A new radionuclide method for the diagnosis of posttraumatic cerebrospinal fistulas

A study of 308 cases

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The authors describe their technique for identifying and localizing posttraumatic cerebrospinal fluid fistulas. The method entails injection of radionuclide tracer into the subarachnoid frontal space with the patient in a sitting position followed by gamma camera scintigraphic recordings. The results in 308 patients are presented; these are compared with those of suboccipital radionuclide cisternography in 40 cases and metrizamide computerized tomography cisternography in nine cases. Transient complications occurred in only three patients.

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CEREBROSPINAL fluid (CSF) fistulas present a frequent problem in neurosurgery. Correct diagnosis and topographical localization of the site of leakage are of great importance since, if suitable surgical therapy is not undertaken, these fistulas very often cause severe recurring infectious meningitis. The methods for detecting and localizing the fistula and determining whether it is unilateral or bilateral are often unsatisfactory, in spite of the technical advances in radionuclide cisternography\(^1\sim8,11,16,17\) and in metrizamide computerized tomography (CT) cisternography.\(^9,10,14,15\)

In the present paper, we describe a new method for diagnosing CSF fistulas, based on frontal subarachnoid injection of the radionuclide tracer,\(^12,13\) and report on the results obtained in 308 patients.

**Clinical Material and Methods**

The method consists of two phases: the surgical preparation and radioisotope examination. The patient is placed under local anesthesia, and two drill holes, 5 mm in diameter, are made anterior to the coronal suture and 5 cm on either side of the midline. The dura mater is not incised. A precise technique for injection of the tracer is essential for a successful radioisotope examination. The dura mater is pierced and the radionuclide material is injected into the subarachnoid space, with the patient in a sitting position. We recommend using a Teflon intravenous-type catheter, 1.2 mm in diameter, connected to a 5-ml glass syringe. With the catheter in position and the syringe held vertically, the piston is allowed to fall under its own weight, thus confirming that the injection is really directed into the subarachnoid space. This procedure avoids possible lesions of the cortical vessels. We inject 3 ml of physiological solution containing 1 mCi of technetium-99m (\(^{99m}\)Tc) pertechnetate. Premedication with potassium perchlorate is performed in order to avoid impregnation of the salivary and parotid glands by tracer.

The scintigraphic recordings by gamma camera must be carried out immediately after the injection, using a lateral view corresponding to the side injected, with the patient in a sitting position with the head leaning forward. When a CSF fistula is revealed, a frontal or rear view is also taken. Afterward, guide marks are placed on the skin with a cobalt-57 marker at the external auditory canal, the external angle of the orbit, and the nasion. Examination of the opposite side is performed 24 hours later; for this a second injection is necessary since the falx cerebri prevents the tracer from crossing into the contralateral side.
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**Fig. 1.** Typical recordings of nonpathological cases after subarachnoid frontal injection. *Left:* Left lateral view, obtained immediately after the injection of tracer, showing homogeneous diffusion at the convexity. There is no abnormal diffusion of the tracer at the base of the skull. *Right:* Right lateral view, made 10 minutes after the injection, showing the perfusion of the cisterns at the base of the skull.

**TABLE 1**

<table>
<thead>
<tr>
<th>Radioisotope Examination</th>
<th>No. of Cases</th>
<th>Pathological Cases</th>
<th>Surgical Cases</th>
<th>Confirmed by Surgery</th>
<th>Not Confirmed by Surgery</th>
<th>Rate of Success (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>during CSF leakage</td>
<td>158</td>
<td>144</td>
<td>158</td>
<td>135</td>
<td>14 False-Negatives</td>
<td>85</td>
</tr>
<tr>
<td>not during CSF leakage</td>
<td>150</td>
<td>141</td>
<td>111</td>
<td>86</td>
<td>9 False-Negatives</td>
<td>78</td>
</tr>
<tr>
<td>total cases</td>
<td>308</td>
<td>285</td>
<td>269</td>
<td>221</td>
<td>23 False-Negatives</td>
<td>82.3</td>
</tr>
</tbody>
</table>

* Anterior or middle ethmoidal fistulas: five cases; posterior ethmoidal fistulas: 11 cases; sphenoid fistulas: three cases; and petrotympanic fistulas: two cases.

**Patient Population**

This method was applied to 308 patients with clinical symptoms of CSF fistula. In 158 cases, the examination was performed during a period of CSF leakage, and in the 150 others without CSF leakage. We carried out a comparison with the results of conventional radionuclide cisternography by suboccipital injection in 40 cases, and with the results of metrizamide CT cisternography in nine cases.

At the beginning of this study, normal criteria were established in 11 patients not suffering from a CSF fistula, but for whom ventriculography had been prescribed (Fig. 1).

**Positive Diagnosis of Rhinorrhea.** The overall results for the series are shown in Table 1. Of the 308 patients administered radionuclide material by frontal injection, 269 underwent subsequent surgery. The other 39 were eliminated from the study since the radionuclide examination was negative and the rhinorrhea was not clinically unequivocal. By the present method, CSF fistulas were demonstrated in 221 of the patients operated on, that is, 82% of the cases. These included 144 cases of anterior or middle ethmoidal fistulas, 53 cases of posterior ethmoidal fistulas, 14 cases of sphenoidal fistulas, and 10 cases of petrotympanic fistulas.

Radionuclide examination by frontal injection was negative in 23 patients (13% of the cases), but surgery revealed a CSF leak through the dura mater. These operations were prompted by the presence of bone lesions due to previous injury and by undoubted clinical evidence of CSF leakage. Conversely, the radionuclide examination was positive in four patients, whereas at surgery no convincing evidence was found of a fistula in the dura mater. Moreover, in three cases the leakage ceased after the operation, coinciding with a negative finding in the postsurgical radionuclide examination. There was no significant difference in the number of positive examinations.
carried out during a period of CSF leakage and after clinical evidence of cessation of CSF leakage ($p = 0.09$).

**Topographical Localization of CSF Fistulas.** By this method, 96.5% of the fistulas in the anterior or middle part of the ethmoid were satisfactorily (Fig. 2 and Table 2). Precise localization of posterior fistulas, ethmoidal or sphenoidal, could not be obtained in 21% of cases, and the association of a bone scintigram using methyl diphosphonate labeled with $^{99m}$Tc injected 6 hours earlier, did not provide any further assistance in the topographical localization of posterior fistulas. Petrotympanic fistulas communicating with the eustachian tube were identified with the help of frontal or occipital views. Lateral diffusion could thus be demonstrated, giving a totally different picture compared to that obtained with the paramedial diffusion of fistulas of the anterior part of the base of the skull (Fig. 3). In 30% of the cases the bilateral character of the fistula was demonstrated, although this had not been suspected on the basis of the x-ray examinations.

**TABLE 2**

<table>
<thead>
<tr>
<th>Location of Fistulas</th>
<th>No. of Cases by Surgery</th>
<th>Imprecise Localization (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>anterior or middle ethmoid</td>
<td>144</td>
<td>139</td>
</tr>
<tr>
<td>posterior ethmoidal &amp; sphenoid</td>
<td>67</td>
<td>53</td>
</tr>
</tbody>
</table>

**TABLE 3**

<table>
<thead>
<tr>
<th>Feature</th>
<th>No. of Cases</th>
<th>Demonstration of Fistula</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Classical Cisternography</td>
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<tr>
<td>during rhinorrhea</td>
<td>30</td>
<td>positive in 10 cases</td>
</tr>
<tr>
<td>rate of success</td>
<td>100%</td>
<td>positive in 1 case</td>
</tr>
<tr>
<td>not during rhinorrhea</td>
<td>10</td>
<td>positive in 1 case</td>
</tr>
<tr>
<td>rate of success</td>
<td>10%</td>
<td>positive in 1 case</td>
</tr>
</tbody>
</table>

* All cases confirmed by surgery.

**Discussion**

The reliability of the radioisotope examinations made by means of frontal injection is unequivocal provided the technique recommended above is strictly followed. The pathological pattern of diffusion of the tracer found in cases of CSF fistula is substantiated by the following findings: 1) The patterns of the gamma camera scintigrams obtained during radioisotope examination with the present method in 11
Fig. 3. Value of the frontal injection method of cisternography in the localization of fistulas. Upper Pair: Right posterior ethmoidal fistula. The frontal view reveals its paramedian location. Center Pair: Sphenoidal fistula. The frontal view shows that the fistula is practically in a midline position. Lower Pair: Right petrotympanic fistula. The frontal view shows the extremely lateral situation of this fistula.
Fig. 4. Results obtained with conventional cisternography by suboccipital injection (left) and with the frontal injection method (right). A comparison of these two techniques, carried out on the same patient during a period of cerebrospinal fluid leakage, shows that suboccipital cisternography is only suitable for demonstrating nasal contamination. In contrast, the examination by frontal injection allowed localization of this large posterior ethmoidal fistula which had not been revealed by conventional cisternography.

control cases were all different from those obtained in patients with a CSF fistula. We did observe, however, in two normal subjects, a very slight movement of the tracer in the posterior ethmoidal region, demonstrating the sensitivity of the method, but the pattern obtained was by no means comparable with that obtained in cases of CSF fistula. Such a physiological pattern could possibly result from diffusion by lymphatic ducts passing through the foramina of the cribriform plate of the ethmoidal bone with the olfactory nerves. 2) The results of the radioisotope examination were confirmed surgically in 82% of the cases. 3) In three subjects with clinical rhinorrhea and a CSF fistula confirmed afterward by surgery, the insertion of swabs in the nasopharynx prevented the fistula from being seen. The fistula was revealed, however, after removal of the swabs, which were found to contain a high level of radioactivity. 4) Although the pertechnetate diffused as expected secondarily and physiologically into the tissues at the base of the skull, this did not prevent correct interpretation of cisternography, provided the recordings were made immediately after injection of the tracer (Fig. 5). Furthermore, we have obtained identical results using other molecules labeled with $^{99m}$Tc serum albumin and $^{99m}$Tc DTPA (diethylene triamine pentacetate). 5) Our experience has not revealed any particular problem concerning the injection into the subarachnoid or the subdural space. If the tracer was accidentally injected outside the dura mater, it scarcely diffused at all, remaining around the injection site.

The failures of the method may be explained by poor diffusion of the tracer resulting from the presence of a pathological obstruction or from adhesive arachnoiditis of the basal cisterns. It was found that failure occurred more frequently when the examination was performed less than 3 weeks after a head injury, after surgery in the frontal regions, or in patients with a cured purulent meningitis. In these cases, we consider it necessary to carry out another examination 1 month later in order to confirm the absence of CSF fistula.

The virtually total safety of the method is demonstrated by the fact that among the 308 patients studied we observed only three complications. Two patients suffered Bravais-Jacksonian seizures, which did not recur afterward, and one case (in an alcoholic patient) was complicated by a temporary hemorrhage resulting from an accidental subcortical insertion of the needle.

Compared with the classical techniques of radionuclide cisternography and metrizamide CT cisternography, the present method represents an improvement in the demonstration of a CSF fistula, in its localization, and, in particular, in the frequent achievement of a positive result when the CSF is not actually leaking. We believe that the effectiveness of the method is due to the route of administration, which allows immediate diffusion of the tracer toward the leak, resulting in a concentration of the radioactivity at the site and consequently better visualization of the location of the fistula.

Although the surgery required for injection of the tracer in the frontal region represents a disadvantage that cannot be ignored, we believe this outweighs the less consistent results obtained with other methods.

**Summary**

The authors present the results accumulated in 308 patients using a new method for diagnosing rhinorrhea based on frontal subarachnoid injection of radionuclide tracer. These results demonstrate the superiority of this method over conventional radionuclide
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FIG. 5. Rapid-sequence views obtained 30 seconds (upper left), 40 seconds (upper right), 50 seconds (lower left), and 60 seconds (lower right) after subarachnoid frontal injection in a case of right ethmoidal fistula. This sequence demonstrates the rapidity with which the ethmoidal fistula is revealed (30 seconds after the injection). The necessity for a rapid recording is revealed.

cisternography, with respect to the positive diagnosis of the rhinorrhea, precision of localization of the fistula and its uni- or bilateral character, and the fact that the method is frequently positive even when CSF is not actually leaking.

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References


17. Zander E, Oberson R: [Diagnosis of cerebrospinal fluid fistulae by radioisotopic cisternography.] Neurochirurgia (Stutt) 10:163-169, 1967 (Fre)

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