the patient’s condition is ameliorated or aggravated after the operation, and to draw from it inferences which may be useful.

An outline of the anatomy of the skull and its contents from which deductions may be drawn that will prevent the surgeon from adopting unsuitable measures.

The skull, the brain, and its dura materal covering (which is the only one of the meninges that really
matters from a surgical point of view) can be roughly represented as follows:—

1. The skull is a rigid shell continuous with the vertebral canal and formed of two laminae, the outer and more tenacious called the external table, and the inner and more fragile called the internal or vitreous table.

2. The brain is a hollow vesicle with a very thick wall continuous with the spinal cord, which is likewise hollow. The irregular cavity in the brain forms the ventricles, the cavity in the spinal cord the central canal of the cord. Three orifices, the two foramina of Luschka and the foramen of Majendie, put the ventricular cavities into communication with the external surface of the brain. It must be remembered that this is merely diagrammatic, but the communication of the ventricular cavities with the sub-arachnoid space is sufficiently proved by the fact that in intra-ventricular hæmorrhages lumbar puncture draws off a blood-stained fluid.

3. The dura mater of the brain, which is continuous with the spinal dura mater, forms a fibrous bag, which lines the skull and the vertebral column without adhering to them.

The brain and spinal cord are in the interior of this fibrous sac, which is filled with the cerebro-spinal fluid, and the latter penetrates to the interior of the ventricles and the central canal of the cord by the foramina of Luschka and Majendie.

(No mention has purposely been made of the arachnoid and its two layers, nor of the supra- and sub-arachnoid spaces, which would only complicate the description without making the following explanations any clearer, for everything goes on as if that very fragile membrane, the arachnoid, did not exist.)

Let us now, with the help of this outline, study the
progress of an infection following an injury of the head and involving the skull, the meninges, and the brain.

After the injury the edges of the infected wound in the dura mater apply themselves to the brain and adhere to it. During the next few hours cerebral oedema is produced in the damaged area, and the swollen brain applies itself more and more firmly to the dura mater, and sometimes even herniates outwardly. Owing to these adhesions the damaged area is isolated from the meningeal cavity, and there is meningo-encephalitis localised to the region of the wound.

This infection may remain localised, but it may also spread gradually, invade the entire sub-dural space, and, through the foramina of Luschka and Majendie, the interior of the ventricles. In the latter case there is generalised meningitis, and the patient quickly succumbs. It is evident that the first thing to be done in order to avoid this fatal development is not to interfere with the existing adhesions between the dura mater and the brain. Any procedure which would lead to the rupture of these adhesions is deplorable. For this reason it is better, during the early stages of the case, to avoid introducing the jaws of large forceps between the skull and the dura mater, and causing pressure on the brain and meninges. For the same reason it is better during the same stage of the case not to practise lumbar puncture; this operation, by withdrawing a certain quantity of the cerebro-spinal fluid from the sub-dural space, causes a diminution of pressure in the ventricles, since all these cavities communicate freely with each other. Consequently there results a diminution of the swelling of the brain; it loses its exact application to the deep aspect of the dura mater, and it is on this close application of the brain to the dura that the limitation of the infection to the damaged area to a great extent depends.
When a projectile penetrates the brain it is situated near the ventricular cavity; around it there is always a zone of infected tissue, and an abscess often forms. When extraction of the missile is taken in hand, there is great danger that the ventricular cavity may be opened and infected.

These elementary considerations are by no means
valueless, for, judging from the publications, the majority of surgeons seem not to heed them. The extreme urgency of cerebral operation, which is accepted almost as a dogma, is by no means proved. Intervention in a penetrating wound of the skull immediately after the injury as it generally is practised can only aggravate the infection by disseminating it. Indeed, the general practice is to enlarge the orifice of entry with a gouge-forceps. This clumsy instrument exercises repeated pressure on the brain and the dura mater, thus forcing into the sub-dural space the septic products contained in the damaged area limited by the adhesions. In what way does removal of a large area of the bone around the fracture, even if it be infected, benefit the patient? Men wounded in this way never die of osteomyelitis of the skull; that is not the danger. The immediate danger is almost exclusively meningitis, and the natural defences of the wounded man are much more effective against meningitis than the illusory help of surgery.

The surgeon must make up his mind that, as far as the brain and the meninges are concerned, he can do nothing, or next to nothing, against infection. The most that he can do is to do no harm, by exercising his prudence and lightness of hand so as to respect scrupulously the protective adhesions which have formed at the periphery of the traumatic area. In the case of the brain he should be satisfied with facilitating by judicious drainage the elimination of all the dead material the presence of which in the middle of the healthy brain substance facilitates, provokes, and encourages infection, and this should be done only if the situation of the wound allows of it. This, in my opinion, should be the limit of the surgeon's action. Should there be a systematic search for metallic foreign bodies, which are the only ones shown with
certainty by radiography? I do not think so, and yet this systematic and immediate search for foreign bodies is a dogma with many operators. Let it be borne in mind that the projectile up to the time of its arriving in contact with the tissues is aseptic, and has, a few seconds before, been raised to a temperature of several hundred degrees; in passing through the head gear, the hair, and the scalp it gets contaminated, but more than that, it draws behind it septic débris which will be the most active cause of infection, but which a radiograph will not show, and which there will never be any question of removing. Under these conditions there is no object in damaging the tissues anew as long as any encephalitis exists, and metallic foreign bodies should only be extracted when this can be done by a method which is precise in the extreme, clean, free from hesitation, and without any rocking of instruments, or pushing backwards and forwards in the brain substance. The foreign body is often not far from the ventricular cavity, which is sometimes separated from the operation area only by a thin layer of brain substance.

I shall return to this subject soon, but I may say here that my preference is, a priori, for extraction by an electro-magnet whenever this is possible—that is to say, whenever we have not to deal with shrapnel. With a powerful electro-magnet acting upon slender rods of soft iron which are introduced into the track of the projectile it is only necessary to approach within a short distance of this to pick it up, as it were, without any extraneous manipulation, which, as I have pointed out above, is of the greatest importance. With the collaboration of my friend, Dr Mondain, I have endeavoured to devise a very simple apparatus based on this principle. The localising apparatus is made entirely of copper, except the seeker, which is of soft iron. After trephining, this seeker is pushed
into contact with the missile and then magnetised by means of a powerful electro-magnet, which draws out both the seeker and the missile without any probing about.\textsuperscript{1}

\textsuperscript{1} By means of experiments on splinters of shell enclosed in a transparent medium of a consistency nearly identical with that of the brain we have found that the magnetised rod does not always draw out the metallic splinter at the first attempt, but that the attempt must be repeated several times. Under such conditions we shall use this arrangement under the control of radioscopy, which will enable us to re-establish the contact with all desirable gentleness as often as may be necessary.
CHAPTER II

TREATMENT OF A PATIENT WITH A WOUND OF THE SKULL

Having laid down these general principles, I can now proceed to the surgical treatment of wounds of the skull.

The hair is cut all over the head with clippers, always starting from the wound when possible, in order to carry the cut hairs away from it. I once more repeat here what I have said above, namely, that it is to be regretted that men are allowed to wear their hair long. This undoubtedly aggravates wounds of the skull, and sometimes makes the preparation of the field of operation very difficult. The scalp must next be shaved over the whole extent of the field of operation, and freed from grease with ether, and finally washed with alcohol, and painted with iodine.

Anaesthesia.—The question of anaesthesia in cerebral surgery is of the greatest importance, and it is surprising to see how little attention is paid to it by surgeons. The question has hardly been raised in any of the discussions on cerebral war-wounds that have taken place in the last two years. It should be the surgeon's aim to disturb as little as possible the relations of the dura mater and the brain in the injured area. He should especially avoid all to-and-
fro movements, and any movements that alternately bring together and separate the dura mater and the brain, as these may rupture the adhesions existing between these two structures. Under general anaesthesia it is very difficult to avoid alterations in the volume of the brain. Coughing and vomiting cause a sudden increase in the intra-cranial venous pressure, and a great tendency for the brain to become herniated. The result is that the whole of the damaged area is shaken up, the brain substance, which is very friable when its surface is cut, is damaged beyond the limits of the wound, the haemorrhage is increased, and the adhesions of the brain to the dura mater are interfered with. In addition, vomiting often lasts for several days after the operation, and this always exposes the patient to the same risks, which are sometimes very serious.

General anaesthesia also necessitates the horizontal position, which greatly exaggerates the venous bleeding in all head operations, as the veins are without valves. This is often of little consequence; but if the surgeon unexpectedly finds himself confronted with a free opening into a sinus, for instance, he meets with difficulties which would not have arisen if the patient had been seated.

Finally, under general anaesthesia the patient cannot be of any assistance to the operator. Under local anaesthesia, on the other hand, the patient can shift or alter his position, and especially he can inspire and expire deeply, which, as we shall see, may be very helpful in the conduct of the operation, particularly in diminishing a venous haemorrhage (inspiration), or in everting the lips of a cerebral wound (expiration).

Technique of Local Anaesthesia in Operations on the Skull.—For more than three years I have performed all serious cerebral and cerebellar operations
under local anaesthesia. I make use of the simple technique which MM. Pauchet and Sourdat endeavoured to popularise in their excellent work in 1914.

The scalp and the skull derive their sensibility from nerves which travel under the skin and the epicranium. They are very easy to reach, and it is easy to infiltrate the tissues which they traverse by following a line which encloses the future field of operation. All the tissues, the skin, epicranium, periosteum, and bone thus enclosed rapidly become insensitive. The dura mater is almost devoid of sensibility, and can be pinched or cut without causing any pain, except near the base of the skull in the temporal region.

*Syringes.*—The syringes should hold 5 or 10 c.c., and there should be several. They must be perfectly air-tight, provided with a metallic top furnished with finger wings, which enable a strong pressure to be put on the piston.

*Needles.*—The needles may be of platinum or steel,
Platinum needles have the advantage of not wearing out, but they soon get blunt, and are very expensive. Steel needles are quickly worn out, and whatever care may be taken of them, they must be often replaced. Nevertheless I prefer them. There should be several of various diameters and lengths, 2, 3, and 4 inches. They should fit the syringes accurately, otherwise there will be considerable loss of the injection fluid, and it will be impossible to tell exactly how much has been injected.

To sterilise the needles and syringes it is sufficient to immerse them in alcohol at 90°C. They should then be rinsed in sterile water just before use. The needles, syringes, and the capsules of novocaine solution should never be boiled in water containing carbonate of soda, as is the custom with most instruments, as novocaine is precipitated by carbonate of soda, and the solution loses all its anaesthetising action.

The anaesthetising solution.—I use a solution of novocaine-adrenalin containing 1 gramme of novocaine and 1 milligramme of adrenalin to 200 c.c. of physiological (artificial) serum. In some very extensive operations I have injected as much as 100 c.c. of this solution without the slightest inconvenience, and in some abdominal operations I have gone up to 200 c.c. without accident, which shows the harmlessness of this method.

Position of the patient.—If it be possible—and in cases most suited for operation it generally is possible—the patient is seated on a chair. The best way is to put him astride on the chair, with his arms supported on the back and his head leaning on his arms. In this way the lateral and posterior portions of the skull are easily exposed, and the patient can maintain this position for a very long time without fatigue. For an operation on the frontal region the
patient sits down and throws his head back and rests it on the edge of the operating table. With the co-operation of my friend, Dr Mondain, I have had a special chair made, which M. Malaquin has been so good as to construct.

Pretty often the patient has to be laid on the operating table, either because he is unconscious, or because some other wound prevents his being seated. In such cases the head must be raised, which is easy with the tables generally used. The operator should then stand on something while operating, otherwise he is too low, and is obliged to operate with his elbows in the air, which is very inconvenient.

Before applying the anaesthetic the operator should satisfy himself as to the possibility of cutting an osteo-plastic flap, and also as to the proper size of the flap. It is possible to operate in this way when-

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**Fig. 11.** — The patient is operated upon in the sitting position. From right to left are shown the positions to be taken for operations on the occipital, frontal, and parietal regions respectively.
ever there is no considerable loss of bone, which is most frequently the case. In very large wounds with great loss of tissue, in which the skull has been widely opened, this method cannot be employed. I shall return to the subject later.

If the bony lesion is of some size the edge of the flap should pass an inch outside it in all directions, otherwise there would be a risk of coming down on splinters detached from the internal table during the section of the bone flap. When the size of the flap, which should always be quadrangular, has been decided upon, the four corners are marked by four intradermic injections of novocaine - adrenalin. To make these injections the needle is pushed into the thickness of the dermis parallel to its surface, taking care to avoid passing through it. When the injection is properly made, there is some difficulty in pushing home the piston of the syringe; this difficulty disappears as soon as the injection becomes subcutaneous.

When the four injections have been made, the fine short needle which has been used is replaced by another 3½ inches long and of a larger calibre. With this subcutaneous injections are made all along the line of the future flap, or rather immediately outside it (see fig. 13). For this purpose the needle is pushed through the scalp at the corners of the flap, which have already been anaesthetised by the intradermic injections.
After a variable, but generally very short, time insensibility of the whole surface of the flap will be obtained; this is easily ascertained by pinching its surface with a Kocher's forceps. One must not expect, however, that the patient will not complain.

Fig. 13.—Four intradermic injections are made at the four angles of the flap. It is at these four perfectly-anæsthetised points that the long needle with which the subcutaneous injections are made will be inserted.
during the operation. A nervous and emotional patient will complain as soon as he suspects that he is being cut or pricked, but he really feels nothing. However, it is very easy to avoid causing the patient this apprehension of the pain which he does not feel, but which he is afraid of feeling, by giving him a whiff of chloroform every now and then; this does not fully anaesthetise him, but completely calms him. A subcutaneous injection of half a milligramme of scopolamine will answer the same purpose.

**Application of a Hæmostatic Suture to the Base of the Flap.**—It is very important to operate bloodlessly, especially as these patients are often very deeply shocked. Therefore before cutting the flap I underrun the whole thickness of the tissues of its base down to the bone with a stout silk suture, as shown in fig. 14. It will be seen that every artery is in this way enclosed by a loop of the suture. The cutaneous flap, when detached from its connections with the rest of the scalp, will be then entirely ischaemic, and will not bleed, and it will only be necessary to place forceps on the peripheral lip of the incision. These forceps fall away from the field of operation, lie lightly on the scalp, enlarge the cutaneous incision, and facilitate the later stages of the operation, without causing any inconvenience. It is only necessary to look at fig. 15 to see this. The formation of the quadrilateral flap is done in three stages by three successive rectilinear incisions.

To prevent any hæmorrhage, an assistant places the ulnar border of his hand on the scalp parallel to the future line of incision and presses vigorously. The surgeon does the same with the ulnar border of his left hand, and incises between his own hand and the assistant's. Then, without removing the hands, small T-shaped forceps of my own design, made by Collin, are placed in all along the edges of the incision.
Fig. 14.—Method of inserting the haemostatic suture, and diagram of the course of the thread.

Fig. 15.—By means of the haemostatic suture the scalp flap, once it is cut, will be entirely bloodless and will not bleed, and it will only be necessary to place forceps on the peripheral edges of the incision.
These forceps, shaped like a short T, and provided with small teeth, grip strongly, never slip, are easily applied, and exert a force-pressure sufficient to make the bleeding after their removal absent or very slight. A similar manœuvre is repeated on the two other sides of the square flap, and when the flap has been thus completed the two lips of the incision are furnished with forceps, and not a drop of blood has been spilt.

At this time and during the rest of the operation
Figs. 17 and 18.—View of the field of operation after turning back the temporary osteo-plastic flap.
the forceps on the internal lip of the incision would be very inconvenient, but as they no longer serve any useful purpose they can be removed. Indeed, the cutaneous flap can no longer receive any blood except through its base, but at this level all circula-

![Diagram](image_url)

**Fig. 19.**—In this figure the forceps are well placed. Those of the peripheral lip evert the skin and uncover the bone. Those of the internal lip placed parallel to the preceding do not separate the scalp from the bone-flap, the nutrition of which it ensures. The figure shows that the operation would have to be performed in the middle of a crowd of forceps if the haemostatic suture did not allow of the removal of the forceps on the flap.

tion in the vessels is intercepted by the suture placed there at the beginning of the operation. The field of operation now has the appearance shown in fig. 18, and once the forceps on the external lip of the incision have been turned out of the way, the operation area is perfectly clear. The removal of the forceps from the edge of the flap is a great advantage, because it is proposed to cut an osteo-plastic flap and not
244 WOUNDS OF THE SKULL

to detach the scalp from the bone; the section of

Fig. 20.—Care must be taken not to pull the cutaneous flap from the bone which it covers. This diagram shows how to proceed to uncover the bone at the point where the perforator is going to work without causing stripping of the flap.

the bone would otherwise have to be done between

Fig. 21.—Doyen's perforating instruments.

two rows of forceps, and would thereby be rendered very laborious.
The use of rectilinear incisions for the cutaneous flap is justified on several grounds. The application of the T-forceps with rectilinear jaws is much easier on the edges of a rectilinear wound. At the end of the operation haemostasis is merely by accurate coaptation of the edges of the incision; this is much more easily done with a straight incision than a curved one, as there will often be puckering at the points where the edges are not brought perfectly together along the latter. When it is proposed to cut an osteo-cutaneous flap the greatest care must be taken not to reflect the scalp from the subjacent

Fig. 22.—Crown trephine. These instruments are difficult to manage, but are strong and do not get out of order.
bone, to which it is only loosely adherent. Therefore when placing the T-forceps on the inner lip of the incision (that of the flap), one should be careful not to throw the handles back towards the centre of the flap, and so evert the edge of it and bare the skull beneath to an undue extent. On the contrary, these forceps must be placed in a position similar to that of the forceps on the other lip of the wound, which can and must be everted in order to uncover enough of the bone to allow the drilling and cutting to be performed easily. The undue exposure of the edges of the osteo-plastic flap by pulling back the scalp has serious inconveniences; it may cause osteitis and necrosis in the edges, which leads to prolonged suppurations all along the incision. If the procedure is properly carried out, it is followed by sound healing in a few days.

When the flap has been marked out, and before dividing the bone along the same line, the edges of the scalp wound, which are generally lacerated, must be excised. This can be done without hæmorrhage in the centre of the ischæmic flap.

Section of the bone.—I cannot describe here the section of the bone in full detail. Personally, I always use my own mechanical apparatus, which enables an osteo-plastic flap of any shape to be cut in a few minutes. But as this volume is intended for surgeons who have only the regulation instruments supplied by the medical service—a circular or a Doyen’s trephine, Gigli’s saw, and Marion’s protector or my dura mater separator—it is only operations performed with these instruments that will be described at first.
CHAPTER III

TRUE CRANIECTOMY

Section of the Bone

A craniectomy is not satisfactory unless it is done quickly, without unduly shaking the patient’s head, and without damaging the brain, or even the dura mater. To avoid shocks to the subject’s head the use of the mallet and chisel should be given up.

Fig. 23.—Marion’s dura mater protector

To avoid wounding the dura mater, the best way is to divide the bone from within outwards, thus moving away from the danger zone instead of towards it. Gigli’s saw allows one to open the skull in accordance with all these requirements.

For this purpose it is sufficient to make a small trephine hole at each corner of the polygon of bone it is proposed to remove, and then to saw through the bridges of bone bounded by these orifices.

In order to operate quickly by this method it is necessary to be able to pierce the skull rapidly and to pass the saw easily from one trephine hole to the other under the bridge of bone which is to be cut. In order that the sawing may be done safely it is necessary to protect the dura mater; the saw
stretched between the two orifices in the skull, represents the chord of the arc of bone bounded by these holes, and, in spite of the fact that the skull is only slightly concave and the holes a short distance apart, the Gigli's saw would otherwise penetrate the convex surface of the brain. Figs. 25 and 26 explain my meaning well.

I shall now describe in succession the method of drilling the holes, of passing Gigli's saw, and of protecting the dura mater.

Opening the skull.—The method of opening the skull laid down in nearly all the classical works is bad. Marion points out the right method in his treatise without laying much stress on it. As a rule, it is advised that the bone should be cautiously broached with the point of the perforator and then the brace and bit substituted for that dangerous instrument. But in order to perforate the skull rapidly it is necessary to drill the hole with the perforator right down to the dura mater, and then quickly to enlarge the bottom of the funnel thus formed with the brace and bit. These two
methods seem to be almost identical; but try them for yourself, and you will be able to judge.

It is evident that caution must be observed when approaching the dura mater, but it is very easy to

follow the progress of the point. On cutting through the thick and resistant external table white chips of bone are detached, then the diploë is opened, and a blood-stained paste escapes which foams up round the instrument; when the internal table is traversed definite bone chips appear again, but this time they are reddened by the blood which continues to ooze from the diploë.

When it is proposed to cut a median symmetrical
osteoplastie flap much time may be gained by proceeding as follows: A first hole is drilled cautiously but not slowly, and while doing so the operator counts the number of turns given to the instrument. In order to perforate the skull a second time very rapidly it will suffice to move the point of the perforator to the corresponding point on the opposite side, and to make the same number of turns at full speed. This method is the simplest if the operator does not possess my hand-perforator, with which it is possible to make a hole in the skull half an inch in diameter without taking any special precautions. Unfortunately Doyen’s perforator and brace and bit require to be perfectly sharp before use. I believe that my hand-perforator is but little known, and that there are only a few specimens in existence, so one has often to be satisfied with the old circular trephine supplied by the medical service. This is a

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**Fig. 26.**—Gigli’s saw is stretched between the two orifices which it traverses, representing the chord of the arc of bone bounded by these holes, and although the skull may be slightly concave and the holes only a short distance apart, the saw cuts into the convex surface of the brain.

**Fig. 27.**—Martel’s hand-perforator, with which it is possible to drill a hole in the skull half an inch in diameter without taking any precaution.
strong instrument which will always cut, even when it is badly kept.

**Gigli's saw. Protection of the dura mater.**—Marion's guide is used to pass Gigli's saw from one trephine hole to the other. This instrument consists of a band of malleable metal with a groove in it (fig. 23), and is supposed to be used as follows: It is pushed through one of the trephine holes and made to emerge from the other; then the saw is slid along the groove between it and the bone, and the bridge of bone is sawn through after withdrawing the guide (fig. 28). These are the instructions for use which Marion gives in his excellent treatise. But the guide may also serve as a protector, for which purpose it is left in place during the sawing. However, whether the guide serves as a protector or not, its passage from one trephine hole to the other is often very difficult. In fact, although it may be malleable it is rigid, and when an attempt is made to push it from one trephine hole to the other, it will be all right if the skull is not very thick and is only slightly convex, otherwise it raises a projection on
the dura mater, pushes up against it, and can only proceed by ploughing a furrow in the brain (fig. 29). Where there are bony ridges on the deep aspect of the skull (as in the occipital region, for instance) Marion’s guide cannot pass over them with certainty.

While using this instrument I have ploughed a rather deep furrow on the surface of a brain. I have

![Diagram](image)

**Fig. 29.**—The cranium is thick, so Marion’s protector is raising a fold on the dura mater and the brain which it will plough up if a rough operator continues to push the instrument onwards.

seen two experienced operators (Professor Segond and Sergius Rabinovitch) do the same, and I know of surgeons who have been obliged to give up passing Gigli’s saw by means of the guide.

It may happen sometimes that after getting the guide into position the saw cannot be made to slide along the gutter; this can be got over by attaching it to the end of the guide, which has a small hole for this purpose. When the guide is withdrawn the saw is drawn with it, but then the instrument serves simply as a tractor and no longer protects anything.

I have designed and got M. Collin to make a small
Figs. 30 and 31.—As it penetrates, the slender steel ribbon, keeping its beak against the bone, fits itself exactly to the interval between the dura mater and the skull, and emerges as soon as it reaches the hole of exit.
tool, which was presented in my name to the Société de Chirurgie by Professor Segond. I have since perfected it, but it still remains very simple (fig. 24). It is a simple steel band about 10 inches long and \( \frac{1}{3} \) inch broad, very thin, perfectly elastic, and highly tempered. The band is curved on the flat. One of its extremities, the beak, which is slightly rounded and thick, loosens the dura mater. Four inches from the beak, on the upper concave surface, there is a hook with its end turned down pointing to the beak. The instrument is passed through one of the trephine holes beak uppermost and pushed, without any precautions, between the dura mater and the bone towards the next opening. As it goes, the slender band of steel, scraping against the bone with its beak, fits exactly the space between the dura mater and the skull, and emerges as soon as it reaches the hole of exit (figs. 30 and 31). It is then only necessary to fasten the Gigli’s saw on to the little hook of the instrument and to pull on the latter. When the saw has been pulled through, the posterior part of the dura mater separator remains in its place and acts

Fig. 32.—The saw having been passed through, the posterior portion of the dura mater separator remains in its place and acts as a protector.
as a protector (figs. 32 and 33). This instrument passes from one trephine hole to the other with the greatest ease, however far apart they may be; it passes over any bony ridges without the slightest difficulty, draws after it the Gigli's saw, and separates it from the dura mater, which it protects efficiently.

Before designing this dura mater separator I had done craniectomies with the usual instruments, and
Fig. 34.—In this operation the dura mater separator has had, in order to pass from one to the other of the two lower trephine holes, to insinuate itself between the sinus and internal occipital crest, which is very projecting and quite visible in the figure.

Fig. 35.—This patient underwent total craniectomy; it took thirty-five minutes to perform the operation.
also with Marion’s guide and Gigli’s saw, so that I am well able to judge of the difference.

All the first craniectomies which I performed with my instrument were difficult. They were cases of cerebral tumour in adult subjects with very hard and thick skulls; seven of the osteo-plastic flaps detached were median, and situated across large sinuses. In particular, I removed rapidly and at a single sitting the whole of the lower portion of the occipital bone up to within nearly $\frac{1}{4}$ inch of the occipital foramen, laying bare the cerebellum, the occipital lobes of the cerebrum, the torcular Herophili, the lateral sinuses, and the superior longitudinal sinus (fig. 34). I have even removed in thirty-five minutes the whole of the vault of the skull without any difficulty from a patient with a very thick and very hard skull who had extreme increase of intra-cranial pressure, which is seldom done except in the post-mortem room (fig. 35). All the patients operated in this way survived the operation; one of them died a month later, but the shock of the operation was not in the least to blame for this.

The operation, performed as I have just described it, is very simple on a normal skull; if the latter is fissured, there may be some difficulty. In this case my dura mater separator, while insinuating itself between the bone and the dura mater from one trephine
Fig. 37.—The bone fracturer is made in two parts, a male and a female portion, which slide on each other by means of a screw controlled by the handle at the top of the instrument. The female portion ends in a flat piece, which is insinuated under the bone-flap; the male piece is fined down to a point, which is supported on the skull just outside the flap. By turning the handle of the instrument the female piece is raised, and with it the flap, which is soon broken across its base.
hole to the other, may hitch against a projection from a fissure; should it do so, it is better not to force it, but to cut a new trephine hole at this

![Diagram](image-url)

**FIG. 38.**—Fracture of the base of a bone-flap by traction with a Farabeuf's retractor. This rough procedure is very badly borne by a patient who is conscious.

spot. Or it may happen that the dura mater separator gets entangled in a laceration of the dura mater. This is very exceptional, but the obstacle can generally be got over by passing the instrument in the reverse direction.

When the section of the bone has been accomplished, it only remains to fracture the base of the bone-flap, which ought to be perceptibly narrower than its upper
edge; in other words, the flap should be shaped like a trapezium with its small side downwards. To effect this fracture without shock I use a very simple instrument, which I designed and had made by

Fig. 39.—The flap is deeply fissured, and is not broken at its base. It is then necessary to cut with Gigli's saw what could not be broken. This figure is purposely incorrect; the flap should be covered by the scalp.

M. Collin (fig. 36). It is in two parts, a male and a female portion, which slide on each other by means of a screw worked by the handle at the top of the instrument. The female portion ends in a flat piece, which is passed beneath the upper edge of the flap; the male piece ends in a point, which rests on the
TRUE CRANIECTOMY

skull just above the flap. By turning the handle of the instrument the female piece is raised and with it the flap, which soon breaks at its base. This breaking of the base of the flap without a shock is important to a wounded man who is not insensible. In default of the instrument which I have just described, and which is not yet on sale, as it had only just been finished when the war broke out, Farabeuf's retractor may be used. The end of the large arm of

![Diagram](image)

**Fig. 40.**—Dalgren's forceps, which require considerable force in handling.

this is introduced beneath the flap, while the heel, resting on the skull, serves as a fulcrum to the lever thus formed. Unfortunately the elevation of the flap obtained in this way is not very great, and is often insufficient to fracture the base. It is then necessary to pull on the retractor without supporting it on anything, and at the moment of fracture the wounded man experiences a violent shock (fig. 38).

If the flap is extensively fissured it may break into several pieces, or at some other point than the base (fig. 39). This accident is annoying, but it can be completely remedied. It is only necessary to pass the dura mater separator under the base of the flap, pushing back the scalp sufficiently to avoid cutting it with the Gigli's saw, which will sometimes
make it necessary to prolong the incisions downwards; the base of the bone-flap is then partially divided so as greatly to facilitate the fracture. In practice this accident should very seldom happen, because this method is only used in cases where the skull,

although perforated, appears to be strong and has no long fissures on the external table. It will be evident that when the skull is shattered there will be no idea of cutting an osteo-plastic flap.

Instead of Gigli's saw, Dalgren's forceps may be used to cut the bone (fig. 40). The great drawback of this instrument is, that it requires the use of considerable force. In any case it cannot be used to divide the base of the flap; Gigli's saw is absolutely necessary for this.
When the osteo-plastic flap has been turned down the operator can see the lesions of the internal table, generally much more extensive than those of the external table, and also the lesions of the dura mater and the brain; all this has been done without any rough manœuvre in the immediate neighbourhood of the wound, as the surgeon has always been working at a distance from it, and has in no way interfered with the damaged area. This, in my opinion, is the great advantage of this method whenever it can be employed, and this should be whenever the condition of the skull allows of a temporary resection, which is often the case. From this time forward the surgeon is no longer acting blindly, as he does in the ordinary method, and we shall now see how he should proceed.

Treatment of the Bone Injury

The internal table may be cleanly perforated. This is often the case with wounds made by bullets, and in such cases there is nothing to be done except to enlarge the orifice with gouge-forceps if the meningeal and cerebral lesions require a drainage-tube to be left in the wound. Much oftener one finds a depression of the internal table, a number of splinters of which are sometimes adherent to the dura mater which they have lacerated. Sometimes they even penetrate into the brain substance. The free splinters must be carefully removed, the large fragments still firmly attached by their bases to the rest of the bone-flap must be put back in place. In other words, the inner surface of the skull in the region of the wound must be smoothed off perfectly. All pointed spicules of bone must be cut off with the gouge-forceps. The flap is firmly held by an assistant, and all projections which are liable to press on the dura mater and the brain are gently chiselled away. Finally, the circumfer-
ence of the perforation is smoothed by removing all damaged pieces of bone with very sharp gouge-forceps.

Fig. 42.—The flap being held quite steady by the assistant, the operator smooths off the orifice of entry of the missile from the internal aspect of the bone.

All these manœuvres should be done while the bone-flap is held firmly in strong forceps by an assistant (fig. 42). It is obviously much less simple than chipping away the skull with cutting pliers
haphazard and without any guide, but it is much more satisfactory from a surgical point of view. When the toilet of the inner surface of the bone-flap has been finished, the surgeon turns to the lesions of the dura and the brain, taking the greatest care meanwhile not to disturb any adhesions that already exist between these two important structures. Detached splinters of the inner table are often adherent to the dura, and they should be removed with the greatest gentleness. If the dura has been torn and a portion of the skull is missing, the presumption will be that this fragment has penetrated the brain through the breach in the dura mater. Gentle search must be made for it there
with the tip of the finger and a forceps, and it will often be found. The lips of the wound in the dura mater must be trimmed, but as a rule this membrane should not be incised.

When the brain itself is injured, an effort must be made to cleanse the cerebral wound as much as possible, but even in this all excessive handling must be avoided. As a general rule one must be satisfied to do this cleansing through the wound in the dura mater just as it is and without enlarging it, but if it is necessary to enlarge it, it must be sutured again. Prolonged irrigation with warm physiological serum seems to me to be the best method of freeing the brain from the numerous and often tiny and hardly visible foreign bodies which it contains. With the finger introduced very carefully into the wound it is sometimes possible to feel the splinters, or even a projectile, which can then be removed with the forceps. The bottom of the wound is also irrigated by means of a glass canula pushed very gently along the finger; to be effective this irrigation must be prolonged, and while it is being carried out the patient must be told to cough or to expire deeply. In certain cases, under the influence of this expiration, the tissues of the wound are everted, as happens with the anus of a patient when he is told to bear down. The irrigation will then be very effective, and will draw out numerous foreign bodies which a rougher handling would have embedded deeply in the cerebral substance.

When the injury is deep and the brain substance around it is much damaged, it is advisable to insert a drainage-tube.\(^1\) This emerges through the enlarged and trimmed orifice made by the missile, and should be withdrawn and cleaned at each dressing, and its

\(^1\) I never use rigid drainage-tubes, but a layer of protective enclosing a small wick (cigarette-drain).
track irrigated for a long time with warm physiological serum so as to get rid of the necrosed brain matter.

When all these procedures have been completed, the osteo-cutaneous flap is replaced and sutured with great care. In order to make the suture exact and regular it is necessary to re-establish precisely the connections which existed between the flap and the rest of the scalp before the operation; this is greatly facilitated by the square form of the flap. A suture is passed through each angle of the flap and fixes it to each angle of the incision on the scalp. Then it is only necessary to suture the three straight incisions—a very simple matter.

The suture plays a most important part in regard to hæmostasis. Ligature of the scalp vessels must not be relied upon to stop the bleeding, but simply the exact apposition of the two edges of the incision by firm suture. While the density of the scalp makes ligature of its vessels very difficult, it also makes firm apposition effectual, where in softer tissues it would be useless. It is important that the two cut edges of a large vessel should be brought exactly face to face in the suture, so that the effects of the approximation shall be exerted equally on both of them. For this purpose the omega incision is much inferior to the rectangular one. When the corners of a rectangular flap have been once secured, each of its sides may be sewn up by interrupted or continuous sutures. The continuous suture is more hæmostatic than the interrupted ones, but it is necessary to remove all the forceps around the incision before applying it, and therefore the patient may bleed a little during its application. Interrupted stitches, well placed, effect excellent apposition and perfect hæmostasis, and they allow of the forceps being removed one by one. The continuous suture is much more rapidly inserted, but it sometimes gives
rise to small sloughs at the edges of the incision, especially if it be left in place too long. It is difficult and somewhat painful to remove, and its final results are never so perfect as those of interrupted sutures. One of the great advantages of the osteo-plastic flap is, that it can be raised again should it be desired to explore the dura mater and the brain anew, and as the suture may have to be repeated several times, it is better to use interrupted ones that cut up the edges of the incision less.

Whichever method is adopted, the sutures must be removed on the third or fourth day; this is the only way to get fine cicatrices, clean and without suppuration. The hæmostatic suture inserted at the base of the flap at the beginning of the operation should be removed at the end of twelve hours, but I have left it for twenty-four or thirty-six hours without any bad result.

This method of operation, as I have already stated, is only applicable where the skull is comparatively sound and allows an osteo-plastic flap to be cut. It would be absurd to be possessed with the desire to apply it in every case. It is excellent in all cases in which the internal table is broken but the external is only slightly fissured or depressed, since it allows the lesions to be treated without leaving a large gap in the skull, as is always the case in the ordinary procedure, in which the operator begins by removing a trephine circle in order to ascertain the condition of the internal table; if this be broken, he removes portions of the skull with cutting-forceps up to the limits of the fracture. In short, he replaces the fractured area by a large loss of substance, which has its inconveniences, since one of the principal occupations of the surgeons at certain neurological centres at the base is to repair these gaps by various measures, which I shall describe at the end of this
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volume. By the method which I recommend the internal table is dealt with directly without touching the external table, and after the lesions of the dura mater, the sinuses, or the brain have been treated, the osteo-plastic flap is replaced without drainage, and after a short time the skull is as firm as ever.

This procedure is also excellent for wounds of the skull and brain when these structures have been struck at right angles to their surface. The lesion then is small, and even the most fervent partisans of drainage cannot claim any advantage in trephining widely. It is of doubtful value in tangential gunshot-wounds or deep furrows by shell-fragments. In these cases it would necessitate the formation of very large flaps, and I then prefer another method, which I shall describe later, but before doing so I wish to say a few words on the various difficulties that may be met with in cutting the osteo-plastic flap.

Difficulties which may complicate the cutting of an osteo-plastic flap.

It sometimes happens that the diploë bleeds freely while the bone is being perforated; it is best to finish the perforation without trying to stop the hæmorrhage. Then the walls of the opening should be smeared with Horsley's wax, which will attain the desired result.

The same thing may occur during the sawing of the bone. Here again the section of the flap must be completed, and it is here that the superiority of mechanical instruments becomes evident, as thereby the operation can be completed in a few seconds.

These hæmorrhages of the diploë are rare; a much more frequent form of hæmorrhage is that produced in the neighbourhood of the trephining when the bone is denuded of pericranium along the line of the incision. I shall return to this later on in connection with occipital and sub-temporal decompression,
where such hæmorrhages are especially serious, but I wish to point out here that the only means of stopping them is to drive a small pointed ivory peg into the orifice that is bleeding and then to cut it off flush with the surface of the skull.

*Injury to the dura mater and the brain with Gigli's saw.*—This accident will not occur if the trephine holes are not placed too far apart, and if care is taken to use a dura mater separator adapted to the trephine with which the holes are made, and especially if watch is kept to see that the protective portion of the dura mater separator is well placed. As the saw represents the chord of the arc of bone which it has to divide, its tendency to penetrate into the brain will be greater the more convex the arc or the more distant the trephine holes from each other (fig. 25). If a large trephine is used and a narrow
dura mater separator, the protective portion of the latter moves about in the holes, and the saw may slip off the instrument and lie on the dura mater in places (fig. 44), but even in this event, if care has been taken at the beginning of the sawing to place the saw properly on the protector, the dura mater will not be wounded.

_Rupture of the meningean artery when fracturing the flap._—When the base of a flap is fractured and, as frequently happens, it lies over the lower part of the temporal fossa, it may happen that the middle meningeal artery may be torn while it is enclosed in the bone. In such cases it is first necessary to verify the position of the artery relatively to the bone, which is not always easy. For this purpose a current of warm physiological serum is very useful to wash away the blood as fast as it flows. If the artery is enclosed in a bony canal, the obliteration of this canal by an ivory peg is indicated, but often this is not the case, and the artery simply lies in a gutter of bone which, while not permitting of direct compression, hinders the application of a ligature. In this case the best thing is to free it for a certain distance by breaking away pieces of the bone above it with the gouge-forceps and then to tie it.

_The opening of a sinus._—This accident must be looked for when raising a flap for a simple fissure of the external table seated in the median line or in the region of the lateral sinus. In fact, as has been often repeated, the internal table is often broken, and its fragments sometimes lacerate the sinus. I have several times found fragments of the internal table embedded in the sinus, which did not bleed until the splinter had been removed. In such cases the best method of haemostasis is to apply to the vascular lesion a flap of muscle or aponeurosis. The suture of the sinuses is very difficult; it may even be said
to be impossible when there is any loss of the vessel wall, for the sinus walls are stretched and inextensible. It is in these very frequent cases of venous hæmorrhages that the superiority of local anaesthesia and the sitting position becomes evident. A hæmorrhage which is formidable in the horizontal position is rendered comparatively trifling as soon as the subject is in a vertical position. I borrowed this method of obliteration of wounds of sinuses by pieces of muscle from Sir Victor Horsley nearly seven years ago. During this period surgeons have made little or no use of it, and during this war my friend, Dr Velter, is the only one I have known to mention it. A short time ago Morestin described to the Société de Chirurgie an operation in which he vainly tried to suture a sinus. It is to be regretted that this technique has not received the official stamp, and has only myself for sponsor.¹

The preceding remarks apply to the wounds placed under Classes 3, 4, and 1 in the classification at the beginning: they may be epitomised thus:

3. Wounds in which the missile has struck the skull at right angles but without penetrating it; here both tables are broken, and the fragments of the inner one are often driven deep into the brain not far from the ventricle, which may be opened in the course of the operation, if it was not opened by the injury.

4. Wounds identical with the preceding, but in which the missile has penetrated into the skull; it then often lies deeper than the splinters which it has driven in with it.

1. Wounds in which the missile, having lost almost all its velocity, strikes the skull direct and produces a depression of the external table to which a fracture of the internal table may correspond.

¹ This method is in common use in the British services.—Editor.
All these wounds have one characteristic in common. The missile which produces them has struck the skull direct, and its passage through the bone is the shortest possible, so that while there is less shattering of the skull, the damage to the bone is of comparatively small extent. This is the condition for which the osteo-plastic flap method is most useful. Unfortunately in a number of very serious cases in which operation has much less chance of success, this technique can only be applied with great difficulty. This is when numerous and deep fissures proceed from the point of entry of the missile and break up the skull over a large area. Under these circumstances the idea of cutting an osteo-plastic flap must be given up, and I consider that the best plan is to adopt the procedure which I shall now describe. It is the same with tangential gunshot-wounds.

**Use of Mechanical Instruments**

I wish to say just a word regarding operations as performed with my set of instruments, because very few surgeons possess it, and because for the last two years I have probably been the only one to use it regularly. I shall describe it, because I owe to the operative facility that it gives me the idea of systematically cutting temporary osteo-plastic flaps whenever that is possible. It is a very strong and simple set of instruments, and consists of an electric motor, or a motor of my own invention set in motion by an assistant, who may be a woman or a child: I prefer this latter motor, because it does not get out of order and can be used anywhere. I shall not describe it, as an examination of the illustration will show the mechanism plainly. The motor, whichever is used, is connected by a cable to a sterilisable tool-holder which is manipulated by the surgeon. My trephine and its bit (figs. 48

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and 48A), or my vertical brace and its protector (figs. 46 and 47), can be mounted on this tool-holder in turn. I shall not attempt to give the details of my trephine; sufficient to say that no matter what force may be put on it, it will pierce the skull without wounding the dura mater or the brain. The proposed osteo-plastic flap being marked out by the incision in the scalp, I pierce a hole at one of the lower corners of the flap and then, substituting the vertical brace for the trephine, I cut three sides of the flap, and fracture the fourth by means of the special apparatus which I designed for that purpose.

The whole operation requires only two to three minutes, and is admirably borne by the patient, who is not made unconscious. It must be stated that the
Fig. 46.—The author's vertical brace.

Fig. 47.—Method of using the vertical brace.
WOUNDS OF THE SKULL

Fig. 48.—The author's perforator.

Fig. 48A.—Manipulation of the perforator.
patient makes no complaint of the vibrations of the instrument; this is a reply to the objection raised by some surgeons to this method.

Treatment of a Gutter-wound

When the skull is ploughed by a missile which has taken a more or less tangential direction relatively to its surface, the cutting of a temporary osteoplastic flap is unfortunately no longer possible, and the operator must make up his mind to adopt another and much more destructive method. The end proposed remains the same: to get rid of the mechanical conditions due to the fracture (compression by splinters, and blood-clots), to arrest the hæmorrhage, to clean the area of the wound by removing all free splinters, and facilitating the elimination of all dead material in its neighbourhood, and all this without adding to the injury or using rough or rash manipulation.

To this end I believe the best way is to cut a broad, rectangular scalp flap, following exactly the procedure pointed out above, but in this case the basal hæmostatic suture can be dispensed with. The real object of this suture is to allow of the removal of all the forceps from the edge of the flap when it is not desired to loosen it from the surface of the skull which it covers, because these forceps would be very much in the way when the bone-flap was cut. But in the present case the flap is turned back away from the field of operation, so that the forceps fixed to its edges are not in the way, and it is sufficient to remove the flap and forceps from the field of operation for them to give no more trouble (fig. 49).

The dimensions of the cutaneous flap should be a good deal larger than those of the wound. The osseous lesions are frequently more extensive than the cutaneous ones, and it is desirable that the former
should be completely visible when the flap has been reflected.

In these tangential wounds the operator finds himself confronted by a more or less deep furrow

in the brain substance itself. Some splinters may penetrate the brain, but, generally, they are superficial, and are not deep in the interior, as is so often the case in apparently less serious wounds produced by missiles striking the skull direct.

The edge of the osseous furrow must be trimmed with the gouge-forceps and healthy dura mater ex-
posed; but in doing this, as in all other surgical operations, I am of opinion that an effort should be made to proceed from the sound to the damaged area, and that it is often dangerous to pass the jaws of the gouge-forceps below the edge of the bone into the damaged region, where there is so much alteration in the structures that it is impossible to get one’s bearings clearly. There is a risk of increasing the damage, of driving in detached splinters which have not yet penetrated the brain, and also of lacerating the dura mater, or of increasing its laceration if it is already opened. The best thing is to trephine about half an inch from the edge of the bone outside the damaged area.

If instead of finding the dura mater intact when it is uncovered, lesions are found extending further than was expected, as often happens, this is got over by trephining again further out. Starting from this opening, a channel is cut with the gouge-forceps direct to the damaged bone. In this way the limits of the injury are thus made evident, and it is then easy to expose it without doing any further damage.

If the dura mater is intact, it is not to be opened on any pretext. It is impossible to emphasise this point too strongly. To open the dura mater in order to evacuate a hæmatoma, or the pulped brain

Fig. 50.—Trimming up the hole in the skull with the gouge-forceps. Care must be taken to avoid using these forceps as a lever and fracturing the cranium rather than cutting it.
resulting from a violent contusion, is to infect almost certainly a focus till then aseptic, and to invite meningitis and encephalitis. Nevertheless there are many surgeons who do this. If, however, the dura mater is injured, if the pulped-up brain matter is

escaping through the opening, if the dura although intact is immobile and blackish, if the existence of a hæmorrhage or an area of softening can be made out, it is quite logical to enlarge the meningeal opening and to evacuate this already infected focus as gently and as completely as possible. The dura mater must be subsequently sutured with care, except about its

Fig. 51.—This apparatus, which has been constructed by M. Adnet in accordance with my instructions, allows one to irrigate the brain with warm serum. In order to vary the temperature of the serum it is only necessary to plunge the tube into boiling water. The temperature of the water is read on a thermometer mounted immediately above the canula.
laceration; here a cigarette-drain must be inserted, as it has the advantage of not being rigid and of not sinking into the brain substance. Nothing is more difficult than completely to empty these collections of blood, pulped-up brain matter, and splinters without injuring the healthy brain tissue which forms the wall of the cavity. The best plan is to feel about with the finger very gently in all directions under a continuous current of warm serum (45 to 50° C.). While this is being done, the patient is told to expire forcibly or to cough, which causes the walls of the cavity to become everted, and makes them more accessible. The finger should be moved methodically and with great gentleness in every direction; sometimes

![Diagram of craniectomy]

*Fig. 52.—The incised dura mater has been sutured, and a cigarette-drain left in the wound.*
it will feel a splinter or some foreign body, which is then withdrawn with forceps. The employment of the warm serum has great advantages; it is very hæmostatic, and by its mechanical action flushes away a quantity of scarcely visible, but often very infective, débris. But it must be remarked that it is very badly tolerated by a patient under local anaæsthesia whose integuments have to be protected with an aseptic mackintosh sheet.

Nothing is more difficult than to define exactly the limits of trephining of this kind. To read certain works published on the subject, it would seem as if it were only necessary to remove its bony covering from the brain to ward off all the complications of an extensive cerebral injury, and that from the moment the injured organ is laid bare over the whole extent of the lesion everything has been done that could be done. This radical removal of bone without regard for any other considerations appears to me to be empirical and devoid of any scientific basis. I know of many wounded men who have recovered quite well without having undergone extensive interference of this kind, and I, personally, remain very strongly opposed to great mutilations which are justified by nothing except the desire to do something at any price, even where nothing useful can be done. When an attempt is made to expose the entire extent of a superficial cerebral wound in order to keep it under supervision, to apply a flat dressing, and to avoid the formation of an abscess below the contused or broken bone about it, this is all quite defensible. But when fissures are followed up and large areas of the skull are removed which have no immediate relation to the deep track in the brain, I cannot understand it at all.

In those more or less tangential wounds of the skull, for which the osteo-plastic flap is not suited,
there are often large losses of the scalp. The bone opening, when it has been trimmed up, is nearly always larger than that in the scalp, and it is common for the dura mater also to be damaged to a great extent. The brain, which forms the bottom of the

Fig. 53.—Raising the scalp-flap, in the centre of which a hole has been made by the missile.

wound, is thus exposed, often for a long time, and it therefore gets infected and often herniated. To guard against these two dangers, infection and hernia, Sargent proposed the ingenious plan of loosening the epieranium from the scalp in such a way as to allow it to slide and to be sutured beneath the orifice in the latter. The brain can thus be perfectly covered in, and the cutaneous wound quickly cicatrises. Drainage is effected by two tubes which protrude
Fig. 54.—Freeing the epicranium on each side of the orifice.

Fig. 55.—Suture of the freed epicranium and obliteration of the orifice in the scalp made by the missile.
from the inferior angles of the flap. The accompanying figures (53–57) borrowed from an article by Sargent will make his method clear.

I have described two methods of operation which appear to me to be the best, and between which a choice can be made according to the case. Preference will be given to the osteo-plastic flap whenever it is practicable, because it offers many advantages. This flap can be made whenever there is the least doubt as to the condition of the internal table or of the brain, and it must be remembered that a small depression in the external table, especially when it is situated in the middle line over the longitudinal sinus, often gives rise to serious trouble. It must also be remembered that sometimes a very small missile may traverse the skull, scarcely leaving a trace, and may nevertheless cause deep cerebral and vascular lesions. The osteo-plastic flap leaves no trace nor any deformity, and it always effects a cerebral decompression by which the patient is benefited; it does not cause cerebral herniae of mechanical origin, as the small classical trephining so often does. It gives a very wide view of the lesions, and that as often as desired, since it can be reopened whenever it is thought necessary.

The second method described, the enlargement of the opening in the bone with the gouge-foreceps, has none of these advantages, but it is indicated whenever the bone injury is considerable and does not allow an osteo-plastic flap to be made.

The results obtained by these two methods depend entirely on the condition of the dura mater and the brain. Whenever the dura mater is intact there is good ground for hoping for a cure, for the two chief complications of wounds of the skull, meningitis and encephalitis, are then avoided. Deep wounds of the brain at right angles to its surface, with splinters
Fig. 56.—Aspect of the flap at the end of the operation; the brain is no longer visible, and is covered by the epicranium.

Fig. 57.—Aspect of the region operated upon a few days after the operation.
driven down not far from the lateral ventricle, are
the most dangerous. They often appear to get
cured, but at the end of a variable time encephalitis
makes its appearance and then ventricular meningitis,
and the wounded man, reckoned as cured by a surgeon
at the front, dies at a base hospital.

Surface wounds of the brain, in which the skull is
opened along a plane tangential to the cerebrum,
do much better. In these wounds the splinters are
generally much less deep than in the preceding one,
the ventricle is further from the seat of infection,
and a flat dressing can be applied. There is no
septic retention, and there is some hope of saving
these patients.

Between these two extreme types are grouped all
the intermediate ones. The surgeon must allow
himself to be guided in their treatment by the few
general principles laid down above, which are: the
almost absolute impotence of the surgeon against
cerebral infection, and the necessity there is not to
counteract, by ill-timed treatment, the efforts which
nature is making to limit the extent of the septic
focus; the utility of working from healthy towards
unhealthy regions; and not to operate haphazard.
CHAPTER IV

SEQUELÆ OF OPERATIONS

Immediate Sequelæ

The sequelæ vary greatly according to the case.

When the patient is fully conscious at the time of the operation, and presents few or no abnormal symptoms, it must be hoped that he will still be in the same condition after the operation, because any fresh symptoms that he may then present will be almost certainly associated with the appearance of meningitis or encephalitis, or will be due to the operative interference.

When the patient presents abnormal symptoms before the operation these will increase or diminish according to their cause, without the surgeon being able to draw therefrom any inferences as to the ultimate cure.

What I mean is this: a patient with increased intracranial pressure (severe headache and vomiting) will be almost immediately relieved by the operation without being in any way safeguarded from grave infective complications. In the same way a patient who shows signs of compression by fragments of bone or blood-clot has a very good chance of having his condition improved after trephining. On the other hand, a subject of traumatic œdema of the brain (paralysis, hemiopia, and aphasia) will often
have his troubles temporarily aggravated after the opening of the skull. It is true that if the oedema is really the only cause, all the morbid phenomena will begin to improve at once, and will finally disappear. On the contrary, if the oedema of the brain plays only a subsidiary part, and if the symptoms are essentially due to destruction of the brain substance, little or no improvement will occur. When the patient is comatose he may become sensible in a few hours; it is then merely a case of cerebral concussion, or perhaps of compression of the brain by hæmorrhage or splinters, and the compression will cease after the operation. But he may remain comatose, and then he will die, because his condition is due to a laceration of the brain incompatible with life, against which operation is powerless.

In short, free opening of the skull in the damaged area for the purpose of trimming and cleaning it up, and of preventing the comparatively tardy infection symptoms, also modifies the immediate symptoms provoked by the wound; by giving room to brain which is oedematous, or compressed by blood or splinters, it alleviates the signs of hypertension, especially the severe headache. By decompressing the brain over the damaged area it exaggerates the functional symptoms connected with the local oedema, and when a hemiplegia, a monoplegia, an aphasia, or a hemiopia are primarily due to the oedema, it is certain that these phenomena will be aggravated immediately after the operation, and will disappear afterwards if no infection appears to complicate matters. It removes the signs of direct compression by splinters; as, for example, Phocas's patient, who entered the operating room blind, and left it with almost normal vision.

It is without effect on destructive lesions.
Post-operative Treatment

A patient with a skull-wound must be dressed on the day following the operation. The incisions in the scalp, even when well sutured, always give rise to free oozing, and as a rule the dressing is completely soaked with blood at the end of twenty-four hours.

I always drain with a cigarette-drain, never with a drain made of resistant tissue. I never use drains of gauze; nothing is more provocative of the retention of septic fluids or more favourable to infection. A gauze drain placed directly down the track of the injury adheres to its walls, obliterates it, and when removed gives rise to bleeding from it, and thus opens the door to infection through a multitude of small oozing vessels. A cerebral drain should be of soft material which has no tendency to adhere. When a rigid drain is placed in contact with nerve tissue it ulcerates it and hollows out a bed for itself. It may thus open the ventricular cavity, which is often very near the bottom of wounds running at right angles to the surface of the brain.

*The cigarette-drain* (fig. 52) is made of a strip of varnished taffeta or of thin rubber rolled round a roll of gauze. The gauze is thus isolated from the walls of the track. Its part is merely to draw outwards, by capillary action, the fluids which accumulate at the bottom of the wound. At the first dressing the cigarette-drain is withdrawn, the gauze which it contains is changed, and is replaced after irrigating its track with an antiseptic solution.

The hæmostatic suture which I place along the base of the flap is removed at the first dressing. It has happened to me to leave it for several days by an oversight, and though it gave no trouble, I consider
it preferable to remove it as soon as hæmostasis is assured by the commencement of cicatrisation.

Very often considerable œdema of the eyelids and the base of the orbit is observed as a sequel of lateral trephining; this is of no moment.

In cases that do well, union of the flap is complete by the fifth day. The sutures are removed on the fourth or fifth day at the latest; there is no advantage in leaving them longer, and at the end of that time they begin to cut through the scalp and cause suppuration.

During the whole post-operative period, as long as the patient cannot be considered cured, the scalp must be kept shaved over all the operation area, and especially around the circumference of the original wound; the drain generally emerges in this area.

When should the drain be withdrawn? Nothing is more difficult to decide, because very often it is just after its removal that a cerebral abscess begins to develop, and necessitates the opening up of the track and fresh draining. I am of opinion that it is best to allow the wound to heal from the bottom, and to shorten the tube in proportion as it is pushed outwards by the new tissue.

The post-operative treatment is not limited to this. The patient must be watched very closely; the surgeon must remember that many complications may supervene in the succeeding weeks or months. A number of men with head-wounds die ten, twelve, fifteen, or eighteen months after the operation which was assumed to have completely cured them. Nothing is more discouraging than these delayed deaths, which are nearly always due to an abscess which develops at the spot from which the projectile was extracted a long time before, leaving absolutely nothing to inform the surgeon at the base as to the probable seat of the lesion, as the cerebral abscess very often
develops without any symptom which allows of localisa-
tion. I shall return a little further on to this very
interesting point when dealing with the extraction
of foreign bodies and the treatment of cerebral
abscesses.

**Meningitis**

Acute diffuse meningitis is without doubt the most
formidable of all the complications of wounds of the
skull, as it kills the patient in the period immediately
following the wound. It never shows itself in wounds
of the skull which do not involve the dura mater,
and it is probable that in the few cases described as
exceptions to this rule there was fracture of the vault
spreading to the base, or even extra-dural collections
opening into the subarachnoid space (see de Joltrain).

As I have said several times, it is common for a
missile fracturing the vault of the skull to give rise
to fissures which often extend a long way down to
the base. These fissures nearly always lacerate the
dura mater, which is very adherent in this region,
and the sub-dural space may then communicate
with the exterior by means of the ear or the nasal
fossae. From this special point of view the use of
the gouge-forceps to break away piecemeal the edges
of a bony gap in the vault is very bad when there are
fissures. With the gouge-forceps the bone is fractured
by a powerful levering and rocking movement rather
than cut. In the course of this, fissures of trifling
length may be extended into the base of the skull.

Fractures of the vault without basal fissures and
without damage to the dura mater are so trifling, that
they should not be classed in the same category as
fractures of the skull with meningeal lesions. Wounds
of the skull with an injury of the dura mater are
always very serious, and frequently become the seat
of meningitis. The infection of the meninges, as I
urged at the beginning of this book, is contemporaneous with the wound, but at that moment it is a meningitis localised to the circumference of the damaged area. The oedema of the brain applies the surface of the organ firmly to the deep aspect of the dura mater, and favours the formation of adhesions and limitation of the infection; but unfortunately this does not always happen. Is it possible to prevent meningitis by operation? I have but little faith in it, and I am convinced that the best chance of avoiding it is rather by abstaining from any interference, however slight. If, however, one studies the publications which have appeared during the last two years on this subject, one finds that surgeons have the idea that early operation, particularly in the form of wide removal of the skull and removal of all splinters, is especially potent against this accident. It would seem as if the mechanism by which these practices are to be carried out were evident, because nobody takes the trouble to give any information on this subject. It seems that the rule is to open up the wound widely, whatever may be its seat, without paying any regard to its topography, and this is an excellent rule, but it is a mistake to imagine that a deep wound of the brain can be opened up by trephining the skull over it. As a matter of fact, nothing is laid open by such an operation; all the ramifications of the brain-wound have not been laid bare, nor has a tunnel filled with infective fluids been converted into a wide-open and easily-drained trench. Even if this had been done, it might be a useful precaution against encephalitis, but not against meningitis. Attentive reflection on what goes on at the periphery of the meningeal wound will enable one readily to understand that any introduction of instruments between the meninges and the brain can only carry the infection a little further
forward below the dura mater, and it is certainly best to limit oneself to practising a cautious trephining, as I have pointed out above.

Some authors have recommended repeated lumbar punctures on men with skull-wounds in order to prevent infection of the meninges. I must confess that such a practice appears to me utterly incomprehensible. The first effect of lumbar puncture is to diminish the volume of the brain, which in shrinking detaches itself from the meninges to which it was adhering. The sub-dural space from being practically only a potential cavity thus becomes a real one, and opens itself widely to infection; this is all that is gained.

Later on, when meningitis is established, and in order to do something, a fairly large quantity (20 to 30 cubic centimetres) of cerebro-spinal fluid can be removed by puncture and replaced by 15 to 20 cubic centimetres of electrargol. This practice is justified by the following reasons: In the course of acute meningitis there is always great hypertension, which is diminished by puncture. Puncture, by diminishing the quantity of the cerebro-spinal fluid, at the same time diminishes the quantity of the toxines contained in it. The injection of electrargol perhaps acts as a microbicicide and antitoxic. By following this method I have certainly seen some cases of acute meningitis cured, but I have seen very few, and it is also possible that they might have got well by other treatment, or by none at all.

To sum up. There is no treatment for acute diffuse meningitis. Preventive treatment of this formidable complication consists, in cases of wounds of the skull without lesions of the dura mater, in treating the bone lesion so as to prevent the formation of an intra-cranial abscess. (The frequency of the formation of these abscesses and their opening into the
subarachnoid space through the ulcerated dura mater is far from being proved.) The treatment, in cases of wounds of the skull complicated by injury to the dura mater and lesions of the brain, consists in trephining with extreme caution, and interfering as little as possible with the protective adhesions already formed.

Finally, when the gouge-forceps are used the greatest care must be taken to use them as a cutting rather than as a breaking instrument.

**Encephalitis and Cerebral Abscess**

The patient who escapes meningitis during the ten days or fortnight following on his wound has great chances of not succumbing to this complication, but for weeks and months he continues to be threatened with encephalitis. During my stay in the base hospitals I saw many trephined patients who to all appearance had long been cured die of this complication. The general condition of such patients declines progressively, but they present no clear symptoms. They get thin, lie in bed, have no energy, and after remaining for a varying time in this condition, they suddenly die. Against such accidents the surgeon is entirely unarmed if the infection does not localise itself. But, fortunately, the encephalitis often gets localised, and a cerebral abscess makes its appearance. The abscess has no clear symptoms any more than the encephalitis, which allow one to diagnose or locate it. But when a patient begins to go downhill, no matter at what period of the case, this complication must be thought of and action taken accordingly. The encephalitis and the abscess develop around the missile when it still lies in the brain, or else in the damaged zone when there is no missile present. In the latter case the abscess is generally superficial and easily accessible.
I shall consider in succession the various cases which may arise.

1. The wound of the skull and brain was comparatively superficial, and there has never been a projectile enclosed in it.—In this case a temporary osteo-plastic flap must be raised at the level of the scar and the dura mater widely exposed. Generally the latter does not pulsate. Most often it is adherent to the brain over a wide area, and special care must be taken not to destroy these adhesions. The brain is often slightly herniated through the old wound in the dura mater. At this point a large needle may be pushed into the brain without any risk of infecting the meningeal cavity, bearing in mind the situation of the ventricle. The needle is pushed steadily onwards, and when the pus is found it is evacuated by an incision parallel to the direction of the subjacent convolution, through the old laceration in the dura mater, and as far as possible without going beyond it. Drainage is effected with a cigarette-drain, which emerges through the opening in the bone made by the projectile in the centre of the osteo-plastic flap. Subsequently prolonged irrigations are carried out with warm dilute iodine solution. The drain should not be withdrawn as soon as the oozing of pus has ceased, for early removal is often followed by rapid re-formation of the abscess.

2. When there is a retained missile.—In the great majority of cases of this type the abscess forms round the foreign body, and the best way to evacuate it is to extract the latter (see Extraction of Projectiles).

3. When there has been a missile embedded but this has been extracted long before the formation of the abscess.—These are certainly the most puzzling cases. If the missile was seated in the centre of the damaged area the abscess will be there also, and will be easy to find; but it often happens that the projectile is
situated a long way from the area of the injury, and the abscess which develops around it, or rather round the foreign bodies which it has drawn in with it, is far from the lesion in the skull. The situation of the latter is therefore no guide to the abscess, which will be very difficult to find in the absence of a projectile, unless this gives rise to localising symptoms.

It would be a good thing if surgeons at the front would tattoo on the scalp of the subjects they operate upon the three points used for the employment of Hirtz's compass when the foreign body was removed, and that they should give each patient the radiographic diagram necessary for this. Then the surgeon at the base will be able to centre the instrument, and to approach with much greater chance of success many abscesses which do not give any localising symptoms.

Cerebral Hernia

The causes of cerebral hernia are various; it sometimes indicates hypertension of the cerebro-spinal fluid symptomatic of a ventricular meningitis which most frequently ends fatally. This kind of hernia is analogous to that observed in patients who have had a decompression performed with incision of the dura mater. It diminishes under the influence of lumbar puncture, and increases when the patient is in the horizontal position. If it be punctured, it is easy to tap the dilated ventricular cavity, and more or less modified cerebro-spinal fluid is withdrawn. This kind of cerebral hernia in a patient with a head-wound has an indifferent prognosis. Its treatment is one of those which is set up against meningitis in vain.

Beside cerebral hernia due to hypertension, we must consider that which often accompanies a cerebral abscess developed about the area of injury. The
mechanism of this is easy to understand. That portion of the brain in which the abscess is developing increases in volume and projects outwards. To this cause, as in the preceding case, is often added a certain degree of hypertension of the cerebro-spinal fluid. The puncture of such a hernia must be made with a trocar large enough to give free passage to more or less thick pus. It will often be necessary to practise aspiration by means of a syringe, therefore it is well to have one with a nozzle adaptable to a trocar or a very large needle. If necessary Potain's apparatus can be used, but only a very low vacuum should be employed, otherwise the cerebral substance will be drawn into the needle, which will get stopped up. The treatment of this form of hernia is similar to that of the cerebral abscess, of which it is symptomatic. The brain must be incised over it and drained (see Cerebral Abscess).

In both the cases just described the cause of the hernia is primarily an increase in the volume of the brain combined with dilatation of the ventricular cavities or the formation of an abscess, but as soon as the hernia is formed it protrudes from the skull through the trephine hole, and then there may be strangulation of its pedicle by the orifices in the dura mater and bone through which it passes. Ödema of the herniated portion then occurs with vascular thrombosis and sloughing. These phenomena are of only secondary importance when they are merely symptoms added to the alarming syndrome of meningitis or cerebral abscess, but they become of primary importance in those early hernias of which the mechanism and the treatment have been so well studied by Leriche (Leriche, Lyon chirurgical, May–June 1916).

Apart from any infection of the meninges or the brain, the latter becomes swollen and ödematous in
the region of the damaged area. This is a general result of contusion, whatever organ be affected.

At the beginning of this little work I laid great stress on this local oedema, which applies the brain to the deep aspect of the dura mater and isolates the great meningeal cavity from the infected region by allowing protective adhesions to form, and strongly urged the necessity of not breaking down these adhesions. This oedema of the brain certainly favours the formation of a hernia through the aperture in the skull. If, in addition, the patient is operated on with his head low and under chloroform, or if he vomits during and after the operation, there will be a still greater chance of a persistent hernia being produced. Its strangulation by the dura mater and the bone causes further increase of its volume. This strangulation is proved by the deep furrow to be seen in the pedicle of these hernias when it is freed by enlarging the trephine opening. The mechanism of these hernias is one of the reasons which make me recommend the large temporary osteo-plastic flap. By this method the damaged region is very widely decompressed, and the brain heaves up the whole flap instead of entangling itself in the bony gap in its centre. Unfortunately this method of procedure is very little known.

The course of these hernias is variable. Some diminish and are cured spontaneously. In other cases the herniated brain tissue, which is always much smaller than it is thought to be, becomes gangrenous, and the portion which forms the base of the hernia gets covered with granulations which undergo cicatrization. In other cases the herniated cerebral tissue gets infected progressively, and a slow form of encephalitis may end in death.

The formation of these hernias must be avoided as much as possible. To this end the operation must
be performed under local anaesthesia, which avoids vomiting and the increased intra-cranial pressure that results from it, and with the patient sitting up in order to avoid congestion of the cerebral veins and the increase in volume of the organ which it entails. Whenever it is possible, a temporary osteoplastic flap is cut in the way already described. This flap widely decompresses the brain and allows itself to be pressed up, and so gets rid of most of the conditions favourable to the formation of cerebral hernias of mechanical origin. When the hernia has formed, it seems that the best thing, as Leriche has clearly pointed out, is to enlarge the trephine opening until healthy bone and dura mater are exposed. This is the essential part of what he says on this subject:

"Early cerebral hernia is seen after inadequate trephining. They are really perfectly curable if we regard them as the mechanical result of a permanent local irritation due to an inadequate trephining, and treat them by enlarging the opening in the bone until we meet with healthy dura and brain tissue."

"Early cerebral hernia appears as the result of a phenomenon which is primarily mechanical and vascular, and everything goes on as if the hernia were caused by a local oedema of the contused brain, pushing it through the opening in the dura and getting it strangulated there because an inadequate bony opening causes faulty circulatory conditions to persist in the contused area."

"The displaced and contused brain matter occupying more than its normal space is cooped up in its envelopes and seeks for more room. In order to effect a cure it must be given room by performing a local decompression. Cerebral wounds, like every serious wound received in war, can only be cured by being given plenty of room; therefore the opening in the bone must be enlarged."
“Where this has been done, and the stricture at the base of the hernia has been relieved, the course of the hernia is as follows:—

“1. The hernia first increases in volume because its tightly grasped pedicle broadens out and the dura mater in the affected area is no longer restrained by bone and protrudes. Sometimes there is a temporary exaggeration of the objective symptoms (paresis), but as a rule the patients are very soon better.

“2. At the end of a fortnight, seldom sooner, and sometimes after two or three days of pyrexia, the hernia is seen to shrink a little without apparent cause.

“3. After this it will be noticed that the hernia pulsates more strongly, and its size varies according to the position of the head. It diminishes when the head is erect, and increases when the patient lies down. This phenomenon is very surprising when first seen. This is the explanation: The hernia consists of a cerebral base surmounted by a layer of blood-clot and more or less waxy granulations with a necrotic aspect. When the process of cure is well started, this superficial stratum, which appears to be rather thick, becomes continuous with the dura mater, which it seems to prolong; the demarcation between the two can no longer be seen, and, in fact, this is a layer which becomes organised and forms the future dura mater or, rather, the newly-formed fibrous lamina which will represent it.

“Little by little, and no doubt partly as a result of the pressure that the cerebral-spinal fluid is always exercising around the neck of the hernia, and partly as a result of the pulsation of the brain, cleavage occurs between the two strata composing the hernia, and the brain parts company little by little with its limiting membrane.
“If lumbar puncture be performed at this stage the hernia sinks down completely, and there is a deep intra-cranial depression over which the edges of the bony gap can be made out. But lumbar puncture provokes violent headache, and is often followed by a mild attack of meningeal inflammation. It serves no useful purpose to provoke this even if it is not dangerous, and therefore I never do lumbar puncture at this stage.”

The cutting of an osteo-plastic flap with the orifice which gives passage to the hernia as its centre is an admirable substitute for the enlargement of the bony gap suggested by Leriche.

Epilepsy

Epilepsy is a common and comparatively late complication of injuries of the skull. Before the war I operated on a number of traumatic epilepsies with very little success, but I have never hesitated to do an operation which I consider absolutely without risk, since it consists in lifting a permanent or temporary flap in the affected region, and since by following the above procedure I have never had the slightest trouble.

I have likewise had frequent opportunities of operating for this complication among the wounded. I have had neither improvement nor cure except when the convulsive crises were due to localised compression of the brain by a splinter or a foreign body. In every other case I have had only very temporary cures, which some surgeons might have published as permanent ones. Everyone who has had any experience of cerebral surgery knows how easy it is to cure an epileptic for a few weeks or months, and how difficult it is to cure him permanently.

It is certain that a splinter must be removed when
it presses on the brain, but it is absurd to open the dura mater on the pretext of separating adhesions which re-form more firmly than ever after the operation, and I have never done such a thing. For those who show epileptic fits which appear to be directly connected with a cerebral cicatrix I employ radiotherapy, and get good results. The X-rays which make cutaneous cicatrices so wonderfully flexible may very possibly not be without action on cicatrices of the brain.

Radium would probably have an analogous action. If, as I hope, I have some lasting successes by this method to record, I shall not hesitate to facilitate the action of the rays over the whole extent of the cicatrices by cutting an osteo-plastic flap which I shall raise at each application of the radiotherapy. Foreign bodies enclosed in the brain may also be the cause of epileptic crises. Their removal is necessary, but it will only bring about a cure in exceptional cases.
CHAPTER V

EXTRACTION OF PROJECTILES

A projectile in the brain ought to be removed. If it be easily accessible, superficial, and right in the injured area, it is found and removed during the careful cleaning up of the wound. If necessary it can be found by the aid of the fluorescent screen.

If it lies deeply or is in some part of the brain far removed from the damaged area it should be extracted when found by one of the numerous devices for the purpose, which differ from one another more in appearance than principle. When the missile has become lodged in the brain far away from the point of entry and is being well tolerated, there is some risk of infecting its original track afresh if it be removed by the route that it followed, and it is better to remove it by another route. This choice of route must be carefully studied; it must traverse only a silent zone of the brain, and must only involve operative injuries that leave no functional troubles behind. Therefore the surgeon must always have before his mind the position of the various cortical centres, and the course of the fibres running from them.

From this point of view comparison of an examination both before and after operation is instructive, and may sometimes result in giving food for reflection.
to the surgeon who looks upon the brain as a homogeneous functionless mass.

It would be well to tattoo three dots which cannot be effaced on the scalp to serve as bench-marks for setting up the localisation apparatus, which I assume to be Hirtz's compass. By the help of this tattooing the wounded man, accompanied by his diagram, can furnish the surgeon under whose care he comes at any surgical centre with the means of discovering the seat of the cerebral abscess which so often develops at the site of a foreign body which has been removed some time previously. If this method were adopted it would be of great service.

**Removal of the Foreign Body**

The search can be made under the fluorescent screen. This is the best method when the search is carried out through the hole in the skull produced by the projectile and does not go beyond the limits of the damaged area. In this case the jaws of the forceps, which move about freely from side to side and up and down, act in a cerebral pulp which is entirely without value; they destroy nothing. I reject this method entirely when search has to be made for a bullet or piece of shell situated deeply in healthy brain tissue along some other route than that followed by the missile. In this case I prefer the electromagnet to any other procedure when the foreign bodies to be dealt with are magnetic. For this purpose I conceived the idea of using a Hirtz apparatus made entirely of copper, except the indicator probe, which is of soft iron. This probe is passed on to the foreign body, which it locates, and is then magnetised by influence and becomes a withdrawal rod. My friend, Dr Mondain, to whom I submitted this idea, has been good enough to assist
me in working it out, and with the collaboration of M. Malaquin we have been making researches on this subject for the last eight months. We have met with many difficulties, which I hope will soon be surmounted.

My friend, Dr Tanton, has just completed an apparatus on the same principle, which he has presented to the Société de Chirurgie, but he has said nothing about the numerous causes of failure to which I have alluded, nor how to avoid them.

It is difficult to obtain sufficient magnetisation of the withdrawal rod. The idea which naturally occurs to the mind is to make this rod form the core of the electromagnet, but an apparatus with only a very feeble power of attraction is obtained in this way. In order to magnetise the rod powerfully we act by influence, using a very large electromagnet which weighs 80 kilos and has an attraction force of 160 kilos.

It is easy to imagine the difficulties in the manipulation of a delicate instrument of precision created by the introduction of such a mass. M. Malaquin has overcome this difficulty with much ingenuity. In spite of the very powerful magnetisation of the withdrawal rod the latter often lets go the foreign body which it is its duty to bring out.

In order to ascertain exactly what takes place in such a case we have experimented with pieces of shell enclosed in a transparent medium of a consistency identical with the brain substance. We have ascertained that when the projectile comes into contact with the withdrawal rod by a pointed extremity the adhesion is bad; in spite of that, by making several attempts one generally succeeds in bringing out the foreign body.

In a case like this the withdrawal rod must be made to touch the projectile more than once without
pushing the latter deeper down into the brain. For this reason it is necessary to operate under the control of the radioscope in such a way as to stop immediately contact is re-established.

Fig. 58 is from an article by Cushing, which shows very well the advantage of using a localisation apparatus to guide the withdrawal rod to the foreign body. In this figure the magnetised shank is clearly seen to miss the projectile by the side of which it has passed.

Unfortunately this procedure with the electromagnet cannot be applied to leaden bullets, and in this case we replace the magnetised indicator probe

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**Fig. 58.**—Illustration from an article by Cushing showing the magnetised shank missing the projectile and passing by the side of it.

**Fig. 59.**—Magnetised withdrawal rod used by Cushing.
by a rod provided at its extremity with two jaws analogous to those of the forceps for the extraction of foreign bodies from the œsophagus. This forceps must be brought almost into contact with the foreign body, opened, pushed forward, and then closed on it. It can then be drawn out without groping about, and all these manipulations are controlled by the radioscope.

There is nearly always some infected cerebral tissue around the foreign body, sometimes even an abscess, therefore it is necessary to drain by means of a cigarette-drain, which is threaded on to the localising shank of Hirtz's apparatus, so as to get it in a good position (see Abscess on the Brain).

The trephine hole which is to give access to the foreign body will generally be just large enough to allow it to pass, and will not need to be enlarged.
CHAPTER VI

CRANIOPLASTY

For a patient with a wound of the skull the method of operation adopted by all surgeons is to make a large opening in the skull, with the orifice made by the projectile as its centre. From this there result extensive losses in the cranial wall, which do not cause any great inconvenience. However, many of the wounded are concerned about them, and some may even be really inconvenienced; there is nevertheless very seldom any imperative indication for a cranioplasty. Cranioplasty is indicated to protect the brain when it is very widely exposed; in such a case a blow upon the exposed region might have serious consequences. It is also indicated when the loss of substance is situated in the frontal region and entails an unsightly deformity. It should be preceded by a careful examination of the wounded man. Any patient presenting signs of even slight hypertension must have his skull left open; closing the opening may then have troublesome consequences, as I have observed, and as many neurologists have likewise remarked.

Protection for the brain and the re-establishment of the shape of the skull are all that is necessary and all that should be asked for from this operation. It is absurd to employ it to reduce by force cerebral hernias, even when of small volume, and it must not
be expected that it will cause vertigo and the various troubles, which the wounded men attribute to the trephining, to disappear.

Many wounded men have small trephine holes about an inch in diameter which have generally been made for the purpose of exploration. Often the dura mater has not been opened, and the brain can scarcely be seen pulsating in the centre of the hole in the skull. These men do not generally require a cranioplasty, as their brains are practically not exposed. Moreover, the deformity is insignificant when it is at the summit or the sides of the head. It is only in the frontal region that it gives rise to an ugly appearance. In my opinion, therefore, except in the frontal region, cranioplasty is useless for small trephinings, which are much the most frequent, because they have been done on men who had but little the matter with them and have survived. Some few patients who have recovered from very serious skull injuries show large losses of bone over which the skin is often largely replaced by cicatricial tissue which pulsates synchronously with the brain. In these cases protective cranioplasty is certainly indicated, but often it cannot be done. In order to implant successfully a shield of any kind of material under the skin it is necessary to be able to cover it with supple and tough integuments, but in such cases the integuments are generally wanting. I have twice tried to do this, and both times I had much trouble to achieve only a partial success.

Many procedures have been suggested for closing cranial defects. I shall only refer to two—cranial prosthesis by metallic plates, and cranioplasty by the use of costal cartilages, or Morestin's method.

The first of these procedures is well known, and easy to apply if the material and the necessary collaborators are available; it gives good immediate
results, but the metallic plates are not always tolerated indefinitely.

Morestin's procedure, as that surgeon has described it, is excellent, and gives the best aesthetic results. I do not think that it is very efficacious in protecting the brain, because the costal cartilages employed do not weld together well, and do not unite to the bone at all. One, two, or three cartilages are taken—the 6th, 7th, and 8th, or preferably the 7th, 8th, and 9th—and these are used just as they are, or cut into small pieces which, when arranged one on the other, cover up the loss of substance. Morestin has described his procedure at full length in the *Bulletins de la Société de Chirurgie*, and has obtained all the results which he had foretold. I have myself used Morestin's procedure with perfect success.

Gosset, taking up the subject from a special point of view, believed that Morestin's procedure should be modified. Every surgeon having any experience of nerve surgery will be surprised to read what he has written on the subject; I quote textually:—

"For my part, I have said that I prefer to apply to the bone defect a true cartilaginous covering made of a single piece and semi-rigid, this semi-rigidity being in a certain number of cases indispensable to resist the thrust of the brain, and still more to allow of the reduction and the retention of a cerebral hernia.

"In one of my cases, for instance, there was a cerebral hernia half the size of an orange; by means of a large cartilaginous plate, firm and yet pliable, I was able completely to reduce, and keep reduced, this cerebral hernia, the thrust of which was really considerable. With strips of cartilage, and especially with mere chips, the maintenance of the reduction would have been impossible." (Bulletin Soc. Chirurgie, March 7, 1916.)
In order to appreciate the surprise which these lines are calculated to produce on a surgeon accustomed to the surgery of the brain, it is enough to know that a difference of a few cubic centimetres more or less in the capacity of the skull, or in the volume of its contents, involves the death of the patient, or, on the other hand, his recovery. Not only compression of but simple pressure on the brain sometimes entails serious accidents, and I do not think that Gosset's method of procedure should be adopted.

Therefore we must keep to Morestín's excellent procedure. Its only drawback is that it requires a preliminary operation, which is not always pleasant for the patient, and may sometimes lead to a serious pleural complication if it be inexpertly done.

In short, I am of opinion that there must be no haste to close in trephine holes, and that the best argument for doing so is the aesthetic one. Morestín's procedure, when it is agreed to by the patient and practised by an expert operator, is very much to be recommended. Metallic prosthesis is difficult to carry out just now, and should be reserved for patients who object to the preparatory operation required by Morestín's procedure.
CHAPTER VII

LUMBAR PUNCTURE

Lumbar puncture is of great service in the treatment of patients with skull-wounds, because it is an easy and harmless means of diminishing intra-cranial tension. It must be used with great caution in the early days of the case, for reasons which I have stated already. Later on, on the other hand, it may be repeated more frequently, and it is my custom to do lumbar puncture on subjects with skull-wounds who are on the way to recovery as soon as they complain of headache or vertigo. It will be as well to take advantage of the lumbar puncture to measure the tension of the cerebro-spinal fluid with Claude’s manometer. The figure found has only a comparative value, and should be merely compared with the figures obtained later on in the same patient.
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18, WARWICK SQUARE, LONDON, E.C. 4

PARIS:

MASSON ET Cie., 120, Boulevard St. Germain.
Extract from
the Introduction by the General Editor,
Sir Alfred Keogh.

The special interest and importance, in a surgical sense, of the great European War lies not so much in the fact that examples of every form of gross lesion of organs and limbs have been seen, but is to be found in the enormous mass of clinical material which has been presented to us and in the production of evidence sufficient to eliminate sources of error in determining important conclusions. For the first time also in any campaign the labours of the surgeon and the physician have had the aid of the bacteriologist, the pathologist, the physiologist and indeed of every form of scientific assistance in the solution of their respective problems.

The achievements in the field of discovery of the chemist, the physicist and the biologist have given the military surgeon an advantage in diagnosis and treatment which was denied to his predecessors, and we are able to measure the effects of these advantages when we come to appraise the results which have been attained.

But although we may admit the general truth of these statements it would be wrong to assume that modern scientific knowledge was, on the outbreak of the war, immediately useful to those to whom the wounded were to be confided. Fixed principles existed in all the sciences auxiliary to the work of the surgeon, but our scientific resources were not immediately available at the outset of the great campaign; scientific work bearing on wound problems had not been arranged in a manner adapted to the requirements,
were not fully foreseen; for the workers in the various fields were isolated or had isolated themselves pursuing new researches rather than concentrating their powerful forces upon the one great quest.

However brilliant the triumphs of surgery may be, and that they have been of surpassing splendour no one will be found to deny, experiences of the war have already produced a mass of facts sufficient to suggest the complete remodelling of our methods of education and research.

The series of manuals, which it is my pleasant duty to introduce to English readers, consists of translations of the principal volumes of the "Horizon" Collection which has been appropriately named after the uniform of the French soldier.

The views of great authorities, who derive their knowledge from extensive first-hand practical experience gained in the field cannot fail to serve as a most valuable asset to the less experienced, and must do much to enable them to derive the utmost value from the experience which will, in time, be theirs. The series covers the whole field of war surgery and medicine, and its predominating note is the exhaustive, practical and up-to-date manner in which it is handled. It is marked throughout not only by a wealth of detail, but by clearness of view and logical sequence of thought. Its study will convince the reader that, great as have been the advances in all departments in the services during this war, the progress made in the medical branch may fairly challenge comparison with that in any other, and that not the least among the services rendered by our great Ally, France, to the common cause, is this brilliant contribution to our professional knowledge.
THE TREATMENT OF INFECTED WOUNDS


"Is as fine an example of correlated work on the part of the chemist, the bacteriologist, and the clinician as could well be wished for, and bids fair to become epoch-making in the treatment of septic wounds.

"I am glad to take the opportunity of expressing the appreciation of British Surgeons at the Front of the value of what is known to us as Carrel's method. The book itself will be found to convey in the clearest manner the knowledge of those details which have been so carefully elaborated by the patient work of two years' experience, but it is only by scrupulous attention to every detail that the best results will be obtained . . .

"The utility of Carrel's method is not confined to recent wounds, and in the following pages those surgeons who are treating the wounded in Great Britain will find all the necessary information for the treatment of both healthy and suppurating wounds."—From Sir Anthony Bowlby's Introduction.

This volume is included by arrangement with Messrs. Baillière, Tindall and Cox.
THE PSYCHONEUROSES OF WAR

By Dr. G. ROUSSY, Assistant Professor in the Faculty of Medicine, Paris, and J. LHERMITTE, sometime Laboratory Director in the Faculty of Medicine, Paris. Edited by Colonel WILLIAM ALDREN TURNER, C.B., M.D., and Consulting Neurologist to the Forces in England. Translated by WILFRED B. CHRISTOPHERSON. With 13 full-page plates. Price, 6s. net. Postage 5d. extra.

The Psychoneuroses of War being a book which is addressed to the clinician, the authors have endeavoured, before all else, to present an exact semeiology, and to give their work a didactic character.

After describing the general idea of the psychoneuroses and the methods by which they are produced, the authors survey the various clinical disorders which have been observed during the War, beginning with elementary motor disturbances and passing on through sensory disorders and disorders of the special senses to disturbances of a purely psychical character. Under the motor system, affections such as paraplegia, the tics and disturbances of locomotion are detailed; under the sensory system, pains and anaesthesias are passed in review; under disorders of the special senses, deafness and blindness are studied; then follows a detailed account of the visceral symptoms and finally some types of nervous attacks and lastly the psychical disorders.

A special chapter is given to a consideration of cerebral concussion and a review of the symptoms following the explosion of shells in close proximity to the soldier. The book ends with a survey of the general etiology of the psychoneuroses of war, the methods of treatment adopted and used successfully by the authors, and finally the points bearing upon the invaliding of the soldier and his discharge from the Army.
THE CLINICAL FORMS OF NERVE LESIONS

By Mme. ATHANASSIO BENISTY, House Physician of the Hospitals of Paris (Salpêtrière), with a Preface by Prof. PIERRE MARIE. Edited with a Preface by E. FARQUHAR BUZZARD, M.D., F.R.C.P., Captain R.A.M.C.T., etc. With 81 illustrations in the text, and 7 full-page plates. Price, 6s. net. Postage 5d. extra.

In this volume will be found described some of the most recent acquisitions to our knowledge of the neurology of war. But its principal aim is to initiate the medical man who is not a specialist into the examination of nerve injuries. He will quickly learn how to recognise the nervous territory affected, and the development of the various clinical features; he will be in a position to pronounce a precise diagnosis, and to foresee the consequences of this or that lesion. In this way his task as military physician will be facilitated.

With this end in view considerable space has been devoted to the illustrations, which are intended to remind the physician of the indispensable anatomical elements, and the most striking clinical pictures. Numerous diagrams in black and white enable him to effect the essential work of localisation. The diagnosis of nervous lesions is thus facilitated.

A second volume will be devoted to the study of the lesions themselves, together with their restoration, and all the methods of treatment which are applicable to such lesions. This will appear immediately.

Together these volumes will represent a complete epitome of one of the principal departments of "war neurology."
THE TREATMENT AND REPAIR OF NERVE LESIONS


The other book published by Mme. Athanassio Benisty, which was devoted to the Clinical Features of Injured Nerves, explained the method of examination, and the indications which enable one to differentiate the injuries of the peripheral nerves. It is a highly practical guide, which initiates in the diagnosis of nervous lesions those physicians who have not hitherto made a special study of these questions. —This second volume is the necessary complement of the first. It explains the nature of the lesions, their mode of repair, their prognosis, and above all their treatment. It provides a series of particularly useful data as to the evolution of nerve-wounds—the opportunities of intervention—and the prognosis of immediate complications or late sequelae.

But it is especially the application of prosthesis which constitutes the principal therapeutical innovation by which our “nerve cases” have benefited. All these methods of treatment ought to be made commonly known, and a large space has been reserved for them in this volume, which will not only furnish an important contribution to the science of neurology, but will enable the medical profession to profit by the knowledge recently acquired in respect of the diagnosis, prognosis, and treatment of nerve-wounds.

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The author's primary object has been to produce a handbook of *surgical therapeutics*. But surgical therapeutics does not mean merely the technique of operation. Technique is, and should be, only a part of surgery, especially at the present time. The purely operative surgeon is a very incomplete surgeon in time of peace; "in time of war he becomes a public disaster; for operation is only the first act of the first dressing."

For this reason Prof. Leriche has cast this book in the form of a compendium of articular therapeutics, in which is indicated, for each joint, the manner of conducting the treatment in the different stages of the development of the wound. In order to emphasize their different periods he has described for each articulation:

1. The anatomical types of articular wounds and their clinical development.—2. The indications for immediate treatment at the front.—3. The technical indications necessary for a good functional result.—4. Post-operative treatment.—5. The conditions governing evacuation.—6. The treatment of patients who come under observation at a late period.
The Treatment of Fractures

By R. Leriche, Assistant Professor in the Faculty of Medicine, Lyons. Edited by F. F. Burghard, C.B., M.S., F.R.C.S. Formerly Consulting Surgeon to the Forces in France.

Vol. II. Fractures of the Shaft. With 156 illustrations from original and specially prepared drawings. Price, 6s. net. Postage 5d. extra.

Vol. I. of this work was devoted to Fractures involving Joints; Vol. II. (which completes the work) treats of Fractures of the Shaft, and is conceived in the same spirit—that is, with a view to the production of a work on conservative surgical therapeutics.

The author strives on every page to develop the idea that anatomical conservation must not be confounded with functional conservation. The two things are not so closely allied as is supposed. There is no conservative surgery save where the function is conserved. The essential point of the treatment of diaphysial fractures consists in the early operative disinfection, primary or secondary, by an extensive sub-periosteal removal of fragments, based on exact physiological knowledge, and in conformity with the general method of treating wounds by excision. When this operation has been carefully performed with the aid of the rugine, with the object of separating and retaining the periosteum of all that the surgeon considers should be removed, the fracture must be correctly reduced and the limb immobilized.

For each kind of fracture the author has given various methods of immobilization, and examines in succession: the anatomical peculiarities—the physiological peculiarities—the clinical course—the indications for early treatment—the technical steps of the operations—and the treatment of those who only come under observation at a late period.
FRACTURES OF THE LOWER JAW


Previous to the present war no stomatologist or surgeon possessed any very extensive experience of this subject. Claude Martin, of Lyons, who perhaps gave more attention to it than anyone else, aimed particularly at the restoration of the occlusion of the teeth, even at the risk of obtaining only fibrous union of the jaw. The authors of the present volume take the contrary view, maintaining that consolidation of the fracture is above all the result to be attained. The authors give a clear account of the various displacements met with in gunshot injuries of the jaw and of the methods of treatment adopted, the latter being very fully illustrated.

In this volume the reader will find a hundred original illustrations, which will enable him to follow, at a glance, the various techniques employed.
Grounding his remarks on a considerable number of observations, Professor Lagrange arrives at certain conclusions which at many points contradict or complete what we have hitherto believed concerning the fractures of the orbit: for instance, that traumasms of the skull caused by fire-arms produce, on the vault of the orbit, neither fractures by irradiation nor independent fractures; that serious lesions of the eye may often occur when the projectile has passed at some distance from it. There are, moreover, between the seat of these lesions (due to concussion or contact) on the one hand, and the course of the projectile on the other hand, constant relations which are veritable clinical laws, the exposition of which is a highly original feature in this volume.

The book is thus far more than a mere "document," or a collection of notes, though it may appear both; it is, on the contrary, an essay in synthesis, a compendium in the true sense of the word.
HYSTERIA OR PITHIATISM, AND REFLEX NERVOUS DISORDERS

By J. BABINSKI, Member of the French Academy of Medicine, and J. FROMENT, Assistant Professor and Physician to the Hospitals of Lyons. Edited with a Preface by E. FARQUHAR BUZZARD, M.D., F.R.C.P., Captain R.A.M.C.T., etc. With 37 illustrations in the text and 8 full-page plates. Price, 6s. net. Postage 5d. extra.

The number of soldiers affected by hysterical disorders is great, and many of them have been immobilized for months in hospital, in the absence of a correct diagnosis and the application of a treatment appropriate to their case. A precise, thoroughly documented work on hysteria, based on the numerous cases observed during two years of war, was therefore a necessity under present conditions. Moreover, it was desirable, after the discussions and the polemics of which this question has been the subject, to inquire whether we ought to return to the old conception, or whether, on the other hand, we might not finally adopt the modern conception which refers hysteria to pithiatism.

This book, then, brings to a focus questions which have been especially debated; it does not appeal exclusively to the neurologist, but to all those who, confronted by paralysis or post-traumatic contractures, convulsive attacks, or deafness provoked by the bursting of shells, have to grapple with the difficulties of diagnosis and ask themselves what treatment should be instituted. In it will be found all the indications which are necessary to the military physician, summarized as concisely as is possible in a few pages and a few illustrations.


Of all the medical works which have appeared during the war, this is certainly one of the most original, both in form and in matter. It is, at all events, one of the most individual.

The authors have preferred to give only the results of their own experience, and if their conclusions are not always in conformity with those generally accepted, this, as Professor Pierre Marie states in his Preface, is because important advances have been made during the last two years; and of this the publication of this volume is the best evidence.

Thanks to the method of radiographing the convolutions after filling the furrows, which has become sufficiently exact to be of real service to the clinician, the authors have been able to work out a complete and novel cerebral pathology, which presented itself in lamentable abundance in the course of their duties, which enabled them to examine and give continued attention to many thousands of cases of head injuries.

Physicians and surgeons will read these pages with profit. They are pages whose substance is quickly grasped, which are devoid of any display of erudition, and which are accompanied by numerous original illustrations.
LOCALISATION AND EXTRACTION
OF PROJECTILES.

By Assistant-Professor OMBRÉDANNE, of the
Faculty of Medicine, Paris, and M. LEDOUX-
LEBARD, Director of the Laboratory of Radi-
ology of the Hospitals of Paris. Edited by
A. D. REID, C.M.G., M.R.C.S., L.R.C.P.,
Major (Temp.) R.A.M.C., with a Preface on
Extraction of the Globe of the Eye, by Colonel
W. T. LISTER, C.M.G. With 225 illustrations
in the text and 30 full-page photographs. Price,
10s. 6d. net. Postage 6d. extra.

Though intentionally elementary in appearance, this com-
pendium is in reality a complete treatise concerning the
localisation and extraction of projectiles. It appeals to
surgeons no less than to radiologists.

It is a summary and statement—and perhaps it is the only
summary recently published in French medical literature—of
all the progress effected by surgery during the last two and
a half years.

M.M. Ombrédanne and Ledoux-Lebard have not, however,
attempted to describe all the methods in use, whether old or
new. They have rightly preferred to make a critical selection,
and—after an exposition of all the indispensable principles of
radiological physics—they examine, in detail, all those methods
which are typical, convenient, exact, rapid, or interesting by
reason of their originality: the technique of localisation, the
compass, and various adjustments and forms of apparatus. A
considerable space is devoted to the explanation of the method
of extraction by means of intermittent control, in which the
complete superiority of radio-surgical collaboration is
demonstrated.

Special attention is drawn to the fact that the numerous illus-
trations contained in this volume (225 illustrations in the
text and 30 full-page photographs) are entirely original.
WOUNDS OF THE ABDOMEN


Dr. Abadie, who, thanks to his past surgical experience and various other circumstances, has been enabled, at all the stations of the army service departments, to weigh the value of methods and results, considers the following problems in this volume, dealing with them in the most vigorous manner:

1. How to decide what is the best treatment in the case of penetrating wounds of the abdomen.

2. How to instal the material organisation which permits of the application of this treatment; and how to recognize those conditions which prevent its application.

3. How to decide exactly what to do in each special case; whether one should perform a radical operation, or a palliative operation, or whether one should resort to medical treatment.

This volume, therefore, considers the penetrating wounds of the abdomen encountered in our armies under the triple aspect of doctrine, organisation, and technique.

We may add that it contains nearly 70 illustrations, and the reproductions of sketches specially made by the author, or photographs taken by him.
MILITARY MEDICAL MANUALS

WOUNDS OF THE BLOOD-VESSELS

By L. SENCERT, Assistant Professor in the Faculty of Medicine, Nancy. Edited by F. F. BURGHARD, C.B., M.S., F.R.C.S. Formerly Consulting Surgeon to the Forces in France. With 68 illustrations in the text and 2 full-page plates. Price, 6s. net. Postage 5d. extra.

Hospital practice had long familiarised us with the vascular wounds of civil practice, and the experiments of the Val-de-Grâce School of Medicine had shewn us what the wounds of the blood-vessels caused by modern projectiles would be in the next war. But in 1914 these data lacked the ratification of extensive practice. Two years have elapsed, and we have henceforth solid foundations on which to establish our treatment. This manual gathers up the lessons of these two years, and erects them into a doctrine.

In a first part, Prof. Sencert examines the wounds of the great vessels in general; in a second part he rapidly surveys the wounds of the vascular trunks in particular, insisting on the problems of operation to which they give rise.

"I should like it to be clearly understood," he concludes, "that the surgery of the blood-vessels is only a particular case of the general surgery of wounds received in war. There is only one war surgery: the immediate operative surgery which we have been learning for the last two years.

"This rule is never more imperative than in the case of vascular wounds. Early operation alone prevents deferred and secondary haemorrhage; early operation alone can prevent the complications which are so peculiarly liable to result from the effusion of blood in the tissues; early operation alone can obviate subsequent complications. Here, as everywhere, the true and useful surgery is a surgery of prophylaxis."

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THE AFTER-EFFECTS OF WOUNDS OF THE BONES AND JOINTS

By AUG. BROCA, Professor of Topographical Anatomy in the Faculty of Medicine, Paris.
Translated by J. RENFREW WHITE, M.B., F.R.C.S., Temp. Captain R.A.M.C., and edited by R. C. ELMSLIE, M.S., F.R.C.S.; Orthopaedic Surgeon to St. Bartholomew's Hospital, and Surgeon to Queen Mary's Auxiliary Hospital, Roehampton; Major R.A.M.C.T. With 112 illustrations in the text. Price, 6s. net. Postage 5d. extra.

This new work, like all books by the same author, is a vital and personal work, conceived with a didactic intention.

At a time when all physicians are dealing, or will shortly have to deal, with the after-effects of wounds received in war, the question of sequelae presents itself, and will present itself more and more.

What has become—and what will become—of all those who, in the hospitals at the front or in the rear, have hastily received initial treatment, and what is to be done to complete a treatment often inaugurated under difficult circumstances?

This volume successively passes in review: vicious calluses—prolonged and traumatic osteo-myelitis (infected stumps)—articular and musculo-tendinous complications—and "dissolving" calluses—terminating by considerations of a practical nature as to discharged cases.

Profusely illustrated under the immediate supervision of Professor Broca, this volume contains 112 figures, all executed by an original process.
ARTIFICIAL LIMBS

By A. BROCA, Professor in the Faculty of Medicine, Paris, and Dr. DUCROQUET, Surgeon at the Rothschild Hospital. Edited and translated by R. C. ELMSLIE, M.S., F.R.C.S., etc.; Orthopædic Surgeon to St. Bartholomew's Hospital, and Surgeon to Queen Mary's Auxiliary Hospital, Roehampton; Major R.A.M.C.T. With 210 illustrations. Price, 6s. Postage 5d. extra.

The authors of this book have sought not to describe this or that piece of apparatus—more or less "new-fangled"—but to explain the anatomical, physiological, practical and technical conditions which an artificial arm or leg should fulfil.

It is, if we may so call it, a manual of applied mechanics written by physicians, who have constantly kept in mind the anatomical conditions and the professional requirements of the artificial limb.

Required, during the last two years, to examine and equip with appliances hundreds of mutilated soldiers, the authors have been inspired by this guiding idea, that the functional utilisation of an appliance should take precedence of considerations of external form. To endeavour, for æsthetic reasons, to give all subjects the same leg or the same arm is to risk disappointment. The mutilated soldier may have a "show hand" and an every-day hand-implement.

The manufacturer will derive no less profit than the surgeon or the mutilated soldier himself from acquaintance with this compendium, which is a substantial and abundantly illustrated volume. He will find in it a survey and a reasoned criticism of mechanisms which notably display the ingenuity of the makers—from the wooden "peg" of the poor man, together with his "best" leg and foot, to the artificial limb provided with the very latest improvements.
TYPHOID FEVERS AND PARATYPHOID FEVERS (Symptomatology, Etiology, Prophylaxis)

By H. VINCENT, Medical Inspector of the Army, Member of the Academy of Medicine, and L. MURATET, Superintendent of the Laboratories at the Faculty of Medicine of Bordeaux. Second Edition. Translated and Edited by J. D. ROLLESTON, M.D. With tables and temperature charts. Price, 6s. net. Postage 5d. extra.

This volume is divided into two parts, the first dealing with the clinical features and the second with the epidemiology and prophylaxis of typhoid fever and paratyphoid fevers A & B. The relative advantages of a restricted and liberal diet are discussed in the chapter on treatment, which also contains a description of serum therapy and vaccine therapy, and general management of the patient.

A full account is to be found of recent progress in the bacteriology and epidemiology of these diseases, considerable space being given to the important question of the carrier in the dissemination of infection.

The excessive frequency of typhoid fever in war time is demonstrated by a sketch of its history from the War of Secession of 1861-1866 down to the present day.

The concluding chapter is devoted to preventive inoculation, the value of which is proved by the statistics of all countries in which it has been adopted.
DYSENTERIES, CHOLERA, AND EXANTHEMATIC TYPHUS

By H. VINCENT, Medical Inspector of the Army, Member of the Academy of Medicine, and L. MURATET, Director of Studies in the Faculty of Medicine, Bordeaux. With an Introduction by Lt. Col. ANDREW BALFOUR, C.M.G., M.D. Edited by GEORGE C. LOW, M.A., M.D., Temp. Captain I.M.S. Price, 6s. net. Postage 5d. extra.

This, the second of the volumes which Professor Vincent and Dr. Muratet have written for this Series, was planned, like the first, in the laboratory of Val-de-Grâce, and has profited both by the personal experience of the authors and by a mass of recorded data which the latter years of warfare have very greatly enriched. It will be all the more welcome as hitherto there has existed no comprehensive handbook treating these great epidemic diseases from a didactic point of view. The articles scattered through the reviews, or memoirs buried in the large treatises, did not respond to the need which was felt by the military physician, in France as well as in distant expeditions, of a work which should bring to a common focus a number of questions which were, in general, very imperfectly understood.

The authors review, in succession, the Clinical details, the Epidemiology, and Prophylaxis of Dysenteries, Cholera, and Typhus. In the section dealing with Prophylaxis, in particular, will be found practical advice as to the special hygiene possible in the case of large collections of people placed in conditions favourable to the development of these diseases.
ABNORMAL FORMS OF TETANUS


Of all the infections which threaten our wounded men, tetanus is that which, thanks to serotherapy, we are best able to prevent. But serotherapy, when it is late and insufficient, may, on the other hand, tend to create a special type of attenuated and localised tetanus; in this form the contractions are as a general rule confined to a single limb. This type, however, does not always remain strictly monoplegic; and if examples of such cases are rare this is doubtless because physicians are not as yet very well aware of their existence.

We owe to MM. Courtois-Suffit and R. Giroux one of the first and most important observations of this new type; so that no one was better qualified to define its characteristics. This they have done in a remarkable manner, supporting their remarks by all the documents hitherto published, first expounding the characteristics which individualise the other atypical and partial types of tetanus, which have long been recognized.

The preventive action of anti-tetanic serum should not cause us to disregard its curative action, the value of which is incontestable. However, a specific remedy, even when a powerful specific, cannot act upon all the complex elements which constitute a disease; and tetanus presents itself, in the first place, as an affection of the nervous system. To contend with it, therefore, a symptomatic medication should come to the aid of a pathogenic medication.—Professor Widal.
SYPHILIS AND THE ARMY


It seemed, with reason, to the editors of this series that room should be found in it for a work dealing with syphilis considered with reference to the army and the present war.

The frequency of this infection in the army, among the workers in munition factories, and in the midst of the civil population where this is in contact with soldiers and mobilized workers, makes it, at the present time, a true epidemic disease, and one of the most widespread of epidemic diseases.

Dr. Thibierge, whose previous labours guarantee his peculiar competence in these difficult and important questions, has, in writing this manual, very notably assisted in this work.

But the treatment of syphilis has, during the last six years, undergone considerable modifications; the new methods are not yet very familiar to all physicians; and certain details may no longer be present to their minds. It was therefore opportune to survey the different methods of treatment, to specify their indications, and their occasionally difficult technique, which is always important if complications are to be avoided. It was necessary before all to state precisely and to retrace, for all those who have been unable to follow the recent progress of the therapeutics of venereal diseases, the characters and the diagnostic elements of the manifestations of syphilis.

Of late years, moreover, new methods of examination have entered into syphilitic practice, and these were such as to merit exposition while the old elements of diagnosis were recalled to the memory.

In short, this little volume contains those essentials which will enable the physician to accomplish the entire medical portion of his anti-syphilitic labours; it will also provide him with the elements of all the medical and extra-medical advice which he may have to give the civil and military authorities in order to arrive at an effective prophylaxis of this disease.

It is therefore a real practical guide, a vade-mecum of syphilography for the use of civil or military physicians.
MILITARY MEDICAL MANUALS

WAR OTITIS AND WAR DEAFNESS. Diagnosis, Treatment, Medical Reports.

By Drs. H. BOURGEOIS, Oto-rhino-laryngologist to the Paris hospitals, and SOURDILLE, former interne of the Paris hospitals. Edited by J. DUNDAS GRANT, M.D., F.R.C.S. (Eng.); Major, R.A.M.C., President, Special Aural Board (under Ministry of Pensions). With many illustrations in the text and full-page plates. Price, 6s. net. Postage 5d. extra.

This work presents the special aspects of inflammatory affections of the ear and deafness, as they occur in active military service. The instructions as to diagnosis and treatment are intended primarily for the regimental medical officer. The sections dealing with medical reports (expertises) on the valuation of degrees of disablement and claims to discharge, gratuity or pension, will be found of the greatest value to the officers of invaliding boards.
MALARIA:
Clinical and Haematological Features.
Principles of Treatment.

By P. ARMAND-DELILLE, P. ABRAMI, G. PAISSEAU and HENRI LEMAIRE.
Preface by Prof. LAVERAN, Member of the Institute. Edited by Sir RONALD ROSS, K.C.B., F.R.S., LL.D., D.Sc., Lieut.-Col. R.A.M.C.
With illustrations and a coloured plate. 6s. net.
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This work is based on the writers' observations on malaria in Macedonia during the present war in the French Army of the East. A special interest attaches to these observations, in that a considerable portion of their patients had never had any previous attack. The disease proved to be one of exceptional gravity, owing to the exceptionally large numbers of the Anopheles mosquitoes and the malignant nature of the parasite (plasmodium falciparum). Fortunately an ample supply of quinine enabled the prophylactic and curative treatment to be better organised than in previous colonial campaigns, with the result that, though the incidence of malaria among the troops was high, the mortality was exceptionally low. Professor Laveran, who vouches for this book, states that it will be found to contain excellent clinical descriptions and judicious advice as to treatment. Chapters on parasitology and the laboratory diagnosis of malaria are included.

Further volumes for this series are under consideration, and future announcement will be made as soon as possible.

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"... The whole book is a refreshingly good one; there is no chapter in it that the student or practitioner can read without profit, and it is particularly strong in its pathology. The illustrations are good, and the plan Dr. Stevens has adopted of reproducing his large microphotographs by direct photography upon a plate exposed in the rays of the epidiascope is certainly a success. ..."—Lancet.

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By R. H. COLE, M.D. (Lond.), M.R.C.P.; Physician for Mental Diseases to St. Mary's Hospital; Examiner in Mental Diseases and Psychology, University of London. With 52 illustrations and plates. Price, 10s. 6d. net. Postage 6d. extra.

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