sis of the spontaneous CSF leakage. EBP treatment is effective in the majority of the patients with spontaneous CSF leakage.

Key words: ^{111}In-DTPA radionuclide cisternography, cerebrospinal fluid leakage, epidural blood patch

INTRODUCTION

Spontaneous leakage of CSF is focused as a cause of orthostatic headache in the last decade[5,8]. The condition is caused by minor head injury of many causes and may disturb patient's daily life. This report summarizes our experiences of 91 patients with spontaneous leakage of CSF, which was confirmed by radionuclide cisternography and treated with injection of autologous blood to the spinal epidural space (EBP treatment). This report is focused on overall results of epidural blood patch treatment along with findings of radionuclide cisternography.

MATERIALS AND METHODS

During last two years from May 2004 to September 2006, we have experienced 131 cases of possible CSF leakage from spinal dura according to the symptoms and MRI findings (Table 1). Possible causes of injury in 131 suspected cases subjected to radionuclide cisternography were summarized as traffic accident in 53% and other head injury in 18%, but 26% could not identify any causes (Table 2). These patients were admitted in the Nagoya City University Hospital and subjected to radionuclide cisternography using 37 MBq ^{111}In-DTPA. For measurement of CSF pressure and injection of radioactive materials, we used 25-gauge lumbar nee-

TABLE 1. Clinical experience of Patients with Spontaneous leakage of CSF

Cases	No of patient
Total cases studied	131
Positive findings for CSF leakage	95 (72.5% of total study)
Male	44
Female	51
Opening CSF pressure in cisternography-proven cases	
CSF hypotension (<60 mmH_2O)	9 (9.5% of total CSF leakage)
CSF normotension (60-200 mmH_2O)	86*

*Mean opening pressure was 132 mmH_2O.

TABLE 2. Total cases studied and cisternography-positive CSF leakage patients

Cause of CSF leakage	Suspected cases	Cisternography-positive cases
Head injury	93 (71%)	67 (71%)
Traffic accident	69 (53%)	47 (50%)
Other causes	24 (18%)	20 (21%)
Unknown	34 (26%)	26 (27%)
Delivery	1	1
Meningitis	2	1
Post lumbar puncture	1	0
Total	131	95

dle with Lancet point to avoid CSF leakage from puncture site. Images were obtained at 1, 2.5, 6 and 24 hours in supine position after injection. Whole body anterior and posterior images were taken using a dual-headed gamma camera (e.cam, SIEMENS) equipped with an intermediate-energy collimator at a speed of 10 cm/min. In addition, multislice single photon emission computed tomographic (SPECT) images of the whole body were obtained for detection of leakage from the puncture hole.

If patients had CSF leakage from spinal dura, epidural injection of autologous blood (epidural blood patch) was done to seal the leakage site. The blood injection was done with 17-gauge epidural injection needle, and 30-40 ml of autologous blood was carefully injected. If patients complained of pain, injection was held until pain was subsiding or ceased. If the leakage site was multiple, divided amount of autologous blood was injected in each site. The procedure was repeated every several months, if symptoms were not improving. Injection was repeated up to three times, and if symptoms lasted, we estimated as failure of the treatment. In 31 cases, radionuclide cisternography was repeated immediately before third epidural injection for evaluating efficacy of epidural blood patch treatment. Effect of treatment was evaluated subjectively and objectively and divided into effective, partly effective, and ineffective.

RESULTS

Summary of radionuclide cisternography-positive patients

Among 131 possible CSF leakage patients, 95 cases (72.5%) showed definite CSF leakage in the radionuclide cisternography (Table 1). Male and female were equally distributed. Intracranial pressure at the time of radionuclide cisternography was summarized in Table 1.

Only 9.5% of the radionuclide cisternography-positive CSF leakage patients showed low intracranial pressure (less than 60 mmH_2O), and other 90.5% showed normal CSF pressure. Mean opening pressure of 88 patients with normal pressure group was 132 mmH_2O.

Possible causes for CSF leakage for radionuclide cisternography-positive patients

Possible causes of CSF leakage in radionuclide cisternography-positive 95 cases were listed in Table 2. The radionuclide cisternography-proven cases had less ratio of traffic accident (50%) as compared to the suspected-cases (53%), and the ratio of other causes of head injury was increased from 18% to 21%, though there was no statistical significance (Table 2).

Site of CSF leakage

The most common site of leakage was lumbar area (41.1%). If we added combined area including lumbar area, 76.9% of total cases showed leakage at lumbar area (Table 3). We tried to identify any differences of leakage sites between low pressure group and normal pressure group, but we could not find any difference in those two groups.

Result of epidural blood patch treatment

We did epidural blood patch treatment in 91 patients among 95 patients with radionuclide cisternography-positive CSF leakage. The treatment was repeated up to 3 times if needed. Total 215 procedures were done in 91 patients, among which 80 cases were evaluated for the effect of EBP treatment (Table 4). The effect of treatment was evaluated subjectively and objectively from the medical record. Among those, 23.5% of the patients were evaluated as

TABLE 3. Site of CSF leakage proven by radionuclide cisternography.

Site of CSF leakage	No. of cases (%)
Cervico-thoracic	2 (2.1%)
Thoracic	1 (1.1%)
Thoraco-lumbar	6 (6.3%)
Thoraco-lumbo-sacral	11 (11.6%)
Lumbar	39 (41.1%)
Lumbo-sacral	17 (17.9%)
Sacral	7 (7.4%)
Undefined (early bladder filling)	12 (12.6%)
Total	95 (100%)

TABLE 4. Result of epidural blood patch treatment in 80 patients.

Result of treatment	No. of cases (%)
cure	19 (23.5%)
improving	50 (62.5%)
unchanged	11 (13.8%)
worsening	0 (0%)
total	80 (100%)

"cure", and 62.5% of the patients showed partial improvement and rated as "improving". Another 13.8% was rated as "unchanged". Notably, we did not encounter any complication or worsening with epidural blood patch treatment, though the procedure has potential risk of spinal cord and nerve root compression.

Effect of epidural blood patch on radionuclide cisternogaphy findings

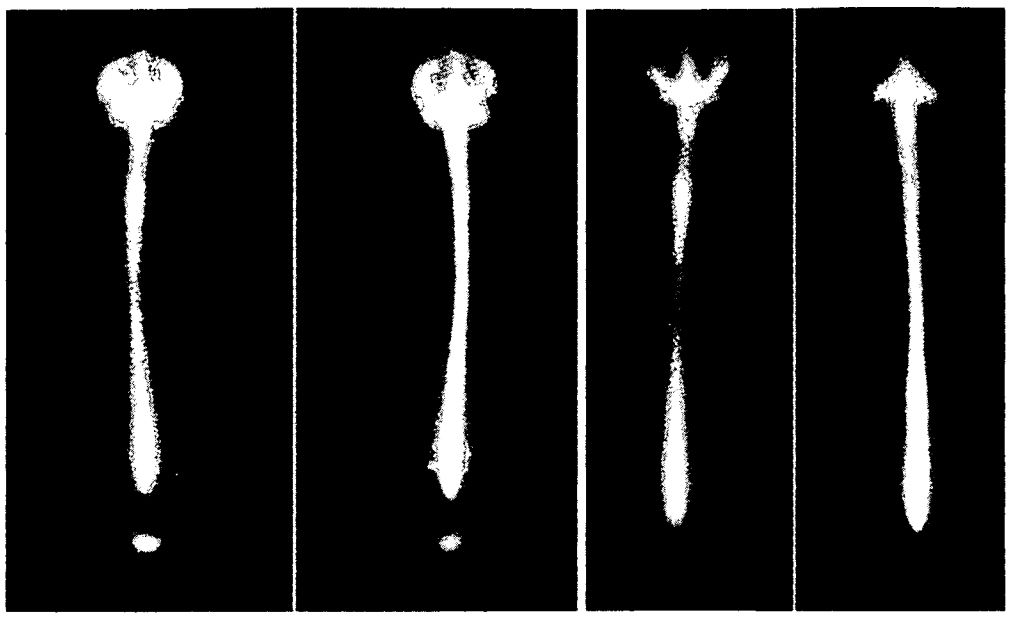
We present a typical case in which epidural blood patch ceased CSF leakage (Figure 1). The case was a 32 year-old male with typical symptoms of orthostatic headache. His radionuclide cisternography showed CSF leakage at bilateral lower lumbar nerve roots, which was completely disappearing after three times of epidural blood patch treatment. His symptoms were much improved as well.

Possible artifact of lumbar puncture on radionuclide cisternography

It is quite reasonable to suppose that lumbar puncture itself may cause CSF leakage at the site of puncture. Therefore we always take multislice single photon emission computed tomographic (SPECT) images of the whole body for exclusion of the artifact from lumbar puncture. However, we realize that leakage of radionuclide from puncture site is rather rare, because we use 25 gauge fine needles. A few but typical case of CSF leakage at the side of lumbar puncture is shown in Figure 2.

DISCUSSION

Post dural puncture headache is a well-known iatrogenic complication, and it may occasionally need surgical repair[1]. Leakage of CSF following dural puncture could be identified



A (front scanning) B (back scanning) C (front scanning) D (back scanning)

FIG. 1. Effect of epidural blood patch on radionuclide cisternography at 6 hours after radionuclide injection.

A: preblood pach front-side scanning, B: preblood patch back-side scanning

C: post 3 times of epidural blood patch treatment (font-side scanning)

D: post blood patch (back-side scanning)

Note disappearance of CSF leakage at lower lumbar nerve root.

with radioisotope cisternography[6]. Leakage of CSF was however, occurring spontaneously without any history of dural puncture. Recent review suggested the incidence of this condition might be estimated as 5 per 100, 000, with a peak around age 40 years[9].

Spontaneous CSF leaks and intracranial hypotension was published initially as a case report[7], and summarized[4,8]. Majority of those cases had postural headache as a chief complaint. They may have nausea, emesis, sixth cranial nerve paresis or local back pain at the CSF leakage site[8]. The Mayo Clinic group[4] summarized diagnostic imaging of those patients, indicating diffuse pachymeningeal gadolinium enhancement and/or subdural fluid collections as a result of brain descent. They named the condition as intracranial hypotension. Among those patients, they identified other pathophysiologic entity, in which symptoms, signs and imaging study were typical for CSF hypotension, but CSF pressure was normotensive. They postulated those condition as CSF hypovolemia[3,4].

In our Institution, we experienced similar patients. The initial patient we experienced was a typical CSF hypotension case, which had diffuse pachymeningeal enhancement and chronic

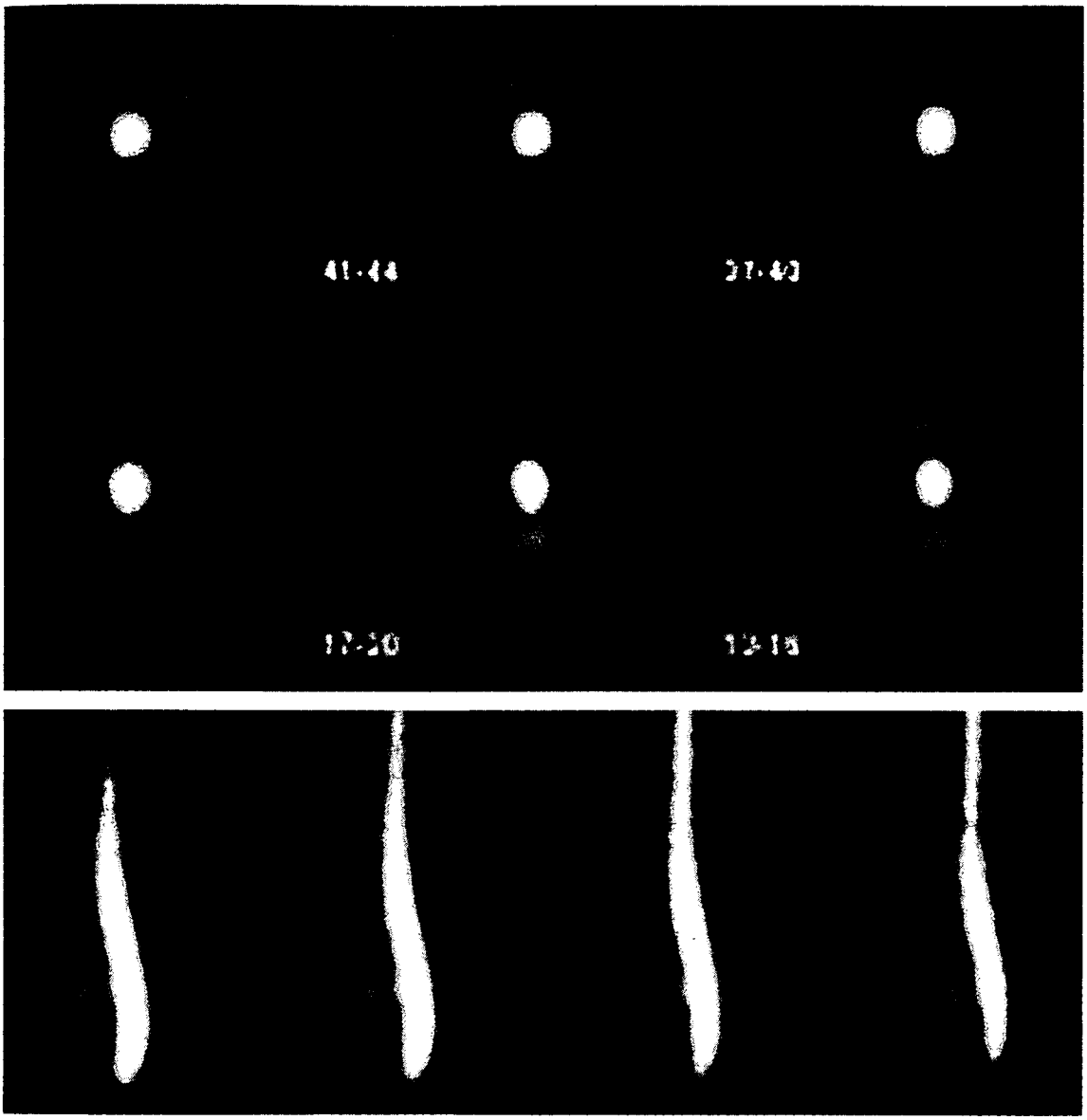


FIG. 2. CSF leakage caused by lumbar puncture.
Transverse scan (top) and sagittal scan (bottom)
Scan was done at 2.5 hours after lumbar puncture. Note CSF leakage at the midline of lower lumbar area and leaked radionuclide material was located at the midline and posterior of the lumbar subarachnoid space. The findings are most probably caused by leakage at puncture hole.

subdural hematoma in both hemispheres. The case showed definite CSF leakage at cervical spine and successfully treated with epidural blood patch treatment (unpublished experience). Thereafter, many referrals were encountered in our Institution, and this report summarizes our experience of 91 cases with CSF hypovolemia. Similar to the Mayo Clinic Experience, major-

ity of the patients showed normotensive CSF pressure, though they showed typical orthostatic headache, and radionuclide cisternography revealed definite CSF leakage. Only 9.5% showed CSF hypotension (opening pressure less than 60 mmH_2O). It is possible to speculate compensatory mechanism such as overproduction of CSF against CSF leakage.

There are several studies for diagnosis of CSF leakage. MRI with gadolinium enhancement was the non-invasive mode of diagnosis. However, sensitivity of the diagnosis was not high. There are many patients in which CSF leakage was present without dural gadolinium enhancement. Descent of the brain on MRI was not a definite diagnostic criteria as well. We therefore relayed on radionuclide cisternography. If radionuclide cisternography showed definite CSF leakage from spinal dura and patient desired treatment, we did blood patch treatment.

Among 131 cases suspected for CSF leakage, 72.5% showed definite CSF leakage (Table 1). This was rather high incidence, which is because of high amount of referrals, and rather strict selection at the outpatient clinic. Indeed, only about half of the referrals were selected as possible CSF leakage patients, and 72.5% of patients performed radionuclide cisternography showed definite leakage. Therefore only around 35% of the total referrals were positive for CSF leakage. Moriyama et al[5] reported that among 57 patients studied, 25 (44%) showed definite CSF leakage from spinal dura. This is similar to our experience as around 35% of the total referrals were radionuclide cisternography-positive patients. The site of leakage was mainly lumbosacral area, which was similarly experienced by Moriyama et al[5].

The main concern about radionuclide cisternography was artifact or false positive findings. The lumbar puncture itself may cause CSF leakage from puncture site. For avoiding this complication, we used 25-gauge needle, by which leakage from puncture site could be minimized. We always take SPECT images for delineation of leakage from puncture site. Example of CSF leakage from puncture hole could be identified (Figure 2), and the appearance of scan picture was quite different from leakage from root sleeve. Inappropriate injection of radionuclide to epidural or subdural space is another possibility as reported by Horikoshi et al[2]. We encountered a few cases in which epidural or subdural injections of the radionuclide were speculated. We repeated the radionuclide cisternography in the different day by which we could exclude this possibility. The other possibility was multiple perineural cysts, which may show similar radionuclide cisternography pattern at lumbosacral area. We were always careful about this possibility and we always check MRI findings at lumbosacral area. Early filling of bladder by radionuclide cisternography is another point of view. However, we do not rely on this finding because early filling of the bladder is observed in the case with leakage from punc-

ture site.

The effect of epidural blood patch treatment was a point of argues. In our experience, 23.5% showed "cure" of the symptoms, and 62.5% showed some improvement in their symptoms, though it varies from definite to mild improvement. The ineffective group was only 14.0%. The effect of treatment was mainly evaluated subjectively and partly objectively with radionuclide cisternography. The subjective observation such as blinded observation should be conducted under scientific basis, and we realize this. Further study including long term effect of epidural blood patch is on the way and will be published elsewhere. It is remarkable to note that there is no worsening of the symptoms by epidural blood patch treatment, because we carefully introduce epidural needle under fluoroscopic control and inject blood. It is still controversial about disease entity of spontaneous CSF leakage and effect of epidural blood patch treatment. Therefore, we are careful about diagnosis and treatment of this syndrome.

CONCLUSIONS

Radionuclide cisternography using ^{111}In-DTPA is useful for diagnosis of the spontaneous CSF leakage. EBP treatment for patients with spontaneous CSF leakage is effective in the majority of the cases.

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