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Case Report

Paradoxical Transtentorial Herniation Caused by Lumbar Puncture after Decompressive Craniectomy

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Although decompressive craniectomy is an effective treatment for various situations of increased intracranial pressure, it may be accompanied by several complications. Paradoxical herniation is known as a rare complication of lumbar puncture in patients with decompressive craniectomy. A 38-year-old man underwent decompressive craniectomy for severe brain swelling. He remained neurologically stable for five weeks, but then showed mental deterioration right after a lumbar puncture which was performed to rule out meningitis. A brain computed tomographic scan revealed a marked midline shift. The patient responded to the Trendelenburg position and intravenous fluids, and he achieved full neurologic recovery after successive cranioplasty. The authors discuss the possible mechanism of this rare case with a review of the literature.

Key Words : Paradoxical herniation · Decompressive craniectomy · Lumbar puncture · Cranioplasty.

INTRODUCTION

Decompressive craniectomy is widely performed to reduce uncontrollable intracranial pressure (ICP) which is difficult to treat by medical management alone[5]. However, patients who undergo decompressive craniectomy may develop an unusual paradoxical herniation[1,4]. To date, only a few cases of paradoxical herniation have been reported, and to our knowledge, only one report on paradoxical herniation after decompressive craniectomy for traumatic brain injury has been issued in Korea[3]. In that case, however, it was not related to lumbar puncture. Measures are needed to raise intracranial pressure against the forces generated by atmospheric pressure and herniation. Here, we present an uncommon case of paradoxical transtentorial herniation after lumbar puncture, which was reversed by the Trendelenburg position and sufficient hydration.

CASE REPORT

A 38-year-old man was presented with mental deterioration after head injury. Two hours after the accident, he became stuporous with Glasgow Coma Scale of 9. Brain computed tomography (CT) revealed a hemorrhagic contusion in the right frontotemporoparietal region and acute epidural hematoma in the left temporo-occipital region (Fig. 1). Routine laboratory tests, which included platelet count, prothrombin time, and activated partial thromboplastin time were within normal limits. He has not taken any antiplatelet agents prior to the injury. The patient underwent emergent decompressive craniectomy on right frontotemporoparietal region, followed by craniotomy for removal of epidural hematoma on the left side (Fig. 2). Postoperatively, he became conscious and was able to obey commands without any neurologic deficit. Five weeks later, he complained of a febrile sensation and had fever by 38.0°C. Brain CT scan showed no midline shift (Fig. 3). Furthermore, his WBC count was increased to 11500/mL and erythrocyte sedimentation rate to 48 mm/hr. Lumbar puncture was performed to rule out pyogenic meningitis. He underwent an uncomplicated lumbar puncture with an 18-gauge spinal needle followed by the drainage of only 20 mL CSF. The opening pressure was 14 cmH_2O without evidence of pyogenic meningitis. CSF analysis revealed 4 WBC cells/mm^3 with glucose level of 50 mg/dL. After lumbar puncture, he complained of severe headache and dizziness. Two days later he was found to be deeply drowsy with left hemiparesis to the extent of having difficulty to obey commands. A brain CT showed marked herniation to the left (Fig. 4). Under the diag-

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nosis of paradoxical transtentorial herniation, he was placed in the Trendelenburg position and sufficient hydration was given intravenously. After the conservative treatment alone, he recovered gradually over a week. By then, he was able to obey commands and showed alert consciousness. Follow-up brain CT revealed resolution of the midline shift (Fig. 5). Cranioplasty was performed 4 months after the head injury and brain CT after cranioplasty showed complete resolution of the shift (Fig. 6).

DISCUSSION

The indications of decompressive craniectomy are expand-

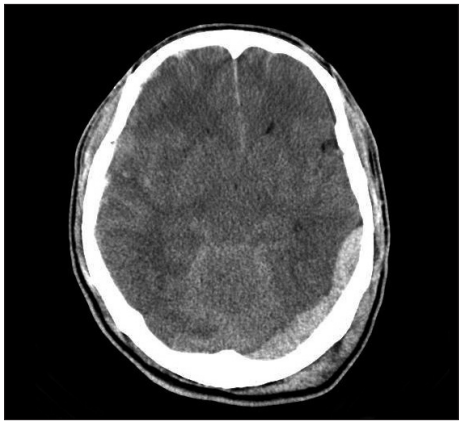

Fig. 1. Initial computed tomography scan shows hemorrhagic contusion in the right fronto-temporo-parietal region with severe brain swelling and epidural hematoma in the left temporo-occipital region.

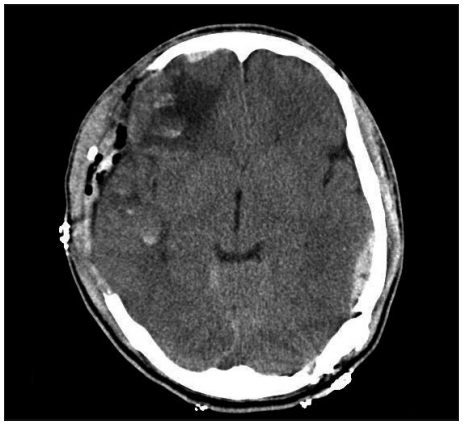

Fig. 2. After emergent right fronto-temporo-parietal craniectomy operation, brain computed tomographic scan shows the removal of epidural hematoma and improvement of brain swelling.

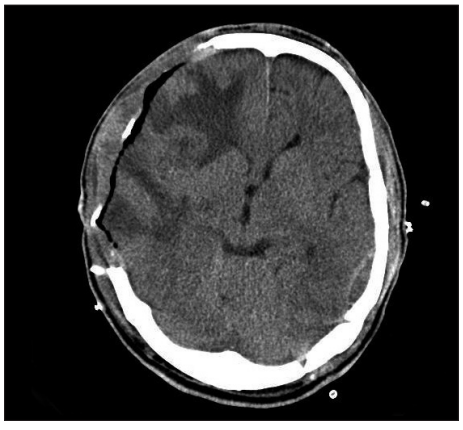

Fig. 3. Computed tomographic scan taken five weeks postoperatively and just before lumbar puncture shows no midline shift.

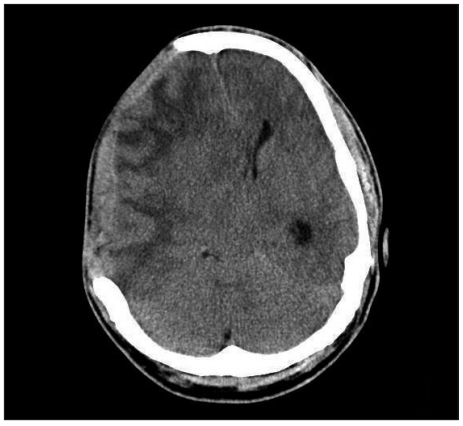

Fig. 4. Brain computed tomographic scan after lumbar puncture reveals midline shift to the left and transtentorial herniation.

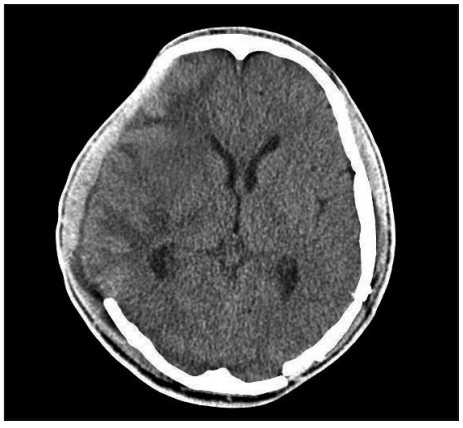

Fig. 5. Brain computed tomographic scan after Trendelenberg position and sufficient intravenous hydration shows the restoration of the midline.

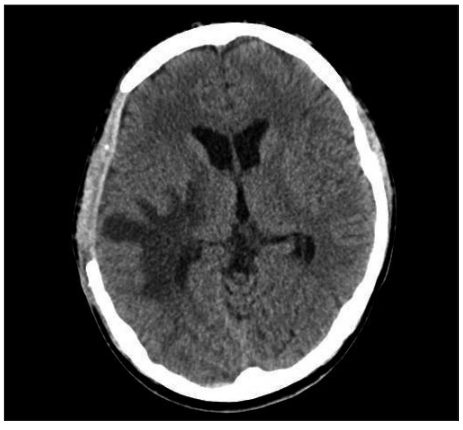

Fig. 6. Brain computed tomographic scan after cranioplasty shows complete resolution of midline shift.

ing[1]. These include traumatic brain injury with medically refractory intracranial pressures, subdural hematoma, and cerebral swelling due to vasospasm after a subarachnoid hemorrhage. Due to the fact that the cranium of the patients who have undergone craniectomy does not provide a rigid structure, the 'invisible' mass effects of atmospheric pressure and gravity can overwhelm the intracranial contents and transtentorial herniation is possible even in the absence of increased ICP[7]. Paradoxical herniation has been referred to as the herniation of a brain that has been decompressed surgically, without any extra-axial lesion that could account for the herniation[7,11]. Those treatments for lowering ICP, such as mannitol, CSF drainage, and hyperventilation, all of which follows the Monro-Kellie doctrine will exacerbate paradoxical herniation, because lowering intracranial pressure increases the pressure gradient across the craniectomy defect[6,7]. This phenomenon is related to the negative gradient between atmospheric and intracranial pressures, which can be exacerbated by an upright posture, CSF leakage, or dehydration[4]. Patients who have undergone CSF drainage, such as, external ventriculostomy, ventriculoperitoneal shunt placement, or lumbar puncture are more susceptible to this phenomenon, for these conditions can lower ICP states relatively than that of extra-cranial pressures. In these situations, the brain is sucked down through the tentorial incisural notch essentially and the foramen magnum potentially[6]. Not surprisingly, the pressure acting over the cerebral cortex may cause neurological deficits. Several authors have claimed that skull defects may create a siphon effect on CSF dynamics, which distorts the dura, underlying cerebral cortex, and venous return, due to scarring and direct pressure to the brain[2,9]. Symptoms may include focal deficits, brainstem release signs, autonomic instability, changes in level of consciousness, and pupil changes[3,4]. There are few cases of paradoxical transtentorial herniation after lumbar puncture causing negative pressure gradient between the intracranial space and the spinal canal[7,11]. Because it is exacerbated by a negative pressure gradient, its management involves eliminating the pressure gradient. In the presented case, we could obtain immediate neurological recovery by placing the patient in the Trendelenburg position and by hydrating adequately. Furthermore, cranioplasty, conceptual conversion of an 'open box' to 'closed box' can sometimes be the definitive treatment for paradoxical herniation. The striking neurological improvements observed in some cranioplasty patients with deteriorated consiousness, particularly in those with sunken scalp flaps, lead to the recognition of 'the syndrome of the trephined'[5]. Schiffer et al.[10] and Liao and Kao[6] reported that focal neurological deterioration could be improved after skull defect reconstruction in some hemicraniectomy patients. Furthermore, CT perfusion studies have found that cranioplasty can improve cerebral perfusion[8]. We successfully managed our patient by adopting the Trendelenburg position and sufficient hydration and by performing early cranioplasty. We advise that the possibility of paradoxical herniation in patients who have undergone decompressive craniectomy when lumbar puncture is performed and lumbar puncture should be carried out carefully in patients with decompressive craniectomy.

CONCLUSION

Although it has been rare, neurosurgeons should keep in mind the possibility of paradoxical herniation in patients that have undergone decompressive craniectomy whenever lumbar puncture is inevitable. We recommend that the Trendelenburg position with adequate hydration and subsequent cranioplasty should be considered as a preferential treatment option.

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