Annals of Nuclear Medicine Vol. 20, No. 4, 333–336, 2006

Unsuccessful tracer injection in radionuclide cisternography revisited

Toru HORIKOSHI,* Yasuhiro ASARI,* Arata WATANABE,* Mikito UCHIDA,* Takako UMEDA,**
Hidehito KOIZUMI*** and Hiroyuki KINOUCHI*

*Departments of *Neurosurgery, and **Radiology, Faculty of Medicine, University of Yamanashi*
****Department of Neurosurgery, Yamanashi Prefectural Central Hospital*

Since cerebrospinal fluid (CSF) leakage is highlighted as a cause of persistent headache, radionuclide cisternography has been increasingly performed in Japan to confirm the disorder, although the limited ability of the examination should be recognized. We present 3 cases in which failure of a tracer injection was strongly suspected. In 2 cases with chronic symptoms, the tracer appeared to be injected into the epidural space, because of irregular initial accumulation of the tracer and lack of diffusion along the CSF cavity. Another is a case with spontaneous CSF leakage confirmed by MRI, and the tracer was thought to be injected into the leaked fluid accumulated in the spinal epidural space. Tracer in the CSF space rapidly disappeared within several hours in all cases. As such cisternographic images may be misdiagnosed as severe CSF leakage, careful interpretation of images in patients especially with no typical MR findings of CSF leakage is necessary. Excessive tracer clearance from the body suggests such technical failure.

Key words: cerebrospinal fluid leakage, intracranial hypotension, radionuclide cisternography, ^{111}In-DTPA

INTRODUCTION

SPONTANEOUS CEREBROSPINAL FLUID (CSF) leakage has been recognized as a common cause of new daily persistent headache.[1] It typically causes orthostatic, but occasionally non-orthostatic headache, with other associated symptoms such as hearing or visual disturbance, cranial nerve palsy or even psychiatric changes, although the mechanisms causing these symptoms have not been fully understood.[2–4] Besides the spontaneous leakage, post-traumatic CSF leakage following mild head or neck injury is recently highlighted in our society as a cause of persistent post-traumatic headache and other miscellaneous complaints which had been formerly regarded as whiplash-associated disorder, post-traumatic syndrome, or Barre-Lieou syndrome.[5–7] Patients with post-traumatic CSF leakage diagnosed by radionuclide cisternography have been increasing in number; however, a discrepancy in clinical presentation between spontaneous and post-traumatic CSF leakage has also been elucidated.[8,9] Why do patients with post-traumatic CSF leakage not show low CSF pressure or MRI findings typical to CSF leakage syndrome? Why are their symptoms resistant to repeated epidural blood patch (EBP) treatment, in contrast to spontaneous CSF leakage which responds well to single EBP? These may mainly be explainable as consequences of persisting CSF fistula and unknown compensatory reactions against this; however, overestimation of CSF leakage by radionuclide cisternography may not be negligible in some. While the usefulness of radiological examinations for CSF leakage has been emphasized, very limited information has been documented in the literature about technical failure in radionuclide cisternography. We experienced 3 cases in which the tracer was thought to be unsuccessfully injected into the epidural space during evaluation of CSF leakage.

Received December 8, 2005, revision accepted March 15, 2006.

For reprint contact: Toru Horikoshi, M.D., Ph.D., Department of Neurosurgery, Faculty of Medicine, University of Yamanashi, 1110 Shimokato, Chuo, Yamanashi 409–3898, JAPAN.

CASE REPORT

Patient 1

A 34-year-old man complaining of chronic headache

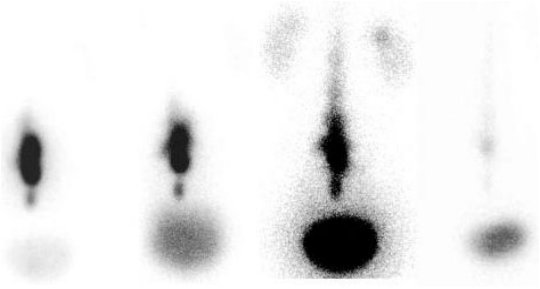

Fig. 1 Radionuclide cisternogram of Patient 1 obtained 30 min (*left most*), 1 (*left*), 3 (*right*), and 6 hours (*right most*) after injection. Irregular serrate-shaped accumulation and ascent of the tracer to the lower thoracic level were seen. The tracer had nearly disappeared at 6 hours and the bladder was densely delineated at 3 hours.

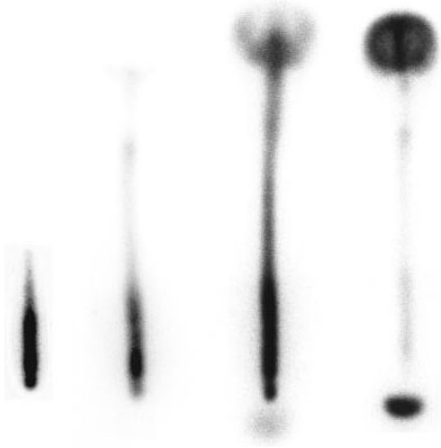

Fig. 2 Radionuclide cisternogram of Patient 1 obtained at our institute at immediately (*left most*), 1 (*left*), 5 (*right*), and 24 hours (*right most*) after injection. Rod-shaped appearance consistent with shape of the dural sac was seen. The bladder was not visualized at 1 hour, but vaguely at 5 hours. A considerable amount of the tracer still remained even at 24 hours after injection.

lasting for more than twenty years consulted to our institute to reevaluate CSF leakage headache which was diagnosed by radionuclide cisternography performed at another hospital several months before. The images were obtained 30 min, 1, 3, 6, 24 hours after injection. Irregular accumulation of the tracer was densely shown at the puncture site and the tracer vaguely diffused with a Christmas tree shape along the spinal axis up to the lower thoracic level (Fig. 1). The tracer was rapidly excreted in the urinary bladder and nearly disappeared from the CSF space within 6 h. Radionuclide cisternography was performed again in our institute, because MRI of the brain showed equivocal sagging of the cerebellar tonsils and narrowing of the prepontine cistern. Radionuclide cisternography with 37 MBq of ^{111}In-diethylenetriamine

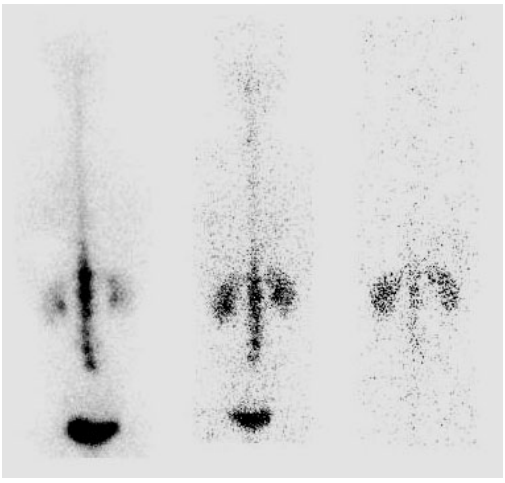

Fig. 3 Radionuclide cisternogram of Patient 2. Whole body images were obtained 2 (*left*), 6 (*center*), and 24 hours (*right*) after injection. Serrate-shaped appearance was seen in the lumbar and thoracic spinal axis. The urinary bladder was visualized densely at 2 hours, and the tracer was mostly disappeared without reaching the cranial cavity by 24 hours.

pentaacetic acid was performed. Antero-posterior and postero-anterior whole-body planar scintigraphic images were obtained with a single headed gamma camera (GCA7100, Toshiba Co. Ltd. Tokyo) immediately after and at 1, 5, and 24 hours after injection. CSF opening pressure was 110 mmH_2O, and tracer was successfully injected. The tracer diffused with time in the shape of the dural sac, and no early excretion into the bladder was found (Fig. 2). Tracer activity was counted in the range of the whole CSF space and ratio against initial value was calculated. To reduce an effect of different attenuation due to bone and soft tissue around the bladder and the CSF space, geometric mean counts of the two-direction images were used after correcting for radioactive decay of the tracer. More than 90% of tracer remained at 5 hours after injection. CSF leakage could not be proved, and the results of the former study were thought to be false due to injection into the epidural space.

Patient 2

A 34-year-old woman suffering from severe orthostatic headache was admitted to an affiliated hospital and was diagnosed as having low CSF pressure headache, since typical findings of intracranial hypotension including diffuse dural enhancement and sagging of the brain were delineated on MRI. To determine the leakage point, radionuclide cisternography was performed. CSF open pressure was negative, and the tracer was injected after confirming reflux of fluid into the syringe. Similarly to the images described above, sizable accumulation of the tracer in the urinary bladder already appeared at 2 hours after injection and a small amount of tracer ascent with time along the spinal axis with serrate-shape accumula-

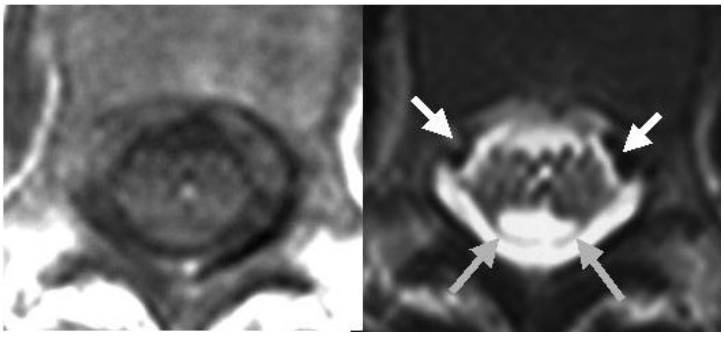

Fig. 4 T1 (*left*) and T2 (*right*) weighted images in the lumbar spine of Patient 2 obtained before Radionuclide cisternography. Dural sac (*gray arrows*) is surrounded by epidural fluid collection and engorgement of the epidural venous plexus (*white arrows*). A crowd of the nerve roots and the cauda equina are seen inside the compacted dural sac.

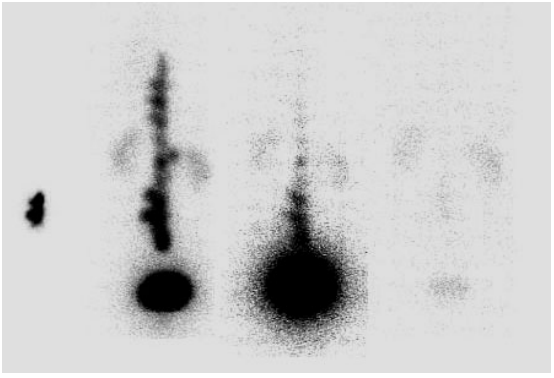

Fig. 5 Radionuclide cisternogram of Patient 3 obtained immediately after (*left most*), 1 (*left*), 5 (*right*) and 24 hours (*right most*) after injection. Serrate-shaped accumulation of the tracer was seen in the lumbar to mid-thoracic spine and disappeared rapidly at 5 hours. The bladder was densely visualized even at 1 hour.

tion, which did not reach the intracranial cisterns (Fig. 3). At first, the extradural tracer accumulation had been regarded as a result of leakage from the dural sac. However, this appearance was strange, compared to those in reported as well as experienced cases with CSF leakage. Considering massive accumulation of fluid in the spinal epidural space and compaction of the dural sac and nerve roots shown on spinal MRI which was obtained before radionuclide cisternography (Fig. 4), the tracer seemed to be injected into the leaked fluid accumulated in the epidural space. Based on the clinical and MRI findings, the patient was diagnosed as having a CSF leakage and epidural blood patch (EBP) was attempted. After the treatment and bed-rest of several days, her symptoms completely resolved.

Patient 3

A 38-year-old man had suffered from vertigo and general fatigue for more than eight years, before consulting our institute. He had no headache or MRI abnormalities of the brain, but radionuclide cisternography was challenged because of his posture-related symptoms. CSF pressure was 75 mmH_2O, and the tracer was injected. However, reflux of fluid into the syringe became poor during the procedure, and no more reflux was observed after injection. Initial cisternographic image immediately after injection showed tracer accumulation in irregular shape which was inconsistent with shape of the dural sac. The tracer extended longitudinally up to the mid-thoracic level, but rapidly excreted into the urine (Fig. 5). Relative tracer activity at 5 hours against initial value was only 13%. The tracer seemed to have been injected outside of the CSF space.

DISCUSSION

Radionuclide cisternography has been used to visualize abnormal CSF kinetics in the cranium as seen in hydrocephalus or CSF leakage through a skull base defect or fracture. In contrast, description of normal/abnormal kinetics of tracer in the spine, especially in cases with injection failure, has been limited. Larson et al. classified the scan appearance of injection failure into three patterns: Christmas tree pattern interpreted as epidural injection, railroad truck pattern as subdural injection, and midline pattern representing tracer injected into the soft tissue.[10] Kawaguchi et al. reported that erroneous radionuclide cisternographic findings are not rare.[11] They found 6 cases of injection failure among 34 patients in whom spinal images immediately after injection were obtained. Five other cases showed overt or equivocal signs of extradural reflux at the site of dural puncture.

In our study, Patient 1 and probably Patient 3 represent typical tracer distribution of false injection into the lumbar epidural space without epidural CSF collection. Even in such instances, tracer extended within a few hours longitudinally up to the lower to mid-thoracic level with serrate-shape appearance similarly to Patient 2, probably

by simple diffusion and absorption through lymph in the epidural space. To determine an inadequate injection in these cases, lumbar images obtained immediately after injection were useful. When tracer is adequately injected, a straight column of activity consistent with the shape of the dural sac and gradual ascent with time along the dural sac can be observed (Fig. 2).

In Patient 2, considerable amount of epidural CSF fluid collection was shown on MRI. The dural sac was compressed by the surrounding fluid, with a crowd of the nerve roots inside, and it seemed rather difficult to insert a needle in the subarachnoid space without causing root pain. In contrast to reported cases in literature,[3,12–15] this case showed an exceptional serrate-shaped distribution of tracer, and early disappearance. If tracer had been injected appropriately in the subarachnoid space, it would not have disappeared in such a short time, even though there might have been a massive leakage. Therefore, we speculated that the tracer was injected into the epidural fluid, although no image immediately after injection was obtained. The tracer might diffuse rapidly along a free fluid in the epidural space and connecting space around the nerve roots, and consequently, a serrate-shaped accumulation appeared on the images. Accumulation of tracer along nerve roots has been recognized as a sign of CSF leakage;[7] however, multilevel serrate-shaped accumulation around the injection site would suggest an injection failure. Abnormal fluid collection outside of the dural sac as well as negative CSF pressure as seen in this case can induce such technical failure. It may be difficult to avoid the error in spite of careful procedure; however, physicians should be aware of this failure especially when extradural fluid collection is confirmed on MRI.

All the three cases showed rapid disappearance of the tracer within 5–6 hours after injection. In Patient 1 and 3, ratio of tracer activity in the whole CSF space against those of initial image was counted. In Patient 3, tracer activity in the whole spinal axis decreased to 13% of the initial value at 5 hours; in contrast, it remained at more than 90% at 5 hours in the normal subject (Patient 1). In our experience of other cases with overt CSF leakage, at least 50% of tracer activity in the whole CSF space remained at 5 hours.[9] Accelerated clearance of tracer may be strong evidence of inappropriate injection.

In conclusion, the potential for epidural injection as well as iatrogenic CSF leakage through a pin-hole on the dural sac caused by needle insertion remains a hindrance in the analysis of radionuclide cisternography.[16] Since tracer injected into the epidural space shows extension along the spinal axis and nerve roots, attention must be paid to interpretation of images. A fluid collection outside of the dura attributed to CSF leakage may also induce the failure. Rapid disappearance of tracer from the body within several hours strongly suggests such failure.

REFERENCES

1. Schievink WI, Maya MM, Moser FG, Tourje J. Spectrum of subdural fluid collection in spontaneous intracranial hypotension. *J Neurosurg* 2005; 103: 608–613.
2. Fitzek S, Smesny S, Fitzek C, Axer H, Wohlfarth M, Vieweg U, et al. Organic bipolar disorder occurring together with spontaneous intracranial hypotension. *Psychiatry Res* 2004; 131: 177–183.
3. Schievink WI. Misdiagnosis of spontaneous intracranial hypotension. *Arch Neurol* 2003; 60: 1713–1718.
4. Ferrante E, Savino A. Nonpostural headache by spontaneous intracranial hypotension. *Headache* 2003; 43: 127–129.
5. Horikoshi T, Watanabe A, Hashizume K, Hashimoto K, Nukui H, Umeda T. Two cases of whiplash associated syndrome successfully treated with lumbar epidural blood patch. *Yamanashi Med J* 2003; 18: 61–65. (Japanese)
6. Shinonaga M, Suzuki S. Diagnosis and treatment of traumatic intracranial hypotension (cerebrospinal fluid hypovolemia). *Neurotraumatology* 2003; 26: 98–102. (Japanese)
7. Moriyama E, Ogawa T, Nishida A, Ishikawa S, Beck H. Quantitative analysis of radioisotope cisternography in the diagnosis of intracranial hypotension. *J Neurosurg* 2004; 101: 421–426.
8. Horikoshi T, Uchida M, Watanabe A, Ikegawa H, Umeda T. Jugular compression and radionuclide cisternographic patterns in patients with chronic headache. *Headache* 2006; 46: 150–157.
9. Horikoshi T, Ikegawa H, Uchida M, Takahashi T, Watanabe A, Umeda T. Tracer clearance in radionuclide cisternography in patients with spontaneous intracranial hypotension. *Cepahlalgia* 2006; 26: (in press)
10. Larson S, Schall GL, Di Chiro G. The unsuccessful injection in cisternography: incidence, cause and appearance. In Harbert JC, ed. *Cisternography and hydrocephalus*. Springfield, Illinois; Charles C Thomas, 1972: 153–160.
11. Kawaguchi S, Iio M, Chiba K, Murata H, Matui K, Yamada H, et al. Study of unsuccessful cases of cisternography. *KAKU IGAKU (Jpn J Nucl Med)* 1977; 14: 243–253. (Japanese)
12. Bai J, Yokoyama K, Kinuya S, Konishi S, Michigishi T, Tonami N. Radionuclide cisternography in intracranial hypotension. *Ann Nucl Med* 2002; 16: 75–78.
13. Schievink WI, Meyer FB, Atkinson JLD, Mokri B. Spontaneous spinal cerebrospinal fluid leaks and intracranial hypotension. *J Neurosurg* 1996; 84: 598–605.
14. Sugino T, Matsusaka Y, Mitsuhashi Y, Murata K, Sakaguchi M. Intracranial hypotension due to cerebrospinal fluid leakage detected by radioisotope cisternography. *Neurol Med Chir* 2000; 40: 404–407.
15. Nowak D, Rodiek SO, Zinner J, Guhlmann A, Topka H. Broadening the clinical spectrum: unusual presentation of spontaneous cerebrospinal fluid hypovolemia. *J Neurosurg* 2003; 98: 903–907.
16. Takahashi M, Momose T, Kameyama M, Mizuno S, Kumakura Y, Ohtomo K. Detection of cerebrospinal fluid leakage in intracranial hypotension with radionuclide cisternography and blood activity monitoring. *Ann Nucl Med* 2005; 19: 339–343.