www.jkns.or.kr 10.3340/jkns.2009.45.5.318 Print ISSN 2005-3711 On-line ISSN 1598-7876
J Korean Neurosurg Soc 45 : 318-321, 2009

Case Report

Extensive Tension Pneumocephalus Caused by Spinal Tapping in a Patient with Basal Skull Fracture and Pneumothorax

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Tension pneumocephalus may follow a cerebrospinal fluid (CSF) leak communicating with extensive extradural air. However, it rarely occurs after diagnostic lumbar puncture, and its treatment and pathophysiology are uncertain. Tension pneumocephalus can develop even after diagnostic lumbar puncture in a special condition. This extremely rare condition and underlying pathophysiology will be presented and discussed. The authors report the case of a 44-year-old man with a basal skull fracture accompanied by pneumothorax necessitating chest tube suction drainage, who underwent an uneventful lumbar tapping that was complicated by postprocedural tension pneumocephalus resulting in an altered mental status. The patient was managed by burr hole trephination and saline infusion following chest tube disengagement. He recovered well with no neurologic deficits after the operation, and a follow-up computed tomography (CT) scan demonstrated that the pneumocephalus had completely resolved. Tension pneumocephalus is a rare but serious complication of lumbar puncture in patients with basal skull fractures accompanied by pneumothorax, which requires continuous chest tube drainage. Thus, when there is a need for lumbar tapping in these patients, it should be performed after the negative pressure is disengaged.

KEY WORDS : Pneumocephalus · Pneumothorax · Spinal tapping.

INTRODUCTION

Pneumocephalus occasionally develops in patients with basal skull fractures. However, extensive tension pneumocephalus secondary to head trauma is rare, and its etiology is controversial. There have been previous reports of tension pneumocephalus of otogenic origin resulting from continuous lumbar drainage or CSF fistulae[1,5,6].

We report a patient who developed extensive tension pneumocephalus that required surgery after undergoing a diagnostic spinal tap. The pathophysiology and management of this clinical entity is discussed with a pertinent literature.

CASE REPORT

A 45-year-old man experienced severe head trauma after being thrown from his car when his pick-up truck rolled over. He arrived at the emergency room complaining of headache, dyspnea associated with chest pain, and back pain. On admission, he was alert and showed no hemiparesis. However, no direct light reflex was elicited in the right pupil, but the indirect reflex was intact. The initial brain computed tomography (CT) scan showed a small amount of epidural hematoma with an isolated pocket of air in the right frontal area (Fig. 1A). Facial bone CT revealed multiple fractures in the frontal sinus, nasal bone, and glabella (Fig. 1B). A chest CT scan was also performed and demonstrated extensive pneumothorax associated with multiple rib fractures (Fig. 1C).

The hematoma collection and basal skull fracture were managed conservatively, and the pneumothorax (mainly in the left chest) was treated by placement of a chest tube that was connected to a four-chamber system with negative pressure (-20 cmH_2O). One week after the injury, he complained of headache and presented with fever, the cause of which was suspected to be a central nervous system (CNS) infection secondary to basal skull fracture. After confirming the absence of an abnormality on contrast-enhanced brain CT, a spinal tap was performed to analyze the cerebrospinal

• Received : December 17, 2008 • Accepted : April 26, 2009
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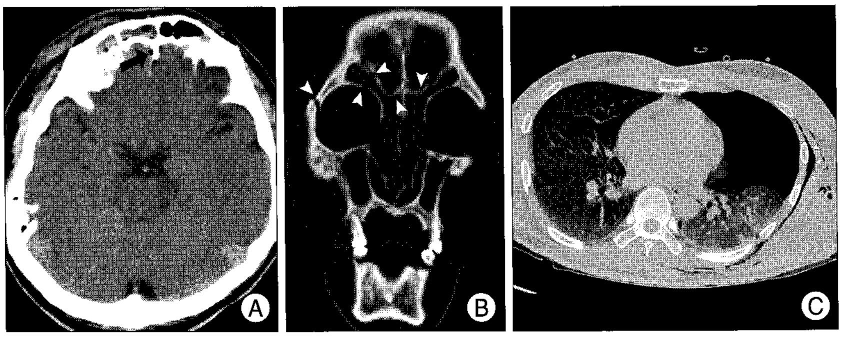

Fig. 1. Computed tomography (CT) scan obtained at admission in a 45-year-old man with a basal skull fracture and pneumothorax. A : Axial CT scan showing a punctuate focus of air around the frontal crest (arrow). B : Coronal facial bone CT scan demonstrating fractures in the right orbital wall and the frontal sinus (arrowheads). C : Chest CT scan revealing extensive pneumothorax and intramuscular emphysema in the left chest wall (arrowhead).

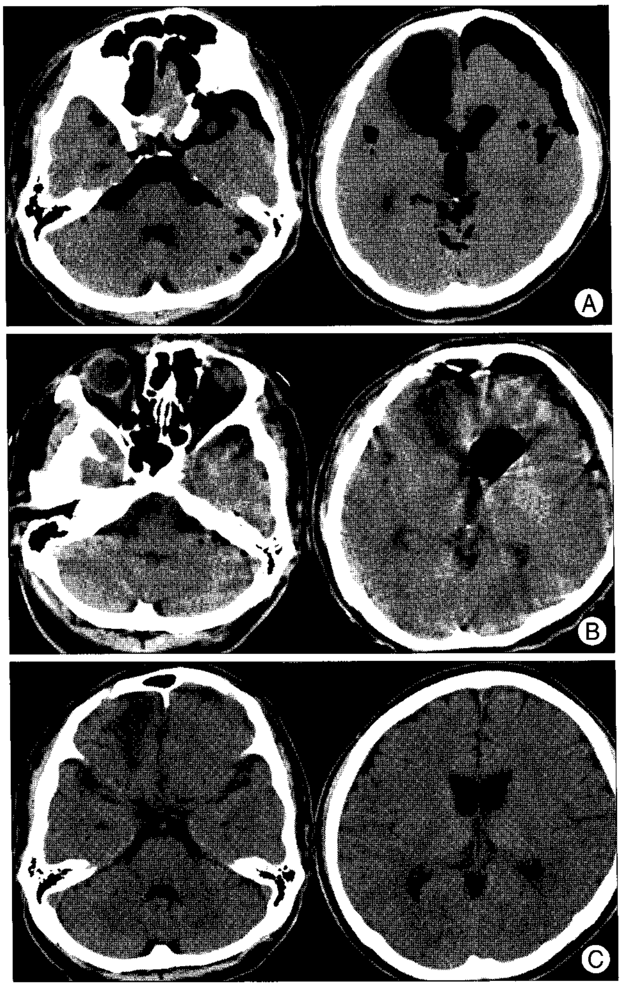

Fig. 2. A : Computed tomography (CT) scans obtained 3 days after a diagnostic spinal tap showing extensive intraventricular, intracerebral, subdural, and cisternal pneumocephalus causing tension in the brain. B : Post-operative CT scan demonstrating that cisterns and ventricles are filled with saline to a certain extent, thus relieving the intracranial pressure. C : Follow-up CT scan obtained 6 weeks after surgery showing normal ventricles and cisterns.

fluid (CSF) in order to investigate the source of the fever. The opening pressure was 20 cmH$_2$O, and no WBCs were found in the CSF. About 5 cc of CSF was obtained for further analysis. Three days after lumbar puncture, the patient became obtunded and lethargic, yet could be aroused. An emergent CT scan detected an extensive pneumocephalus originating in the area of the frontal skull base fracture and extending into the cerebral cisterns and ventricles causing brain compression (Fig. 2A).

The patient underwent an emergency operation because his brain was compressed by entrapped air, which made him drowsy. A small incision was made in both eyebrows, and then saline infusion was performed via two frontal burr-holes. The expected sudden gush of escaping air was not observed. The chest tube was clamped before surgery. The negative pressure was disengaged during surgery, and the tube was removed 3 days after surgery. Immediate post-operative CT scan demonstrated that some of the air had drained out (Fig. 2B). The patient recovered with no neurologic deficits, but he remained somnolent for a couple of days. A CT scan performed 6 weeks after the surgery demonstrated that the pneumocephalus had completely resolved (Fig. 2C), and he was doing well at the 8-month follow-up examination.

DISCUSSION

Pneumocephalus, the presence of air within the cranial vault, results from a variety of causes. Certain conditions are needed in order to develop this disorder, including a connection between the CNS and the external environment, air traversing through this connection, and enough air present to cause symptoms. Head trauma is the most common cause, followed by neoplasm, infection, and surgical complications[4]. Air within the brain parenchyma, termed intracerebral pneumocephalus, accounts for tears in both the dura and arachnoid matter.

Two theories have been proposed for the mechanism behind the development of pneumocephalus. Dandy[2] described a "ball valve" mechanism in which air travels in only one direction. As air enters the cranial cavity, the intracranial pressure rises. The pressure gradient between the atmosphere and intracranial space is therefore reduced, and the osteomeningeal fistula is then tamponaded by brain tissue. As a consequence, air is trapped in the intracranial space. The other theory, the "Inverted-soda-bottle effect", was proposed by Horowitz[3]. He postulated that negative

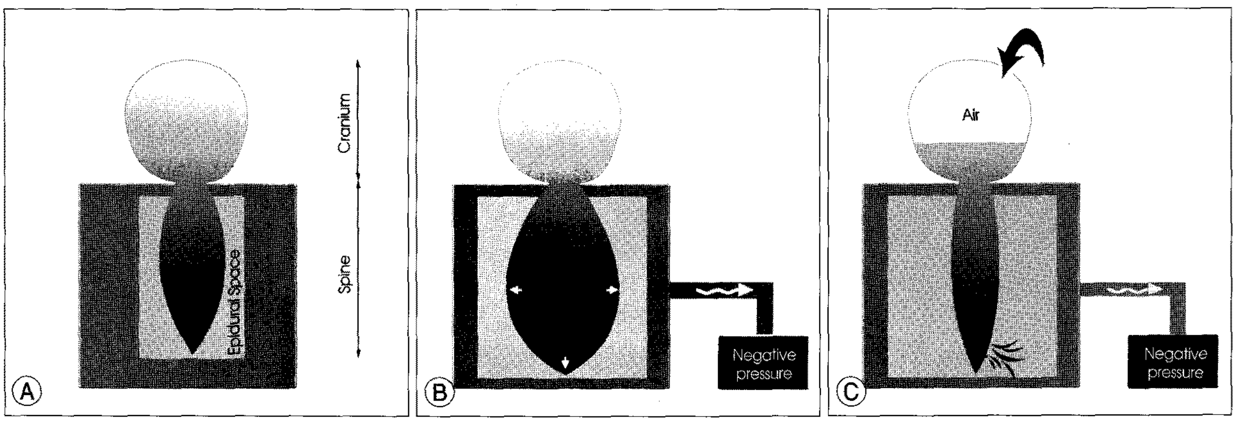

Fig. 3. Schematic drawings showing the mechanism of extensive pneumocephalus caused by negative pressure. A : Schematic drawing of the normal status of the body. B : When negative pressure is applied, the spinal epidural space expands, and the subdural space is distended, leading to a decrease in the intracranial pressure. C : In the presence of cerebrospinal fluid (CSF) fistulae, air may be drawn into the subdural space. If spinal tapping is attempted, CSF may leak continuously, and extensive pneumocephalus may finally occur.

intracranial pressure (ICP) results from excessive loss of CSF through an iatrogenic lumbar drain or settling into the distendable spinal subarachnoid space or simply drainage via normal pathways with physiologic activity such as inspiration or the Valsalva maneuver. However, when there are fistulous connections between the intracranial and outer space, air can enter the intracranial space in response to a negative pressure gradient.

There have been several reports of extensive tension pneumocephalus caused by continuous lumbar CSF drainage. However, the cases were all related to excessive CSF drainage for the treatment CSF fistulae. In our case, lumbar puncture was the only performed procedure to identify the cause of the infection. An important factor that could differentiate our case from the previously reported cases is that the patient had a huge pneumothorax resulting from multiple rib fractures, and pneumothorax had been treated by placement of a chest tube that was connected to a negative pressure bottle since his admission. Even after diagnostic spinal tapping, the chest tube had been engaged with negative pressure. Consistent with the "Inverted-soda-bottle effect", the patient was in a state of constant inspiration in the presence of CSF fistulae. Furthermore, we provided a CSF leakage site at the thecal sac. The extensive tension pneumocephalus seemed to develop as a result. It is likely that the negative pressure chest tube caused the spinal arachnoid space to be distendable, providing a chance for pneumocephalus to occur. The rapid release of CSF through a tapping site at the thecal sac then caused a rapid influx of air into his head resulting in extensive tension pneumocephalus (Fig. 3).

This case illustrates two important clinical lessons. First, when there are basal skull fractures that can allow CSF fistulae and pneumothorax to develop simultaneously, attention should be paid when treating the pneumothorax with a negative pressure chest tube. If chest tube insertion is essential, the negative pressure should be reduced from the normally applied value, and lumbar tapping or drain insertion must be avoided. When there is a need for lumbar tapping or drain insertion, it should be performed after the negative pressure is disengaged. Second, although the etiology of tension pneumocephalus is uncertain, a good result could be achieved with an early diagnosis and prompt treatment using burr hole trephination and saline infusion.

CONCLUSION

We report a rare case of extensive tension pneumocephalus in a patient with multiple facial and basal skull fractures accompanied by tension pneumothorax. Spinal tapping during negative pressure chest tube engagement for tension pneumothorax seems to be a causative factor of tension pneumocephalus. One should be aware that even diagnostic spinal tapping can induce life-threatening tension pneumocephalus in such clinical setting, and disconnection of chest tube suction might be an initial indispensible key step in its management.

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