Tension Pneumocephalus as a Complication of Lumbar Drainage for Cerebral Aneurysm Surgery

—Case Report—

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Abstract

A 66-year-old man developed tension pneumocephalus after failed lumbar drainage before clipping surgery for a ruptured anterior communicating artery aneurysm. After puncture with a Tuohy needle, the spinal catheter could not be inserted into the spinal dura, so surgery proceeded without the catheter placement. The patient's neurological status deteriorated suddenly into coma within 15 hours after uneventful clipping of the aneurysm. Computed tomography revealed tension pneumocephalus with marked brain shift. Intracranial hypotension was probably caused by continuous cerebrospinal fluid leakage from the iatrogenic spinal dural tear, resulting in air entry and accumulation into the cranium from an unidentified opening of the cranial dura. The patient was immediately treated with autologous epidural blood patch administration in the lumbar spine, followed by reopening of the craniotomy incision and flap to evacuate the accumulated air. The patient made a quick and uneventful neurological recovery after the rescue procedure.

Key words: tension pneumocephalus, lumbar drainage, subarachnoid hemorrhage, epidural blood patch

Introduction

Pneumocephalus is defined as presence of air in the cranial cavity.^{2,4,6,8-11)} Pneumocephalus was originally described as an autopsy finding in a patient who died of ethmoiditis,^{6,9)} and is relatively common after cranial surgery. The small amount of residual intracranial air is usually absorbed spontaneously and seldom becomes symptomatic. In contrast, tension pneumocephalus is an accumulation of air trapped in the cranial cavity resulting in elevated intracranial pressure (ICP) and neurological deficits. Tension pneumocephalus was first reported after head trauma,^{6,9)} and a number of cases have been reported as a postoperative complication of cranial, transphenoidal, and spinal surgery.^{2,4,6,8-11)} Therefore, neurosurgeons must understand the origin and corrective procedure.

We describe a case of tension pneumocephalus that occurred after a failed attempt at lumbar drainage before cerebral aneurysm surgery.

Case Report

A previously healthy 66-year-old man suddenly suffered severe headache while driving. After a short rest, his headache subsided and he did not seek medical attention. Ten days later, his headache recurred, and he went to see a local physician. He was found to be mildly confused and was referred to our service. On examination, he showed signs of mental disorientation, with a Glasgow Coma Scale of E4V4M6. He had no other neurological deficit. Brain magnetic resonance imaging revealed a small amount of subarachnoid hemorrhage (SAH) and increased volume of the lateral ventricle (Fig. 1). Cerebral angiography revealed an anterior communicating artery aneurysm which was thought responsible for the SAH and the resultant communicating hydrocephalus. He was admitted and taken to the operating theater on the 15th day after onset.

After induction of general anesthesia, lumbar

Received April 1, 2008; Accepted March 12, 2009

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Fig. 1 Fluid-attenuated inversion recovery magnetic resonance image showing a small amount of subarachnoid hemorrhage (arrow) and increased size of the lateral ventricle.

drainage to facilitate brain retraction was attempted, which is routine for ruptured aneurysm surgery in our institution. After puncture of the spinal dura with a 14G Tuohy needle at the L4-5 interlaminar space, a good stream of cerebrospinal fluid (CSF) was noted. However, repeated attempts to advance the spinal catheter through the Tuohy needle were unsuccessful. Finally, we decided to proceed to craniotomy without catheter placement, with the expectation that the CSF leakage would cease spontaneously due to the tamponade effect of the surrounding soft tissue. He underwent standard right frontolateral craniotomy, and clipping of the aneurysm was carried out uneventfully. We thought that the frontal sinus was not violated by the craniotomy. After discontinuation of anesthesia and extubation, he could obey verbal commands and move all four extremities. He was transferred to a neurosurgical ward for postoperative care.

Fifteen hours after surgery, his conscious level deteriorated suddenly into coma, and left hemiparesis as well as dilation of the right pupil occurred. Brain computed tomography (CT) revealed a large amount of intracranial air with marked brain shift, indicating a diagnosis of tension pneumocephalus (Fig. 2). Intracranial hypotension caused by continuous CSF leakage from a spinal dural tear after the dural puncture, followed by air entry into the cranium from an unidentified opening of the cranial dura, was thought responsible for the tension pneumocephalus.

He was taken to the operating theater immediately, and an autologous epidural blood patch injection into the L4-5 interlaminar space was performed to terminate the CSF leakage. Subsequently, the

Fig. 2 Computed tomography scan showing a large amount of air with marked brain shift, indicating a diagnosis of tension pneumocephalus.

Fig. 3 Postoperative computed tomography scan showing marked reduction of the intracranial air and brain shift.

cranial incision and flap were reopened to evacuate the intracranial air. The ICP appeared to be elevated, and a “pop” sound, which we thought represented the escape of the trapped high pressure air, was heard when the cranial dura was reopened. The intracranial cavity was filled with ample saline to replace the air. The edge of frontal bone, which had been cut by a prior craniotomy, was covered with a pericranial flap, although the frontal sinus seemed to be intact after inspection. The cranial dura was sutured water-tight and sealed with fibrin glue.

His consciousness level improved immediately after the rescue surgery. Postoperative brain CT showed marked reduction of the intracranial air and brain shift (Fig. 3). The patient later required ventriculoperitoneal shunt placement for communicat-

ing hydrocephalus, and was discharged home 60 days after surgery.

Discussion

Several hypotheses have been proposed to explain the development of tension pneumocephalus. The most likely mechanism in the present case is the inverted soda-pop bottle phenomenon: when the bottle is inverted, soda pours out, leaving an empty space of negative pressure above the fluid level.⁽⁶⁾ The same effect can occur when CSF is siphoned out in specific situations such as the sitting position and the CSF diversion system. Positive pressure air rushes into the intracranial space via the bony/dural defect to fill in the negative pressure space created by the loss of the CSF. Dural defect is a prerequisite for the development of tension pneumocephalus, so all patients with an intradural lesion have the risk of developing tension pneumocephalus. The present case emphasizes the importance of suturing the dura water-tight at craniotomy closure. Despite our belief that the frontal sinus had not been violated in the initial surgery, a small defect in cranial dura/frontal sinus might have been present, through which air had entered. Several factors in addition to lumbar drainage may be associated with the development of post-surgical tension pneumocephalus: nitrous oxide anesthesia; long duration of surgery; presence of hydrocephalus; and intraoperative administration of mannitol.^(2,4,6,8-11) In the present case, all four factors were probably present and might have contributed to the development of tension pneumocephalus.

Pneumocephalus is a known complication of lumbar drainage, but is mostly self-limiting and rarely becomes symptomatic.^(1,3,5) The CSF leakage from the dural tear usually ceases spontaneously after catheter removal due to the tamponade effect of the surrounding soft tissue. In the present case, the CSF leakage was continuous and uncontrolled from surgery into the postoperative period, which might have resulted in a large amount of CSF loss and the consequent introduction of a large amount of intracranial air. Retrospectively, lumbar drainage might not have been necessary, because the elevated ICP due to hydrocephalus could have been controlled by draining CSF through ventriculostomy or surgical dissection, such as opening of the lamina terminalis. Lumbar drainage is an established method in cerebral aneurysm surgery to facilitate brain retraction,^(6,7) but the procedure is not entirely free from complications and the benefit needs must be weighed against the risks.

The present case shows that a dural tear created by lumbar drainage for cranial surgery must not be left untreated. We expected that the CSF leakage

from the dural tear would cease spontaneously without intervention. Once a dural puncture with a large-bore needle is performed, the drainage catheter must be placed within the spinal dura. If the catheter cannot be inserted despite rigorous effort, epidural blood patch to seal the dural tear may be a good rescue procedure to prevent further CSF leakage and development of tension pneumocephalus, which is potentially life-threatening.

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