INFUSION CISTERNOGRAPHY

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A source of error in cerebrospinal fluid (CSF) infusion tests is leakage at the dural puncture site. The addition of a bolus of radionuclide to the infusion fluid was helpful in detecting the existence of leakage as shown by increased infusion pressure in six of eight patients studied with and without scintigraphic evidence of leakage. Comparison of CSF dynamics in 26 patients studied by infusion cisternography and conventional cisternography showed similar patterns, suggesting no alteration of CSF dynamics by the artificial CSF infusion. Combining the two tests, therefore, resulted in simple identification of the leakage and saved the patient time and discomfort.

The lumbar CSF infusion test to determine absorptive capacity is used for selecting patients for shunt surgery (*1–3*) and when testing shunt function (*4*). A source of error in this test is leakage to the epidural space during the infusion. Leakage may be due to recent lumbar punctures for pneumoencephalography or cisternography, it may occur if the dura is punctured more than once during the infusion test, and it may even take place around a spinal needle in situ (*5*).

To detect leakage to the lumbar epidural space during the CSF infusion test we have combined the test and conventional cisternography into one test, which we have termed infusion cisternography.

PATIENTS AND METHODS

The patients were referred for investigation of suspected hydrocephalus. Infusion cisternography was performed in 107 patients, 26 of whom had had prior conventional cisternographic examination. If the patient had had a previous lumbar puncture, the infusion cisternography was delayed at least 7 days.

Infusion cisternography. The equipment consisted of a 19-gage spinal needle, a pressure transducer fitted with a disposable fluid chamber, plastic tubing, a 50-ml syringe driven by a constant-rate infusion pump, and a potentiometer recorder (*6*). Under local anesthesia lumbar puncture was performed with the patient in a sitting position. The radionuclide (400 μCi of ^{169}Yb-DTPA) was infused as a 7-ml bolus (7 ml was the total volume of needle, pressure chamber, and tubing) followed by approximately 15 ml of artificial CSF prepared after the method of Elliott and Jasper (*7*). If the absorptive capacity of the patient was greatly reduced, less volume was infused. The infusion rate was 1.5 ml/min and the steady-state pressure level was used as an index of absorptive capacity. With the patient in the lateral position, imaging was performed with a scintillation camera immediately after the infusion. The views obtained included (A) the lumbar region to detect infusion leakage (prior to removal of needle), (B) the cervical region to determine the ascent of the radionuclide (after removal of the needle), and (C) the lumbar region to detect postinfusion leakage. In addition, anterior, posterior, and lateral images of the head were obtained at 4, 24, and 48 hr after infusion.

Epidural clearance of ^{169}Yb-DTPA. In four patients who had lumbar puncture performed for suspected spinal subarachnoid block, the spinal needle was withdrawn to the epidural space and 50 μCi of ^{169}Yb-DTPA (in 2 ml of saline) were injected. The disappearance of the radionuclide from the injected region was detected by the scintillation camera operated in dynamic mode and clearance curves were displayed on a multichannel analyzer. Serial scintiphotos were also obtained.

RESULTS

Needle in situ. There was a marked concentration of radionuclide in the lumbar dural sac in all 107 patients. In 99 cases, the outer margins of the ac-

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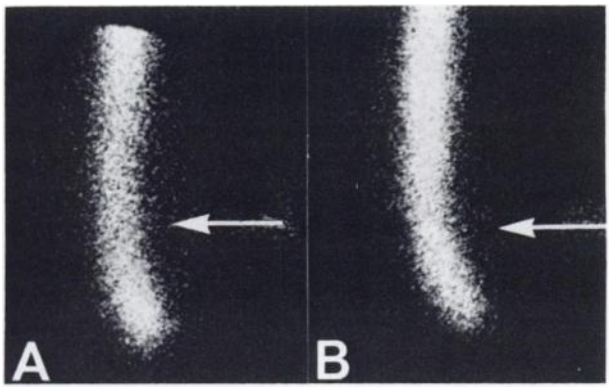

FIG. 1. With spinal needle in situ (two patients), sharp outer margins of radionuclide indicate no leakage into epidural space during infusion. Arrows indicate site of puncture.

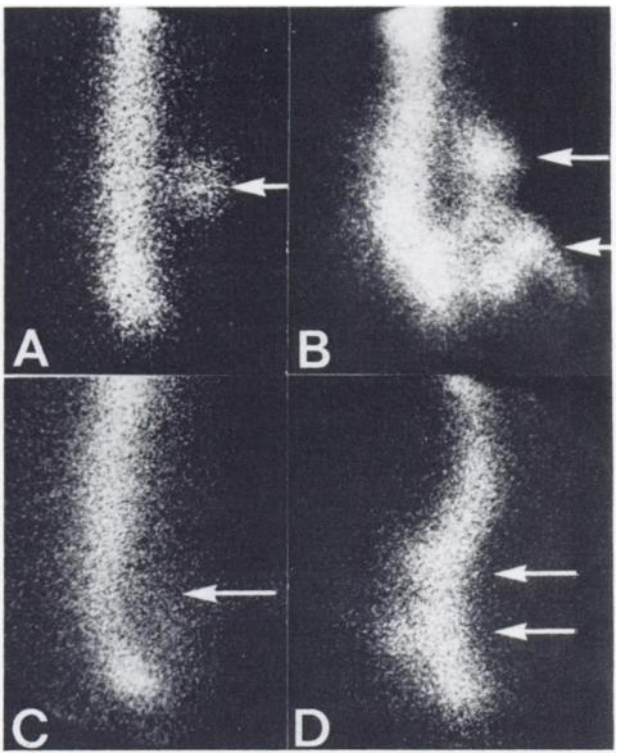

FIG. 2. With spinal needle in situ (four patients), indistinct outer margins of radionuclide indicate leakage into epidural space during infusion. Arrows indicate site of puncture.

tivity were sharp (Fig. 1). In eight patients the margins were indistinct, which suggested leakage into the epidural space (Fig. 2). Three patients who had had two dural punctures for the infusion cisternography were found to have greater epidural leakage of radioactivity than the other five patients who had had a single dural puncture. In the eight patients with indistinct radionuclide margins, repeat examination 10 days later revealed sharp outer margins in each and an increased CSF steady-state pressure level in six of them (Fig. 3).

Needle removed. In four patients who showed leakage with the needle in situ, the escape of activity increased when the needle was removed. Furthermore, epidural leakage was found in another 18 patients. In nine patients the epidural leakage caused the cisternography to fail as too little radioactivity reached the intracranial CSF spaces. The results from the lumbar imaging before and after removal of the needle are summarized in Table 1.

Paired cisternograms. During infusion cisternography the leading edge of the radionuclide was usually

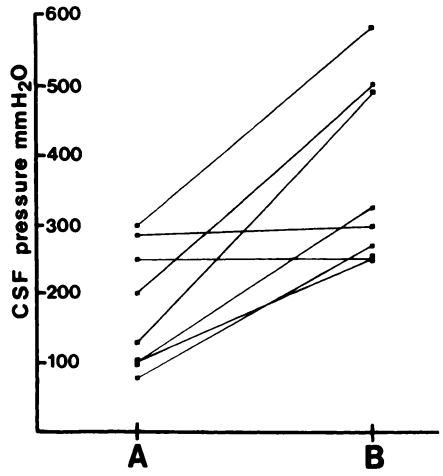

FIG. 3. Steady-state pressure level during CSF infusion as index of absorptive capacity. (A) Eight patients show leakage into epidural space during infusion; (B) repeat tests without leakage show increased steady-state pressure level in six patients.

TABLE 1. LEAKAGE TO THE LUMBAR EPIDURAL SPACE

Leakage	Needle in situ		Needle removed
	One puncture	Two punctures	
0	99	0	81
+	3	0	10
++	2	1	5
+++	0	2	11

TABLE 2. CSF FLOW PATTERNS IN 26 PATIENTS HAVING INFUSION AND CONVENTIONAL CISTERNOGRAPHY

Convexity flow pattern	Duration of ventricular reflux			
	0 hr	<24 hr	24–48 hr	>48 hr
Normal	5	0	1	0
Delayed	3	2	8	1
Block	0	0	2	3
Asymmetrical	1	0	0	0

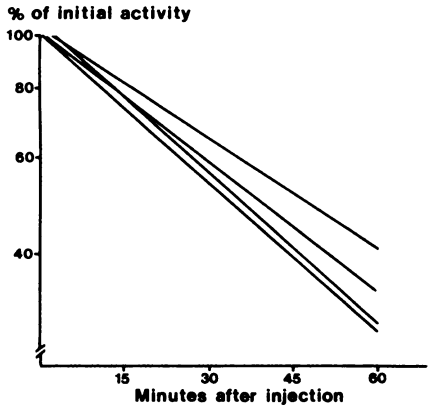

FIG. 4. Epidural clearance of 50 μCi of ^{169}Yb-DTPA in four patients. Radiopharmaceutical injected epidurally in 2 ml of normal saline.

found at the upper cervical level on the first images. Paired infusion cisternograms and conventional cisternograms in 26 patients revealed no apparent difference in rate or pattern of movement as revealed in the 4-, 24-, and 48-hr examinations. These 26 patients represented a variety of intracranial flow patterns (Table 2).

Epidural clearance of ^{169}Yb-DTPA. The clearance was monoexponential with a half-time ranging from 34 to 48 min (Fig. 4). The scintiphotos showed that the radioactivity did not diffuse out of the epidural space. Evidently, the rate of disappearance was mainly determined by resorption and excretion.

DISCUSSION

Infusion cisternography appears to fulfill three prerequisites required for the detection of CSF leakage into the epidural space. First, the lumbar CSF must contain the isotope during the entire infusion period. When infusing the radionuclide as a bolus in 7 ml of artificial CSF, a high concentration of the radionuclide invariably appeared in the lumbar dural sac at the end of the infusion. Second, imaging must be performed before the needle is removed, otherwise leakage which occurs after the spinal puncture needle is removed may be interpreted as infusion leakage. Third, the radionuclide that leaks into the epidural space during the infusion procedure must not be absorbed into the systemic circulation before imaging is performed. While sequential images of the lumbar region during infusion would probably be the best method for detecting leakage, this is not practical. With the needle in situ, the time from the start of the infusion to the lumbar imaging was about 30 min. This can be considered acceptable when the rate of clearance of ^{169}Yb-DTPA from the epidural space is considered. Conceivably, not all invalid infusion tests will be detected by this method, but the most serious errors may well be avoided.

One objection to the infusion cisternograms is that the immediate cephalad transport of the radionuclide and the CSF pressure changes in connection with the infusion might alter the intracranial CSF flow pattern. However, the nearly identical paired infusion cisternograms and conventional cisternograms in the 26 patients indicate that the infusion technique does not influence the cisternographic pattern.

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