Practical Approach to Pediatric Intensive Care

4th Edition

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Foreword
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Transport of Critically Sick Children

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INTRODUCTION

All critically ill children need careful handling of transport process starting from referring hospital or home (as the case may be) to admitting hospital to ensure safe transport. Imagine you are a resident posted at a primary healthcare center, and receive a call from an ambulance service about Master a, 10-year-old boy who had an accidental fall from the roof and is being brought to your center. He had loss of consciousness on site with ENT bleed. Your center B does not have neurosurgical services, and the nearest hospital with specialist services is 50 km away. Among the decisions you would face to undertake such a transfer, include what ambulance to take him in, who to take him with (staffing), what equipment to take him with, how to take him (pretransport stabilization), when to take him (transport policies). Through this chapter, we will try and cover some of the above conundrums.

- Basics of transport medicine (types of transport)
- How the ride will affect the patient? (transport physiology)
- What to transfer in? (structure, standardization, and types of ambulances)
- What to transfer with and how to transfer? (transport bag and checklist)
- When to transport? (transport policies, pretransport stabilization)
- Whom to transport with? (staffing)
- Concept of retrieval medicine and critical care transport teams (CCTT). In this chapter, a comprehensive process of critical care transport is discussed to prevent a not so uncommon issue of deterioration during transport and sometimes even severe morbidity and mortality.

WHY PEDIATRIC TRANSPORT IS NEEDED?

There exists a tiered system of healthcare, in most resource-limited settings, with differential resource allocation and referral level at each tier.[1-3] This is compounded by the lack of appropriately manned pediatric intensive care units (PICUs) in most rural settings,[1,4,5] lack of financial resources and insurance coverage, intensive care unit (ICU) bed availability, and overcrowding of available beds.[1,4-7] There exists a need for transportation across health tiers, due to paucity of ICU resources at lower tiers, and uneven distribution of PICUs, with metropolitan clustering.[8-10] This leads to a major service delivery challenge, compounded by transportation availability, distance decay, distance measures, and travel time.[11-13] In a large country like India, the issue of safe transport for seriously ill children is more complex and is still in the early stages of its development. Many a times, a critical patient is brought to the hospital by car, taxi, or autorickshaw.[14] This is especially complicated for children.

Types of Transport

The type of transport can be classified based upon the indication of transport, number of teams involved in the transfer among others **(Table 1)**. Depending upon the number of centers required in the transport, viz., referring hospital, receiving hospital, or specialized transport service, the transport can be classified as 1-way, 2-way, or 3-way transport. Each has its advantages and disadvantages **(Fig. 1)**.

Table 1: Some terms used in transport.[16,17]

Primary transfer/ scene transfer	Movement of patients from scene of injury or illness, to the nearest receiving hospital
Extended primary transfer	Movement of a patient from the scene of injury or illness to a specialist center or trauma center, bypassing the nearest hospital to reach a center more appropriate to the needs of the patient
Secondary transfer	Movement of a patient from any hospital facility (emergency department/ward/critical care facility/operating theatre) to another center
"Clinical" transfer	Patient transfer for specialty treatment or investigation not provided at referring hospital
"Capacity" transfer	Patient transfer for specialist treatment or investigation normally provided at referring hospital, but which is not currently available. The use of the term "nonclinical transfer" should be avoided. Transfers for capacity reasons may still be clinically necessary and are sometimes critical
Repatriation	Patient transferred back to referring hospital or a hospital nearer the patient's home address
Interhospital transfer	Transfer of a patient between hospitals
Intrahospital transfer	Transfer of a patient between areas/ departments within the same hospital site

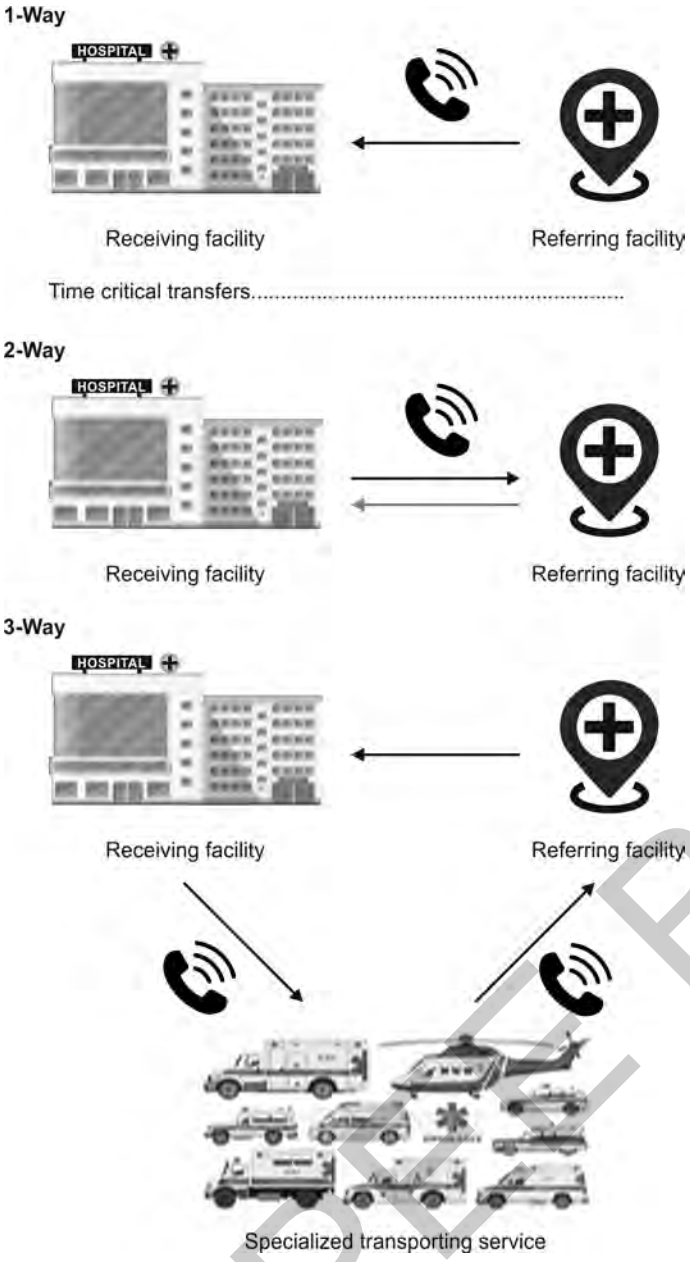

Fig. 1: Description of types of transport as per number of centers involved.

The advantages of two-way and three-way interhospital patient transfers include the following:

- Entire team—paramedics, nurses, and physicians have transport training and experience.
- Outcomes are reported to be better for patients transferred by trained teams.
- Dedicated equipment, including critical care equipment like ventilators and monitors, are present for transporting critically ill patients.
- Equipment and drugs are prepared beforehand with specialist teams.

  But for critical transfers as neurosurgical emergencies, few guidelines recommend that they should be undertaken as an one way transfer, to decrease transportation time.[15]

Transport Physiology

Transferring a patient, poses unique challenges to the transferring team, with the staff, cramped into limited space, and limited movement possible, due to strapping on by seat belts. In ground transport, other environmental factors as acceleration (positive, negative, and angular) may have effect on both staff accompanying and patients. This effect is exaggerated if the patient is sick (volume depleted, on positive pressure, or shock). These parameters are particularly exaggerated, in aero transport, be it helicopter or fixed wing transport. Other environmental factors as vibration, temperature alterations, lack of humidity control, and changes in barometric pressure are also marked in such an environment. The following is in brief a literature summary, on the effects of transport on human physiology (patient/transfer crew) **(Table 2 and Fig. 2)**.

WHAT TO TRANSFER IN?

We shall now discuss the mode of transport that the doctor may choose to undertake the transport, and the considerations in choosing the same.

Mode of Transport

This can include ground, air, and water. Which modality is appropriate is decided by a number of factors as stated in the **Tables 3 and 4**.

For the purpose of this chapter, we will be concentrating predominantly on ground transport, viz., ambulance transfer. A transport before being undertaken, needs to be planned, one needs to decide his ambulance, run pretransport checklists, prepare a well-equipped transport bag, and stabilize the patient as much as one can, prior to undertaking the transport.

Ground Transport: Ambulance

Ambulance is the most important part of the transport and is the backbone of any transport service. Ambulance as per National Ambulance Code,[30] published by NISC (National Injury and Surveillance Trauma Registry and Capacity Building Centre), is defined as "a specially equipped and ergonomically designed vehicle for transportation/emergent treatment of sick or injured people and capable of providing out of hospital medical care during transit/when stationary, commensurate with its designated level of care when appropriately staffed." When choosing an ambulance for undertaking a transfer, one needs to take into account the nature of patient emergency, as it determines the type of ambulance to be chosen.

Types of Road Ambulance

Road ambulances are designated as follows based on the level of care they can provide.

- *Type A road ambulance/medical first responder road ambulance:* Designed to provide emergent out of hospital medical care to patients when stationary. This vehicle may

Table 2: Effect of transport-related factors on patients' physiology.

During ground transport	
Effect of G forces/ acceleration	During acceleration, blood moves toward feet, while during deceleration, blood moves toward head. Well-filled patients tolerate transfer better. Upon exposure to positive G forces, blood will "pool" in the feet resulting in decreased cardiac preload, decreased cardiac output, and blood pressure[18]
Effect on CNS	During deceleration, the intracranial pressure increases due to action of Cephalad forces, blood and CSF are pulled into the cranial cavity leading to a rise in ICP and reduction in cerebral perfusion pressure which may worsen secondary brain injury.[18] This is important in patients who already have a raised ICP as their cerebral perfusion may be further compromised during deceleration. A head up tilt of 15° will reduce this effect[19]
Effect on GIT	During deceleration, the stomach and gastric content are displaced upward leading to regurgitation of gastric content, especially if there is lower esophageal junction incompetence as is common in the sedated unwell patient[18,20]
Musculoskeletal system	During deceleration, axial loading of the spine occurs, potentially worsening unstable spinal injuries[18]
During aerotransport	
Lung	• There is a reduction in alveolar oxygen tension, and may result in requirement of escalation of oxygen support • Pneumothoraces will expand as height increases, worsening gas exchange and potentially causing a tension pneumothorax. ICD should not be clamped during a flight[18,21] • High altitude pulmonary edema (HAPE) consists of a spectrum of pulmonary dysfunction, ranging from minimal dyspnea on exertion to a productive cough with blood-tinged sputum[22]
Bowel gas	Patients with ileus, bowel obstruction, or following bowel surgery have increased bowel gas and the expansion of this gas can distend the bowel leading to perforation or anastomotic breakdown. Hence, guidelines recommend insertion of NG tube and keeping the same on free-dependent drainage or flying with cabin pressurization[2,6]
Brain	Pneumoencephalum and open head fractures, can potentially expands, resulting in features of increased intracranial pressure. This compounded by high altitude hypoxia, hypotension, or secondary brain injury may result in detrimental effect on traumatic brain injuries[2,7]
Medical equipment	For cuffed endotracheal tubes, on ascent, the cuff pressure increases causing mucosal ischemia, and on descent it will decrease leading to a cuff leak. Cuff pressure should be measured regularly especially following changes in altitude or the cuff should be filled with saline [18,20]
Effect of vibration	Monitoring devices as automated NIBP cuff and ECG may show erroneous readings[18,20,23] Worsen bleeding by dislodging clots and preventing hemostasis[2]
Effect of temperature	For aircraft, as altitude increases the air temperature decreases by roughly 2°C per 1000 ft. Hence, the patient temperature should be monitored regularly, especially during prolonged transfers.[18,20] Adequate heating equipment as blankets and heating devices should be present as appropriate and flight tested

(CNS: central nervous system; CSF: cerebrospinal fluid; ECG: electrocardiogram; GIT: gastrointestinal tract; ICD: ischemic cerebrovascular disease; ICP: intracranial pressure; NG: nasogastric; NIBP: implantable cardioverter-defibrillator)

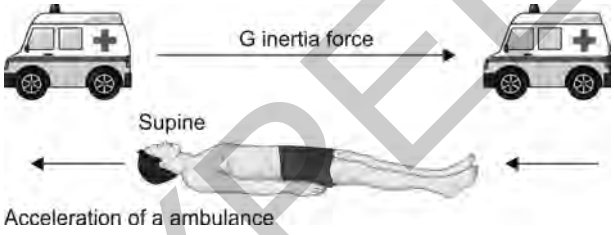

Fig. 2: Depiction of how acceleration affects a patient's body, lying head first in the direction of ambulance.

be any Central Motor Vehicle Rules (CMVR) approved category M or L vehicle suitable for the terrain to be used in but will not have the capability to transport patients in supine state or provide them medical care inside the vehicle.

- *Type B road ambulance/patient transport (PT) vehicle road ambulance:* Designed and equipped for the transport patients who are not expected to become emergency patients.
- *Type C road ambulance: Basic life support (BLS) ambulance:* A vehicle ergonomically designed, suitably equipped and appropriately staffed for the transport and treatment of patients requiring noninvasive airway management/basic monitoring.
- *Type D road ambulance: Advanced life support (ALS) ambulance:* A vehicle ergonomically designed, suitably equipped and appropriately staffed for the transport and treatment of emergency patients requiring invasive airway management/intensive monitoring.

Before we go ahead, let us discuss some important aspects of an ambulance, viz., its structural specifications and discuss about the concept of national ambulance service.

Ambulance Structure

The constitutional and functional requirements of road ambulances in our country are codified as the national ambulance code. The ambulance service providers should ensure that their ambulances meet this safety standard.[30] The transporting doctor should be aware of the structure and location of various equipment's in the ambulance, he is transporting in. This orientation should ideally be a part of the induction process and should be done during the downtime. This situational awareness is important, as once strapped in the chair, the reach envelope of the doctor is quite curtailed, hence the equipment location in an ambulance should be known to all the staff.[31] The limited reach envelopes during

Table 3: Considerations for deciding mode of transport while transporting a critically ill patient.*

Time and distance indicators[24-27]	
Distance	Distance to the closest appropriate facility is too great for safe and timely transport by ground ambulance.
Transport time	Minimize out of hospital time
Timely treatment	• Specific life-saving treatment, available at specific center, not available at the referring facility (or scene) • Extracorporeal life support (ECLS), transplant
Transport delays	Use of ground or air transport (e.g., weather or weather-related obstacles, traffic congestion, construction, road obstacles, location of patient, and distance)
Critical care	The patient requires critical care support (e.g., monitoring, personnel, medication, and special equipment) during transport that is not available from the local ambulance service
Logistic factors	
Inaccessible area	Area inaccessible to regular ground traffic, impeding ambulance egress, or access to the scene because of environmental obstacles or conditions, weather-related events (e.g., floods and heavy snowfall), traffic congestion, wilderness rescue, or other geographic considerations
Local ground resources	Emergency medical coverage, local hospitals-trained manpower
Situation	Disaster situation

*May vary as per patient condition, transport policy, resources available, treating doctors, and patients families decisions.

Table 4: Properties of ground ambulance, helicopter, and fixed-wing aircraft.[28,29]

	Ground ambulance	*Helicopter*	*Fixed wing aircraft*
Space for team and equipment	Sufficient (4–5 team members)	More limited (3–5 team members)	Variable (≥4 team members)
Distance for reasonable transport	Up to 400 km	Up to 650 km	Any distance
Noise	Relatively little	Very loud	Loud
Weight limitations	Unlimited	Limited (impacted by distance and weather)	Variable (as per aircraft and conditions)
Advantages	Easy availability and convenient	• Rapid transit time over extremely long distances • Cabin size larger than helicopter's	• Rapid transit time • Ability to reach remote areas
Disadvantages	Not ideal for long distances	• Airport required bad weather may affect • Noise and vibration interference • Expensive	• Unobstructed landing space required (field, helipad, etc.) with limitations of weather • Limited range because of fuel capacity • Limited cabin space • Noise and vibration interference • Expensive

transport and equipment requiring frequent access are depicted in **Figures 3A and B**.

National Ambulance Service

Thirty-five states/UTs have the facility where people can dial 108 or 102 telephone number for calling an ambulance. Dial 108 is predominantly an emergency response system, primarily designed to attend to patients of critical care, trauma and accident victims, etc. Dial 102 services essentially consist of basic PT aimed to cater the needs of pregnant women and children though other categories are also taking benefit and are not excluded. JSSK entitlements, e.g., free transfer from home to facility, interfacility transfer in case of referral, and drop back for mother and children are the key focus of 102 service.[32]

Now that we know, what ambulance to call, we will concentrate on what to do before the transport. It is well known that a well-planned transport is a safe transport. Hence, to adopt a structured, protocolized approach to transport of a critically sick child, the concept of checklist, have structured handovers, and the practice of using a structured transport bag, should be adopted. Let's start with the checklist concept and pretransport stabilization.

HOW TO TRANSPORT?

Pretransport Preparation

One should remember that transporting in an ambulance is delivery of critical care as one would in an emergency room or ICU, but in the middle of nowhere, moving at 80 km/h, while strapped in a chair with a seat belt. So, one needs to be prepared and anticipate adverse events, these can be minimized by following structured pretransport preparation. Checklists are an effective tool to improve care process and safety and reduce mortality and morbidity of patients. No matter how expert you, may be well-designed, checklist

can improve the outcome. They are useful at various stages of the interhospital transport process: prior to starting the transport, during the transport itself, and finally, after the transport is completed. The pretransport checklist may need to be modified as per the service provider, available resources, hospital policies, patient type and nature of emergency, among other considerations. Such a checklist predominantly focusses on communication, equipment, ambulance, staffing, drugs, and infection control measures. Let's now examine each aspect of these checklists in detail.

Communication Checklist

A doctor must undertake some important communication exercises, before a transport. These include the following:

- Ensure the patient identifiers are confirmed, patient ID bracelet is confirmed and the patient allergies identified and communicated between the two hospitals.
- Communication between the referring and receiving hospital:
  - There should be a designated phone line for the transport calls and enquiries.
  - The staff at the point of communication should obtain vital statistics (name of the patient, age, diagnosis, referring physician's name and telephone number, etc.), mobilize the appropriate transport team (based on standard protocols).
  - Ideally, the transport team should also check the logistics of the transport, including checking local weather conditions (this is particularly important during monsoon season as there is always a chance of road blocks and flooding).
  - The referring physician should coordinate directly with the transporting physician; this will improve the care of the child and will allow the receiving PICU to be

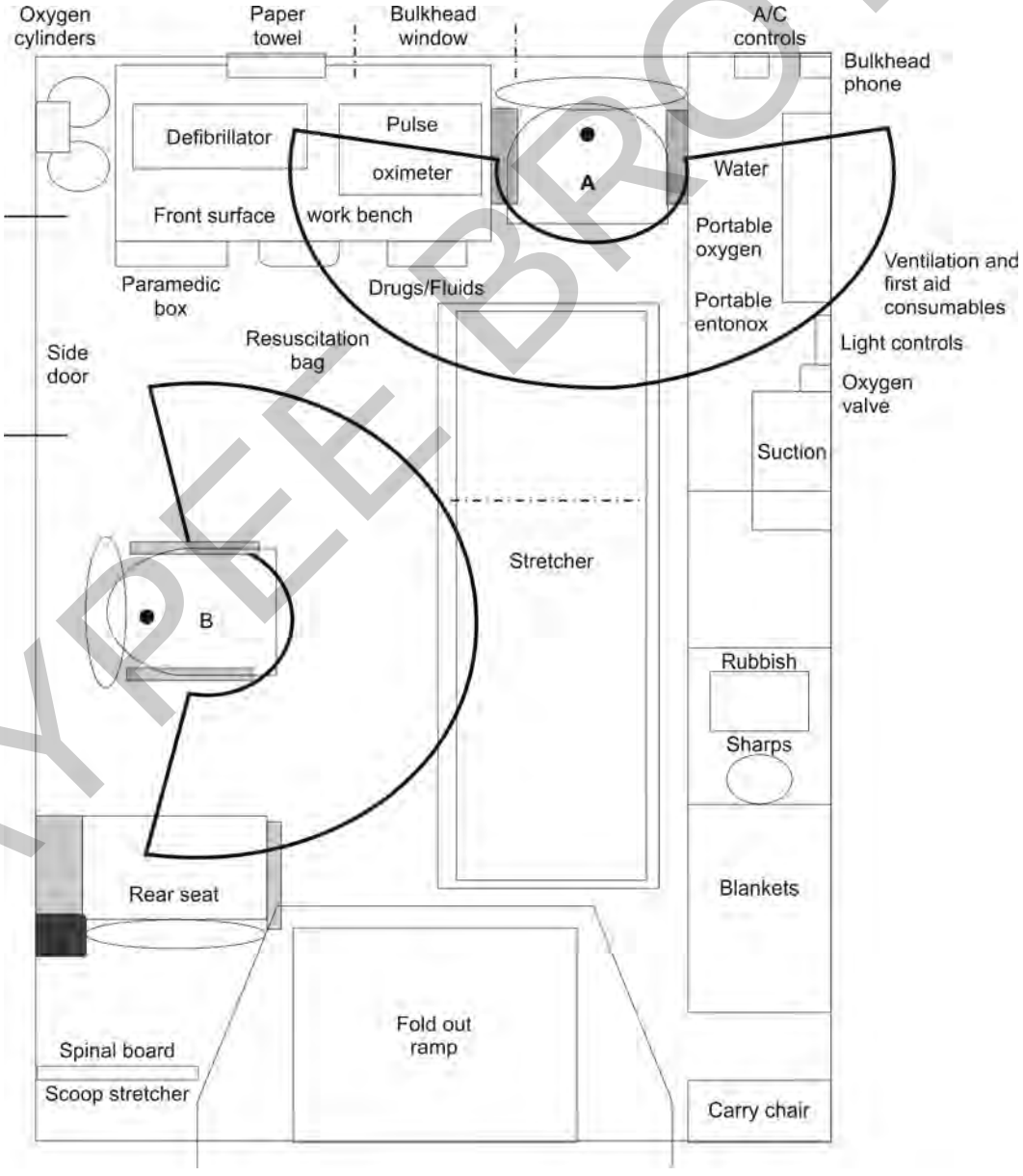

Fig. 3A

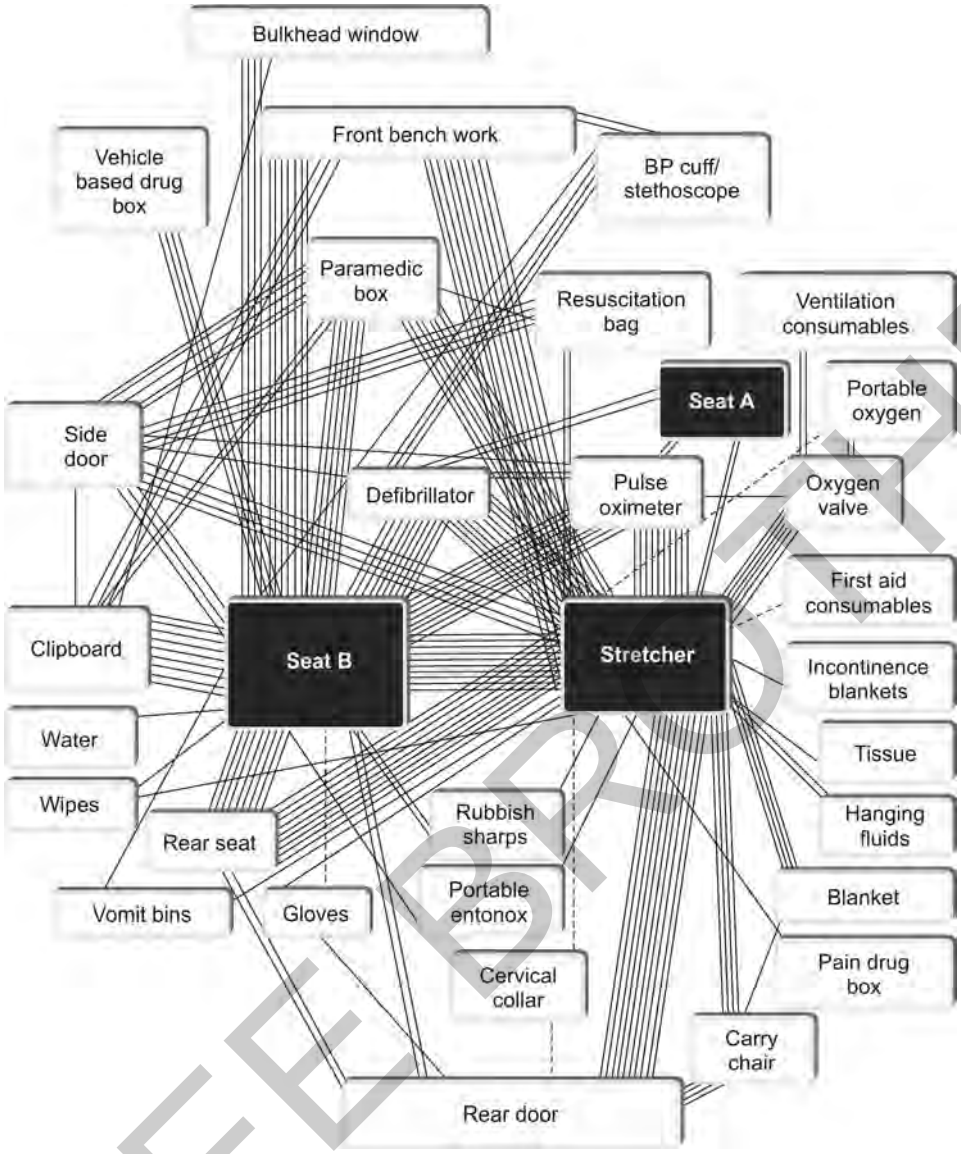

Fig. 3B

Figs. 3A and B: (A) Reach envelopes for seat A and seat B, usually doctor sits in seat A, and staff nurse in seat B; (B) Schematic links between the paramedics and the equipment (schematic link analysis, each line represents 4 links up to a maximum of 40 links, dotted lines indicate important links that occurred less than four times).
Source: Reproduced with permission from Ferreira J, Hignett S. Reviewing ambulance design for clinical efficiency and paramedic safety. Applied Ergonomics. 2005;36(1):97-105[31]

better prepared for the patient's arrival. The receiving physician, must have the final authority to accept the transport call.[29]

- The referring hospital should send the appropriate documentation which includes appropriate transfer letter, including the radiological and investigational data. The documentation should include time of starting, arrival, and transport times. It should have appropriate demographic details to facilitate admission, and appropriate patient identifiers, to ensure that the right patient is transported to the right center. This communication is ongoing, and at any moment, if there is a new development, that may need academic input or further information to the receiving team, it needs to be done on an ongoing basis. For example, if the patient was not intubated when the journey started, and got intubated en route, it is better to call the receiving hospital ahead, so that they may arrange a ventilator for the patient.
- To ensure ongoing communication, it is best to have mobile numbers of the receiving and referring consultants and the transporting team, to ensure they are on the same page with regards to patient condition.

▪ *Communication with parents:*

- One parent should accompany the child. The receiving hospital may be informed of who will be accompanying alongside.
- The other parent should be updated on destination hospital and timeframe, so they may reach independently.

- They should be debriefed on the risks anticipated during transport, including the anticipated scenarios, preparedness, and anticipated response by the medical team, e.g., if a patient with arrhythmia is being transported, with the defibrillator pads on the body, and there is a chance child might require defibrillation en route, it is better to talk through the steps with the relatives, before the transport, to avoid panic en route.

- *Communication between the team members:* It is better to assign roles for emergency scenarios before embarking on a journey in an ambulance, with one's team members. This is especially important in situations as cardiac arrest, as who will be look after the airway, drugs, and chest compression.
- *Communication with the driver:* Even before embarking on an Uber journey, one would inform the destination and identify the driver. Before entrusting one's journey in hands of a driver, especially if he is stranger a quick debriefing might be helpful. A quick ambulance driver checklist might be helpful, but it is better checked in the downtime than during active retrieval **(Table 5)**.

Transport Bag

There should be a dedicated transport bag, which should be available for intrahospital and interhospital transports. It should be sealed and in ready to use condition. It should be subject to checks as per standardized checklist, every time before resealing. It is preferable to have subsections in the bag or smaller bag in the bigger transport bag for each scenario as needed. This bag may have different composition as per hospital policy, ambulance type, patient condition, transporting doctor, available skill set/manpower resource among others. An example of the contents is mentioned below.

Table 5: Driver-related checklist.

	To be checked with driver
Driver name	
Vehicle number	
Driver fitness certificate	
Lights (headlight/tail light)/siren working	
Tyres pressure/fuel adequacy assessed	
Destination is known to the driver	
Any route obstructions/traffic jams anticipated en route	
Weather: Any anticipated problems as rain	
Oxygen content adequate for journey	
Is liaising required for red corridor	
Communication equipment as contact numbers given to base team/referral/ referring hospital as needed	
Fire extinguisher adequate/checked	
Biomedical waste disposal equipment adequate including spare PPE as needed	

A transport team should ideally have a dedicated checklist of all equipment's, which is checked during downtime, so that it is ready to go, during emergency mobilization.

- *Airway bag:* When transporting a ventilated patient or a patient with unstable airway, it is wiser to intubate prior to transport to ensure a safe transport. Due to the risk of accidental airway dislodgement due to the transport related factors, it is advisable that the doctor transporting such a patient should have a ready airway bag (grab bag), with him at all times, along with ambu and Bains circuit, so that in case of such an event, immediate bag and mask can be resumed, till definitive airway is established **(Table 6)**.
- *Respiratory bag:* The transport bag should have a dedicated respiratory bag section, which should include all the equipment required for the transport of a child with respiratory distress. This may vary depending upon the transporting team training and service competence. Some established pediatric critical care transport services as CATS, London can undertake transport of patients on inhaled nitric oxide, advanced ventilation **(Fig. 4)** illustrates some examples of transport ventilators, that are commonly used in India, and high flow heated humidified oxygen, each of these service additions require additional training, equipment preparation and stocking for en route transfer, pretransport checks, checklists, and monitoring concerns. A sample respiratory bag constitution is being given alongside **(Table 7)**.
- *Circulation bag:* Every transport bag should have a dedicated bag with circulation-related equipment, which include equipment to monitor circulation (invasive/ noninvasive) and start lines (peripheral/central: as per transporting team training/competencies) **(Table 8)**.
- *Additional equipment bag:* While transporting additional equipment are needed, which should be bundled up in appropriate bags and included in the checklists **(Box 1)**.

Drug Bag

The drug list depends upon the type of patient being retrieved and kind of emergencies locally prevalent. For example, ambulances catering to area with high scorpion sting, might want to carry prazosin among other drugs. The following is a brief example of drugs, that maybe carried by the ambulance team. If a team is carrying narcotics and other controlled substances, then strict adherence to guidelines for their safe storage, prescription, and use are essential **(Table 9)**.

Some medications including surfactant, selected neuromuscular blocking agents, fosphenytoin, lorazepam, and prostaglandin are best stored at cold temperature.[29] Always remember to keep the fridge drugs in the transport bag, when starting on a retrieval. Also remember to always periodically screen the drugs for date of expiry. If there are preloaded syringes, they should be appropriately labeled in terms of name, strength, and discarded as per manufacturer's recommendations.

Table 6: Sample airway bag.

Equipment name	*Specifications*	*Number*	*Tick after checking*
Laryngoscope handles (ensure it is working, light is being turned on, compatible with blades)	Small	1	
	Large	1	
Laryngoscope blades (check blades are compatible with each handle)	Miller 0,1	1 each	
	Magill 1	1 each	
	Mac 1, 2, and 3	1 each	
Batteries	Appropriate size for the laryngoscope handles	4 unopened (checked)	
Yankauer suction catheter	Small, large	1 each	
Dynaplast	(preferably pre-cut to appropriate sizes)	2–3	
Scissors		1	
Uncuffed endotracheal tubes (ETTs)	Size 2.5, 3.0, 3.5, 4.0, and 4.5 mm (at least 2 each)	2 each	
Cuffed ETTs	Size 3.0–8.0 (at least 2 each)	2 each	
10 mL syringe	To inflate the cuff	2–3	
Laryngeal mask airway	Size 1.0, 1.5, and 2.0,	1 of each size	
Guedel airway	0, 1, 2, 3	1 of each size	
Facemasks	0, 1, 2, 3	1 of each size	
Suction tubing	Appropriate size	1 of each size	
Bougie	Adult and pediatric	1 of each size	
Intubation stylet	Appropriate size	2 of each size	
Suction catheter	Assortment of sizes (6, 8, 10)	2 of each size	
Magill's forceps	Pediatric and infant (preferably)	1	
Stethoscope	Pediatric	1	
Pen torch	With batteries	1	
Appropriate ambu with appropriate size masks	Appropriate for age, with tubing's to connect to the oxygen supply	1	
ET cuff gauge manometer		1	
Bains circuit	Flow inflating bag, appropriate size and type to be chosen as per patient's condition	1	

Fig. 4: Some examples of transport ventilators.

Table 7: Sample respiratory bag constitution.

Equipment name	*Specifications*	*Number*	*Tick after checking*
Ayre's T piece	0.5 L, 2 L	1 each	
Oxygen tubing		2	
Ambu bag	Pediatric, adult With reservoir and tubings with appropriate mask (pediatric, infant, and adult)	1 each	
Oxygen mask	Adult, pediatric	1 each	
Nebulization mask and circuit	Adult and pediatric	1 each	
Nasal Prongs	Adult, pediatric, and infant	1 each	
Stethoscope		1	
Self-inflating bag with a reservoir	Adult (1,500 mL), pediatric (500 mL)	1 each	
Intercostal chest drains	16–24 French	1 each	
ICD insertion set		1	
Chest drainage Underwater seal collection device	For emergency needle thoracostomy	1	
Non rebreathing mask	Adult, pediatric	1 each	
If ventilator is being used			
Ventilator circuit	Pediatric, adult	As per patient condition and age	
Saturation probes	Neonatal, infant, and pediatric		
$ETCO_2$ probes	Depending upon the compatibility with monitor and circuit		
Bacterial filter	Adult, pediatric		
Heat moisture exchangers	Adult, pediatric		

($ETCO_2$: end-tidal carbon dioxide; ICD: ischemic cerebrovascular disease)

Table 8: Sample circulation bag.

Equipment name	*Specifications*	*Tick after checking*
Equipment to start peripheral venous access • Alcohol swabs • Syringes • Intracath (age appropriate: 16–26 G) • Tape/IV plaster to fix the intracath, with splints as age/location appropriate • IV flush to check for patency • With additional connectors as 3-way tap, octopus	Age appropriate and as needed	
• IV fluids • Crystalloids and colloids		
Glucometer		
Thermometer		
Central line/arterial line kit		
• Infusion pumps • Should be precharged during downtime • With adequate battery back up		
Monitoring equipment • ECG, oximetry, noninvasive blood pressure (NIBP), temperature, capnography, and point of care blood gas monitoring systems (as iSTAT) • *For monitoring ECG:* ECG dots, leads are needed • *For NIBP:* Age appropriate BP cuffs are needed, when invasive BP is being used, ensuring prechecks, line securement, zeroing, and positioning need to be checked • Invasive channels (preferably 2) for CVP and invasive BP on Monitor		
• Equipment for urinary catheterization including Foley Catheter 6, 8, 10 × 1 each • Urobags, tapes for fixing as needed, syringe, NS for inflating, sterile gloves, sterile gauze to clean, with antiseptic as per policy		
Equipment for inserting NG tube, with appropriate size NG and infant feeding tubes, bile bags, syringes with check, and stethoscope. Ideally, pH strops should be there to check position as well		
Monitoring equipment including NIBP cable/neonatal NIBP cable/BP cuffs (infant/pediatric/adult)/ECG cable/ECG dots/temperature probes		
Alternate equipment to start lines as IO needles, e.g., EZ IO system with age appropriate needle		
Specialized team may carry central line set and arterial line set, with portable ultrasound, with disposable sheets		

Apart from the above, the staff nurse transporting should have an emergency drug bag which should be on her person, just like doctor should have a dedicated airway bag. This emergency drug bag should have prelabeled prechecked syringes as per patient's condition, e.g., resuscitation drugs and sedation drugs. One must ensure the adequate labeling and complete closed loop communication during transport to avoid transport related adverse events.

Other Checklists

After preparing the transport bag, one should also run over the other checklists, to ensure readiness for transport, these include, document, ambulance, staffing, and infection control checklists.

Document checklist: The other important checklists include a document checklist, imagine having travelled 500 km to transport a child, and having forgotten the patient documents, viz., radiological and clinical papers, which cannot be faxed, and having to make a trip again only for that. It is better to have a ready checklist that ensures that all paperwork is in place, before undertaking such a long duration transfer **(Box 2)** may help in that regard. This also includes many important algorithms and protocols, which can be great ready reckoners

Box 1: Additional equipment bag.

- Oxygen key
- ID/allergy bracelets as per policy
- Syringes and needles all sizes, 50 mL, 20 mL, 10 mL, 5 mL, 2 mL, 1 mL, and needles of appropriate sizes
- IV sets
- Replogle tube
- Disposable slide sheet
- Nonsterile gloves
- Gloves
- Biomedical waste bags
- Adjustable neck collar
- Spine board
- Restraints (splint/sling for immobilization as needed)
- Gauze
- Tourniquet

Table 9: Drug bag.[29]

Type of medications	*Examples*
Antiarrhythmics	Adenosine, amiodarone, lidocaine, procainamide, and magnesium sulfate
Antiepileptics	Lorazepam, fosphenytoin, phenobarbital, diazepam, and midazolam
Antimicrobials	Ampicillin, gentamicin, ceftriaxone, and acyclovir
Anaphylaxis therapy	Racemic epinephrine, diphenhydramine, cimetidine, and glucagon
Bronchodilators/ asthma therapy	• Levolin, ipratropium, terbutaline, methylprednisolone, aminophylline, and hydrocortisone • Asthalin respirator solution (5 mg/mL: 15 mL) • Ipravent (250 microgram/mL: 15 mL) • Budecort respules (0.5 mg)
Narcotic analgesics	Fentanyl, morphine, and ketamine
Neuromuscular blocking agents	Rocuronium, succinylcholine, and pancuronium
Resuscitation medications	Epinephrine, atropine, and calcium gluconate
Reversal agents	Flumazenil, naloxone, some centers recommend sugammadex as well.
Infusion medications	Dopamine, dobutamine, epinephrine, lidocaine, prostaglandin E1, noradrenaline, and milrinone
Intravenous fluids	Terbutaline, 0.9% saline, lactated ringers, albumin 5%, dextrose 10%, dextrose 25%, and isolyte P
Antihypertensive	Hydralazine
Electrolytes	Calcium gluconate (10%), sodium bicarbonate, and potassium chloride
Sedative/Hypnotics	Midazolam, thiopental, and ketamine
Miscellaneous	Acetaminophen, activated charcoal, dextrose, furosemide, heparin, hydrocortisone, mannitol, sodium bicarbonate, surfactant, furosemide, xylocard (2%), and water for injection
Fridge medications	Fridge medications as insulin, IVF NS 500 mL (cold saline), tetanus toxoid, etc.
With syringes, needles, bungs, and saline flushes	

Box 2: Documents checklist.

- Difficult airway algorithm
- Nomograms—blood pressure (BP), body surface area (BSA)
- Ambulance equipment checklist
- Pediatric transport bag content checklist
- Transport ventilator quick reference guide including trouble shooting
- Critical care record of transfer
- Nursing charts—observations
- Infusion prescriptions
- Transfer handover notes—medical and nursing
- Ambulance breakdown plan and checklist

Box 3: Infection control checklist.

- Triage of patient based on referral information for infection control precautions (contact, droplet, or airborne)
- Access to personal protective equipment (PPE)
  - *Contact:* Gloves, plastic apron
  - *Droplet:* Gloves, plastic apron, and surgical face mask
  - *Airborne:* Gloves, full length gown, FFP2/3 mask, and visor/goggles
- Personal protective equipment (gloves, plastic apron, gown, visor/ goggles, and FFP2/3 mask)
- Adequate garbage bags to dispose as needed

for new recruits when faced with sick patients and decrease adverse events.

Ambulance checklist: This checklist may be done alongside driver checks **(Table 5)** and should be done during downtime, to ensure a ready, preprepared ambulance for any emergency.

- Adequate oxygen and medical air available
- Familiarity with ambulance equipment (ventilator, infusion pumps, and defibrillator).
- Ambulance crew aware of destination, GPS available if required.
- Safety briefing (severe weather, team fatigue, team familiarity, and role allocation for nonclinical emergencies such as ambulance crash or fire).
- Ensure restraints on the patient, seat belt use by the staff members prior to undertaking the transport.
- Ensure staffing has had adequate food and hydration prior to shift, and a quick snack for long transfers.
- Ensure the staff as enough rest between shifts prior to the shift.
- Ensure the staff has used the toilets especially before long ambulance drives.

The staffing checklist should include ensuring readiness includes ensuring staffing with adequate competencies. This is especially required for personnel undertaking specialized transports as rotor wing transport, ECMO transport, etc. where familiarity with process, protocols and equipment is essential.

Additional checklists, which have assumed special importance during COVID times is the infection control checklist. One needs to ensure adequate isolation precaution specific PPE, equipment, and disposal availability prior to transport **(Box 3)**. One needs to clean the ambulance post-transport after undertaking such transport as well.

WHEN TO TRANSPORT?

Now that we have discussed about how to transport and pretransport preparedness by the means of preparing a dedicated transport bag and validated checklists, we need to discuss how the transporting doctor needs to stabilize the patient prior as much as possible prior to undertaking any transfer.

Pretransport Stabilization

The interventions while traveling in the ambulance or aircraft can be technically difficult and associated with a higher risk of complications, stabilization is best performed at the referring hospital before transport.[33] There are two types of transport policies that can be followed for pretransport stabilization, and depends on the kind of patient being transported:[24]

1. "Stand and play" means transporting the patient only after stabilizing. This is the policy that is followed most, especially during long transport. Suppose an intensivist is called to receive a patient of septic shock from a PHC, he might want to start a central line, intubate as needed, start vasopressors, before starting on the ambulance ride, in order to have a relatively stable child during transport, this can be classified as a stand and play policy, whereby, the clinician is stabilizing as much as he can before the transport.
2. "Scoop and run" means transporting the patient without wasting much time at the scene. This policy is followed in trauma and bleeding situations or where facilities for stabilization are limited/are not available. Even in these situations, stabilization of the airway and fluid resuscitation, if possible, should be done. Suppose, an intensivist is called to retrieve an ongoing intracranial bleed. He would still want to stabilize as much as he can, as intubation, fluid resuscitation as needed, but it is imperative that this patient is transported to the dedicated neurosurgical center, so that definitive management can be done. In this situation, a scoop and run policy might be more appropriate.

Now lets us discuss some important considerations, with regards to transportation of a child with specific system involvement.

Considerations in Intrahospital Transport of a Child with Respiratory Involvement

The following are some of the issues to be addressed prior to undertaking the transport of a child with respiratory involvement.

- Ensure endotracheal tube (ETT) tip position satisfactory; even slightly high position may not be acceptable for transport. Preferable to get an airway secure and confirm position by means of a chest X-ray before transport.
- Ensure ETT tapes are dry; change if wet. Consider using Melbourne strapping method.[34]

Box 4: Equations to calculate oxygen.

$$\text{Time (remaining) (hours)}^{36} = \frac{\text{Pressure (remaining)} \times \text{Volume (initial)}}{\text{Pressure (initial)} \times \text{Flow rate (L/min)} \times 60}$$

The amount of time that a tank will supply oxygen can be determined using the following formula:

Minutes of oxygen flow = Cylinder pressure × Cylinder factor/Flow of oxygen (L/min)

Cylinder factor of a size D, E, and H tank is 0.16, 0.28, and 3.14, respectively[29,37]

- Do good ET suction and oral suction just before shifting.
- Inflate cuff, check cuff pressure by cuff gauge manometer if available.
- A chest radiograph should ideally be obtained before the transport team's departure, to verify position of ETT and ruling out pneumothoraces. A nasogastric tube for gastric decompression should be placed.[29]
- Optimize oxygen therapy, as mentioned in **(Box 4)**.
- Ensure ventilation adequate, if using a transport ventilator, may consider, doing a gas on the transport ventilator, to ensure that there is adequate ventilation and oxygenation. Ensure good chest rise and stable vitals while bagging before shifting.
- Use adequate heat moisture exchanger/bacterial filter as age appropriate for ventilated patients.
- Preferably use waveform capnography for ventilated patients.
- Ensure ambulance/transport bag has advanced airway equipment as per difficult airway algorithm as laryngeal mask airway (LMA) or I-gel stylets, and bougie. For advanced transport teams, having a video laryngoscope as Airtraq might be helpful.
- Ensure the oxygen saturation (SpO_2) and end-tidal carbon dioxide ($ETCO_2$) alarms are adequately set, and the alarm volume is kept at the highest setting for the duration of transport, as it can get very loud during ambulance transport.

Ventilator specific:

- When using ventilators, ensure daily, pretransport checks are done in the ventilators, to ensure circuit checks etc. are completed, so that transport ventilators are in ready to use condition. This should be done in downtime.
- Ensure adequate age-specific ventilator is available, with age-appropriate settings.
- Ensure age-appropriate tubings are connected for the transfer.
- Adjust alarm settings as per patient, and increase the volume to the highest setting.
- Check appropriate mode, high pressure, and leak/disconnection alarms. Ensure all sensors (flow/oxygen/CO_2 is calibrated).
- Ensure monitoring of the serial ventilatory parameters is being done for the duration of transport.

- If the transport service uses specialized equipment as high flow nasal oxygen therapy ensure, enough oxygen is calculated prior to undertaking such a high oxygen load transfer.
- If the transport service is undertaking retrievals with inhaled nitric oxide, ensure adequate peruse checks are done, also ensure adequate gas supply, alarm limits (high/low iNO/NO_2, etc.)
- Carry an airway bag, should be handy with the doctor, who is transporting and should be different from the dedicate airway bag, in the dedicated generic pediatric transport bag. This ensures early airway maintenance and adequacy in the times of accidental tube dislodgement. This usually includes appropriate ET tube (at least appropriate size, 1 size bigger and smaller), laryngoscope handles (checked with batteries), laryngoscope blades (age appropriate) (straight/curved), LMA, dynaplast/micropore, stylet/bougie, Guedels's oral airway, scissors, suction catheter, batteries as needed suction tube with connector, torch, stethoscope, and oxygen mask. Additionally, two modes of ventilation, viz., ambu bag (flow independent) and Ayre's T piece (flow dependent), with connected tubing's, and mask, should be there, at the head end of the patient, to ensure in the case of accidental tube dislodgement, it can be secured in a timely manner **(Fig. 5)**.

Oxygen: A number of reports have described the morbidity associated with having an inadequate number of cylinders during transport.[35] There are certain nomograms which exist to help calculate the number of cylinders required, cylinder size, volume of oxygen, flow rate, and time left.[35] Few equations are given in **(Table 10)**, but will depend on the local availability of cylinders, cylinder type being used. A dedicated oxygen committee in every hospital should be made, to help for formulating institution policy and instructing doctors, on rational usage of oxygen, oxygen delivery device appropriateness, training for amount of oxygen required, and ensuring adequate stock is maintained with the hospital or ambulance service.

Fig. 5: An example of grab bag, with all airway equipment handy with doctor transporting intubated patients. It should have ideally at least 3 ET tubes (appropriate size, 1 size and bigger and smaller).

Considerations in Intrahospital Transport of a Child with Cardiovascular Instability

The following considerations are helpful while transporting a child with cardiovascular instability:

- Ensure IV-line patency, at least two wide bore IV accesses should be secured.
- Ensure adequate monitoring for electrocardiogram (ECG), blood pressure (BP) is in place.
- Ensure heart rate alarm limits are set. Ensure BP alarm limits are set, and BP is autoinflate mode, with set cycle of inflation/deflation as per clinical condition.
- Ensure alarms are set, and the volume of alarms is at highest, so that they are easily audible above the ambulance siren/vehicular noise.
- Ensure monitoring targets for vital parameters as heart rate, respiratory rate, BP (SBP/MAP), urine output, and sedation/paralysis scale are predecided, prior to transport, between the team members, so in case of any deviation; it is caught early and rectified as needed.
- Ensure fluid boluses are taken as needed. Drugs bag (fluids, sedation, and resuscitation)
- Ensure inotropes/vasopressors are preloaded as needed.
- Ensure emergency drugs as adrenaline are taken alongside.
- Ensure staff nurse has adequately packed emergency drug bag, with each syringe, prelabeled, with drug name, dilution boldly mentioned, to avoid TRAE. Drugs as adrenaline, atropine may be kept as needed. Intubation drugs for situations as accidental tube dislodgement as midazolam, ketamine, paralytics may be kept as needed. Vasopressor infusions maybe made ready for starting in emergency as per patient condition. Additional drugs may be needed on a case-to-case basis, as retrieval of IEM as hyperammonemia.
- Ensure enough syringe pumps are taken, ensure enough battery backup in each syringe pump. Infusion pumps charged and loaded. Ensure occlusion alarms are set, to check for occlusion and secondary extravasation en route.
- Monitor should be fully charged, connected, and checked.
- Ensure prior to loading on the stretcher and then into the ambulance, the invasive catheters tucked and secured (chest drains and Foley's).
- Consider stopping feeds for an adequate duration, as per patient condition, especially for patients with unstable airway prior to transport.
- Ensure equipment for staring additional lines en route is present as intracath/veinflo, IO needle.
- Ensure automated external defibrillator, with pads and paddles are available, in case an arrhythmia child is anticipated to require a shock en route, consider putting the pads before the transfer.

Practical Approach to
Pediatric Intensive Care

Salient Features

- Practical approach-based textbook for pediatricians and intensivists involved with taking care of critically ill children
- Divided in various sections addressing respiratory, cardiovascular, neurological and gastroenterological issues including life-threatening infections requiring multiorgan support
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- Sections on pediatric critical care training, trauma, critical care nursing, statistics, pediatric intensive care unit (PICU) guidelines, brain death, end-of-life care guidelines, immunotherapy, transplantation of liver, heart, lung and kidney are also included.

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Printed in India

Available at all medical bookstores
or buy online at www.jaypeebrothers.com

JAYPEE BROTHERS
Medical Publishers (P) Ltd.
EMCA House, 23/23-B, Ansari Road,
Daryaganj, New Delhi - 110 002, INDIA
www.jaypeebrothers.com

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ISBN 978-93-90020-80-5