PERSONAL PRACTICE

Paediatric intensive care transport

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A British Paediatric Association (BPA) working party into paediatric intensive care has recommended that children requiring such care should be moved to regional units by dedicated paediatric emergency transport teams.[1] Emergency transport of systems are less well developed in Britain than in many other European countries, Australia[2] and the USA[3] and there is no nationally agreed policy or standard for the transport of sick children between hospitals in Britain. Some children are transferred by ambulance crew alone, most by a doctor-nurse team from the referring hospital. Relatively few children are transported by experienced paediatric intensive care transport teams.

The study of Sharples *et al* identified potentially avoidable factors in 32% of 81 children dying from head injury in a UK health region.[4] Inadequate management of the airway and poor management of transfer between hospitals were thought to have contributed to many of these deaths. Nationally agreed guidelines, such as those published in the USA by the American Academy of Pediatrics[5] and the Society of Critical Care Medicine,[6] would help to set standards for interhospital transport of children in Britain.

Macnab reported the incidence of iatrogenic and secondary insults occurring during interhospital transport of children and related the occurrence of these events to the level of training of the escort staff.[7] Categories of 'avoidable insult' identified included failure to stabilise adequately, failure to treat ominous changes in vital signs, and failure to prevent airway problems. An average of 1·48 insults for each call occurred in patients transferred by regular ambulance staff, despite the presence of a referring hospital doctor during many of the transports. In contrast, an average of 0·13 incidents occurred if a child was transported by a trained team sent out from the regional paediatric intensive care unit (PICU) consisting of medical and paramedical staff.

Edge *et al* prospectively evaluated the incidence of morbidity during high risk interhospital transport of children by non-specialised staff from referring institutions and retrieval by a team from their regional PICU.[8] Adverse clinical events occurred in 2% of transports undertaken by the specialised team and in 20% of those undertaken by non-specialised staff.[8] Such evidence, and that gained by audit in PICUs in the UK strongly supports the concept of specialised transport teams. The same volume outcome argument used to justify regional specialised units applies to transport; the more you do, the better your results.[9] Many referring units would agree with this and also see the additional advantage of retaining their scarce staff resources within their own hospital, rather than losing them for prolonged periods of time on transport duties.

Paediatric intensive care transport teams

ORGANISATION

There will always be significant variations in transport systems among different hospitals and regions, reflecting their different populations, needs, and resources. Common to all, however, is the need to coordinate service provision, training, and audit. Protocols must be established to deal with common clinical and administrative issues. A paediatric intensivist experienced in transport medicine should direct the transport service. The recent BPA report into the care of critically ill children recommends that the provision of paediatric emergency transport services should be the responsibility of regional health authorities and their successor bodies.[1]

STAFF

If a regional PICU offers a transport service, the overriding benefit to the child is the early input of a specialised intensive care doctor and nurse, the 'transport team'. Team members must be trained to undertake a full range of procedures including airway and ventilator management, and vascular access and monitoring. They must also be completely familiar with the transport environment, including the operational and safety features of the particular vehicle they are using. The BPA report recommends that teams should consist of a doctor of consultant or senior registrar status and an experienced registered sick children's nurse.[1]

EQUIPMENT

All drugs, fluids, and equipment necessary for stabilisation and transport should be carried by the team. Table 1 provides a basic list of equipment required. It must be regularly checked and serviced. Contents of medical bags must be replenished after each use and a checklist of contents is useful at this time. Restocked equipment boxes can then be

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Table 1 Equipment required during transport of critically ill children

Monitor	Electrocardiograph Blood pressure (cuff and invasive) Pulse oximetry Temperature Small, lightweight, robust
Ventilator	Capable of ventilating infants and children of all ages Small, lightweight and economical gas usage
Infusion pumps	Small, lightweight, long battery life
Resuscitation equipment, drugs	Stored in boxes, contents checked against inventory Access individual items without unpacking
Portable oxygen supply	Provide high pressure (4 bar) supply and low pressure metered flow
Document folder	Recording chart, audit form Information for parents Telephone numbers
Maps	Useful if ambulance crews are driving out of area
Protective clothing	Warm jackets with multiple zip pockets
Portable telephone	Relatively inexpensive Provides independent communication facilities for the team

sealed, knowing they are ready for immediate use.

Transport monitors must be robust, operate safely in all types of vehicle, and function for prolonged periods of time on their internal battery. Devices such as the Propak (Protocol Systems) achieve this in a compact and rugged monitor which is now used extensively. I have found the device to be extremely reliable in daily service for intrahospital and interhospital transport, and have used the internal power source for up to 12 hours during international transfers without any problems.

A transport ventilator capable of ventilating infants and children is required, as hand ventilation can be inconsistent and unnecessarily restricts the activity of the accompanying doctor. Portable ventilators such as the Dräger Oxylog (Dräger Ltd) are suitable for use in children of all ages, and are small, lightweight, do not require compressed air, and are economical in their use of oxygen.

COMMUNICATION

Rapid and clear communication is essential. Firstly, the regional PICU should make available and publicise a telephone 'hotline' through which a referring doctor can rapidly contact an experienced intensivist for advice or patient referral. Secondly, the team members must communicate well with one another, referring hospital staff, parents, and ambulance staff. The team must be able to contact their PICU and the referring hospital, and be contactable by them. This is easily achieved through provision of a portable telephone. Reliance on a third party communications network to pass messages, such as that of the ambulance service, is not satisfactory, discouraging clinically important two way communication between the team and PICU consultant or referring hospital. Finally, the team has a responsibility to advise the referring unit of the successful transport of their patient soon after arrival in the regional PICU. The referring unit should ideally be advised regularly of the progress their patient is making. Further contact with referring units through an outreach education programme, aimed at providing information about resuscitation and transport, should also be considered by regional PICUs.

MODE OF TRANSPORT

The team should be available 24 hours a day and be able to mobilise immediately. The manner in which transport is arranged will depend on the urgency of the case, the resources available to the team, and local geographical or meteorological factors. In practice, the local ambulance service is likely to be the principal provider. Procedures must be established with the ambulance service to clearly identify requests. In urgent cases, in which a referring hospital requires assistance with resuscitation and stabilisation, a 'blue light' response is justified, but safety of the team, patient, and public is of the utmost importance. The team must never exert pressure on a driver or pilot to take unnecessary risks. Likewise, transport providers must never exert undue pressure on a medical team to transport an improperly prepared patient.

In many areas of the country, ambulance services provide helicopter air ambulances, usually aimed at providing a rapid response to the scene of accidents. Helicopters are an ideal vehicle for use by a paediatric transport team over distances greater than 50 miles, or for shorter distances when responding to urgent calls in heavily congested urban areas (table 2). They are expensive to operate, but their use can be justified if improved response times lead to improved clinical outcome, or facilitate the cost effective centralisation of services. With the exception of Scotland, there is no national coordination of the provision of helicopter services. If such a coordinated approach was adopted for the whole of the UK, it is likely that service quality would improve and costs would decrease.

The air ambulance environment (helicopter or fixed wing) is different from that of a ground ambulance. For this reason alone, children should never be subjected to transport in aircraft except by a team trained in this task. The BPA guidelines on air transportation of neonates and young children, published in 1989 are useful, but require revision to take account of an increased availability of civilian air ambulances and contain insufficient guidance on team composition and training.[10]

Table 2 Choice of transport vehicle

Road ambulance	
Advantages	Rapid mobilisation (15–30 min) Relatively inexpensive Large working area Ability to stop for procedures
Disadvantages	Slow, 15 mph urban, 60 mph rural
Helicopter	
Advantages	Rapid mobilisation if service available Fast, ground speed 150 mph
Disadvantages	Limited work area in smaller aircraft Relatively expensive Suitable landing area required Operation can be limited by weather

THE ROLE OF THE REFERRING HOSPITAL

After agreement by a regional team to transport a sick child, the responsibility for organisation lies with the regional unit. On arrival at a referring hospital the team should be offered a full handover of the nursing and medical aspects of the patient and be introduced to the child's parents. It greatly assists the team if copies of medical notes and radiographs, as well as key specimens (for example, maternal blood, cerebrospinal fluid) are available to accompany the patient. If possible, a 'local' nurse should be allocated to assist the team. Local knowledge is invaluable in achieving rapid access to pathology or radiographic services, telephones, and even refreshments.

Preparation for transfer

The condition of the children involved is usually unstable. A lengthy period of preparation is often needed to ensure that maximum possible stability is achieved.[11] Only then should transfer begin. There is absolutely no place for a 'scoop and run' policy, a description of a situation in which an inadequately assessed and prepared patient is transported precipitately. Whitfield *et al* reported the time taken by paediatric transport teams to prepare children for transport. The median stabilisation time for 1193 ventilated children was 74 minutes (range 18–419), increasing to 150 minutes (range 55–419) for those children who in addition were receiving inotropic support.[12]

The aim of interhospital transfer by a specialist retrieval team is to provide a quality of intensive care during transport indistinguishable from that available in the regional PICU. Monitoring, drug and fluid administration, and mechanical ventilation should not be interrupted. Diagnostic facilities (for example, radiology, blood gases) cannot be provided en route, however, so it is essential that all necessary investigations are completed before transfer. For example, suppose a child was subjected to interhospital transfer with inadequate preparation and the arterial oxygen saturation decreases. This could be due to unrecognised malposition of the endotracheal tube, a pneumothorax, inappropriate settings on the transport ventilator, or a genuinely 'new' clinical problem. A chest radiograph and blood gas, after a period of stabilisation on the transport ventilator before leaving, would have provided a great deal of reassurance.

Unexpected problems occur, but in my experience, most adverse events result from poor planning and preparation. The transport environment is noisy, poorly lit, and access to the patient is often restricted. If a child is properly prepared for transfer, few procedures other than monitoring will be required in these difficult conditions even if the distance is long.

A structured approach to the assessment and preparation of a child is required before setting out.

AIRWAY AND VENTILATION

A failure to adequately assess and manage the airway, and the associated need for assisted ventilation, is probably the most common cause of morbidity associated with transport. Always ask the question 'does this child need assisted ventilation or intubation to secure the airway?' If there is any doubt about either of these points, intubation should be undertaken before departure, as emergency intubation while travelling is often difficult or hazardous.

Except in patients with a fractured base of skull, nasal obstruction, or significant coagulopathy, every child should be intubated nasotracheally. A nasotracheal tube can be securely fixed, is less likely to become kinked or dislodged, and causes less discomfort than an orotracheal tube. It must be securely taped to the face to minimise movement down into a bronchus or out of the larynx. Correct position of the tube – that is, with its tip in the mid-trachea – must be confirmed by a chest radiograph immediately after intubation. Humidification of inspired gas is essential throughout and is most easily accomplished by using an in-line condenser humidifier. As an alternative, small aliquots of sterile saline (0·5–1 ml) may be instilled into the airway to provide humidity and assist in clearance of particularly tenacious secretions. All intubated children need regular (hourly) endotracheal suction. A failure to provide suction or humidification during transport can and does lead to tube blockage and atelectasis.

CIRCULATION

A failure to adequately resuscitate shocked infants and children before setting out is another trap for the unwary. Blood volume deficits and ongoing colloid losses must be replenished, guided by clinical response and monitoring of heart rate, arterial pressure, and central venous pressure. Colloid solutions such as Haemaccel (Hoechst) or 4·5% human albumin solution are often used for initial volume replacements in aliquots of 10 ml/kg followed, if indicated, by crossmatched blood. If low cardiac output persists despite volume replacement to euvolaemia, inotropic support should be started using dopamine or dobutamine 5–20 μg/kg/min into a large vein. In refractory cases, more potent inotropic drugs such as adrenaline or noradrenaline will be required.

MONITORING

Monitoring during transport must be comprehensive. Clinical monitoring is clearly important and must continue, but auscultation is difficult in moving vehicles, and therefore reliable electronic monitoring is essential. It should also be noted that audible alarms may be undetected against background noise. Facilities to acquire an electrocardiogram, invasive and non-invasive blood pressure, pulse oximetry, and temperature electronically must be available during all transports. Ideally, end tidal carbon dioxide should be monitored in ventilated patients, especially those with head injuries or non-traumatic coma.

Table 3 Predeparture checklist. This checklist is designed to apply to all children. The list does not address the particular additional requirements of individual diseases

Airway	Is their airway secure? If not, intubate
Endotracheal tube	Securely fixed? Correct position? Always review chest radiograph after intubation Clear secretions? Always suction tube before departure
Ventilation	Note respiratory rate or ventilator settings Blood gas satisfactory?
Circulation	Fully resuscitated?
Oxygen	Adequate supply available for transfer? (Calculate requirement and carry at least an additional 30 min supply)
Monitoring	Monitoring equipment is working? Alarm limits set?
Drugs/fluids	Sedation/analgesia in place? Infusions running reliably? Adequate volumes for journey? All potentially necessary drugs available? Sufficient resuscitation and maintenance fluids available for journey? (Blood, colloid, crystalloid)
Devices	Nasogastric tube – on free drainage? Chest drains – connected to Heimlich valve and drainage bag? Urinary catheter/bag needed? Intravenous and arterial cannulae secure? Ensure all devices are well secured and protected
Copies of notes/ radiographs	
Parents	Fully informed? Aware of final destination, PICU telephone number, etc
Receiving PICU	Briefed on patient problems Aware of transport details including estimated time of arrival
Ambulance	Patient, staff, and equipment loaded securely?

Measurement of urine output should be considered during prolonged transfers.

ANALGESIA AND SEDATION

Assessment of a child's need for analgesia, sedation, and neuromuscular blockade should be performed before departure. After a loading dose (typically 0·1–0·2 mg/kg), continuous intravenous infusion of morphine 10–40 μg/kg/hour can be used to provide analgesia. Many practitioners consider that critically ill intubated children should be paralysed during transport, as a restless child is difficult to reassure and essential tubes and devices may therefore be put at risk. Paralysis may be achieved without adverse haemodynamic consequences using vecuronium 0·1–0·2 mg/kg intravenously. Additional sedation may be provided with a continuous intravenous infusion of midazolam 1–5 μg/kg/min.

In addition to these general considerations of the airway, ventilation, circulation, and analgesia, many 'disease specific' issues arise which are beyond the scope of this paper.

PREDEPARTURE CHECKLIST

Meticulous attention to detail in the preparation of the patient and equipment should minimise the possibility of equipment problems and clinical instability during transport. I strongly recommend the use of a predeparture checklist even to those who frequently transport children (table 3). No airline pilot, however experienced, approaches takeoff without first running through a detailed checklist.

Conclusions

Interhospital transport by specialised teams is well established in neonatal medicine, and has been shown to reduce the incidence of 'secondary insults' when older children are transported. All critically ill children in Britain should have access to paediatric intensive care facilities, and a service trained to move them swiftly, but safely, to these facilities.

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