INTRODUCTION
A cerebral aneurysm is an abnormal blood-filled dilatation of a blood vessel resulting from disease of the vessel wall. They are commonly found incidentally when imaging is performed for another reason, or when conducting family screening. It is an important diagnosis in the medical environment due to its risk to flight safety and mission effectiveness. Through risk of rupture, leading to subarachnoid haemorrhage, symptoms and signs associated with mass effect, impact with negative G exposure on treated and untreated lesions, and the residual effects of treatment. This case describes a small aneurysm in an aviator and the risks associated with it, particularly in the fast jet environment, which does impose significant and unique stressors on the individual. It highlights the difficulties with aeromedical decision making when, despite the depth of evidence available, the risks remain unquantifiable.

CASE HISTORY
The patient is a 33 year old male Air Combat Officer (ACO) in the Royal Australian Air Force. He is married with children. He is currently serving in a scheduled desk job, but has 2230 flying hours as an ACO, and 265 flying hours as a pilot.

An Air Combat Officer within the Air Combat stream is employed as aircrew on the F/A-18F Super Hornet. In the Super Hornet, they are teamed up with the Pilot, to operate state of the art mission systems including aircraft systems, electronic warfare equipment, sensors including radar and infra-red targeting systems and weapons. Roles of the Super Hornet are varied and complex in nature and include air-to-air combat, air-to-ground and air-to-surface weapons employment.

The patient's brother died unexpectedly in his 30s from a ruptured Arteriovenous Malformation (AVM), and from this, it was recommended that the family undergo screening, although AVMs are considered sporadic vascular lesions. There is no known genetic association between AVM and aneurysm, though individuals of course can have both.

The patient underwent CT Angiogram of the brain circulation on 3 Feb 15, which demonstrated a likely 1 – 2mm aneurysm located in the cavernous portion of the right internal carotid artery. He had been and remains asymptomatic, with no neurological signs or symptoms. He is a non-smoker and social drinker, with no past medical history of note, including no hypertension or vascular disorders. He participates in exercise, though does not undertake weightlifting. The Neurosurgeon indicated that the risk of haemorrhage from this aneurysm, in this location, was practically zero, and that there was no indication for any further intervention.

LITERATURE REVIEW OF INTRACRANIAL ANEURYSMS
The prevalence of intracranial saccular aneurysms by radiographic and autopsy series is estimated to be 3.2% in a population without comorbidity, a mean age of 50 years, and a 1:1 gender ratio. Of patients with cerebral aneurysms, 20 to 30% have multiple aneurysms. Aneurysmal subarachnoid haemorrhage occurs at an estimated rate of 6 to 16 per 100,000 population. Rupture of an intracranial aneurysm is believed to account for 0.4 to 0.6% of all deaths. Approximately 10% of patients die prior to reaching the hospital. The role for genetic factors in the pathogenesis of intracranial aneurysm formation is supported by studies that have found an increased risk in patients with some known hereditary syndromes and by the occurrence of aneurysms in families. Familial aneurysms tend to rupture at a smaller size and younger age than sporadic aneurysms. Siblings often experience rupture in the same decade of life. There is, however, no identified genetic link between aneurysms and arteriovenous malformations.

Intracranial aneurysms are the major aetiology of subarachnoid haemorrhage (SAH). Risk factors for SAH include hypertension, cigarette smoking and heavy alcohol consumption, none of which are pertinent for the patient. Most intracranial aneurysms are asymptomatic unless they rupture, and so they are usually found incidentally or when a patient presents with SAH. Some unruptured aneurysms can become symptomatic due to the mass effect of the aneurysm – headache, visual acuity loss, cranial neuropathies, pyramidal tract dysfunction, and facial pain. Ischaemia can occur as a result of emboli originating from within an aneurysm.

Two large prospective studies have reported on the natural history of unruptured intracranial aneurysms. The International Study of Unruptured Intracranial Aneurysms (ISUIA) assessed 1692 patients with 2686 unruptured, untreated aneurysms, and the Unruptured Cerebral Aneurysms Study (UCAS) assessed 6697 aneurysms in 5720 patients. Both noted size and location were associated with the risk of rupture. They both confirmed that the rates of aneurysmal rupture were lower in smaller aneurysms. The size cut point in both studies for defining low risk of rupture was 7mm. Another prospective study followed 374 patients with 448 aneurysms that were less than 5mm in size; the annual average rupture rate was 0.54% overall; 0.34% for single aneurysms, and 0.95% for multiple aneurysms. In this group, aneurysm rupture risk was somewhat higher in those less than 50 years of age and those with aneurysms more than 4mm in size.

ABSTRACT
An asymptomatic 33 year old male Air Combat Officer was recommended to have a CT cerebral angiogram, based on a family history of a vascular anomaly. A 1-2mm aneurysm located in the cavernous portion of the internal carotid artery was discovered. Neurosurgical advice was obtained which indicated that the risk of haemorrhage from this aneurysm in this location is ‘practically zero’, and that there is no indication for any intervention. The fast jet environment does impose significant stress on the individual however, and aeromedical decision making is often more difficult when, despite the depth of evidence available, the risks remain unquantifiable. This paper discusses the literature review conducted, the risk factors for rupture and risks of rupture, precipitating events, treatment, monitoring, and advice for the affected individual. The aeromedical disposition of the affected individual is outlined.

Both the ISUIA and the UCAS, as well as other studies, have found that the risk of aneurysm rupture varied according to its location. Cavernous carotid artery aneurysms had the lowest rates of rupture. The cumulative five-year rate of rupture according to aneurysm site and size at diagnosis: For 7 to 12mm aneurysms, rupture rates for cavernous carotid aneurysms was 0%. Studies did not report on aneurysms smaller than 7mm. An acute trigger event such as physical exertion appears to occur in some cases of aneurysm rupture. The Australasian Cooperative Research on Subarachnoid Haemorrhage Study of 338 people found that patients with SAH were more likely to have engaged in moderate or greater exertion in the 2 hours prior to SAH than in the same 2hr period on the previous day (Odds Ratio 2.7, 95% CI 1.6 to 4.6). Emotionally stressful life events have not been convincingly shown to be a trigger for aneurysm rupture.

The ISUIA investigators concluded that in patients without a history of previous SAH, it is unlikely that any therapy would be able to improve upon the untreated natural history of aneurysms that are smaller than 7mm. Using the ISUIA data, for 40 year old patients, treatment was ineffective or not cost effective for small aneurysms (<12mm) located in the cavernous carotid artery.

Annual imaging with Magnetic Resonance Angiogram is recommended. Patients with aneurysm (size and location not defined) should be instructed to avoid smoking, heavy alcohol consumption, stimulant medications, illicit drugs, excessive straining and valsalva manoeuvres.

The risks associated with straining and valsalva manoeuvres are unquantifiable however, as the literature does not differentiate between sizes and locations of aneurysms when providing this advice, nor does it quantify the degree of straining, for example amount of heavy weights that should be avoided. Valsalva manoeuvres are also variable, being dependent on why a valsalva is being performed, with some barely increasing the intracranial pressure, and others being very forceful, raising the intracranial pressure to levels which may cause aneurysmal rupture. The level of intracranial pressure required to cause rupture of an aneurysm is not defined in the literature, with many confounding factors limiting research in this area.

A 1 – 2mm aneurysm, located in the cavernous portion of the right internal carotid artery, is at very low risk of rupture in an average individual, in normal environmental conditions, and the patient can be reassured. There is no evidence of a genetic link for this patient, and screening of the patient’s mother and two sisters was negative for both aneurysm and AVM.

There is no indication in the patient’s past history that he has difficulty with descent in an aircraft, including eustachian tube dysfunction and rhinitis (allergic or otherwise). He is unlikely to require a strong valsalva to ventilate the middle ear cavity; and of course aircrew should not fly with a cold or rhinitis symptoms in any case.

The fast jet environment provides very different challenges to a ground based environment and these must be carefully evaluated when considering the aeromedical disposition of an individual with an intracranial aneurysm, particularly when assessing risks associated with straining and valsalva manoeuvres.

According to Newton’s First Law, a manoeuvring aircraft is under the influence of an accelerative force directed towards the centre of the turning circle (i.e. centripetal acceleration). Newton’s Third Law states that for every action there is an equal and opposite reaction. This is the subjective sensation experienced by aircrew of increased weight and limb heaviness (i.e. the centrifugal or inertial force). Force is proportional to the square of the velocity, so the faster the turn the bigger the force. Force is inversely proportional to radius of turn, so the tighter the turn the bigger the force. In aerospace medicine, the direction of force applied to the human is referred to in terms of the centrifugal or inertial force, which is the human perception of the environment. Positive Gz (+ Gz) is the head to foot inertial force. Negative Gz (- Gz) is the foot to head inertial force.

Another trigger event which is a cause of SAH is Valsalva manoeuvres. Valsalva manoeuvres are also variable, being dependent on why a valsalva is being performed, with some barely increasing the intracranial pressure, and others being very forceful, raising the intracranial pressure to levels which may cause aneurysmal rupture. The level of intracranial pressure required to cause rupture of an aneurysm is not defined in the literature, with many confounding factors limiting research in this area.

DISCUSSION

A 1 – 2mm aneurysm, located in the cavernous portion of the right internal carotid artery, is at very low risk of rupture in an average individual, in normal environmental conditions, and the patient can be reassured. There is no indication in the patient’s past history that he has difficulty with descent in an aircraft, including eustachian tube dysfunction and rhinitis (allergic or otherwise). He is unlikely to require a strong valsalva to ventilate the middle ear cavity; and of course aircrew should not fly with a cold or rhinitis symptoms in any case.

The fast jet environment provides very different challenges to a ground based environment and these must be carefully evaluated when considering the aeromedical disposition of an individual with an intracranial aneurysm, particularly when assessing risks associated with straining and valsalva manoeuvres. Force is proportional to the square of the velocity, so the faster the turn the bigger the force. Force is inversely proportional to radius of turn, so the tighter the turn the bigger the force. In aerospace medicine, the direction of force applied to the human is referred to in terms of the centrifugal or inertial force, which is the human perception of the environment. Positive Gz (+ Gz) is the head to foot inertial force. Negative Gz (- Gz) is the foot to head inertial force.

Another trigger event which is a cause of SAH is Valsalva manoeuvres. Valsalva manoeuvres are also variable, being dependent on why a valsalva is being performed, with some barely increasing the intracranial pressure, and others being very forceful, raising the intracranial pressure to levels which may cause aneurysmal rupture. The level of intracranial pressure required to cause rupture of an aneurysm is not defined in the literature, with many confounding factors limiting research in this area.

AEROMEDICAL DISPOSITION

Taking into account the small size and location of the patient’s cerebral aneurysm, and the ability to avoid - Gz manoeuvring (although acknowledging the small risk of an airborne recovery action resulting in unforesen application of -Gz), at medical board the patient was deemed fit to continue flying in a fast jet environment, with the restriction that he was unfit to perform aerobatic manoeuvres (display aerobatics with intentional – Gz) , and not to lift heavy weights.

CONCLUSION

The patient has a very small cerebral aneurysm located in the cavernous portion of the internal carotid artery. A literature review provided the evidence that the risk of rupture was very low in normal environmental conditions. The fast jet environment is unique however, and a negative Gz manoeuvre can increase cerebral blood pressure, placing the patient at risk of aneurysmal rupture. When determining fitness to fly, consideration of the flight environment and the operational characteristics of the platform are required to ensure flight safety is maintained, and the risk to the patient is as low as reasonably practicable.
REFERENCES


