A British Medical Association Lecture ON CEREBRAL TUMOURS.

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CEREBRAL tumours are unique in the nature and the variety of the symptoms they produce, in the diagnostic problems they present, and in the difficulties which must be overcome by the surgeon who endeavours to approach them. Moreover, they are by no means uncommon in every class of practice, and the general physician, the ophthalmic surgeon, and the aural specialist must all be prepared to meet them; they are more destructive to the patient than any other class of tumour, and they affect personality in a manner which must always arrest our interest and arouse our sympathy. There can be few conditions which make a more widespread appeal.

In the short time at my disposal I propose to glance at cerebral tumours from three points of view—those of the physiologist, the physician, and the surgeon—and to reply briefly to three questions: How do these tumours produce symptoms? What symptoms do they produce? How may they be approached? Naturally a full reply to these questions would involve an elaborate treatise, but even their brief consideration gives some insight into the problems which confront the cerebral surgeon.

THE PRODUCTION OF SYMPTOMS.

The brain differs from all the other organs of the body in the fact that it is enclosed in a rigid case, which entirely modifies the conditions of its circulation, and in the existence within and around it of a secondary and independent circulation, that of the cerebro-spinal fluid. Tumours produce their effects not, as might be supposed, from the pressure they exert on the cerebral tissue, but from the interference they produce with the arterio-venous and the cerebro-spinal circulations. Let us first consider the latter.

The cerebro-spinal fluid is continuously secreted by the choroid plexuses, chiefly in the lateral ventricles, and from these it flows through the foramina of Monro into the third ventricle, from which it is conveyed by the aqueduct of Sylvius to the fourth ventricle, escaping by the foramina of Luschka and Magendie into the subarachnoid space, to be finally discharged by the Pacchionian bodies into the superior longitudinal sinus. A tumour involving the cerebral hemispheres may grow to a huge size without ever affecting this circulation. On the other hand, even a small tumour situated in the interpeduncular space, in the corpora quadrigemina, or at any point below the tentorium, may obstruct the flow, and by producing a secondary hydrocephalus may cause a sharp rise in the intracranial pressure. Such a rise in pressure is associated with general symptoms of the utmost severity, and to this consideration alone is very largely due the contrast in immediate danger between supra- and infra-tentorial tumours. Above the tentorium the general symptoms are mild, and surgery is comparatively easy; below, the conditions are always critical, and surgical intervention will only too often be fatal. By the secondary hydrocephalus the cerebellum is forced down through the foramen magnum till it forms a cone, which may reach as low as the third cervical lamina, crushing beneath it the medulla and the vital centres it contains.

These general indications include the classical symptoms of intracranial pressure, headache, vomiting, and papilloedema. I would insist, however, that only in a secondary sense are these the symptoms of an intracranial tumour, and that every effort should be made to effect a diagnosis

before they arise. To wait for them is as unreasonable as to wait for acute intestinal obstruction before diagnosing a tumour of the colon. When, however, these classical symptoms occur they are of great importance, and present very definite characters. The headache is constant, but with severe exacerbations. It is often severe on waking, and it is increased by anything which raises the intracranial pressure, such as exertion, excitement, or even stooping. Vomiting is also marked on rising in the morning; it is independent of food, unaccompanied by abdominal pain, not preceded by nausea, and therefore occurs as a sudden projectile act without warning. Papilloedema may be present in a severe degree before it becomes subjectively obvious to the patient in blurring of vision, but, as a rule, when it is at all marked, a careful examination of the visual fields will show some degree of contraction for small, white objects. Transient attacks of blindness may occur, but persistent diminution of vision means that atrophy has commenced, and complete recovery of visual power is then impossible. The swelling of the disc may be accompanied by retinal haemorrhages, and is generally, though not always, most marked on the side of the lesion.

Among other general symptoms are a certain loss of initiative, mental lassitude and drowsiness, attacks of giddiness, slowing of the pulse, and possibly generalized epileptiform convulsions. A transient diplopia, occurring, as it may, at a very early stage, should be regarded as a symptom of the very first importance. These are all symptoms of high intracranial tension, and as such they may appear apart from cerebral tumours in such conditions as renal disease, severe anaemia, or lead poisoning. The latter are, however, readily excluded.

It is, however, to the local effects produced by a cerebral tumour that we must direct our attention if we are to discover its precise situation. The mere pressure of a tumour on the actual cells of the brain would probably be entirely without result were it not for the interference with the cerebral circulation by which this pressure must in practice be accompanied. It is a clearly established law of cerebral pathology that congestion means irritation, and anaemia paralysis. Now the first effect of the pressure of a tumour must be interference with the venous return and congestion of the region of the brain concerned. If this happens to be the sensorimotor cortex the irritation may show itself in the production of Jacksonian fits, starting in that region of the body which the particular portion of the motor cortex supplies. As the tumour grows and the pressure increases the capillaries will be compressed, anaemia will be produced, and paralysis will replace the irritation; but, in addition to an increase in the actual pressure at any one point, we have an extension of the area involved, so that, in fact, we shall have a spreading area of paralysis surrounded by a zone of irritation. The whole effect is enhanced by the fact that every now and then an acute oedema may arise around the advancing tumour, increasing the general pressure and producing a dangerous exacerbation of the symptoms, sometimes the abrupt prelude of a fatal termination.

TUMOURS OF THE ROLANDIC AREA.

The most important portion of the cerebral cortex, from the point of view of intracranial tumours, is undoubtedly that which lies in front of the fissure of Rolando, the precentral or ascending convolution. It differs histologically from any other portion of the cortex, since here alone are found clusters of giant pyramidal cells of Betz, from which arise the great pyramidal tracts. It is essentially the final area through which the volitional control of the brain is conveyed to the muscles. It originates nothing, but it transmits movement formulae for the execution of various skilled acts, the formulae being prepared by the synthetic action of other centres—visual, auditory, sensory, or psychic. It has, in addition, the important function of inhibiting muscular tone, the muscles being thus held ready for instant response to the transmitted formulae. Its destruction, therefore, leads to a loss of volitional control and to an increase in muscular tone which hampers useful action.

In this area the different portions of the body are represented by centres arranged in a very precise manner (Fig. 1). At the extreme upper end commence the centres

FIG. 1.

for the leg, the toes and ankle being represented actually on the mesial surface of the hemisphere. Passing downwards, the knee and hip are followed by the trunk, which lies just opposite the superior genu of the fissure. Below this come in order the shoulder, elbow, wrist, fingers, and thumb. The tongue and larynx follow. Just in front of the hand area is a special area for the control of the conjugate movements of the eyes and rotation of the head to the opposite side.

When a tumour affects this region it gives rise to symptoms, as we have already explained, by the interference with the circulation which it produces. When the pressure is slight and only congestion results, irritation is produced; when it is more severe we have anaemia and paralysis; and inasmuch as the tumour is steadily advancing there will usually be a zone of paralysis surrounded by a zone of irritation. The phenomena of irritation in this region have a very characteristic form, first described by Hughlings Jackson, and universally known as Jacksonian fits. The characteristics of these are that they start in a precise region of the body, always the same, and that they spread to other regions in a definite order, corresponding exactly to that in which the centres are arranged in the cortex. They may be preceded by twitching or tingling in the part, and they commence with a stage of tonic spasm, passing into a series of clonic jerks as the centres become exhausted. Consciousness is only lost if the convulsions become generalized. The fits may occur at any interval, from months down to minutes, and a very important feature is that they are always followed by definite weakness in the portion of the body in which the fit starts.

Cortical paralysis has equally striking features. It is essentially a paralysis of movements, and not of individual muscles, or even muscle groups. Stimulation of the centres in the motor cortex gives rise to definite movements, such as flexion of the elbow or abduction of the arm, in each of which certain muscles contract with nicely balanced force, whilst other antagonistic muscles are relaxed in suitable degree. Destruction of the centre removes from the individual the power of initiating the movement concerned, and at the same time the removal of cortical inhibition and control compels the limb to take up a characteristic attitude. Thus, in a complete hemiplegia, where the whole cortical control is removed, the arm will take up a position of adduction, with flexed wrist and fingers. The leg, on the other hand, will be adducted and extended at the hip, and extended at the knee and the ankle. In partial lesions other attitudes may be adopted. In all cases the paralysis will be accompanied by an increase in tone in the muscles and by an increase in the deep reflexes.

The growth of a tumour pressing on the motor area will therefore give rise to a characteristic clinical picture—Jacksonian fits, followed by weakness in the region of origin, and a steadily advancing paralysis. The latter spreads, as before, in accordance with the arrangement of

the cortical centres, and thus presents certain peculiar features.

As an example of the mode of spread I may cite a case where the fits always started with twitching of the left thumb. After a few moments the tonic stage came on, a tonic spasm spreading successively to the fingers, wrist, and arm, and simultaneously to the left side of the face and tongue, whilst at the same time the head and eyes were forcibly turned to the left. The spasm terminated in a series of clonic jerks, and only occasionally did the fits spread to the leg, when they became general, with loss of consciousness.

Immediately in front of the precentral area lies the intermediate precentral area, in which it is probable that motion formulae are constructed and retained, and that the memory for skilled acts resides. Upon its integrity depends the accurate performance of actions which we have learnt by practice to execute with facility, whilst its destruction, especially on the left side, may abolish the possibility of such acts, although there may be no paralysis in the ordinary sense. Such a condition is known as motor apraxia. By far the most important example is in lesions of the posterior extremity of the left inferior frontal convolution in right-handed individuals, the area of Broca, in which is stored the memory of those movements involved in speech. The loss of this area makes voluntary speech impossible, although the individual may know exactly the words he wishes to use, and may be able to look them up in a dictionary. In the involvement of the area by a tumour these symptoms are diagnostic, but the area is of further importance to the surgeon, since, whenever possible, he will avoid its neighbourhood, and will plan his explorations so as to leave it intact.

Behind the fissure of Rolando lies the post-central convolution, where are grouped centres for sensory reception, roughly corresponding in arrangement with the motor centres we have just described. Injury to this area may produce in the corresponding region of the body a loss of postural sense, of localization, of touch, or of the perception of the degrees of heat and cold, and it is of diagnostic import that this loss is irregular in distribution and in the extent to which each element of sensation is affected. Irritation produces a sensation of tingling in the corresponding area, and as these sensory centres are in such close proximity to the motor centres it follows that a tumour is likely to involve both, and that tingling in a limb may be the definite precursor of a Jacksonian convulsion.

It will thus be seen that on the lateral aspect of the brain there exists a wide area interference with which produces characteristic symptoms. A tumour in this region may therefore be located in many cases with the most minute precision, but the area is of almost equal importance in the diagnosis of tumours which reach it from other regions of the brain. Thus, the first indication of a frontal tumour may be given from involvement of the motor area in its backward extension, whilst tumours of the occipital and temporal lobes may remain equally obscure until the sensorimotor cortex is affected. We have, however, another means at our disposal for the localization of cerebral tumours—in the effects which they produce upon the visual tracts—and these we must now consider.

TUMOURS INVOLVING THE VISUAL TRACTS.

The tumours of which I have so far spoken have as their chief characteristic some interference with motion. Another group, not perhaps so common, but even more fascinating in the problems it furnishes for diagnosis, interferes with vision. Visual impressions starting in the retina pass through the whole length of the brain to the occipital lobe behind. The fibres of the optic nerves decussate in the optic chiasma in such a way that the visual impressions from the visual fields on each side of a median plane are transmitted entirely to the opposite side. Through the optic tracts impulses from the contralateral fields are carried back to the external geniculate body and the pulvinar of the thalamus. From the former run tracts connecting it with the mid-brain and with the centres which control the movements of the eyes. From the latter spread out the optic radiations, looping round the descend-

ing horn of the lateral ventricle to reach their destination in the cortex of the occipital lobe. It is to this final portion of the optic path that I would for a moment direct your attention.

The optic radiations are so arranged that the upper fibres receive impulses from the upper portions of the retinae, the lower from the lower. This order they maintain right up to the point when they terminate in the cortex above and below the calcarine fissure on the mesial aspect of the occipital lobe. In relation to tumours of the occipital lobe itself this distinction is not of importance, for, as a rule, the whole visual area is involved, with resulting disturbances of vision in the contralateral visual field. These disturbances may be of two kinds—irritative or paralytic. The former are more likely to be produced by cortical tumours, and appear as flashes of light, often coloured and suggesting fireworks. Probably the fortification lines of migraine are due to vascular disturbance in this region. Deep tumours, on the other hand, produce a gradual contraction of the visual field on the opposite side, best shown by testing with small objects, white or coloured. The superficial tumours again tend to spread forwards over the cortex and to involve the lower sensorimotor areas, producing numbness in the opposite face or hand. The deep tumours tend to involve the posterior part of the internal capsule, producing sensory changes in the opposite half of the body and paresis in the opposite leg.

But to the optic radiations themselves we owe a syndrome as beautiful as any in cerebral pathology, and in the hands of Cushing they have supplied the key to what was one of the most obscure regions of the brain (Fig. 2). These

FIG. 2.

radiations as they leave the optic thalamus wind forwards, outwards, and finally backwards round the descending horn of the lateral ventricle, occupying as they do so the posterior part of the temporal lobe. Their arrangement in upper and lower groups connected with the upper and lower portions of the retinae has already been noted. A tumour, then, in the lower part of the right temporal lobe will involve those fibres which carry impulses from the opposite upper visual field, and the left upper quadrant will be blind, and we have the condition known as a left upper quadrantic homonymous hemianopia. The discovery of these quadrantic hemianopias has revolutionized localization in the temporal lobes.

It is typical of quadrantic hemianopias that the visual defect is incomplete, and it is owing to this fact that they have so long escaped attention. They can only be discovered by the most accurate and painstaking perimetry, and only at an early stage of the development of the tumour. A rough perimetry will miss them entirely, and in a late stage they will be merged in a complete hemianopia, but if found they are almost conclusive evidence of a tumour in the temporal lobe.

But the temporal lobe yields another symptom as bizarre as any in cerebral symptomatology. When a tumour involves the uncus the patient is liable to peculiar attacks, lasting for a few seconds and perhaps recurring many times in the day. In these he is overpowered by a dreamy sensation, the world seems remote, and voices sound far away. In this state he may have curious hallucinations of smell, taste, hearing, or vision. The first two are perhaps the most common, and though sometimes pleasant are usually so repulsive as to produce an expression of disgust on the face. Those of vision are very curious, and form

definite pictures, such as a row of black cats or a little figure, in contrast to the visual disturbances seen in tumours of the occipital lobe. These pictures are the same on every occasion, and they are always in the blind portion of the visual field. The combination of a quadrantic hemianopia with uncinata attacks thus forms a very complete and exact syndrome, distinguishing sharply, when it occurs, tumours of the temporal lobe.

SURGICAL ACCESS TO THE BRAIN.

The problem of obtaining easy access to the interior of the skull has become of increasing importance with the modern demand for large openings, in which it shall be possible to replace the bone without fear of risking its vitality. The problem raises several questions, the first of which is that of access to the skull itself. It is a curious example of tradition that until quite recently it was generally believed that contact with the scalp must be maintained if the blood supply of a bone flap was to be preserved.* I have, however, demonstrated conclusively that the vascular supply of the bone and of the scalp are entirely independent, so that the scalp may be turned down freely without the slightest prejudice to the vitality of an osteoplastic flap, which derives its vascular supply entirely from its muscular pedicle. The free exposure of the skull is obviously the first stage towards easy access to the brain.

There are three primary regions from which the brain can be approached—the temporal, occipital, and frontal—and in each instance the scalp flap required presents certain peculiarities.

In the temporal region a flap of any dimensions may be formed, care being taken that the anterior portion of the incision lies well in front of the ear, so as to avoid injury to the superficial temporal artery. In this instance a great advantage is gained by first marking out the pedicle with two small incisions, one in front of, and one behind, the ear, tunnelling through with a blunt dissector in the areolar layer, passing one blade of a soft intestinal clamp through the tunnel so formed, and with it clamping the base of the pedicle. If this is done there will be no bleeding whatever from the cut margin of the flap itself, and the attention of the surgeon can thus be directed solely to preventing bleeding from the opposite side of the incision. After the incision has been made and the bleeding arrested the whole flap can be turned down as far as the clamp at its root without the division of anything except soft areolar tissue, and without bleeding from a single point.

In the occipital region the scalp can only be turned down as far as the superior curved line of the occipital bone, since below this point it is firmly attached to the muscles. If an attempt is made to raise it beyond this point the origin of the occipitalis muscle must first be divided, and the skin must then be dissected away from the muscles, to which it is united by dense and vascular fibrous tissue, and bleeding may be considerable. With the methods of approach which we now adopt we always respect this attachment, and never go beyond it. None the less we can turn down osteoplastic flaps in this region, and even remove the bone, without ever detaching the scalp from the muscles to which it so firmly adheres.

In the frontal region superb access to the bone may be obtained by very simple means. If an incision is carried boldly across the bregma, coming down just in front of the ear, it will be found that the whole of the forehead can be turned down without the slightest difficulty, even beyond the upper margins of the orbit. It is true that the anterior branch of the superficial temporal artery is divided, but the forehead has an ample blood supply apart from this. I would again point out that even in this region the vitality of the bone is in no way jeopardized, and that an osteoplastic flap consisting of one-half of the frontal bone may be formed with perfect success on the temporal muscle as a base. When the scalp flap is replaced the suture line is entirely out of sight, and the nerve supply of the forehead is still intact. I have repeatedly carried out all these procedures under local anaesthesia with a conscious patient; there has been an entire absence of

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either shock or pain; and in the case of the frontal flap the only additional precaution taken was to cover the patient's eyes and face with a sterile bandage.

CONTROL OF HAEMORRHAGE.

The control of haemorrhage from the scalp is a matter of the very first importance to which sufficient attention is rarely paid. Any loss of blood at this point is entirely unjustifiable and may prejudice the further stages of the operation very seriously. Bleeding from the smaller vessels is best controlled by a preliminary injection of the whole line of incision with 1/2 per cent. novocain, to which about 1 per cent. of 1 in 1,000 adrenaline has been added. At the same time it is our custom to infiltrate the whole of the subaponeurotic space in the operation area with the same solution. If this is done half an hour before the operation there will be no bleeding at all from the smaller vessels, and only the larger arteries will require attention. These may be seized in special forceps, such as those of De Martel, which grasp the whole thickness of the scalp, or they may be compressed by seizing the galea in artery forceps and drawing it over the cut area. The arteries themselves it is impossible to seize owing to the density of the tissue in which they lie. Personally I use small steel clips which are crushed with forceps on to the margin of the scalp. They hold it quite firmly without injury, they are so small that they are not in the way, and at the end of the operation they are very easily removed. In the case of the temporal flap I have already described the means by which bleeding from its margins is prevented. In the frontal flap the incision lies in a watershed area where vessels are very small, and the only two vessels which bleed are the anterior branches of the superficial temporal artery. The absolute bloodlessness of this line of incision is remarkable and a very great advantage.

DIVISION OF THE BONE.

Even when the skull has been freely exposed the actual division of the bone presents a mechanical problem of no mean order. With the old methods it involved an expenditure of time and a degree of exertion on the part of the surgeon which only too often left both patient and surgeon physically exhausted, at a moment when the real business of the operation was only about to begin. It has long seemed to me that it should be possible to cut through the skull entirely by hand if the problem could only be reduced to the terms of ordinary engineering. I have now succeeded in devising an appliance by which the skull can be divided entirely by hand with great facility and so smoothly that the operation can be easily accomplished on the conscious patient under a local anaesthetic. The appliance was specially designed for the formation of large osteoplastic flaps, and it enables the surgeon to form these with a facility, a rapidity, and a precision hitherto unapproached.

The principle on which it works is the entirely novel one of securing a steel peg in the skull at the centre of the proposed flap and using this as a fulcrum round which can turn a powerful lever carrying a cutting tool. The cutting tool is a narrow chisel such as is used by turners for parting their work, and it cuts in the skull a narrow circular channel with extreme precision. The groove is cut on a bevel, and one advantage of the method is that the bone flap can be replaced with the absolute accuracy of a ground glass stopper. Naturally so novel an instrument requires some practice before it can be used with facility, but when this is attained large bone flaps can be cut with an ease and rapidity hitherto unattained, and we have seen a four-inch flap turned down in the temporal region in four minutes without any apparent effort on the part of the surgeon.

OSTEOPLASTIC FLAPS.

Having shown the possibility of obtaining a full exposure of the skull by first removing the scalp, and having described the apparatus at our disposal for dividing the bone, I will now discuss the actual formation of osteoplastic flaps. These are required in three regions—lateral, posterior, and anterior—and as the method of formation is in each case distinct, I will deal with them separately and in this order.

Lateral approach by means of a temporal flap is the commonest mode of access to the brain. Not only is it required for the removal of tumours in the sensorimotor region and in the temporal lobe, but it is often the most convenient and effective method of obtaining decompression. A large scalp flap is first turned down, as has been already described, bleeding from the flap being controlled by a clamp across its base, and from the scalp by clips attached to its margin. The total loss of blood should be trivial, and all bleeding must be absolutely checked before the next step is taken. The scalp flap and the exposed area are carefully protected by gauze pads moist with warm saline.

The bone flap required is now marked out with a compass, and the bone is divided round three-quarters of a circle with the craniotome, the temporal muscle which is to form the hinge being carefully preserved. Elevating levers are inserted and the thin bone in the temporal fossa is cracked, when the bone flap can be turned down and out of the way. The bone usually cracks at a point half an inch or more from the base of the skull, and it is convenient to strip down the temporal muscle as far as the temporal crest and to remove the thin bone with punch forceps. In this way maximum use can be made of the opening in the skull, and if the bone is replaced the defect left at its base forms a very useful subtemporal decompression.

Posterior approach to the brain has usually been obtained by piecemeal removal of the occipital bone below the lateral sinuses, and this has been generally regarded as a region entirely unsuited to the formation of osteoplastic flaps. The situation has, however, been entirely altered by the craniotome, which enables huge osteoplastic flaps to be turned down in this region with precision and safety, affording an access to the cerebellum, the brain stem, and the occipital lobes never before achieved. At the same time the bone, in whole or in part, can be replaced with perfect accuracy and with absolute security. The effectiveness of the method can be sufficiently judged from the fact that the whole of the back of the skull, from the lambda to the foramen magnum, can be turned down in five minutes with the utmost ease, without the slightest violence, and often without any change either in the pulse rate or the blood pressure of the patient.

A scalp flap is first turned down, as we have already described, as far as the superior curved line of the occipital bone, to which it is attached. This flap should overlap the proposed skull flap by half an inch. A point is now selected about half an inch above the external occipital protuberance, and here a hole is drilled for the centre pin. The bone at this point is very thick, and it may not be necessary to drill completely through; indeed, it is an advantage not to do so, as a large emissary vein may be encountered. Should, however, bleeding occur, it is immediately stopped by the insertion of the centre pin, which is then secured in place. The skull is cut as usual, and as it is here often half an inch or more in thickness the power of the craniotome is fully demonstrated. A channel is cut which divides the thick bone completely and extends below the lateral sinus on each side. With a specially guarded chisel the extremities of this channel are extended towards the foramen magnum, when it will be found that on raising the bone the whole posterior margin of the foramen magnum is included in the fragment. Seizing the upper margin of the bone in forceps it is drawn forcibly backwards, so as to avoid injury to the medulla, and it is then turned downwards over the nape of the neck, still attached, of course, to the whole of the nuchal muscles.

The only risk in this procedure is that of haemorrhage from the large emissary vein which communicates between the torcular Herophili and the vascular diploë of the occipital bone. In raising the bone this vein is torn, and the finger of an assistant must be immediately applied to stop the haemorrhage. A small piece of muscle, cut ready for the purpose, is now applied and held in place by the finger for three minutes, when it will be found to adhere firmly and to have stopped the bleeding. Occasionally a similar but smaller vein may be torn from the superior longitudinal sinus, but it is easily dealt with in a similar

manner. There would seem to be no risk whatever of injury to the sinuses themselves.

The field now obtained is very remarkable. In the centre lies the torcular, the lateral sinuses spreading outwards on each side, whilst above these the occipital lobes are exposed to an extent of perhaps two inches. Ideal access to the cerebellum is offered, and, if necessary, the posterior arch of the atlas can be removed. But most important of all is the relaxation of the tentorium which results from the removal of its posterior support, so that it can now move upwards freely and release the pressure on the medulla. Provided there is no undue pressure on the upper chamber this may provide sufficient decompression without any opening of the dura, and in a case of mid-brain tumour with secondary hydrocephalus this procedure alone was sufficient to secure permanent relief. In any case a combination of this with aspiration of the ventricles will give all the relief of tension that can be desired.

Mobilization of the tentorium, so far as I am aware, is an entirely new procedure, and it is only rendered possible by the occipital osteoplastic flap which has been described. Without the craniotomy the formation of such a flap is scarcely a mechanical possibility, for it demands the clean cutting of the densest part of the skull over a very large circle. The trauma to the patient which would result from attempting to do this by any other method would be so serious as to prohibit its performance. Moreover, the flap must be turned down with great rapidity if serious haemorrhage is to be avoided from the large emissary vein, to which reference has been made. With the method here described the actual turning down of the bone flap is practically instantaneous, and in no case has the bleeding remained uncontrolled for a longer period than two seconds. I am so impressed with the value of mobilization of the tentorium that I feel that this possibility alone justifies the invention of the craniotomy.

Anterior approach is rendered much easier by the frontal scalp flap, which has already been described. This places the whole of the frontal region at our disposal, and allows the formation of osteoplastic flaps on a generous scale. The thick anterior portion of the temporal muscle, the origin of which extends right up to the angular process of the frontal bone, furnishes an ideal hinge and preserves an adequate blood supply. If the craniotomy is used the centre will generally be placed a little above the temporal line, and the line of division of the bone will be just above the superciliary arch and to one side of the middle line, although the latter may be crossed without risk if a really full exposure is desired.

This method of approach furnishes admirable access to the frontal lobe, and, if this is displaced, to the falx cerebri, in its anterior portion. It is, however, of still greater value in the approach which it offers to the pituitary gland. If the bone flap is properly formed it will be found that the whole of the bone overlying the frontal lobe has been removed, and that the lobe can therefore be displaced upwards with quite unusual facility. If the hyperextended position of the head is adopted it will be found that the frontal lobe actually falls away from the orbital plate, so that the route to the pituitary is opened up even without mechanical retraction, and all contusion of the brain is avoided.

There is no art in which the human factor is more important than in surgery, and it is therefore well that surgeons should have at their disposal a large variety of methods from which to choose. The stock of any instrument maker will show the efforts that have been made to meet their individual requirements, but I have sometimes wished that surgeons themselves would realize the essentially mechanical nature of some of the problems by which they are faced and the technical skill required to use successfully the elaborate appliances now placed at their disposal. It would be an immense advantage to the student if at some point of his training he were taught something of the mechanic's art, and realized the cunning of the hand involved in the dexterous use of even the simplest tool; for whatever the ingenuity of the instruments provided for the surgeon's use their success must ultimately depend on the skill of the hand which uses them.

THE SPA TREATMENT OF DISEASE.*

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ALTHOUGH it cannot be claimed that there is anything strikingly new or original in the remarks that follow, it should in extenuation be borne in mind that systematic study of this branch of medicine has hitherto, I believe, found no place even in British universities so enlightened as that which this Branch is fortunate enough to possess within its area, and a presentation of some of the problems involved may not be without interest.

The virtues of the chalybeate waters of Spa, near Liège in Belgium, were known as early as the fourteenth century, and so famous was this resort some 300 years later that the word "spa" or "spaw" was adopted in this country as the generic term for any spring or well possessing medicinal properties, and later became extended to comprise any town or locality in the neighbourhood of such a spring.

The use of natural waters in the treatment of disease is, however, much older than this, and has obtained from remote times in most widely separated parts of the world—for instance, amongst the Greeks, Romans, Mexicans, Japanese, and Russians, to mention only a few. Even the Father of Medicine himself, Hippocrates, admittedly the greatest exponent of the healing art of all time, has every right to be regarded as a spa physician, since the site of the temple at Cos, where he practised, was, like that of the other Asclepia, selected for its climatic and other natural advantages, and great use was made of hydrotherapeutic and other physical methods of treatment—combined, however, it must be confessed, with a good deal of ritual and mystification. At one time there were as many as sixty or seventy of these temples of health or Asclepia in Greece, and many of them, being situated in the neighbourhood of healing springs, may be said to have combined the functions of present-day hospitals and spas.

In the early days of the revival of spa treatment haphazard drinking of, and bathing in, the waters were resorted to, but with their later development, as the result of experience and the scientific study of hydrology, their internal administration and external application became to some extent systematized, though modifications were, and always will be, necessary to meet individual needs. Many valuable adjuncts in the form of douches, massage, electrical treatments, physiotherapy, and so on have been added.

It is estimated that every year over one million persons seek relief at the European spas alone, and the fact that spa treatment has held its own for so long and is increasing rather than waning in popularity—notwithstanding the fierce competition of the latest synthetic drugs, animal extracts, vaccines, serums, psychotherapy, and the great development of surgery—leads to the natural query, What are the factors to which its success is to be ascribed? The answer, even by those who firmly believe that certain classes of patient will obtain benefit from spa treatment which they will obtain so rapidly and completely in no other way, is by no means easy.

These factors may be considered under three heads. The first may be termed the hydrotherapeutic—namely, the benefit to be gained from the administration of water internally and its application externally, considered as water simply and without regard to any other constituents. Secondly, the pharmacological factor—that is to say, the effect of the salts, gases, colloids, radium emanations, etc., which may be present in the water concerned, its electrical conductivity, and osmotic function. And thirdly, the general hygienic and psychical factors.

Internal Administration of Waters.

It is possible that much of the benefit of spa treatment is due to drinking large quantities of water. Many natural waters are isotonic, or nearly so, and can be taken in

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