Aeromedical evacuation

Aeromedical evacuation is used to transfer critically ill patients over large distances or where road transfer would be impractical due to terrain, road condition, traffic etc. It comprises fixed wing aircraft or rotary wing (helicopters). Aeromedical transfer may be required to upgrade the level of critical care facility or to repatriate a patient from overseas.

The principles of patient transfer by air are identical to those for road inter-hospital transfer with the same level of monitoring and treatment and attention to patient and medical team safety. The peculiarities of the aeromedical environment need additional consideration.

Choice of aircraft

**Speed and distance**

Helicopters typically cruise at 120–150 knots (220–280km/h) with a useful radius of 50–300km. Time taken to prepare and launch the helicopter and also fuel endurance limit their advantages for very short or long distances, but the advantage over fixed wing aircraft is the ability to operate from the internal noise levels are frequently >95dB(A) such that normal conversation is impossible. Auscultation is redundant, as is reliance on audible monitor alarms. Intercom headsets are required for crew communication. Earplugs are used for all patients regardless of conscious state to reduce hearing damage. Cabin lighting may be poor due to the dangers of distracting the aircrew and adversely affecting pilot night vision. Blue or red lighting is contraindicated due to the dangers of distracting the aircrew and adversely affecting pilot night vision. Blue or red lighting is contraindicated as it may induce confusion and disorientation. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia. Vibration is greatest at take-off and landing and may induce vertigo in patients with incomplete myelodysplasia.

**Fixed wing flights**

Continuous noise, vibration, changes in temperature, cramped space, ultraviolet radiation and time zone changes contribute to high levels of fatigue. Limited chance for rotation of medical personnel en route may mean extended working hours; therefore, appropriate rest periods prior to and after flights should be scheduled in staff rosters. Staff should ensure they are physically fit to fly, not suffering from the effects of respiratory infections and be under the residual effects of neither medication nor alcohol. Neither helicopters nor small fixed wing aircraft have toilet facilities. Axial tilt, acceleration and deceleration forces may be significant during take-off, landing and extreme turbulence in fixed wing aircraft. Adverse effects on haemodynamics and cardiac output may result. Altering patient orientation within the cabin during the flight to attenuate these forces is impractical.

Cabin heating may be poorly controlled or slow to respond to changes in temperature. Staff must be vigilant in monitoring the patient’s temperature and avoiding hypothermia, and ensure they also wear suitable flight clothing.

**Atmospheric pressure**

**Oxygen**

Dalton’s Law dictates that the partial pressure of oxygen decreases with altitude. Except for operations in high mountainous regions, this is not usually a problem for helicopters (typical cruise altitudes 1000–2000f). Fixed wing jet aircraft fly at greater altitudes for reasons of aerodynamic efficiency and thus require cabin pressurization. According to the age and efficiency of the airframe and pressurization system, a set ‘cabin altitude’ can be achieved. Commercial aircraft fly at altitudes up to 30 000ft and typically achieve cabin altitudes of 7000ft. Atmospheric pressure at this altitude is 586mm Hg compared with 760 mm Hg at sea level. Corresponding PaO₂s are 73 and 103 mm Hg. Critically ill patients with high alveolar arterial gradients may become hypoxic at such cabin altitudes despite FiO₂ of 1.0. Prior consideration must be given to anticipated increased oxygen requirements at altitude. If necessary, the aircrew can be requested to provide sea level cabin pressurization. Typically this necessitates flying at altitudes of 20 000ft, which increases fuel consumption. Aside from cost implications, this may necessitate more frequent refuelling stops, which will significantly increase journey time with roll-on implications for patient safety, battery requirements, total oxygen requirements, fatigue, etc. Adverse meteorological conditions may on occasion prevent flying at lower altitude.

**Pressure**

According to Boyle’s Law, as the atmospheric pressure falls, gas volume increases. At a cabin altitude of 7000ft this represents an increase of 27% as opposed to 8% at a typical helicopter altitude of 2000ft. Travellers will be familiar with expansion of air in nasal sinuses, the middle ear and the GI tract, but careful consideration must be given in disease states. Pneumothoraces, pneumocephalus, bubble emboli and trapped air in the abdominal cavity post-laparotomy will all expand proportional to the drop in cabin pressure. Consideration should also be given to splitting orthopaedic casts. Chest drain should be inserted where necessary prior to departure and left in situ for the duration of the flight. All surgical drains should be unclamped and patent. ETT cuffs should either be filled with saline or have their pressure rigorously checked and adjusted in-flight. Ensure pulmonary artery catheter balloons are fully deflated.

**Equipment: key points**

Whilst the standard of monitoring needs to be equivalent to that in an ICU, aeromedical equipment needs to fulfil additional criteria:

- Portability and size. Each aircraft has a maximum permitted payload, and smaller helicopters are particularly limited in this regard. Trade-offs may have to be made with total fuel carried to allow additional weight, but this adversely affects flight endurance. Aircraft performance is significantly affected by ambient temperature and
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Preparing the patient for transport

As far as possible the patient must be stabilized prior to transfer. Any necessary interventions and treatments need to be done prior to leaving the referring hospital e.g. chest drains, X-rays, invasive pressure monitoring.

A formal handover of the patient by medical and nursing staff is essential, as are written notes, results of investigations and copies of imaging procedures. The referring medical staff should communicate directly with the receiving institution medical staff. The transfer team should speak directly with the receiving staff if further advice is required, and confirm an approximate arrival time. Recent blood results including biochemistry, glucose and haemoglobin are essential. ABGs must be examined after the patient has been stabilized on the transport ventilator. For anything other than short transfers, monitoring ABGs en route is recommended. The importance of rigorously securing the airway cannot be overemphasized. All IV access, infusion lines, monitoring equipment, drains, etc. must be checked, rechecked and secured. Spare IV access is essential. Arrange infusion lines and monitoring equipment such that they are free from tangling and lie in such a fashion that they will be accessible according to the particular aircraft used. Access to the patient’s limbs, chest and abdomen may be restricted in flight, depending on the layout of the aircraft. Always plan for the worst case scenario, and consider how emergency re-intubation or CPR would be performed in the cabin.

Prior to moving the patient, all loose equipment around the patient should be safely secured to guard against downdraft from helicopter blades or wind when moving the patient around exposed airport areas. The patient must be secured onto the stretcher with a harness approved for aviation use.

Before leaving the referring hospital, a final check of the patient, equipment and team is performed and contact made with the aircrew to ensure the aircraft is fully fuelled, ready to receive the patient and there are no problems with the planned routing.

Safety

The aircraft is an unfamiliar environment for most medical staff. Safety of the patient and aeromedical team is paramount. Staff must undergo training in aeromedical evacuation and an orientation to the equipment and aircraft, with emphasis placed on common aircraft emergencies, emergency evacuation procedures, emergency depressurization, communication procedures and survival equipment. The tail rotor and main rotors of helicopters can be lethal, and even provide hazardous obstacles when motionless. Underwater escape training from a helicopter simulator is recommended where flights may take place over water.

Without proper training, disorientation and confusion are likely, and the ability for staff to provide the best patient care will be adversely affected. A study examining the ability of medical staff to provide CPR to mannequins during helicopter flight showed significant differences between those who had undergone training in aeromedical evacuation and those who had not.

No pressure must be put on the aircrew to alter their normal safety procedures. The captain has the final say on whether the conditions are suitable for flight, no matter what the condition of the patient.

Clinical governance mechanisms should be in place for reporting and investigation of critical incidents.

Further reading
