

PRINCIPLES OF TRANSPORT OF A SICK NEONATE

Introduction

- the transport of sick neonates involve pre-transport intensive care level resuscitation, stabilisation and continuing intra-transport care to ensure that the child arrives in a stable state.
- organised neonatal transport teams bring the intensive care environment to critically ill infants before and during inter-hospital or intra-hospital transport.
- the basis of a safe and timely transport is good communication and coordination between the referring and receiving hospital to ensure adequate stabilisation pre-transport and continuing intra-transport care.
- there is a rare need for haste.
- there must be a balance between anticipated clinical complications that may arise due to delay in definitive care and the benefits of further stabilisation.

Special considerations in neonates

- *apnoea*: premature and septic babies are especially prone to apnoea
- *bradycardia*: hypoxia causes bradycardia, heart block and asystole in newborns
- *oxygen toxicity*: to lungs and retina - especially important in the premature baby
- *reversal to fetal circulation (Persistent pulmonary hypertension of the newborn PPHN)*: can be precipitated by hypoxia, hypercarbia, acidosis and sepsis
- *hypothermia*: mechanisms of thermoregulation are less developed; neonates have a larger body surface area: mass ratio. Non shivering thermogenesis is induced by the oxidation of brown fat. If the bowels are exposed, the heat and fluid loss are compounded by evaporation. The effects of hypothermia are acidosis and subsequent PPHN, impaired immune function and delayed wound healing.
- *hypoglycaemia* – neonates lack glycogen stores in liver, and fat deposits
- *jaundice* – worsen in the baby with sepsis or intestinal obstruction.

Mode of transport

Careful consideration must be made as to the mode of transport.

- the best mode of transfer is “in utero” as far as possible, e.g. a mother in premature labour should be managed in a centre with NICU facilities or if a surgical anomaly has been detected antenatally, the mother should be advised to deliver at a centre with paediatric surgical facilities.
- for post natal transfers, the advantages and disadvantages of road, air (helicopter or commercial airlines) and riverine transport must be considered in each child. If air transport is chosen, then the effects of decreased atmospheric pressure on closed cavities and the lack of working space must be taken into account. Transport incubators with monitors, ventilators and suction equipment are ideal.

Air Transport

A number of patients are transported by commercial airlines with pressurised cabins flying at higher altitudes or by helicopters flying at lower altitudes but without pressurised cabins. There are special problems associated with air transport:

- *changes in altitude* – physiologic changes associated with altitude are due to the decreased atmospheric pressure causing a decreased oxygen concentration and expansion of gases. This becomes especially important in children with air trapped in closed cavities e.g. pneumothorax, pneumoperitoneum, volvulus and intestinal obstruction. These cavities must be drained before setting off as the gases will

expand and cause respiratory distress. Children requiring oxygen may have an increased requirement and become more tachypnoeic at the higher altitude. Assessment of hypoxia can be difficult due to poor lighting.

- *noise and vibration*: in addition to causing stress to the baby and the transport team, there is usually interference with the monitors especially pulse oximeters. It is also impossible to perform any procedures.
- *limited cabin space*: prevents easy access to the baby especially in the helicopters. The commercial aircraft and current helicopters also are not able to accommodate the transport incubators. The baby is thus held in the arms of a team member.
- *weather conditions, availability of aircraft*: speed of transfer may be compromised “waiting” for the availability of aircraft/flight or for the weather to change. Stress and safety to the baby and team during poor weather conditions needs to be considered.
- *take off and landing areas*: special areas are required and there will be multiple transfers, e.g. hospital – ambulance – helicopter – ambulance - hospital
- *finances*: air transport is costly

Pre-transport stabilisation

Transport of the neonate is a significant stress on the child - they can easily deteriorate during the journey. The presence of hypothermia, hypotension and metabolic acidosis has a significant negative impact on the eventual patient outcome. It is also almost impossible to do any significant procedures well during the actual transport. Therefore, stabilisation pre-transport is critical to ensure a good patient outcome.

The principles of initial stabilisation follow the widely recognised ABC's of resuscitation:

- Airway
- Breathing
- Circulation/ {Communication}
- Drugs/ {Documentation}
- Environment/ {Equipment}
- Fluids – Electrolytes/ Glucose
- Gastric decompression

Airway management

- establish a patent airway
- evaluate the need for oxygen, frequent suction (Oesophageal atresia) or an artificial airway (potential splinting of diaphragm).
- security of the airway – The endotracheal tubes (ETT) must be secure to prevent intra-transport dislodgement
- chest X-ray – to check position of the ETT

Breathing

The need for intra-transport ventilation has to be assessed:

- requires FiO₂ 60% to maintain adequate oxygenation
- ABG – PaCO₂ >60mmHg
- tachypnoea and expected respiratory fatigue
- recurrent apnoeic episodes
- expected increased abdominal/bowel distension during air transport

If there is a possibility that the child may require to be ventilated during the transfer, it is safer to electively intubate and ventilate before setting off.

However, there may be certain conditions where it may be preferable not to ventilate if possible, e.g. tracheo-oesophageal fistula. If in doubt, consult the receiving surgeon or paediatrician. If manual ventilation is to be performed throughout the journey, due consideration must be taken about fatigue and possible erratic nature of ventilation.

Circulation

- heart rate and perfusion (capillary refill) are good indicators of hydration status
- blood pressure in a neonate drops just before the baby decompensates.
- minimum urine output should be 1-2 mls/kg /hr. The baby can be catheterised or the nappies weighed (1g = 1 ml urine)
- ensure a reliable intravenous access (at least 2 cannulae) before setting off.
- if the child is dehydrated, the child must be rehydrated before leaving.

Fluid therapy

Resuscitation fluid:

- rate – 10 – 20 mls/kg aliquots given as boluses over up to 2 hours according to the clinical status
- type – Normal Saline or Hartmann's solution
- If blood loss then whole blood or pack cells may be needed when ready.
- this fluid is also used to correct ongoing measured (e.g. orogastric) or 3rd space losses. The perfusion and heart rates are reliable indicators of the hydration.

Maintenance fluid:

- rate : Day 1 (age): 60 mls/kg
 Day 2: 90 mls/kg
 Day 3: 120 mls/kg
 Day 4 onwards: 150 mls/kg
- type: If there are ongoing or anticipated losses in the surgical neonate, e.g. intestinal obstruction, gastroschisis, the recommended solution is ½ Saline + 10% D/W. Watch out for hyponatraemia and hypoglycemia.

Communication

Good communication between the referring doctor, transport team and the neonatologist / paediatric surgeon will help better coordination of the transfer, stabilisation of the baby before transfer, timing of the transfer, and preparedness of the receiving hospital.

- inform the receiving specialist and emergency department of the receiving hospital
- name and telephone contact of the referring doctor and hospital
- patient details
- history/ physical findings/provisional diagnosis/investigations
- current management and status of the baby
- mode of transport/ Expected Times of Departure and Arrival at referral centre
- destination of the patient (e.g. A&E, NICU, Ward)

Drugs as required

- antibiotics: most sick neonates will require antibiotics
- analgesia/ sedation: especially if the baby has peritonitis or is intubated
- inotropes
- vitamin K
- sodium bicarbonate

Documentation

- history including antenatal and birth history/ Physical Findings/ Diagnosis
- previous and current management
- previous operative and histopathology notes, if any
- input/output charts
- investigation results/ X-rays
- consent - informed and signed by parents especially if high risk, parents not escorting
- parents' contact address and telephone numbers, if not escorting
- mother's blood - 5-10 mls for cross match, if the mother cannot escort the child

Environment

- Neutral Thermal Environment – environmental temperature at which an infant can sustain a normal temperature with minimal metabolic activity and oxygen consumption
- optimal temperature for the neonate (axilla) – 36.5 – 37.0 C
- prevention of heat loss
As the mechanisms of heat loss are radiation, conduction, convection and evaporation, prevention of heat loss involves maintaining an optimal ambient temperature as well as covering the exposed surfaces:
 - transport incubator – would be ideal
 - wrap the limbs of the baby with cotton, metal foil or plastic.
 - do not forget a cotton-lined cap for the head.
 - care of the exposed membranes (See section on Abdominal wall Defects)
 - warm the intravenous fluids

Equipment

(Please see table at the end of chapter)

Check all equipment - their completeness and function before leaving the hospital

- monitors: cardiorespiratory monitor/ pulse oximeter for transport would be ideal. However, if unavailable or if affected by vibration, perfusion, a praecordial stethoscope and a finger on the pulse will be adequate.
- syringe and/or infusion pumps with adequately charged batteries
- intubation and ventilation equipment and endotracheal tubes of varying sizes
- oxygen tanks – ensure adequacy for the whole journey
- suction apparatus and catheters and tubings
- anticipated medication and water for dilution and injection
- IV fluids, tubings. Pre-draw fluids or medication into syringes if required during journey

Gastric decompression

- an orogastric tube will be required in nearly all surgical neonates especially if the baby has intestinal obstruction, congenital diaphragmatic hernia or abdominal wall defects.
- the oral route is preferred as a larger bore tube can be inserted without compromising the nasal passages (neonates are obligatory nasal breathers). However, the orogastric tube can easily dislodge and the position needs to be checked regularly. 4 hourly aspiration and free flow of the gastric contents is recommended.

Immediately before departure

- check vital signs and condition of the baby
- check and secure all tubes
- check the completeness and function of equipment
- re-communicate with receiving doctor about current status and expected time of arrival

Intra-transport Care

- **Staff** - Ideally, there should be a specialised neonatal transport team. If not, the medical escort should be a neonatal trained doctor with/without a neonatal trained staff nurse. A minimum of 2 escorts will be required for the ventilated/critically ill baby. The team should be familiar with resuscitation and care of a neonate. They should also be able to handle critical incidents. The team members should preferably not be prone to travel sickness!
- **Safety of the Team** must be a priority. Insurance, life jackets and survival equipment should be made available for the escort team and parents.
- **Monitoring**: regular monitoring of the vital signs, oxygenation and perfusion of the should be performed
- **Fluids** : intravenous fluids must be given to the ill child to prevent dehydration and acidosis during the transport. Boluses need to be given as necessary depending on the assessment of the perfusion and heart rate of the child. If catheterised, the urine output can be monitored. The orogastric tube should be aspirated as required.
- **Temperature Regulation**: a check on the baby's temperature should be made. Wet clothes should be changed if required especially in the child with abdominal wall defects. Disposable diapers and one way nappy liners can be very useful here.
- **Critical Incidents** – preoperative preparation is to minimise the critical incidents as these can cause loss of life and stress to the transport team.

Arrival at the Receiving Hospital

- reassessment of the baby
- handover to the resident team

Special Surgical Conditions

Oesophageal Atresia with /without Tracheo-oesophageal fistula

(These babies have a risk of aspiration of saliva as well as reflux of the gastric contents through the distal fistula)

- evaluation for other anomalies e.g. cardiac, pneumonia, intestinal atresias
- suction of the upper oesophageal pouch – A Replogle (sump suction) tube inserted and continuous low pressure done if possible. Otherwise, provide frequent intermittent (every 10-15 mins) suction of the oropharynx throughout the journey.
- ventilation only if absolutely necessary if there is a tracheo-oesophageal fistula as it may lead to intubation of the fistula, insufflation of the GI tract, and possible perforation if there is a distal atresia of the bowel.
- warmth
- fluids - Maintenance fluids and resuscitation fluids as required
- positioning - Lie the baby lateral or prone to minimise aspiration of saliva and reflux
- monitoring – Pulse oximetry and cardiorespiratory monitoring

Congenital Diaphragmatic Hernia

- evaluate for associated anomalies and persistent pulmonary hypertension of the newborn (PPHN)
- ventilation - Intubation and ventilation may be required pre-transport. Avoid ventilation with a bag and mask; low ventilatory pressures used. A contralateral pneumothorax or PPHN need to be considered if the child deteriorates. If the baby is unstable or on high ventilatory settings, the baby should not be transported. Frequent consultation with a Paediatric Surgeon will be helpful to decide when to transport the baby. If a chest tube has been inserted, it should not be clamped during the journey.
- orogastric tube — gastric decompression is essential here and a size 6 or 8 Fr tube is inserted, aspirated 4 hourly aspiration and placed on free drainage.
- fluids – caution required as dehydration and overload can precipitate PPHN
- monitoring
- warmth
- consent - high risk
- positioning – lie baby lateral with the affected side down to optimise ventilation
- air transport considerations

Abdominal Wall Defects

Exomphalos and Gastroschisis are the more common abdominal wall defects. Fluid loss and hypothermia are important considerations in these babies.

Gastroschisis - defect in the anterior abdominal wall about 2-3 cm diameter to the right of the umbilicus with loops of small and large bowel prolapsing freely without a covering membrane.

Exomphalos -Defect of anterior abdominal wall of variable size (diameter of base) It has a membranous covering (amnion, Wharton's jelly, peritoneum) and the umbilical cord is usually attached to the apex of the defect. The content of the large defect is usually liver and bowel but in the small defect the content is just bowel loops.

- evaluation: for associated syndromes and cardiac anomalies (more commonly in babies with exomphalos).
- fluids: IV fluids are essential as the losses are tremendous especially from exposed bowel. Boluses (10-20 mls/kg) of normal saline/ Hartmann's solution must be given frequently to keep up with the ongoing losses. A maintenance drip of ½ N/S + 10% D/W at 60 – 90 mls/kg (Day 1 of life) should also be given. Hypoglycemia can occur in about 50% of babies with Beckwith-Wiedemann's Syndrome (exomphalos, macroglossia, gigantism).
- orogastric tube – gastric decompression is essential here and a Size 6 or 8 Fr tube is inserted, aspirated 4 hourly and placed on free drainage.
- warmth – pay particular attention to temperature control because of the increased exposed surface area and the fluid exudation causing evaporation and the baby to be wet and cold. Wrapping the baby's limbs with cotton and plastic will help.
- care of the exposed membranes – The bowel/membranes should be wrapped with a clean plastic film (*Clingwrap/Gladwrap*) without compressing, twisting and kinking the bowel. Please do not use a "warm, saline soaked gauze" directly on the bowel as the gauze will get cold and stick to the bowel/membranes. Disposable diapers or cloth nappies changed frequently will help the keep the child dry. The baby may need to be catheterised to monitor urine output.
- positioning – place baby in a lateral position to prevent tension and kinking of bowel

Intestinal Obstruction

May be functional e.g. Hirschsprung's disease or mechanical e.g. atresias, volvulus.

Fluid loss with dehydration and diaphragm splinting needs to be assessed for.

- evaluation – for associated syndromes and cardiac anomalies.
- fluids – Intravenous fluids here are essential, too.
 - boluses - 10-20 mls/kg Hartmann's solution/normal saline to correct dehydration and replace the measured orogastric losses.
 - maintenance - $\frac{1}{2}$ N/S + 10% D/W.
- orogastric tube – gastric decompression is essential here and a size 6 or 8 Fr tube is inserted, aspirated 4 hourly and placed on free drainage.
- warmth
- monitoring – vital signs and urine output
- air transport considerations

Table 1. Pre-departure checklist

Equipment	Medication
<ul style="list-style-type: none"> • transport incubator (if available) • airway and intubation equipment all available and working (ET tubes of appropriate size, laryngoscope, Magill forceps) • batteries with spares • manual resuscitation (Ambu) bags and masks of appropriate size are available and in working order • suction device functions properly • oxygen cylinders are full • a spare oxygen cylinder is available • oxygen tubing • infusion pumps are functioning properly • intravenous cannulae of various sizes • needles of different sizes • syringes and tubings • suture material • adhesive tape, scissors • gloves, gauze, swabs (alcohol and dry) • stethoscope, thermometer • nasogastric tube • pulse oximeter (if available) - working order, set alarm limits • cardiac monitor if indicated • chest clamps (if an underwater chest drain is present) 	<ul style="list-style-type: none"> • intravenous fluids <ul style="list-style-type: none"> - normal saline - Hartmann's solution - 5% albumin - 1/5 N/S + 10% D/W - dextrose 10% • ionotropes <ul style="list-style-type: none"> - dopamine - dobutamine - adrenaline • sedative <ul style="list-style-type: none"> - morphine - midazolam • blood products if indicated • others <ul style="list-style-type: none"> - atropine - sodium bicarbonate - sterile water for injection - normal saline for injection
<p>Patient status</p> <ul style="list-style-type: none"> • airway is secured and patent (do a post-intubation chest X-ray before departure to make sure ET tube is at correct position) • venous access is adequate and patent (at least 2 IV lines) • intravenous drip is running well • patient is safely secured in transport incubator or trolley • vital signs are charted • all drains (if present) are functioning and secured 	<p>Documents</p> <ul style="list-style-type: none"> • patient notes, referral letter • X-rays • consent form • vital signs chart • input/output charts • maternal blood (for infant)

Necrotising Enterocolitis

- evaluation – these babies are usually premature and septic with severe metabolic acidosis, coagulopathy and thrombocytopenia. There may be an associated perforation of the bowel or gangrenous bowel, initiating the referral to the surgeon.
- ventilation – most of the babies may require intubation and ventilation before setting out especially if are acidotic.
- fluids – aggressive correction of the dehydration, acidosis and coagulopathy should be done before transporting the baby. May require replacement of gastric aspirates during the journey if significant
- orogastric tube with free flow and 4 hourly aspirates– essential
- drugs – will require antibiotics and possibly inotropic support that needs to be continued during the journey
- peritoneal drain – If there is a perforation of the bowel, insertion of a peritoneal drain with/without lavage with normal saline or dialysate solution should be considered. This can help to improve the ventilation as well as the acidosis.

Intrahospital Transport

- use transport incubator if available
- ensure all parties concerned are ready before transfer
- send team member ahead to commandeer lifts, clear corridors
- ensure patient is stable before transport
- skilled medical and nursing staff should accompany patient
- ensure adequate supply of oxygen
- prepare essential equipment and monitors for transport
- ensure venous lines are patent, well secured
- infusion pumps should have charged batteries. To decrease bulk of equipment,

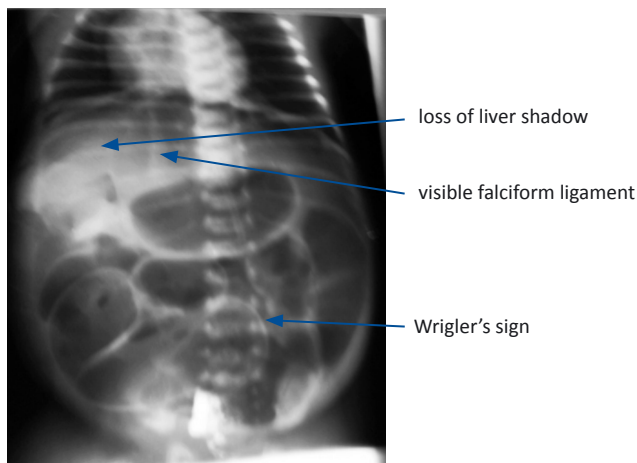


Figure 1: Supine abdominal X-ray showing free intraperitoneal gas – loss of liver shadow, visible falciform ligament and Wrigler's sign