

**CASE REPORT**

# AEROSINIUSITIS

## — AN EXPERIENCE OF TREATMENT OF TWO CASES —

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### Abstract

Aerosinusitis is not a rare entity of the disease, but not usually encountered at the general practice of ENT. We have experienced three operations of two cases of this condition which occurred in the fighter pilots: the interceptor F-4EJ and F-15 J, of the Japan Air Self Defence Force. The symptoms of maxillary pain of the affected side during the landing approach and purulent nasal discharge thereafter was noted in all case, as described in the literature. Pre-and postoperative pressure trial was done to all cases. The operation done was conventional maxilloethmoidectomy under local anesthesia and, during the operation, cicatric closure of the fontanelle, which was surgically open was found in all cases and the counter opening was made at the inferior meatus. Recurrence was not noted thus far observed.

Jet-engined aircraft which attains high performance brings great altitude changes therefore, pilots or crews and passengers are exposed to great barometric changes, so that it inevitably raises the incidence for aerosinusitis. But the incidence of the passenger aircraft for aerosinusitis is controlled to the minimum because the comfortability of the air travel is one of their important factors; on the other hand, it is not the first importance for the mission-oriented tactical aircraft. The pressurization is lowered so that it is considered the incidence of these aircraft for aerosinusitis is relatively high as compared with the former. However, the onset of the aerosinusitis is not directly correlated with barometric changes of environment within the aircraft; therefore we cannot say that this condition is thoroughly understood, although it is deeply related to the pathology of the openings of the sinus and its surroundings.

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### — Key words —

aerosinusitis, sinus barotrauma, pressurization, barometric change, sinus pain

## I. Introduction

Aerosinusitis is not a rare entity of diseases, but normally, not usually encountered at the general practice of ENT. WE have carried out 2 cases of surgical treatment of this condition which occurred in the pilots of Japan Air Self Defense Force, and we would like to report our experience with the reviews of the literature.

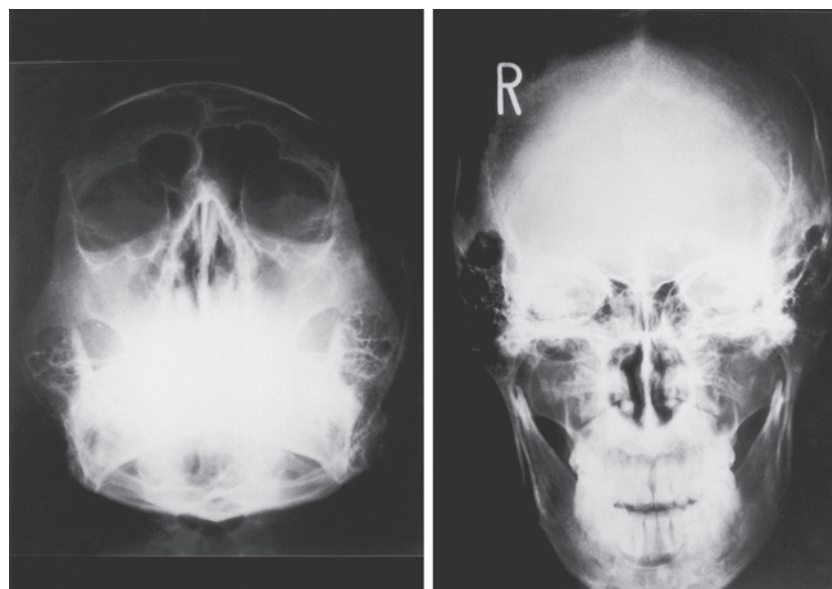
## II. Cases

Case 1: 30-year-old male; JASDF pilot, F-4EJ Interceptor aboard. (Fig. 1) About 3 years before the first visit, bilateral maxillary pain was noted when crossed the altitude of 3,000ft during the descent for landing approach. Thereafter, purulent nasal discharge continued for a while but soon disappeared by the treatment at the local ENT clinic. 3 months before the first visit, bilateral maxillary pain was noted, which was not endurable when crossed the altitude of 3,000ft while descending; the descent was aborted and the altitude was regained and this procedure relieved him from the pain. After that, the approach by the minimum descending rate was done and the landing was successful. The patient visited us, having been diagnosed as the aerosinusitis.

Physically, any endonasal pathological manifestations were not found at the first visit such as nasal polyp or discharge, but purulent choanal flow was seen at the epipharynx. X-ray studies showed bilateral clouding of the



**Fig. 1** F-4EJ Interceptor



**Fig. 2** X-ray films of the Case 1  
note: the clouding of the bilateral maxillary sinus.

maxillary sinus. (Fig. 2)

The patient was admitted for treatment. The decompression trial was done preoperatively at the artificial climate chamber which caused the bilateral maxillary pain when descending at about the altitude of 6,000ft and worsened at about 3,000ft. (Fig. 6)

Surgical treatment was done; first the right, and then after a week, the left maxilloethmoidectomy was done under the local anesthesia. During the surgery, occlusion of the fontanelle by the scarring tissue was revealed bilaterally.

The decompression trial was done again postoperatively but not revealed any troubles and patient was discharged.

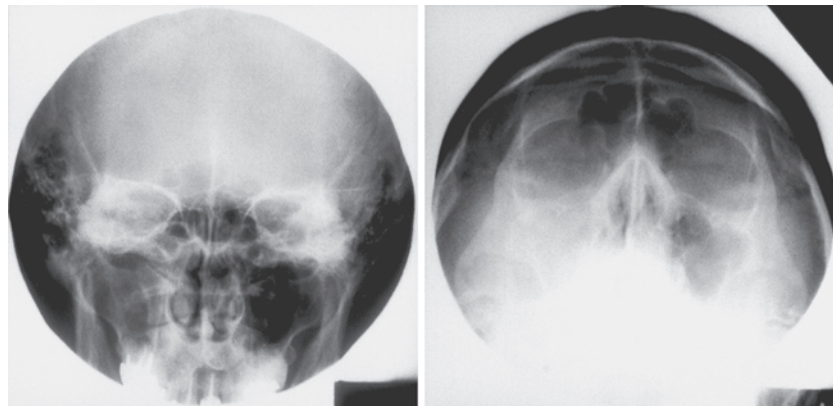
Case 2: 39-year-old male; F-15 J Interceptor aboard. (Fig. 3) 3 years before the first visit, the right maxillary pain was noted occasionally; when having a cold. About 3 weeks before the first visit, the pain was likewise noted when landing approach. The patient was diagnosed as aerosinusitis at the Self Defence Force clinic of the base and visited us. As the past history, the patient received the surgery of the right maxilla for the resposition of the front wall fracture 9 years before.

Physically, any pathological manifestations were not noted both endonasally or in the throat, but X-ray films

and imaging studies showed the clouding of the right maxillary sinus. (Fig. 4, 5a and 5b) The patient was admitted to ENT. The pressure trial was done preoperatively in the HBO Chamber at 2.0 ATA by the usual air, although the order of the procedures of the pressurization and depressurization was reversed. (Fig. 6) However, the maxillary pain was not noted. The right maxilloethmoidectomy was done under the local anesthesia. The occlusion of the fontanelle was revealed in addition to the old front wall fracture.



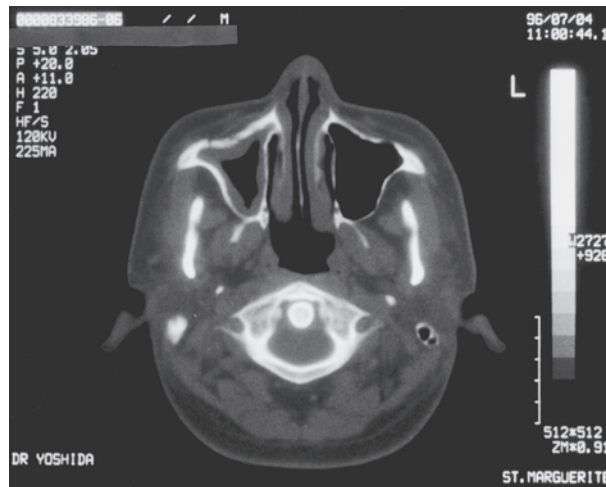
**Fig. 3** F-15J Interceptor



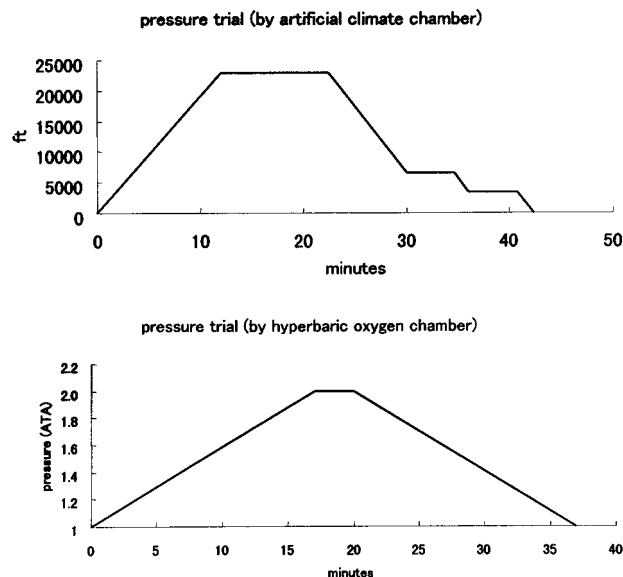
**Fig. 4** X-ray films of the Case 2  
note: the clouding of the maxillary sinus, rt.



**Fig. 5a** Imaging Film of the Case 2: MRI Section at the First Visit note: the complete clouding of the maxillary sinus, rt.



**Fig. 5b** Imaging Film of the Case 2: Preoperative CT Section note: the mucosal thickening of the maxillary sinus, rt. in an interval by the conservative drug therapy.



**Fig. 6** Pressure Trial: in Artificial Climate Chamber (above) and in Hyperbaric Oxygen Chamber (below)

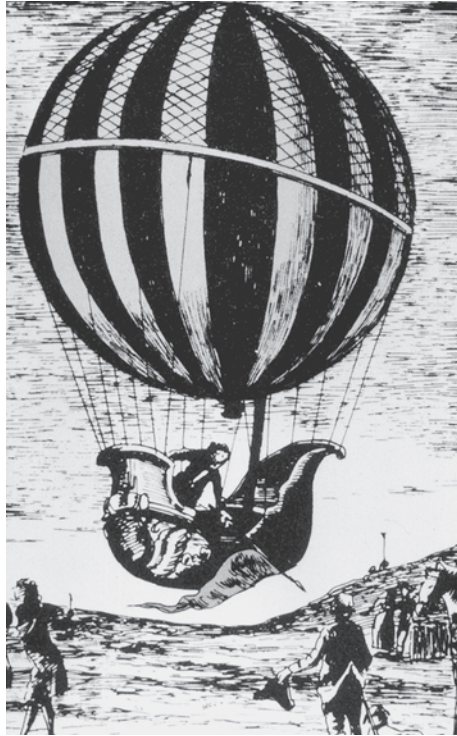
The pressure trial was done again postoperatively and confirmed that any troubles were not caused, so that the patient was discharged.

### III. Discussions

#### A. Definition

“Aerosinusitis is an acute or chronic inflammation of one or more of the nasal accessory sinuses produced by a barometric pressure difference between the air or gas inside the sinus and that of the surrounding atmosphere” by Campbell.<sup>1)</sup> Of course, it is designated by other terminology, but what they mean is the same. Therefore, the disturbances by the compressed air work<sup>2)</sup>, by the under sea labor or by the diving<sup>3)</sup>, or to the extreme, by the mountain climbing and the elevator rides in the buildings are included to this word. In this sense, the word “Barotrauma”<sup>4)</sup> seems more suitable to define those conditions.<sup>5)</sup> So other synonyms, such as barosinusitis<sup>5)</sup>, vacuum headache<sup>6)</sup> etc, are also used.

However, the authors take it for granted that aerosinusitis is the most suitable word to denote this pathologic entity. Because by the historic consideration, it is widely used and moreover, the incidence of this condition is by



**Fig. 7** Hydrogen Balloon by Charles and Robert in 1783



**Fig. 8** The Zero Fighter and the Late Ace SAKAI aboard, the Mt. Fuji in the back

far prevalent during the flight by aircraft.

#### B. Historic consideration

Before the invention of aircraft, the incidence of sinus troubles due to the change of atmospheric pressure was known. On December 1st, 1783, Charles and Robert, brothers of the French, experimented the flight of the hydrogen balloon only by 10 days later after the first flight of the heat balloon by Mongolfier which had been the first manned flight against the terrestrial gravitation. (Fig. 7) At the second flight on that day, only Charles aboard, he noted the pain in his right ear and maxilla, and he attributed this phenomenon to the expansion of the air contained in the cellular tissue of the organ.<sup>(quoted from 7)</sup> This is considered the very first report of the aerosinusitis of the mankind.

In 1878, Paul Bert described sinusitis, which occurred to the compressed air workers.<sup>(quoted from 8)</sup> Mann mentioned that this condition was caused by the same mechanism of the pressure change as the sinusitis of the under sea divers, although it was not due to the flight of the aircraft.<sup>3)</sup> In 1892, Black described the incidence of “worst cold they had had in years”, caused by the change of the pressure though it took place very gradually, when moved to



the high mountains of Colorado from the Seacoast.<sup>9)</sup>

It was after 1903 when the aircraft was invented by Wright Brothers, that the mankind was exposed to severe change of atmospheric pressure that they had never experienced before, by the rapid movement in the air along to the vertical direction.

In 1919, Marchaux and Nepper mentioned that the disturbances of the cephalic pneumatization might cause the pain or syncope in worst case, adding that this condition was most likely to occur when landing, because the pressure gradient was highest and during which the concentration was most intensely required for pilots.<sup>10)</sup>

Spectacular development of the aircraft was noted in the history thereafter. Brouwer in 1935, already described that the sinusitis was an occupational disease of pilots.<sup>(quoted from 11)</sup>

In 1941, Herrmann wrote an intensive report of submucosal sinus hematoma of the Dive Bomber Pilots.<sup>12)</sup> In Japan, an ex-pilot of the former Japanese Imperial Navy Flight Squadron, Petty Officer 1st Class, Saburoh Sakai, also honorably designated “the Ace of the Zero Fighter,” described the severe pain around the forehead and the orbits in details which seemed to have been caused by the frontal aerosinusitis. He wrote in his book “Winged Samurai”, this experience during the test flight of the Zero Fighter in 1940.<sup>13)</sup> (Fig. 8) He experienced nonendurable pain or rather shock deep in the both eyeballs and in the half of the head at crossing the certain altitude exactly at 1500ft, during the descent for the landing approach, and curiously enough, which disappeared by non-intentional sudden ascent based on the pilot’s instinct of avoiding the hazards. Several attempts were made for the descent, but aborted by the sudden onset of the pain when crossing the altitude and relieved by the rapid maneuver of the ascent. This pain occurred to him exactly at 1,500ft, as if measured by the altitude meter. The Valsalva maneuver was tried again and again but failed to relieve him from the pain. The pain when crossing some certain altitude during the descent and its relief by the rapid ascent was also reported by some authors abroad.<sup>14)</sup> This might be the very first description of the aerosinusitis in our country.

During and after the World War II, the special attention was focused on the correlation of the pressure change by the flight and the ENT diseases, especially diseases of the luminal organs such as the tympanum and the paranasal sinus probably due to the fast development of the aircraft as the warbirds which exposed the mankind to rapid change of the pressure.

Many reports were made until then, but the reports by Campbell established the disease entity of aerosinusitis, when he made public of his consecutive theses in 1942~45. In 1942, he used the word “aerosinusitis” in his first report,<sup>15)</sup> and in 1945, he proposed the classification of this condition based upon the description of his five cases with the consideration of its pathophysiology and histopathology.<sup>8)</sup> The classification is described later in details, the type of the obstructive and that of the non-obstructive which was further classified into first to third degrees by the severity.<sup>1)</sup>

In the Japanese literature, Takahashi et al proposed the classification of the disease into five types based upon their consideration of the mechanism of the disease in relation to the changes of the pressure, the temperature and the humidity of the cabin, and the pathophysiology of the sinus.<sup>16)</sup> And Sato et al also postulated the disease mechanism in consideration of the pressurization of the actual passenger aircraft.<sup>17)</sup>

### C. Incidence

Not many reports on were made on the exact incidence in the actual flight. But Brouwer reported without precise statistics, the incidence of the sinusitis in the pilots was greater than their otitis.<sup>(quoted from 11)</sup> Cocke, as the experience of the military surgeon, wrote that aerosinusitis was much more often encountered than in the description by Campbell in which he wrote that the incidence of the aerosinusitis against that of the aerotitis was 1/20,<sup>1)</sup> rather, 1 to 4.<sup>11)</sup> Wright et al reported 1.6%,<sup>18)</sup> and 3~4% by Kraus.<sup>19)</sup>

As far as the civil flight was concerned, the incidence of the distress in the ears and the noses combined was 0.5~8% by Bear.<sup>4)</sup> But the statistics of the nasal symptoms alone were not found. In the early days of the studies of the aerosinusitis by the simulation of the hypobaric chambers, the incidence was 1.9% out of 35,000 flights by Campbell<sup>8)</sup>; 2.4% for the well-trained, 3.5% for the non-trained by Kraus.<sup>19)</sup>

After 1970, in the reports by Smith et al of the U. S. Navy, the incidence was 1.16% out of 252,564 flights during the 10 years.<sup>20)</sup> In the reports by Emery et al, 0.91% in the flights of 25,000 ft of altitude, whereas 0.55% in the flights above 40,000 ft.<sup>21)</sup>

On the other hand, Hanna et al of the U. S. Air Force reported the incidence of 1.59% before 1964 and 1.86% after 1965.<sup>22)</sup> For the otitis media, Whaley reported that the incidence of the barotrauma was greater in the hypobaric simulation chambers than in the actual flight.<sup>23)</sup> Wright and Boyd mentioned that they were reluctant to affirm the naive acceptance of the results by the chamber trial of the aerosinusitis, because there was a room for the doubt if the changes of the temperature, the humidity and other terrain factors were exactly simulated in the same manner as in the actual flights.<sup>18)</sup>

#### D. Altitude and Flight duration

Some considerations are seen in the literature between the altitude and the incidence, but they are only a few. And one thing is clear that aerosinusitis of the obstructive type in the third degree by Campbell's definition was seen in the pilots of the high altitude flight. Out of 12 cases of paranasal hematoma, reported by Wright et al, 8 cases occurred after the high altitude flight.<sup>24)</sup>

According to the report by Smith et al, the incidence of aerosinusitis was 0.5% for the flight at 25,000ft, whereas 1.66% for 40,000ft<sup>20)</sup>. That is, the higher the flight altitude gets, the higher the incidence rises. They explain that this is due to the denitrogenation with 100% oxygen in the preparation for the high altitude flight, caused by the biological differentials of the absorption of two gases to the tissues.<sup>20)</sup>

The correlation of the climb, the descent rate and the incidence is considered positive, as in the report of cases of hematoma by Herrmann in the pilots of dive bombers<sup>12)</sup>. The greater the climb or the descent rate is, the higher the incidence for the risk rises. With the advent of jet engine, the performance of the aircraft was much promoted. Dickson et al warned the situation, comparing the incidence for barotrauma in the crews on jet aircraft with that for conventional piston-engined, with the result of higher incidence on jet aircraft and concluding that the high performance aircraft endangered crews to the barotrauma. But their report did not differentiate sino and otitic incidence.<sup>25)</sup>

However, the incidence in the pilots of the heavy bombers was reported, although the rate of the altitude change was relatively small. Thus it suggested for the subtle etiology of the disease. It is not clear whether the total flight time of the pilots and the incidence are correlated or not. Bear reported that the minimum time for the occurrence of the disease was 50 hours and the maximum time was 5,000 hours.<sup>4)</sup> Simonyi reported that there hardly existed the correlation between the total flying time and the incidence as far as civil flights were concerned; he studied 100 pilots for at least 7 years to get the conclusion, but adding that his study was all on civil aviators and not subjected to frequent, sudden changes in barometric pressure as in those of military aviation.<sup>26)</sup>

#### E. Symptoms

The most common symptom is the pain over the affected sinus, and said to be nonradiating.<sup>4)</sup> But in the case of the frontal sinusitis, it is said to radiate from the frontal region up towards vertex between and behind the eyes.<sup>27)</sup> 'The pain like a sting by the bees'<sup>1)</sup> or 'excruciating or stabbing pain'<sup>28)</sup> is the usual description by many authors. The pain of the eye is also often complained. Next come the nasal obstructions and the pressuring sensations of the affected sinus.<sup>4)</sup> Other symptom is the lacrimation<sup>18)</sup> and nasal bleeding at once<sup>27)</sup> or later.<sup>5)</sup> This bleeding later on is due to the outflow of the accumulated blood in the sinus.<sup>28)</sup>

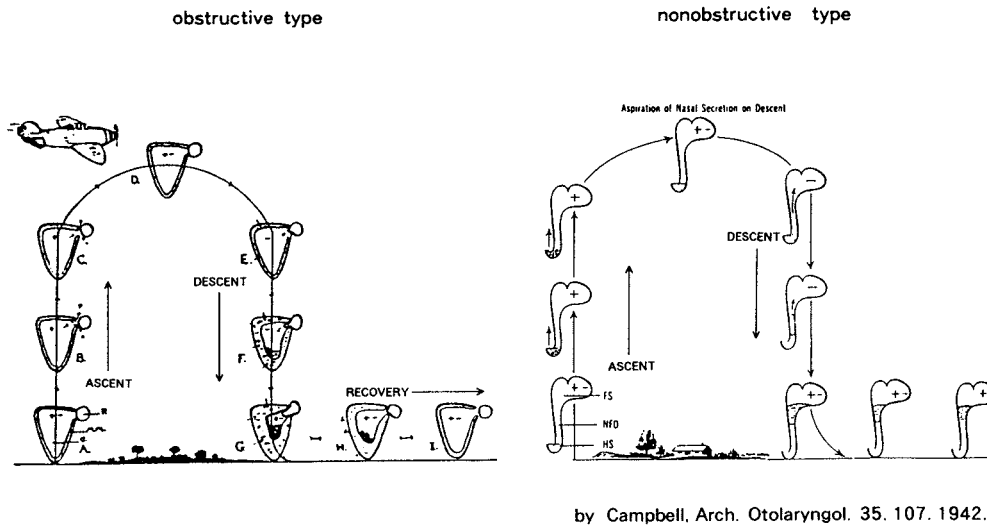
The syncope or the loss of conscience was reported rare, but Ashikawa et al reported the syncope case of a pilot, F-86-F aboard, during the rapid descent.<sup>29)</sup>

Neurological involvement due to barometric changes is sometimes reported as otitic barotrauma, but few are reported as sinus complication, However as the barotrauma during the dive, some cases of neurologic complication were reported; Indicula reported the upper lip numbness during the recompression for the treatment of the bends, which was considered not by the decompression sickness but by the maxillary barotrauma.<sup>30)</sup> Neuman also reported the numbness of the upper lip, the upper teeth and the face during the SCUBA dive to repair the submarine propeller. The depth of the dive was insufficient for the development of decompression sickness, so its cause was suspected as the maxillary barotrauma.<sup>31)</sup> But these were not aerogenic in origin.

#### F. Sinus affected

The sinus is likely affected in frontal,<sup>1)</sup> maxillary, and their combination at this order by many authors.<sup>19)</sup> Most authors reported the highest incidence of the frontal, but Wright et al reported the highest of the maxillary.<sup>18)</sup>

Our two cases of three affected sides are all maxillary and compatible with the report of Wright et al.



**Fig. 9** Mechanism of Aerosinusitis: Obstructive (left) and Non-obstructive (right)

The involvement of the ethmoid was not reported as the primary, although the combination of the ethmoid and the maxillary or the frontal was reported.<sup>4)</sup> The involvement of the sphenoid was reported rare.<sup>6)</sup>

This is explained by the fact that the ethmoid or the sphenoid sinus reveal so slight or so vague symptoms if affected, that the identifying the localization of the affected sinus is difficult by the presenting symptoms.<sup>1)</sup> It is considered that in contrast to the ethmoid and the sphenoid, the frontal and the maxillary have their relatively small openings compared with the inner spaces, which are easily damaged by the inflammatory or other pathological processes, thus resulting in the checking valve mechanism.

#### G. Mechanism of the disease

Based on Campbell's report, its pathology is classified into two types; the type of non-obstructive and that of obstructive.<sup>1)</sup> That is, the aerosinusitis of the non-obstructive type is the infection due to the retrograde flow of the accumulated mucus or pus into the sinus by the pressure differentials during the descent because of the inflammation in the nasal cavity proper.

On the other hand, the aerosinusitis of the obstructive type is in the case of the patients with the polyps or the swollen inflamed mucosa which obstruct the ostiums of the sinus and thus creating the checking valve mechanisms. That is to say, the failure of the compensatory processes to cancel the relatively negative pressure of the sinus against the relatively positive pressure of the environment during the descent, resulting in the secretion of the mucus, creating the transudate or the exudate or causing the hematoma. (Fig. 9)

Campbell further classified the obstruction into three grades, based on the clinical symptoms;<sup>1)</sup> the first degree is the hypersecretion of the mucus for the compensation of the negative pressure, and the pain is slight, if any, so usually not medicated. The second degree is the localized or generally swollen mucosa with the transudate or the exudate, accompanied by the pain or the hyperesthesia which persists for a while after the descent. Usually the slight fever and leucocytosis are seen. The third degree is the most severe of all, that is, extreme hypertrophy of the mucosa, and sometimes the bleeding into the sinus space or into the submucosa is seen, and ablation of the mucosa from the bones could occur. Accompanied by the intense pain subjectively, the fever and the leucocytosis are seen, and there is the possibility of serious infections. 1 to 3 weeks are needed for the improvement but insulted tissues will not be healed completely.<sup>1)</sup>

Wright et al reported that when the valve mechanism worked from the inside so that the communication of the intrasinus space to the outside was disturbed, the relative positive sinus pressure caused the pain, because the sinus pressure within was increased compared with the decreasing environmental pressure during the ascent.<sup>18)</sup>

They also reported referring to Crosson and others, that the sudden increase of the environmental pressure pulled the mucosa around the ostium inward. Its opening being so small compared with the inner space causing the



valve mechanism, thus the onset of this condition resulted, even if the normal ostium was concerned.<sup>18)</sup>

According to Kraus, a relative negative pressure within a sinus is more painful than an equal amount of positive pressure.<sup>19)</sup> This is compatible with the clinical manifestation by many authors. Campbell also postulated that the onset mechanism worked often during the descent.<sup>8)</sup> This phenomenon indicated that the communication from the nasal cavity proper into the sinus was much more easily disturbed.

However those with polyps that disturbed the communication of the sinus airway, would not show any symptoms even if they were aviators had been reported.<sup>28)</sup> This suggests the subtle mechanism of the onset of the aerosinusitis.

On the other hand, Fascenelli et al reported, based on the study of the X-ray films of the sinus of many aviators, that pathological findings especially of the maxillary sinus, were not related with their total flight time, concluding that the barotrauma had nothing to do with maxillary sinusitis, So he made the objection to the notion that the maxillary sinusitis was an occupational disease of aviators.<sup>32)</sup>

He later made an additional report in which he wrote, that almost identical incidence of radiographic evidence of maxillary sinus abnormality was seen in a control group of asymptomatic nonflyers.<sup>33)</sup>

Already in 1945, Bateman reported dome-shaped radiological opacity in the absence of symptoms and other clinical signs in the flying men and that he would not take no action in these cases.<sup>34)</sup>

Moreover, based on the controlled study of 200 asymptomatic with abnormalities against control group of 200 nonflyers, Hanna wrote that a significant number of asymptomatic individuals had an abnormality of paranasal sinuses, although these abnormalities were not causally related to the performance of flying duties.<sup>35)</sup>

Iwabuchi et al also reported a higher incidence for asymptomatic sinusitis in the general population, than having been expected before, after the introduction of MRI in the clinical practice.<sup>36)</sup> However, Yanagawa et al postulated repeated exposure to barotrauma was the cause of asymptomatic sinusitis, because the MRI examination revealed a relatively high trend of mucosal thickening in the service divers, although statistical difference to the control was not proved.<sup>37)</sup>

#### H. X-ray findings

X-ray examination is, as in other sinus diseases, of great importance. Films should be taken soon after the onset of the disease, and followed by consecutive studies. Films having been taken before the onset, would be preferable at present.

Findings of the films are varying from mucosal hypertrophy to complete clouding, but the differential diagnosis of whether hematoma or inflammatory process is hardly possible only on films.

Fascenelli recommended a Towne's view, a Waters' view, a submental vertex, a PA view and one lateral view as the routine projections.<sup>32)</sup> But we usually think views of Caldwell's, Waters' and a lateral one are enough.

The contrasting films used to be also important to evaluate the hypertrophy and the clearance activities of the sinus mucosa. But nowadays, imaging devices such as MRI and CT take over the place for imaging diagnosis.

#### I. Treatment

Most authors agree that conservative treatment is the first choice of this condition, and surgery will be then considered on the recurrence of the disease, or endonasal abnormalities, such as polyp or prominent deflection are found in the patients.<sup>38)</sup>

That is, ascending to the altitude on which the symptom occurs and followed by the gradual descending, is the first step, if possible.<sup>22)</sup>

If reascending is not possible, topical or general administration of decongestants and anti-inflammatory agents, and Valsalva's maneuver to cancel the negative pressure of the sinus should be done. When purulent process occurs, antibiotics and anti-inflammatory drugs should be administered, as in the usual cases of sinusitis. Sinus irrigation will be needed, in the cases of severe clouding of the maxillary sinus. Surgery will be indicated, as mentioned above, in the cases of the recurrence, or in the cases in which the clouding is seen which suggests the hematoma, or in the cases in which the manifestation is seen which represents the occlusion of the sinus ostium by the polyps, or severe septal deviation, or other findings that suggest rheological disturbances of nasal flows.<sup>39)</sup>

Recent advances of endoscopic surgery was introduced to this condition by Bolger et. al., applied to their four cases of aviators and brought good result.<sup>40)</sup> Although controversy exists whether endoscopic surgery has merit

over conventional method, or “classic sinus surgery” in the author’s terminology, less invasive approach is preferable, if sinus function of communication to the outer environment is reestablished. They proposed the idea of “ostiomeatal complex” to evaluate the sinus function from the anatomical view point. That is, the middle meatus in the relation of the anterior ethmoid and the frontal recess to which two major sinuses, the maxillary and the frontal drain. They later compared endoscopic and conventional surgery and reported the efficacy of the new method.<sup>38)</sup> They confirmed the merit of this procedure by the long-term follow-up of 54 aviators for up to 6 years.<sup>41)</sup>

#### J. Accident / incident cases

The fatal accident by the aerosinusitis has not been reported in the Japanese literature; however, at least a single case which was suspected to be caused by the incapacitation due to this condition was reported in the English literature. It was written that an instructor pilot, at the front seat onboard, in the tandemly double seated jet aircraft, trainer T-38A, with his undergraduate pilot in the back for night instrument training, put off his oxygen mask by the epistaxis and in order to clear his maxillary sinus for the relief of the pain, both presumably caused by the aerosinusitis, crashed.<sup>42)</sup>

Three cases of incidents by the aerosinusitis were reported for the period 1968 through 1972 in the USAF; two cases occurred on the descent, and one occurred on ascent complicated by aerotitis, all affecting the frontal sinuses.<sup>43)</sup>

Fatal accidents due to the loss of conscience by the aerosinusitis were, thus far we have studied, have not been reported, other than one syncope case which did not result in fatality in the Japanese literature as mentioned above. Although fatal cases by the alternobaric vertigo were reported.<sup>29)</sup>

#### K. Prophylaxis

Most cases reported in the literature, presented condition of preceding upper respiratory tract infection of any kind to some degree,<sup>44)</sup> so that, in first place, those who are affected with above condition should not be permitted to fly in the prophylactic view of disease.<sup>45)</sup> In case they have to fly, clearing the nose thereby to maintain the nasal passages, cancelling the negative pressure by the Valsalva’s maneuver and preventive administration of anti-congestants and anti-inflammatory drugs will be necessary.<sup>39)</sup>

On the other hand, the regulation of the pressure, the humidity and the temperature in the cockpit or the cabin are the important factors of the onset. However, these are beyond the conscious control of passengers or aviators, both of the airlines and the military service.<sup>22)</sup> We refrain ourselves to discuss this issue here.

Furthermore we have to say, aviators professionally aboard should be qualified by the law for the physical fitness<sup>46)</sup> and they already fulfilled the legal requirements, and furthermore, the onset of this condition is more or less accidental. We think the procedure soon after the onset, such as drug intake or topical application, is enough as the treatment for the aerosinusitis.

**Table 1** Pressurization of Aircraft

Tactical Aircraft		
Fighter · Trainer	T-1, T-33,	2.75
	T-4	4.0
	T-2, F-1, -4, -15	5.0
Cargo · Utilities	YS-11	4.16
	C-1, -130	7.5
Reconnaissance · Patrol	P-3C	6.5
	E-2C	8.8
Passenger Aircraft	DC-10	7.6
	A-300	8.25
	L-1011	8.44
	B-767	8.6
	B-747	9.0
Spaceship	Space Shuttle	14.7
		(psi)

L. Pressurization schedule

The pressurization of the aircraft is classified into three categories: isobaric, differential and intermediated control. Isobaric control is the schedule in which internal pressure, generally expressed in terms of equivalent altitude, is remained constant when the ambient pressure changes with the aircraft altitude. Differential control is the schedule in which differential pressure between in-and outside of the aircraft is kept constant although the ambient pressure varies with altitude. Intermediate control is between isobaric and differential.<sup>47)</sup>

Now let us take the difference of the passenger and the tactical aircraft into consideration. When the jet engine was introduced as the propulsion method, its maneuverability was spectacularly improved for the airplanes of both



Fig. 10 B-747 Passenger Aircraft

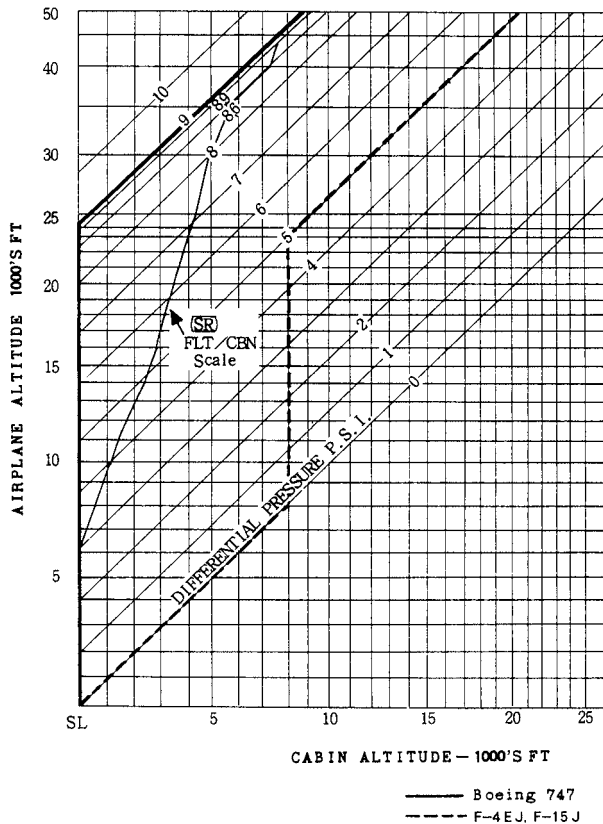


Fig. 11 Pressurization Schedule:

Cabin or Cockpit Altitude (horizontal) vs. Airplane Altitude (vertical) Continuous line representing B-747; isobaric control until 24,000ft above sea level where differential becomes 9psi and maintain its differential thereabove. Broken line representing interceptor, F-4EJ and F-15J; no pressurization until 8,000ft and maintain its pressure until 23,800ft where differential becomes 5psi and adopted differential control thereabove.

kinds, i. e., the passenger aircraft and that of the military services alike, especially the vertical direction is concerned, and it caused great changes in the pressure differentials. As for the passenger aircraft, their pressurization is done as possible as they can to maintain the comfortability in the cabins. In this case, isobaric control is adopted until the altitude of somewhere over 20,000ft, usually around 20,000~25,000ft, and then differential control is adopted thereabove with differential pressure of about 8<sup>4)</sup> or 8.6~9<sup>47)</sup> lb/in<sup>2</sup> (psi), although intermediated control is adopted to short range aircraft to prevent metal exhaustion. Therefore, the incidence for the diseases by the pressure changes is expected controlled to the minimum.

On the other hand, as for tactical aircraft which are mission oriented so that their maneuverability is of the first importance to pursuit the high performance, the pressurization is not in the first place rather than the comfortability of flight.<sup>38)</sup> Moreover, in order to suppress the burst of the planes by the bullet-hits from the pressure within, and also preventing the rapid decompression by bail-out, the pressurization is lowered in the cockpit. In this case, no pressurization is adopted or differential 0 psi until some certain altitude, and kept isobaric until next some certain altitude is reached where usually the differential value is about 5<sup>4)</sup> or 3.5~5<sup>47)</sup> lb/in<sup>2</sup> (psi). Then again adopted differential control thereabove. That is to say, its pressurization schedule is relatively lowered as compared with passenger aircraft. Therefore it may play a role in the occurrence of the aerosinusitis of the tactical aircraft.<sup>48)49)</sup> (Tab. 1, Fig. 10 and Fig. 11)

#### IV. Conclusions

The experience of the treatment and the pressure trial of two cases of the aerosinusitis are reported with the review of literature.

1) The aerosinusitis is a relatively rare entity of the disease caused by the pressure change during the flight, but not negligible to the ENT practitioners.

2) Its occurrence is minimized in the cabins of the passenger aircraft, which are so pressurized that of which environment is maintained in the comfortable state; but it is not considered as the first importance in the cockpits of mission-oriented tactical aircraft.

3) The mechanism for onset of the aerosinusitis is related to the pressure gradient between the sinus within and without and its changes by the time scale, and to the conditions of the openings and their surrounding tissues; but its true cause is remained to be worked out.

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## 航空性副鼻腔炎

### —2症例の手術的治療経験—

吉田 泰行

セント・マーガレット病院耳鼻咽喉科

—キーワード—

航空性副鼻腔炎, 気圧外傷, 圧変化, 副鼻腔疼痛

航空性副鼻腔炎は希な疾患ではないが、通常の耳鼻咽喉科臨床では多く遭遇するとは言い難い。われわれは航空自衛隊邀撃戦闘機F-4EJ及びF-15Jのパイロットの2例、3側の手術経験をえたので文献的考察を加えて報告する。各症例の主たる症状は先人の報告にあるように罹患側の着陸進入時の上顎痛であり、以後膿性鼻漏を伴っていた。全例で術前及び術後に耐圧試験を行い、通常の上顎洞篩骨洞根本術を局麻下に施行した。術中全例とも自然孔の癒痕閉鎖を認めたため手術的に開孔し、下鼻道に対孔も作成した。術後は観察可能な範囲で再発は見られなかった。

エンジンのジェット化に伴い、航空機は高性能化し高

度変化も大きくなり、それに伴って機内の操縦者や搭乗員及び乗客は圧変化にさらされるようになった。その結果航空性副鼻腔炎の発症の可能性も増えたと思われる。しかし旅客機においては居住性の向上も重要な因子のひとつであるため、その発症は与圧により極力押さえられていると考えられる。一方、任務遂行第一の戦術機においては居住性のための与圧は可能な限り押さえられており、その発症は前者と比して高いのではないかと考えられる。だが本症例の発症には副鼻腔の開孔部との周囲の状態が深く関わっているとはいえ、機内の与圧と発症とを単純に結び付ける訳にはいかない点もあり、本疾患の治療及び予防のための更なる解明が待たれる。