# You're the Flight Surgeon

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You are the flight surgeon at an installation without on-base emergency services. At approximately 01:00 the on-call phone rings with an urgent message from the squadron step desk. A student weapon systems officer has experienced severe frontal sinus pain, causing early termination of the sortie. You are asked to meet the crew at the step desk.

Upon arrival at the step desk, your patient is a 25-yr-old man with no past medical history. He tells you that on initial climb out, the B1 crew reached a cabin altitude of just over 16,000 ft (4877 m) when they discovered that a slow depressurization was occurring in the cabin. The patient reset the dump valve in an attempt to stabilize the cabin pressure and this caused the cabin altitude to drop instantaneously to 6000 ft (1829 m). The patient went on to report that this sudden repressurization seemed to "jar his sinuses," and he began to feel frontal sinus pressure, but no pain. The B1 ascended in an attempt to reach an asymptomatic elevation, but this did not relieve the patient's symptoms. As the B1 descended into home base, the patient stated that his sinus pressure began to migrate from his paranasal sinuses to behind both of his eyes. The pressure was accompanied with extreme, debilitating pain (9/10). He denied headache, dizziness, or changes in vision. He self-administered intranasal oxymetazoline, which offered partial relief of his symptoms. On exam he appears uncomfortable and his forehead is tender to palpation. Both tympanic membranes are intact with no evidence of blood or fluid. He states that he is unable to clear his right ear. There is no epistaxis.

## 1. What is the best, initial course of action?

- A. Prescribe ibuprofen 800 mg three times a day as needed for pain with nasal saline irrigation twice a day.
- B. Reassure the patient that now that he's landed, the pain will resolve on its own.
- C. Prescribe a 1-wk course of intranasal oxymetazoline, oral decongestants, analgesics, and a course of steroids.
- D. Obtain an immediate noncontrast computerized axial tomography scan of the sinuses.

## ANSWER/DISCUSSION

**1. C.** Sinus barotrauma, or aerosinusitis, is the inflammation of one or more of the paranasal sinuses caused by a pressure gradient between

the sinus cavity and the ambient environment.<sup>14</sup> The sinus system is equipped with ostia that allow for the free passage of air between the sinuses and nasal cavity and, ultimately, the environment so that a pressure equilibrium can be maintained.

Boyle's law states that the volume of gas in an enclosed space is inversely proportional to the pressure exerted on it.<sup>11</sup> As an aircraft ascends into the atmosphere, atmospheric pressure begins to fall. The reduction in air pressure leads to the expansion of gases within body cavities such as the sinuses. During descent, atmospheric pressure increases and gases within body cavities begin to compress.

Multiple organs normally contain air. In healthy, easily distensible organs such as the lung or bowel, changes in atmospheric pressure are usually of no consequence because of the organs' elastic properties and their spacious location within the chest and abdomen. The sinus cavities, however, are encased in bone, which does not allow for distention.

Sinus barotrauma is the result of sinus ostia compromise, which can be caused by infection, inflammation, or mechanical obstruction. When the ostia are compromised, air cannot passively move through the sinuses from areas of higher to lower pressure.<sup>9</sup>

For aviators who experience sinus barotrauma in flight, management includes ascending to an altitude that relieves the symptoms, administrating topical nasal decongestants, and performing the Valsalva maneuver to equalize the pressure across the sinuses. Once the pain has resolved, a slow descent can usually prevent further symptoms.

Many patients with sinus barotrauma will present with pain over the frontal (97%) and/or maxillary sinuses. The ethmoid and sphenoid sinuses are rarely implicated as the source of pain. The pain is often described as a sensation of pressure or tightness over the affected sinus.<sup>2</sup> Bloody rhinorrhea will be experienced by 13% to 58% of patients.<sup>14</sup> Pain in the retro-orbit or maxillary dentition can also be experienced. In some, there is pain with palpation of the sinuses, or with sudden changes in head position.

Once the patient with acute sinus barotrauma has landed, typical treatment includes a 1-wk course of nasal and oral decongestants, analgesics, and a tapering course of steroids. Intranasal glucocorticoids should be used as first-line treatment to suppress possible polypoid disease and to prevent the formation of future polyps. If a diagnosis of nasal polyposis is made and polyps are severe or refractory to

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intranasal glucocorticoids, oral glucocorticoids can be used.<sup>6,14</sup> A diagnosis of intranasal polyps should also prompt a referral to otolaryngology for etiology determination and management input.

After making the diagnosis of sinus barotrauma and explaining the treatment plan to the patient, you restrict him from flying duties. You also tell him to continue ibuprofen and intranasal oxymetazoline as needed overnight and follow up with you in the morning to receive the remaining prescriptions. The patient follows up as instructed and begins oral pseudoephedrine, analgesics, and intranasal steroids. The patient presents during morning sick call 6 d later for continued sinus pain. He has not had any improvement in his ability to perform the Valsalva maneuver and now, whenever he blows his nose, he suffers from brisk epistaxis for 2–3 min. On physical exam of the nares, you are unable to visualize an active source of bleeding.

### 2. What should you do next?

- A. Recommend nasal irrigation with saline.
- B. Increase the dose and duration of oral pseudoephedrine.
- C. Obtain a noncontrast computerized axial tomography (CT) scan of the sinuses.
- D. Provide the patient with nasal packing materials and tell him not to blow his nose.

## ANSWER/DISCUSSION

**2. C.** During descent, the air within the sinuses contracts. If the sinus ostium is obstructed because of redundant mucosa, polyp, tumor, or thick mucoid secretions, air cannot flow into the ostium, resulting in a negative pressure vacuum. This vacuum effect may stress the mucosal lining to such a degree that mucosal edema, serosanguinous exudate, or submucosal hematoma may result, leading to brisk epistaxis.<sup>14</sup> In the case of our aviator, rapid repressurization led to an increase in cabin pressure, resulting in contraction of air within the sinus cavities.

Conversely, during ascent, air expands and the excessive pressure that develops within the sinuses usually escapes through the sinus ostia. As an example, if the maxillary ostium is blocked because of mucosal edema from an upper respiratory tract infection (URI), air cannot escape through the ostium and the positive pressure within the sinus continues to increase. The pressurized air will eventually dissect into the surrounding tissues, following the path of least resistance.<sup>14</sup>

The diagnosis of sinus barotrauma is made clinically based on the history and physical exam. Physical exam features may be prominent depending on the degree of trauma. A CT scan of the sinuses can be used to assess for fluid, blockages, and anatomic abnormalities that may increase the likelihood of sinus ostia obstruction. For those clinicians who choose plain films of the sinuses as their initial imaging modality, the Weissmann Classification can be used to stage the severity of sinus barotrauma (**Table I**).<sup>14</sup>

The aviator's noncontrast CT scan of the sinuses reveals air-fluid levels, mucosal edema, and soft tissue densities.

#### 3. What should you do with this new information?

A. Refer to otolaryngology (ENT).

B. Begin an H-1 antagonist.

- C. Start an antibiotic from the penicillin class.
- D. Instruct the patient to perform nasal irrigation more aggressively.
- E. A and C.

Table I. Weissmann Classification

CLASS	SYMPTOMS	PLAIN FILMS	PATHOLOGY
	Transient discomfort	Normal	Slight swelling
II	<24 h of pain	Mucosal thickening	Serosanguinous rhinorrhea
	Severe pain (squeeze only)	Obliterated sinus	Hematoma/mucosal avulsion

## ANSWER/DISCUSSION

3. E. Risk factors for the development of sinus barotrauma include active URI, allergic rhinitis, nasal polyposis, tumors of the sinuses or nasal cavity, and a previous history of sinus barotrauma.<sup>14</sup> Although our aviator did not have a history of recent URI, antibiotics can be used to prevent secondary infection. Antibiotic treatment may result in the selection of resistant organisms, so care must be taken if antibiotic treatment is pursued. The traumatized mucosa can be a source of bacterial growth due to the inability to clear secretions, the blood and transudate that is present, and the altered oxygen tension. Antibiotics are also used in cases where bacterial sinusitis is thought to be the inciting cause. Amoxicillin is considered the first-line therapy because of its narrow spectrum and low cost. There has been increasing antimicrobial resistance to amoxicillin, so the addition of clavulanate improves coverage for resistant bacterial strains. In patients who are allergic to penicillins, doxycycline is a good alternative. Streptococcus pneumoniae is highly resistant to macrolides and secondor third-generation cephalosporins, so these medications are not recommended for empiric therapy. In the setting of bacterial sinusitis, trimethoprim-sulfamethoxazole is also not recommended as an empiric therapy because of high rates of Haemophilus influenzae resistance.1

Antihistamines may be helpful in cases that are associated with allergic rhinitis because they decrease the vasodilation and vascular permeability of mucosal vasculature; our aviator does not have a past medical history of allergies, so this treatment is not indicated.

If oral medications fail to resolve pain and pressure, referral to ENT is indicated for the performance of procedural techniques designed to reestablish ventilation and mucociliary clearance of the sinuses.<sup>4</sup> Anatomic derangements are also managed by removing areas of disease and lesions such as polyps.<sup>10</sup> Sinus polyps can cause mechanical blockage of the ostia, leading to sinus barotrauma. Functional endoscopic sinus surgery is a technique that has been used with great success to treat sinus barotrauma by establishing drainage pathways.<sup>7</sup> Balloon sinuplasty is a catheter-based technique used to dilate the sinus ostia to create ventilation and drainage. It is often used as an adjunct to functional endoscopic sinus surgery, creating a "hybrid" procedure.<sup>12</sup>

To decrease the chances of a secondary bacterial infection, you prescribe a 7-d course of amoxicillin-clavulanate and refer the patient to ENT. During intranasal examination by ENT, polypoid mucosal changes were seen. Balloon sinuplasty of the frontal sinus ostia was

# **AEROMEDICAL DISPOSITION**

Sinus barotrauma is a pathological state that can occur to any patient exposed to pressure changes, most notably in aviators and deep sea divers. In the flying population, the highest rates of significant sinus barotrauma occur during hypobaric training for military recruits and flight surgeons (1.5-4%).<sup>14</sup>

After an episode of sinus barotrauma, 92% of aviators continue flying duties without recurrence. Current Air Force guidance does not require a waiver for a history of sinus barotrauma, but cases of severe and chronic sinusitis, either causing frequent missed duty or requiring ongoing ENT follow-up more than annually, are disqualifying for retention and flying duties.\* After an episode of sinus barotrauma, it is recommended that the patency of the osteomeatal complex be verified by having the aviator complete an altitude chamber ride up to 8-10,000 ft (2438-3048 m).8 In the sister services and Federal Aviation Administration (FAA), a history of sinus barotrauma is not necessarily disqualifying, but a history of chronic sinusitis can be. In the Navy, if chronic sinusitis is treated with sinus surgery, a successful barofunction run in a low pressure chamber is typically required before a waiver can be granted.<sup>5</sup> In the Army, chronic, severe, suppurative sinusitis that is complicated by chronic or recurrent polyps may render a soldier unfit for continued military service if the condition does not respond to treatment.<sup>13</sup> Local FAA Aviation Medical Examiners can grant airman medical certificates for sinusitis if there is a good response to treatment with the intermittent use of topical or nonsedating medications. The airman may not have any medication side effects for the medical certificate to be granted. If the sinusitis is severe, requires the continuous use of medications, or is affected by changes in barometric pressure, the case must be elevated to the FAA for final aeromedical disposition.<sup>3</sup>

In the case of our aviator, operational and mission effectiveness was reduced because it took 43 d from the onset of symptoms until his return to flying status. The prevention of sinus barotrauma is best achieved when at-risk individuals are identified and either prevented from flying or given medications to reduce the burden of inflammation and edema. In the military setting, grounding at-risk individuals is the safest course of action because if barotrauma occurs immediately before, or during, landing procedures, the event could culminate in an aircraft mishap.<sup>8</sup> Aviators are briefed on the importance of not flying with a URI, or during a flare-up of any condition that may result in edema of the nasal and sinus mucosa, i.e., seasonal allergies. Unless aviators with known polypoid disease undergo surgical correction, they do not routinely complete an altitude chamber ride.

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