CEREBROSPINAL FLUID IN 302 CASES OF INTRACRANIAL TUMOUR, ABSCESS, AND SUBDURAL HAEMATOMA

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Intracranial tumours differ greatly as regards the possibility of diagnosis from the clinical history and examination alone, without the aid of ancillary investigations. There is rarely any difficulty in cases with the classical triad of progressive history, focal manifestations, and increased intracranial pressure. The various types of tumour behave differently, however, in their effects on the brain and on intracranial pressure, depending on their pathology, rate and manner of growth, and situation. Thus there may be no focal manifestations to reveal the position of a tumour, the presence of which is virtually certain from signs of high intracranial pressure, or, on the other hand, there may be no increase of intracranial pressure to suggest tumour as the cause of a focal disturbance; also, a detailed history, which is so important, may not be available. Again, some tumours produce only general manifestations such as fits, dizziness, or headaches, which are often due to other neurological conditions or to general medical causes. In many cases, therefore, clinical examination must be supplemented by ancillary tests, the choice of which should depend upon the nature of the desired information and upon full appreciation of their value and limitations.

Points in Diagnosis

Ancillary methods of diagnosis should always be used with discrimination, never as a routine, and only when diagnosis remains uncertain or requires amplification to guide treatment; they are not to be regarded as short cuts to diagnosis, replacing careful clinical examination. Simple, easily performed tests like lumbar puncture are apt to be used unnecessarily, without regard to whether they are likely to be helpful, especially when the clinical examination is not as thorough as it might be. Moreover, belief in the necessity for lumbar puncture is naturally influenced by the clinician's neurological experience and the type of clinical material—that is, whether the test is used merely to amplify the diagnosis of tumour or is used in the hope of excluding tumour or of obtaining positive evidence of an organic lesion.

Neurosurgeons and physicians no doubt view diagnostic lumbar puncture for brain tumour from different standpoints, and neurosurgeons, by reason of their greater experience of tumours and simulating conditions, should use it less than physicians. It is of interest to recall that in Cushing's clinic lumbar puncture was never used for diagnostic purposes—a policy which he soon adopted after the occurrence of fatalities attributable to the test (which still occur) and because the additional information obtained was negligible. The belief that lumbar puncture is of little value to neurosurgeons does not apply, however, to its proper use by clinicians who only occasionally encounter cerebral tumours.

Lumbar puncture, as opposed to visualizing procedures like ventriculography or arteriography, yields numerical

results which, alone, do not provide specific evidence of tumour, and only rarely do so when considered along with the clinical findings. Moreover, although usually regarded as a safe procedure, lumbar puncture is potentially dangerous in cases with high intracranial pressure and can be fatal, and there is always the slight risk of meningitis. It is therefore important, for the proper and safe use of the test, to assess its value and its limitations in tumour cases by determining how useful it may be (a) as a general or specific test of tumours, and (b) in the management of known tumour cases, either as a means of foretelling the pathology and operability of the tumour or as a possible substitute for more complicated and dangerous methods of investigation, such as ventriculography.

The literature concerning diagnostic lumbar puncture for brain tumour is scanty, and has perhaps given a false impression of the frequency of what may be regarded as the complete fluid syndrome—namely, raised pressure, increased protein, and sometimes xanthochromia and moderate pleocytosis. It was evident from the earlier studies of small groups of cases that there is no constant C.S.F. picture characteristic of brain tumours, nor, because of their great variety in type and situation, would it be expected. Later analyses of larger series, with special attention to the situation and pathological type of the growth, again showed that spinal fluid examination is rarely conclusive in the differential diagnosis of tumour from other diseases of the brain; and that one-third or more of tumour cases have normal fluid, while an abnormal fluid is not by itself diagnostic of tumour. It was shown, however, that tumours of certain types or in certain situations commonly have either normal or abnormal fluids as the case may be (Greenfield and Carmichael, 1925; Hare, 1935; Merritt and Fremont-Smith, 1937). The fact that the spinal fluid is often normal detracts from the value of the test, but the discovery of abnormal fluid as the sole evidence of organic disease, when symptoms have been attributed to conditions such as neurosis or idiopathic epilepsy, is important. We have endeavoured to go a stage further by assessing the fluid findings in relation to the more common clinical syndromes and difficulties which confront the neurosurgeon, and to estimate their value to the general physician in preliminary diagnosis.

The diagnosis of intracranial tumour requires answers to three questions: (1) Is a tumour present? (2) Where is it? (3) What kind is it? Patients may be divided into three categories depending on how far these questions can be answered from the clinical findings alone.

1. *Suspected or Probable Intracranial Tumour.*—Progressive symptoms suggest the possibility of tumour, but there is no papilloedema. It is in the general investigation of this large group of patients that lumbar puncture could be of great value in verifying or excluding tumour.

2. *Unlocated Intracranial Tumour.*—Signs of increased intracranial pressure reveal almost certainly the presence of a tumour or other space-occupying lesion, but there are no focal manifestations to indicate its position. An appropriate diagnostic method such as ventriculography is usually required to locate it as lumbar puncture does not help.

3. The symptoms and signs are so characteristic that clinical (and x-ray) examination by itself provides definite evidence not only of the presence of a tumour but also of its situation, and sometimes also its pathology—for example, some cases of tumour involving the optic chiasm, meningioma, brain-stem glioma, and metastatic tumour. Lumbar puncture is unnecessary, and treatment can be decided without further investigation. Sometimes, however, additional information regarding pathology—for example, whether the tumour is a glioma or a meningioma—would be helpful in surgical management if

it could be obtained easily, but, as will be seen, the cerebrospinal fluid rarely helps in this respect.

With these clinical categories and problems in mind we have analysed the C.S.F. findings in 302 consecutive cases of histologically verified intracranial tumour, abscess, and subdural haematoma which were seen by us at the National Hospital, Queen Square, London, during two and a half years (1935-8). Many patients did not have operation, and there were 145 necropsies. All tumours were examined histologically by Dr. J. G. Greenfield. This report was delayed by the war, but further experience has confirmed our conclusions, with certain additions that will be mentioned.

The lumbar spinal fluid was obtained in 286 cases and the ventricular fluid in 128. All fluid examinations were made by Dr. J. G. Greenfield or Dr. J. N. Cumings. Our analysis concerned protein content and cell count, the only constituents affected by tumours. The protein was measured by Mestrezat's diaphanometric method, and up to 60 mg.

TABLE I.—Lumbar C.S.F. Protein with Intracranial Tumours

Type and Situation of Tumour	Total Protein in Lumbar C.S.F. (mg. per 100 ml.)	
	Normal	Increased
<i>Gliomas (125 cases)</i>		
Astrocytomas:		
Cerebral	25, 25, 30, 30, 30, 35, 35, 35, 40, 45, 45, 45, 55, 55, 55	65, 70, 70, 80, 80, 80, 100, 110, 125, 150, 440
Corpus callosum ..	30, 40, 40	70
Thalamus, midbrain ..	30, 30, 30, 50	70, 80, 90, 90, 120, 140, 150
Cerebellar—adults ..	45, 45, 50, 60	70, 150
" children ..	40, 40, 45	70, 80, 90, 140
Intraventricular ..	55	
Glioblastomas:		
Cerebral	20, 25, 30, 40, 40, 40, 45, 50, 50, 50, 55, 60, 60, 60, 60	65, 65, 70, 75, 90, 90, 100, 100, 100, 120, 120, 130, 150, 180, 220, 240, 320, 400, 800, 1,280
Corpus callosum ..		190, 220, 260, 300, 400
Thalamus, midbrain ..		110, 120, 160
Oligodendrogliomas ..	35, 40, 40, 40, 50	65, 80, 85, 90, 110, 120, 160, 200
Medulloblastomas ..	45, 60	80, 90, 190
Ependymomas ..	60	70
Gliomas pontis ..	30, 40, 50, 55, 60	70
Glioma of infundibulum ..		240
<i>Meningiomas (62 Cases)</i>		
Cerebral convexity ..	30, 40	65, 70, 90, 90, 90, 125, 130, 140, 160, 160, 175, 175, 180, 220, 240, 280
Parasagittal	40, 40, 45, 50, 60	90, 100, 125, 130, 170, 350, 360
Olfactory groove ..		120, 180, 220, 500
Tuberculum sellae ..	40, 60	80, 90, 90, 100, 120, 120, 160
Sphenoid ridge ..	55	80, 100, 140, 175, 190, 200, 220, 300, 450
Middle fossa	60	95, 120
Posterior fossa ..		70, 100, 130, 140, 220
Intraventricular ..		120
<i>Neurofibromas (16 Cases)</i>		
Acoustic		100, 180, 180, 220, 350, 360, 400, 440, 640, 720, 750, 880, 900
Trigeminal		380
Multiple		240, 280
<i>Pituitary Tumours (36 Cases)</i>		
Chromophobe adenomas ..	35, 50, 55	70, 70, 75, 80, 90, 90, 100, 100, 100, 120, 130, 150, 150, 180, 180, 680, 760
Acidophil adenomas ..	30, 40	80, 110, 180, 190
Craniopharyngiomas ..	20, 35, 40, 50	75, 80, 80, 90, 100, 140
<i>Miscellaneous Groups (37 Cases)</i>		
Metastatic	30, 55	75, 80, 100, 120, 150, 560
Haemangiomas:		
Cerebellar	45	80, 90, 220, 480
Parietal	25	70
Angiomas	60	140
Sarcoma—cerebral ..	60	180
" cerebellar ..	20, 40, 50	
Colloid cyst—III vent. ..	35, 55	
Dermoid—III vent. ..		320
Pinealoma		175
Epidermoid—petrous ..		75
" parasellar ..	60	
Chordoma of sphenoid ..		160
Tuberculoma (multiple) ..	60	
Subdural haematoma ..	45, 45, 50, 50, 60	80, 90

per 100 ml. in the lumbar fluid and 10 mg. per 100 ml. in the ventricular fluid were regarded as normal. A cell count of less than five cells per c.mm. was taken as normal.

In Table I the total protein values in all cases are given in order to convey a clearer impression of the relative ranges of figures than would be presented by any arbitrary grouping into degrees of abnormality.

Lumbar Fluid

Tumours

Astrocytomas.—The protein figures were rather low, and more than half were normal. In only one instance were the cells increased (8 cells). The protein values did not seem to be influenced by the situation of the tumour, by its character, whether cystic, solid, or calcified, or by its proximity to the ventricles.

Glioblastomas.—These had a much wider range of protein figures than the astrocytomas; they were sometimes very high, but were often normal. In 13 cases (30%) there was a considerable increase of cells (14 to 70) and the fluid was usually deep yellow or orange. Pleocytosis with xanthochromia in known tumour cases was characteristic of glioblastoma; it occurred with all glioblastomas of the corpus callosum. Post-mortem examinations showed that the ventricular walls were extensively infiltrated in all cases with increased cells, but not in those without pleocytosis, even though there was marked increase of protein. The type of cell varied, but it is of interest that the percentage of polymorphs in two cases was as high as 32 and 84 respectively. The cases with moderately raised protein usually had colourless fluid without increase of cells: the thalamus and midbrain glioblastomas were in this category.

The rarer types of glioma showed no distinguishing features. One case of medulloblastoma had 9 lymphocytes.

Meningiomas.—The protein was more often increased with meningiomas than with gliomas and frequently was very high, but it was sometimes normal. In 7 instances the fluid was faintly yellow, but never so deeply coloured as with some glioblastomas. Among 62 cases pleocytosis occurred in only 2, each with 8 cells. There was no difference between meningiomas over the convexity of the cerebral hemisphere and those on the skull base, both having a wide range of figures; nor was there any relationship to the age of the patient, duration of symptoms, size or type of tumour, or intracranial pressure.

Neurofibromas.—This was the only group in which the protein in the spinal fluid was always increased; the figures were usually very high, and when above 350 mg. the fluid was slightly yellow. The cells were never increased. There was usually a moderate elevation in the middle of the Lange curve.

Pituitary Tumours.—The fluid showed no special features and there was no relationship to the consistency of the adenoma or to its position, whether intrasellar, suprasellar, or with intracranial extension. Two cases, without apparent reason, had exceptionally high protein and yellow fluid. One case of craniopharyngioma had 9 cells.

Metastatic Tumours.—All tumours were bronchogenic in origin except one from the kidney. The fluids showed a wide range of protein values, but no increase of cells. (Ten recent cases of metastatic bronchial tumours had similar protein figures, ranging from normal to 150 mg., but three of them had increased cells with 9, 14, and 85 lymphocytes.) In the case with 560 mg. of protein the meninges and ventricular walls were diffusely infiltrated with bronchogenic tumour cells without any localized

tumour formation; the lumbar fluid was straw-coloured and contained only one cell. All other fluids were colourless.

Blood-vessel Tumours.—The three cases with high protein had yellow fluid.

Pinealoma.—In this single case the fluid was colourless and contained 87 cells, including one polymorph. Two recently observed cases had 60 mg. protein with 8 lymphocytes, and 136 mg. protein with 30 lymphocytes respectively.

Tuberculoma.—Three recent cases all had increased cells—7, 10, and 75 lymphocytes with 90, 20, and 25 mg. of protein respectively.

Cerebral Atrophy.—Progressive hemiparesis, mental deterioration, fits, and other cerebral symptoms may be associated with cerebral atrophy, the diagnosis of which rests upon ventriculographic demonstration of dilated ventricles. This condition sometimes has to be considered in the differential diagnosis of brain tumours. In a number of recently observed cases the spinal fluid was usually normal but occasionally contained a slight excess of protein.

Chronic Subdural Haematomas

In this curable condition, which clinically often resembles hopeless cerebral gliomas and is apt to be missed, the protein figures were comparatively low, usually normal. In one case the fluid was straw-coloured and in another there were 8 cells.

Abscesses

The lumbar fluid was normal in 40% of this small group of abscesses. In the remainder the protein was considerably increased, and the number and type of cells varied, as shown in Table II, depending presumably upon whether

TABLE II.—Lumbar C.S.F. Protein and Cells with Abscesses

Situation of Abscess and Source of Infection	Total Protein (mg. %)	Cells
Frontal: Frontal sinus ..	40	2 lymphocytes
" " " " ..	40	0
Parietal: Carbuncle of hand ..	70	2.5 lymphocytes
" Pulmonary ..	80	5 cells; 80% polymorphs
" Osteomyelitis of arm ..	160	290 cells; 48% "
Temporal: Otitic ..	40	0
" " " " ..	150	9 cells; 44% "
" " " " ..	160	7 lymphocytes
Cerebellar: Otitic ..	35	4
" " " " ..	200	9

the abscess was still surrounded by a zone of encephalitis or had become firmly encapsulated, and whether there had been any recent meningitis or recurrent encephalitis.

Spinal fluid examination in 15 cases of abscess recently treated in a general hospital (Leeds Infirmary), where they are probably seen earlier than in a neurological hospital, gave similar results as regards protein content, the highest figure being 80 mg., but the cells were more often considerably increased—namely, six cases had only one cell, three a slight increase of 8 to 12 cells, and six a considerable pleocytosis ranging from 22 to 300 cells; polymorphs were usually but not always present, and they were more numerous, up to 50%, with the higher counts.

A slight or even considerable increase of lymphocytes is of no value in differentiating abscesses and tumours, as it may occur with either. The presence of polymorphs, however, is strongly in favour of abscess when the fluid is colourless, because in tumour cases they are found only with glioblastomas, which can be readily distinguished by the yellow fluid.

It is of interest that the fluid findings in 7 recently observed cases of presumed acute pyogenic encephalitis, which resolved without abscess formation and with dis-

appearance of focal signs, resembled those due to abscess: all had normal protein except one with 75 mg., while the cells varied from normal to 350, usually with a mixture of polymorphs. Thus the spinal fluid gives no indication whether an acute cerebral infection has progressed to abscess formation or will resolve.

It may be mentioned that turbid fibrinous fluid with marked increase of cells, mainly polymorphs, indicates acute meningitis, which is usually obvious clinically, but an abscess may also be present. Also, it should be emphasized that lumbar puncture is often dangerous with abscess owing to the risk of producing a pressure cone, and consequently, because of the non-specific findings, it should not be done unless absolutely necessary.

Comment on Lumbar Fluid Examinations

1. The spinal fluid findings alone are not diagnostic of intracranial tumour. Increased protein indicates an organic lesion, but not necessarily tumour, and normal protein does not exclude tumour.

2. The lumbar fluid examination taken in conjunction with clinical findings is of value in two circumstances: (i) Cerebral tumours with deep yellow fluid, high protein, and moderate pleocytosis can be identified as glioblastomas invading the ventricle. With this exception no distinction is possible between infiltrating and non-infiltrating tumours. (ii) Acoustic neurofibromas always produce high protein, and can therefore be excluded in cases of cerebello-pontine angle syndrome with normal fluid.

3. The spinal fluid is of no value in determining the situation of an unlocated tumour with papilloedema.

4. Regarding the more common clinical syndromes and difficulties, the following observations may be made:

(a) Of tumours that may resemble acoustic neurofibromas clinically, meningiomas in the cerebello-pontine angle had protein values of 130, 140, and 220 mg., which were similar to the lower figures for neurofibromas, while gliomas of the pons had normal protein.

(b) The clinically similar cerebellar tumours in childhood, astrocytomas and medulloblastomas, cannot be distinguished by lumbar puncture.

(c) It was sometimes difficult clinically to distinguish between cerebellar and frontal tumours; the latter included meningiomas, oligodendrogliomas, astrocytomas, and glioblastomas. The lumbar protein in these instances was normal or only slightly raised, which was also the common finding with cerebellar gliomas.

(d) As regards parasagittal tumours, the wide range of protein values for meningiomas (40 to 360 mg.) makes it impossible to differentiate them from gliomas, mostly astrocytomas, although the figures for gliomas were limited to between 70 and 130 mg.; so that a very high protein suggests meningioma.

(e) Tumours in the chiasmal region—tuberculum sellae meningiomas, pituitary adenomas, and craniopharyngiomas—cannot be differentiated. It may be emphasized that normal C.S.F. does not exclude tumour as the cause of unexplained failing vision with progressive visual field defect and perhaps optic atrophy.

(f) It is often impossible clinically, even with ventriculograms, to identify the pathological types of tumours in the region of the pineal and midbrain. Pinealomas may be distinguished from other tumours by excess of cells when present, but it appears from some case reports that the cell count may be normal. The protein values in four cases of midbrain astrocytoma were 50, 70, 80, and 140 mg., in two glioblastomas 120 and 160 mg., and in one ependymoma 60 mg.; in none were the cells increased.

(g) The C.S.F. does not help in the identification of metastatic tumours.

(h) A slight increase of cells from 5 to, say, 10 is of no diagnostic significance, as it occurs with most types of tumour and with abscess; but it is noteworthy that, as regards tumours, more than 10 cells were found only with glioblastomas, pinealomas, metastatic tumours, and tuberculomas. No tumour cells were identified in the fluid, but their occurrence has occasionally been reported by others in cases of medulloblastoma or metastatic tumour.

5. In the diagnosis of abscess the C.S.F. is of little value. The presence of polymorphs is suggestive, as they were not found with tumours, except some glioblastomas with xanthochromic fluid, but they may also occur with resolving pyogenic encephalitis.

6. Spinal fluid is of no value in the diagnosis of chronic subdural haematoma.

Ventricular Fluid

The cerebrospinal fluid from one or both lateral ventricles was obtained during ventriculography or operation in 128 cases, 16 of which had not previously had lumbar puncture. As ventricular fluid cannot be obtained without a surgical procedure its examination has no place in the preliminary investigation of brain tumours; moreover, analysis of the findings showed that they are of little real value in diagnosis or in the surgical management of known tumour cases.

Fluid was obtained from both ventricles in about one-half of the 74 cases in which the tumour was situated above the tentorium; in the others only one ventricle was tapped, usually on the side opposite to the tumour. The frequency of increased ventricular protein with the more common supratentorial tumours (astrocytoma, glioblastoma, and meningioma) is shown in Table III.

TABLE III.—Ventricular C.S.F. Protein with Supratentorial Tumours

Type of Tumour	No. of Patients	Ipsilateral Ventricle		Contralateral Ventricle	
		No. Examined	No. with Increased Protein	No. Examined	No. with Increased Protein
Astrocytoma ..	24	17	8 (47%)	23	7 (30%)
Meningioma ..	19	7	5 (71%)	19	9 (47%)
Glioblastoma ..	16	5	4 (80%)	15	8 (53%)

In most cases with posterior fossa tumours fluid was examined from only one ventricle. In the 19 instances in which both ventricles were tapped the fluids were identical whether the protein content was normal or increased; and it is assumed that this is true for all midline tumours—cerebellar, pineal, third ventricle cysts, and craniopharyngiomas.

Astrocytomas.—Fluid was examined from 37 cases. All 13 patients with cerebellar astrocytomas, mostly children, had normal ventricular fluid except three with an increased protein content up to 35 mg. (the medulloblastomas showed similar results). As regards the 24 cerebral astrocytomas, it is noteworthy that the fluid was normal in both ventricles in 9 out of 16 bilateral examinations. One case with a pedunculated 50 g. astrocytoma within one lateral ventricle had a protein content of only 5 mg. in each ventricle. The abnormal fluids rarely contained more than 50 mg. in the ventricle on the side of the tumour.

Glioblastomas.—The fluid was more often abnormal than with astrocytomas, but the protein values were similar in range; the fluid was, however, sometimes normal in both ventricles.

Meningiomas.—There was no essential difference between meningiomas and gliomas as regards frequency and degree of abnormality in the ventricular fluid. It was

normal in both ventricles in only 2 out of 7 cases. In half the cases there was, as with glioblastomas, increased protein content in both ventricles.

Oligodendrogliomas.—The protein content was raised in the homolateral ventricle in 2 out of 4 cases to 20 and 50 mg. respectively, but was normal in the contralateral ventricle in all 5 cases examined. Post-mortem specimens showed that invasion of ventricular walls by these tumours produces less change in the fluid than is produced by other gliomas.

Ependymomas (Fourth Ventricle).—The protein was raised to 15–20 mg. in all 3 cases examined.

Haemangiomas.—Of the 7 cerebellar cases the ventricular fluid was normal in 5, but in the others it was raised to 60 and 180 mg. (480 mg. in the lumbar fluid) respectively.

Acoustic Neurofibromas.—Three out of 9 cases showed an increase of protein ranging from 15 to 40 mg.

Metastatic Tumours.—Two of the 3 cases examined showed normal fluids on both sides.

Other Tumours.—The fluids were normal in all 7 cases of craniopharyngioma, in 2 cases of colloid cyst of the third ventricle, and in the single case of pineal tumour.

Abscesses.—In one case of cerebellar abscess (lumbar fluid protein, 200 mg.) the ventricular protein was raised to 25 mg. The protein was slightly raised in 2 cases, but there was no increase in cells.

In the entire series there were 8 cases with exceptionally high protein content (100–1,000 mg.) in both lateral ventricles—namely, two large cerebral astrocytomas, two glioblastomas, two meningiomas, one cerebellar haemangioma, and the case of diffuse metastatic infiltration of the meninges and ventricular walls mentioned previously. The fluids were usually yellow.

Comment on Ventricular Fluid Findings

Examination of ventricular fluid from one or, when obtainable, both sides is of little value in diagnosis or in deciding treatment. With unilateral supratentorial tumours the protein in the ventricle on the side of the tumour may be normal or increased, but it may also be increased in the contralateral ventricle; moreover, the fluid may be normal in both ventricles with a tumour in one cerebral hemisphere or in the midline above the tentorium or in the posterior fossa.

Comparison of the protein content in the lumbar and ventricular fluids has been advocated as a means of localizing tumours to the posterior fossa, to the third ventricle, or to one cerebral hemisphere (Merritt, 1935). It is our opinion, however, that combined puncture has no practical value, as it does not supply sufficiently accurate information for surgical purposes; if the clinical findings are inadequate for determining the precise localization, visualizing methods such as ventriculography are necessary.

Pathogenesis of Changes in the C.S.F.

We have no observations about the origin of excessive protein and cells in the cerebrospinal fluid. The various theories regarding this have been discussed by Greenfield (1936). There are probably several mechanisms, of varying importance in individual cases—namely, transudation of protein from the surface of the tumour, liberation of protein and cells from within a degenerating tumour that has infiltrated through the ventricular wall, or drainage of protein from oedematous brain surrounding the tumour. The last mechanism is, we believe, the chief factor with convexity meningiomas, which are often associated with

marked oedema throughout the cerebral hemisphere and high spinal protein. It is unlikely that stasis of the fluid circulation, resembling that seen below spinal tumours, is an important cause of excessive protein with brain tumours or that pleocytosis is due to meningeal reaction.

Spinal Fluid Pressure

Although this investigation was concerned with the clinical value of spinal fluid examination, a few remarks may be added about lumbar C.S.F. pressure and its measurement. The borderline of abnormally high pressure is assumed to be 180 to 200 mm. of water. Undue importance is apt to be attached to the lumbar pressure as conclusive evidence for or against an intracranial expanding lesion, and, moreover, lumbar puncture to verify high pressure may be dangerous.

It must again be stressed that papilloedema makes lumbar puncture unnecessary and that even before papilloedema appears many tumours can be diagnosed on clinical grounds alone. On the other hand, high pressure may be the only objective evidence of an intracranial expanding lesion.

The importance of carefully positioning the patient is sometimes overlooked and too high a reading is obtained. The lumbar needle and the centre of the head must be on the same level, and the patient must be completely relaxed and breathing easily. It is customary to facilitate insertion of the needle by fully flexing the head, trunk, and legs. Before taking measurements, however, the neck should be straightened to avoid constriction of the jugular veins, and the thighs extended slightly to avoid compression of the abdomen. Pressure readings taken under general anaesthesia are of no value.

The danger of death from coning after withdrawal of lumbar fluid in cases with high intracranial pressure is well recognized but often ignored. Coning is better known at the foramen magnum with posterior fossa tumours, but it is probably more common and more dangerous at the hiatus tentorii in cases with supratentorial tumours, especially rapidly growing gliomas, also abscesses, middle meningeal haemorrhage, and acute subdural haematomas, all of which commonly produce very high pressure before papilloedema appears. The danger of coning can be avoided, first, by not doing lumbar puncture unnecessarily; secondly, by removing not more than the required minimum of 2 ml., drop by drop, using always a Greenfield needle of fine calibre with manometer to control the escape of fluid; and, thirdly, by not doing jugular compression (patency of the needle can be proved by abdominal compression). Jugular compression is commonly done in brain tumour cases, but it is valueless and potentially dangerous, and need never be used; in spinal cases, on the other hand, jugular compression is of vital importance and should never be omitted. In high-pressure cases we have seen several deaths directly attributable to lumbar puncture: death usually occurs after six to twenty-four hours and not immediately.

As is well known, the C.S.F. pressure may be high without papilloedema and, conversely, owing to spontaneous fluctuations, the pressure may be normal temporarily in patients with papilloedema; a single reading may therefore be misleading. Also, the lumbar pressure is sometimes lower than the intracranial pressure when the latter is high and is associated with partial coning at the hiatus tentorii (Smyth and Henderson, 1938).

The common practice after lumbar puncture of raising the foot of the bed to prevent headache should never be

used in tumour cases, because that position raises the intracranial pressure still more; the head should be raised to lower the pressure.

Summary

Diagnostic lumbar puncture in cases of either suspected or known intracranial tumour is used more often than is necessary, and without due regard to its limited value and potential dangers. It is not part of routine neurological examination, and should always be used with discrimination.

Many tumours have normal fluid, while increased protein is often due to conditions other than tumour.

The value of spinal fluid examination in known tumour cases is negligible, except sometimes in confirmation of acoustic neurofibromas and in the identification of some deep cerebral glioblastomas invading the ventricle, and perhaps in the identification of pinealomas.

Although lumbar puncture is of very little value in specifically verifying or excluding intracranial tumour, or in the management of neurosurgical cases, it is nevertheless useful in preliminary investigation. The discovery of increased protein or high C.S.F. pressure may reveal an unsuspected organic lesion, possibly tumour, but normal fluid never excludes tumour.

Lumbar puncture has little value in the diagnosis of abscess, and it is often dangerous, as also in other cases of rapidly increasing intracranial pressure, owing to the onset of very high pressure before papilloedema appears. The danger attached to lumbar puncture should be carefully balanced against its limited diagnostic value.

Comments are made about the measuring of lumbar pressure and its value.

We wish to express our thanks to the staff of the National Hospital, and especially to Dr. J. G. Greenfield, for permission to use his records and for helpful advice.

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A draft Order in Council has been laid before Parliament giving the outline of the proposed arrangements for the next census in Britain, proposed to be held on April 8, 1951. Censuses are expected to be held on the same day in Northern Ireland, the Channel Islands, and the Isle of Man as well as in Great Britain. It is proposed to obtain information on the distribution of the people by area, sex, age, and marital condition; the size and composition of households; where people were born, where they live, and where they work; what their nationality is; their occupations and industries; whether they are still at school, college, etc., or, if they have finished whole-time education, at what age they finished; whether the dwelling is structurally separate, how many rooms it has, and whether the household has or shares a piped water supply, a kitchen sink, a cooking stove, a water closet, and a fixed bath. In the case of married women under 50 it is proposed to ask the date of marriage and the number of children. The questions that will be asked will relate to questions of fact and not of opinion and will be made as simple as possible. Though in total the questions will exceed those asked in 1931, they have practically all been asked at one or other of the previous censuses held in this century. Returns are required to be made for every person alive in the country at midnight ending the census day and for certain other persons who, though outside the country at that time, are normally resident in the country—for example, persons on a fishing or coastwise voyage. Particulars will be obtained of all Service men and women as well as of civilians.