Targeted Epidural Blood Patch Under O-Arm–Guided Stereotactic Navigation in Patients with Intracranial Hypotension Associated with a Spinal Cerebrospinal Fluid Leak and Ventral Dural Defect

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■ OBJECTIVE: **Targeted epidural blood patch (EBP) at the site of a presumed cerebrospinal fluid leak reportedly has better outcomes than non-targeted EBP; however, it is associated with a higher risk of wrong-site injection, such as iatrogenic subarachnoid or intramuscular injections, which lead to reintervention because of the insufficient coverage of injected blood.**

■ METHODS: **Eight patients with intracranial hypotension owing to a CSF leak diagnosed with myelographic computed tomography (CT) and thin-cut magnetic resonance imaging (MRI) received an epidural blood patch under O-arm–guided stereotactic navigation.**

■ RESULTS: **The leak site was identified on the basis of myelographic CT findings of a micro-spur, epidural contrast medium extravasations, and MRI findings of a ventral dural defect. During the EBP procedure, no iatrogenic dural puncture or subarachnoid injection occurred because O-arm–guided stereotactic navigation provided real-time feedback on the needle trajectory. O-arm CT revealed the sufficient coverage of injected blood following the first injection in 6 of 8 patients. In the 2 remaining patients, a second injection was performed during the same session because of insufficient coverage at the previous site. In all patients, complete recovery from orthostatic headaches was achieved after a single session.**

■ CONCLUSIONS: **O-arm–guided navigation facilitated EBP by enabling real-time observations of the needle trajectory and distribution of injected blood while simultaneously avoiding major complications, such as wrong-site injections or reintervention.**

INTRODUCTION

Intracranial hypotension is a condition in which cerebrospinal fluid (CSF) leaks from the subarachnoid space into the epidural space.[1] Spinal dural defects and meningeal diverticula are the two most common entities associated with the dural pathology.[2] The epidural blood patch (EBP) at a nontargeted lumbar level was originally introduced as the treatment of choice for intracranial hypotension caused by a spinal CSF leak.[3,4] Targeted EBP at the site of a presumed leak on myelographic computed tomography (CT) or magnetic resonance imaging (MRI) has recently been reported to achieve better outcomes than nontargeted EBP.[5-8] However, this procedure is associated with a higher risk of wrong-site injections.[7,9,10] Real-time tracking of the needle tip is critical in the EBP procedure. Although targeted EBP under fluoroscopic guidance has been performed, it does not provide sufficient information on the needle trajectory or spine, particularly at the upper thoracic levels because the shoulder joint decreases image quality.[7,10] The O-arm has been introduced for neuronavigation in the field of spine fixation surgery for the intraoperative confirmation of screw trajectory and has become widespread as an alternative to fluoroscopy.[11-13] Therefore, we attempted to use O-arm–guided navigation for the intraoperative confirmation of needle trajectory to obviate major complications, such as wrong-site injections and reintervention. This study aimed to describe the use of

Key words
- Cerebrospinal fluid hypovolemia
- Computed tomography-myelography
- Disc herniation
- Epidural blood patch
- Osteophyte

Abbreviations and Acronyms
CSF: Cerebrospinal fluid
CT: Computed tomography
EBP: Epidural blood patch
MRI: Magnetic resonance imaging

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Table 1. Radiologic Findings and Clinical Outcomes After Targeted Epidural Blood Patch in Patients with a Spinal CSF Leak

Patient Number	Age (years)	Sex	Symptoms	Intracranial Pressure (mm H_2O)	Micro-spur on CT	Presumed Dural Defect on MRI	Targeted EBP (Number of Injections)	Amount of Blood Injected (mL)
1	21	Female	OH, neck pain, vomiting	1	C7/T1	C7/T1	T3/4 (1)	24
2	40	Female	OH, vomiting, ear fullness	0	C7/T1, T1/2	T1/2	T2/3 (1)	4
3	41	Female	OH, vomiting, ear fullness, hearing disturbance	0	T1/2	ND	T1/2 (1)	25
4	33	Female	OH, vomiting	3	T1/2	T1/2	T2/3 (1)	25
5	46	Male	OH, vomiting, tinnitus	10	T1/2, T2/3	ND	T3/4 (2)	20, 15
6	30	Female	OH, vomiting, ear fullness, tinnitus	3	T2/3	T2/3	T3/4 (1)	25
7	34	Female	OH, back pain, vomiting, ear fullness,	2	T2/3	ND	T4/5 (2)	20, 20
8	31	Female	OH, vomiting	6	T1/2	ND	T1/2 (1)	18

CT, computed tomography; MRI, magnetic resonance imaging; EBP, epidural blood patch; OH, orthostatic headache.

O-arm–guided stereotactic navigation for targeted EBP placement and patient outcomes.

METHODS

This study protocol was approved by the Institutional Review Board at the Tokyo Metropolitan Neurological Hospital. All patients gave full written informed consent for O-arm–guided EBP with general anesthesia. Regarding study participation, written patient informed consent was not obtained because this study was retrospective. A public notice that provided information on this study was instead given on the Tokyo Metropolitan Neurological Hospital website.

Patient Population

Participants were 8 consecutive patients (mean age, 35 years; range, 21–46 years; male:female ratio = 1:7) with orthostatic headaches and a diagnosis of intracranial hypotension owing to a spinal CSF leak. Intracranial hypotension was diagnosed with MRI, which disclosed typical findings such as diffuse thickening of the dura mater, downward displacement of the cerebellar tonsilla, and bilateral chronic subdural hematomas. A spinal CSF leak was diagnosed with CT myelography and fast imaging employing steady-state MRI. The potential leak site was identified on the basis of three findings: the presence of a calcified or ossified micro-spur around the dural sac, the presence of a dural defect around the spur, and epidural contrast medium extravasations.

Targeted EBP Under O-Arm–Guided Stereotactic Navigation

Under general anesthesia, the patient was placed in the prone position on the X-ray fluoroscopic operation table (Allen Spinal System; Allen Medical Systems, Acton, Massachusetts, USA) and the head was fixed with a 3-point Mayfield head holder. A reference array was attached to the Mayfield holder. The O-arm was positioned to observe the potential leak site. Under O-arm–guided stereotactic navigation, a 17-gauge spinal needle with the Suretrak locating device (Medtronic, Minneapolis, Minnesota, USA) was inserted at the site of the suspected CSF leak. In our case series, blood was injected into the dorsal epidural space with the patient in the prone position, which facilitates blood spreading over the ventral epidural space. A loss of resistance with the air technique was used, and a small amount of air in the epidural space was confirmed with O-arm CT. A 4:1 ratio of autologous blood and contrast medium was injected. The distribution of injected blood was then confirmed with O-arm CT. To reduce radiation exposure, the patient's thyroid and hip were covered with a radiation protector, and the operator left the room during image acquisition. Radiation exposure was measured using badge dosimeters (PMD-117; Aloka, Tokyo, Japan) to monitor the thyroid and torso in the last 2 patients. Dosimeters were attached to the inside of the thyroid protector and the outside of the torso at the level of T10.

Data Analysis

The following clinical and radiographic data were analyzed: patients' symptoms, intracranial pressure measured via lumbar puncture, the presence of a micro-spur around the dural sac on CT, the presence of a dural defect around the spur on MRI, targeted spinal levels of EBP, the amount of blood injected, the presence of chronic subdural hematomas, and radiation exposure. The clinical outcomes of orthostatic headaches and other symptoms were assessed before EBP, 1 and 6 months after EBP, and at the final follow-up visit. The work status of patients (full-time work, part-time work, or unemployed) was assessed before the onset of orthostatic headaches, before EBP, 1 month after EBP, and at the final follow-up visit.

RESULTS

Symptoms Associated with Intracranial Hypotension

Patients reported the following symptoms: severe orthostatic headaches (100% of patients); neck and back pain (38%); nausea