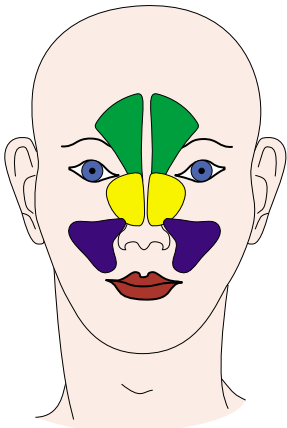




THE EFFECTS OF ASCENT AND DESCENT ON GAS COLLECTIONS WITHIN THE BODY.

By Dr. Dougal Watson



Facial Sinuses

“Mummy my ears just went pop!” chiming from the back seat as you drive the family in the hills.

The RAAF Doctor’s advice to aircrew “You should never fly when you’ve got a cold, not even a hint of a cold.”

“BUUURRRRP !!!” or similar unmentionable noises denoting escape of gas from the body as you climb towards 8,000 ft.

A Royal Flying Doctor Service speaker advising a group of doctors concerning air ambulance usage Always x-ray penetrating injuries, where air may have entered the body part involved, before you consider Air Ambulance transport. When in doubt insist on a sea level cabin altitude. This is especially important for open skull fractures and penetrating eye injuries.

What do these four, seemingly unrelated, events have in common? You’ve bothered to read this

far, so I have little doubt that you've read the title and now realise that these are all manifestations of the expansion of gas within cavities of the human body during ascent in altitude.

Background

Most aviators will remember from their license studies that as you climb in our atmosphere the air density and the air pressure fall. This occurs in the real atmosphere as well as the ICAO International Standard Atmosphere that your texts mention. The drop in pressure is such that at 18,000ft. the air pressure is around half that of sea level, and at about 33,000 ft. it is a quarter of it's sea level value. This reduction in air pressure has a number of possible adverse effects on aviators, gas expansion within body cavities is covered here while decompression sickness hypoxia, and rapid decompression will be

discussed in subsequent articles.

The laws of gas behaviour dictate that as the pressure falls a given amount of gas will expand (mass and temperature remaining constant). There are a number of collections of gas within the body. So as a person within an aeroplane, is subjected to progressively higher altitude (and therefore progressively less air pressure) the collections of gas within his body will expand. This is not a problem if the collection of gas communicates freely with the outside (as with the mouth, nose, and to a degree the sinuses and the middle ear cavity). The gas merely expands and escapes to the outside atmosphere. But if the gas doesn't communicate freely with the outside it's expansion will cause a build up in pressure on the cavity walls which can cause discomfort. Dain. And even impair the function of the organ involved (consider gas trapped in tooth abscesses or fillings, or the sinuses when you've got a cold).

Several areas of the body normally contain gas, these include the lungs and air-passages, the sinuses of the face, the stomach and bowel, and the middle ear cavity. Gas may be present in other areas of the body under abnormal circumstances such as the gas produced when a tooth abscess forms, or sometimes a small amount of gas will occur under a tooth's filling and after an accident gas may be able to enter the skull, the chest or abdomen, or even the eye. The effects that gas expansion has on each area of the body will be considered individually.

The Middle Ear Cavity

The ear drum separates the middle ear cavity from the outside. The soft walled Eustachian tube connects the middle ear cavity to the back of the throat. Figure 1 shows the normal middle ear at sea level, you will notice that the ear drum is not bulging in either direction and that the pressure

within the middle ear equals the outside air pressure.

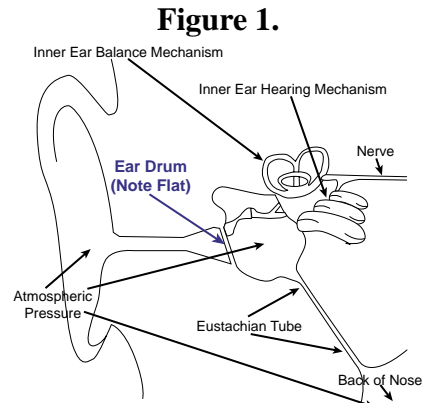


Diagram of the normal ear at sea level showing the flat drum and middle ear pressure equal to the outside air pressure.

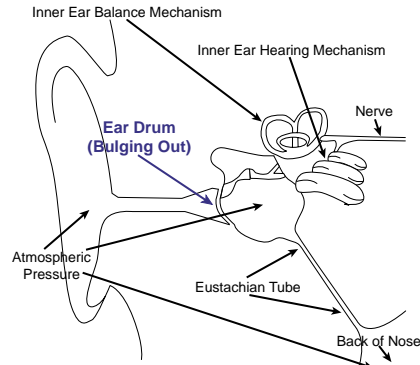
During ascent the gas (air) in the middle ear cavity expands and a small amount of pressure builds up against the ear drum causing them to bulge outwards ever so slightly (that 'fullness'

you feel in your ears just before they ‘Pop’). This pressure builds until it is sufficient to vent gas through the floppy walled eustachian tubes. As the gas vents the ear drum settles quickly back into it’s normal position. This venting of gas and movement of the drum is the ‘popping’ feeling we all know so well (see figure 2.). Popping of the ears is completely normal and usually occurs every 500 to 1,000 ft. of ascent, you may not even be aware that it is happening. Yawning swallowing, and chewing tend to make it easier for the eustachian tube to open and so can assist in popping the ears.

Conversely, during descent, as the air pressure increases the gas within the ear cavity will contract producing a slight vacuum. Normally the ear drum will bulge inwards slightly with a similar ‘fullness’ as before and then air will vent into the middle ear cavity, again with a ‘pop’. Because of the floppy walls of the eustachian tube

the air tends to have more difficulty moving in this direction than in the previous example.

Figure 2.



The effects of increasing altitude on the middle ear. Note the drum bulging outward and the increased pressure compared to the outside. The ‘pop’ is the ear drum moving quickly back to its normal position as the pressure vents through the Eustachian tube.

Problems will develop if the air cannot vent Inwards or outwards through the eustachian tube

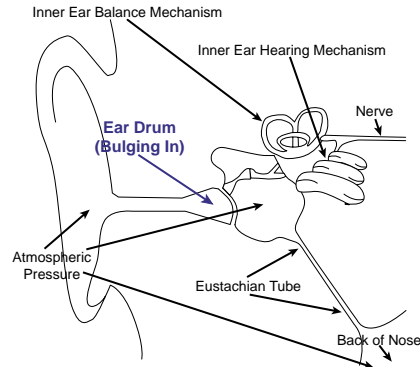
to equalise pressure with the outside. If for some reason the eustachian tube is blocked air will not be able to move into or out of the middle ear to equalise pressures.

Pressure will build up in the middle ear cavity during ascent (or conversely a vacuum on descent) causing the drum to bulge further than before and cause pain. If the eustachian blockage is not relieved and the descent (or ascent) continued the drum will bulge further and further until it ruptures or tears, causing sudden short lived severe pain followed quickly by some relief of discomfort and impaired hearing (Fig.3)

The most frequent cause of blockage to the eustachian tubes is the common cold. The membranes lining the eustachian tube become swollen effectively blocking the tube. So now you can appreciate why flying with a cold is dangerous, and in fact why an ordinary cold is

sufficient to ‘ground’ our Air Force pilots. Normal eustachian tubes are often partially blocked during descent and many people may get milder versions of the problems outlined above.

Figure 3.



Descent with a blocked Eustachian tube will cause a progressive increase in pressure on the ear drum. Eventually, if the pressure is not relieved, the drum will rupture (Otic barotrauma).

Interestingly children and babies have shorter

straighter eustachian tubes than adults and tend to have less difficulty equalising the middle ear pressure (“popping”).

Some susceptible individuals can suffer from severe dizziness (vertigo) when the pressure in their middle ear cavity isn’t equalised with the outside. A pilot can be rapidly and completely disabled by even mild vertigo.

Otic Barotrauma, literally meaning “ear-pressure-damage”, is the medical term for the problems mentioned above.

It’s well enough to know about such problems, but it’s just as important to know what you, as the pilot, can do about them. First, and foremost, it’s downright foolish to fly when you’ve got a cold, the flu, sinusitis or any similar problem. Air Force pilots are not permitted to fly with any of the above problems and usually ground themselves without necessarily seeing a Doctor.

The CAA regulations are not as rigid as those of the RAAF and many GA pilots do fly when suffering from colds etc. Most of these pilots do not suffer major problems, but do they realise the risk they are taking (and the risk that their poor unsuspecting passengers are taking)?

Air Force pilots are not permitted to fly with any of about problems and usually ground themselves without necessarily seeing a Doctor. The CAA regulations are not as rigid as those of the RAAF and many G.A.pilots do fly when suffering from colds etc. Most of these pilots do not suffer major problems, but do they realise the risk they are taking and the risk that their poor unsuspecting passengers are taking?

Sudden perforation of an ear drum can be quite a disabling occurrence.

Chewing gum or sucking sweets can assist the eustachian tubes in opening and may help avoid

discomfort or even ear drum damage.

Decongestant tablets such as Sudafed and sprays such as Drixene act by reducing the swelling around the eustachian tubes thus making it easier for them to open. These medications are fine for passengers in aircraft but should not be used by pilots. Although not specifically banned by the CAA, I would suggest that if you need these medications to fly you are putting yourself and your passengers at unnecessary risk.

The other main methods of relieving pressure in the middle ears and avoiding otic barotrauma are active manoeuvres such as swallowing and chewing already mentioned, and the Valsalva Manoeuvre. This involves increasing the pressure in your nose and throat by trying to blow your nose while keeping your mouth and nose tightly closed. This increase in pressure will often be enough to force the eustacian tube open and

relieve the pressure, or vacuum within. If you are not familiar with the Valsalva I suggest you contact your DME (CAA Designated Medical Examiner) for advice and training.

If you do, for example, run into such ear problems on descent and are unable to clear your ears using the Valsalva manoeuvre you can always climb again (fuel permitting) until your ears are comfortable then begin a slower descent profile clearing your ears more frequently. The reverse applies to ear discomfort during ascent where relief will be afforded by descent.

The Sinuses

The sinuses are air filled cavities situated within the bones of the face and skull. They open into the back of the nose through thin tunnels in the bone (See Figure 4).

As with the middle ear cavity, the air within the

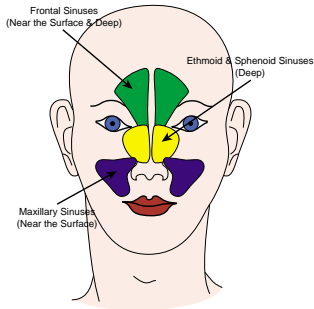
Figure 4.

Diagram showing some of the sinuses around the nose.

sinuses expands on ascent and contracts on descent. Normally the sinuses vent to the back of the nose easily and little more than a tickling sensation is felt. If, however, the linings of the sinuses are swollen and their tiny vent tunnel blocked the air will not be easily able to move to and fro to equalise pressure with the outside. This can be caused by inflammation of the sinus'

membranes during a cold or sinusitis. When pressure (or a vacuum) builds up in the sinuses it is felt as pain in an area of the face corresponding to the sinus concerned. Pain may be felt in the forehead, the cheek, or deep within the head and can be quite severe and accompanied by profuse watering of the eyes. you don't need me to tell you that severe pain and constant profuse tears in your eyes is going to impair your aircraft control and decision making.

To avoid this sinus barotrauma (sinus-pressure-damage) ids common sense and a little bit of knowledge that we need. As before, flying with a head cold or sinusitis puts you and your passengers, at an unnecessary risk Don't do it! If you, or your passengers, do get some sinus problems during ascent or descent treatment is much the same as with middle ear cavity problems. Firstly try nasal decongestants (e.g. Drixene) if you have them, this may reduce the

swelling enough to let the air vent. The Valsalva manoeuvre doesn't tend to work as well with sinuses as with the ear, but it still worth trying this procedure to equalise the pressures. If these efforts are unsuccessful and the symptoms persist, or worsen you should return to the altitude you were at prior to problems (again, fuel permitting). The subsequent descent should be taken at a slower rate allowing the sinuses to equalise pressure as you go.

Abdominal Distension

It is perfectly normal for our stomach and intestines to contain around a litre of gas. This is a mixture of swallowed air and other gasses produced by digestion. From the principles discussed earlier it's not going to be too difficult to deduce what will happen to this gas on ascent. Of course, with ascent this gas will expand and when it has expanded sufficiently it will usually

vent itself from the body via the mouth or the anus.

Gas expansion in this way does not generally cause problems. However some people, often relatively inexperienced aircrew, do have difficulty venting this expanding gas during ascent and suffer a bloated feeling and some abdominal pains. On the rare occasion this pain can be severe.

Abdominal distension with altitude will be increased if there is more gas in the stomach and intestines to begin with. This can occur with intestinal infections (e.g gastro'), increased air swallowing (anxiety, or rushing a meal and not chewing enough prior to swallowing your food), and certain gas causing foods (cabbage, cauliflower, brussels sprouts, turnips, raw apple, dried peas and beans, fizzy drinks and I've even heard some people mention that baked beans can

cause increased gas production).

People who frequently fly at high altitude soon become quite expert at venting the expanding gas from their stomach and intestines and avoid foods and drinks that disagree' with them prior to flight.

The Lungs

The lungs and wind-pipe are full of air yet virtually never are there problems as the air expands. The airways leading from the lungs are quite large and usually allow the expanding gas to vent easily without causing a pressure build-up. There has never been a case of lung damage due to gas expansion at the ascent rates normally encountered in General Aviation, and to my knowledge none have occurred even with explosive cabin decompression (e.g. if a 747 loses an emergency door at altitude).

Lung damage would be highly likely if an

individual were to hold their breath during such a rapid decompression, the expanding gas would not be able to vent as usual and pressure would build up. The only situation where this is likely is in a practice Decompression Chamber run, and all participants are thoroughly briefed prior to such runs.

The Teeth

Large changes in altitude can cause toothache (Barodontalgia = pressure-tooth-pain). The reason this occurs is either the presence of small pockets of gas in deep (usually unlined) fillings, or collections of gas in areas of decay, gum inflammation, or root abscesses The pain can be quite severe.

There is little you can do, except descend, to treat this pain. A high degree of dental hygiene and care is mandatory for aviators. Regular checkups with your dentist avoid this unnecessary risk of

incapacitation.

Introduced Gas

The above are all (with the exception of the tooth filling) natural collection of gas within the body but items worth realising that gas can be introduced into the body in a variety of abnormal circumstances. These situations are really the realm of a doctor but it is certainly worthwhile that GA pilots are, at least, aware of them (You may have flown for the Flying Doctor or performed a Medical Evacuation and wondered why the Medical staff insisted on “sea level cabin altitude”).

Consider a bullet wound to the chest or abdomen, or a badly fractured skull with a large cut over it, or even an eye injured when a small sliver of metal flew into it. All of these are potentially circumstances where air may have. abnormal entered and be trapped within the body. Consider again the fractured skull where a small amount

of air has entered the skull through the cut and fracture. What happens if this patient ascends in altitude (e.g.. aerial ambulance transport where sea level cabin is not maintained)? The small quantity of gas trapped within the skull will expand and put pressure on the brain, not a desirable situation in someone who already has a head injury.

This doesn't mean you should refuse to carry people with these injuries, the medical staff involved decide whether the patient is fit for aerial transport or not. If the facilities are available they will usually x-ray such an injury to see if there are any abnormal collections of gas. Still, it doesn't hurt for your to understand “why”, you probably won't curse as much when the nurse insists on a sea level cabin next time.

Conclusion

Changing barometric pressure, especially if rapid,

can cause discomfort and damage unless the pressure within the body's gas containing cavities is able to equilibrate with the outside air pressure. With practice and experience aircrew are able to avoid, or treat, these pressure related problems.

* THE FALL IN AIR PRESSURE DURING ASCENT CAUSES EXPANSION OF GAS WITHIN THE BODY (AND VICE-VERSA). EUSTACHIAN TUBES ARE ESSENTIALLY FLOPPY VALVES AND SHOULD BE OPENED REGULARLY DURING DESCENT.

* PREVENTION IS FAR BETTER THAN CURE SO DON'T FLY WITH A COLD, WATCH WHAT FOODS YOU EAT, AND VISIT YOUR DENTIST REGULARLY.

* IT MAY BE WORTHWHILE HAVING A BOTTLE OF NASAL DECONGESTANT SPRAY IN THE CABIN TO HELP IF PROBLEMS ARISE (YOURSELF OR PASSENGERS).