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Pneumocephalus as a Rare Complication of Adolescent Idiopathic Scoliosis Surgery; A Case Report and Literature Review

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Abstract

Introduction: Surgery on adolescent idiopathic scoliosis (AIS) deformity has known complications thoroughly debated in the literature. All around the world, there may be a few spine surgeons who have heard about "pneumocephalus" as a postoperative complication of a simple otherwise uncomplicated AIS surgery we described here.

Case Presentation: We report a unique case of pneumocephalus after an otherwise uncomplicated AIS surgery in a 12-year-old girl. This report is unique because no apparent intraspinal canal invasion was carried out during the surgery, and pneumocephalus after AIS surgery without any apparent spinal canal invasion has not been reported previously.

Conclusion: Pneumocephalus is a very rare but possible complication after AIS surgery. Proper diagnosis and treatment of this complication depends on the surgeon's previous familiarity with it and knowing the possibility of its occurrence.

Keywords: Pneumocephalus; spinal surgery; idiopathic scoliosis; complication

Introduction

Pneumocephalus is the presence of gas in the cranial cavity. This expression was first used in an autopsy of a traumatic case by Thomas AL in 1866 [1]. Pneumocephalus can be induced by a variety of causes but occurs mostly after head traumas or cranial surgeries [2, 3]. Pneumocephalus may also be a complication that occurs in intracranial malignancies, infections, neurosurgical interventions, otolaryngologic procedures, diagnostic interventions, or even after spinal surgeries [4-6]. The patient can present with gradually worsening headache, irritability, vomiting, nausea, and dizziness [5]. In this report, we presented this rare complication in a 12-year-old girl patent undergone an otherwise uncomplicated scoliosis surgery, and reviewed the relevant literature.

Case Presentation

A 12-year-old otherwise healthy girl was admitted with the diagnosis of adolescent idiopathic scoliosis (Lenke 3CN; right T4-T11: 53°, left T12-L4: 50°, Figure 1). The patient had no significant past medical history and all physical exams were normal except for spinal deformity. Preoperative spinal magnetic resonance imaging (MRI) showed no significant abnormalities and laboratory blood tests were normal. After obtaining informed consent (from the parents) and assent (from the patient), she was scheduled for posterior spinal deformity correction surgery.

Figure 1: Preoperative upright spinal radiography shows a double thoracic and lumbar scoliosis.

The patient was operated on in a prone position and a routine posterior spinal fusion surgery was carried out. The patient was operated on under general anesthesia with posterior spinal fusion and pedicular screw fixation carried out from T4 to L4 without any unexcepted event throughout the surgery. The operation lasted five hours and intraoperative blood loss was around 480cc, our fixation system was the pedicular screw and Cobalt-Chrome rod, and our pedicular screw insertion technique was the free-hand technique. We received no even small evidence of abnormal motor or sensory neuromonitoring signals or incidental cerebrospinal fluid (CSF) leakage. We did not have any significant medial pedicular broach, no apparent CSF leakage, and no other evidence indicating dural involvement. In imaging, no significant medical placement of the screws was detected intra- or postoperatively, although we did not take computerized tomography scanning routinely after uncomplicated scoliosis

surgery. A blood transfusion was not needed. Immediate postoperative evaluation was completely normal, but the patient was transferred to the intensive care unit (ICU) for better care. Postoperative images were ideal as shown in Figure 2.

Figure 2: Postoperative spinal radiography shows almost complete curve correction with acceptable global balance

The day after the surgery, the patient was checked again, neurologic and visual exams were completely normal but the patient complained of a mild headache. The pain was localized to the frontal area of the head without any peripheral neurologic deficit and deteriorated while sitting or standing (resembling the scenario usually seen after lumbar puncture). The pain was simply attributed to the routine postoperative state and anesthetic effects after such lengthy procedures.

On the second postoperative day, while we expected a gradual improvement in the general situation, the headache worsened. A neurosurgical consultation followed by brain computerized tomography (CT) scanning was carried out (Figure 3). CT revealed the presence of air in the frontal subarachnoid space (pneumocephalus).

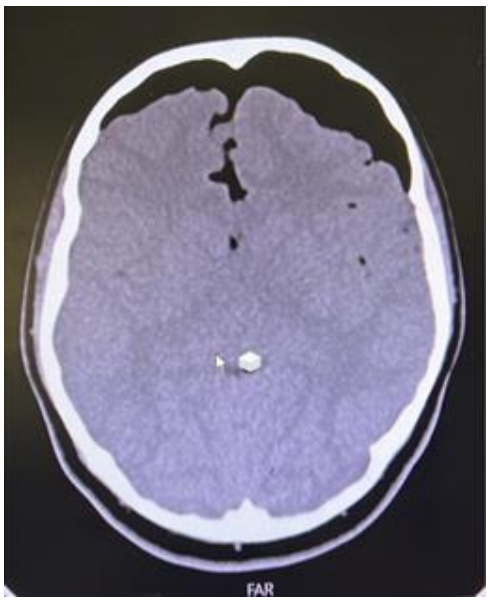

Figure 3: First postoperative brain CT of the patient on the second postoperative day. Pneumocephalus was frankly observed in the frontal area with some compressive effect on the brain

The patient was conservatively treated with 100% oxygen, bed rest, hydration, mild antiepileptic drug (phenobarbital), and close monitoring. Clinical complaints were gradually improved but she was maintained in hospital for more three days. On the fifth day after the operation, CT scanning was repeated and a significant decrease in air volume in the frontal brain area was confirmed (Figure 4).

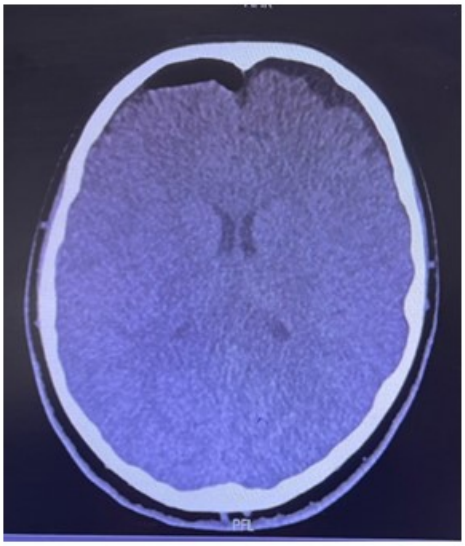

Figure 4: Brain CT on the 5th postoperative day revealed air volume shrinkage in the frontal space

She was discharged with good mental and physical condition on the sixth postoperative day. The patient was followed up for three years, and she is satisfied with the result of the surgery without any late postoperative complications.

Discussion

Pneumocephalus is defined as a pathological collection of gas within the cranial cavity. It can be located intra-axially (epidural, subdural, subarachnoid) or extra-axially (parenchymal, intraventricular, intravascular) [3]. In the literature, a wide variety of situations including idiopathic (spontaneous), trauma, infection (by gas-producing pathogens), tumor (especially brain or skull base), or iatrogenic (surgeries disrupting the dura mater) causes have been mentioned in creating this phenomenon [2-6]. Pneumocephalus can also appear as tension (tension pneumocephalus), in which case it is considered a neurosurgical emergency and usually requires urgent intracranial decompression by different surgical interventions such as craniotomy or twist-drill trephination [7, 8].

Pneumocephalus during spinal surgeries is rarely reported [5, 9-12]. These patients may present with a variety of symptoms including headache, nausea, dizziness, altered mental status, CSF rhinorrhea, vomiting, or convulsions [7]. Computerized Tomographic (CT) scanning is the most reliable imaging technique for the diagnosis of pneumocephalus because of the low density of air presented on CT scans (approximately -1000 Hounsfield Units). This modality can even detect as little as 0.55 ml of intracranial air [13]. In most of cases, pneumocephalus can be managed conservatively with bed rest, head elevation usually 30°, oxygen supplementary therapy, and many other supportive methods [14].

We conducted a comprehensive study on relevant reported cases using databases including PubMed, Web of Science, Elsevier, and Scopus. The keywords were (Pneumocephalus) AND (Spinal surgery). We found 53 case reports but 51 of them reported pneumocephalus after laminectomy or spinal decompression. Only two papers mentioned pneumocephalus after spinal deformity surgery, both of them declared a misplacement in the pedicular screw and both of them re-operated the patient and re-

paired the dural tear [11, 12].

Several theories exist for the etiology of pneumocephalus. Ball valve theory of Dandy is an unidirectional movement of air from the outside environment into the cranial cavity. This is the mechanism behind pneumocephalus following positive pressure ventilation [15]. Inverted-soda-bottle effect of Horowitz and Lunsford is another theory that quoted excessive loss of CSF due to drainage in a physiological way during Valsalva or via lumbar drain could lead to low intracranial pressure (ICP) and trapping the air in the vacuum created inside the cranium [16].

The development of pneumocephalus during epidural injections can be due to a loss of resistance barriers used to identify the epidural space [17]. The entry of air through the meninges can be due to accidental injection, inadvertent dural puncture, or the differential pressures between the cranial cavity and atmosphere. Anesthesia-induced pneumocephalus is another type that may be attributed to the use of nitrous oxide. The blood–gas partition coefficient of nitrous oxide is 34 times greater than that of nitrogen. This causes nitrous oxide to diffuse into the cranial cavity faster than nitrogen or air [18]. In the case we operated on, we didn't use nitrous oxide positive pressure ventilation or epidural injections for anesthesia.

The case we presented seems to be unique as none of the above theories are relevant. Throughout the surgery, no apparent CSF leakage, dura puncture, or even a single questionable trajectory involving the canal was noticed in the placement of the pedicle screws. All pedicle screws were inserted by free-hand techniques confirmed later by a biplanar fluoroscopy. In none of them, open spinal cord exploration was needed or carried out. Although, we believe there may be an invisible dural tearing during pedicular screw insertion might be occurred we did not notice that led to this rare complication. It is certainly more research needed to be carried out to find out other etiologies for developing pneumocephalus after such otherwise uncomplicated (no dural tear, no infection, no pedicular screw misplacement, etc.) spinal deformity surgeries.

Conclusion

Although pneumocephalus can occur rarely after spinal deformity surgeries, the spinal surgeons should be aware of the possibility of this complication. Thry should insert the pedicular screws precisely with special concern about the medial pedicular penetration, be carefully aware of any CSF leakage during screw insertion, and inspect intraoperative fluoroscopy precisely.

Whenever postoperative unexplained complaints like headache or dizziness develop especially upon standing and sitting while it gets better with lying down, this complication should be vigorously suspected.

Ethical Standards

This study is a case report and ethical standards are followed according to COPS. This patient has been treated with a standard and scientific method and all data including photos are anonymous.

Conflict of Interest

The authors declare that there are no conflicts of interest

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Informed Consent

Written informed consent was obtained from the patient's parents for publication of this case report and accompanying image. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Authors' contribution

The manuscript has been read and approved by all the authors, the requirements for authorship as stated earlier in this document have been met, and each author believes that the manuscript represents honest work.

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