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# Technical Review and Considerations for a Cerebrospinal Fluid Leakage Study

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Within the past decade, published diagnostic algorithms for cerebrospinal fluid (CSF) leakage have included  $\beta$ -2-transferrin analysis, rigid nasal endoscopy, high-resolution CT, CT cisternography, CT fluorescein lumbar puncture, and MRI but have not included the nuclear medicine CSF leakage study. However, some physicians still use this study today. This case report reviews the procedure and data calculations for the study. The presented case demonstrates how patient ingenuity in maintaining a compromised pledget for counting after sneezing contributed to the final diagnostic outcome. The patient was a 58-y-old man who presented with persistent nasal drainage and headaches, with no history of previous head trauma or surgery. The patient was referred to the nuclear medicine department for a CSF leakage study, which had positive findings and led to a final diagnosis of a large dural and skull defect posteriorly over the ethmoid sinuses.

**Key Words:** CSF leakage study; rhinorrhea; pledget analysis

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**T**he use of nuclear medicine imaging to diagnose and localize cerebrospinal fluid (CSF) leakage is currently not common practice. Recently published algorithms for CSF leakage have not included nuclear medicine as an imaging technique (1–4) and have indicated that CT is the most beneficial diagnostic tool. Yet, some physicians still order the CSF leakage study, with an average of 5 such studies performed annually at a local institution. Physicians may order this procedure to further evaluate patients when routinely ordered examinations have negative or inconclusive findings or when the leakage is intermittent (5,6). Technologists must be prepared to successfully complete the CSF leakage procedure and be aware of current routine imaging that provides greater diagnostic information.

## CASE REPORT

Recently, a 58-y-old man with persistent nasal drainage and headaches was referred to the nuclear medicine department

for CSF leakage imaging. The patient's previous evaluation with glucose strips was negative for draining; however, that type of diagnostic procedure has been found to be unreliable (7). The patient reported no previous head trauma or surgery, and no previous imaging studies had been performed.

After receiving an explanation of the procedure and giving written consent to undergo it, the patient received a 40.3-MBq (1.1 mCi) injection of <sup>111</sup>In-diethylenetriamine-pentaacetic acid intrathecally via lumbar puncture, by a radiologist using fluoroscopic guidance. Before the injection, the referring otolaryngologist placed 1 cotton pledget into each nasal cavity. A review of the literature indicated that up to 3 pledgets may be placed in each nasal cavity (8). The use of pledgets is the most crucial step during this procedure and allows the continuous detection of CSF leakage throughout the study (8). Acetazolamide (Diamox; Wyeth), the only medication that may interfere with this study, may delay distribution of the dose throughout the CSF system and possibly cause reflux into the ventricles. It is recommended that patients stop taking this drug at least 2 d before the procedure (9).

After the intrathecal injection, the patient rested in the supine position for 6 h to prevent or minimize possible severe headaches from the injection technique. At 6 h after injection, planar images of the patient were acquired posteriorly over the injection site and spinal column to demonstrate adequate injection technique (Fig. 1). Adequate injection is determined by lack of kidney and bladder visualization. Figure 2 demonstrates an example of dose extravasation, because the bladder can be seen.

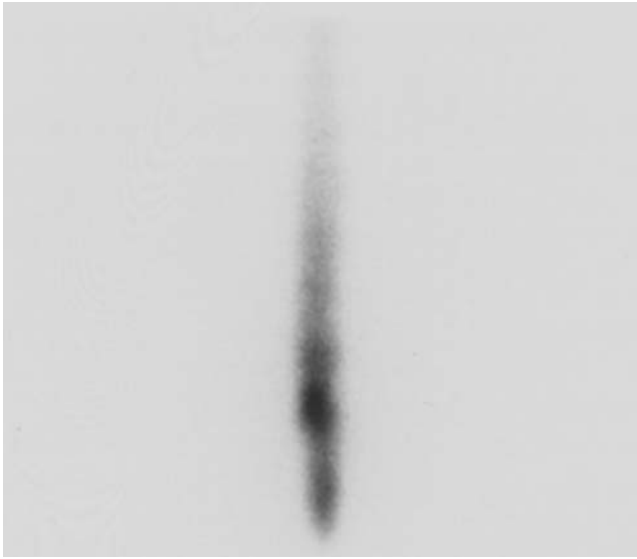
At 24 h after injection, anterior, right lateral, and left lateral planar images of the patient's head were obtained as the patient was positioned to encourage CSF leakage (Fig. 3). Abdominal imaging can be helpful because if a leak is in the nasal sinuses, the patient may swallow the labeled CSF fluid and show radiopharmaceutical uptake in the stomach (Fig. 4). The presence of tracer in the region of the stomach can be considered positive for rhinorrhea (10). Qualitative images are important for the completeness of the procedure. However, images may prove inconclusive or lead to a false-negative interpretation (8). Images associated with this patient were considered to show normal findings and were not available for publication. Figures 1–4 are examples from other patients.

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**FIGURE 1.** Example 6-h postinjection image demonstrating normal dose flow in spinal column. Kidneys and bladder are not seen.



**FIGURE 2.** Example 4-h postinjection image with dose extravasation indicated by bladder visualization.

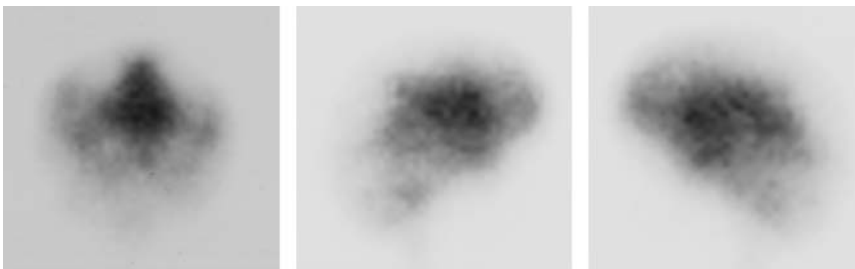
Quantitative analysis is imperative during the study (10). A single cotton pledget was placed into each of the patient's nasal cavities and labeled as to whether the pledget was from the left cavity or the right cavity. To compare the radioactivity in the nasal pledgets with that in the patient's plasma serum sample, we calculated the ratio of counts per gram in each pledget to counts per gram in the plasma serum. A greater activity per gram of nasal secretion than per gram of plasma was the expected indication of a positive finding, because CSF activity is greater than plasma activity after intrathecal injection (11). At the institution where this procedure was performed, ratios of greater than 1.5 are considered positive. However, positive findings may include a ratio difference of as high as 4:1 (8).

For the quantitative calculations, a sample of the patient's blood was drawn immediately after removal of the nasal pledget. Each pledget and the blood sample was weighed separately on a standard gram scale. For accuracy, the weight of each dry pledget and test tube was subtracted. A well scintillation counter was used to obtain counts for the pledgets, blood sample, and room background. Two readings of each were obtained, and the average net count was used for final calculations (Table 1).

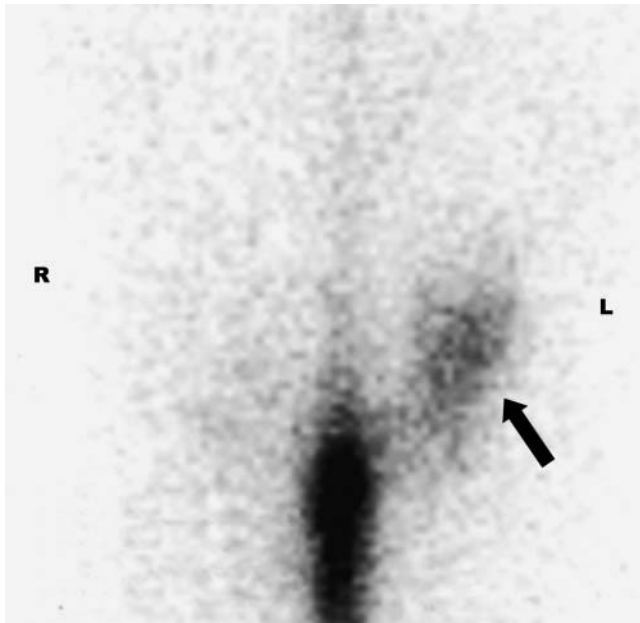
The left pledget demonstrated an elevated ratio of 1.6:1. The right pledget ratio was 0.82:1 and was considered normal. The patient happened to expel the right pledget from his nasal cavity when he sneezed while sleeping. The patient collected the expelled pledget and tested the sample with a glucose strip, which showed the presence of CSF. The patient put the pledget and positive glucose strip into a plastic bag and returned them to the nuclear medicine department the following day. This step allowed for completeness of the procedure. Following the CSF leakage study, the patient had a bifrontal craniotomy for further evaluation and surgical treatment. According to the surgical report, the CSF leakage was associated with a large dural and skull defect posteriorly over the ethmoid sinuses. The location of the defect accounts for the leakage from both the left and the right nasal cavities indicated in the quantitative analysis and glucose testing.

## DISCUSSION

The use of nuclear CSF leakage imaging was more prominent and considered more diagnostically valuable (12) before the advent of CT and MRI. These radiographic imaging techniques are superior in detecting the leak and



**FIGURE 3.** Example 24-h postinjection images demonstrating no evidence of CSF leakage. From left to right are anterior, right lateral, and left lateral views.



**FIGURE 4.** Example anterior image demonstrating swallowed radiopharmaceutical and dose accumulation in stomach (arrow) during CSF leakage study. This presentation is considered positive for leakage.

identifying its exact anatomic location, allowing for improved treatment. Several diagnostic algorithms for the detection and localization of CSF leakage have been published (1–4,13), and there has been both agreement and disagreement about these within the literature. Authors have agreed that  $\beta$ -2-transferrin assists in establishing the presence of CSF leakage (1,3,4,14). In fact, Bateman argued that all patients suspected of having CSF leakage should undergo the test to avoid unnecessary invasive intra- and extracranial procedures (13).  $\beta$ -2-transferrin is a protein produced by the brain and is found only in CSF, aqueous humor, and perilymph, making the test invaluable in the investigation of suspected CSF rhinorrhea (13). However, lack of conclusive results may suggest the need for further investigations, including imaging.

Once the presence of CSF leakage has been established, specific localization of the leak is essential for successful

treatment. Authors agree that rigid nasal endoscopy, high-resolution CT, CT cisternography, and MRI have individual benefits in leakage diagnosis, with CT being the test most often used (1,3,4). However, disagreement exists about the priority of each imaging tool.

High-resolution CT has been proposed as the only imaging technique necessary in identifying a leakage site associated with bony defects (13). High-resolution CT does not depend on active CSF leakage at the time of the investigation and can reliably demonstrate the precise site of the bony defect (15). MRI is useful in soft-tissue defects (13) and is beneficial when meningocele, encephalocele, or tumor is suspected (16).

If high-resolution CT or MRI is inconclusive, CT cisternography may be considered. Recently, Rice determined that IsoView (ITEDO Software) CT cisternography is the most definitive test to identify a site of active leakage (1). However, some investigators have suggested that fluorescein lumbar puncture with CT should supersede CT cisternography (4,13); these studies did not use the IsoView vector graphics program with CT cisternography, however.

When the presence and site of CSF leakage cannot be confirmed, intrathecal fluorescein with CT can be considerably beneficial (16). Some institutions use intrathecal fluorescein preoperatively for diagnosis and intraoperatively for localizing the leakage (1).

Even with these routine studies, the findings may be false negative for CSF leakage. Some physicians may still use the nuclear CSF leakage study in select patients when the leakage site has not been clearly demonstrated or is intermittent.

## CONCLUSION

CSF leakage procedures are not routine in the nuclear medicine department. However, a periodic review of such rarely performed procedures is always warranted. Technologists who are educated about the published diagnostic algorithms can help their colleagues acquire the most appropriate diagnostic information on the patient. Finally, educating patients about these types of procedures is imperative so that the patients can help ensure the success of the study.

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**TABLE 1**  
Quantitative Data for CSF Leakage Study

Parameter	Background	Plasma serum	Pledget	
			Left	Right
Sample A count	276	4,430	7,899	4,501
Sample B count	286	4,485	7,751	4,523
Average count	281	4,457	7,825	4,512
Net count		4,176	7,544	4,231
Fluid grams		1.7	1.9	2.1
Average net count per gram		2,456.4	3,970.5	2,014.7
Sample-to-serum ratio			1.62:1	0.82:1

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