American Journal of Case Reports

e-ISSN 1941-5923
© Am J Case Rep, 2026; 27: e953059
DOI: 10.12659/AJCR.953059

Received: 2026.02.06
Accepted: 2026.05.15
Available online: 2026.07.23
Published: 2026.XX.XX

A Case of Pneumocephalus on Valsalva Maneuver: A Case Report and Literature Review

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Financial support: None declared
Conflict of interest: None declared

Patient: Female, 45-year-old
Final Diagnosis: Spontaneous pneumocephalus
Symptoms: Headache
Clinical Procedure: —
Specialty: Critical Care Medicine

Objective: Unusual clinical course

Background: Pneumocephalus is defined as the presence of air within the cranial cavity. Spontaneous onset is rare, with most cases arising secondary to head trauma or surgical procedures. The most common symptom is headache, a frequent concern in the emergency department, with a broad differential diagnosis. The diagnosis is based on a simple brain computed tomography (CT), while the etiological assessment involves magnetic resonance imaging (MRI) and consultation with otorhinolaryngologists. Most cases of pneumocephalus can be managed conservatively; however, some require urgent surgical intervention.

Case Report: We report the case of a 45-year-old woman with no history of recent trauma or neurosurgical procedures who developed a sudden-onset occipital headache following a Valsalva maneuver. The pain worsened with head movement. Neurological and otorhinolaryngological examinations were unremarkable. Brain CT revealed a small, isolated pneumocephalus localized to the posterior fossa. No anatomical defect was identified on CT and MRI. The patient was managed conservatively. Her symptoms progressively resolved, and follow-up imaging demonstrated spontaneous resorption of the intracranial air. The favorable course suggests spontaneous closure of a potentially Valsalva-induced intracranial sinus cavity.

Conclusions: This case highlights the importance of neuroimaging in patients presenting with atypical headaches in the emergency department. Despite its rarity, pneumocephalus remains an underrecognized condition in emergency medicine. In addition to describing an unusual presentation, this report includes a review of previously published cases of Valsalva-induced spontaneous pneumocephalus and contributes a further example to the limited literature on this subject.

Keywords: Emergency Medicine • Headache • Pneumocephalus • Valsalva Maneuver

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/953059

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Introduction

Pneumocephalus, also known as pneumocranium, is defined as the presence of air or gas within the cranial cavity. It is an uncommon condition, most frequently associated with trauma, neurosurgical procedures, infections, or otorhinolaryngological interventions. Spontaneous pneumocephalus is relatively rare, representing approximately 0.6% of all cases, and remains a poorly understood phenomenon [1]. Clinical manifestations vary according to the volume of intracranial air, its location, and the rapidity of onset. Headaches are the most common presenting symptom; however, confusion, lethargy, focal neurological deficits, meningeal signs, dizziness, nausea, and vomiting can also occur [2].

We describe the case of a patient who presented to the emergency department with an atypical headache following a Valsalva maneuver, ultimately diagnosed as pneumocephalus. Given the rarity of spontaneous pneumocephalus and its often non-specific clinical presentation, reporting this case together with a review of previously published cases adds to the existing literature and may assist clinicians in recognizing this uncommon condition, especially when triggered by a Valsalva maneuver.

Case Report

A 45-year-old woman presented at our emergency department with persistent headaches fol- lowing a Valsalva maneuver, which she had performed to relieve a sensation of ear fullness. The headache was constant, non-pulsatile, localized to the occipital region, and exacerbated by movement. She also reported photophobia but denied nausea or vomiting. Clinical examination, including a detailed neurological assessment, was unremarkable. The patient had a history of migraines with aura but described this headache as distinct from her usual migraine episodes. She had no other known past medical history and was not receiving any ongoing treatment.

A non-contrast brain CT scan revealed an isolated pneumocephalus in the posterior fossa, with no identifiable cause (such as sign of trauma or sinus pathology) (**Figure 1**). Given the risk of intracranial infection, empirical antibiotic therapy with amoxicillin/clavulanic acid was initiated but subsequently switched to clindamycin following an allergic reaction. She was admitted to the neurology department for observation. Brain magnetic resonance imaging (MRI) performed 2 days later demonstrated residual pneumocephalus beneath the tentorium cerebelli and in the cerebellopontine angle cisterns, but no evidence of fistula or petrous apex abnormalities. Spinal MRI and anterior rhinoscopy were also unremarkable.

Following multidisciplinary discussion, the leading hypothesis was a transient opening of an intracranial sinus-like cavity induced by the Valsalva maneuver, possibly due to a pre-existing weakness in the cavity wall. The favorable clinical and radiological evolution suggested spontaneous closure. At a follow-up consultation 6 weeks later, she remained asymptomatic except for persistent right ear fullness, with no otolaryngological abnormalities detected. Repeat brain CT confirmed complete resolution of the pneumocephalus.

Discussion

The first cases of pneumocephalus were reported after head trauma or surgery. In 1884, Chiari described pneumocephalus post-mortem in a patient with ethmoiditis induced by a forced Valsalva maneuver [3]. Since 1970s, the advent of the CT imaging has considerably improved its diagnosis.

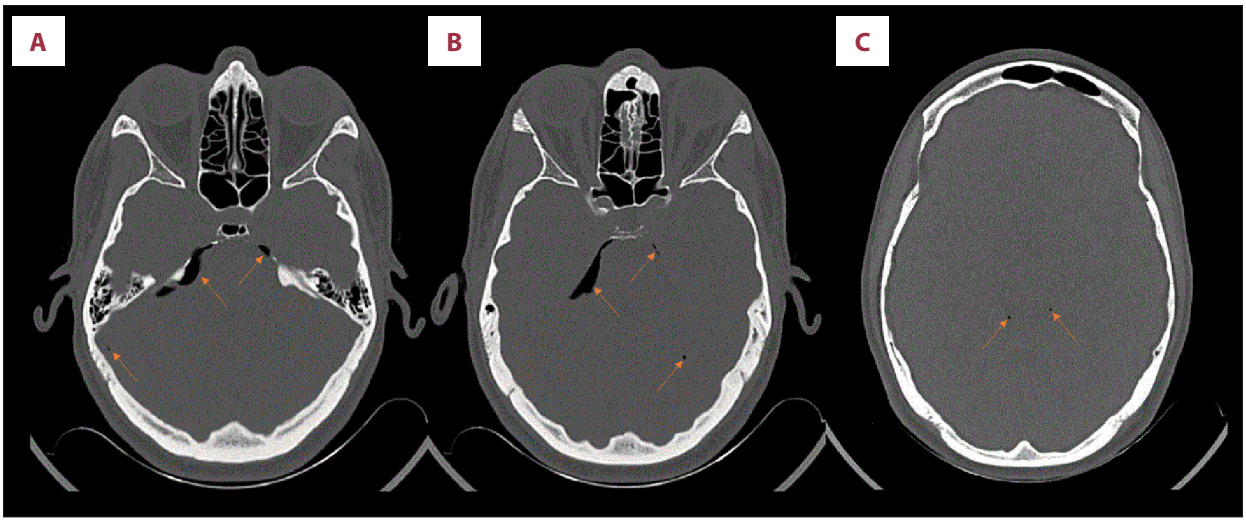

Figure 1. (**A-C**) Axial unenhanced CT on bone window showing pneumocephalus (arrows).

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The literature distinguishes several subtypes of spontaneous pneumocephalus, including tension and non-tension pneumocephalus, each with specific clinical implications and management. Non-tension pneumocephalus is usually asymptomatic and resolves spontaneously, whereas tension pneumocephalus is a rare but severe neurosurgical emergency caused by intracranial air exerting pressure on the brain parenchyma [4]. Pneumocephalus is also classified anatomically as extradural, subdural, subarachnoidal, intraparenchymal, or intraventricular [5]. Based on the clinical and radiological findings in this case, the pneumocephalus observed was intradural, specifically located in the posterior fossa beneath the tentorium cerebelli and within the cerebellopontine angle cisterns. In the absence of trauma, surgical intervention, or identifiable sinus pathology, and given the spontaneous resolution, this case corresponds to spontaneous non-tension pneumocephalus. Although some case reports describe pneumocephalus as minor, moderate, or massive, there is no clear classification based on volume [6]. The clinical significance lies in the physiological impact of intracranial air, particularly in cases of tension pneumocephalus, where mass effect can result in neurological deterioration.

Two mechanisms have been proposed to explain spontaneous pneumocephalus [7]:

1. Inverted Bottle Effect (Siphon effect): This occurs in situations of reduced intracranial pressure, such as from a dural leak or the presence of a cerebrospinal fluid shunt, allowing air to replace cerebrospinal fluid.
2. Ball-Valve Mechanism: This involves the entrapment of air within the intracranial compartment. For this to occur, there must first be a bony defect (typically in the temporal bone), providing communication between the mastoid cells to the intracranial space. Secondly, a pressure gradient between the middle ear and the intracranial space is required to facilitate air ingress. In susceptible individuals (eg, those with congenital defects of the tegmen tympani or marked hyperpneumatization of the mastoid air cells), increased middle ear pressure caused by actions such as nose blowing, sneezing, swallowing, coughing, or performing the Valsalva maneuver can generate a positive pressure differential, forcing air into the intracranial space.

The underlying mechanism of pneumocephalus in our patient corresponds to the ball-valve mechanism.

In most cases, non-tension pneumocephalus is asymptomatic and resolves spontaneously. However, some patients have sudden, severe headache, sometimes accompanied by nausea and vomiting. Cerebrospinal fluid rhinorrhea can also occur. Patients can present with neurological signs such as confusion, altered consciousness, or, less often, focal neurological deficits mimicking stroke. Seizures are rare but reported [8]. Additional symptoms can include otalgia, tinnitus, imbalance, and a sensation of aural fullness. Meningeal irritation signs may be found on examination. A rare but pathognomonic sign is a splashing sound synchronous with head movement [1], a cerebrospinal splash-like noise detectable during head movements, which indicates the coexistence of intracranial air and fluid.

The diagnosis of pneumocephalus is primarily based on imaging, with non-contrast CT as the gold standard. CT precisely visualizes intracranial air and its location, detecting volumes as small as 0.5 mL [9]. This high sensitivity is due to the marked density difference between air and brain tissue, allowing even very small volumes of pneumocephalus to be rapidly identified [6]. CT is also essential for assessing severity, particularly in identifying tension pneumocephalus, a neurosurgical emergency. In addition, CT helps exclude other urgent causes of sudden headache, such as subarachnoid hemorrhage. In our case, CT revealed a non-tension pneumocephalus with air confined to the posterior fossa, without skull fracture or sinus pathology. MRI is useful for follow-up but is less sensitive for intracranial air detection [6]. However, MRI is valuable for identifying underlying structural abnormalities, such as meningeal fistulas or skull base malformations. Other investigations can be relevant for establishing the underlying etiology. Cerebrospinal fluid leaks can be assessed by measuring biomarkers, particularly in nasal secretions [10]. In cases of high suspicion, when laboratory tests come back negative, MRI (or CT) cisternography with an intrathecal injection of gadolinium can be useful [11]. A detailed CT scan, such as one focused on the temporal bone, can be helpful in locating a bone defect, particularly in preparation for surgical treatment [10]. Multidisciplinary collaboration with otorhinolaryngologists is essential. Endoscopic examination and otogenic evaluation allow exclusion of a sinus lesion and identification of an otogenic source of pneumocephalus, respectively, particularly in cases of mastoid hyperpneumatization [12]. In our case, these otorhinolaryngology evaluations were performed.

Uncomplicated pneumocephalus is generally managed conservatively. Strict bed rest in the supine position is recommended to minimize intracranial pressure. High-flow oxygen therapy, delivered by a non-rebreather mask or other systems, promotes intracranial air resorption through a diffusion gradient mechanism, in accordance with Fick's law [13]. This often results in early clinical and radiological improvement. In severe cases, hyperbaric oxygen therapy may accelerate intracranial air reduction and symptoms relief [14]. Surgery is rarely required in cases of benign pneumocephalus. The indications for surgical management are tension pneumocephalus, failure of conservative treatment, and presence of a significant bony defect. Endoscopic endonasal surgery is the gold standard for treating anterior skull base leaks, with reported success rates exceeding 90% [15]. This minimally invasive approach relies on precise localization and exposure of the bony

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Table 1. Reported cases of spontaneous pneumocephalus due to Valsalva maneuver.

Authors (year) [Ref]	Etiology	Location	Symptoms	Location of air entry	Treatment
Maier (1996) [12]	Valsalva maneuver	Right parieto-temporo-occipital region, epidural	Headache, visual scotoma	Mastoid	Mastoidectomy seal
Babl (1999) [7]	Valsalva maneuver	Subarachnoid space	Headache	Sphenoid sinus	Surgery
Anorbe (2000) [19]	Valsalva maneuver	Right parieto-occipital region	Retroauricular swelling	Mastoid, petrous temporal bone	Surgical closure of the mastoid antrum
Schrijver (2003) [20]	Valsalva maneuver	Epidural	Asymptomatic	Mastoid	Conservative
Richards (2004) [10]	Coughing, sneezing, nose blowing	Extradural	Swelling in ear area, otalgia, cheek and jaw pain/paresthesia	Mastoid	Mastoidectomy seal
Tucker (2008) [21]	Nose blowing	Epidural	Headache, nausea	Mastoid	Surgery
Singh (2010) [22]	Valsalva maneuver	Left middle cranial fossa	Confusion	Tegmen tympani, temporal bone	Conservative
Mohammed (2011) [5]	Sneezing, nose blowing	Extradural	Headache	Temporal bone	Conservative
Rabello (2013) [23]	Valsalva maneuver	Extradural, parietal region	Aural fullness, nasal obstruction and pruritus, headache	Mastoid	Conservative
Mirone (2015) [24]	Nose blowing	Intraparenchymal, left frontal lobe	Loss of consciousness, hemiparesis, anosmia	Ethmoid sinus	Surgery
Pishbin (2015) [25]	Coughing	Intracranial, disseminated	Headache, nausea	Pneumosinus dilatans	Conservative
Baba (2016) [26]	Sneezing	Extra-axial, right cerebral hemisphere	Headache, rhinorrhea	Sphenoid sinus	Surgery
Wu (2018) [27]	Sneezing	Left occipital lobe	Headache, dizziness, epistaxis, tinnitus, otorrhea	Mastoid	Conservative
Boninsegna (2019) [28]	Nose blowing	Subdural and intraventricular	Headache	Cribriform plate	Surgery

defect, followed by multilayer reconstruction using autologous grafts. For larger defects, vascularized pedicled flaps improve repair durability and reduce recurrence risk. For temporal bone defects—particularly involving the tegmen tympani or squamous portion—a middle cranial fossa approach may be indicated. This involves a craniotomy with extradural exposure to identify bony and dural defects, followed by multilayer dural repair and reconstruction. In emergency situations, especially with tension intraventricular pneumocephalus, ventriculostomy may be required for rapid intracranial decompression prior to definitive surgical repair [16].

In most cases, pneumocephalus resolves spontaneously. Air resorption typically occurs within a few days to 2 to 3 weeks, especially when the air volume is small and no fistula persists. There are no clear recommendations regarding the duration of follow-up in cases managed conservatively. However, the available literature consistently supports close clinical and radiological monitoring. Spontaneous resolution occurs in approximately 80% to 90% of reported cases without complications or severity factors. Prognosis depends on the underlying etiology. Spontaneous or infectious forms may have a poorer outcome, particularly if diagnosis and treatment is delayed. The most

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serious complication is tension pneumocephalus (< 5% of cases), which can lead to rapid neurological deterioration, requiring urgent surgical intervention [17]. Other complications include infections (meningitis or brain abscesses), reported in 5% to 10% of cases, especially in post-traumatic or postoperative pneumocephalus associated with a dural breach [18]. This explains why our patient initially received antibiotic prophylaxis.

Spontaneous intracerebral pneumocephalus of otogenic origin is a rare condition, with to our knowledge only 14 cases reported in the medical literature. We conducted a literature search to identify cases of spontaneous pneumocephalus induced by Valsalva maneuver. The search was performed in PubMed up to October 2024. We used the keywords "spontaneous pneumocephalus", "Valsalva maneuver", and "nontraumatic pneumocephalus". References cited within the selected papers were also reviewed to identify additional relevant reports. This cases of spontaneous intracerebral pneumocephalus of otogenic origin are listed in **Table 1**.

Conclusions

Pneumocephalus often remains undetected due to its non-specific clinical presentation. The advent of CT has significantly improved diagnosis accuracy, allowing rapid detection and precise localization of intracranial air. This case of pneumocephalus following a Valsalva maneuver illustrates the importance of prompt recognition and diagnosis to ensure appropriate management. Our case adds to the limited literature on spontaneous pneumocephalus and highlights the potential for spontaneous resolution in selected cases. It also underscores the importance of multidisciplinary management and close clinical and radiological follow-up. However, within the limited literature on this topic, the mechanisms underlying the development of spontaneous pneumocephalus remain unclear and warrant further investigation in future studies.

Department and Institution Where Work Was Done

Emergency Department, CHU (Centre Hospitalier Universitaire) UCLouvain (Université catholique de Louvain) Namur-Godinne, Belgium.

Consent for Publication

The patient gave his written content for all part of the material referenced here.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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