

ENCEPHALOGRAPHY IN CASES OF INCREASED INTRACRANIAL PRESSURE *

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Encephalography is an invaluable diagnostic procedure which until very recently has been used far too infrequently in the diagnosis of cerebral conditions. By the term encephalography is meant the spinal subarachnoid insufflation of air for the purpose of roentgenographic examination of the brain, as contrasted with ventriculography in which method the air is introduced directly into the lateral ventricles through trephine openings in the skull.

My experience with encephalography in cases of increased intracranial pressure would seem to indicate that the reluctance with which most neurological surgeons in the past resorted to this method was not entirely justified. During the past year in the Cleveland Clinic 24 encephalograms have been made in the cases of 19 patients in whom the spinal fluid pressures varied from 260 to 850 millimeters of water. Very few untoward symptoms have resulted from the procedure; as a matter of fact, it has been found that patients with brain tumor usually do not have as severe an immediate reaction to a spinal insufflation as do patients in whom other cerebral conditions are present.**

Encephalography should be resorted to in the diagnosis of cerebral conditions only after a careful history of the patient has been secured and a painstaking examination has been made. However, our experience would seem to indicate that in a very considerable number of cases in which a craniotomy is indicated an encephalogram should be made prior to operation. Few general surgeons will operate upon a kidney without a pyelogram having been made or upon a stomach without an x-ray examination of the gastro-intestinal tract. On the other hand, many patients with brain tumor have been subjected to an exploratory craniotomy with resultant negative findings, when a cerebral pneumogram would have more adequately localized the lesion. With the present refinements in technic, encephalography may be said to be com-

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**This lessened immediate reaction to encephalography in cases of brain tumor is probably due to the fact that as the cerebral sulci are obliterated by increased pressure, little or no air gains access to the sulci. Apparently it is the subarachnoid cortical air which in most cases causes the subjective complaints.

paratively safe, when the serious nature of the conditions which indicate its use is considered. Furthermore, by this procedure in many instances gross alterations in the cerebral structure may be diagnosed which can only be guessed at by any other method of examination, not excluding necropsy.

The technic of encephalography is very simple and therefore its application is much wider than that of ventriculography. At the Cleveland Clinic the procedure of encephalography is as follows: The patient is given a hypodermic injection of one grain of codeine and $1/150$ grain of scopolamine one hour before the time set for operation. A preliminary spinal fluid pressure reading is made with the patient in the horizontal position after which he is placed in the encephalogram chair which is mounted on wheels. If the patient is cooperative, local anesthesia is used, but if a general anesthetic is indicated, avertin is preferred. The spinal puncture needle, after being introduced into the lumbar spinal canal with the patient in the sitting position is connected with two two-way stopcocks and a ten c.c. syringe which are placed end to end. A spinal manometer is connected to the side-arm of one stopcock, the side-arm of the other stopcock being used for the ejection of fluid from the syringe and for the aspiration of air. An initial pressure reading is then made with the patient in the sitting position following which five or ten c.c. of air is injected before any fluid is withdrawn. The fluid is withdrawn in five c.c. amounts and air is substituted in similar amounts until no more fluid can be obtained. The pressure reading is followed closely and is not allowed to fall below the original reading when the patient was in the horizontal position. If the pressure falls too rapidly more air is injected. If less than sixty c.c. of fluid is obtained and the patient complains of sub-occipital pain, an obstructive hydrocephalus should be suspected and the operator should hold himself in readiness to perform a ventricular tap in case of respiratory embarrassment.

During the insufflation of air, the patient's head is gently manipulated forward and backward and from side to side in order to insure a satisfactory emptying of the lateral ventricles. When the operation has been completed, roentgenograms are made with the patient still sitting in the encephalogram chair. If a view of the descending horns of the lateral ventricles is desired, further films should be made with the patient in the horizontal lateral position. This position is necessary in order to empty the descending horns which are dependent and therefore contain fluid when the patient is in the erect posture.

If the patient presents definite evidence of increased intracranial pressure the surgeon should be prepared to operate as soon

as the films are available, the reason for this being that the fluid tends to re-accumulate more rapidly after it has been once withdrawn. Thus if the pressure was high before the procedure, alarming symptoms may develop eight or twelve hours later unless a tumor is removed or a decompression provided. In the series of cases here reported no unfavorable postoperative symptoms were noted which could be traced to the previous air insufflation. One patient, who was not operated upon, died twelve hours after encephalography had been performed. Similar accidents, however, have followed ventriculography, ventricular estimation or even a simple spinal puncture. This patient, by the way, was critically ill before the procedure, and at necropsy was found to have an extensive encephalomalacia involving one entire hemisphere.

If an obstructive hydrocephalus is present, or if the brain is markedly distorted by a rapidly expanding hemispheric lesion, the ventricles may fail to empty properly. However, complete emptying of the ventricles has been observed in the case of obstructive hydrocephalus due to posterior fossa as well as to suprasellar tumors.

Failure to obtain satisfactory films by encephalography is probably not of more frequent occurrence than by ventriculography if the proper technic is observed. The preliminary injection of five or ten c.c. of air prior to the withdrawal of the fluid helps to insure satisfactory films and has not caused annoying symptoms. After the films have been obtained, the surgeon should correlate the roentgenographic findings with the clinical findings and should plan his operation accordingly.

The preliminary intravenous administration of concentrated glucose, or a ventricular tap, does not appear to be necessary either from the standpoint of safety to the patient or for the insuring of satisfactory films.

In analyzing the data in the accompanying table, it will be found that of sixteen cases of suspected brain tumor the lesion was correctly localized by encephalography in twelve instances, and in the remaining four cases the presence of a brain tumor was definitely excluded. Of the cases localized by the encephalography, cerebral hemispheric tumors were present in seven, a suprasellar cyst was present in one, and four were cases of posterior fossa lesions. In two of the last four cases a subsequent ventriculogram was performed in order to substantiate the findings from the encephalogram. In four cases a suspected brain tumor was definitely excluded by the encephalogram findings, the final diagnoses in these four instances being as follows: Spontaneous subarachnoid hemorrhage in one case, external hydrocephalus in two cases, and subdural

SUMMARY OF THE 19 REPORTED CASES

<i>Case No.</i>	<i>Age and Sex</i>	<i>History</i>	<i>Positive Finding</i>	<i>Eye Examination</i>	<i>Skull X-ray</i>	<i>Spinal Pressure Horizontal Position</i>
1 225924	25 yrs. Male	Generalized headache for 5 months. Diplopia 5 weeks. Unsteadiness and dizziness 1 month.	Negative	O.D.—3 D. O.S.—3 D. Visual acuity O.U.—6/6. Fields full.	Convolutional atrophy with atrophy of dorsum sellae.	650 mm.
2 234680	22 yrs. Female	Occasional headache and dizziness for 12 months. Weakness of right arm and leg with bilateral numbness for 6 months. Occasional vomiting for 3 months. Constant headache for three weeks.	Sluggish corneal reflexes. Deviation of tongue to left. Mild right hemiparesis with hyper-reflexia. Bilateral Babinski, more marked on the right.	O.D.—1+D. O.S.—1+D. Visual acuity O.D.—6/6 O.S.—6/6. Fields show a slight contraction of the left superior quadrant in both eyes.	Dilated vessel grooves in left frontal region.	315 mm.
3 232621	39 yrs. Female	Headache for 7-8 years. Occasional convulsions for 1 year. Failing vision for 6 months. Vomiting and vertigo.	Mental torpor and irritability. Non-functioning left 8th nerve, both cochlear and vestibular. Bilateral Babinski.	O.D.—2 D. O.S.—2 D. Advanced secondary atrophy. Complete blindness.	Erosion of posterior clinoids.	470 mm. 10 c.c. removed 190 mm.
4 230060	30 yrs. Female	Headache for 3-4 years. Vomiting and failing vision for 2 weeks.	Obesity. Pupils react sluggishly to light. Left 3rd and 6th nerve weakness. Occasional rotary nystagmus.	O.D.—6 D. O.S.—4 D. Secondary optic atrophy. O.U.—counts fingers.	Negative	450 mm.
5 232232	45 yrs. Male	Generalized headache for 3 months. Stupor for 1 week.	Nystagmus, bilateral Babinski. Lower left facial palsy. Questionable left hemiparesis. Stupor.	O.D.—2 D. O.S.—2 D.	Negative	100 c.c. 50% glucose intravenously 400 mm.
6 233329	40 yrs. Male	Occasional right Jacksonian motor and sensory attacks with transient hemiparesis. Duration 5 months. Headache and vomiting for 1 month.	Negative	O.D.—1 D. O.S.—1 D. Visual acuity O.U. 6/5. Fields full.	Negative, calcified pineal not displaced.	270 mm.
7 234060	13 yrs. Male	Occasional headache and vomiting for 2 years. More frequent during past 3 months. Drowsiness and enlargement of head 4 months. Failing vision and diplopia 3 months. Staggering gait 1 month. Blindness for past week.	Sluggish mentality. Rather large head. Blindness, nystagmus. Absent corneal reflexes. Postive Romberg. Ataxia. Hyperactive patellars. Bilateral Babinski. Cracked pot sound on percussion of head.	O.D.—4½ D. O.S.—2½ D. Blind.	Marked separation of sutures.	550 mm.
8 231215	35 yrs. Male	Generalized headache, increasing in severity for past month. Completely irrational for past 48 hours.	B.P. 130/80. Temperature 101. Pulse 70. R. 20. Dehydrated. Stupor alternating with delirium. Stiff neck, positive Kernig and bilateral ankle clonus.	O.U. No choking of optic discs.	Negative	700 mm. Struggling 10 c.c. removed 200 m.m.
9 227448	18 yrs. Male	Lack of physical and sexual development. Headache for past month.	Physical and sexual development of about 10 years.	O.U. Early choking. Visual acuity O.U.—6/10. Fields show bitemporal inferior quadrant loss for green.	Intrasellar calcification. Sella normal.	510 mm.

Case No.	Initial Pressure	Final Pressure	Fluid Removed	Air Injected	Anesthesia	Findings	Operation	Remarks
1 225924	?	?	80 c.c.	?	Local	No subarachnoid air. The anterior horns of the lateral ventricles are displaced to the right.	Left frontotemporal craniotomy with complete removal of frontotemporal meningioma.	Encephalogram performed in this case following introduction of a cannula into right ventricle.
2 224680	515 mm.	440 mm.	74 c.c.	82 c.c.	Avertin	No subarachnoid air. Air in posterior horns, none anterior.	Left frontal craniotomy with complete removal of midline chondroma arising from dura and sagittal sinus on left side.	A postoperative encephalogram showed dilated ventricles in about normal position.
3 222621	440 mm.	380 mm.	195 c.c.	205 c.c.	Local	No subarachnoid air. Uniform dilatation of lateral and third ventricles. Fourth ventricle not visualized.	Suboccipital craniectomy with complete removal of left acoustic tumor.	The history in this case was unreliable and the patient uncooperative in the neurological examination. Clinical diagnosis confirmed by encephalogram.
4 230060	520 mm.	?	27 c.c.	27 c.c.	Local	No subarachnoid air. Lateral ventricles displaced to left. Right ventricle compressed.	Large right temporal decompression.	Blood and spinal fluid. — Wassermann four plus. Colloid Gold 1111210090. Three cells. Diagnosis—right fronto-temporal tumor or gumma.
5 232232	680 mm.	300 mm.	109 c.c.	118 c.c.	Local	Small amount of subarachnoid air over left hemisphere. None over the right. Left ventricle displaced to the left. Right ventricle not visualized.	Craniotomy with partial removal of right temporal lobe glioma. Decompression.	
6 233529	490 mm.	200 mm.	107 c.c.	115 c.c.	Local	No subarachnoid air. Slight displacement of ventricles to right. Roof of left ventricle depressed. Dilated third ventricle.	Left frontoparietal craniotomy with partial removal of glioma in left preolantic area at vertex.	
7 234050	410 mm. following intravenous 50% glucose	350 mm.	220 c.c.	230 c.c.	Avertin	Enormous obstructive hydrocephalus with obliteration of third ventricle. Body of right ventricle pushed upwards and filling defect of body of right ventricle. No shift of midline structures. Some cortical air present.	Right frontoparietal craniotomy with evacuation of large gliomatous cyst and removal of large solid glioma which compressed the third ventricle.	Three weeks prior to encephalography an attempted ventricular tap disclosed a gliomatous cyst in the right parietal region containing 130 c.c. Ventriculogram and cystogram at this time showed the cyst with an obstructive hydrocephalus apparently due to compression of the third ventricle by a solid tumor. Death from pneumonia 2 weeks postoperatively.
8 231215	475 mm.	390 mm.	96 c.c.	90 c.c.	Avertin	No subarachnoid air. Left ventricle dilated and right very much compressed. Both displaced very markedly to left.	No operation.	Sudden death 12 hours after encephalogram due to respiratory paralysis. Necropsy disclosed encephalomalacia of the entire right cerebral hemisphere.
9 227448	660 mm.	450 mm.	42 c.c.	55 c.c.	Avertin	No subarachnoid air. Lateral ventricles greatly dilated as shown by the position of a small bubble of air in each. No air in third ventricle. Fourth ventricle and aqueduct visualized.	Right frontal craniotomy with complete removal of large suprasellar cyst.	Patient died 6 hours postoperative. In this case death was ascribed to operative trauma to the structure in the interpeduncular region. The pituitary stalk and tuber cinereum were lacerated during the removal of the cyst capsule.

SUMMARY OF THE 19 REPORTED CASES — Continued

Case No.	Initial Pressure	History	Positive Finding	Eye Examination	Skull X-ray	Spinal Pressure Horizontal Position
10 226915	19 yrs. Female	Obesity with increasing mental sluggishness for 5 years. Delayed and irregular menses with onset at 18 years.	Mental sluggishness, obesity with scanty pubic hair.	O.U.—Secondary optic atrophy. Visual acuity O.U.—6/7.5. Fields contracted.	Pronounced convolutional atrophy.	280 mm.
11 226710	20 yrs. Female	Occasional headache for 2 years. Constant headache for 2 months with vomiting, failing vision and mild ataxia.	Mild right hemiparesis with ataxia. No nystagmus.	O.D.—3 D. O.S.—3+D. Visual acuity O.D.—6/7.5. O.S.—6/10. Fields full.	Negative	450 mm.
12 199065	37 yrs. Male	Headache for 5½ years. Bilateral tinnitus for 3 years. Vomiting and failing vision for 1 year.	Nystagmus. Absent corneal reflexes. Lower right facial paresis. Mild bilateral nerve deafness. Positive Romberg. Pharyngeal and palatal reflexes absent.	O.D.—4 D. S.D. Visual acuity O.D.—6/7.5. O.S.—6/10. Fields show a concentric contraction.	Negative	310 mm.
13 225002	27 yrs. Male	Severe attack of quinsy 5 months ago. Occasional left Jacksonian attacks with bilateral tinnitus 2½ months.	Slight exaggeration of left patellar reflex. Complete deafness in left ear. Moderate nerve deafness in right. Vestibular responses absent on left.	O.D.—2 D. O.S.—1 D. Fields show a questionable right homonymous cutting.	Negative	290 mm.
14 223183	18 yrs. Female	Operation for cervical adenitis 9 months ago. Left parietal headache for 3½ months. Failing vision and diplopia for 2 weeks.	Operative scar right cervical region. Mild internal strabismus. Right ptosis congenital. Positive Romberg. Tenderness in left parieto-occipital region.	O.D.—S.D. O.S.—4 D. Visual acuity O.D.—6/60. O.S.—6/30. Fields full.	Negative	2/15/30 7/60 mm. 2/24/30 8/60 mm. 4/2/30 8/60 mm.
15 222046	16 yrs. Male	Pneumonia with septicaemia 9 weeks previously. Right sided headache and left hemiparesis for 6 weeks.	Tenderness in right frontotemporal region. Left hemiplegia.	O.D.—3 D. O.S.—2 D. Vision well preserved. Questionable left homonymous hemianopsia.	Slight separation of sutures. Small area of osteomyelitis right frontotemporal.	410 mm. 15 c.c. removed 160 mm.
16 160860	25 yrs. Male	Proxysmal excruciating headaches for 6 years. Failing vision for 2 months.	Negative	O.D.—8 D. O.S.—6 D. Numerous hemorrhages. O.D.—4/60. O.S.—1/60.	Negative	550 mm. 15 c.c. removed 180 mm.
17 228417	37 yrs. Male	General weakness. Protrusion of eyes and deafness in left ear for past 4 months.	Generalized adenopathies. Very marked exophthalmos of left eye. Moderate exophthalmos of right eye.	O.D.—1+D. O.S.—1+D. Visual acuity O.U.—5/5. Fields full.	Negative	450 mm. 13 c.c. removed 225 mm.
18 222298	42 yrs. Female	Headache increasing in frequency for past 8 months. Dizziness, diplopia and failing memory.	B.P. 130/70. Mild mental confusion. Left pupil larger than right. Babinski right.	O.D.—1 D. O.S.—1 D. Visual acuity O.D.—6/12. O.S.—6/10. Fields show right homonymous cutting.	Negative	310 mm.
19 229980	23 yrs. Male	Mild cranial trauma 14 months ago. Headache, vomiting and dizziness for 7 weeks. Loss of 35 pounds in weight. Failing vision.	Emaciated. Bilateral loss of sense of smell.	O.D.—1 D. O.S.—1 D. Fields full. Visual acuity O.U.—6/6.	Negative	360 mm.

Case No.	Initial Pressure	Final Pressure	Fluid Removed	Air Injected	Anesthesia	Findings	Operation	Remarks
10 226915	?	?	60 c.c.	60 c.c.	Local	Air between cerebral hemispheres and beneath tentorium. No air in ventricles.	Suboccipital craniectomy with attempt to relieve obstruction of aqueduct.	Encephalogram diagnosis of obstructive hydrocephalus verified by ventriculogram. 375 c.c. removed from ventricles. Patient died 48 hours after operation. Autopsy showed a congenital obstruction of aqueduct of Sylvius.
11 226710	700+ mm.	220 mm.	45 c.c.	45 c.c.	Local	Air obstructed at the foramen magnum.	Suboccipital craniectomy with evacuation of right cerebellar glommatous cyst.	Encephalogram diagnosis obstructive hydrocephalus. Verified by ventriculogram.
12 199065	600 mm.	?	55 c.c.	55 c.c.	Local	Air blocked at the foramen magnum.	Suboccipital craniectomy disclosed chronic arachnitis.	Respiration ceased during administration of anesthetic for craniectomy. Reinstated by ventricular tap.
13 225002	700 mm.	200 mm.	110 c.c.	100 c.c.	Local	Decreased amount of subarachnoid air. Ventricles displaced to left. Roof of right ventricle depressed.	Drainage of brain abscess of right vertex behind motor area. Streptococcus.	Encephalogram showed abscess to be situated posterior to previous exploration.
14 233183	?	?	2/15/30 100 c.c. 2/24/30 110 c.c. 4/2/30 110 c.c.	80 c.c. 90 c.c. 80 c.c.	Local Avertin Avertin	2/15/30—Very little subarachnoid air. Ventricles displaced to rt. Compression of left posterior horn. Rt. ventricle larger than left. 2/4/30—Little change in picture. 4/2/30—Further displacement to the right.	2/11/30—Drainage of extradural abscess. 4/7/30—Parietal craniectomy with evacuation of very large extradural tb. abscess.	Culture of pus sterile. Spinal pressure remained high in spite of apparently adequate drainage. Encephalograms disclosed no evidence of abscess elsewhere. Complete recovery following radical evacuation of large amount of caseous material.
15 23264	700 mm.	?	92 c.c.	75 c.c.	Avertin	Fourth ventricle contained air but there was none above this point.	Drainage of right frontotemporal staphylococci abscess 4-5 ounces.	Previous operation disclosed a small extradural abscess in frontal region. Enceph. performed because of suspected multiple abscesses. Films unsatisfactory.
16 160980	750 mm.	270 mm.	195 c.c.	185 c.c.	Avertin	Very pronounced increase in subarachnoid air. Very mild ventricular dilatation.	Right subtemporal decompression	No recurrence of headaches. Pressure entirely relieved. Diagnosis—external hydrocephalus of unknown etiology
17 223417	590 mm.	200 mm.	146 c.c.	125 c.c.	Local	Ventricles normal. Left ventricle incompletely emptied. Marked increase in subarachnoid air.	Right subtemporal decompression.	Patient died 2½ months after operation with generalized lymphoid hyperplasia.
18 232398	625 mm.	240 mm.	74 c.c.	67 c.c.	Local	No subarachnoid air. Ventricular system normal.	Left subtemporal decompression.	Spinal fluid was definitely bloody. Blood and spinal fluid Wassermann negative. Diagnosis—spontaneous subarachnoid hemorrhage.
19 229980	550 mm.	?	120 c.c.	120 c.c.	Local	Subarachnoid air normal. Very mild ventricular dilatation. Otherwise normal.	Right subtemporal decompression with evacuation of large serous subdural effusion.	As the intracranial pressure was not relieved following the first operation, two subsequent encephalograms were performed which disclosed no evidence of tumor. Left subtemporal decompression was also performed. At present the intracranial pressure is entirely relieved and the patient is well on the road to recovery.

effusion in one case. Of three cases of brain abscess, the lesion was correctly localized in two and in the third case the lateral ventricles failed to fill.

Of the nineteen cases here reported, fourteen patients are living at the present time and in the case of nine of these fourteen the cure is apparently complete. Patient No. 17 died of a systemic condition four months after a right subtemporal decompression had been done. Patient No. 10 died seven days after encephalography, 48 hours after a ventriculogram had been made and a suboccipital craniectomy performed which failed to relieve a congenital stricture of the aqueduct of Sylvius. Patient No. 7 died of pneumonia two weeks after the evacuation of a large gliomatous cyst containing 150 c.c. and the removal of a large solid glioma which was pressing upon and obstructing the third ventricle. Patient No. 9 died with symptoms of a vasomotor collapse six hours after the complete extirpation of a large suprasellar cyst. Patient No. 8 died of respiratory failure twelve hours after encephalography, and necropsy in this case disclosed extensive encephalomalacia.

In some of the above cases an encephalogram was not necessary for the localization of the tumor; however, the films gave added proof that a tumor was present, so that if it were not found on the cortex, the operator could feel more justified in making a sub-cortical search.

SUMMARY

It appears that encephalography is a safe procedure in cases of increased intracranial pressure provided the surgeon is prepared to operate immediately after the findings from the encephalogram have been obtained. The autopsy table has shown that no one is infallible in cerebral localization and the neurological surgeon who spurns such laboratory aids as cerebral pneumography must pay the price in a higher percentage of negative explorations.