REVIEW

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Practical Neurology, 2004, 4, 322–325

Neurological disease at 30 000 feet – what is an acceptable risk for your pilot?

INTRODUCTION

Fitness to fly is not defined merely by the absence of disease. The standards for aircrew are such that even without significant disease an individual may not be considered fit to fly, for example if there is significant myopia. In contrast, even documented conditions, such as coronary artery disease, may not preclude fitness to fly in certain circumstances. The medical standards are set with the aim of maintaining flight safety at an acceptable level.

WHAT IS AN ACCEPTABLE RISK?

A zero risk environment is unattainable. In aviation therefore the concept of 'acceptable risk' has been developed (Tunstall-Pedoe 1984). This approach uses an overall fatal accident rate which is reasonably achievable (one in 10 million flights). To simplify the calculations which follow, each flight is deemed to last 1 hour, though most commercial flights are much longer. It is further postulated that no one component (crew failure, airworthiness, mechanical failure, air traffic control, flight operations) should contribute more than one-tenth of the total risk, so that each component risk should not exceed one in 100 million hours. The pilot is regarded as just one component. 'Crew failure' includes pilot error plus medical incapacitation; however, since medical incapacitation only accounts for 10% of the 'crew failure' component, with the other 90% being accounted for by an error or errors on the

part of the pilots (Tunstall-Pedoe 1992), then a medical cause for fatal accidents should occur no more than one in 1000 million hours. It has been calculated (Tunstall-Pedoe 1984) that a 1% per annum risk of incapacitation in a pilot, in a multicrew environment, with good incapacitation training, would meet the required target fatal accident rate (these calculations relate to a multicrew environment, in single pilot operations all phases of the flight are critical, and any incapacitation could have more serious consequences). This 1% per annum risk matches the best rates obtained following recovery from myocardial infarction and coronary artery bypass surgery (Serruys & Breeman 1992). The model of cardiac disease was chosen because this is the most common cause of loss of medical certification of fitness to fly – 13/31 (42%) of all cases in the UK in 1995 (CAA Medical Division).

Therefore, a professional aircrew member may be deemed fit to fly in a multicrew environment if the incapacitation rate associated with the disease in question is equal to, or less than, 1% per annum. A class 1 medical certificate is required for professional pilots in Europe. For private flying a class 2 medical certificate is required and the restriction used in this capacity is that of a safety pilot. In the presence of any disease the certification options are: unfit (temporarily or long-term), fit for class 1 certification with a multicrew restriction, or fit for unrestricted certification (the term 'multicrew

restriction' means that a pilot is permitted to fly an aircraft as a copilot, or with a copilot, but not alone). Air Traffic Controllers also require a UK class 1 medical certificate with the restriction for another controller to be in close proximity. This review covers the approach to professional aircrew.

SPECIFIC NEUROLOGICAL ASPECTS

Neurological disease accounted for about one-third (21/67) of cases of loss of professional medical certification in the United Kingdom in 2002 (CAA Medical Division). It is not possible to cover all the reasons in a review such as this, but merely the basic principles with some specific examples. Neurological assessment of fitness to fly must take account not only of the present physical fitness of the pilot, but also the prognosis of a particular condition and its possible impact on flight safety. For aviation purposes, it is convenient to divide neurological disorders as shown in Table 1. Individual assessment by a neurologist and an aviation physician is required, but general guidelines are presented here.

FIXED DEFICIT, LOW RISK OF PROGRESSION

This group mainly includes injuries to the central or peripheral nervous system, or residual disability following an illness in the past. When the cerebral hemispheres have been involved in disease or injury, the neuro-psychological sequelae may impair cognition, affect or judgement and there may be an increased risk of epilepsy. It is self evident that these sequelae could have a major impact in the aviation environment. The effect of any fixed disability is readily assessed in a flight simulator.

Head injury

The assessment of 'fitness to fly' depends on the degree of recovery of cognition, mood and motor function as well as intact special senses and an acceptable risk of post-traumatic epilepsy. The severity of the original head injury may be assessed by (Jennett 1975):

- duration of unconsciousness;
- duration of post-traumatic amnesia (PTA);
- presence of a skull fracture and the presence or absence of a dural tear;
- presence of any neurological deficit.

The duration of PTA is one of the more robust parameters and suggested periods of unfitness are shown in Table 2.

Various complications increase the risk of epilepsy (Table 3). The definition of 'initial' risk has varied but has been taken by Jennett, in Table 3, to be within one week of injury. The table shows facets of the injury that if observed in the first week then influence the pilot's risk of further fits. Late epileptic seizures enhance the risk of post traumatic epilepsy. The risk of epilepsy falls by 75% after two years (Jennett 1975) and even following severe head injury, if no seizures have developed after five years, the risk falls to that of the general population (Annegers & Kurland 1980). Depending on the initial level of risk, if there have been no fits at any time and epilepsy has not developed after two years and the patient is not on any antiepileptic medication, the pilot may return to flying with a multicrew restriction and, after five years, consideration may be given to its removal.

FIXED DEFICIT, RISK OF PROGRESSION OR RECURRENCE

Cerebrovascular disease

The prognosis following stroke or transient ischaemic attacks (TIA) is poor. The overall risk of recurrence is generally taken as 5% per annum and is cumulative. Thus, after five years, about one-quarter will have had a recurrence and another quarter will have died due to myocardial infarction (Sacco *et al.* 1982; Dennis *et al.* 1990). Rothwell *et al.* (2004) have shown that although the age specific incidence of stroke has fallen by 40% in the last 20 years, no change has occurred

Table 1 A classification of neurological disease for aviation medical certification

Fixed deficit	Low risk of progression	Spinal injury
	Peripheral nerve lesions	
	Post neurosurgery	
	Head injury	
	Risk of progression or recurrence	Multiple sclerosis
		Cervical myelopathy
	Progressive	Head injury and epilepsy
		Stroke
		Parkinson's disease
No fixed deficit	Episodic and single events	AIDS
		Motor neurone disease
		Epilepsy
		Transient global amnesia
		Migraine
		Cluster headache
		Transient ischaemic attack

After a single episode of demyelination with good recovery, it is possible to return to flying with a multicrew restriction

in the early case fatality. Coull *et al.* (2004) have shown in the Oxford Vascular Study that the *early* risk of stroke following a transient ischaemic attack is higher than previously thought, being 8% at seven days and 17% at three months. Following a minor stroke the figures were similar. In the light of these figures it is unlikely that a return to flying would be possible, particularly as a recurrent TIA may be just as incapacitating as a stroke.

Of course these epidemiological data in cerebrovascular disease are based on the general population and extrapolation to aircrew may not be valid. If a younger individual suffers a stroke and is found to have a remediable lesion (e.g. a cerebellar vascular malformation which has been completely eliminated) and no other risk factor is present, an individual assessment may allow a return to flying.

Subarachnoid haemorrhage

The most common causes are ruptured berry aneurysm and sometimes arteriovenous malformations. If an infratentorial aneurysm is clipped, it is not associated with a significant risk of epilepsy. If the aneurysm is above the tentorium, the risk of epilepsy is up to one-third (Cabral 1976) and the pilot will be declared unfit for two years. He or she will then be considered for a return to flying with a multicrew restriction if there have been no fits. If there is no recurrence of bleeding after five years, consideration may be given to an unrestricted class 1 medical certificate. Perimesencephalic haemorrhage has

a better prognosis and multiple aneurysms a worse prognosis. In the case of an arteriovenous malformation, any of the treatment options, including total removal or occlusion, may not reduce the risk of epilepsy and the pilot is likely to be considered long-term unfit. The evidence base for this, however, is somewhat limited and each case is considered individually.

Multiple sclerosis

This condition does occur in the pilot population and is not an absolute contraindication to flying. When the diagnosis is made, the pilot is declared temporarily unfit until appropriate investigation has been completed by a neurologist. After a single episode of demyelination with good recovery, it is possible to return to flying with a multicrew restriction. Because recurrences tend not to result in *sudden* incapacitation, the risk is acceptable. Regular follow-up and reports from a neurologist are mandatory.

Parkinson’s disease

Certification is usually possible in the early stages and performance can be assessed in a flight simulator.

NO FIXED DEFICIT, EPISODIC AND SINGLE EVENTS

Migraine

Of this group the most common in aviation practice is migraine. The variable and unpredictable natural history makes assessment for certification difficult. The aura, if present, can cause problems, particularly if the individual experiences visual upset. Even headache alone, particularly with photophobia, may cause a significant performance decrement which can raise safety issues in critical phases of flight, i.e. during take-off or landing. On this basis migraine is managed as shown in Fig. 1. It is important to understand that these are only guidelines and each case is assessed individually.

Cluster headache (periodic migrainous neuralgia) is characterized by repeated episodes over several weeks, usually with long periods of remission. These patients may return to flying with a multicrew restriction if off all treatment and symptom free for a period determined individually. The removal of this restriction depends on follow up and discussion with the neurologist.

Epilepsy

A diagnosis of epilepsy is disqualifying due to

Table 2 Minimum period of grounding based on duration of post-traumatic amnesia (Merry 1999)

DURATION OF PTA	MINIMUM PERIOD OF GROUNDING
Momentary	Two – six weeks
More than one hour	Two months
More than 12 h	Four months
More than 24 h	Six months
More than one week	12 months

Table 3 Complications of head injury associated with an increased risk of post traumatic epilepsy (modified from Jennett 1975)

	INITIAL RISK (%)
Penetrating brain injury	40
Blunt head injury, with depressed skull, fracture/dural tear	30
Intracerebral haematoma	35
Focal neurological signs	30
Early epileptic seizure	25
Post traumatic amnesia > 24 h	4

the potentially serious impact on the flight deck and risk of recurrence. A single seizure is associated with a recurrence risk of 52–78% over the next three years (Hopkins *et al.* 1988; Hart *et al.* 1990). Even after this period the recurrence risk probably exceeds 1% per annum although there are no long-term studies. If, however, after 10 years there is no continuing risk of seizures in the opinion of the neurologist and the patient has been off all medication for at least two years, recertification may be possible. This is likely to be with a long-term multicrew restriction for professional flying.

Benign febrile convulsions before the age of five years have no impact on future medical certification. Similarly, benign Rolandic epilepsy has a very low recurrence risk over the age of 15 years. When the diagnosis is well documented by a neurologist, certification is possible after 10 years seizure free.

CONCLUSIONS

- The basic question in all cases is 'will the disease or its treatment interfere with the safe execution of the flying task?'
- The answer to this question requires close co-operation between the aviation physician and neurologist, and a thorough assessment of the risk of any incapacity or an incapacitating incident.
- With this approach many pilots with neurological conditions may be safely returned to flying.

ACKNOWLEDGEMENT

This article was reviewed by Dr Colin Mumford, Edinburgh

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Figure 1 Medical certification in migraine