SEDATION IN MEDICAL RETRIEVAL – CHALLENGES AND FUTURE PRACTICE

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INTRODUCTION
Medical retrieval involves providing high-level care to sick patients despite the challenges of difficult environments. It is from the knowledge of the physiological and environmental changes that occur in flight that allows for prevention and management of adverse events that may occur. The specific challenges of the aerospace environment must be identified, understood and subsequently managed in order to deliver safe and effective care during retrievals. One important aspect of care that is impacted by the aerospace environment is sedation.

Sedation is an important tool for transporting acutely unwell patients and is commonly used in those requiring medical retrieval. In an Australian setting, of the 3770 inter-hospital transfers performed by NMRA Careflight from January 1998 to December 2002, 75% required mechanical ventilation and therefore also sedation. Sedation is important as it facilitates not only comfort for the patient, but also the ability to perform important procedures that are not appropriate with a conscious patient. It can also be used when patients are highly agitated and may cause harm to themselves or others during transportation.

When delivering sedation in any environment it is important to consider the risks to patients, especially in situations outside hospitals such as in the flight environment. Despite its importance and regular use, research into sedation and its risks in aeromedical retrieval is scarce. However it is known that adequate sedation is important, as both over and under sedation can lead to poorer outcomes for patients, such as unsuccessful extubation if over sedated or patient discomfort or violence if under-sedated.

One of the most serious risks of sedation is called anaesthesia awareness, which is the explicit recall by the patient of events occurring while they were sedated. Although uncommon it can have serious and lasting psychological effects such as Post Traumatic Stress Disorder. It is ranked the second most serious complication of anaesthesia by anaesthetists only behind death, and it is believed to occur around between 0.02 and 1% of surgical patients.

Patients in the aeromedical environment are likely to be at a higher risk of sub-optimal sedation and

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ABSTRACT
Anaesthetic Awareness is the recall of events that occur during sedation and is a serious complication thought to occur in 0.1 to 0.2 % of the general surgical population. Sedation is an important tool used in medical retrieval, however its use in the aerospace environment is unique in its challenges for clinicians. Many of the patients carry risk factors for anaesthetic awareness and the mode of anaesthesia appropriate for the aerospace environment, total intravenous anaesthesia, also carries a higher risk compared to other methods. In addition the aerospace environment has other challenges not specific to sedation including noise distractions and the physiological effects of high altitude on patients which can impact on the ability to provide adequate sedation. Given all this, patients receiving sedation during medical retrieval would seem to be at a higher risk of anaesthetic awareness than many of their counterparts on the ground. For many high risk patients in hospitals technology such as brain monitoring has been shown to be effective in reducing awareness. Therefore as patients in the air are as likely, if not more likely to be at risk of awareness the use of this aid in medical retrieval is raised for consideration. However this technology will only ever be an adjunct to clinical expertise and an overall understanding of the flight environment and its challenges will allow for best patient care possible and the reduction of awareness during sedation.
anaesthesia awareness than patients in hospitals.\(^5\) This is because they often carry, or are exposed to, the factors shown in table 1, that increase the likelihood that they will experience anaesthesia awareness.\(^12\) They are often more severely ill than the average surgical patient, less often haemodynamically stable and, due to the nature of the aeromedical environment, are more likely to receive only intravenous anaesthesia.\(^3\) They also can have other risk factors not dissimilar to some of the higher risk patients in hospital such as difficult intubation and equipment failure, as well as the use of neuromuscular blocking agents. These drugs alone double the risk of awareness as they reduce patient movement, a key sign of poor sedation.\(^8\) Together, these factors place patients undergoing air medical retrieval at an increased risk of anaesthesia awareness when compared to their peers undergoing surgery in a well-resourced, controlled environment.

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<thead>
<tr>
<th>Risk Factors for Anaesthesia Awareness</th>
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<tr>
<td>Severe Illness</td>
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<tr>
<td>Trauma Induced Haemodynamic Instability</td>
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<td>Difficult or Prolonged Intubation</td>
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<tr>
<td>Equipment Failure</td>
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<tr>
<td>No Pre-Medication</td>
</tr>
<tr>
<td>Staff Ignorance of Risk of Awareness</td>
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<tr>
<td>Total Intravenous Anaesthesia</td>
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<tr>
<td>Using IV Boluses of Anaesthetic Drugs</td>
</tr>
<tr>
<td>High Altitude</td>
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<td>Use of Neuromuscular Blocking Agents</td>
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**CHALLENGES OF SEDATION**

One of the main environmental factors in aerospace medicine is increased altitude. This is important in relation to Boyle’s law, which states “at a constant temperature, the volume of a given gas is inversely proportional to the pressure of which it is subjected to.” In simple terms, increased altitude causes a decrease in gas pressure, which then causes the volume of gases to increase.\(^2\),\(^13\) These changes in altitude mean gaseous anaesthetics are not commonly used for sedation in the flight environment.\(^3\) One issue with gaseous anaesthesia at higher altitude is that oxygen, carbon dioxide and vapor analyzer’s accuracy are all affected by changes in pressures.\(^14\) These analyzers need recalibration to different altitudes and if not done, may give readings inaccurate by up to 20%.\(^14\) Furthermore, even if these gases could be delivered accurately, some agents such as nitrous oxide are completely ineffective at high altitude.\(^14\) Also, more practically, the size of the equipment required for gaseous anaesthesia is too large for the constrained flight cabin. The equipment must instead be lightweight, small, reliable and mobile.\(^15\) Due to these reasons, total Intravenous anaesthesia (TIVA) is the preferred method both to initiate and maintain sedation throughout a medical retrieval.\(^3\) However TIVA carries the highest incidence of anaesthesia awareness of all methods of sedation.\(^3\),\(^10\) This was shown in the large study by Pandit et al, in which it caused 18% of awareness events despite only being used in 8% of cases. This constitutes greater than a two-fold overrepresentation.\(^3\),\(^10\) There are a number of drugs and combinations that can decrease this risk, however TIVA is still not as effective at preventing awareness as anaesthetic gas agents.\(^10\)

Vibration, turbulence, acceleration and deceleration are other environmental factors that impact the ability to safely sedate patients during medical retrieval. Vibration for instance, increases the need for anaesthetic drugs and analgesia in order to overcome the physical stimulus to the patient.\(^16\) The main sources of vibration are the engines, gearbox and rotors in helicopters.\(^16\) Vibration can also cause disconnection or lodgement of intravenous (IV) and arterial lines or endotracheal tubes which complicates sedation and monitoring, especially when this sedation is usually via intravenous agents. Acceleration and deceleration can also pose challenges if medical equipment, such as syringe pumps, are not properly secured.

Another factor is the noise of the flight environment, which is generated by the engine as well as air passing over the aircraft creating friction.\(^16\) If significant, this can make it difficult for the medical team to monitor a sedated patient. Along with other distractions presented within the flight environment, noise may mean that audible alarms are not heard and communication between the team is more difficult.\(^11\) Whilst these individual factors alone may seem insignificant, together they form a larger constellation of factors which may contribute to sub-optimal sedation.\(^16\)

**CURRENT AND FUTURE PRACTICE**

Improving current practice is one way of reducing the risk of adverse outcomes during sedation. This is demonstrated by a study that showed 96% of cases of anaesthesia awareness occurred in the context of substandard care, meaning a large amount of this serious negative outcome is potentially avoidable.\(^8\)

Most factors are inherent to the aerospace environment and their impacts are difficult to mitigate. One possible approach to delivering safer sedation in the aerospace environment is to better identify and detect inadequate sedation, rather than attempting to overcome unmodifiable environmental factors. The clinician needs the ability to accurately and quickly assess sedation to optimize outcomes.\(^17\) However, some of the current clinical indicators used
to measure sedation, such as blood pressure and heart rate, have been shown to be subjective and unreliable. This has lead to the use of clinical sedation assessment scores, which are widely used to better assess a patient’s current level of sedation and aid clinicians to maintain optimal sedation.

One such clinical sedation assessment is the Richmond-Agitation sedation score (RASS). It has been validated in a number of studies, has good inter-reliability between users, and is also easy to learn and quick to use. It assesses a patient from aggressive (score of +4) through to alert and calm (score of 0) and finally unrousable (score of -5). It is obtained by observing if the patient is agitated or alert, if not then assessing their response to verbal stimuli, and if still no response then physical stimuli. The main issue with the Richmond agitation sedation scale is that it relies on the patient’s ability to communicate or move, which is inhibited with the use of neuro-muscular blockers or if the patient has substantial hearing or visual deficits. The inability to apply RASS with paralyzed patients is important as these patients are at high risk of inadequate sedation and complications such as anesthesia awareness. In fact, in one study up to 10% of critically ill patients with therapeutic paralysis were inadequately sedated. Subsequently, there has been an interest in a non-subjective measure of sedation that can be used as an adjunct in addition to clinical assessments such as the RASS. This has lead to the development of machines capable of applying algorithms to electroencephalograms (EEGs).

The Bispectral Index (BIS) machine is one such example, using an EEG trace to identify different brain waves at differing levels of anaesthesia. It then produces a number between 0 (deep anaesthesia) and 100 (awake), with consensus that a score between 60 and 70 is adequate sedation for most procedures. It has been extensively tested across a wide range of patient populations and has been shown to be effective in reducing both over and under sedation, and especially effective at reducing the risk of anaesthesia awareness. One such study showed a decrease in the risk of anaesthesia awareness of 82% with use of the BIS machine, with many others showing similar benefits, especially in the setting of TIVA. In fact, the NICE guidelines in 2012 stated that these monitors are recommended during anaesthesia in high risk patients.

The BIS machine has many of the characteristics required for the retrieval environment. It is battery powered, weighs less than 1.5 kg and was shown in a small study to not be affected by the vibration of the flight environment. However there are very few studies, all with small sample sizes, investigating its use in medical retrieval, therefore further research is required.

BIS values have been shown to correlate to RASS scores, and therefore can be used as an adjunct to RASS or other sedation assessments. Like the RASS, BIS was able to reliably differentiate inadequate from adequate sedation. Therefore BIS would be useful in cases where the RASS score is unobtainable or as an adjunct to confirm the level of sedation as determined by the RASS.

There are however a number of limitations for the use of the BIS machine. It is confounded by a number of factors such as cerebral ischemia and which sedating medication is used. Therefore, the BIS machine should not be used solely as an indication of sedation. Also, a recent study with volunteers who were paralyzed whilst conscious, showed BIS values suggesting deep sedation or general anesthesia. This raises questions about the accuracy of BIS monitoring with paralyzed patients. Thus, there remains controversy of its efficacy in patients receiving neuro-muscular blockades in addition to other sedating agents. Certainly, BIS monitoring should only be used in conjunction with clinical assessment as part of thorough management of the sedated patient, but not as a stand-alone tool.

**CONCLUSION**

The aeromedical environment can be a challenging one for clinicians and patients alike. Sedation is a key part of clinical care to many severely ill patients requiring retrieval, and its safe practice is paramount. Over-sedation causes prolonged recovery for patients, whilst under-sedation can cause anaesthesia awareness. Overcoming the environmental factors that impact sedation may not always be entirely possible but using further aids in the hope of improving the standard of practice is achievable. Identifying the challenges and being aware of the risks of sedation can make a substantial difference, as well as using sedation assessment scores such as the Richmond-Agitation sedation scale. Development of newer clinical adjuncts like BIS monitoring is required to offer more sedation information to the clinician, although with awareness of its limitations. When all implemented together, sedation in the sky may become safer than it has ever been.

**REFERENCES**


