Isotope Cisternography in the Diagnosis and Follow-Up of Cerebrospinal Fluid Rhinorrhea

Giovanni Di Chi ro, M.D., Ayub K. Ommaya, F.R.C.S.,* William L. Ashburn, M.D.,† and William H. Briner‡

Section on Neuroradiology, Medical Neurology Branch, National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland

Localization of the leakage site in cases of cerebrospinal fluid (CSF) rhinorrhea, both posttraumatic and spontaneous (nontraumatic), is often an arduous and always a challenging diagnostic problem. The possible sites are numerous: through the frontal sinus, the lamina cribrosa, the sphenoid sinus via the sella, and the petrous bone via the middle ear and the eustachian tube (Fig. 1). Furthermore, the fistula may be located on the side opposite to the "dripping nostril" or the sources of leakage may be multiple.

Diagnostic procedures for CSF rhinorrhea include the use of dyes, fluorescent substances, radiography, and radioactive tracers (Table 1). Dyes and fluorescein usually are not very informative for the localization of the fistula and, in addition, may be dangerous.26,34,44 Plain x-rays and even detailed tomographic studies are frequently disappointing. In our opinion, no convincing evidence has yet been offered for the value of Pantopaque as a localizing agent for the CSF leaks, and this x-ray opaque medium is not always innocuous.18,28 Radioactive counting of cotton pledgets placed in strategic points of the walls and roof of the nose and nasopharynx prior to the subarachnoidal introduction of a radiation emitter36 fails to give morphologic information about the leakage.

This report deals with the diagnostic possibilities of isotope cisternography (pictorial scintiphography of the head after introduction of a radioactive tracer into the subarachnoidal spaces) for the localization, demonstration of the cause, and follow-up of cerebrospinal fluid rhinorrhea. We have used isotope cisternography in over 30 cases of traumatic and nontraumatic leaks. The method is usually successful, always informative. It is simple and, if the proper technique is followed, innocuous. Because the isotope cisternogram represents an accurate and reliable pictorial demonstration of the endocranial subarachnoidal cavities, we actually "see" the site of leakage and, not infrequently, the entire fistulous track.

The radioactive tracer is introduced in most instances by lumbar puncture, exceptionally by the suboccipital route. A fine gauge needle is preferred for the lumbar puncture, to avoid excessive subarachnoid tearing and thus minimizing extravasation of the tracer into the subdural or epidural lumbar spaces. Every attempt should be made to obtain a straight, clean puncture, and repeated "stickings" at the same sitting should be avoided. Injection of the radioactive tracer after a "bloody" lumbar puncture will in most instances result in a conventional brain scan, as after intravenous (systemic) introduction, rather than a cisternogram. The tracer may be diluted in the syringe with some CSF. The radioactive compounds for isotope cisternography and ventriculography which we have employed through the years are listed in Table 1.

Radioiodinated human serum albumin (RIHSA) has been our tracer of choice for a

Received for publication September 21, 1967.

* Associate Neurosurgeon, Surgical Neurology Branch, National Institute of Neurological Diseases and Blindness, NIH, Bethesda, Maryland.
† Chief, Diagnostic Radiosotope Section, Department of Nuclear Medicine, Clinical Center, NIH, Bethesda, Maryland.
‡ Chief, Radiopharmaceutical Service, Clinical Center, NIH, Bethesda, Maryland.
TABLE 1
Investigative procedures for localization of CSF leaks*

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Material and Methods</th>
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<tbody>
<tr>
<td>Dyes</td>
<td>1. methylene blue&lt;br&gt;2. phenolsofonphthalein&lt;br&gt;3. indigo carmine</td>
</tr>
<tr>
<td>X-ray</td>
<td>1. plain&lt;br&gt;2. tomography (See ref. 2)&lt;br&gt;3. pneumoencephalography&lt;br&gt;4. subdural pneumography (ref. 32)&lt;br&gt;5. Pantopaque (refs. 30, 33, 39, 42, 43)</td>
</tr>
<tr>
<td>Photoluminescent Substance</td>
<td>fluorescein (ref. 34)</td>
</tr>
<tr>
<td>Isotope Counting</td>
<td>1. 32PNa (ref. 4)&lt;br&gt;2. RIHSA (ref. 35)</td>
</tr>
<tr>
<td>Isotope Cisternography and Ventriculography</td>
<td>1. Colloidal 131I-Au (See refs. 7, 10, 23, 41)&lt;br&gt;2. Autologous 111I-tagged CSF (See refs. 9, 12)&lt;br&gt;3. Low protein RIHSA (10 mg/cc, fresh approx. 500 µCi; for lumbar and intraventricular punctures and within surgical shunts. See refs. 11, 16, 22, 36)&lt;br&gt;4. 99mTc pertechnetate (for intraventricular puncture and within surgical shunts. See refs. 15, 19, 38)&lt;br&gt;5. 99mTc human serum albumin (Te-HSA) (See ref. 31)&lt;br&gt;6. High specific activity 99mTc human serum albumin (high specific activity—Te-HSA) (See refs. 15, 16, 38)</td>
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* References have not been included for routine or now abandoned procedures.

long time. Prior to its introduction, as in conventional brain scanning, the thyroid should be blocked with "cold" iodine. It is of fundamental importance to inject into the subarachnoidal space low protein, high specific activity RIHSA. A fresh 1% solution* (concentration 500 to 250 µCi per cc) should be used. Thus, in the technique of isotope cisternography in order to administer the adult dose of 100 µCi, 0.2 to 0.4 cc (2 to 4 mg of albumin) is injected intrathecally. In children, 50 µCi (1 to 2 mg of albumin) is sufficient. Using low protein, high specific activity RIHSA, we have never seen aseptic meningitis or other complications related to the tracer in several hundreds of isotope cisternographic and ventriculographic studies. In both of the two recently reported cases of aseptic meningitis following subarachnoidal introduction of RIHSA, a 6% solution was used.5,37 Thus, the amount of albumin injected intrathecally was very high (28 mg and more than 100 mg respectively).

In the last year, we have extensively employed for cisternography15,16,38 high specific activity Technetium-99m human serum albumin (99mTc-HSA), which we are also using by the intravenous route for conventional brain scanning.17 Our method of preparing this compound, described in detail elsewhere,16 is a modification of a method originally suggested by Richards and Atkins.40 In general, it consists of an acid reduction of pertechnetate ion in the presence of iron and ascorbic acid prior to coupling to the protein. Non-organically bound 99mTc is subsequently removed by ion exchange chromatography, and the product is sterilized by membrane filtration. Appropriate control testing is then carried out to determine the quality of the resultant compound. The high specific activity-99mTc-HSA dosage employed for isotope cisternography has been 2 mCi in adults and 1 mCi in children. Due to the fact that in our preparations the specific activity varies from 1.5 up to 12 mCi per mg, we virtually never have to inject intrathecally more than 1 mg of albumin.

Technetium albumin is an ideal tracer for the isotope-cisternographic study of the CSF leaks. With the dosage of 1 or 2 mCi, high count rates are insured. The radiation to the patient is negligible due to the short half-life (6 hours) and the absence of beta emission. In addition, the Anger type camera can be used very efficiently with the 140 kev gamma photon of the 99mTc. A disadvantage of 99mTc-HSA is that its short half-life makes impractical the studies at 24 to 48 hrs (late scans). For this reason, we occasionally use a double tracer technique: high specific activity-99mTc-HSA for the early (up to 6 hours) and RIHSA for the late (24 to 48 to 72 hrs) records. The 99mTc-pertechnetate (99mTcO4-) cannot be used for isotope cisternography because it is resorbed locally at the site of the lumbar injection, and it is not transported with the cerebrospinal fluid.9,12

* The Abbott Laboratories "RISA," for instance, is a 1% solution.
The flow pattern of the injected tracer which has been previously described in numerous publications is not related to, or modified by, the patient’s position or movement. This flow insures that the radioactive tracer reaches the areas of the brain base which are critical sites for the CSF leaks in the first hours after the lumbar injection.

Serial scanning or scintiphotography (camera) of the head is initiated 30 to 60 minutes after the introduction of the tracer (RIHSA or Tc-HSA). We carry out scanning with the Tetrascanner (Fig. 2) which with its four probes arranged in opposite pairs in planes at right angles allows four simultaneous views; anterior, posterior, right, and left lateral. Our camera is of the Anger type. Any of the commonly used rectilinear scanners or fixed devices (cameras), however, can be employed for isotope cisternography.

The patient should preferably be examined in the position in which the CSF leakage is likely to occur; this is with the head down in most instances. The Anger camera is ideal for this purpose. This device can accommodate to any position and with it, the tracer may be “photographed” while it drips, mixed with the CSF, from the patient’s nose. The lateral scintigraphic views are more frequently informative in the diagnosis of the CSF rhinorrhea. The sagittal views, however, are also helpful particularly when the source of leakage is in the posterior fossa, where these views may be crucial for the diagnosis (Fig. 3).

It is important to record on the scintigrams the landmarks of the patient’s head (nasion, external auditory meatus, inion). These will be helpful for the exact localization of the leak. One may also superimpose the scan or the enlarged scintiphotogram (camera) on the patient’s skull x-rays. After acquiring familiarity with the appearance of the normal isotope cisternogram, the investigator will be able to recognize the endocranial topography directly on the scan.

The great majority of the leak sites are

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Fig. 2. Patient being examined with Tetrascanner.
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recognized in the 1, 2, or 3 hours scans. Obviously, if the meningeal break is in the posterior fossa, the 1-hour (or even the 30-minute) scinti-record is the most important (Fig. 3 left). The 1- and 2-hour scans are particularly important for the middle fossa fistulas, especially with leaks from the sella turcica (Fig. 3 right). Far anterior leaks on the other hand are better seen in the 3- to 6-hour scans (Fig. 4 left). Generally speaking, the more anterior the leak, the more useful are the later scans. Occasionally the 24- or even 48-hour scans may be helpful in cases of cystic subarachnoidal collections communicating with the nasal cavities.

It is important to recognize that the demonstration of the fistulous track (Fig. 4 right) is not an indispensable element for the localization of the leak. This is particularly true for the breaks through the floor of the sella turcica into the sphenoidal sinus caused by expanding intrasellar subarachnoidal cysts. These intrasellar CSF collections (Fig. 5), which lead to the formation of the so-called

Fig. 3. Left: Early, 30-to-60 minute, posterior cisternogram (camera). Tracer penetrates from left pontocerebellar cistern into petrous bone (arrow) and via middle ear and eustachian tube reaches nasopharynx. Right: 2-hour lateral cisternogram (camera) showing leakage from sella turcica (arrows).

Fig. 4. Left: 4-hour lateral cisternogram showing leak at level of frontal sinus (arrow). Right: 2-hour lateral cisternogram showing leakage from middle part of lamina cribrosa. Entire track is demonstrated (arrows).
FIG. 5. Pneumoencephalograms of three intrasellar subarachnoidal cysts responsible for nontraumatic CSF rhinorrhea. One cyst fills almost entire sella (arrow, A), another, its anterior half (arrow, B), and a third one is demonstrated in both lateral and frontal views (arrows, C and D).

"empty-sella," are frequently the source of nontraumatic CSF rhinorrhea. In these instances, we may recognize an intrasphenoidal collection of radioactive fluid (Fig. 6). Thus, the sphenoidal concentration of radioactivity, which may persist for days, clinches the localizing diagnosis even without demonstration of a track. The crucial fact is that the morphology of the radioactive tracer distribution (isotope-cisternogram) is constant and well determined in its pattern. Deviations from the normal morphology, exactly as with pneumoencephalography, are pathological findings which need to be explained. Modifications of the cisternographic appearance of the radioactive "pools" (sphenoidal sinus collections, for instance) with changes in position of the patient, from supine to prone for example, may also be of diagnostic help.
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Fig. 6. Three examples (A, B, C) of radioactive tracer accumulation into sphenoidal sinus (arrows). Compare with normal cisternogram (D).

Fig. 7. Leakage into frontal sinus (arrow, A), no longer demonstrable after successful surgery (B).
The method of isotope cisternography is also ideal for the follow-up of postoperative cases (Fig. 7). We have repeated this procedure several times in many of our patients.

In the not too rare cases in which the "identification" of the fluid as CSF is questionable, and when non-CSF rhinorrhea is considered as a diagnostic possibility, a negative isotope cisternogram will be a strong indication against the CSF nature of the leaking fluid.

Finally, the isotope cisternogram may lead to the correct diagnosis in cases in which dural and subarachnoid tears, most frequently posttraumatic, are responsible for recurrent meningitis in the absence of a clinically recognizable leak. We have seen one case of "subclinical" rhinorrhea in which a posttraumatic cyst-like subarachnoid formation was communicating with the nasal cavities (Fig. 8) and thus was responsible for recurrent meningitis. Similar cases, also studied with isotope-cisternography, have recently been reported by other authors.24

**Summary**

Isotope cisternography is a reliable, informative, simple and innocuous method for localizing the site of leakage in cases of cerebrospinal fluid rhinorrhea. In addition, this procedure gives morphologic data on the area adjacent to the meningial-bony break or the fistulous track which cannot be obtained by any other method. Isotope cisternography can be safely repeated to follow-up cases after surgery.

**References**

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