Considerations for infant aeromedical transport in England

In England most infant inter-hospital transfers are by road, with only a small number of specialist transport teams performing aeromedical transfers. The governance, logistical and technical issues relating to organising and performing a flight transfer are considerable. This article reflects on some of these challenges based on evidence and the experience of the authors. Case studies are used to illustrate the rationale for using aircraft and tips are offered to help staff prepare infants and their parents for the journey.

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Key points

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1. Infant aeromedical transport is increasingly accessible but places high demands on a transport service in terms of education, training and equipment provision.
2. Aeromedical transport should be supported by robust quality measurement and governance structures.
3. Infant and staff safety should be at the forefront of an organisation's approach to aeromedical transport.
4. Understanding the requirements and restrictions of aeromedical transport can help the referring team prepare the infant for flight.

The objectives of any aeromedical transfer should be the same as that for a road transport:

- to move an infant to the right place, at the right time, for the right care (as close to home as possible), using the right team, and the right mode of transport
- to ensure the efficient and effective continuity of care
- to undertake every transport in a way that maximises safety, comfort and dignity and minimises pain and distress.

Understanding the clinical needs of the infant is key to the appropriate utilisation of aeromedical resources. However, a decision to use a specific mode of transport should also be based on local circumstances and must take into account the scope of the transport service, the geographical environment and the availability of aircraft and landing sites. Equity of access to aeromedical transport is variable within England as the current local and national arrangements leave many infants without a clear referral pathway.[1] Reports and surveys have suggested that current capacity for children's aeromedical transport does not meet demand.[2,3,4]

There are several reasons why aeromedical transport might be considered:

1. Time-critical (stabilisation): the specialist transport team needs to get to the referring unit quicker than can be achieved by road, eg when specialist equipment or personnel are required for stabilisation.
2. Time-critical (clinical): the infant needs to get to the receiving unit quicker than can be achieved by road, eg when the definitive emergency treatment is required within a specific time window, or when the clinical condition requires the journey time to be minimised.
3. Service provision: the distances involved mean that the time taken by road could place an excessive operational burden on the service. Aeromedical transport reduces the total travel time for the team and allows the service to use its resources more efficiently.
4. Logistical/physiological: journey times have the potential to be extended if the service has to transfer an infant a long distance for specialist treatment or repatriation. By road these journeys can be physiologically demanding and logistically complex.
5. Location: international and offshore transfers are usually completed by aeromedical transport.

Air ambulance providers in England operate on either a commercial or charitable model or a hybrid of both.[5] There are around 20 air ambulance charities that operate helicopter emergency medical services (HEMS) with varying levels of NHS collaboration. In addition, a small number of commercial air ambulance companies operate fixed wing air ambulances for aeromedical transfers. There is also a charitable rotary wing service, The Children's Air Ambulance (TCAA), which works in partnership with a number of regional paediatric and neonatal transport services in England.

Education and training

Specialist training in transport nursing involving air ambulances is currently limited and yet should be mandatory for nurses working in this extremely complex and challenging field.[6] The core clinical skills required to transfer a sick child are essentially the same as for road transport, however there are several additional challenges to consider, which include (with examples):

- Ergonomic restrictions of the cabin environment *(challenges in accessing the side of the infant that is alongside the cabin wall, or having to load the stretcher into the aircraft through a narrow cabin door)*
- Physiological changes associated with altitude *(reduced partial pressure of oxygen leading to impaired oxygen delivery or expansion of trapped gas in a cavity)*
- Environmental challenges associated with flight *(in-flight turbulence, loading in a weather exposed airfield or haemodynamic compromise associated with acceleration forces experienced in fixed wing aircraft)*
- Complexity of transfer logistics *(arranging secondary road transports from landing sites or working around airport opening times)*
- Interfacing with the culture of aviation *(understanding aviation jargon or appreciating the strict restrictions on pilot operating hours)*.

A key challenge for teams offering infant aeromedical transport relates to the total number of flight transfers undertaken in England, which is relatively low when compared to road transfers.[7,8] Ideally the level of aeromedical activity of a service should be balanced with the number of staff trained and expected to undertake a flight transfer. A service that performs only a few aeromedical transfers each year may find it a challenge to maintain competencies and familiarity among staff. A comprehensive education and training programme is required. Simulation (**FIGURE 1**) may go some way to make up for an individual clinician's lack of flight experience.[9] In the transport context it has a limited evidence base, although some relevant technical and non-technical skills have individually been validated through simulation. Simulation can also be used to improve teamwork between the clinical team and the pilots.[10,11]

Helicopter pre-flight checks	
Questions	**Response**
Communication check	Yes
Mobile phones	Off
Stretcher and straps	Packed
Passenger harnesses	Secure
Patient harness	Secure
Airway pouch in cabin	Yes
Bag valve mask in cabin	Yes
Reservoir mask in cabin	Yes
Suction checked	Yes
Patient ear protection	Yes
Stretcher flat for take-off	Yes
External monitor screen	Connected
Battery levels	Battery...
Oxygen contents	Contents...
Air contents	Contents...
Nitric contents	Contents...
Evacuation plan	Discuss

FIGURE 2 An example of a pre-flight checklist.

Troubleshooting tips for a ventilated patient in flight	
Check patient	Chest movement? Check end-tidal CO_2 ETT moved? Blocked? Pneumothorax?
Check ventilator	Gas supply ball – white? Pressure dial – cycling? Circuit – intact?
Check air and oxygen	Cylinder contents? Cylinder switched on? Hose connected?
Check nitric oxide	Cylinder contents? On? Nitric monitor reading? Flowmeter ball? Check all connections
Check infusions	Inotrope lines trapped? Lines disconnected? Venous access issue?
Check monitor	Check leads, both ends Interference? Try using defibrillator or portable sats to monitor

FIGURE 3 An example of an action card. Key: CO_2 = carbon dioxide, ETT = endotracheal tube.

FIGURE 1 Simulation training: a mock-up of a cabin.

Safety and risk

Aeromedical transport has clinical, personal and corporate risk. It is advisable to incorporate a risk assessment into the preparation for each flight covering team experience, fatigue, transport modality, weather and other factors that may influence safety. There should be clear separation between aviation and clinical tasking, and also from commercial pressures. The referral pathway should prevent transport teams from disclosing information on patient acuity to the pilots at the initial request stage. This helps to isolate weather-related flight planning decisions from emotional influence.

Transport teams approaching the aviation environment must be aware that it is complex and can be distracting. The clinical team should respect the principle of the 'sterile cockpit' which cautions against disturbing the pilots during critical phases of the flight, eg take off and landing. Use of checklists can help to reduce errors (**FIGURE 2**) and action cards can be used as prompts to help deal with in-flight emergencies (**FIGURE 3**). Clinicians

must take into account that their usual diagnostic tools may not be useful in flight, eg a stethoscope cannot be used while wearing a helmet or when the engines are running. Effective physiological monitoring is essential and end-tidal carbon dioxide measurement should be mandatory for intubated patients to confirm placement of endotracheal tubes or tracheostomies.

Equipment

Approval for medical devices on aircraft is a complex and expensive area. A European standard[12] outlines the requirements for equipment in air ambulances. Changes in temperature, barometric pressure and humidity will be more extreme than on road journeys and increased exposure to vibration may be significant. The standard ensures that equipment is designed to operate safely and effectively in the aviation environment and includes limits on electromagnetic interference. Importantly:

- Medical devices that have been demonstrated to meet European standards can be carried, although suitability for a particular aircraft type would still have to be determined.[13] Alternatively, equipment can be approved as part of an aircraft modification, where the medical device is considered part of the aircraft.
- Special attention must be paid to devices which rely on power from lithium batteries.[14] Recently reported battery failures have resulted in incidents that have placed aircraft and passengers at risk.[15]
- There are particular challenges associated with the carriage and delivery of nitric oxide (NO). NO used as an inhaled pulmonary vasodilator in a well-ventilated hospital does not pose a high risk but may do so when used in the cabins of some aircraft due to confined space and limitations of air circulation.
- There are some items of medical equipment that are routinely used in infant road transfers for which no aviation safety approval exists, eg high flow oxygen therapy units and heated humidifiers that are designed to be used in a hospital setting have not undergone appropriate shock, vibration and electromagnetic interference testing. They also may require a continuous power source which may not be available.
- Equipment should be appropriate to the infant's weight, gestation and temperature stability. A heated mattress (either electric or chemical) used in conjunction with a Ferno BabyPod can be very effective but should not be used in place of a transport incubator if that is what the infant requires.

The standards may seem frustrating; however the European aeromedical industry has an enviable safety record that is embedded in a culture of fastidious attention to detail. This culture has brought benefits for health care: checklists, anonymous incident reporting, crew resource management and pre-procedure briefing are all innovations that originated in aviation.

Quality and governance

In 2011 the Paediatric Intensive Care Society Acute Transport Group noted an unmet need for high quality, coordinated, benchmarked aeromedical transport, which was likely to increase with the proposed geographical reconfiguration of specialist services.[16] Since the transport process does not exist in isolation, within the healthcare system there are many influencing conditions that can affect outcome. Although timing data, such as response and journey times, are easy to measure and have value for quality assurance,[17] transport services should also measure the effectiveness of aeromedical transport by gathering data on safety, utilisation and outcome.[18] The experience of the family should also influence service improvement.[19] Good governance practice would suggest that utilisation data should be available to share with other services, although opportunities for benchmarking are limited as services vary in their scope and activity. External accrediting organisations may provide a means of comparison with established international practices that have evolved by consensus. Participation in cross-service quality metric datasets can provide an early-warning of quality issues,[20] illuminating any deviations from standards over time.

The development of children's aeromedical services has not been without controversy.[21] The need for such services has been openly challenged, with scrutiny

FIGURE 4 A helicopter transfer.

over performance and effectiveness since flying infants is a low-volume activity with some additional risks. Any team transferring a patient by air should be able to match or exceed established road transport standards.

Preparing your patient for flight

The exact clinical preparations required should be discussed with the specialist transport team. They will be similar to those expected for a road transport but may include specific aviation considerations. Particular attention should be paid to the environmental and physiological challenges anticipated with aviation. Glass-bottle chest drains should be changed for dry-seal drains and gastric tubes should be placed on free drainage. The patient will require ample medication and hydration for the journey and may need multiple points of venous access (perhaps including a central line) and an arterial line. Low dependency infants should be dressed appropriately; a hat is required to minimise heat loss. Notes, X-rays and scans should be prepared in the appropriate format and translated if written in another language. The team may be on a tight time schedule that is not within its control due to aviation operating restrictions; any help you can give in advance will be appreciated.

If a parent wants to travel with their child, check first with the transport team whether this is possible; there may be weight or space restrictions. The transport team will need to know the parent's weight and the weight of their luggage and will ask the parent some basic medical questions to ascertain their fitness to fly. If it is not possible for the parent to travel in the aircraft, the team may need assistance in arranging alternative transport for them. An agreement to take a parent may have to be rescinded should the weather or destination change (necessitating extra fuel requirements or a technical stop). It is important that you do not make guarantees on behalf of the transport team. Do emphasise flexibility, especially in emergency cases.

If you, or the parents, have questions regarding the safety of aeromedical transport it would be best to refer these to the transport team who will be able to answer for the particular mode of transport it is using. It is important to present the family with a rational justification for flying, and to acknowledge any concerns they might have. The parents may want to know about the experience and number of pilots, and the familiarity of the transport service with this type of journey. Statistical safety comparisons between long road transports and short flights often contain assumptions and generalisations. Modern twin-engine, instrument-flight-capable aircraft operating as air ambulances in the UK have a good safety record. Most inter-hospital flights operate between airports or pre-designated helipads under the same aviation rules as commercial passenger airliners.

FIGURE 5 Loading twins onto a fixed wing aircraft.

Case studies

The following case studies describe examples of infant aeromedical transports. Although they are based on real journeys the details have been changed to ensure confidentiality.

Case study 1: Air ambulance helicopter

An infant required urgent assessment for congenital vascular malformation in a specialist centre that was three hours away by road. He was triaged as appropriate for helicopter transfer. An air ambulance was requested to meet the team on the roof-top helipad at the referring hospital. The flight to London took about an hour with the advantage that the aircraft could land close to the receiving hospital, reducing exposure to unpredictable city traffic. NO therapy was utilised in flight as the equipment was approved for use in the aircraft (**FIGURE 4**).

Case study 2: Fixed wing repatriation

Premature twins, delivered while their family was visiting relatives, required repatriation from Scotland to Yorkshire. The team was able to utilise a fixed wing air ambulance that accommodated two stretchers. This was a more efficient use of resources than the dedication of two ambulances to undertake the entire journey by road. The working environment on the aircraft was preferable to being in a road ambulance as once at cruising altitude the team were able to safely move around the cabin (**FIGURE 5**).

Case study 3: Search and rescue helicopter for transport to ECMO centre

An infant was brought into an emergency department suffering from respiratory distress. The transport team deployed by road and assisted the local clinicians with a prolonged and complicated stabilisation. This child's best hope of survival was prompt delivery to a centre offering extra-corporeal membrane oxygenation (ECMO). The nearest ECMO bed was four hours away by road. The National Maritime Operations Centre in Fareham was contacted for assistance and a Sikorsky

S-92 helicopter was tasked from Humberside airport. The S-92 is a large, powerful modern aircraft that can appropriately be used to respond to a life-threatening emergency providing a large, warm, bright cabin complete with electrical power and oxygen (**FIGURE 6**).

Conclusion

Air transport is not a practical option for transport teams to undertake on an occasional basis. The logistical complexity and training needs of air transport require time, commitment and a minimum activity to achieve and maintain safety. *Ad hoc* aeromedical transport exposes the service, team members and infant to an unacceptable level of risk. However, if a transport service takes a considered approach to aeromedical risk and applies this to all its journeys, it may have the additional effect of improving safety for road transports.

The interests of the child should be central to its journey. Any team embarking on a transport by air must assess the clinical needs, the resources available and the demands of the journey against its own skills and experience, and the equipment and support available to it. If the infant needs to fly, the package of care must be the most appropriate for the case.

Declaration of interest

IB chairs TCAA clinical partner team equipment user group (receiving no remuneration).

FIGURE 6 A coastguard Sikorsky S-92 helicopter.

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