Transport of a Sick Neonate

Summary of Recommendations

- **The development of efficient transport systems is crucial to the implementation of regionalization of perinatal care.**
- **Transportation of the sick or preterm babies to a centre with expertise and facilities for the provision of multi-organ intensive care improve outcomes.**
- **Neonates needing special or intensive care should preferably be transported by a skilled transport team through an organized teamwork.**
- **Appropriate equipments and vehicle customized for neonates should be available for safe transport.**
- **Pre-transport stabilization is the most vital step in the whole process of transport.**
- **Adequate and timely communication with the family, referring hospital and the support group is essential.**

Writing Group : *Chairperson*: Satish Saluja; *Members*: Manoj Malviya, Pankaj Garg; *Reviewers*: Girish Gupta, Naveen Jain

Introduction

Treatment of the sick neonate in specialized neonatal intensive care units (NICU) has been associated with decrease in mortality and morbidity. In the early 1960s, neonatal transport was first used to make intensive care accessible to those neonates who needed it.[1] Subsequently, organized emergency neonatal transport systems developed and became an important component in the regionalization of perinatal care.[2-5] In utero transfer is the safest transfer but unfortunately, preterm delivery, perinatal illness and congenital malformations cannot always be anticipated, resulting in a continued need for transfer of babies after delivery.[6] These babies are often critically ill, and the outcome is partly dependent on the effectiveness of the transport system.[7] Facilities for neonatal transport in India are dismal. Most neonates are transported without any pre-transport stabilization or care during transport. Any available vehicle is used, which often takes long hours and place where to take the baby is also not well recognized. There is an acute shortage of neonatal beds and majority of the sick neonate in need of urgent admission are dumped in pediatric wards with inadequate infrastructure. Often, these neonates are shunted from one health facility to another.[8]

With less experienced staff, the risk of adverse events on such transports can be greater than with well equipped and trained staff.[9-11] Many of the babies thus transported are cold, blue and hypoglycemic and 75% of the babies transferred this way have serious clinical implications.[12-14] Mathur et al in a study to evaluate WHO classification of hypothermia observed that in sick extramural neonates, the presence of weight less than 2000 g, associated illness (birth asphyxia, neonatal sepsis and respiratory distress) and physiological derangements (hypoxia, hypoperfusion and hypoglycemia) were associated with higher mortality and suggested that these factors should be considered adverse factors in hypothermic neonates. Their presence should classify hypothermia in the next higher category of severity in WHO classification.[15]

In this guideline, an attempt has been made to address the following questions regarding neonatal transport:

- Why transport of sick neonates is necessary?
- What is the difference between self transport and organized transport?
- Which babies need transport?
- What are different types of transports?
- How to organize a Neonatal Transport System?
- What special care needs to be given for a sick neonate requiring transport?
- What are the different modes of transport?
- What are the situations which need special precautions during transport?
- How should one communicate for neonatal transport?
- What are the medico-legal issues related to neonatal transports?
- How the family should be supported while transport?
- What are the alternative transport modalities?

Why is transport of sick patients necessary?

In India, majority of the deliveries still occur at home (approximately 60% in rural areas as per NFHS 3). Although hospital based deliveries need to be promoted, delivery of sick neonates needing special care will still take place at places with extremely limited resources, necessitating need for transport. Transportation of the sick or preterm babies to a centre with expertise and facilities for the provision of multi-organ intensive care has been shown to improve outcomes.[16] Prematurity, asphyxia and sepsis are the most common cause of neonatal mortality in our setting.[17] many of these are easy to correct and a significant decrease in neonatal mortality can occur if specialized care can be made available to these neonates. With the initiative of state governments in developing Special Care Newborn Units (SCNU) at District Hospitals, many of the sick neonates can be provided better newborn care if they are timely transported in a stable condition. Also transport from these SCNU to higher center should be made possible when necessary.

What is the difference between self transport and organized transport?

Organized transport service provides almost the same level of monitoring and the quality of care during the transport that is available in the advanced care facility. Ideally it should have the ability to provide mechanical ventilation, multiple fluid infusion therapy and cardio-respiratory monitoring. In India, most sick neonates are transferred by their parents or paramedical personnel either in private vehicles or poorly equipped ambulance. There is currently no dedicated neonatal transport service provided by the states in India.

Evidence: There is enough data to suggest that the transport by a skilled organized team reduces neonatal mortality and morbidity.[18-19] Some innovative models for transport are being tried in few states like Tamil Nadu, Kerala, Andhra Pradesh and Madhya Pradesh. In a retrospective analysis done over a period of 33 months from an experience on a regionalized transport network in and around 250 kms of Hyderabad, biochemical and temperature disturbances were more common in babies transported on their own as compared to specialized neonatal transport service. Neonates transported by the hospital team had significantly higher survival as compared to those who came on their own.[20] Some of the private hospitals in the country offer neonatal transport services; however, it is quite expensive.

Recommendation: Neonates needing special or intensive care should preferably be transported by a skilled transport team through an organized effort

Which babies need transport?

Infants requiring advance medical and/or nursing care exceeding what is available in their current settings will need transfer to a higher health facility. Example is a preterm neonate with respiratory distress (severe retractions and grunt) but facilities for respiratory support (CPAP, mechanical ventilation) are not available. The broad indications for which neonatal transport should be considered are given in table 1[21]:

What are different types of transports?

The need for transport could be from home to a health facility or from a lower health facility to a higher health facility or a referral center.

Neonatal transfers can be categorized as follows:

1. From Home to Hospital
2. Intra-hospital transport (including delivery rooms, operation theatres, neuroimaging and special procedures)
3. To facilitate specialist management of the neonate (movement to a regional center for cardiac, neurological, renal or surgical opinion)
4. Retrieval from a peripheral hospital for ongoing intensive care (when mothers deliver prematurely without warning)
5. Returning infants to local neonatal units following care elsewhere (either locally or long distance) – *Reverse Transport.*[22]

How to develop a neonatal transport system?

The Committee on Perinatal Health proposed a system for regionalized perinatal care and defined three levels of hospital care, which served throughout the 1970s and 1980s as a national model for the rapid development of neonatal referral centers.[23] This model required the development of a neonatal transport system, which was associated with a significant reduction in the US neonatal mortality rate. The American Academy of Pediatrics (AAP) formed a Task Force on Inter-hospital Transport and developed guidelines.[24]

Evidence: In India, neonatal health care delivery is unregulated, patchy and not standardized.[25] Many smaller centers attempts to provide Level II or III with inadequate staffing and equipments resulting in deficiencies in the quality or constancy of care. The existing evidence from the developed countries indicates that better regionalization of neonatal care is associated with better outcomes.[26-28]

Recommendation*:* There is need to develop perinatal regionalization with special care newborn units at district level and referral centers at state level. To make this operational we need to create a neonatal transport system.

The key components of a Neonatal Transport System are:

- Human Resource
- Vehicles and equipments
- Communication and Family Support
- Documentation and consent form
- Feed back to Referring unit

Human Resource: The doctor or nurse in organized neonatal transport service or accompanying person in case of community transport which could be ASHA worker, ANM a paramedic trained / untrained or a family member should be trained in essential newborn care during transport, identification of danger signs and their immediate remedy.

A. Leadership:

1. Medical director: A physician with specialty training in neonatology or equivalent expertise.
2. Manager: Works closely with the medical director and controls day to day management, budget and maintenance of equipment. The manager may be a nurse or paramedic personnel.

B. Team members:

Most transport teams in western countries have a neonatal-trained nurse. Other programs use anesthetists, respiratory therapists, paramedics or a combination of these three disciplines.[29] Physicians are frequently added to the basic team depending on the needs of the patient and the competency of team members.

Evidence: No difference in outcomes has been observed when neonates are transported by trained paramedics / RN or physicians.[30, 31] In a recent study a Physician-Nurse and Nurse-Nurse teams for neonatal transport were compared to study mortality, transport-related morbidity, overall transport times and outcome of procedures performed by transport nurses. Outcomes for the 2 types of teams were equivalent. Non-physician teams responded more quickly and spent less time at the referring facility.[32]

Recommendation*:* Trained nurses or paramedics for transport services are not available in India. Most units involved in organized neonatal transport utilize the services of residents and fellows working in neonatology for this purpose. However, we need to develop a cadre of nurses and paramedic personnel for more effective neonatal transport.

C. Vehicle and Equipments:

An ideal design of the vehicle and equipments for transport should have consideration of weight, fixation, power and gas requirements.

Transport vehicle:

The ambulance used for neonatal transport should, at a minimum, meet the requirements for a basic life support ambulance.[33] In order to accommodate neonates the ambulance must provide:

1. Secure fixation of the transport incubator to the cot rails.
2. Secure fastening of other equipment (e.g. Oxygen and air tanks, monitoring equipment)
3. Independent power source to supplement equipment batteries to guarantee uninterrupted operation of the incubator and other monitoring and supportive equipment.
4. Necessary adapters to access the ambulance power source should be readily available.
5. Environmental conditions that reduce the risk of temperature instability, excessive noise and vibration, infection.
6. Rapid and safe transport without compromising safety.

Design of Ambulance: Unlike adult ambulances there are no specific guidelines available for the design of neonatal ambulances. An ideal ambulance would be clinically efficient and would provide safety for the patient and the transport staff. Ambulance design should be based on ergonomics principle of clinical activities inside the ambulance and local road and weather conditions. It should provide adequate width

and height to accommodate Neonatal System (built in unit that has stretcher with incubator/ ventilator, monitoring devices, oxygen cylinders), suction apparatus and minimum two seats for transport staff. Following are the general principles/ recommendations, based on experience and not on scientific evidence, should be consider in ambulance designing.

Types of Vehicle: Most ambulances in India are the makeshift of commercial vehicles like van, SUV or mini truck, modified to the designed and specification of the purchaser.

Van or Mini-truck:

- Distance: up to 300 km (6-10 hours)
- Advantage:
    a. Adequate room (height and width) for Neonatal System (transport incubator) and transport staff for seating and monitoring.
    b. Neonatal system can be customize to the need of the purchaser
    c. In emergency, enough room to perform procedure like endotracheal intubation.
    d. Family member can accompany with transport team and patient
- Disadvantage: High Cost

Long SUV or Minivan:

- Distance: up to 100-150 km
- Advantage: Easily available, cost effective
- Disadvantage: require removal of back seat, front seat can be turn backward and can be utilized next to Neonatal System for staff for monitoring. Not enough space to perform any emergency procedure. Family member cannot accompany the patient

For ongoing treatment and care during journey a relatively larger vehicle is preferable, for full access to the neonate especially in an incubator. Speed and stability (lateral roll and front–back impact on braking) of the vehicle is very important. The quality of the new generation of chassis cabs has improved performance in terms of acceleration, cruising speed, braking. However, most of the commonly used vehicles for transport in India are highly inadequate for smooth travel.

Trolley / Incubator position: Offside mounting of incubator as compared to transverse mounting is quick and easy to load and enables more staff to be seated by the side with clear vision of the baby. Offside mounting is better fixed to the ambulance and provides more straightforward access for re-intubation if needed.

Fixation of equipment: In the event of a collision, as a result of severe deceleration forces, unsecured items or people in the rear of the ambulance may suffer severe collision, resulting in severe injury. Unsecured items of equipment may become projectile and also cause severe injury or death. To overcome this, various fixation devices have been developed. European Committee for Standardization has produced standards for the securing of all persons, items and transport incubators in ambulances.[34, 35] The entire system should be able to withstand a 10 G force in 5 directions (forward, rearward, left, right and vertical). This 10 G represents the forces encountered when a vehicle travelling at moderate speed is

involved in a collision resulting in rapid deceleration (e.g. a vehicle travelling at 50 kmph coming to a complete halt in 1 m, or a vehicle travelling at 30 mph coming to a complete halt in 3 ft).

Speed of Vehicle: The speed limit guidelines for the ambulances are variable and depend on the traffic and road conditions. The National Health Service (NHS) permits a higher speed for medical ambulances, approximately 10 – 20 mph above the permissible speed limits on various motorways. However, considering the road and traffic conditions in our country, it may be advisable to keep strictly to permissible speed limits and may be lower, especially where the traffic congestion is too high and road conditions are poor and bumpy. Over speeding in our conditions may be associated with higher risk of accidents and destabilization of patient. Adequate stabilization and preparation for anticipated complications (eg chest tube drainage for pneumothroax and adequate sedation for the baby with PPHN) before transport will avoid temptation for over-speeding.

Recommendation: Speed of the ambulance should not be more than 15-20 km/hr over the posted speed limit.

Equipment

The transportation of neonates requires several equipments (table 2):

Power backup: All the equipment in use should have a battery back and should be kept fully charged in anticipation of transport request. An alternating current 240 V power source can be provided in the ambulance by two methods, a dedicated generator or an inverter. Sufficient adaptors should be available to make quick changeover to available mode of power supply.

Gas supplies: Make sure the cylinders are filled prior to onset of journey and will last the duration of transport. In case of long journeys, keep spare cylinders and equipment to change the cylinders. Most of the cylinders with the transport incubator last for not more than 2 hours. The ambulance should have large oxygen and air cylinders which can last for the duration of transport. Adaptors to fit these both type of cylinders should be available and the personnel accompanying the transport should be well versed with technique of changing the cylinders.

Specific equipment items

Ventilators: Ventilators or T-piece device or self / flow inflating resuscitation device is an essential equipment as most babies are referred for respiratory support. Some of the commercially available transport systems have ventilators that are integral to the incubator system (Air-Shields Globetrotter TI500, Draeger Medical) or standalone systems (Pneupac® babyPAC™, Smiths Medical). These systems are now capable of functioning well at the full range of rates and inspiratory times required for neonatal practice

Transport Incubators: Some of the available transport incubator systems which provide adequate temperature control even in extreme conditions are (Airborne 750i, GE Healthcare; Air Shields Globetrotter TI 500, Draeger Medical). Active warming consumes considerable amounts of power. Make sure the incubator has its own battery and also works well on available external power sources. A new solution to assist warming during transport is the use of phase-change gel mattresses which very effectively warm infants through release of latent heat of crystallisation. With correct temperature activation, these devices can be an alternative method to warm a cold infant during transfer.[36]

It is important to secure the neonate inside the incubator. A rearward facing seat with a 5-point body harness has been used in adults which is inappropriate for a premature neonate with respiratory failure. Placing a belt over the top of a neonatal patient will provide some protection if the ambulance drops vertically, but provides virtually no protection to a supine or prone patient in the event of a head-on collision. Neonatal harnesses are now commercially available (Neo-restraint, Paraid Medical) which consists of a series of foam wedges and straps, than can be adjusted to the position and size of the infant within the transport incubator

Syringe Infusion Pumps: For neonatal transport, syringe infusion pumps are probably the best suited to deliver both maintenance fluids and drug infusions. Most pumps work on 240 V power source and many work with an internal rechargeable battery that last for 4 hours, but the batteries may be unreliable. Only few function from an external 12 V DC power source. However, there is risk of extravasation, unless the device has variable pressure alarms which are specific for neonatal use.

Monitors: A multi-parameter monitor is preferable. However, a lightweight portable pulse-oximeter is a good alternative. Most of the conventional probes are very sensitive to motion and give fallacious readings. Pulse oximeters and monitors which use Massimo technology would minimize or eliminate such artifacts. Although end-tidal CO2 (ETCO2) monitoring yields consistent quantitative errors in neonates, trend information may be helpful. ETCO2 monitor can be very useful in determining the placement and patency of an endotracheal tube.

How to organize a neonatal transport system?

The preparation would depend whether the transport is from Home to Health facility or Pick from a Health Facility by an organized transport team.

Once a decision for transport is taken the principles of neonatal transport are

- Assessment
- Stabilization before transport
- Care during transport

Principals of transport remain same for any type of transport.[43]

*Pre-transport stabilization***:** Available models for pre-transport stabilization and care during transport are:

- STABLE: **S**ugar, **T**emperature, **A**rtificial breathing, **B**lood pressure, **L**aboratory work, **E**motional support.[37]
- SAFER: **S**ugar, **A**rterial circulatory support, **F**amily support, **E**nvironment, **R**espiratory support.[38]
- TOPS: **T**emperature, **O**xygenation (Airway & Breathing), **P**erfusion, **S**ugar[39]

Evidence: Hypoglycemia, hypothermia, poor perfusion and oxygenation have been shown to be associated with high mortality in transported neonates.[40] TOPS, a simplified assessment of neonatal acute physiology gives a good prediction of mortality in these neonates.[39] Prior stabilization and adequate care during transport results in decreased of hypoglycemia, acidosis and mortality.[19] Innovative techniques like thermocol boxes have been shown to be low cost and effective method for neonatal transport.[41] Plastic

wraps or bags, skin-to-skin care and transwarmer mattresses all keep infants warmer, leading to higher temperatures on admission to neonatal units and less hypothermia.[42]

***Recommendations**:* Stabilization of sick neonates before and care during transport to maintain euglycemia, normothermia, adequate oxygenation and perfusion should be the utmost priority.

Step 1: Assess the baby and depending on facilities available check for Temperature, airway, breathing, circulation and sugar

Step 2: Temperature: Correct hypothermia if present before transport – KMC, provide warm clothing or under radiant warmer at stabilization unit or referring centre, as most transport incubators are not able to actively warm the hypothermic baby

Step 3: Airway: Assess airway for presence of any secretions (suction if present) and position of neck (place shoulder roll)

Step 4: Breathing: Assess for respiratory distress; assess whether baby requires ventilation (PPV device such as self inflating bag)

Step 5: Circulation: Check Heart rate, CRT, Urine output, Blood pressure (if feasible); Assess the need of fluid bolus; Check what fluids baby is getting and whether baby is on inotropes; Adjust infusion of inotropes as per need

Step 6: Sugar: Check sugar with glucometer; If Blood glucose < 40 mg/dl, give 2 ml/kg of 10% Dextrose through intravenous line; Check the patency of iv cannula and start IV fluids; Laboratory workup: Check all investigations of baby; Check all the medications received.

Step 7: Transport personnel: Mother/ Attendant/ ASHA from community or basic health facility. Trained nurse, paramedic or physician at the referring hospital

Step 8: Equipment: Ambulance if available or any other vehicle preferably drought free

What care should be given during transport?

Temperature maintenance: Use a transport incubator if available. Kangaroo mother care (KMC) by mother or attendant is a useful way to maintain temperature. Kangaroo mother care is a good method of temperature maintenance during transport especially in resource limited conditions when transport incubators are not available [44]. Other methods like adequately covering the baby, and using improvised containers (thermocol box, basket, polythene covering) may help in maintaining temperature

Airway and breathing: Keep neck of the baby in slight extension position; if airway is unstable, it is better to intubate and transport; if intubation is not considered necessary / possible, short PPV or CPAP can be provided using a T-piece resuscitator.

Circulation: Assess perfusion for warm peripheries, capillary refill time of ≤3 seconds, tone and activity, and blood pressure. Stabilize perfusion before moving the baby to the ambulance. Syringe pumps are required to use inotropes with accuracy.

Check oxygenation: Continuous Pulse oximeter monitoring is preferable; observe for central cyanosis; if possible perform blood gas analysis before and during transfer

Communication: Inform SCNU / NICU to arrange and organize baby cot and keep the over head radiant warmer on.

Feeds: It is best to not attempt feeding sick babies with abnormal sensorium or severe respiratory distress before or during transfer. A well baby at risk of hypoglycemia may be fed in addition to IVF; if baby can accept provide breast feeds; if not give expressed breast milk (EBM) with spoon or paladai; if EBM not available give any available milk continue IV fluids if the baby is sick.

What are the different modes of transport?

The choice of vehicle will depend upon clinical urgency, traveling distance, weather conditions and its availability. Published data comparing the efficacy and safety of road vs. air transport are scanty.

Road Ambulance*:*

Indications: For distance from 10- 200 kms
Advantages:

- Relatively easily available, lower costs, least influenced by weather
- More space, better patient access
- Can be stopped or diverted to the nearest hospital if necessary for any emergency interventions

Disadvantages:

- Retrieval time is influenced by speed limitations, traffic delays and road conditions

Rotary Wing (helicopter):

Indication: For distance from 50- 300 kms

Advantage:

- Speedy retrieval, better utilizations of medical staffs (less travel time and out of hospital)

Disadvantages:

- High costs, limited space, may be influenced by weather conditions, require a landing site close to the hospital, limited patients access, high noise and vibration levels
- Not pressurized: altitude generally 2000-3000 feet (not less than 500)

Fixed Wing Aircraft:

Indication: For distance from greater than 200 km

Advantage:

- Good for long distance retrievals, reasonable space and access to patient, family can travel with their baby

Disadvantages:

- Require near by airport, immigration clearance, longer retrieval time and assistance with road transport

Problems with Air Transport: There are certain issues related to air transport, which need to be taken into account.

High altitude: The barometric pressure in a standard airline carrier is 565 mm Hg as compared to 760 mmHg at sea level resulting in reduction of partial pressure of oxygen. Every effort therefore must be made to maximize oxygen delivery in hypoxic infants by other means before an air transfer by maintaining an adequate systemic blood pressure and hemoglobin concentration.[45] Air expands at high altitude and innocuous air leaks at sea level are likely to become significant. Even trivial air leaks should be drained before embarking on air transport. Infants at risk of air leaks, like meconium aspiration syndrome, should be transported with cabin altitude set at sea level.

Take off and landing: Rapid acceleration during take off, with the infant secured head forward, theoretically results in reduced cerebral perfusion. Conversely, on landing, rapid deceleration may cause a sudden rise in venous cerebral perfusion. There is provisional evidence that premature infants undergoing transfer may have a higher incidence of intraventricular bleeding.[46, 47] However, the clinical effect of these controllable events requires clarification.

Thermal issues: There is a temperature drop of 2°C for every 300 m of altitude, and in unheated military helicopters this may put high demands on the transport incubator system (TIS). A reliable method of measuring infant temperature during transport must be used. Reducing heat loss and conservation of battery power on the TIS include use of Isocovers, Transwarmer mattresses, bubble wrap, and hats. The incubator used for air transport must always have fully charged batteries at the beginning of a transfer. DC power cables suitable for both the aircraft and the ambulance should be taken.

Noise and vibration: Vibration is not usually detrimental to the infant, but can dislodge lines and tubes and adversely effect monitoring equipment.[48] Consideration should be given to equipment specifically designed to minimise the effect of movement artifact such as pulse oximetry using Masimo or Oxismart technology. During transport all lines should be secure and visible, particularly arterial lines, to allow observation without the need to open the incubator. Visual rather than audio alarms should be used where possible. The long term effects of exposure of the newborn infant to excessive sound remain unclear.[49, 50]

Transport in specific conditions

Respiratory distress syndrome: Transport issues in babies with RDS (HMD, MAS, Congenital diaphragmatic hernia or others) depend on management of primary condition. If baby requires ventilation depending on clinical judgment he/she should be ventilated. Oxygenation, perfusion should be maintained throughout the transport. Ventilation should also be well supported during transport in babies with apneas,

birth asphyxia. Primary aim should be to maintain adequate oxygenation and prevent hypoxemia. If there are minimal oxygen needs, oxygen may be supplemented with nasal catheters with a flow rate of less than 2l/min. However, in cases of moderate to severe respiratory distress or high oxygen needs, CPAP may be considered.

Air leak syndromes: Even mild pneumothoraces may worsen during transport due to vibrations and bumps of the ride, resulting in erratic ventilatory pressures. Hence, it is advisable to drain the pneumothorax adequately and preferably keep a chest tube in place before departure. During transport, underwater seal systems are bulky and difficult to manage in ambulance. The pleural drainage may depend on a continuous suction being applied to the system. Moreover, the chest tube and its connections may move and get dislodged with the movement or vibrations of the ambulance. Management of pulmonary interstitial emphysema should include using minimal ventilatory pressures to maintain sufficient oxygenation.

Esophageal atresia: A continuous suction with the help of two catheters (one attached to suction and the other left open to air) should be done during transport in babies with esophageal atresia to prevent pulmonary aspiration.

Meningomyelocele: The exposed swelling on the back should be covered with guaze piece soaked in normal saline and baby should lie on the side and not back during transport.

What is the role of CPAP during transport?

Evidence: Although CPAP therapy is now widely accepted therapy for acute respiratory failure within NICU setting, limited evidence is available for its safety and efficacy during transport. Bomont and Cheema.[51] in a retrospective study showed that Nasal CPAP appears to be a safe method of respiratory support for a carefully selected group of infants during land based ambulance transfers. Out of 100 patients (84 patients by doctor led and 16 patients by nurse led team) 5 patients (2=intubation and 3=stimulation and reposition of prongs) required intervention during transport. The integral Babylog 2000 ventilator was used to generate CPAP during transport. Authors in this study emphasized that experience with nasal CPAP and familiarity with equipment is essential for transport team before it is used on transport. One of the author of this guideline had used Bubble CPAP safely in selected patients (RD with FiO2 less than 40%,) during both air and land transport in Australia. There are no reports of safety and efficacy of CPAP during transport in Indian context.

Recommendation*:* CPAP therapy during transport is recommended when the transport team has sufficient clinical experience to CPAP therapy and familiarity with CPAP equipment in NICU setting, the team is led by pediatrician and / or registrar trained in ET intubation and resuscitation and the ambulance is fully equipped with adequate space to perform necessary procedures. Nasal CPAP cannula commonly used may be unstable during transport and frequent dislodgement is common. Nasopharyngeal CPAP may be an effective alternative with properly inserted endotracheal tube through the nostril into the posterior pharynx. This technique may be more easily fixed and effective during transport. However, if the neonate is unstable on CPAP, intubation may be necessary to provide mechanical ventilation / PPV.

What is the role of intubation before transport?

Decision to intubate before transport is determined by underlying pathophysiology, potential for deterioration and travel distance. For example a patient with severe meconium aspiration syndrome with

respiratory distress and high oxygen requirement should be intubated for potential of developing PPHN and pneumothoraces. Following are general indications where ET intubation is preferable before transport:

- Respiratory distress worsening with increasing oxygen requirement (FiO2 of more than 70%)
- Recurrent apnea
- Recurrent seizures
- Congenital heart disease on prostaglandin E1 infusion of more than 0.05 microgram /kg/min (risk of apnea)
- Congenital diaphragmatic hernia
- Limited space and skills to perform any resuscitation

Elective intubation of babies with significant distress is favored by most; however there is no data to support that elective intubation is needed in all infants with respiratory distress. If neonatal transport ventilator is not available, T piece resuscitator or Neopuff can be considered which in addition to PPV breaths will also deliver PEEP. However, if T-piece resuscitator is not available, bag and tube ventilation may be provided. Positive pressure ventilation can be accomplished by hand-bag ventilation for transports of short duration. Studies in adult patients have revealed that bag-valve ventilation was as effective as with transport ventilation; however there is no similar data in neonates.[52]

What is the role of administering surfactant before transport?

Evidence: Surfactant therapy is one of the seminal discoveries in neonatology which has been shown to decreased mortality and morbidities in preterm infant with hyaline membrane disease (HMD). Many aspects (rescue vs. preventive, synthetic vs natural, single or multiple doses) of its use have been extensively studied in NICU context, but limited data are available for its use before or during transport. Two retrospective studies found surfactant therapy before transport to be safe with no different in mortality and one study found lower oxygen requirement and fewer mechanical ventilations days compare to control group.[53,54] (Level 3b) Unnecessary delay of surfactant therapy may worsen the outcomes. The OSIRIS study[55] found that even short delay (mean age of 3 hours instead of 2 hours) in surfactant treatment increases risk for death or BPD by 11%. The studies of early surfactant therapy (prophylactic or few hours) showed that it reduces incidence of pneumothrorax. This potential benefit has more relevance for transporting a patient with HMD as given the difficulty in management of pneumothoraces during transport.

The factors which will determine surfactant therapy includes severity of the underlying disease, distance from receiving hospital, competence of transport team and cost. Traditionally in western model of full stabilization before transport, surfactant therapy is recommended if there is radiological evidence of hyaline membrane disease with oxygen requirement of more than 40% at the referring hospital

Following are some of the important points one should consider before use of surfactant therapy by transport team

1. Competence of transport team staff in intubation
2. Efficiency in management of immediate complication of surfactant therapy (desaturation, pulmonary hemorrhage, tube block)

3. Understand the changes in lung physiology (compliance) and ventilator management following surfactant therapy
4. Availability of x ray and blood gas (optional) at referring hospital. The hospital where x-ray and blood gas facilities are limited and the travel distance is short, surfactant therapy is best delayed.

Recommendation*:* Intubated infants with severe RDS should receive exogenous surfactant therapy before transport if transport team is led by pediatrician efficient and experienced in surfactant therapy.

What should be done in case the neonate deteriorates during transport?

Evidence: Evidence regarding the most appropriate action for the patient who deteriorates during transport is scanty. The most appropriate action depends on the level of skills of transport team in resuscitation, space and equipments available in the ambulance, and the distance from the receiving hospital.

Recommendation*:* The two major strategies can be used in case of acute deterioration are:

- Stop the vehicle and resuscitate: If skills and space is available stop the vehicle and resuscitate (ET intubation or chest tube insertion for pneumothorax).
- Don't perform procedure in a moving vehicle; get to the nearest hospital, stabilize, before proceeding.

How should one communicate during transport?

Success of transport process depends on the effective communication between the referral (sending) and receiving institute. A dedicated communication centre or telephone line at the receiving institute to contact the transport team or neonatologist will enhance transport process. Ideally, a dedicated communications centre with mobile help lines operating 24 hours a day, 7 days a week should be developed to allow for constant communication during the triage process and transport. An alternative method of initial contact is for the referring physicians to call the NICU directly and have the unit personnel place them in contact with the appropriate transport team, which could be from the referral hospital or a dedicated transport team.

Communication for neonatal transport before, during and after reaching referral centre:

Subsequent to decision for transport – communication with parents and family:

a. Nature and severity of illness and the need for transport
b. Facilities available at Referral hospital including infrastructure, details of key personnel. Give examples of previous successful transfers and outcomes
c. Type and mode of transport and time needed to reach the referral hospital
d. Names and contact numbers of key personnel at Referral hospital
e. Possible need for emergency procedures during transport
f. The availability of bed should be asked before starting transport and referred hospital should be informed in advance.

g. If referred hospital refuses to accept patient due to some reasons, bed facility should be asked in other health care facilities and baby should be transported by same team to the place where bed should be available.
h. Till the time of admission of baby to referred health care facility, the transportation team should not leave that health care facility.
i. Responsibilities of Referring Institute:

- Patient demographic details (name, age, sex, gestational age and weight, place and name of referring hospital)
- Reason for transfer
- Detail perinatal history, labor and delivery, neonatal resuscitation
- Current patient status, therapy and laboratory data (eg CBC, blood sugar)
- Potential for deterioration and need for advance therapy like mechanical ventilation and exchange transfusion or diagnostic evaluation
- Referral note with Provisional diagnosis and treatment given so far
- Consent form from parents

Communication during transport: Mobile telephones should be made available to contact referring or referral hospital in case of any emergency or breakdown. It also helps to inform approximate time the transport team is likely to reach the referral hospital. This helps especially when the NICU is away from the emergency services where the transport vehicle is likely to reach. To avoid destabilization, the team from the referral centre should preferably receive the neonate at entry to the hospital.

Communication between the treating team at the referral centre and the transporting team: Information regarding condition of the neonate and treatment details before and during transport should be documented and handed to treating team. After initial stabilization at the NICU, the treating team should communicate with the family and attending personnel, explain about condition of the baby, likely diagnosis, prognosis, duration of stay and approximate finances involved. Family attendants should also be helped with place to stay, closer to the hospital. If the mother has accompanied the baby, it helps to admit her in the maternity wards.

Feed back communication with Referring centre: Team at Referral centre shall call or send a written communication to the members of referring regarding the condition of the baby with details of medical illness, likely diagnosis, prognosis and likely duration of stay. Once improved and stable, the infant may be transported back (reverse transport) for ongoing care with written details of treatment details and its duration.

What are the medico-legal issues associated with transport? [57]

Most medico-legal problems are a result of poor communication and provision of inadequate information. The condition of baby, risks involved during transport and financial implications of transport and treatment at the referral centre should be discussed with family and documented and the case record. If baby dies during transport:

- The ambulance should be stopped and CPR should be performed as per NRP guidelines

- If baby dies on the way, he/she should be first taken to the higher health facility
- Casualty admission should be done. Parents should be explained and death certificate made by the medical personnel of higher health care facility
- It's the responsibility of transporting team to make death certificate of baby

How should the family be supported during transport process?

Families of the sick newborn are under considerable stress, and the transport team can provide sensitive support. Parents need accurate information about the newborn's clinical condition and prognosis, and an opportunity to ask and have questions answered by the team. They need information about the anticipated time frame of the transport and about the receiving hospital (location, contact telephone numbers, personnel). Information can be shared about anticipated procedures, operations or clinical studies. Parents should see and have an opportunity to touch their baby prior to the transport. Parents should preferably accompany the baby during transport. If the mother is accompanying the baby, then her medical needs during transfer and after reaching referral hospital must be addressed.

What are the indigenous ways to transport a sick neonate in the absence of ambulances and transport equipment?

In absence of availability of proper ambulance and equipment for the transfer of a sick neonate, some innovative methods used in the past can be used. Thermocol boxes have been used to maintain neonate's body temperature.[41] However, it needs to be of appropriate size to accommodate the infant and have enough ports to maintain air circulation and observe the baby. Even though this low cost intervention was found to be effective, one needs to be careful as the sick may neonate may suddenly deteriorate. The accompanying care provider should be familiar with the danger signs and immediate actions to be taken, if neonate deteriorates. In today's era of air-conditioned cars and taxis, ambient temperatures inside the vehicle can be maintained between 26 – 28^{o}C. The accompanying person could provide kangaroo mother care during transport, to maintain euthermia.[44] The infant should be given direct breast feeding or supplemental feeds with spoon or paladai during transport so as to prevent hypothermia. The vehicle should be halted during feeding.

Table 1: Indications for transport

- Very Low birth weight Infants especially below 1250 g
- Prematurity: Gestational age $\leq$ 32 wks
- Respiratory distress or apnea
    - Requires supplemental O_2
    - Apnea requiring bag and mask ventilation
- Cyanosis persisting despite oxygen therapy
- Hypoxic ischemic encephalopathy
    - Requires intubation and assisted ventilation
    - Develops seizures activity
    - Multi-organ involvement
- Sepsis with signs of systemic infection
- Jaundice with potential for exchange transfusion
- Active bleeding from any site
- Infant of diabetic mother or Hypoglycemia unresponsive to recommended treatment
- Surgical conditions
- Congenital heart disease (antenatal diagnosis or suspected)
- Heart failure or arrhythmia
- Suspected metabolic disorder
- Severe electrolytes abnormalities
- Infants requiring special diagnostic and/or therapeutic service

Table 2: Equipments required for neonatal transport

Thermal support equipment and supplies:

- Transport incubator
- Thermometer and/ or temperature monitor and probes
- Plastic wrap, Insulating blankets, Heat shield

Respiratory support equipment:

- Oxygen and air cylinders with appropriate indicators of in – line pressure and gas content
- Flow meters, Oxygen tubing and adapters
- Oxygen hood, neonatal size masks and cannula
- Oxygen analyzer, Pulse oximeter
- Neonatal positive pressure bags
- Continuous positive airway apparatus: nasal prongs, endotracheal tube
- Mechanical ventilator with back up circuit
- Endotracheal tubes: 2.5, 3.0, 3.5, 4.0 mm
- Laryngoscope with size 00, 0 and 1 blades
- Laryngoscope batteries and extra lamps
- Endotracheal tube holders and tape to secure ET tube

Suction equipment:

- Mucus suction trap, Suction catheters (5, 6, 8, 10, 12 F)
- Regulated suction with gauge limiting < 100 mm Hg
- Feeding tube (8 Fr) and 20 ml syringe for oro-gastric decompression
- Sterile gloves, Sterile water for irrigation

Monitoring equipment

- Stethoscope, cardiac monitor, pulse oximeter
- Glucometer for blood sugar evaluation

Parenteral infusion equipment

- Intravenous catheters (24, 26 guaze)
- Syringes (2, 5, 10, 20, 50 ml)
- Splint, Transparent dressings or micropore
- Three way stopcocks, IV chamber sets / Micro drip sets
- Intravenous administration tubing compatible with infusion pump

Medications

- Calcium gluconate 10%
- Epinephrine (1:10000) prefilled syringes, Sodium bicarbonate
- Dopamine, dobutamine, Morphine, Midazolam
- Normal saline, Phenobarbitone, Surfactant

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Annexure

1. **Sample Referral Note and Documentation Sheet-I (Another version of Referral form is available at the website www.nnfpublication.org)**

Date _____ Time _____

Address _____

_____

Name _____ Mother's Name_____ Father's Name _____

DOB _____ TOB _____ Sex __

Duration of Pregnancy _____ LMP _____ EDD _____

Birth Details

Mode of Delivery _____ Attended by _____

Place of Delivery _____

Time of 1st Cry _____ Apgar 1 min ___ 5 min ___ 10 min ___

Resuscitation details: Tactile stimulation / Free flow oxygen /
Bag & Mask Ventilation / Chest compressions

Duration of: O_2 _____, Bag & Mask Vent. _____, Chest compression _____

Birth weight _____ grams

Clinical course

Feeding well Yes / No, Breast feeds Yes / No, Spoon Feeds Yes / No

Type of feeds EBM / Formula / Any other milk Diluted milk Yes / No

Passage of Urine Yes / No Stool Yes / No

Reason for transfer: LBW / Respiratory distress/ Not feeding well/ Convulsions/ Jaundice/ Malformation/ Any other

Examination Findings

Jaundice Yes / No Any congenital malformations _____

Soles Warm/Cold, Trunk Warm/Cold Temperature _____ ^{o}C

Heart Rate ____ / min Resp Rate ____ / min Chest Retractions Yes / No

Central Cyanosis Yes / No CFT < 3 sec / > 3 sec

Receiving oxygen Yes / No With Nasal canula / Face mask / Oxyhood FiO_2 ___%

SaO_2 ____% Dxtx _____ mg%

Time of Last Feed

Investigations with date

_____

_____

_____

Treatment Given

_____

_____

_____

Place to which being referred _____

Mode of transport _____ Accompanying person _____

Name and Phone number of person at Referral Hospital _____

_____

Signatures, Name, Date and Time

2. **Sample Consent form**

I, Mr./Ms. _____ _____ (relation) of B/O_____ hereby give consent to transport my baby to neonatal unit of _____ Hospital, _____. I have been fully explained by Dr. _____ about my baby's condition. I fully understand the nature of illness of my child and have been informed about risk and untoward incidents which may occur during transport. The likely course of illness, treatment and duration of stay at the referral hospital has been explained to me.

I have been explained about the referral hospital which has facilities to treat my child's illness. I also understand the financial implication of the transport and treatment at the referral hospital.

I also give my consent for any emergency procedures which may be needed during transport. In case baby deteriorates during hospital, the baby will be taken to the nearest available health facility.

Signature	Signature of Doctor
Name	Name
Relation	
Date	Date
Time	Time

Name and Signature of Witness

Information about various currently working emergency transport services models in India is available at www.nnfpublication.org