Pneumocephalus associated with epidural and spinal anesthesia for labor

Sudama Reddi, MD

Valentyna Honchar, MD

Matthew S. Robbins, MD

Abstract

Headache resulting from dural puncture in epidural and spinal anesthesia is usually secondary to a CSF leak. Pneumocephalus may also occur in this setting but has not been well-characterized. Although the risk factors for a CSF leak and pneumocephalus may overlap, their rates, clinical features, and treatments may be different. Our retrospective review of 182 patients with acute headache in the antepartum, peripartum, and postpartum settings yielded a 5:1 ratio of postdural puncture headache to pneumocephalus. The 3 patients with pneumocephalus had the defining characteristic of thunderclap headache during anesthesia. Early diagnosis is helpful as treatment with supplemental oxygen may hasten recovery. Pneumocephalus should be considered as a possible etiology of thunderclap headache in the setting of epidural and spinal anesthesia. *Neurol Clin Pract* 2015;5:376-382

Postdural puncture headache (PDPH) is a common cause of headache in parturients receiving epidural or spinal anesthesia, with an incidence between 0.5% and 1.7%.¹ The risk of accidental dural puncture while performing epidural insertion during labor is 1 in 67.² Pneumocephalus in the obstetrical setting usually results from accidental injection of air into the intrathecal space from the “loss of resistance” technique, which is used to identify the epidural space during spinal or combined spinal/epidural anesthesia.³ This technique uses the perception of a sudden change in resistance detected upon insertion of the epidural needle tip, resulting in the easier injection of air, saline, or both into the epidural space.⁴ Headache resulting from dural puncture is typically secondary to a CSF

Department of Neurology & Neurotherapeutics (SR), University of Texas Southwestern Medical Center, Dallas, TX; Department of Neurology (VH, MSR), Albert Einstein College of Medicine, Bronx, NY; and Montefiore Headache Center (MSR), Bronx, NY.

Funding information and disclosures are provided at the end of the article. Full disclosure form information provided by the authors is available with the **full text of this article at Neurology.org/cp**.

Correspondence to: marobbin@montefiore.org

The most common clinical presentations of pneumocephalus include headache, nausea, vomiting, seizures, dizziness, cranial nerve palsies, hemiparesis, and encephalopathy.

leak but can rarely be associated with pneumocephalus. The clinical features and time of symptom onset can potentially be helpful in differentiating these causes of peripartum headache, aiding in rapid recognition and treatment. We aimed to present our experience with pneumocephalus and to describe its rate, clinical features, and outcomes when encountered during labor.

METHODS

We retrospectively reviewed consecutive inpatient neurologic consultations for acute headache in women who were pregnant, in labor, or within 6 weeks postpartum at the Jack D. Weiler Hospital of Montefiore Medical Center, an urban tertiary hospital in the Bronx, NY. Medical records within a registry of all neurologic consultations for acute headache in the antepartum, peripartum, and postpartum settings were reviewed for a 5-year period from July 1, 2009 through June 30, 2014. Headache diagnoses were made according to International Headache Society criteria⁵ where appropriate.

Standard protocol approvals, registrations, and patient consents

Our institutional review board approved the study, but the requirement for informed consent was waived because of the retrospective design.

RESULTS

Our review captured 182 patients in the antepartum, peripartum, or postpartum settings who were referred for acute headache, which included 3 patients with pneumocephalus (1.6%). During the same time period, we evaluated 15 patients with PDPH after lumbar anesthesia (8.2%), yielding a 5:1 ratio of PDPH to pneumocephalus.

Case reports

Case 1 A 30-year-old woman underwent lumbar epidural anesthesia for term delivery. Within seconds of lumbar needle manipulation, she experienced a sudden, explosive, maximal-at-onset right frontal headache and neck pain. Although there was no CSF return, the needle was repositioned and an epidural catheter was placed. Her headache was remarkably worse during recumbency but improved when she was upright. Several hours later, she had an uneventful, normal spontaneous vaginal delivery, but the following day her ongoing headache was complicated by neck stiffness and binocular vertical diplopia on leftward gaze. Her past medical history was notable only for infrequent migraine without aura.

She was afebrile and normotensive. General and neurologic examinations were notable for nuchal rigidity, mydriasis of the right pupil, mild right ptosis, and vertical diplopia on left gaze, consistent with a partial right third cranial nerve palsy.

Brain MRI revealed hypointensity on gradient-echo sequence (GRE) in the suprasellar cistern and in the frontal horn of the left lateral ventricle, confirmed to be air (pneumocephalus) on subsequent head CT (figure 1). The patient's headache and ophthalmoparesis resolved gradually with high-flow oxygen and nonsteroidal anti-inflammatory agents over the subsequent 2 days.

Case 2 A 32-year-old woman with no prior headache history received combined spinal and epidural anesthesia for term delivery. She reported an immediate, severe right frontotemporal

Figure 1 Case 1 imaging

Head CT without contrast (A) shows a small amount of subarachnoid air in the suprasellar cistern. Axial brain MRIs with gradient-echo sequence (B, C) reveal air in the left lateral ventricle and suprasellar cistern. Regions of air are noted with an asterisk.

headache radiating to the back of the head along with neck pain seconds after needle insertion into the intrathecal space. Headaches were worse when upright and improved when recumbent. She had an otherwise uneventful vaginal delivery.

She had normal blood pressure and was afebrile. She had decreased range of neck movements secondary to pain but the remainder of her neurologic examination was unremarkable. Brain MRI showed a small amount of subarachnoid air in the quadrigeminal cistern and along the right tentorium, which was confirmed on subsequent head CT (figure 2).

Her headache resolved with opioids, caffeine sodium benzoate, and cyclobenzaprine over 2 days.

Case 3 A 28-year-old woman with no prior headache history underwent lumbar epidural anesthesia for term delivery. Initial attempt for an epidural catheter placement was unsuccessful and resulted in a “wet tap” with CSF leakage. She reported sudden, maximal-at-onset holoccephalic headache within seconds of inadvertent intrathecal needle insertion. Her headache improved when lying recumbent and worsened when sitting up. She had an epidural catheter successfully placed several hours later and a subsequent uneventful vaginal delivery. Twenty minutes postpartum she developed lightheadedness and brief unresponsiveness in the setting of hypotension. Her past medical history was notable only for nephrolithiasis. Shortly after fluid resuscitation, she was afebrile and normotensive and her general and neurologic examinations were unremarkable.

Head CT without contrast revealed moderate intraventricular and small amount of subarachnoid air in the bilateral frontal horns of the lateral ventricles (figure 3). The patient’s headache resolved gradually with high-flow oxygen and acetaminophen over the next 2 days.

DISCUSSION

We encountered pneumocephalus as a rare cause of headache in the obstetrical setting. All 3 patients underwent lumbar anesthesia (epidural or combined spinal/epidural) in the upright position for term delivery and within seconds of needle insertion experienced a sudden, explosive, maximal-at-onset headache. Neuroimaging studies revealed air in the suprasellar cistern and left lateral ventricle in the first patient, in the quadrigeminal cistern in the second patient, and in the bilateral frontal horns of the lateral ventricles in the third patient.

The differential diagnosis of peripartum thunderclap headache includes reversible cerebral vasoconstriction syndrome, aneurysmal subarachnoid hemorrhage, cerebral venous thrombosis, cervical artery dissection, pituitary apoplexy, and pneumocephalus. Other less frequent

Figure 2 Case 2 imaging

Head CT without contrast (A) confirms a small amount of subarachnoid air in the quadrigeminal cistern. Axial brain MRIs with gradient-echo sequence (B, C) demonstrate air in the quadrigeminal cistern. Regions of air are noted with an asterisk.

causes may include spontaneous intracranial hypotension, intracranial infection, acute hypertensive crisis, ischemic stroke, and primary thunderclap headache.⁶

Pneumocephalus is defined as the presence of intracranial gas, including the intraventricular, intraparenchymal, subarachnoid, subdural, and epidural compartments. It is more commonly encountered in the setting of neurosurgical procedures or craniofacial trauma. Although rare, it can also be encountered after other invasive procedures, including lumbar puncture and spinal and epidural anesthesia. Few cases of pneumocephalus following accidental dural puncture during epidural anesthesia have been reported in the literature. They typically featured patients receiving epidural anesthesia while in the sitting position and experiencing immediate onset of headache after epidural catheter insertion that improved on lying recumbent.^{4,e1–e5}

Pneumocephalus following spinal or combined spinal/epidural anesthesia usually results from air injected into the intrathecal/subarachnoid space during use of the loss of resistance technique that is used to identify the epidural space.⁴ There has been no consensus on the use of air vs saline for this technique, although complications associated with the use of air include pneumocephalus, spinal cord and nerve root compression, retroperitoneal air,

Supplemental Data

Neurology.org/cp

Figure 3 Case 3 imaging

Head CT without contrast (A–C) shows a small amount of subarachnoid air in the bilateral frontal horns of the lateral ventricles (A, B), left sylvian fissure (A), and cerebral convexities (A, C). Regions of air are noted with an asterisk.

Once diagnosed, treatment with high concentrations of supplemental oxygen may hasten recovery, and in our patients the prognosis was excellent after early recognition.

subcutaneous emphysema, and venous air embolism, none of which are associated with the use of saline.⁷

Two main mechanisms have been postulated for the development of pneumocephalus in the context of lumbar anesthesia. The ball-valve theory posits that sneezing, coughing, valsalva maneuver, and other positive pressure events force air through a dural defect, which then resists the egress of air and, if significant, leads to tension pneumocephalus.⁸ In the inverted bottle theory, CSF drainage leads to a negative intracranial pressure gradient that may be relieved by the influx of air.⁹ The latter mechanism may be responsible in case 3, in which contemporaneous CSF leakage was confirmed.

The most common clinical presentations of pneumocephalus include headache, nausea, vomiting, seizures, dizziness, cranial nerve palsies, hemiparesis, and encephalopathy. Although the procedural risk factors (including operator experience) for a CSF leak and pneumocephalus may overlap, the clinical features may diverge (table). Headaches associated with pneumocephalus have a rapid onset, are severe, are typically worse or not relieved in recumbency, are sensitive to movement, and are attributed to cephalad migration of intracranial air with irritation of the intracranial meninges.^{7,10–12} PDPH has a later onset and the pain is relieved when the patient lies down but is provoked or worsens with sitting or standing.¹³

Diagnosis is by head CT, as it is most sensitive and specific to detect minimal quantities of intracranial air, which has a Hounsfield coefficient of $-1,000$.³ Air in the magnetic field has a low magnetic susceptibility, causing signal loss on T2 GRE on MRI.¹⁴ In 2 of our patients, immediate availability of MRI was used to exclude other causes of thunderclap headache, although in many clinical circumstances (as in our third patient) an emergent CT is most feasible and available.

Treatment of pneumocephalus with supplemental oxygen in the supine position is common, as reports have demonstrated accelerated resolution of intracranial air collections with its use.^{15,16} High oxygen concentration reduces the partial pressure of nitrogen, the main constituent of intracranial air collection, in the blood, creating a gradient for diffusion into the bloodstream.¹⁷ Hyperbaric oxygen therapy may also be useful in severe cases.¹⁸ In the era of pneumoencephalography, various medical therapies to treat postprocedure headache were used, including prophylactic or postprocedure corticosteroids, dihydroergotamine, aspirin, lorazepam, and desmopressin.^{e6–e12}

Our findings have clinical implications. Although thought to be rare, peripartum pneumocephalus may be more common than previously recognized and should be considered as an occasional etiology of headache following lumbar epidural/spinal anesthesia. Our patients with pneumocephalus had the defining characteristic of immediate thunderclap headache during manipulation in the lumbar region during attempted anesthesia. Clinical clues to the diagnosis that distinguish the syndrome from a CSF leak may include a severe headache at the initiation of epidural or epidural/spinal anesthesia rather than a delayed pattern and a headache that may not be relieved in recumbency, which could reflect air recirculation to structures that are particularly pain sensitive or obstruct CSF flow. Once diagnosed, treatment with high concentrations of supplemental oxygen may hasten recovery, and in our patients the prognosis was excellent after early recognition.

The strengths of our study include the capture of pneumocephalus cases with high clinical and radiographic detail within a registry of neurologic consultations for acute headache in the

Table Characteristic and distinguishing features of pneumocephalus and postdural puncture headache

Characteristic features	Pneumocephalus	Postdural puncture headache
Clinical presentation	Headache, nausea, vomiting, dizziness, cranial nerve palsies, hemiparesis, lethargy	Headache, nausea, vomiting, neck stiffness, visual changes, abducens palsy
Headache characteristics	Worse with movement and may not be relieved with recumbency or supine position	Worse on sitting up and improved on recumbency (orthostatic)
Onset after lumbar anesthesia	Immediate, thunderclap	Delayed (hours to days)
Quality	Thunderclap	Pressure
Severity	Maximum at onset	Mild to moderate at onset, ultimately progressive to severe
Duration	Days	Days or weeks
Treatment	100% oxygen	IV fluids, analgesics, caffeine, lumbar epidural blood patch
Imaging findings	Hypodensities in subarachnoid space (ventricles, cisterns) on CT and corresponding hypointensities on MRI gradient-echo sequences	Pachymeningeal enhancement on brain MRI, often with subdural fluid collections or hematomas, brain sag, and pituitary hyperemia

obstetrical setting. Rates of pneumocephalus and PDPH may be representative of neurologic consultation in the obstetrical setting within an urban tertiary care hospital. The ratio of PDPH to pneumocephalus may be underestimated because routine or typical cases of PDPH may not have prompted neurologic consultation. We also did not assess for the procedural experience of the anesthesiologists, which is a risk factor for both pneumocephalus and PDPH. Prospective studies to better capture the rates of pneumocephalus and PDPH in concert in the obstetrical population are indicated. Our report suggests that headache attributed to pneumocephalus may have a specific phenotype and is deserving of consideration for entry into the International Headache Society classification.⁵

REFERENCES

1. Nath G, Subrahmanyam M. Headache in the parturient: pathophysiology and management of postdural puncture headache. *J Obstet Anaesth Crit Care* 2011;1:57–66.
2. Flaatten H, Rodt S, Rosland J, Vamnes J. Postoperative headache in young patients after spinal anaesthesia. *Anaesthesia* 1987;42:202–205.
3. Schirmer MC, Heilman C, Bhardwaj A. Pneumocephalus: case illustrations and review. *Neurocrit Care* 2010;13:152–158.
4. Saberski LR, Kondamuri S, Osinubi OY. Identification of the epidural space: is loss of resistance to air a safe technique? A review of the complications related to the use of air. *Reg Anesth* 1997;22:3–15.
5. Headache Classification Committee of the International Headache Society (IHS). The International Classification of Headache Disorders, 3rd edition (beta version). *Cephalalgia* 2013;33:629–808.
6. Glover RL, Vollbracht S, Robbins MS. Headache rounds: acute postpartum headache. *Headache* 2014;54:1073–1084.
7. Nafiu OO, Urquhart JC. Pneumocephalus with headache complicating labour epidural analgesia: should we still be using air? *Int J Obstet Anesth* 2006;15:237–239.
8. Delgado JM, Ingley AP. Treatment of pneumocephalus after endoscopic sinus and microscopic skull base surgery. *Am J Otolaryngol* 2010;31:226–230.
9. Lunsford LD, Maroon JC, Sheptak PE, Albin MS. Subdural tension pneumocephalus: report of two cases. *J Neurosurg* 1979;50:525–527.
10. Simopoulos T, Peeters-Asdourian C. Pneumocephalus after cervical epidural steroid injection. *Anesth Analg* 2001;92:1576–1577.
11. Abram SE, Cherwenka RW. Transient headache immediately following epidural steroid injection. *Anesthesiology* 1979;50:461–462.
12. Ahlering JR, Brodsky JB. Headache immediately following attempted epidural analgesia in obstetrics. *Anesthesiology* 1980;52:100–101.

13. Benzon HT, Linde HW, Molloy RE, Brunner EA. Postdural puncture headache in patients with chronic pain. *Anesth Analg* 1980;59:772–774.
14. Yoon SJ, Oh GS, Lee SJ, Lee BR, Chun JU, Yu IK. Pneumocephalus in patients with orthostatic headache. *J Clin Neurol* 2008;4:89–93.
15. Gore PA, Maan H, Chang S, Pitt AM, Spetzler RF, Nakaji P. Normobaric oxygen therapy strategies in the treatment of postcraniotomy pneumocephalus. *J Neurosurg* 2008;108:926–929.
16. Kim YJ, Baik HJ, Kim JH, Jun JH. Pneumocephalus developed during epidural anesthesia for combined spinal-epidural anesthesia. *Korean J Pain* 2009;22:163–166.
17. Dexter F, Reasoner DK. Theoretical assessment of normobaric oxygen therapy to treat pneumocephalus. *Anesthesiology* 1996;84:442–447.
18. Paiva WS, de Andrade AF, Figueiredo EG, Amorim RL, Prudente M, Teixeira MJ. Effects of hyperbaric oxygenation therapy on symptomatic pneumocephalus. *Ther Clin Risk Manag* 2014;10:769–773.

AUTHOR CONTRIBUTIONS

S. Reddi acquired, analyzed, and interpreted the data and drafted, revised, and gave final approval to the manuscript. V. Honchar acquired, analyzed, and interpreted the data and revised and gave final approval to the manuscript. M.S. Robbins conceived and designed the study; acquired, analyzed, and interpreted the data; conducted the statistical analysis; and revised and gave final approval to the manuscript.

STUDY FUNDING

No targeted funding reported.

DISCLOSURES

S. Reddi and V. Honchar report no disclosures. M.S. Robbins serves on the editorial boards for *Headache* and *The Einstein Journal of Biology and Medicine*; is a section editor for *Current Pain and Headache Reports*; has received royalties for educational activities with the American Headache Society, American College of Physicians, Prova Education, SUNY Downstate, and North Shore-LIJ Hofstra School of Medicine; and receives book royalties for *Headache* (Neurology in Practice series) from Wiley (2013). Full disclosure form information provided by the authors is available with the **full text of this article at Neurology.org/cp**.

Related articles from AAN physician and patient resources

Neurology® Clinical Practice

Diagnostic and therapeutic spinal interventions: Epidural injections

August 2014;4:347–352.

Neurologic complications of anesthesia: A practical approach

August 2013;3:295–304.

Continuum® • ContinuumJournal.com

Neurologic Complications of Anesthesia

February 2011;17:134–147.