Isotope Cisternography in Hydrocephalus with Normal Pressure

Case Report and Technical Note

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NORMAL pressure hydrocephalus is a recently recognized clinical entity,\textsuperscript{1,18} Since intellectual deterioration is one of its principal manifestations, it may be counted among the pre-senile dementias. Soon after its recognition came the report of its successful surgical management in the form of ventriculo-atrial shunting.\textsuperscript{1,4,19} It therefore seems desirable to develop a simple and safe test to identify those patients who can be expected to benefit from the shunting procedure.

On the basis of our experience, we believe that isotope cisternography and ventriculography offer information in the diagnosis of normal pressure hydrocephalus which is not available by other means. It is a safe and relatively simple examination. This report will discuss isotope cisternography and ventriculography in relation to hydrocephalus with normal pressure. It will also describe a typical case in which this procedure played an important part both in the diagnosis and in the postoperative treatment after the successful establishment of a ventriculo-atrial shunt.

Technique

The patient receives 10 drops of Lugol's solution three times a day for 3 days, beginning 1 day before the injection of isotope.\textsuperscript{2,3} This minimizes the uptake of liberated I\textsuperscript{131} by the thyroid gland.

On the morning of the examination, a lumbar puncture with a No. 22 gauge needle is performed, the cerebrospinal fluid pressure is measured, and samples are collected for routine laboratory analysis. Then 100 microcuries of I\textsuperscript{131} human serum albumin are injected. Since the flow of the isotope is independent of the patient's position, it is not necessary to confine the patient to any particular body posture after injection. However, we advise the patient to stay in bed for a few hours to minimize leakage of isotope from the subarachnoid space at the puncture site.

Scanning of the head in anterior and lateral positions is done at 3, 6, and 24 hours after injection. When the isotope flow is unusually slow, we often add a 48-hour scan. We use either a photoscanner with a 3-inch crystal or an Anger camera for this purpose.

The normal 3-hour scan shows radioactivity in the cervical spinal canal and in the basilar cisterns (Fig. 1). Six hours after injection, the activity reaches the frontal poles and the Sylvian fissures. At 24 hours, most of the isotope is collected along the superior sagittal sinus, with an even and symmetrical distribution over both cerebral convexities in the anterior view. Very little is ever seen in the occipital areas.

In our experience with over 40 patients, only an occasional mild temperature elevation or headache a few hours after injection of the isotope has been observed. There has been no aggravation of the pre-existing symptoms during or after this procedure.

The only serious complication has been a single case of aseptic meningitis, which occurred in a questionable cerebrospinal fluid leak within a few hours after injection of the isotope and which responded to symptomatic treatment; this case and a similar one have been reported in detail elsewhere.\textsuperscript{5,25}

Case Report

A 55-year-old white man was admitted on December 5, 1965, 1 year after an automobile accident in which he had received
Fig. 1. Normal isotope cisternogram, anterior and left lateral views, 3, 6, and 24 hours after injection of radioiodinated human serum albumin into the lumbar subarachnoid space.

scalp lacerations. He had been treated at a local hospital after the accident, where skull films had been reported as negative and a scalp laceration of the left occipital region had been sutured. He had been conscious, but had no recollection of the accident until 4 days later. A lumbar puncture was not performed. The only abnormal finding noted at the time of discharge was an uncertain and shuffling gait.

Because of progressive awkwardness of his right limbs, difficulty in walking, loss of balance, poor memory for recent events, blurred vision, and frequent right-sided headaches, he was referred to the Neurosurgical Service at Edward J. Meyer Memorial Hospital.

Examination. Physical examination was normal. There was moderate impairment of memory. Cranial nerve functions were normal. Deep tendon reflexes were equal with plantar flexor responses. Coordination and perception of all sensory modalities were intact. There was a mild, right-sided weakness. The patient's gait was unsteady, shuffling, and broad-based. Bowel and bladder control were normal.

The spinal fluid was clear, with a protein content of 14 mg% and a pressure of 100 mm. Cervical spine films showed spondylosis with disc degenerations at C-5 through C-7. Chest and skull x-rays were normal. An Hg-203 brain scan was also normal. Electroencephalography showed a moderately severe slow wave abnormality in the frontotemporal regions.

A pneumoencephalogram showed a rather marked symmetrical communicating hydrocephalus (Fig. 2). Only a small amount of air could be seen in the basilar cisterns and none over the cerebral hemispheres. A left carotid arteriogram showed only stretching of the anterior cerebral artery, indicating dilated ventricles. The patient deteriorated markedly following the air study, with increased headaches, confusion, and aggravation of his symptoms lasting for several days. A considerable amount of residual air remained in the lateral ventricles on follow-up skull films.

It was assumed that obliteration of the subarachnoid space of the cerebral hemispheres had caused alteration of the cerebrospinal circulation, and to ascertain this a cisternogram was performed. Six hours after injection of the isotope, the cerebral ventricles were partially filled; isotope could also be seen in the basilar cisterns and in the cervical spinal canal. At 24 hours, all the isotope was in the ventricles (Fig. 3). The size and shape of the ventricles were quite comparable to those seen on the pneumoenceph-
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Fig. 2. Normal pressure hydrocephalus. The pneumoencephalogram shows communicating hydrocephalus with marked dilatation of the lateral ventricles and somewhat less dilatation of the third and fourth ventricles. No air is seen over the cerebral convexities.

There was no activity in the Sylvian fissures nor over the cerebral hemispheres, and, in particular, there was no accumulation of the isotope in the area of the superior sagittal sinus. The 48-hour scan showed the same distribution of the isotope, but with diminished activity, as some absorption presumably had taken place in the ventricles.

From the findings on the pneumoencephalogram and isotope cisternogram, we concluded that the patient was unable to absorb all his cerebrospinal fluid due to blockage in the basal cisterns and compensatory absorption of CSF was occurring within the lateral ventricles. The symptoms and findings were consistent with the diagnosis of normal pressure hydrocephalus, probably a consequence of his head injury. At a lumbar puncture repeated 6 weeks later, the pressure fluctuated between 150 and 170 mm of spinal fluid.

First Operation. A ventriculoatrial shunt was performed using a medium pressure Holter valve. The patient immediately showed considerable improvement. Blurred vision cleared, headache disappeared, and walking was much better. He was discharged improved, with the ventricular shunt still functioning.

Second Examination. When seen 2 months later, the patient was free of headaches, and his memory was slightly improved. It was noted, however, that he was not walking as well as he had immediately after surgery and was using a cane for support. On palpation, the valve appeared collapsed and non-functioning. A chest x-ray revealed the jugular catheter to be retracted in the neck.

Second Operation. Reoperation was performed; the jugular catheter was found looped in the internal jugular vein. The entire shunt was removed and replaced by a Pudenz-Heyer valve. At the time of surgery, 50 microcuries of radioiodinated human serum albumin were introduced into the right lateral ventricle and scanning performed 24 hours later. The ventricles were outlined and were smaller than preoperatively.

Second Postoperative Course. Postoperatively, the patient had two generalized seizures, followed by some temporary left-sided weakness. His recovery was otherwise uneventful, and he was discharged on anticonvulsant therapy.

On re-examination 6 months later, the patient complained of minor bouts of headache and occasional dizzy spells related to change in position. His gait had improved markedly, and he required no support. His thought processes had also improved considerably.

He was re-admitted on December 15, 1966, for re-evaluation. Skull and chest films showed the tips of the catheters unchanged.
FIG. 3. Normal pressure hydrocephalus. Preoperative isotope cisternogram 3, 24, and 48 hour scans show the isotope entering the ventricular system, with none seen over the cerebral hemispheres or in the region of the superior sagittal sinus. The dilatation of the lateral ventricles is similar to that seen on the pneumoencephalogram (Fig. 2). Note also the slow removal of the isotope from the ventricles.

and in proper positions. The isotope cisternogram was repeated, and it was noted that the lateral ventricles were definitely smaller than preoperatively (Fig. 4) while the flow of the isotope into the ventricular system and its removal was considerably faster. At 6 hours, almost all of the isotope was in the ventricles, and at 48 hours only traces of the isotope remained, indicating that the shunt was functioning well.

When last examined in June, 1967, the patient had continued to improve, and his

FIG. 4. Normal pressure hydrocephalus. Postoperative isotope cisternogram 1 year after the first shunting procedure. Note that the ventricles are much smaller than preoperatively. Flow of the isotope into and out of the ventricles is more rapid, indicating satisfactory function of the ventriculo-atrial shunt.
gait was normal. The headaches only occurred with heavy and strenuous work. His memory was good and the neurological examination normal. The shunt appeared to be functioning well. He had returned to work as a bulldozer operator.

Discussion

Isotope cisternography, first described in 1963 by DiChiro,6-13 is a means of studying the cerebrospinal fluid circulation.14,17,20 Normally, the isotope injected into the spinal theca ascends in the spinal canal, enters the basilar cisterns, then passes over the cerebral hemispheres, where it collects along the superior sagittal sinus.27,29 Although absorption of the injected material is thought to take place over all of its course, by far the largest amount is absorbed along the superior sagittal sinus.29 The entire process takes about 12 to 48 hours. The direction of flow of the injected material relies upon the current of cerebrospinal fluid not upon the patient's position. The speed of flow depends upon the rate of absorption, interference from any existing pathology, and the age of the patient (being faster in children).

In contrast to air, isotope injected into the lumbar area under normal circumstances does not enter the cerebral ventricles. It has been shown by Bering and others5 that fluid produced by the choroid plexus sets up a current flowing out of the ventricles. When the normal intracranial flow pattern of the CSF is altered by obliteration of the subarachnoid space, either over the cerebral convexities or at the basilar cisterns, or when absorption into the superior sagittal sinus is blocked, the spinal fluid must seek alternate routes. Under these circumstances, the current in the aqueduct and fourth ventricle is reversed, and the injected isotope enters the ventricular system. Apparently the walls of the lateral ventricles are also capable of absorbing some of the excess fluid. This absorptive capacity is thought to be increased with dilatation of the ventricles. If the capacity of absorption is sufficiently increased to handle the excess fluid, an equilibrium is reached and the process of gradual enlargement of the lateral ventricles ceases. This, then, results in compensated hydrocephalus.

When this alternate method of absorption cannot keep pace with the production of cerebrospinal fluid, at least under periods of temporarily increased demand, the syndrome known as normal pressure hydrocephalus results. The outstanding symptoms of normal pressure hydrocephalus are impairment of memory, mental slowness, unsteady gait, and, in some cases, urinary incontinence. Headache is either absent or negligible. In severe cases, akinetic mutism has been reported.20,21 The gait disturbance is explained by the impairment of pereventricular leg fibers either by demyelination of vascular origin 25 or by stretching.19,21 Messert, et al.,20,21 spoke of four phases of "periventricular white matter syndrome" to explain the symptoms caused by the continuing enlargement of the ventricles. Yakovlev21 referred to the gait disturbance as "paraplegia of hydrocephalus." In two of our patients, seizures prompted the clinical investigation. Previously, seizures have not been mentioned as a symptom of normal pressure hydrocephalus.

As indicated in the term, the spinal fluid pressure is normal or slightly lower than normal. Pneumoencephalography shows communicating hydrocephalus with diffuse dilatation of the ventricles, especially of the lateral ventricles. No air reaches the area of the superior sagittal sinus and depending upon the site of obstruction of the subarachnoid space, little or no air is seen in the basilar cistern or over the cerebral hemispheres.7 New22 reported more than normal amounts of air in the Sylvian fissures, but none over the parasagittal region. Follow-up skull films after pneumoencephalogram usually show slower than normal rate of absorption of air from the ventricles. In association with this, there is aggravation of the clinical symptoms such as prolonged and intense headaches, nausea, vomiting, and dizziness.3,4 Marked lethargy or stupor may also be seen. These changes presumably are related to a very tenuous balance of cerebrospinal fluid production and absorption which is disturbed by the procedure.

The etiology of normal pressure hydrocephalus is variable.4,6,18,19 The development of communicating hydrocephalus following trauma21 or subarachnoid hemorrhage due to ruptured aneurysm or following intracranial surgery is well known.7,16,28 Cronqvist suggested that the presence of a large amount of
blood in the basal cisterns and possibly other unknown factors cause fibrotic reaction of the arachnoid leading to obstruction of the cerebrospinal fluid passage. In most of these cases, however, the developing hydrocephalus is associated with increased intracranial pressure and, therefore, requires prompt treatment. Only in a few reported cases was a low or normal pressure recorded.\(^{16}\)

Foltz\(^{15}\) several years ago recognized the progression of low pressure hydrocephalus and the beneficial response to a shunting procedure. However, it was not until the classic report of Adams, et al.,\(^{1,19}\) that this entity and its symptomatology was explained and surgical treatment advocated. In their report, the "hydraulic-press hypothesis" was compared to the effect of the CSF on the dilated ventricular walls surrounded by the relatively elastic brain tissue.\(^{18}\)

An understanding of the basic mechanism in normal pressure hydrocephalus suggests its treatment. Basically, it consists of removal of the excess cerebrospinal fluid from the ventricular system. Summers and Matthews\(^{20}\) described early experiments with an electrically operated pump connecting the lateral ventricle with the superior sagittal sinus which removed small amounts of fluid at a constant rate. Their experience in infants indicates that the amount of fluid to be removed to maintain satisfactory balance in these infants is in the order of 1.5 to 5.0 cc per hour. Similar experience in adults has not yet been elaborated. This pump is not yet available for clinical use. Usually the medium- or low-pressure Holter valve or the normal-pressure Heyer-Pudenz valve has been used for ventriculoatrial shunting; they appear to have been working satisfactorily.

### Summary

The etiology and symptomatology of normal pressure hydrocephalus have been briefly reviewed. The technique of isotope cisternography has been discussed and illustrated with a case report of hydrocephalus with normal pressure successfully treated by a ventriculo-atrial shunt. The findings in this condition have been compared with the normal isotope flow pattern.

We consider isotope cisternography a valuable method for investigation of normal pressure hydrocephalus. The procedure is a safe and relatively simple examination with no disturbing side effects.

### References


22. NEW, P. Personal communication, 1966.