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Civilian aeromedical retrievals (the Australian experience)

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Key points

- Various forms of retrieval and retrieval services exist.
- Capability of the referral service needs to be identified early.
- Unwell patients are at increased risk of physiological derangement during aeromedical transfer.
- Management of certain conditions require specific treatment plans to account for the pathophysiology and aviation changes.
- Logistics, communication, and follow-up are vital to successful retrievals.

Retrieval medicine is the process by which suitably qualified and trained personnel utilize appropriate equipment and transport platforms to clinically manage and safely transport a patient from one location to another.[1]

Retrievals can be subclassified into primary, secondary, and tertiary. Primary retrieval is the transport of patients to their initial hospital reception. This may be their nearest hospital, or directly to a larger and more distant centre such as a designated trauma centre.[2,3] Secondary retrievals move patients from a non-specialized hospital to a higher level of clinical care such as for neurosurgery, interventional cardiology, complex obstetrics, or paediatrics. Tertiary retrievals transport patients between two similarly specialized hospitals.

In 'modified primary retrievals', an injured or unwell patient has already been taken to an initial health facility that has minimal capacity to increase the level of care to that provided in the prehospital environment. In these circumstances, the retrieval team apply similar practices to a true primary retrieval, albeit in a more controlled clinical environment.[3]

In Australia, owing to the large land mass and relatively low population density, specialized medical services are clustered mostly in coastal urban centres. Therefore, many referrals are from rural and remote areas where access to specialist medical services is limited.[2]

Journeys range from a few kilometres and a few minutes in major capital cities to several thousand kilometres over many hours from isolated rural communities. While distance might not be limiting, other access issues such as terrain and weather extremes play roles in the structure of services.

Most retrieval occurs within state health system jurisdictions or within state boundaries. If there is need to transfer patients interstate or internationally, pre-existing agreements between the relevant authorities are important to safely facilitate transfer. These patients have often received initial medical care at the place of presentation. With the increased ease and popularity of travel, particularly to developing nations with limited healthcare capacity, international retrievals/repatriations are becoming common. They bring with them unique logistic and cultural issues for the retrieval team, in addition to the challenges of medical retrieval.

Retrieval services are structured using a combination of doctors, nurses, paramedics, drivers, aircrew, and administrative staff. There are varying levels of interaction between the different disciplines, depending on the structure and culture of the organization. Retrieval services can be hospital-based, independent, military, private, public, or not for profit. Increasingly, *ad hoc* retrieval services are being replaced in favour of more structured permanent services. Depending upon jurisdiction, retrieval teams may need to satisfy civilian aviation rules, including health, security, drug, and alcohol checks before working as aircrew in the aeromedical setting.

Aviation and altitude

Air travel comes with inherent physiological changes and health risks, even for healthy people. These changes are less well tolerated by unwell patients and the health risks associated are magnified.[1,2,4]

Helicopters used for aeromedical retrieval, in general, do not have pressurized cabins and therefore operate below 10 000 feet above sea level (FASL). Fixed-wing aircraft pressurize cabins to between 7000 and 8000 FASL (similar to commercial airliners). At sea level, the partial pressure of inspired oxygen is 149 mm Hg, while at 8000 FASL, this decreases to 108 mm Hg.[4] This is the equivalent of breathing 15% inspired oxygen at sea level. Therefore, relative hypoxia (either due to altitude or inadequate pressurization of the aircraft) is common. Potential effects include myocardial ischaemia, syncope, impaired mental performance, and loss of consciousness. Supplementary oxygen may be required in flight if the aircraft is not pressurized to sea level cabin altitude.[4]

Immobility during long transport increases the risk of thromboembolic events. Noise, temperature, and vibration stress can all have a deleterious effect on patient stability and create a demanding work environment for medical crew. Motion sickness can be a serious complication for the obtunded or unwell patient as well as for the retrieval team, and routine prophylaxis should be considered.[4] Fear of flying and of heights are both factors that may need to be dealt with before loading a patient for their flight.

In addition to changes in the partial pressure of gases with increasing altitude, specific knowledge of and compensation for the changes in atmospheric pressure is required. The physical effects on the body of decreasing barometric pressure include the expansion of gas-filled cavities such as the middle ear, lungs, sinuses, gastrointestinal tract, and potential spaces such as the pleural space. If the patient's clinical condition requires, the cabin may be pressurized at or near sea level or the flight level reduced to increase the barometric pressure. Conditions necessitating this include severe hypoxia, undifferentiated major trauma, bowel pathology, and diving-related illnesses. When pressurized to sea level cabin altitude, aircraft cannot reach their normal cruising altitudes. They carry higher fuel loads, fly lower and slower, which will reduce their flying range and may expose them to increased turbulence and adverse weather conditions.

Referral

The determination process for prioritizing and appropriately allocating retrieval assets is multifactorial. These are summarized in Table 1. Communication with the receiving team (where known) is mandatory, to agree on a clear management plan. When determining the mode of transfer, several considerations are important. Helicopters are able to access more referral sites than fixed-wing aircraft, but have a shorter range, a more confined work area, louder noise, and more vibration stressors. Transfer by road usually allows easy access to referral sites and allows easier stopping with less ambient noise, but at the expense of a much slower transfer time.

Table 1. Factors affecting the decision to retrieve

Referral factors
- Referrer's skills in diagnosis and resuscitation
- Resources available
- Contingency plan/nearest available support services

Patient factors
- Natural history of disease
- Response to initial treatment
- Urgency of transfer
- Complications
- Social factors (including willingness to fly)
- Size, weight, mobility of patient

Retrieval team
- Capacity
- Equipment
- Personnel
- Skills

Receiving hospital
- Accepts referral
- Bed availability, availability of intensive care bed, etc.
- Ability to manage referral, i.e. interventional capacity

Aviation factors
- Distance (including need for refuelling)
- Time
- Weather
- Terrain (including availability of landing strip, helipad, road access)
- Destination

Logistical factors
- Safe working hours
- Skill set of team
- Other demand on resources
- Cost

Preflight

Assessment and stabilization

The structured assessment of airway, breathing, circulation, neurology, and other major factors is conducted before patient movement. Preferably, this is conducted at the referral healthcare facility, although this may contribute to significant delays while the retrieval team are transported between the retrieval aircraft and the referral hospital or patient location. Alternatively, the patient may be brought to the departure point/airstrip by the referral team. Pragmatism will occasionally necessitate a focused primary survey before initial movement and a more detailed assessment at either the receiving hospital or before a longer flight.

'Scoop and Run' *vs* 'Stay and Play' has long been a point of divergence across many retrieval medicine experts and retrieval services around the world.[3] In essence, there are patients who will benefit *most* from a rapid assessment, minimal stabilization, and prompt transfer to definitive care. Others will deteriorate significantly *en route* without the initiation of further stabilization by

the retrieval team before transfer. The decision regarding which of these principles may be most appropriate in a given circumstance is complicated, varying not just with patient and pathology factors, but also with local skill, transport team skill, logistics, and time to definitive care.[1,3]

Initiation of reliable monitoring is important during this assessment and stabilization phase. This may range from an oxygen saturation probe to invasive monitoring with insertion of central venous and arterial access. With the confounding risks of air travel, clinicians must be mindful of both the potential for deterioration in the air, the limited ability to escalate treatment in flight and balance this with the need for timely transportation. Intubating a patient at an airstrip may not be optimal, but is likely to be more successful than attempting the same on a rapidly deteriorating patient wearing seatbelts, in turbulence, at altitude.

One of the most hazardous times for a patient is the time of transfer from the hospital to the aircraft. This is more difficult when extra transfers are necessary; for example, when the patient needs ambulance transfers to and from the aircraft. Risk increases with increasing number of individual patient movements.[3] Apart from the potential disconnection and dislodgement of tubes and monitoring, there are hazards to staff. Obese or intoxicated patients, exposure to extremes of weathers, limited visibility, and hazardous environments all challenge effective prehospital care delivery.[2]

Preparation for inflight management and monitoring

Equipment and monitoring used inflight should be light, portable, robust, and familiar. Monitors need to utilize both visual and auditory modalities due to the presence of bright ambient light and noise pollution. Monitors and equipment have limited battery life and not all aircraft have the facility to charge equipment in flight. The more parameters used on a monitor, the higher the power consumption. Back-up power supply is necessary for vital pieces of equipment. Specialized equipment such as point-of-care pathology devices and ultrasounds may be considered where necessary. A number of professional bodies have guidelines about the minimum requirements for transportation.

Apart from initial resuscitation and monitoring, a number of critical care and comfort matters are necessary to facilitate transportation. The extent to which these are managed depends upon the time and distances involved in transit.

While pain relief is often an acceptable minimum during short primary transfers, the use of complex techniques such as regional and neuraxial block requires expertise, equipment, and time to establish and manage. Nevertheless, these techniques should be considered, particularly for longer transfers. Attention to pressure care areas is also important, especially in the muscle-relaxed and ventilated patient.

All patients should have i.v. access, although the use of i.v. fluids may be limited to longer flights or where there are clinically significant changes to the blood volume or electrolyte status of the patients. A urinary catheter should be considered, for comfort or for monitoring of urine output. Glycaemic control and nutrition both need attention during long flights. Insulin requiring diabetic patients are a group in which it is necessary to maintain ongoing administration of exogenous insulin, albeit with a goal of a relatively higher blood glucose level than the usual targets (4–10 mmol litre^{-1}). As in intensive care, tight glycaemic control during transport may lead to complications of hypoglycaemia.[5] Enteric feeds are normally ceased and disconnected, although supplemental fluid may be required. Gastric tubes should ideally be aspirated periodically to ensure decompression of the stomach. In ventilated patients, free draining gastric tubes are recommended to prevent dilatation and improve ventilation dynamics.

Inflight

Reassessment and management in the case of deterioration

The ongoing assessment of the patient during transportation is different from that in hospital. During flight, continuous direct observation of the patient supplemented by monitored data is essential. Strategies used on the ground to ameliorate deterioration (including positioning, institution of drugs and infusions, suction, or escalation of respiratory support) are difficult or impossible to adopt during transport. In flight, access to the patient is limited due to cabin size and patient position. All personnel need to be restrained and equipment securely stowed during key phases of flight, due to potential turbulence at lower altitudes, thus limiting rapid access. Communication with the patient, fellow crewmembers, and ground teams are limited due to aircraft noise and isolation. Performing procedures of any kind in the air is difficult, even for the most experienced aeromedical practitioner. Commencing and maintaining cardiopulmonary resuscitation in flight remains very challenging. Therefore, pre-emptive performance of procedures for expected deteriorations such as intubation, central venous access, and a plan for deterioration is vital before departure.

Post-flight

Transfer to the destination medical facility

A plan for offloading the patient and transfer to the definite facility must be confirmed. The patient may need a further road transfer, which may require continued medical escort. Adequate equipment, drugs, and monitoring will be required for the road transfer.

Handover

At the destination, after introductions and identification, the patient is handed over to the receiving team. Various methods exist for handover. Whichever method is used, it should be structured and locally agreed upon to ensure the transfer of relevant verbal and written information. The patient is normally under the care of the retrieval team until formal handover has been completed.

The retrieval team plays only a transient role in the care of a critically unwell patient. However, it is often at a time of high stress and emotions, particularly for families. Clear communication and regular clinical updates to coordinating agencies therefore remains essential.

Disease-specific management

The ventilated patient

Positive pressure ventilation is instituted in many patients to manage obstructing airways, ventilatory failure, circulatory collapse, and neurological defects and derangements. Transport ventilators should comply with the national standards, including all alarm warnings. As audible alarms may not be heard in aircraft, visual alarms should be activated concurrently. Electrically powered turbine ventilators will reduce oxygen use and are preferred for longer distance transfers. Ventilators vary in their capability to compensate for altitude and monitoring expired tidal

volumes. Measurement and display of minute volumes is required, particularly after ascent and descent. Tracheal tube cuff pressure should also be monitored and adjusted to avoid tracheal mucosal injury from excess pressure after climb. Pneumothoraces need to be drained before departure as they will expand during ascent, causing circulatory compromise.

Non-invasive ventilation

The use of non-invasive ventilation (NIV) has a controversial role in transportation.[6] Some patients with less severe hypoxia or other respiratory failure may be safely transported with NIV, negating the need for intubation in already compromised patients. The deterioration of the patient, failure of NIV, and the need to intubate inflight are major hazards. A risk assessment must be carried out before transfer, and if the risk of deterioration, failure, or intubation is deemed to be a real possibility, NIV may not be the most appropriate choice.

When electing to transfer using NIV, several considerations should be made. Rapidly progressing pneumonia is unlikely to benefit from NIV, while pulmonary oedema from congestive cardiac failure might be well managed with NIV. A trial on the ground to ensure the patient tolerates and responds to the technique is necessary, with escalation to invasive ventilation if unsuccessful. Equipment challenges may also arise; not every transport ventilator can provide NIV, and those which do may require very high flow rates (up to 30 litre min^{-1}) and hence have unachievable compressed gas requirements. Turbine ventilators are better suited for transport NIV due to their reduced compressed gas requirements.

Cardiac disease

The transfer of a patient for interventional cardiology services is one of the most common reasons for aeromedical retrieval.[2] Monitoring for arrhythmias and the ability to defibrillate/pace is necessary. Managing cardiogenic shock may include the use of inotropes, vasodilators, and ventilatory support. In cases where there will be a time delay to percutaneous coronary interventions, advice about thrombolysis should be sought. Patients who have experienced cardiac arrest may be receiving therapeutic cooling. This may be continued in flight with appropriate protocols, cooling interventions, and monitoring.

Non-cardiogenic shock

Invasive monitoring such as central venous pressures and ultrasound-guided intravascular volume assessment to guide vasopressor and inotropic therapy may be necessary. The time required, equipment, and sterile set up available need to be considered in conjunction with the patient stability and likely transfer time. In longer transfers, apart from initial resuscitation, these patients may need intubation, ventilation, and attempts to correct the underlying process before transfer to an aircraft.

Trauma and surgery

The issues related to trauma in the military prehospital setting are covered well in a previous article.[7] These principles apply in the civilian setting. If available, blood products should be taken on all major trauma retrievals. Approved temperature-controlled blood shippers are available. If used and monitored appropriately, unused products may be returned for future use. When there is a need for urgent surgical care such as with testicular torsions, incarcerated hernias, or ongoing haemorrhage, expediting transfer is vital. The use of tranexamic acid, maintenance of temperature, permissive hypotension, and damage control resuscitation are all current concepts in the acute management by the retrieval team. In cases of acute abdomen or obstruction, the use of gastric decompression should be considered.

Paediatrics

The management of the deteriorating child requires appropriately skilled personnel and equipment. Issues of consent both at origin and destination and also to aid in assessment, comfort, and management of the child lend weight to the transfer of a parental figure. Neonatal transportation should ideally be performed by specialized services.[8] Transfer of the mother may be as either a passenger or an extra patient depending upon her clinical status.

Obstetric pathology

Transfer of the obstetric patient is due to either complex obstetric pathology or need for neonatal input. The management of preterm labour including tocolysis should be undertaken in conjunction with the receiving obstetric unit.[9] Initiating treatment of preeclampsia including the use of magnesium infusions will decrease the risk of seizures in a hostile environment. Team members should be able to manage the safe delivery of a baby, provide neonatal resuscitation, and manage a post-partum haemorrhage; however, all reasonable attempts must be made to avoid delivery in transit.

Psychiatric transfers

The transfer of patients with altered mental state poses a risk of harm to the crew and aircraft. Techniques for safe sedation may be necessary for the transfer. Intubation is very rarely needed and exposes the patient to risks and delays transport to the necessary psychiatric services. I.V. sedation is often very effective.

Table 2. Organizational considerations in aeromedicine

Error and incidents
- Orientation programme
- Ongoing information updates
- Risk identification systems
- Incident reporting systems
- Follow-up systems

Crew
- Selection of crew
- Ongoing maintenance of professional standards
- Personal health management
- Fatigue management and shift work
- Substance use and misuse

Aviation safety
- Regulations of the civilian aviation authority
- Air traffic control
- Weather, landing strip information
- Logistical management systems

Aircraft safety
- Approval for modification of aircraft for medical purposes
- Approval of equipment for aviation use
- Ongoing aircraft maintenance
- Servicing and updates of equipment and systems (e.g. oxygen delivery)
- Cleaning of aircraft and infection control
- Warning systems for airline safety

Ketamine-based sedation has been used effectively in this patient group.[10] Security personnel may need to be present on the flight.

Follow-up and audit

Because of the transient role of the retrieval service in the care of the patient, ongoing feedback from the receiving hospitals is necessary to ensure quality of care is maintained. A system needs to be in place to ensure that patient outcomes and discharge information is disseminated to pertinent individuals. This is particularly important in cases where there have been poor outcomes or errors.

A number of organizational factors are necessary for the accreditation of the retrieval service.[2] In additional to those of a normal healthcare provider, these include aviation and transportation factors. See Table 2. Systems including occupational health and incident management need to be in place at an organizational level. As with any healthcare organization, the retrieval service needs to undergo an accreditation process to ensure the quality of service provided to patients meets the standards set by the overseeing body and ensuring the personnel and systems are appropriate for the services rendered. Retrieval organizations may also utilize checklists, manuals, and guidelines in order to facilitate the safe practice of medicine in hostile and challenging conditions.[2]

Declaration of interest

None declared.

MCQs

The associated MCQs (to support CME/CPD activity) can be accessed at https://access.oxfordjournals.org by subscribers to *BJA Education*.

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