Case Study

Subarachnoid Haemorrhage and Intracranial Aneurysm in a Military Aviator: Factors Determining Aeromedical Disposition

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Introduction

Intracranial aneurysms (IA) are acquired lesions of the cerebral circulation with a prevalence of 3.6 – 6.5% of the population over 30 years of age. Subarachnoid haemorrhage (SAH) only affects a very small proportion of these individuals, but the consequences of this are potentially devastating and the fatality rate is high. The reported annual incidence of SAH varies from 2 to 22.5 cases per 100,000 people (0.002 – 0.023% per year). The most significant risk factors for rupture of an IA are size and site. The surgical implications of acute aneurysmal SAH have been well described previously by Jackson as sudden incapacitation affecting command and control of the aircraft, remoteness from definitive medical care, and the impact such an event has on crew resources and performance.

This report documents a case of SAH from an intracranial aneurysm of the posterior inferior cerebellar artery (PICA), suddenly occurring in a young naval aviator which was successfully treated with full recovery, and discusses the factors to be considered in determining aeromedical disposition with a view to a return to military flying.

Case Report

At initial presentation the patient was a 31 year old male Aviation Warfare Officer (AvWO) in the Royal Australian Navy, qualified on S-70 Seahawk helicopters, and working as an instructor with 750 hours of flying experience. His only past history of significance was hypertension treated with perindopril since 2006. His mother had also been previously diagnosed with an intracranial aneurysm.

While on vacation in January 2012 he presented to a regional civilian hospital after he developed a sudden onset of post-coital occipital headache associated with nausea and vomiting. He displayed no neurological signs or symptoms at the time, routine blood screens were normal and a CT scan with contrast showed no subarachnoid blood. He was transferred to a major tertiary referral hospital when a lumbar puncture revealed blood staining of the cerebrospinal fluid, indicative of SAH. On arrival there he remained alert and oriented with GCS of 15 and no findings on examination of the cranial nerves and peripheral nervous system. Admission to hospital was arranged for a neurosurgery consult and further investigation. CT angiography and digital subtraction angiography (DSA) failed initially to reveal any evidence of aneurysm, however a repeat DSA one week later revealed a small aneurysm at the origin of the left PICA. He was taken to theatre the following day for repair of the aneurysm via a left-sided far lateral posterior fossa craniotomy. At surgery, a 1 mm sessile thin-walled dissecting aneurysm was found at the PICA origin. The aneurysm was repaired using a felt sling as it was quite friable, and a Codman clip to hold the wrapping. Post-operative DSA showed no evidence of the aneurysm and mild narrowing at the aneurysm site. He was discharged from neurosurgical intensive care after three days and continued to make an uncomplicated recovery while taking aspirin, metoprolol and nimodipine. No anticonvulsant medications were required.

During his hospital admission he had both neurological and neuropsychological assessments. The neurologist determined that as the aneurysm was not cortical, there was no increased risk of seizures occurring over and above the background risk of seizures in the general population. His neuropsychological testing showed no impairment of learning, cognition, language, coordination or higher order executive functioning. He was discharged from hospital after 21 days. Review by the neurologist and neuropsychologist four months post-operatively confirmed the findings above and affirmed his full recovery and low seizure risk, although he was still experiencing some mild early morning headaches. Cerebral angiography in April 2012 showed no aneurysm, and aspirin was ceased. He was recommenced on perindopril for control of hypertension.

A follow-up CT angiogram was arranged at 12 months from surgery in January 2013. This appeared to show a residual 5 mm aneurysm at the PICA origin but no evidence of intracranial haemorrhage. This finding prompted further investigation with formal catheter angiography with 3D reconstructions, which failed to show any residual aneurysm.

This aviator came to Aircrew Medical Employment Category Review (AMECR) in August 2013 to determine his fitness to fly. The determination of the Board was to return him to flying in a supernumerary or teaching role as a passenger in fixed wing aircraft (King Air) only. He was excluded from occupying a control seat, and from any aerobatic maneuvering. These restrictions were to be reviewed after a further 12 months. This was based on a discussion of the risks following aneurysmal SAH which include:

- recurrence of bleeding
- formation of further aneurysms
- risk of seizures

In preparation for a second AMECR the aviator underwent further specialist review in the latter part of 2014, at which time he remained well and symptom free. A repeat cerebral angiogram in September 2014 was normal with no evidence of residual or recurrent PICA aneurysm or any other aneurysms. The neurosurgeon recommended that follow-up be scheduled every two years with MRA/CTA or CTA/CT, as opposed to every 3 to 5 years for the general risk of a recurrence.

Abstract

A Royal Australian Navy aviator was diagnosed with a subarachnoid haemorrhage after sudden onset of occipital headache, the result of a small aneurysm of the left posterior inferior cerebellar artery. The aneurysm was surgically wrapped and clipped through a posterior fossa craniotomy, and the patient made a full and uncomplicated recovery. Except in rare cases, subarachnoid haemorrhage and intracranial aneurysms are generally considered to be disqualifying for military aviation. Even with good recovery of neurological functioning, complications such as seizures, risk of rebleeding, and de novo occurrence of other aneurysms are all significant concerns due to the risk of sudden incapacitation. This paper will examine the aeromedical factors particular to this case that influenced a favorable aeromedical decision-making outcome.


About the Author

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population. He estimated that the lifetime risk of recurrence of the target PICA aneurysm is approximately 1%, but also estimated a 20% probability of a patient who has had a previous aneurysm developing another aneurysm in their lifetime. The neurologist also reassessed him regarding his risk of seizures, given that he has never had a seizure and there is no family history of seizures. He reassured that based on cited literature his risk of seizure continued to be comparable that of the general population. He maintained that those who develop seizures after SAH have risk factors not present in this patient’s history.

The Board was now to determine whether the restrictions previously imposed could be lifted allowing this aviator to continue with his military flying career unhindered.

**DISCUSSION**

SAH is generally disqualifying for military aviators. The US Navy does not allow waivers for any aviators who have had surgical repair of a leaking intracranial aneurysm, or any other intracranial procedures. In guidelines produced for the US Air Force, Van Sooy and Hessbrooke cite data which describes the high rate of mortality (32-67%) and morbidity (20-30% disabling sequelae) usually associated with SAH, with deficits of memory and executive function being common. They describe the most significant neurological complications of SAH as re-bleeding, vasospasm, hydrocephalus and seizures. As a result, the United States Air Force generally does not waive survivors of aneurysmal SAH due to the high rate of associated problems and re-bleed risk. This data however does not take into account size and site of the IA which caused the bleeding, or surgical approach and outcomes.

**The flight environment**

As an AvWO, this aviator flies helicopters or pressurised twin turboprop training aircraft at ambient or cabin altitudes below 10,000 feet. Although not a pilot, he does have a need to operate from a control seat of rotary wing aircraft in his primary role. As an instructor, he occupies a non-control seat but supervises students occupying a control seat. The flight environment in which he operates does not involve high levels of positive or negative Gz or anti-G straining, or pressure breathing. At high levels of positive Gz, cerebral perfusion pressure falls dramatically and is only maintained by countermeasures such as the anti-G straining manoeuvre. A greater risk is negative Gz, which increases cerebral perfusion pressure, however this is balanced to some extent by the rise in cerebrospinal fluid pressure which negates any transmural pressure gradient and minimises the risk of vascular rupture. Hyponatraemia at high altitude resulting in arterial oxygen tensions below 45 mmHg causes reflex vasodilatation of the cerebral arteries with concomitant rise in cerebral blood flow. This is offset by the reflex vasoconstrictive effect of hyperventilation that accompanies the hypoxic ventilatory response. For this aviator in a maritime role, the only time intracranial pressure may rise is during a forced Valsalva manoeuvre on descent to clear ears of trapped gas.

Helicopter underwater escape training (HUET) and helicopter emergency egress device (HEEDS) training is required every two years. History of intracranial haemorrhage is considered a contraindication to recreational diving. It is unlikely that infrequent and short duration breath-holding during escape from a helicopter under water, or breathing from an underwater air supply, would appreciably increase cerebral arterial pressures sufficient to put at risk the repaired aneurysm.

**Seizure risk.**

The published literature supports the neurologist’s opinion that the patient does not have a substantially increased risk of seizure. The incidence of single unprovoked seizures in the general population is 23 – 61 per 100,000 person-years, or approximately 0.061% per year. The cumulative risk of seizures in patients with a good recovery after neurosurgical treatment for non-middle cerebral artery aneurysms is 0.019% at 2 years, 0.03% at 5 years and 0.034% at >9 years. It can therefore be said that his ongoing risk of sudden incapacitation from seizure does indeed approximate that of the general population, and is well below 1% per year, generally regarded as an acceptable threshold of risk in civilian commercial aviation.

**Risk of re-bleeding.**

The International Subarachnoid Aneurysm Trial (ISAT) provides cumulative mortality data that shows there is a slightly less than 15% risk of mortality in the first five years after neurosurgical treatment of IA, or about 2-3% per year risk. The causes of these deaths in the study population however were mostly related to complications arising in severely dependant individuals, cardiac causes, and cancer. There were only two fatalities as a result of the treated aneurysm re-bleeding, and no cases of bleeding from other aneurysms. The cumulative risk of re-bleeding out to 7 years was approximately 4%, with the majority occurring in the first 12 months. This results in an annualised risk of 0.57% per year, however this data did not stratify risk based on the type or site of aneurysm.

**New aneurysm formation.**

The neurosurgeon was of the view that there could be a 20% lifetime risk of developing a further aneurysm. Knowing there is a family predisposition, this statistic is somewhat concerning. In the published literature, familial predisposition is a well-recognised non-modifiable risk factor for the formation and rupture of IAs, and is more likely to cause multiple IAs due to an underlying biologically conferred vulnerability. In follow-up studies from 7.2 to 9 years after treated IAs, de novo aneurysms were found in 7.1% to 8% of patients respectively, with a rate of occurrence of 0.89% to 0.97% per year. Longer-term follow up for a mean of 16 years has demonstrated recurrent IA formation in 30% of subjects with previously treated SAH. If linear risk is assumed in this population over time this equates to a 4.15% rate of de novo IA per patient-year. This study also suggests that the risk of continuous aneurysm development persists throughout life. This rate exceeds a 1% per year risk threshold. This risk is mitigated by the fact that MRI/CT has been recommended every 2 years to detect such an occurrence. However the risk of new IA in a 2-year window may be between 2 and 8% based on the above data. It also does not completely eliminate the risk of such a de novo aneurysm bleeding between scans, or if the imaging fails to detect an aneurysm, recognising that the original bleed was from an aneurysm of only 1mm which was missed on initial CTA. Reassuringly, the ISAT study showed no mortality as a result of other aneurysms bleeding or from other forms of intracranial haemorrhage. Other studies show that in patients with a prior history of SAH, de novo IAs <10mm have a rupture rate of approximately 0.5% - 0.7% per year, but this varies depending on the site of the aneurysm. So, if an aneurysm did form and if it went undetected for two years, it’s rupture rate is very low and within a 1% per year tolerance.
AEROMEDICAL DISPOSITION

Based on the data reviewed, the prognosis for this patient is generally favourable. To summarise, the aviator is now more than three years since the SAH, and has made a complete recovery. The risk of seizures and re-bleeding from the target aneurysm is minimal, and within an aeromedically acceptable range. The risk of further new aneurysm formation is possibly in the order of 1–4% per year, mitigated by second yearly scans. The risk of bleeding from one of these de novo IAs is approximately 0.5 – 0.7% per year, but the risk of aneurysm formation will persist life-long. The flight environment is relatively benign, and he operates in a multi-crew setting. A recommendation was therefore made to return the aviator to unrestricted flying duties with the follow-up protocol of scans every two years.

CONCLUSION

SAH from IAs can be life-threatening conditions that can result in serious neurological morbidity in survivors. As such, they most commonly result in permanent disqualification from aviation duties. This case demonstrates that in certain cases where recovery is full, and neurological function is maintained, even an underlying predisposition to further IA formation can be risk managed to allow a return to flying duties for aviators in certain flying roles. Each case must be assessed on its merits and careful consideration given not only to the statistical risks of aeromedically significant problems, but also the specific flight environment and role of the patient.

REFERENCES


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