On Brain Pressure and Trephining. By T. Claye Shaw, M.D., Medical Superintendent of the London County Asylum, Banstead.

It is now several years since I first proposed the operation of trephining the skull in general paralysis of the insane, at about the same time that Dr. Batty Tuke independently operated for the same disease. Others have also performed similar operations, but the results have not been publicly recorded or collected. Sufficient time has not elapsed, nor have the cases been sufficiently numerous to determine the future of the operation, whether it is of sufficient service to justify its frequent employment or whether it must be dismissed to the limbo of useless remedies. I have published cases where considerable temporary improvement has resulted, where life has been prolonged, and distressing symptoms alleviated, and I propose to give to the Association the short details of a hitherto unpublished case where no candid critic could, I think, deny the improvement that I claim for him. This much may be said for the operation—that it seems harmless when carefully performed, no fatal result having, as far as I am aware, ever resulted. The apprehended after-results, as regards local tenderness, liability to injury at the trephined spot, bulging of the contents of the cranium, are phantoms which have no basis of fact. I fear, indeed, that we have not been bold enough in our measures. Mr. Harrison Cripps, who performed the earlier operations for me, recommends the removal of a much greater extent of bone, of a piece indeed about three inches square, and he would do it on both sides of the skull. Of the after results of removing so large a piece of bone I should have no more fear than I have of the present comparatively small area; the great objection I have to the removal of so much bone is the long time required for the operation. Another point is with reference to the time chosen for the operation. I think it should be done earlier, it seems hopeless to do it in the later stages, after there is much thickening of the membranes and destruction of tissue—as far, at least, as any hope of cure is expected, anything, indeed, beyond relief.

The sole ground for the operation is the relief of pressure; if there is no increase of pressure I can see no justification for it. Should it prove to be of advantage in

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relieving pressure, then the operation should not be confined to cases of general paralysis, but should be extended to other cases of insanity, where unrelieved pressure leads to dementia. I present indeed to your notice a case of ordinary nerve disorder where I recently performed the operation, and in which some of the symptoms were relieved, though the case is still *sub judice* as regards finality.

The great question then to decide is:—Is there pressure in the earlier stages of general paralysis and in other forms of insanity? If there is, can any more direct means be taken to relieve it than by opening the skull?

The signs of pressure on which I would rely are:—

1st.—Pain. The dull, heavy, or throbbing pain that patients complain of seems from its character and diffuseness (it is commonly described as a "weight," a "feeling of tenseness") to be of the kind experienced in ordinary meningitis, where the flushed face and quick pulse and swelling of the brain denote pressure in a sense that cannot be doubted.

2nd.—The fact of flattened convolutions, seen after death, as the result of increased pressure and wasting combined.

3rd.—That in all the operations I have seen, except one, where trephining was performed for traumatic epilepsy, the moment the bone was removed the aperture was filled with a bulging mass of brain and membranes in which no pulsation could be noticed at first, but which afterwards pulsated freely when the membranes were incised and the fluid drained off. Can there be any more pronounced sign of pressure than this?

I must in truth state that after the operation I have seen no sign of bulging, but it must be remembered that both before and after the operation a large depletion has been going on; the patient has been prepared for the operation by keeping a recumbent position, his diet has been low, and during the operation itself he loses a good deal of blood from the scalp, besides a considerable quantity drained off from the brain itself, added to which is the pressure of the atmosphere directly on the soft tissue, the bone being removed.

I do not propose to go into the question of blood-pressure in the brain in health, beyond saying that whilst in ordinary untaxed cerebration the pressure is probably equal to about ten millimetres of mercury, the same cannot be said of disease. One of the potent agents in the circulation of the

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brain is the molecular change due to the action of the elements, and when this is *constant*, as in worry, overwork, or actual inflammatory mischief, we have all the elements for causing pressure. Prolonged cellular action means increased flow of blood, swelling of tissue, and impeded discharge by the veins, and if this condition is permanent and unrelieved by sufficient rest the result is what pathology teaches us, dilated capillaries, gorged veins, and atrophied cells. After a time matters accommodate themselves, serum takes the place of wasted tissue, functioning ceases, and equilibrium is restored; *then* there is no pressure to speak of, except at odd times, when there may be a renewed flicker of excitement and a repetition of the process above described; but the mischief is now done, and the relief for drainage of fluid can be of little permanent advantage. Therefore I say that the earlier period of engorgement is the one when measures for relief should be undertaken. If proof is wanted of the statement that molecular change in the brain causes increased arterial circulation it may perhaps be well illustrated as follows:—In acute maniacal excitement with a rapid pulse it has been not uncommon to prescribe digitalis in large doses. Now here we may see the medicine given until the pulse becomes weak and intermittent, but there is no relief to the brain; let, however, sleep occur and the pulse at once becomes quieter, whilst the mental symptoms are alleviated or disappear. To the pressure of the brain may also be attributed many of the aberrations of function, for the relations of the parts to one another must be intimately disturbed, and if so their functioning must be irregular. When through continuance of the process atrophy results, nothing can be expected but what we see, viz., dementia. French authors have particularly insisted upon this.

To the three signs of pressure above given I would now add that the symptoms themselves of acute insanity point to it, whether they be of the violent or stuporous form. But what, it may be asked, can be said of those cases where the insanity seems caused by purely debilitating instances, such as starvation, hyper-lactation, exhausting disease? What evidence is there of pressure here? Well, there are thousands of ill-fed and badly nourished persons round about us in daily life, but it does not appear that they go insane unless some special factor is super-added, such as hereditary taint, worry, or trouble, a factor that, when it

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exists, sets up the greater degree of prolonged molecular change that leads ultimately to pressure. It may be that in debilitated states the volume of blood passing through the brain is diminished, and the brain thereby reduced in volume with consequent distortion of the arrangement of its parts, resulting in disordered function. In such a case, no doubt, compensatory serum would be supplied, but its relation to the brain substance would be different from that of the blood in proper conditions, and would tend to increase the pressure to which the brain is subjected by the withdrawal of its normal support. In such a case we cure the pressure by improving the quantity and quality of the blood, cause the brain to expand and resume its normal relations, and in doing so get rid of the compensatory fluid.

I believe that I am correct in saying that the specific gravity of the brain is increased in acute insanity; if so this is another fact pointing to increased pressure, for whether the increased density be due to swelling, effusion of inflammatory products, or larger amount of blood, the result must be the same, and this too whether the symptoms are of the excited, depressed or negative order.

In the gelatine casts shown in connection with this subject it will be observed that there is a marked depression over the seat of the trephined spot; this is due to the sinking in of the scalp at the place of the opening and to the fact that the thick fibrous membrane that supplies the place of the bone taken away is much thinner than the tissue removed, though it is very strong—so strong indeed is it that it practically becomes as firm as the bone itself, and thus quickly re-establishes the fault that originally existed. This, then, is one of the defects of the operation, that there is no continuous drainage, and this doubtless must be provided for if the operation is to be any permanent use, unless indeed a very large piece of bone is removed. In the two post-mortems I have had, it was found that the upper surface of the convolutions was firmly attached to the fibrous membrane just spoken of, thus preventing pulsation and probably accounting for any absence of bulging or other pressure sign.

It is difficult to conceive how any direct experiments to prove pressure can be made either by gauges or by the introduction of elastic substances into the holes made in the skull; probably the best is the one that we have naturally in the anterior fontanelle of an infant where crying and

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struggling produce bulging, whilst states of exhaustion, diarrhœa or collapse show a manifest depression. It might be possible by an adaptation of the spring-balance to estimate the amount of pressure in these cases, but I am not aware that this has been done. In the case I am about to relate the patient says that on exertion he feels a swelling and pulsation at the trephine hole, but when at rest the appearance is rather that of a depression.

To quote Cappie, "keeping in mind that the mass of blood that can be drawn upon is limited, and that the enclosing space is rigidly fixed, one of the immediate consequences of any alteration in its distribution is *pressure*. If any set of vessels becomes more distended with blood the part involved must take up more room than before, and the tension of the centre must be increased. The brain when functionally active has an expanding tendency; under the influence of the commotion caused by flow of blood through the capillaries the bulk of the brain mass must be positively greater than when the organ is at rest."

I am quite sure that a surgical operation should be only resorted to when other remedies have failed, but if it be granted that pressure exists in acute insanity, either of the excited or depressed type, and ordinary means seem useless it would appear that nothing is left but the operation.

If the brain trouble seems connected with an impoverished state of the blood it will probably be relieved by tonic treatment, but in other forms of pressure where it has been attempted without success to lower pressure by purgatives and general lowering treatment, or cold applications, an operation would seem to be indicated. At any rate, a patient should not be allowed to lapse into dementia without its being tried.

In connection with this subject, it is right to mention some cases reported by Dr. Alfred Parkin, of Hull, on the treatment of chronic hydrocephalus by *basal* drainage, published in the "Lancet," July, 1893. He made an opening under the superior curved line of the occiput and to the right of the middle line, exposing the under surface of the cerebellum. To use his own words, "I can only describe the rapid recovery from what was almost complete coma to the relief of the intra-cranial pressure by the withdrawal of fluid." "The mode of operating (at the base) is extremely easy, and gives ready drainage at a place which is easily kept aseptic."

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The first of two cases that I wish to bring before the meeting is that of a man, aged 32 years, a general paralytic.

He was admitted in April, 1882, with marked and characteristic mental and motor symptoms, and who during the early months of 1893 had epileptiform attacks of a serious nature, sometimes on one side, sometimes on the other. He was trephined by Mr. Lockwood, on March 19th, and he is still alive, and, though demented, able to go about and to read. An inch trephine was used, and I show the piece of bone removed (specimen). After the dura mater had been removed and some thickened pia removed, a trocar and cannula were pushed several inches into the brain in the direction of the lateral ventricle, but only a few drops of serum came through the cannula. When the piece of bone was removed the brain and membranes swelled up into the opening, and on incising the membranes a quantity of serous, clear fluid escaped. Not a single bad symptom appeared, and in a few days the man was about again. *Since the operation he has not had an epileptoid seizure of any kind*, and for some time the symptoms were relieved, *i.e.*, the headache disappeared; he was able to hear much better, and became much more intelligent. After a time, as usual, the hole became firmly closed by fibrous membrane, but notwithstanding this there has been no return of the fits. In all human probability but for the operation the man would have died long ago, but here he has been going about as usual, and it seems almost impossible not to connect the cessation of fits with the operation, which was done more than twelve months ago. I produce a cast in gelatine of the present state of the head, showing the scalp depression.

Since writing the above this patient died from gradual exhaustion a few days ago, but there was no return of the convulsions. It was found post-mortem that the brain substance was quite adherent to the fibrous membrane, so that secretion of fluid was impossible. In this last particular we seem to have an argument against keeping the wound open, for it would appear as if after a time there is no chance of fluid being secreted in what was the sub-dural space.

The next case is that of a man, aged 28 years; admitted June 24th, 1892.

His symptoms were of great pain over a definite part of the head, with feeling of tension and impulse to commit acts of violence—no delusions or hallucinations. There was some history of injury at an earlier date over the spot where the pain was felt, but no depression was to be felt. Some convulsions occurred about two months after admission, but they were probably hysterical in character. Though he never did actually commit any act of violence, he declared that it was only with great difficulty that he restrained himself. He readily submitted to all forms of treatment, being extremely anxious to return to work, but, nothing proving of any avail, I proposed to him the removal of a piece of bone from the painful part, and to this he

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agreed. On January 7th, 1894, he was trephined by Mr. Lockwood, and I produce the piece of bone removed. From external appearances before the operation one would not have said that there was much sign of pressure; his pulse was quiet, his temperature normal; he seemed pale and rather anæmic, as if he had been suffering from exhausting disease, but when the skull was opened the subjacent brain and membranes (which appeared to be healthy) bulged prominently, and *there was no pulsation* to be seen. On opening the dura mater and dissecting it away a considerable quantity of fluid escaped, and soon afterwards pulsation returned. The wound was closed in the ordinary way, and the usual rapid recovery ensued without any bad symptoms. The result has been complete freedom from headache, so that he is now able to read any length of time without fatigue, but there has not been any material improvement in the impulsive feeling.

I quote the case especially to show that pressure may exist in persons with melancholia and absence of arterial tension as indicated by the pulse at the wrist. The gelatine cast accurately shows the present state of the head with the depression. The fibrous tissue in the opening is not, however, at present very firm, and the patient says that on exertion he feels pulsation and the rising of a sort of swelling at the foramen. With the consolidation of the fibrous tissue these symptoms will disappear, and it will then be interesting to note whether the headache reappears. Had it not been for the ocular evidence of pressure it might have been said that the case was one of pure hysteria, and that any benefit derived was from the operation *per se;* even if this were so it would be justifiable, but I fear that there is organic disease, and that the tension is the result of it. In order to test the effect of withdrawing the atmospheric pressure upon the soft tissue over the opening, I used a cupping glass of 1·75 inches diameter at the brain, when on exhausting the air the depression was at once obliterated, the skin rising well up to the adjoining surface of the scalp; the skin was also slightly reddened, and pulsation was very perceptible, this latter fact pointing to the probable union of the convolutions and the superjacent tissue, as in the post-mortem that I described a few minutes since. At the moment when the vacuum was produced, and the skin and tissue rose to the level, a distinct failure of the pulse for at least three beats was noticed. In order to ascertain, if possible, the actual amount of brain pressure I introduced the patient to Professor Leonard Hill, of University College,

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and under his direction the following experiment was performed:—A small glass flask was enclosed in a larger one, moulded so as to fit the curve of the scalp around the trephine-hole; the inner flask abutted on and accurately fitted the hole, and it was filled with water. This inner flask communicated with a mercurial manometer and with a pressure bottle, by means of which a bubble of air, serving as an index, could be made to move when the pressure on the scalp over the hole was increased or lowered. The desired object was to find what pressure would be needed to be exerted upon the fluid in the inner bottle in order to depress the pulsating brain in the foramen. The fluid in the bottle was a solution of salt, 0·6 per cent. When a vacuum was made in the outer flask the skin of the scalp rose considerably, and effectually cut off the inner flask containing the fluid and resting closely on the tissue over the hole from the chamber in the outer vessel. It was found that the pressure required to drive the skin and tissue over the hole down was equivalent to 6 millimetres of mercury. Dr. Hill found that in the dog the pressure was equal to about 10 m.m. of mercury. Some of the difference may be accounted for by the pressure being taken in the male subject in the upright position, and possibly in the fact that the normal brain tension has been lessened by the changed conditions due to the operation, for it is evident that there is now no sub-dural space, but the actual tissue of the convolutions is firmly adherent to the under surface of the membrane formed in the hole made by the trephine. It can scarcely be that the normal brain pressure in man is less than that of the dog (viz., 10 m.m. of mercury), and if so, then the operation has clearly reduced the normal pressure. It is curious to note how injurious are the effects when even a small addition to the normal pressure is made. Thus, Dr. Hill found that when more than 0·5 c.c. of saline fluid were introduced into the cranial cavity, there was a lasting rise of cerebral pressure and these physical results, viz., slowing to stoppage of the respiration, rise of blood pressure and slowing of the heart, and alteration of the size of the pupil; whilst greater amounts than 1 c.c. caused a maintained rise of arterial pressure, sighing, and death. Another interesting and unexpected result of Professor Hill's experiments is that the blood vessels, *and not the lymphatics*, form the pathway of absorption of fluid from the sub-dural space, as shown by the fact that a methyl blue solution of salt, driven into the sub-dural space at the rate

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of 1 c.c. a minute, will appear in the urine in about 30 minutes.

Dr. Hill makes a further note on the above case which is interesting in relation to the whole subject:—Suspecting that the upright position of the patient had much to do with the diminished tension, as shown in the dog, he experimented on an animal placed in three different positions. I give his remarks verbatim:—

He says: "The conclusion I draw from Wednesday's experiment is that the patient's intra-cranial pressure in the upright position is about zero, rising a few millimetres of Hg. above zero in expiration, or coughing, or when he lowered his head. The cardiac and respiratory movements also oscillated about zero.

"I found yesterday in a large dog that the normal intra-cranial pressure was (1) 10-12 m.m. Hg. when the animal lay horizontal; (2) zero when the animal was tilted with the head highest; (3) 20-30 m.m. Hg. when tilted with the head lowest.

"The patient's skin is depressed over the hole unless coughing or excited; he has a low tension pulse and, therefore, a low tension brain. On the other hand, in a healthy infant the fontanelle is slightly full. I have no doubt if we measured the patient in the horizontal position we should find the pressure positive as in the dog. According to all my work, the normal intra-cranial pressure is the same as the blood pressure within the capillaries of the brain.

"The blood pressure is the only possible origin of intra-cranial pressure, unless one conceives that the cerebro-spinal fluid is *actively secreted* as the saliva is to a pressure higher than the blood pressure. My experiments are very decidedly against this, because serum introduced within the cranial cavity with a pressure higher than the normal intra-cranial pressure, is at once absorbed by the blood vessels, and the intra-cranial pressure, therefore, rapidly returns again to normal.

"Most of the force of the heart is spent in overcoming the elasticity of the cerebral vessels; what remains is the intra-cranial pressure.

"A foreign body, such as a bag of fluid or a blood clot, can, if forced into the cranium, on the other hand, permanently raise the intra-cranial pressure, because non-absorbable. When the foreign body is driven in, blood must

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be forced out of the brain, or cerebro-spinal fluid from the cavity, in order to make room for it; when blood is thus forced out of the capillaries of the brain the intra-cranial pressure becomes that of the arterioles or arteries.

"Cerebro-spinal fluid, when drawn off from the cranium, is very quickly re-excreted. A dog thus may yield 100 c.c. or more cerebro-spinal fluid in 24 hours, and thus, if an animal is trephined and cerebro-fluid drawn off and the hole closed, the fluid rapidly collects again and the blood-pressure becomes normal.

"I think some of these points must be brought into very careful consideration in discussing any physical alteration of brain-pressure by trephining."

It thus appears that the patient's pressure being zero in the upright position corresponds with that of the dog in the same position, and it would seem that in ordinary circumstances of health and rest the intra-cranial pressure is zero, rising when the blood pressure is increased, as by change of posture, or running, coughing, excitement, or inflammatory action.

No advantage is gained by leaving the hole open, whereas in syncope the proper position for the patient is either a horizontal one or with the head pointing downwards; in apoplectic effusion, etc., where it is desirable to lessen the blood pressure, the head should be raised.

I am much indebted to Dr. Bond for his kindness and skill in preparing the plaster and gelatine casts, and for reading this paper in my unavoidable absence.

On Cerebral Pressure. By John Macpherson, F.R.C.P.E., Medical Superintendent, District Asylum, Stirling.

The term cerebral pressure requires more exact definition, and ought, I think, to be entirely superseded by a more generic, comprehensive, and intelligible name. It should not be taken in the limited sense of only including fluid pressure, but should be extended so as to embrace a large variety of clinical and pathological conditions.

It may be either acute or chronic, but when acute it falls to be dealt with entirely by the surgeon and general physician. When chronic it more often comes under the notice of the psychiatric physician or the neurologist. Generally speaking, when, in addition to continued mental

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