Determination of CSF shunt patency with a lumbar infusion test

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The authors report on the potential role of the lumbar infusion technique in the determination of cerebrospinal fluid (CSF) shunt patency. The test was performed in a series of 12 patients and reliably predicted shunt patency. This method of assessment proved to be superior to computerized tomography scanning because of its ability to demonstrate the CSF dynamics rather than the ventricular size.

KEY WORDS • cerebrospinal fluid shunt • intracranial pressure • hydrocephalus • computerized tomography • lumbar infusion test

Clinical status and computerized tomography (CT) scanning are the most convenient methods of assessing patency of a cerebrospinal fluid (CSF) shunt. When either of these methods is not conclusive, then other means of ascertaining shunt function may be necessary. Such methods include: injection of contrast medium or radioactive substances into the flushing device; 1,2 digital compression of the flushing device to determine response; assessment of flow by Doppler ultrasound methods; 3 temperature change determinations in a flowing CSF column; 4 and a lumbar infusion test. 5 Assessment of shunt function by one of these techniques is indicated in patients who fail to improve after shunting, or whose ventricles remain enlarged on CT scanning. We have found the lumbar CSF infusion technique reliable in assessing shunt function in patients with communicating hydrocephalus.

Technique

Anesthesia is induced with 2% Xylocaine (lidocaine). Two No. 18 lumbar puncture needles are then inserted into the lumbar subarachnoid space at adjacent levels. Through one needle, three incremental volumes of artificial CSF (Elliott's A solution) are injected with a constant-rate infusion pump at rates of 1.5, 2.0, and 2.5 cc/min for 10 minutes, respectively. The other needle is connected to a transducer to record changes in CSF pressure, which are displayed on a chart recorder. If the shunt is patent, the CSF pressure does not rise, even with an infusion rate of 2.5 cc/min for 10 minutes. Conversely, if the shunt is blocked, the CSF pressure rises precipitously, even at the lowest infusion rate. A partially blocked shunt may function at low infusion rates but fail to accommodate higher rates.

Shunt patency was tested by this means in 12 adult patients whose symptoms and signs were believed to be attributable to a blocked shunt. There were three patients with normal-pressure hydrocephalus (NPH), eight with communicating hydrocephalus (as a result of congenital causes in three, subarachnoid hemorrhage (SAH) in three, head injury in one, and brain tumor in one), and one patient with pseudotumor cerebri. The shunt was believed to be patent in seven patients, partially patent in one, and blocked in four.

Illustrative Case Reports

Case 1

This 56-year-old man presented in 1975 with ataxia, diplopia, and nystagmus due to an Arnold-Chiari malformation (Type 2). To control increased intracranial pressure (ICP) due to the development of communicating hydrocephalus, the patient underwent posterior fossa decompression supplemented by placement of a low-pressure ventriculoperitoneal shunt. He was well until 6 years later, when he developed severe intermittent headache, verified by plateau waves, stiff neck, and nausea. The ventricles were found to be of normal size on CT scanning (Fig. 1). Digital compression of the shunt pump produced a normal re-
The patient's symptoms were completely relieved after shunt revision, with insertion of a low-pressure Pudenz valve. The follow-up lumbar infusion test was entirely normal (Fig. 2 right).

Case 2

This 68-year-old man presented with the classical triad of progressive dementia, ataxia, and urinary incontinence, indicative of NPH. The diagnosis of NPH was reinforced by an abnormal CT scan and abnormal lumbar infusion test (Figs. 3 left and 4 left). A low-pressure lumboperitoneal shunt was inserted, and the patient improved dramatically. Computerized tomography scanning showed that the ventricular size had not decreased at all (Fig. 3 right), and therefore a postoperative lumbar infusion test was performed to assess shunt function. In this infusion test, the CSF pressure did not rise, even with an infusion rate of 2.5 cc/min, indicating a widely patent shunt (Fig. 4 right). In this case, ventricular size was not a good index of neurological function.

Case 3

This 19-year-old woman presented with intermittent headache, vague symptoms and episodes of tingling in all extremities, arthalgia of various joints, flatulence, sacroiliac pain, abdominal cramps, and periods of anxiety. At the age of 2 years, she had suffered an SAH from an anterior communicating artery aneurysm. A Holter ventriculoatrial shunt was inserted to manage postoperative communicating hydrocephalus. Her present symptoms were believed to be functional, since it was assumed that the communicating hydrocephalus had arrested. This supposition was reinforced by the CT scan, which showed small ventricles (Fig. 5). However, the lumbar infusion test was grossly abnormal, and had to be abandoned.
Lumbar infusion test of shunt patency

because of a steep rise in CSF pressure during the second infusion, when all her symptoms were reproduced (Fig. 6). Further confirmation of blockage was obtained by ICP monitoring (Fig. 7). On examination, the shunt was found to have pulled out of the jugular vein. A low-pressure ventriculoperitoneal shunt was inserted, and all symptoms were relieved.

Discussion

In children, the usual symptoms and signs of a blocked shunt are headache, nausea, vomiting, and alteration in level of consciousness. In adults, vague headache, fatigue, and bizarre symptoms and signs not usually attributed to raised ICP may be the presenting complaints associated with a blocked shunt.

The CT scan will frequently be misleading in the determination of blockage, since ventricular size does not always correlate with neurological function. Nowhere is this more evident than in adolescents graduating from pediatric hospitals, whose hydrocephalus is assumed to have arrested. These patients have small slit ventricles, yet the intraventricular pressure may be extremely high (as in Case 3). This was true in four of the 12 patients in our study. “High-pressure normocephalus” may be an appropriate name for this syndrome.6

In some patients with onset in adulthood of hydrocephalus of various etiologies, we have found that improvement in clinical status was not always accompanied by a reduction in ventricular size (see Case 2).

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**Fig. 4.** Case 2. Graphs showing cerebrospinal fluid (CSF) pressure recorded during the lumbar infusion test. *Left:* Preoperative test shows impairment of CSF absorption. *Right:* The postoperative test shows completely normal recordings, correlating with substantial clinical improvement.

**Fig. 5.** Case 3. Computerized tomography scan showing small ventricles in a patient with communicating hydrocephalus with a shunt in place.

**Fig. 6.** Case 3. Recording of cerebrospinal fluid pressure during the lumbar infusion test, which was discontinued because of a steep rise in pressure.
If clinical improvement is not as expected, CT scanning alone will provide only an anatomical assessment of the size of the ventricles. The lumbar infusion test is helpful because it provides a physiological correlate of the ICP dynamics.

There have been no complications with the lumbar infusion test, even though the volume of infused artificial CSF is greater than the amount of CSF normally produced by the choroid plexus. We have found that infusion of large volumes is necessary to adequately stress the CSF absorptive and diversionary capacity of the system. Similar low-pressure valve systems were used in all of our 12 patients before and after revision, so that different flow characteristics did not affect the test.

An accurate assessment of shunt patency can be confidently obtained with the lumbar infusion test: CSF pressure rises substantially in a blocked shunt and remains normal in a patent shunt.

References

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