let me know them, and let the public have them, or cause them to be known by writing papers and giving lectures. I shall always be glad to have them, because I cannot get anybody else to enthuse himself on the subject and collect evidence. I have tried to get economists to take it up, and they have expressed their great interest, but they do not get much further. Sir Josiah Stamp was quoted by Prof. Collis in a lecture as having put the value of a human individual at £250, and then it was enlarged to £350, and then to £500. I wrote to Sir Josiah Stamp and asked what was the figure. He said he could not make out how they got the figure, or how he gave it; that he had looked through his notes, and if he could find any more, he would tell me. A year passed and then I wrote

him again—he is now general overseer of the London, Midland and Scottish Railway—and he said it was true he was interested, but he did not think there was much value in the figure. Two or three other professors of economics have professed an interest in it and hope I will go on with it. I want economists to go in for it and get the figures; also our whole profession. We are often getting clear instances where expenditure of money does give a very definite financial return, and if you get such instances I hope you will test them thoroughly and prepare statements on that line. Such instances are more obvious in the tropics and in connexion with the services. If you get such instances, I shall be very glad if you will pass them to me; I will promise to make good use of them.

TECHNIQUE IN THECAL PUNCTURE:

THE PERFECT OPERATION.

BY

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THE usual site for thecal puncture is in the lumbar region. Because it is not given to every housewife, much less to every doctor, to be "handy with a needle," the practitioner should not perform the operation unless his opportunities have given him special experience both as regards technique and, equally important, as regards the diagnostic lessons which are to be learned from seeing the flow of cerebro-spinal fluid.

LUMBAR PUNCTURE: PRACTICAL POINTS.

Practical points for the performance of a perfect lumbar puncture: The first is the *avoidance of pain*. There are two special reasons why the operation should be painless. If the patient is in a ward and is hurt he may be, directly or indirectly, the cause of another patient declining the operation. In many conditions—for example, cerebro-spinal syphilis of any variety—the progress of the disease and the effect of treatment can be assessed only by repeated examinations of the cerebro-spinal fluid. If lumbar puncture is quite painless a patient will always consent to subsequent operations.

A second factor which should be regarded as essential is that the specimen of *cerebro-spinal fluid* collected shall be as it was in the subarachnoid space. The admixture of a *little* operative blood can be calculated for in a cell count, but absolute accuracy is imperilled. The perfect operation implies painlessness and the absence of a single red cell in the specimen. These requirements can be met.

The *diagnosis* of any condition should be made primarily from the facts obtained in the history and from the clinical examination. Our practice

is to write down before we operate what we believe to be the condition of the cerebro-spinal fluid.

Let us assume that the patient is not a sick man in the ordinary sense of the term. He is told that we require to make an examination of his back. He is given an opportunity to empty his bladder and rectum. We have a choice of two positions in which he may be placed for the examination, either bending down from a stool or lying on a bed. His back must be properly illuminated and in such a way that the operator will not cast a shadow on it. If the doctor is right-handed the patient is asked to lie on his right side with the trochanter of his right femur on—not within—the edge of the bed. However poor the condition of the mattress may be, his body, in this position, is supported by the rigid frame of the bed. Also in this position we shall be able to hold the test-tube upright beneath the hilt of the needle. The pillows are removed. For a reason which will be explained later the inexperienced operator will find it is convenient in routine work to raise the *head* of the bed on blocks. If a subtentorial tumour has been diagnosed we may, if we wish, raise the *foot* of the bed before operating. The patient, lying on his right side, should curl himself into a ball as far as he can, and it is most important that his right shoulder, which is underneath, should be well forward. If he lies on his right humerus instead of on the axillary border of his right scapula his vertebral column will be rotated and difficulty may be experienced in the operation. A piece of wool is placed on the bed beneath the proposed site of puncture and tucked under the patient. When the position of the patient is correct—and upon this success depends—he should not move. He should be properly protected from cold. Before operating it is convenient to visualise the subarachnoid space. The opportunity of seeing it as it really exists occurs only during the skilled performance of a laminectomy operation. It cannot be demonstrated in the dissecting room.

The *needles*—two at least should be prepared—should be fine and properly bevelled. With their stylets they are placed for half a minute in a small

quantity of water which is boiling. They are then transferred to a dish which contains a small quantity of spirit. It is *essential* that they shall not be shown to the patient, and no one is permitted to refer to them by name in his hearing. A 2 c.cm. glass syringe is useful as a handle for the needle. The syringe serves also to clean the needle with spirit after the operation. The syringe need not be boiled. It is placed ready in the spirit and the needle attached. When the needles are trans-

The figure shows how a troublesome patient may be trussed into position with a roller towel and a ruler. It also shows the incorrect position of the right shoulder, which should be further forward, beneath the patient.

ferred from the boiling water to the spirit care must be taken that they do not come into contact with the syringe until they are cold.

The only other requirements are a piece of lint, two small swabs, two or more sterilised, unbroken test-tubes which have been labelled, a tube of ethyl chloride, a small piece of plaster, and smelling salts. The proper working of the ethyl chloride spray should be proved and not assumed.

A patient who is unconscious from an anæsthetic, disease, or injury, or whose skin is analgesic from hysteria or organic disease such as tabes dorsalis, spinal cord tumour, &c., will not require the ethyl chloride spray. If he is unconscious we must be careful that his position does not obstruct his breathing, a warning which applies particularly to stout patients with apoplexy. Incontinence should be anticipated and the perineum properly protected.

A patient who is very ill or excited—perhaps because he has been hurt at a previous operation—may be given an injection of morphia prior to the operation. A patient who is violent or troublesome from any cause may be trussed into the correct position by means of a roller towel and a stick or stout ruler. The loops of the towel are passed over his head and legs and the length is tightened up by rotating the ruler. This method is convenient when we have to operate without assistance on a mentally affected patient. (See figure.)

THE OPERATION DESCRIBED.

The operator now washes up and cleans the patient's skin with one of the swabs which has

been dipped into the spirit in the dish. In routine work there is no occasion to use iodine. With his right hand he holds the syringe and attached needle rigidly in one piece. With a nail of his left hand he impresses the skin at the site of the proposed puncture. Without taking his eyes from the impression he picks up the ethyl chloride tube with the piece of lint. He tells the patient that he will probably feel something cold and he sprays the impression. The spray will obscure the impression, and it is important that the operator shall not remove his gaze from the site of it while he pushes the ethyl chloride tube down. With the right forefinger along the shaft of the needle he makes the puncture in the middle line, at the same time engaging the patient in conversation. The puncture having been made the syringe is detached. It is very rarely that a stylet is needed. Let us assume that cerebro-spinal fluid flows. We resist the temptation to use immediately one of the test-tubes which the assistant presses upon us, and we allow the first few drops of fluid to be collected by the wool. When we are sure of a proper sample we collect it, and we are careful to avoid any contact between the test-tube and the needle which may be heard by the patient. If, from the position of the needle, the fluid has to flow in an uphill direction it will tend to flow from the outlet back along the surface of the needle. A satisfactory flow into the tube can be obtained by attaching to the outlet of the needle a small rectangular hollow metal tube, or the patient's trunk may be rotated so that the needle outlet is dependent.

When a specimen has been collected into each of two tubes the needle is briskly withdrawn, the wound cleansed with the other swab dipped into the spirit, and then sealed with the plaster. The labels are now filled in and the fact that the specimen is from the lumbar sac stated. The tubes are placed in a rack and care must be taken that they suffer no injury. It is chiefly on this account that two specimens have been collected. The props are now taken from the head of the bed and placed at the foot. The patient is asked what he felt and he replies, "Nothing except the cold." He is given a drink, the blinds are drawn, and he is encouraged to sleep. A single small pillow may be allowed. If platinum-iridium needles are used and if the doctor himself invariably draws spirit through them after an operation he will never have any anxiety about the state of the lumen. The smoothness and polish of the surface of the needle is important. The condition of the lumen is more important. With experience the point is never turned and the needle rarely needs sharpening.

POST-OPERATIVE EFFECTS.

From the patient's point of view it is convenient to perform the operation in the evening. He should stay in bed the next day when the back should be examined and the plaster removed. Without laying emphasis on it he should be allowed to know that he may have a headache when he gets

up, but that it can readily be treated (aspirin, pituitary extract, intravenous hypotonic saline). Headache is usually evidence that a healthy fluid has been withdrawn, but the majority of all patients who are punctured under favourable circumstances have no headache. If the patient has complained of a twinge of pain in a lower limb during the operation he should be told before we leave him to demonstrate to himself and us that he can freely move both lower limbs at all joints. This is in view of the possibility of such a pain suggesting a hysterical palsy. On a few occasions a nervous patient has fainted during the operation. Such an occurrence is no reason for stopping the operation.

CAREFUL TECHNIQUE ESSENTIAL.

We should not be in a hurry. We should be assured of the correct position of the patient before we start the operation. We should make certain that the operation will be successful at the first attempt. We should not be satisfied unless the specimen of fluid is proved to contain no single red cell due to the operation. The chief risks of thecal puncture—meningitis and a broken needle—are reduced to an almost negligible quantity by remembering them and by a careful technique. I have witnessed a man die from septic meningitis due to lumbar puncture. In a puncture above the lumbar sac there is a risk of injury to the spinal cord. Experience alone teaches us how to avoid this.

We operate through a low interspace. If operative hæmorrhage is encountered there is no risk of the fluid at a higher level being contaminated if the patient is inclined downwards towards his feet. There is practically no risk of it when the patient is lying flat. If there is operative bleeding we withdraw the needle and put it aside, but not in the dish with the other needles. With a fresh needle the operation is performed through a higher space. Operative bleeding may be considerable, and in such a case it may happen that there is no flow of fluid. The examiner may think that he has failed to enter the subarachnoid space. A subsequent operation within the week will show xanthochromia. The theca may be punctured at any or every space from the lumbar region up to and including the occipito-atlantal space (cistern puncture). The anatomical features of the laminæ and spines at different levels should be visualised, and also the narrowing of the sac at certain sites from enlargements of the cord within. It is necessary carefully to visualise the rotation of the spine in cases of scoliosis, and the position of the spine in obese patients in whom no bony landmarks can be palpated.

Provided that the precautions indicated in this paper are taken the writer does not know any contra-indication to thecal puncture, and experience teaches that a successful operation can be performed in 100 per cent. of cases less a small fraction. *Failure to collect fluid* by lumbar puncture has occurred on three occasions in the writer's experience. Two of the patients were proved to have

circumscribed serous spinal meningitis, following cerebro-spinal fever, and tetanus with intrathecal treatment, respectively. The other patient had a cystic tumour of the pineal body.

A house physician recently performed lumbar puncture on a man in whose fluid no abnormality was anticipated. The pathologist reported the presence of large numbers of cells which, at the moment, he could neither describe nor explain. The cistern fluid withdrawn for purposes of control contained no cells. We then discovered that the cells were from bone-marrow. The operator and the patient both appeared to be ignorant of the fact that the needle had been thrust into bone. The fluid contained no blood.

Thecal Puncture, Post Mortem.—It is sometimes very helpful to see and examine the cerebro-spinal fluid after death. It flows as readily then (at any rate immediately after death) as during life. We are called to a patient who is moribund. His fluid has not been examined and no diagnosis has been made. He dies in our presence. In one such case we were able to exclude apoplexy and other varieties of intracranial hæmorrhage from the possible causes of death. In another patient the fluid obtained immediately post mortem showed the complete picture of cerebro-spinal syphilis, and our post-mortem diagnosis of general paralysis, based on this and on the story obtained subsequently, was probably correct.

LESSONS TO BE LEARNT FROM A NAKED-EYE INSPECTION OF THE FLUID.

The diagnostic possibilities of thecal puncture—therapeutics apart—make it one of the most important operations in medicine.

The *pressure* may be estimated if we wish by a manometer, but this is rarely required. A raised pressure is found commonly in cases of meningitis and intracranial tumour, if the channel is free from the ventricles to the needle outlet. It may also be raised in cases of apoplexy and subarachnoid hæmorrhage. No harm is to be anticipated in a case of meningitis by allowing the fluid to escape in a spurt, but it must not be permitted in a case of intracranial tumour. But however raised the pressure may be, the flow will not be excessive through a fine needle, and in any case it can be controlled readily enough by the finger.

In health and in many diseases the *colour* of the fluid is that of water. It is termed colourless. But the fluid may be cloudy or purulent, or it may be yellow (xanthochromia). A yellow colour may occur in a fluid withdrawn from below the site of a block in the subarachnoid space. Such a fluid will sometimes clot in the test-tube almost as it is collected. The recognition of the abnormal colour is important. A woman whose breast had been removed some years before had signs of a cauda equina lesion (metastasis). We anticipated a yellow fluid but withdrew one which was colourless. On altering the position of the needle point very slightly a few drops of bright yellow fluid flowed

and were collected in a fresh tube. A further slight alteration in the position of the needle allowed a colourless fluid again to flow. But the clinical diagnosis was clinched by the fact that we did not miss the evidence afforded by those few yellow drops, which flowed from a locus in the subarachnoid space.

More commonly the yellow colour is due to pre-existing hæmorrhage. The fluid may be yellow in cases of severe jaundice. The lumbar fluid of a patient who had a tumour in the mid-brain was colourless for some weeks. It then became yellow during the progress of the disease, but no obvious hæmorrhage had occurred into or around the tumour.

THE OCCURRENCE OF HÆMORRHAGE.

As regards the presence of *blood* in the fluid no difficulty occurs in practice in deciding whether it was there prior to the operation or was caused by it. If the needle has caused the bleeding (it is usually from injury to vessels on the posterior surface of the vertebral bodies; for obvious reasons bleeding from this source should not occur except during puncture of the lumbar sac) the drops of fluid are thick with blood, and usually after a moment the fluid is colourless. Red cells will, however, be found in the later sample collected. If a fluid, bloody from operation, is centrifuged or allowed to stand the supernatant fluid is colourless. On the other hand, if the blood pre-existed the operation the samples collected are uniformly coloured, and when the tube is allowed to stand the supernatant fluid is yellow. If the bleeding has already stopped the fluid will be yellow throughout for the next few days without any deposit of blood.

The usual sources of hæmorrhage into the subarachnoid space are apoplexy and rupture of a basal aneurysm, which may be congenital. The term "spontaneous subarachnoid hæmorrhage" is given to cases in which the cause is not determined. Hæmorrhage may occur after trauma such as a fall out of bed. It may occur like hæmorrhage elsewhere in association with nephritis and high blood pressure. Some cases, but not all, of hæmorrhage into the thecal sac have symptoms which resemble those of acute meningitis. The fluid may be expected to contain a little blood after severe trauma to, or surgical operations on, the skull or spine.

Cerebral hæmorrhage does not always cause unconsciousness, but if there is unconsciousness, and usually when there is not, we should anticipate a bloody fluid. The clinical diagnosis of apoplexy is thus readily confirmed. If the test were made more often we should hear less of the supposed diagnostic difficulty between, e.g., opium poisoning and apoplexy. A few moments naturally elapse before the lumbar fluid is bloody in apoplexy. A patient was described during a ward visit as a candidate for apoplexy. He had his apoplexy while we were in the ward. The cerebro-spinal fluid withdrawn within two minutes of his losing consciousness was colourless. In five minutes it was bloody.

Globulin Test.—If it is important to confirm a provisional diagnosis at the bedside from a colourless fluid we may learn a great deal by adding to part of it an equal quantity of saturated ammonium sulphate. The mixture becomes bluish-white in colour in the presence of an excess of globulin.

Cell Counting.—The reader is referred to an easy method, adopted by some for counting blood leucocytes, which is described in the *Journal of the Royal Naval Medical Service* for October, 1917. No special counting chamber is needed.

It is not the purpose of this paper to describe laboratory methods of examining cerebro-spinal fluid. The common tests, apart from bacteriological investigation and injection into guinea-pigs, are the Wassermann reaction and cell count, the estimation of albumin and globulin, chlorides, sugar, and urea, and the assessment of the gold curve.

PURPOSES OF LUMBAR PUNCTURE.

In conclusion, it may be convenient to enumerate some of the purposes of lumbar puncture other than those for examination of the cerebro-spinal fluid. They are: For the injection of air for pneumo-radiography, or lipiodol below a suspected block in the subarachnoid space; for the injection of salvarsanised blood serum and other sera; for the injection of spinal anæsthetics; for washing out meningeal exudate through an exit made by cistern or ventricular puncture, or for the injection of oxygen in some cases of meningitis; for the treatment of migraine; for the relief of coma in sunstroke, fractured base, uræmia, and other conditions; for the estimation of the alcohol content of the fluid; for the relief of increased intracranial pressure. A man who had a tumour of his third ventricle was frequently found lying with the head flexed and unable to extend it. During the course of lumbar puncture he was always enabled to extend it, to his great relief. The same man on one occasion had a sudden attack of complete unconsciousness. Consciousness was restored and he was able to speak normally in 20 seconds from the introduction of the needle.

Cistern Puncture has many of the uses of lumbar puncture. In addition, it affords a method of comparing the pressure, colour, and content of the fluids above and below a block in the subarachnoid space, and also of relieving headache in some cases of cervical subarachnoid block. With reference to the injection of lipiodol by cistern puncture we should remember that in cases of sepsis or difficulty we may inject it alternatively, with due precautions into the cervical thecal sac.

Ventricular Puncture.—We have performed this operation for the diagnosis and temporary relief of internal hydrocephalus, for the injection of sera, and recently in the early stage of apoplexy for relief by aspiration. Possibly migraine might be relieved thereby. We have referred already to its use as an exit for solutions injected from below for the purpose of washing away meningeal exudate.