

HYPERBARIC CISTERNOGRAPHY: EXPERIENCE IN HUMANS

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The results of hyperbaric cisternography in 30 patients are presented. An impressive decrease in the failure rate of cisternography was noted with the hyperbaric technique. Hyperbaric cisternography facilitates removal of the radionuclide from the lumbar puncture site and increases the rate of flow cephalad. This permits earlier examination times as well as increased counting efficiency. No alterations in tracer flow in the intracranial CSF pathways were observed when compared with conventional cisternography. It appears that hyperbaric cisternography is safe and offers many advantages over conventional cisternography, including decreased failure rate, shortening of the early part of the study, higher counting efficiency, and probably decreased radiation exposure to the lumbar nerve roots and the lower spinal cord.

Many nuclear medicine laboratories have experienced high failure rates in the performance of the radionuclide cisternogram (1), most probably because of extravasation of the radionuclide from the subarachnoid space through the lumbar puncture site and/or disappearance of the radioisotope from the lumbar subarachnoid space, secondary to a combination of slowed flow of the CSF cephalad and rapid local absorption. As a result of these factors, too small a quantity of the radiopharmaceutical ascends into the head for successful imaging to be performed. Hyperbaric cisternography has been proposed by the authors (2) as a modification of conventional radioisotope cisternography which may offer a possible solution for these problems.

In our experience, the use of 10% dextrose in water (D₁₀W) as a vehicle for the normally used radiopharmaceutical has decreased the failure rate of conventional cisternography. In addition, hyperbaric cisternography appears to offer other advantages

over conventional cisternography including shortening the time required for the initial phase of the study and reducing the absorbed radiation dose to the lumbar spinal cord and nerve roots.

The authors have previously described the results of studies with hyperbaric cisternography in Macaca monkeys (3). The purpose of this report is to communicate the results of hyperbaric cisternography in humans.

METHOD

Thirty consecutive patients referred to the Nuclear Medicine Service for radionuclide cisternography were studied by the hyperbaric technique. Each patient was prepared in the usual manner for lumbar puncture. The patient was positioned lying on his right or left side on a table tilted 15–20 deg from the horizontal so that the patient's head was considerably lower than the lumbar injection site. The L4-5 subarachnoid space was punctured with a 20-gage spinal needle, and a solution of the radiopharmaceutical (usually in a volume less than 1.0 cc) plus 3 cc of D₁₀W was injected at an even, moderate rate. The needle was removed immediately in most cases and left in place for as long as 5 min in a few cases. The patient remained on his side, in the Trendelenberg position, for 20 min. Sequential scintiphotos were made with the scintillation camera imaging over the spine and head to follow the progress of the ascent (or gravitational descent) of the radiopharmaceutical toward the head. Either ^{99m}Tc-albumin, ¹³¹I-albumin, or ¹¹¹In-DTPA were made hyperbaric by the addition of D₁₀W. Comparison of the quality of images obtained with these hyperbaric

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radiopharmaceuticals and the extent of delineation of anatomical detail was made.

Two patients who were referred for radionuclide cisternography twice had the conventional cisternography and the hyperbaric procedure on separate dates.

RESULTS

The clinical indications and results of the 30 cisternograms are summarized in Table 1. Seventeen of the 30 cisternograms were interpreted as normal. Of the 30 hyperbaric cisternographic procedures, there was only one failure, representing an incidence of 3%. It is thought that this was due to an extra-arachnoid injection.

Figure 1 shows the scintiphotos obtained at various times during the course of hyperbaric cisternography. The patient shown in Fig. 1A had a normal cisternogram, while the patient of Fig. 1B had "normal pressure hydrocephalus". His cisternogram showed penetration of the ventricles by the radiopharmaceutical, ventricular enlargement, and delayed resorption and flow around the convexities.

Figure 2 shows hyperbaric studies performed with ^{99m}Tc -Albumin (5 mCi), ^{131}I -albumin (100 μCi), and ^{111}In -DTPA (475 μCi). The three studies demonstrate the differences in resolution of CSF pathways seen with the three radiopharmaceuticals used in this study. In two patients a 5-mCi dose of ^{99m}Tc -albumin was injected as the sole radiopharmaceutical. The increased dose permitted 48-hr scintiphotos to be obtained.

Figure 3 shows a comparison of a hyperbaric study and a conventional cisternogram of a 59-year-old male. The two studies, performed 3 months apart, show nearly identical flow patterns.

Figure 4 provides a comparison of the spinal clearance of the radiopharmaceutical in a 70-year-old

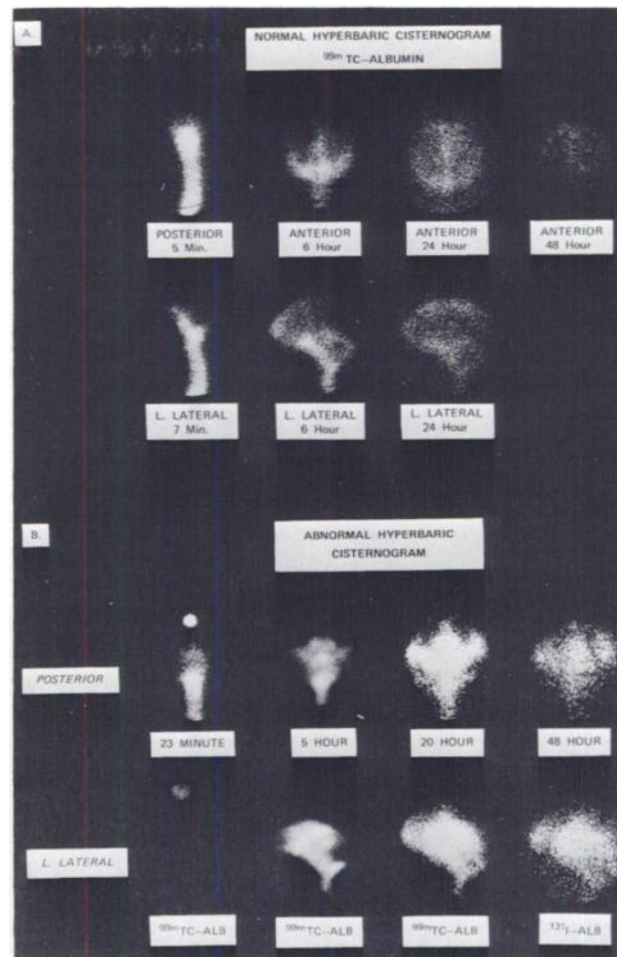


FIG. 1. A is normal hyperbaric cisternogram. Scintiphotos at 5 and 7 min postinjection show tracer activity in basal cisterns. Scintiphotos obtained at 6, 24, and 48 hr postinjection show a normal symmetrical flow of radiopharmaceutical with no ventricular penetration. B is abnormal hyperbaric cisternogram. Scintiphoto obtained at 23 min postinjection shows tracer activity in basal cisterns (radioactive marker is at top of patient's head). Scintiphotos at 5, 20, and 48 hr postinjection show that radiopharmaceutical enters ventricles and is not cleared from ventricular system. Study was obtained following simultaneous injection of ^{99m}Tc -albumin (4 mCi) and ^{131}I -albumin (100 μCi) in D_{10}W solution.

TABLE 1. INDICATIONS OF CISTERNOGRAMS PERFORMED AND RESULTS

No. of patients	Indication for cisternography	Cisternogram results		
		Normal	Abnormal	Equivalent
20	Dementia. R/O normal pressure hydrocephalus	10	10	
4	Evaluation of cerebrovascular disease	2	1	1
2	Evaluation for CSF otorrhea	2		
2	Trauma	1	1	
1	Fungal meningitis	1		
1	Pseudotumor cerebri	1		
30	Totals	17	12	1

male who underwent cisternography by the hyperbaric technique and by the nonhyperbaric technique on two different dates. At 5 min postinjection, most of the radioactivity injected by the hyperbaric technique has left the lumbar region, and at 17 min activity is seen in the head. In contrast, the nonhyperbaric study shows considerable activity still in the lumbar region at 20 min and little activity above the thoracic region at 30 min.

DISCUSSION

There has been considerable controversy about the causes of the failure rate in radionuclide cisternography. Larson, et al (4) found that prior lumbar puncture did not increase the failure rate as had been believed by many. Kieffer, et al (1) documented

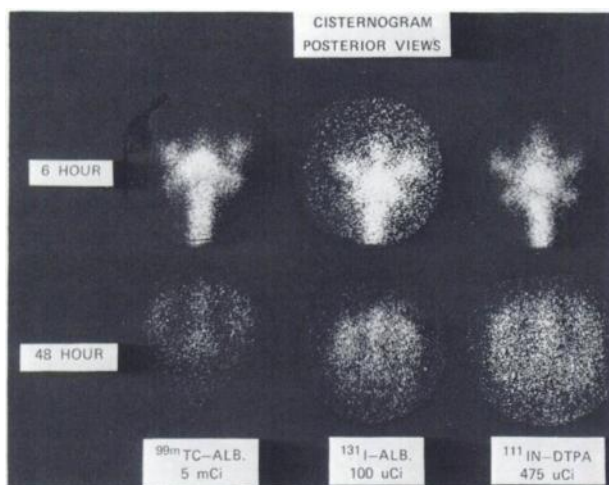


FIG. 2. Hyperbaric cisternograms performed on three different patients with three radiopharmaceuticals used in study are shown. Hyperbaric ^{99m}Tc -albumin (5 mCi) and ^{111}In -DTPA (475 μCi) images provide superior resolution of CSF pathways compared with images using hyperbaric ^{131}I -albumin (100 μCi).

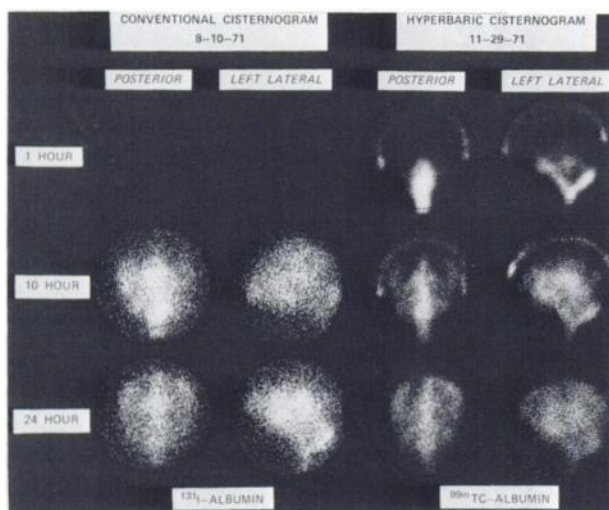


FIG. 3. Scintiphotos from conventional cisternogram and hyperbaric cisternogram performed on same patient (59-year-old man with dementia) 3 months apart are shown. Both cisternogram techniques result in nearly identical flow patterns, providing evidence for premise that hyperbaric technique does not alter representation of CSF flow which is seen on cisternogram.

significant leakage of the radiopharmaceutical at the puncture site on serial scintiphotos of the lumbar region in 13 of 54 cases. This leakage became evident only at 2 and 4 hr after the lumbar puncture.

The failure rate of conventional radionuclide cisternography has been variously reported as 11–24% (1,4). In striking contrast to these reports, the results presented in this paper indicate a failure rate of only 3%. It would seem reasonable therefore to conclude that the hyperbaric technique described here offers an effective method of improving the success rate for cisternography.

The one unsuccessful study of the 30 performed

in this series was presumed to be due to an extra-arachnoid injection. The probable extra-arachnoid distribution of the radioactive material was apparent to the physician when scintiphotos were taken of the spine at 20 and 30 min postinjection. Furthermore, the hyperbaric radioactive solution failed to progress cephalad with the swiftness characteristic of hyperbaric cisternograms. In cases of unsuccessful non-hyperbaric cisternograms, the examiner is usually unaware for several hours that the study is doomed to failure.

The specific gravity of cerebrospinal fluid is normally about 1.006, whereas the D_{10}W solution is about 1.034, representing a significant difference in baricity. With the patient in the Trendelenberg position, the effect of gravity upon the hyperbaric radiopharmaceutical appears to prevent leakage of the radiopharmaceutical at the arachnoid puncture site by facilitating the immediate transport of the hyperbaric solution cephalad. If leakage occurs, it most likely would be CSF and not the hyperbaric agent. The hyperbaric technique may decrease the tendency for local absorption caused by the slow flow of the radiopharmaceutical toward the head and relative stagnation of the labeled substance in the lumbar area as with conventional cisternography.

One serious reservation which the authors originally had about hyperbaric cisternography was that the hyperbaric properties of the radiopharmaceutical might cause distortions in the CSF flow patterns seen. Seventeen of the 30 patients studied with hyperbaric cisternography had normal cisternograms with symmetrical flow over both cerebral hemispheres and no ventricular penetration. This supports the premise that the injected hyperbaric solution loses its hyperbaricity very soon after injection into the lumbar subarachnoid space and is unaffected by positions of the head. The anesthesia literature tends to support this by suggesting that the hyperbaricity of a glucose solution is lost in 1–2 min after injection into the lumbar subarachnoid space (5). Apparently, in hyperbaric cisternography when the radiopharmaceutical arrives at the level of the cisterns it flows with the CSF current and is no longer influenced by gravity, having become isobaric with respect to the CSF. This crucial premise that the hyperbaric technique does not alter the representation of CSF flow from that which would be shown by a non-hyperbaric cisternogram is reinforced by the results shown in Fig. 3. The same pattern of CSF flow, except for earlier appearance of the tracer in the basal cisterns and a greater counting rate in the hyperbaric study, was seen with both techniques.

In a case of suspected CSF rhinorrhea or otorrhea where the clinicians may want confirmation of their

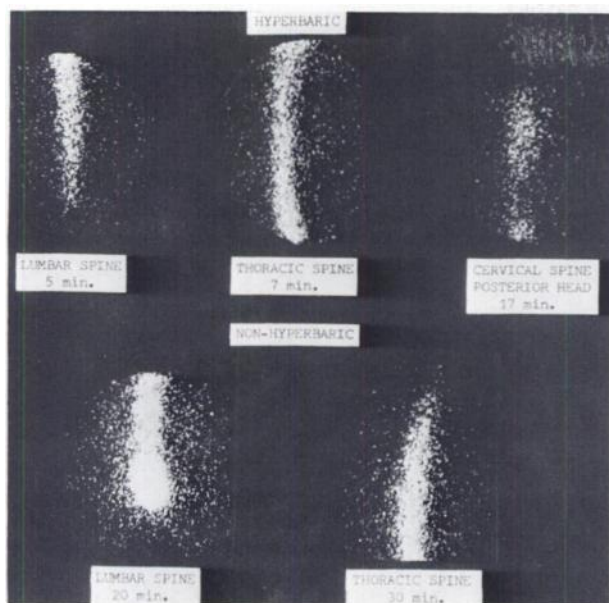


FIG. 4. Scintiphotos comparing rates of spinal clearance of hyperbaric radiopharmaceutical and nonhyperbaric radiopharmaceutical. Two studies were performed on same patient on different dates. Note rapid clearance from lumbar spine at 5 min postinjection and appearance of counts in head at 17 min using hyperbaric technique. In contrast, at 20 min considerable activity remains in lumbar region and little activity is seen above thoracic level at 30 min when conventional nonhyperbaric technique is used.

clinical suspicions as soon as possible, hyperbaric cisternography may offer an advantage over conventional radionuclide cisternography since visualization of the basal cisterns and possibly the site of CSF leakage might be accomplished as early as 20 min postinjection, depending on the location of the leakage.

Comparing the three radiopharmaceuticals used in these studies, ^{99m}Tc -albumin was at a disadvantage since, unfortunately, at 48 hr there was not enough activity remaining for satisfactory imaging when the usual dose of 2 mCi was used. However, injection

of 5 mCi of ^{99m}Tc -albumin provided enough counts at 48 hr to give a good image with a 10-min exposure. The radiation absorbed dose calculations at the level of the lumbar nerve roots for 3 mCi ^{99m}Tc -albumin and 100 μCi ^{131}I -albumin administered conventionally are fairly comparable (6). However, because of the accelerated clearance of the radioactivity from the lumbar subarachnoid space with the hyperbaric technique (3) (Fig. 4), we would anticipate that a significant reduction in the radiation absorbed dose would result compared with conventional cisternography. As sufficient kinetic data are accumulated, an estimate of this reduction can be made. One might be able to justify increased quantities of radiopharmaceuticals, such as ^{99m}Tc -labeled hyperbaric agents, in order that images at 48 hr might be obtained at no increase in the radiation absorbed dose.

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