

Pneumocephalus Following Combined Spinal-Epidural Anesthesia: A Case Report Analysis

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Abstract

Background: Combined spinal-epidural anesthesia (CSEA) is widely used in clinical anesthesia due to its rapid onset, reliable anesthetic effect, and strong controllability. Although advancements in technique have reduced the frequency and severity of common complications, reports of rare and serious complications such as pneumocephalus, remain scarce. **Case Report:** This article presents a case of pneumocephalus following CSEA in a middle-aged female patient undergoing surgery for an intrauterine space-occupying lesion. The patient experienced severe headache postoperatively, and imaging confirmed the presence of intracranial air. After receiving active symptomatic treatment, the patient recovered and was discharged. **Conclusion:** This case underscores the importance of adhering to standard anesthesia protocols and increasing awareness of rare CSEA complications, particularly the risk of pneumocephalus. Early recognition and timely management are crucial. There is a need to further enhance training and research in anesthetic procedures to improve clinical anesthesia quality and ensure patient safety.

Keywords

Combined Spinal-Epidural Anesthesia, Pneumocephalus, Intrauterine Space-Occupying Lesion, Anesthesia Complications, Clinical Anesthesia Quality

1. Introduction

Combined Spinal-Epidural Anesthesia (CSEA), an advanced technique that merges the benefits of spinal anesthesia and epidural anesthesia, has been widely adopted in clinical practice, particularly demonstrating outstanding efficacy in obstetric and lower abdominal surgeries. CSEA not only provides rapid and effective anesthesia

but also enables prolonged postoperative analgesia through epidural administration, thereby significantly enhancing patient comfort and satisfaction. However, despite its well-established technique and high safety profile, there remains a certain risk of complications associated with CSEA in clinical use. The loss of resistance to air (LORA) technique is widely used for identifying the epidural space, but there have been reports of complications, such as spinal and nerve root compression, pneumocephalus, and venous air embolism [1]-[3]. Among the potential complications, pneumocephalus is a rare but potentially serious condition [4]. Existing research primarily focuses on the mechanisms and preventive measures related to pneumocephalus. However, there is relatively little literature specifically addressing the mechanisms and management strategies for pneumocephalus induced by CSEA. This case report aims to fill this knowledge gap by providing a detailed analysis of a typical case of pneumocephalus following CSEA. It explores the underlying mechanisms, clinical manifestations, diagnostic approaches, and treatment methods associated with this complication. Through an in-depth examination of this case, we aim to offer valuable insights for clinical anesthesiologists, aiding them in better recognizing and managing this rare but critical complication. Early recognition and prompt treatment of pneumocephalus are crucial for reducing patient distress and improving postoperative recovery outcomes.

2. Case Report

The patient, a 52-year-old female weighing 53 kg and standing 157 cm tall, was admitted for hysteroscopic resection of an endometrial lesion under combined spinal-epidural anesthesia (CSEA). Preoperative examinations, including routine blood tests, liver and kidney function tests, coagulation profile, and electrocardiogram, were all within normal limits. The patient had a self-reported history of cervical spondylosis, which had not been investigated or treated, and was classified as ASA II. Upon entering the operating room, the patient was monitored with electrocardiography, showing a heart rate of 82 bpm, blood pressure of 130/80 mmHg, respiratory rate of 18 bpm, and SpO₂ of 97%. An intravenous line was established, and 500 ml of Ringer's solution was infused. The patient was positioned in the right lateral decubitus position for the puncture. On assessing the puncture site, it was noted that the interspinous spaces were poorly exposed. The L3-4 interspace was chosen for puncture. The initial midline approach was difficult, and the needle did not reach the epidural space. The approach was then changed to a paramedian route. After the needle entered the epidural space, an air injection test was performed with less than 1 ml of air. The spinal needle was inserted, but no cerebrospinal fluid (CSF) was seen. After two adjustments of needle direction without success, assistance from a senior physician was requested. The department chief took over and switched to the L2-3 interspace, where the epidural space was successfully accessed. Less than 1 ml of air was injected for confirmation, and after ensuring the needle was in the epidural space, a spinal needle

was introduced. CSF flowed smoothly, and 2 ml of 0.75% ropivacaine was diluted to 3 ml with CSF and injected slowly into the subarachnoid space. The total dose of 0.5% ropivacaine administered was 15 mg. The spinal needle was then removed, and a 4 cm epidural catheter was placed without difficulty, with no blood or CSF return upon aspiration. The patient was positioned supine, and the anesthetic level was confirmed at T10 with good effect, and the patient reported no discomfort as the surgery commenced. The patient was sedated intraoperatively with midazolam and dexmedetomidine. The 40-minute surgery proceeded smoothly, with stable vital signs throughout. At the end of the procedure, the anesthetic level remained at T10, and the epidural catheter was removed before the patient was transferred to the ward.

Six hours postoperatively, the patient reported headache after turning over, described as a pulling sensation across the entire head without associated dizziness, nausea, or vomiting, and the pain was alleviated by lying still. Physical examination revealed clear consciousness, fluent speech, supple neck, normal bilateral pupillary reflexes, and intact sensation and muscle strength in all four limbs. The patient was advised to increase fluid intake, maintain bed rest, and continue observation, with further imaging and specialist consultation if symptoms did not improve. Eight hours postoperatively, a head CT revealed multiple intracranial air pockets in the pre-pontine cistern, bilateral cerebellopontine angle cisterns, sub-tentorial space, and alongside the right cavernous sinus (**Figure 1**). No significant abnormalities were noted in the brain parenchyma, ventricles, cisterns, or sulci, and the midline structures remained centered. A consultation with neurosurgery recommended head elevation, dynamic observation, and periodic head CT scans. On postoperative day 2, the patient's headache persisted despite bed rest. By postoperative day 3, the headache had significantly improved, and there was no dizziness, nausea, or vomiting, allowing the patient to move out of bed. By postoperative day 5, the headache had completely resolved, and the patient reported no other discomfort. Although a repeat head CT was recommended, the patient declined further imaging. On postoperative day 6, the patient was asymptomatic and was discharged from the hospital. One month after the operation, the patient was followed up by telephone without any significant discomfort.

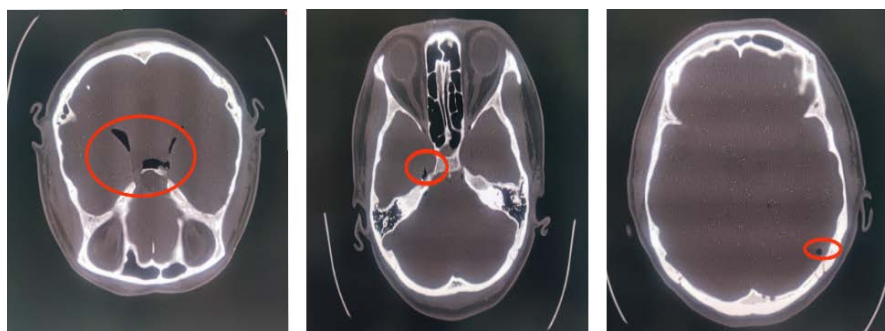


Figure 1. Axial computed tomography (CT) scan of the head indicating the presence of intracranial air (Shown by the red oval).

3. Discussion

The patient in this case experienced a pulling sensation headache across the entire head following CSEA, with a postoperative CT scan revealing multiple intracranial air pockets. The symptoms gradually resolved with conservative treatment. This case highlights a rare but serious complication of combined spinal-epidural anesthesia, pneumocephalus. CSEA is commonly used in gynecological surgeries due to its high success rate and excellent postoperative analgesia. However, if a significant amount of air inadvertently enters the epidural or subarachnoid space during the puncture, there is a risk of air migrating into the cranial cavity, leading to pneumocephalus [5].

The mechanism of pneumocephalus is primarily related to the accidental entry of air into the subarachnoid or epidural space during anesthesia. During combined spinal-epidural anesthesia, improper technique or significant anatomical difficulty during the puncture can lead to incomplete sealing of the epidural or subarachnoid space, allowing gas to enter the cranial cavity. This risk is particularly elevated with multiple puncture attempts, where repeated attempts or misjudgment of anatomical structures can further increase the likelihood of gas entry. Postoperatively, changes in patient positioning, such as transitioning from supine to sitting or standing, can facilitate the movement of air into the cranial cavity, resulting in increased pneumocephalus. The clinical manifestations of pneumocephalus are similar to those of low cerebrospinal fluid (CSF) pressure headaches, with symptoms such as headache, nausea, and vomiting. However, the headache associated with pneumocephalus is characterized by a pulling sensation across the entire head and is not entirely dependent on positional changes. A head CT scan is a crucial diagnostic tool for detecting pneumocephalus, as it can clearly reveal intracranial air density shadows. In this case, the patient's head CT scan clearly showed multiple intracranial air pockets, which, combined with the clinical symptoms, confirmed the diagnosis of pneumocephalus.

In this case, the patient's unique underlying factors played a crucial role in the development of pneumocephalus. Firstly, the patient's anatomical features may have increased the difficulty of the puncture, particularly due to poor exposure of the interspinous spaces. Anatomical challenges, such as narrow or irregular spinal interspaces combined with suboptimal positioning, could cause instability of the puncture needle when accessing the epidural or subarachnoid space, increasing the risk of gas entering the cranial cavity. Additionally, the patient underwent multiple puncture attempts, which not only heightened the likelihood of gas ingress but also potentially caused local tissue or vascular damage during the procedure, further increasing the risk of gas entering the subarachnoid space. The presence of gas in the subarachnoid space may have led to its upward migration along the spinal and neural pathways, eventually entering the cranial cavity and causing increased intracranial pressure. Postoperative positional changes may have exacerbated gas movement, leading to the onset and worsening of symptoms.

The treatment for pneumocephalus primarily involves conservative management,

including strict bed rest, adequate hydration, and symptomatic pain relief, with the goal of promoting the natural absorption of the air. High-flow oxygen therapy has also been shown to accelerate the absorption of air by increasing the partial pressure of oxygen, which facilitates the diffusion of gases out of the bloodstream [6]. In cases where symptoms are severe or there is a large accumulation of air, further interventions may be necessary. In this case, the patient's symptoms gradually resolved with conservative treatment, highlighting the importance of early recognition and appropriate management. The patient had a good prognosis, with no evidence of long-term neurological damage, indicating that timely management of pneumocephalus often leads to favorable outcomes. Anesthesiologists should adhere strictly to aseptic techniques during CSEA to prevent the entry of air into the epidural or subarachnoid space, thereby reducing the risk of complications.

To effectively prevent pneumocephalus following CSEA, the following multifaceted measures are recommended: First, conduct detailed preoperative imaging studies (such as MRI or CT) and body assessments to clarify spinal anatomical structures and aid in accurate puncture site localization, particularly for patients with complex anatomy or a history of spinal surgery. Next, during the actual puncture, it is advisable to use saline instead of air to reduce the risk of gas entering the subarachnoid and cranial cavities, and to use real-time imaging guidance (such as ultrasound or fluoroscopy) to enhance the accuracy and safety of the procedure. Additionally, ensure that the puncture is performed by an experienced anesthesiologist to minimize the need for multiple attempts. If the initial puncture fails, it is recommended that a senior physician take over. Furthermore, employing fine needles and flexible catheters can help reduce the likelihood of gas ingress, thereby lowering the risk of increased intracranial pressure. Finally, postoperative monitoring is crucial; closely observe the patient for any symptoms such as headache, nausea, or vomiting, and promptly perform imaging studies to rule out pneumocephalus if such symptoms arise.

Additionally, the accidental entry of air into the subarachnoid or epidural space during anesthesia can lead to various other complications, including but not limited to pneumothorax, cardiovascular system effects, neurological impacts, and local inflammatory reactions [3] [7] [8]. Although these complications are relatively rare, their potential severity requires clinicians and anesthesiologists to remain highly vigilant and to implement appropriate preventive and emergency response measures to ensure patient safety and treatment efficacy. Specifically, if air enters the thoracic cavity, it may result in pneumothorax, with clinical manifestations such as chest pain, dyspnea, and tachypnea, increasing the risk of lung infection and necessitating immediate intervention. Moreover, the entry of a large amount of air into the bloodstream can lead to arrhythmias, cardiac insufficiency, or even myocardial infarction, requiring urgent cardiovascular support and treatment. When air is injected near the spinal cord in the epidural space, it may cause direct compression or impact on the nervous system, leading to neurological

dysfunction or pain, with symptoms such as paresthesia, numbness, or limited motor function. The presence of air may also trigger a local inflammatory response, presenting as localized pain, swelling, and exudate formation, which should be managed with anti-inflammatory treatments and other appropriate medical measures. Furthermore, the entry of air into the epidural or subarachnoid space may increase the risk of infection, particularly if aseptic techniques were not strictly followed during the procedure. Infection may present with symptoms such as fever, localized redness, and pain, requiring prompt anti-infective treatment. The accidental introduction of air may also be accompanied by local vascular injury, leading to hematoma formation, which could compress surrounding tissues and necessitate confirmation through imaging and possibly surgical intervention.

This case highlights the clinical risks of pneumocephalus following combined spinal-epidural anesthesia and underscores the importance of precise technique and anatomical assessment during complex puncture procedures. Clinical practice should enhance monitoring for patients with difficult punctures and multiple attempts to prevent gas entry into the cranial cavity. Future research should focus on optimizing puncture techniques and improving imaging guidance to reduce the incidence of pneumocephalus. Additionally, exploring methods for early detection and intervention of pneumocephalus could improve patient management strategies. In summary, although the probability of complications arising from epidural air injection is low, clinicians and anesthesiologists must closely monitor patient responses and be prepared to manage any potential emergencies. By doing so, optimal treatment outcomes can be achieved while ensuring patient safety.

4. Conclusion

In conclusion, this case report serves as a reminder that, while CSEA is a safe and effective anesthesia technique, the potential complications must not be overlooked. Strict adherence to procedural guidelines and vigilant postoperative monitoring can significantly reduce the incidence of complications, thereby enhancing patient safety and satisfaction.

Consent for Publication

Written informed consent was obtained from the patient for the publication of clinical details and associated images.

Availability of Data and Materials

The datasets generated or analyzed during this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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