

Frontal Sinus Barotrauma in an Airliner Passenger with Undiagnosed Allergic Rhinitis

Marn Joon Park; Seo Jun Kang; Gyu Tae Kim; Sungryeal Kim

BACKGROUND: Sinus barotrauma, or arosinusitis, occurs during rapid atmospheric changes in aviation, primarily affecting the frontal sinus. Mucosal swelling from a cold or allergic rhinitis (AR) can obstruct pressure equalization, leading to mucosal tears, cranial pain, and nasal bleeding. Despite its significance in aerospace medicine, high-quality imaging, nasal endoscopy, long-term outcomes, and the impact of AR management on sinus barotrauma remain inadequately documented in the literature.

CASE REPORT: A 29-yr-old healthy male healthcare provider experienced severe frontal sinus barotrauma during aircraft descent, presenting with intense frontal headache, ocular pain, and left epistaxis, with head computed tomography revealing a fully opacified left frontal sinus. Despite experiencing persistent severe AR symptoms daily, he had never been diagnosed or treated for AR, and his symptoms worsened during the flight. The clinical presentations and image findings suggested a diagnosis of frontal sinus barotrauma. His initial treatment included oral decongestants, antihistamines, and acetaminophen. Remarkably, follow-up computed tomography/magnetic resonance images over 2 wk, 1 mo, and 1 yr demonstrated the spontaneous resorption of the submucosal hemorrhage in the frontal sinus. Furthermore, though concurrently diagnosed with perennial AR due to house dust mite and cat fur sensitization, the patient's effective pharmacological management of AR symptoms led to an uneventful flight 1 yr later.

DISCUSSION: This case demonstrates that submucosal hemorrhages in the affected sinus generally resolve spontaneously within a year. Also, it highlights the critical need for diagnosing and managing sinonasal disorders in symptomatic individuals before flights to prevent sinus barotrauma.

KEYWORDS: paranasal sinus, frontal sinus, barosinusitis, barotrauma, arosinusitis.

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Sinus barotrauma, also referred to as barosinusitis or arosinusitis, is a clinical condition characterized by sudden epistaxis or severe pain in the head, brow, eye, forehead, tooth, or face. Among the four paranasal sinuses, the maxillary, ethmoidal, frontal, and sphenoid, the frontal sinus is most vulnerable to developing sinus barotrauma due to its narrow and long natural outflow tract.¹ Common sinonasal disorders such as allergic rhinitis (AR) or upper respiratory infections (common cold) can exacerbate this vulnerability by causing mucosal swelling, which further narrows and obstructs the already constricted drainage pathway.^{2,3} This mucosal swelling in the frontal sinus outflow tract impedes air from equalizing the pressure gradient between the sinus and external atmospheric pressure, often leading to a “rupture” or “tearing” of the mucosa that covers the affected frontal sinus, detaching the mucosa from the sinus bony wall during rapid pressure changes.² As the mucosa

is “torn” or “ripped” from the sinus bony wall during these events, this can result in the development of submucosal hemorrhages, visible on head imaging, and can also cause bloody nasal discharge and bloody postnasal drips in barosinusitis patients.^{2,4}

While submucosal hematomas associated with sinus barotrauma are reported to spontaneously decrease in size over

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time, as noted in one case report where the decreased hematoma was observed in a 2-mo follow-up magnetic resonance (MR) image, the comprehensive natural course and duration of complete resorption of these hemorrhages remain undocumented in the medical literature to date.⁴ Moreover, although numerous studies and review articles have indicated a correlation between various sinonasal disorders that can cause mucosal swelling, as a potential risk factor for developing sinus barotrauma, there is a lack of detailed case reports elucidating the association with AR and revealing the impact of AR treatment on the prevention of sinus barotrauma.⁵

Herein we report a case of severe frontal sinus barotrauma that occurred during the descent of a commercial airliner in a patient with previously undiagnosed and untreated AR, despite having symptoms of AR. This case report encompasses the patient's history, clinical presentations, high-resolution computed tomography (CT)/MR and nasal endoscopy images, and long-term imaging surveillance up to 1 yr. It further demonstrates that effectively managing AR with pharmacological treatments can result in uneventful subsequent flights. This case highlights the critical importance of diagnosing and managing sinonasal disorders, including AR, in symptomatic individuals before flying to minimize the risk of developing sinonasal mucosal swelling and thus preventing sinus barotrauma.

CASE REPORT

This investigation was approved by the institutional review board of the Inha University Hospital (Investigation No. 2023-02-014). The institutional review board approved a waiver of the informed consent due to the retrospective design of the study and noninclusion of any personally identifiable information.

A previously healthy 29-yr-old man who worked as a health-care provider was referred to the otorhinolaryngology clinic

following a visit to the emergency department due to severe frontal headache and left ocular pain accompanied by left-sided epistaxis. Upon taking his history, the patient reported year-round, persistent symptoms of alternating nasal obstruction and watery rhinorrhea, which suggested the presence of AR, although it had not been diagnosed or treated.

On the day of his flight, the patient did not experience any symptoms suggestive of a recent history of upper respiratory infection, such as sore throat, myalgia, fever, or cough. However, he recalled that his nasal cavity felt completely congested on both sides, with frequent sneezing upon boarding and throughout the flight. The patient was on a commercial aviation airliner when his symptoms developed immediately upon the aircraft's descent.

The initial head CT image (**Fig. 1**) showed no intracranial lesions; however, an opacification filling his left frontal sinus was noticed (**Fig. 1A**). Nasal endoscopy (**Fig. 2**) revealed a mildly deviated septum to the left, mucoid discharge, and diffuse mucosal swelling in both nasal cavities, with the inferior turbinates being most severely swollen, pale, and hypertrophied (**Fig. 2A**). Remarkably, the patient's left middle meatus, where the frontal sinus drains, was severely edematous and showed pooling of bloody-serosanguinous discharge (**Fig. 1B**) on nasal endoscopy. These findings strongly suggested a diagnosis of severe sinus barotrauma in his left frontal sinus. Additionally, the patient reported constant symptoms of nasal congestion, watery rhinorrhea, sneezing, and nasal itching, all indicative of an AR. Since the pain and epistaxis decreased a little bit within a few hours, the patient was discharged with 1 wk of oral decongestants, antihistamines, and acetaminophen for pain relief, and he reported that his pain and bloody nasal discharge and postnasal drips gradually decreased over a few days.

Two weeks after the initial visit, the patient's symptoms had significantly improved, with reduced frontal sinus opacification on CT (**Fig. 3A**), confirming acute sinus barotrauma. It was classified as class 3 acute frontal sinus barotrauma, as by

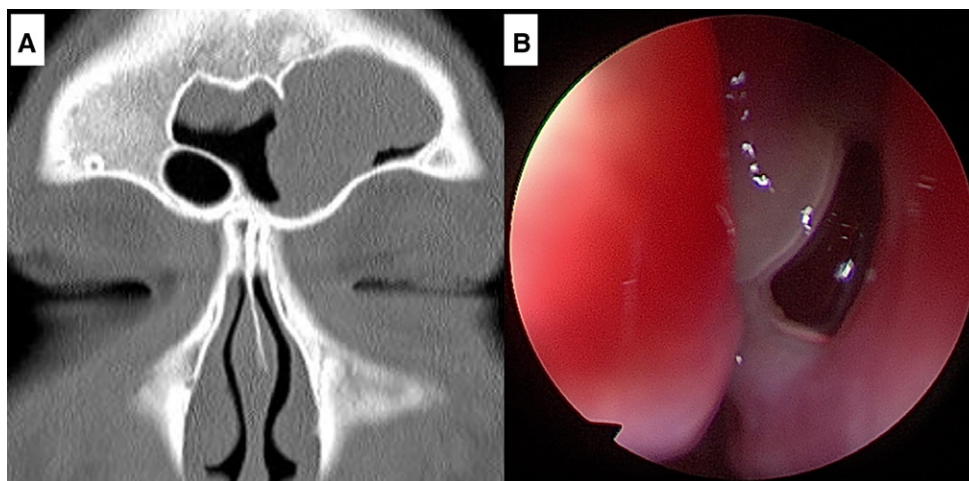


Fig. 1. Initial head CT and nasal endoscopy images of an acute left frontal sinus barotrauma/barosinusitis/aerosinusitis. A) Initial head CT image showing an opacification in the left frontal sinus. B) Nasal endoscopy image of the left middle meatus showing a severe mucosal swelling with serosanguinous discharge drained from the left frontal sinus.

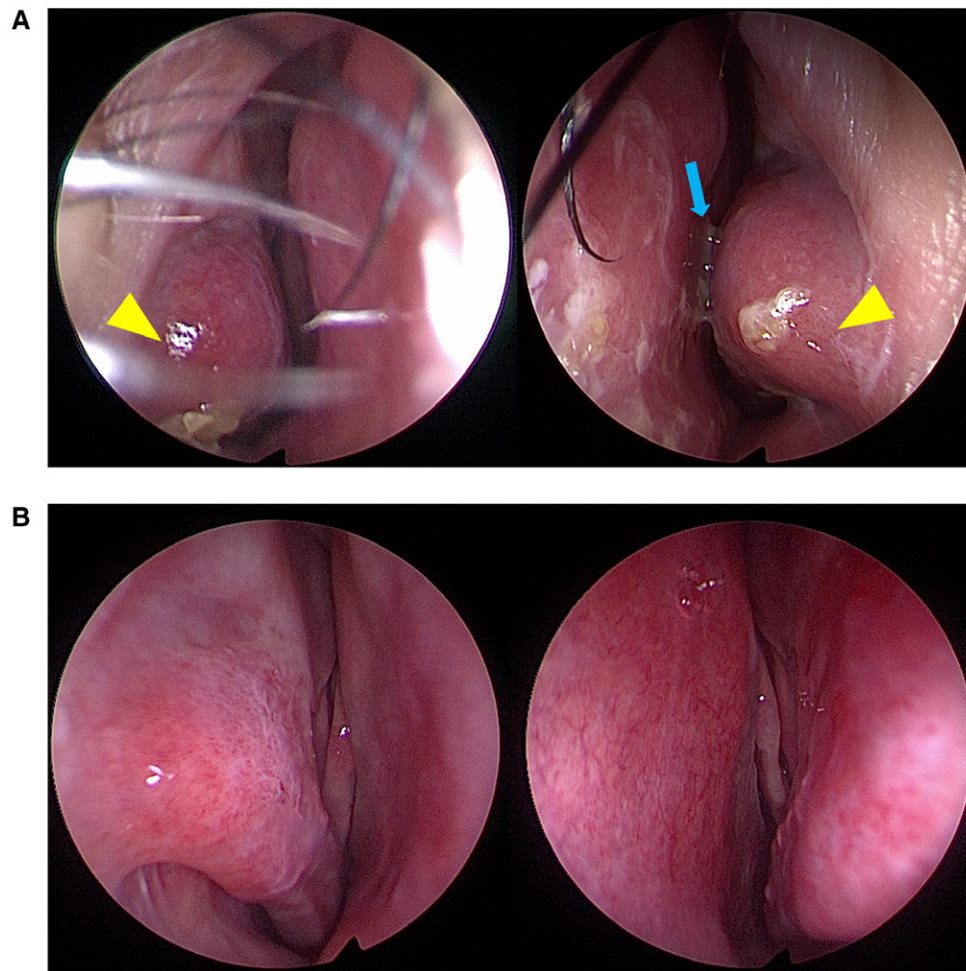


Fig. 2. Initial and 1-yr follow-up nasal endoscopy images. A) Initial nasal endoscopy of both nasal cavities demonstrating a typical nasal endoscopy finding in an AR patient with swelling of the inferior turbinate bilaterally (yellow arrowheads), making the nasal airway narrow, pale mucosa due to swelling, and watery to mucoid discharge (blue arrow). B) With an appropriate pharmacological management for AR, the turbinate swelling is reduced, with no secretions and pale mucosa, as well as the wider and patent nasal airway.

definition it was a single incident with symptoms persisting >24 h with complete sinus opacification on imaging.^{2,5}

Furthermore, the patient's serum allergen-specific immunoglobulin E assay revealed sensitization to house dust mite

allergens and cat fur, confirming the diagnosis of perennial AR due to house dust mite and cat fur indoor aeroallergens. The patient then received medical treatment with intranasal corticosteroids and oral antihistamines, complemented by



Fig. 3. Gradual and spontaneous resorption of submucosal hemorrhage/hematoma due to the frontal sinus barotrauma over 1-yr follow-up images. A) Head CT image on 2-wk follow-up. B) Head-MR image on 1-mo follow-up. C) Head-MR image on 1-yr follow-up showing a completely resolved submucosal hematoma in the left frontal sinus.

nasal rinsing, allergen avoidance, and indoor environmental control.⁶ He responded very well to the treatment and achieved good control of his symptoms.

On the head MR imaging at the 1-mo follow-up, it was confirmed that the opacification in his left frontal sinus was consistent with a submucosal hemorrhage and hematoma, characterized by high T1 and T2 signals without contrast enhancement (**Fig. 3B**). As the imaging showed gradual resorption of the submucosal hemorrhage over time, the patient was presented with the option of undergoing functional endoscopic sinus surgery (FESS) to widen the natural drainage pathway of the frontal sinus, thereby aiming to prevent relapsing symptoms due to pressure changes during aviation travel.^{7,8} However, as the initial symptoms had significantly subsided and the patient had no immediate plans for future flights, the decision was made to defer surgery and continue with the pharmacological management of AR.

At the 1-yr follow-up visit, the patient's head MR image showed complete resolution of the submucosal hemorrhage in the left frontal sinus (**Fig. 3C**), and the narrowed frontal sinus outflow due to mucosal swelling shown on the initial CT image (**Fig. 4A**) became patent, as the mucosal swelling was no longer prominent (**Fig. 4B**). Given that the patient's AR was effectively managed with pharmacological therapy, he was advised to maintain his treatment regimen. Additionally, he was cleared to travel on commercial airliners, with specific precautions recommended by the authors. Specifically, he was prescribed with an oxymetazoline topical nasal decongestant spray and instructed to apply it 30 min before ascent and descent, but only if he experienced AR symptoms or nasal congestion prior to boarding. This protocol was implemented to ensure the patient's safety and prevent recurring sinus barotrauma events. Nonetheless, at his last visit, the patient reported an uneventful flight and noted no symptoms or signs of barosinusitis or AR during subsequent travel, without even needing to use the prescribed topical nasal decongestants.

DISCUSSION

In patients experiencing sinonasal mucosal swelling, specifically secondary to AR or upper respiratory infections, narrowing of the frontal sinus outflow tract due to mucosal edema may predispose them to frontal sinus barotrauma during both ascent and descent phases of air travel.⁷ During ascent, elevated positive intranasal pressure can become trapped within the obstructed sinus, exerting expansive force against the sinus walls, a phenomenon termed “reverse squeeze.”² Conversely, during descent, negative pressure develops within the sinus, potentially causing mucosal “detachment” or “tearing” from the bony sinus walls if air entry remains obstructed.² Previous studies have consistently demonstrated that sinus barotrauma occurs more frequently and with greater severity during aircraft descent compared to ascent, which aligns with our clinical observations, wherein the patient experienced significantly exacerbated pain and submucosal hemorrhage secondary to negative pressure-induced mucosal injury during descent.^{2,3,7}

Hence, to prevent barosinusitis, it is crucial to assess and treat conditions that may cause sinonasal mucosal swelling before boarding an aircraft.^{2,5} Mucosal swelling is a reversible physiological response, either due to dilation of the arterioles and capillary vessels in the nasal mucosa's erectile tissues or to inflammatory cytokines released by local inflammatory cells.⁶ Therefore, if an individual notices symptoms of nasal congestion prior to boarding or during ascent or descent, such as from a common cold or an abrupt allergic reaction, taking oral or topical (nasal) decongestants can help minimize the risk of developing sinus barotrauma. However, these decongestants should be used with caution due to their potential adverse effects.⁹ Oral decongestants, typically containing alpha- and beta-adrenergic agonists such as phenylephrine or pseudoephedrine, relieve nasal mucosal congestion via vasoconstriction but may elevate systemic blood pressure.¹⁰ Topical decongestants, primarily potent alpha-adrenergic agonists (phenylephrine or oxymetazoline), rapidly reduce

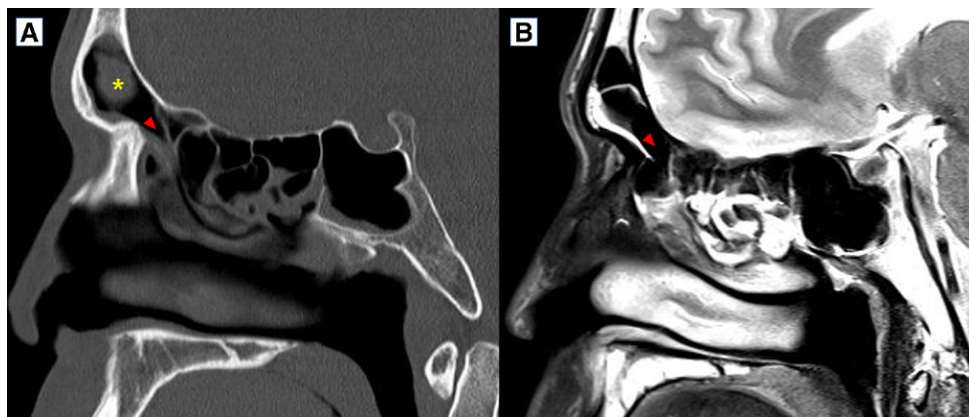


Fig. 4. Changes in the frontal sinus outflow tract patency following AR treatment. A) Upon initial visit, the patient's left frontal sinus outflow tract is obliterated with mucosa edema/swelling (red arrowhead), thus causing a frontal sinus barotrauma and submucosal hemorrhage (asterisk). B) On 1-yr MR image, with the appropriate management of the AR, the frontal sinus outflow tract mucosal edema was eliminated (red arrowhead), thus making the outflow tract patent and enabling air passage for pressure equalization.

mucosal swelling but carry risks of rebound congestion and rhinitis medicamentosa if used beyond 1 wk and may adversely affect systemic blood pressure.¹⁰ Therefore, routine use should be avoided in patients with cardiovascular disease, hypertension, or benign prostatic hypertrophy, reserving them for acute, short-term symptom relief, such as prior to air travel.

Our patient had severe, persistent symptoms of AR, rhinorrhea, sneezing, itching, and nasal obstruction, with year-round symptoms, yet it was not diagnosed, assessed, or treated prior to the barotrauma event. Moreover, our patient experienced worsening AR symptoms, suggesting in-flight aeroallergen provocation, likely from house dust mites, in a sensitized nasal mucosa. Allergic inflammation of the sinonasal mucosa induced severe mucosal swelling, leading to obstruction of the frontal recess and impaired pressure equalization, thereby creating a pressure gradient that resulted in tearing and hemorrhage of the frontal sinus mucosa, the underlying pathophysiology of sinus barotrauma. In such patients, accurate assessment of AR to identify the causative allergen, coupled with environmental control measures and a nasal rinsing on a daily basis, as well as routine pharmacological treatment with an intranasal corticosteroid and adjunctive oral antihistamines, significantly mitigates sinonasal mucosal swelling and prevents the development of sinus barotrauma, even without the need for systemic or topical decongestants.⁶ However, in cases where AR control is inadequate with conservative management, an adjunctive surgical option such as inferior turbinoplasty, which aims to reduce the volume and reactivity of the inferior turbinate, may be considered.¹¹ Nevertheless, our patient showed very good compliance to medication and well tolerated pharmacological therapy; thus, the turbinate surgery for the alleviation of AR symptoms was not performed.

Since our patient exhibited significant improvement of sinus barotrauma symptoms following conservative management, surgical intervention with FESS, which involves removal of bony partitions and drilling to widen the narrow frontal sinus drainage pathway, was not initially recommended.¹² However, the patient was counseled regarding surgical options in the event of persistent or recurrent barosinusitis. Notably, even after a single severe episode, FESS is strongly advised for pilots, aircrew, or frequent flyers due to safety concerns related to recurrent sinus barotrauma and because surgical intervention effectively reduces recurrence risk and ensures optimal aviation safety.^{2,7,8}

One of the notable and novel findings in our case report was the spontaneous resolution of frontal sinus opacification, initially resulting from submucosal hemorrhage secondary to sinus barotrauma, observed over a 1-yr follow-up period. In terms of a large submucosal hemorrhage filling the affected sinus as observed in our patient, it is widely recognized that such hematomas may spontaneously resorb over time.⁴ However, the literature has not reported the exact duration required for complete resorption, nor has it provided long-term

follow-up CT or MR images 1-yr postbarosinusitis.⁴ While it has been documented that frontal sinus submucosal hemorrhages gradually resorb, as confirmed by MR imaging, these images typically show a decreased but still persistent hematoma at 2 mo post-event, suggesting that a longer period is necessary for full resolution.⁴ Our case contributes novel evidence to the field, with imaging that reveals a completely resolved submucosal hematoma at the 1-yr follow-up. This case underscores that while the resolution of submucosal hemorrhage following sinus barotrauma is gradual, it can eventually be complete.

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