A technique for evaluation of ventricular shunts using Amipaque and computerized tomography

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A technique involving the combined use of Amipaque (metrizamide) and computerized tomography scanning is described for the evaluation of ventriculoperitoneal and ventriculoureteral shunt function. The results of three illustrative cases from a series of nine patients are given. In five patients, the technique demonstrated obstruction that was later confirmed at surgery. In the other four patients, it showed patency in the shunt system, and no surgery was performed, thereby obviating unnecessary shunt revisions.

KEY WORDS □9 Amipaque (metrizamide) □9 ventricular shunt □9 computerized tomography

THE understanding of disorders of the cerebrospinal fluid (CSF) circulation has improved significantly with the advent of computerized tomography (CT) scanning and more recently with the development of Amipaque (metrizamide), a non-ionic, water-soluble contrast agent.4,18 In hydrocephalic patients who have been treated with CSF diversion procedures, it is often necessary to test the patency of the shunt systems. Maneuvers and studies previously described15,16 for assessment of ventricular shunt function are sometimes unsuccessful in establishing a definitive diagnosis of shunt function. Recently, we have evaluated a technique for studying ventriculoperitoneal (VP) and ventriculoureteral shunt patency using Amipaque combined with a CT body scanner. The purpose of this paper is to report this technique and describe its use in three illustrative cases.

Technique

The study is performed in the radiology department. After shaving and sterile preparation of the area with Betadine solution, a No. 25 butterfly needle is inserted percutaneously into the ventricular reservoir. If there is an obstruction at the ventricular end of the system, it may be impossible to obtain CSF. In the absence of ventricular obstruction, however, preliminary manometric studies are performed in order to determine ventricular pressure, valve competence, and distal runoff.

Amipaque (3 to 6 cc of 220-mg iodine/ml) is then injected into the reservoir, and a CT scan is immediately made in a plane through the head such that the lateral ventricles are visualized. Recently, we have used a plain lateral skull film and have successfully detected the presence of the contrast agent in the lateral ventricle. If the ventricular catheter is open, Amipaque is promptly visualized proximally in the occipital horns of the lateral ventricles. Even though plain skull films provide successful visualization of the Amipaque in the lateral ventricle, we have had difficulties in detecting the contrast agent in the peritoneum by that means. It may be that a much higher concentration of the contrast agent is needed in the peritoneal cavity before plain abdominal x-ray films can detect the Amipaque than the intraventricular doses we are using at the present time. In any case, we are reluctant to increase the doses because of the known side-effects of Amipaque when used in large doses, such as nausea, vomiting, headaches, and seizures.2

We then proceed with CT scanning of the peritoneal cavity. In most cases, the Amipaque is seen in the ventricles immediately, and in the peritoneal cavity 3 to 9 minutes following percutaneous injection into the reservoir; however, in some cases, we have had some difficulties visualizing the contrast agent in the peritoneum in normally functioning shunts. In some cases, it is necessary to pump the valve or flushing device several times before the contrast agent is seen.
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in the peritoneum. With normally functioning shunts, CT scans of the abdomen at the appropriate level (which is correlated with a plain abdominal x-ray film to relocate the tip of the catheter) will demonstrate the Amipaque in the most dependent areas of the abdominal cavity just below the tip of the peritoneal shunt catheter. With intraluminally obstructed catheters, the body scanner may show contrast medium in the peritoneal shunt tubing, but none diffusely within the peritoneal cavity. Finally, patency and functional integrity of the shunt may be correlated with a repeat follow-up ventricular CT scan 24 hours after the injection. Drayer and Rosenbaum5 have demonstrated that persistence of Amipaque in the lateral ventricles after 24 hours indicates malfunction.

Case Reports

Since February, 1979, we have used this technique to assess shunt patency (which appears to correlate with shunt function in our limited series of selected patients) in nine patients (eight adults with VP shunts and a child with a ventriculoureteral shunt) in whom CSF shunts were inserted from 2 days to 36 months prior to the study. Shunt malfunction was suspected in most cases, but we were unable to confirm this by simpler means. In each instance in which shunt malfunction was later confirmed at operation (five cases), the technique established the diagnosis preoperatively. In those cases in which the shunt was subsequently shown to be functioning (four cases), the technique demonstrated patency of the shunt. To describe the value of this procedure, three illustrative cases are reported.

Case 1

This 36-year-old man had a history of metastatic carcinoma of the bladder previously treated with palliative chemotherapy. He was admitted to Emory University Hospital in January, 1979, after 3 weeks of progressive headaches, nausea, vomiting, and ataxia. ACT scan demonstrated multiple brain metastases and obstructive hydrocephalus secondary to a lesion in the cerebellar vermis, with obstruction at the level of the fourth ventricle. Ventriculoperitoneal shunting was performed with immediate relief of the symptoms of increased intracranial pressure. On the 2nd postoperative day, the patient awoke complaining of headache, nausea, and vomiting. Shunt malfunction was suspected. To test patency of the system, 3 cc of metrizamide was injected into the shunt via the ventricular reservoir, and CT cuts were obtained both at the level of the lateral ventricles and at the peritoneal end of the shunt system. The study confirmed that the shunt mechanism was functioning (Fig. 1). The headache worsened over the next 12 hours following the study, but then rapidly subsided with complete resolution of all symptoms 36 hours after the study. The patient was discharged asymptomatic on the 7th postoperative day.

Case 2

This 26-year-old man was admitted with delirium and jaundice due to liver failure and biliary obstruc-
Case 3

This 10-year-old girl with a history of myelomeningocele, hydrocephalus, and numerous shunt procedures was admitted with nausea, vomiting, and headaches of 5 days' duration. A CT head scan showed markedly dilated ventricles. A diagnosis of malfunctioning ventriculoureteral shunt was made. Preliminary manometric studies demonstrated patency of the ventricular end of the shunt system, but distal function (at the ureteral end) could not be determined. Therefore, she underwent cystoscopy, which showed the distal catheter partially obstructed and coiled up in the bladder. During the cystoscopy procedure the distal (ureteral) end of the shunt was excised, and the tip of the catheter repositioned in the left ureter. Because there was no improvement after revision, 6 cc of metrizamide was instilled into the shunt in an effort to assess patency. An immediate CT head scan revealed layering of the contrast material in the right lateral ventricle. On CT scan of the lower abdomen; the contrast agent appeared promptly in the bladder via the shunt (Fig. 3). The CT scan of the renal pelvis showed no contrast material, which excluded the possibility of excretion of the Amipaque by way of the kidney. The patient's condition improved, and she was subsequently discharged from the hospital.

Discussion

Numerous reports have described different methods to determine CSF shunt patency with water-soluble contrast medium.\(^1,5,16\) In a study of 113 examinations performed in 75 patients with a variety of shunt devices (predominantly VP shunts), Savoardo, et al.,\(^16\) found that 70 examinations demonstrated malfunctioning shunts. They used Dimer-X (meglumine iocar-
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FIG. 3. Left: Computerized tomography (CT) scan demonstrating contrast agent in the left occipital horn of the lateral ventricle. The ventricles are moderately dilated, despite a recent shunt revision which was followed by a dramatic clinical improvement. Right: Abdominal CT slice shows the contrast agent in the bladder (arrow) consistent with a functioning ventriculoureteral shunt.

mate) as the contrast agent, combining it with plain roentgenograms in a technique similar to that described in this report. These workers concluded that the technique was reliable, and had eliminated unnecessary changes in normally functioning shunts. Nevertheless, these authors emphasized that those cases with slow clearing of the contrast medium from the shunt system, especially those requiring “pumping” of the shunt valve, create difficulties in interpreting the results of the examination. In the latter cases, they believed that the most likely cause was malfunctioning of the ventricular catheter caused by the choroid plexus creating a “valve mechanism” with partial obstruction.16

One of the advantages of the technique described in the present report is that the higher resolution of CT scanning allows the use of a very small total dose of contrast agent and thereby reduces the risk of causing toxic side-effects. The amount of Amipaque used in this study is well within the recommended safe dosage range for cisternography.2 Another advantage is that intracranial pathology is more clearly delineated (for instance, porencephalic cysts communicating with the ventricular system can be differentiated from arachnoid cysts) with the combination of CT scan and metrizamide.3 None of the nine patients in the present study experienced untoward reactions as a result of the procedure. One of the difficulties with this technique has been in interpreting cases with slow clearing of the contrast medium, which sometimes require pumping of the shunt valve to demonstrate contrast agent in either the peritoneal cavity or bladder. In the latter cases, it has been hypothesized that, during the injection, the contrast agent is introduced into the shunt system at a pressure higher than the CSF pressure, and, thus, the contrast medium injected with pressure could theoretically overcome a partial obstruction (therefore resulting in a false-negative study) when in reality shunt malfunction is present, usually from incomplete obstruction at the ventricular end.16 In theory, mechanical pumping of the shunt valve could also have the same effect and result in a false-negative study in the face of the shunt valve malfunction. It has been our experience that in cases in which pumping of the valve was required to demonstrate the presence of contrast agent in the peritoneal cavity, those shunts have been functioning. In this situation, we perform a follow-up ventricular CT scan 24 hours after metrizamide injection, as described by Drayer and Rosenbaum.3 Persistence of Amipaque in the ventricular system after 24 hours is correlated with shunt malfunction.
A variety of tests have been developed in the last 20 years to assess ventricular shunt function. In 1966, Di Chiro and Grove developed a method for the evaluation of surgical and spontaneous CSF shunts with the use of isotope scanning. The major shortcoming of their technique was that the test was not applicable to VP shunts because it depended on the emptying of the isotope, technetium-99m ($^{99m}$Tc), from a ventriculovascular shunt into the bloodstream and absorption of the latter by the parotid gland, which was scanned along with the ventricles within 30 minutes following the injection. In 1970, Matin, et al., developed a method of CSF scanning for ventricular shunt function by means of a lumbar subarachnoid installation of iodine-131 human serum albumin (RISA). Similar tests have been devised using radionuclide material injected into a shunt reservoir. In some cases, the radionuclide ($^{99m}$Tc-pertechnetate) has been visualized proximally and distally by using sequence scintigraphy with localization of shunt obstruction at either end.

Other tests have quantitated the rate of clearance of radioactivity from the shunt reservoir, and have found that normally functioning shunts clear the radionuclide within 3 minutes, but abnormally functioning shunts have either a prolonged clearance period or no spontaneous clearance of the radioisotope. All of these methods using radionuclides have two major shortcomings. The first is the use of radioactivity, which is known to have deleterious effects in man with repetitive and long-term exposure. This is particularly important in hydrocephalic children who may require shunt testing many times in their lives. The long-term consequences of repetitive exposure to radioactivity during shunt testing are unknown. The second disadvantage is that the examination methods offered with the use of radioisotopes produce images that are not applicable to VP shunts because it depended on the emptying of the isotope, technetium-99m ($^{99m}$Tc), from a ventriculovascular shunt into the bloodstream and absorption of the latter by the parotid gland, which was scanned along with the ventricles within 30 minutes following the injection. In 1970, Matin, et al., developed a method of CSF scanning for ventricular shunt function by means of a lumbar subarachnoid installation of iodine-131 human serum albumin (RISA). Similar tests have been devised using radionuclide material injected into a shunt reservoir. In some cases, the radionuclide ($^{99m}$Tc-pertechnetate) has been visualized proximally and distally by using sequence scintigraphy with localization of shunt obstruction at either end.

A method employing a Doppler ultrasound flowmeter for determining shunt patency has been described. The major disadvantages of this technique are that the site of obstruction is not well established, and that the technique requires certain expertise, especially in interpreting the variable sounds produced in this test.

The method described in this report appears to be a good procedure to use when simpler techniques, such as percutaneously performed manometric studies in conjunction with compression of the shunt valve or flushing device, fail to confirm shunt function, especially in those clinical conditions in which previous CT scans are not available for comparison, or when CT findings and other clinical data are either not definitive or inconclusive. This method has been used in a selected and limited number of patients, and, even though in our experience it has proved useful, the technique needs further experience with a larger group of patients before definitive conclusions and guidelines are established.

References


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