



# Turkish Neonatal Society guideline on the safe transport of newborn

Türk Neonatoloji Derneği yenidoğan bebeğin güvenli nakli rehberi

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## Abstract

The rational presentation form of perinatal care in developed countries is evaluated within the regionalization program. Neonatal transport is the main step for the regionalization of perinatal care. It is a very important factor for reducing neonatal mortality and morbidity, especially in developing countries. Neonatal transport is a system integrity that includes more than one essential matter. Neonatal transport requires special hardware and serious organization because it can be a caused of mortality and morbidity in its own right. This guideline deals with the transport of newborn infants (definitions, personnel, technical equipment, stabilization conditions, special medical conditions, communication), and the current situation in our country and standard approaches. It should not be forgotten that changes in public space will also change the approach and that every baby should be evaluated within himself or special conditions.

**Keywords:** Newborn, organization, transport

## Öz

Gelişmiş ülkelerde perinatal bakım, bölgeselleştirme programı çerçevesinde değerlendirilmektedir. Yenidoğan nakli perinatal bakımın bölgeselleştirme modelinin temel basamağıdır. Gelişmekte olan ülkelerde yenidoğan mortalite ve morbiditesini azaltan önemli bir etmendir. Yenidoğanın nakli birden fazla temel özellik içeren bir sistem bütünlüğüdür. Yenidoğanın nakli kendisi mortalite ve morbidite nedeni olabildiğinden özel donanım ve ciddi organizasyon gerektirir. Bu rehberde yenidoğan bebeğin nakil organizasyonu (tanımlar, personel, teknik ekipman, stabilizasyon koşulları, özel tıbbi durumlar, iletişim), ülkemizdeki var olan durum ve standart yaklaşımlar eşliğinde ele alınmaktadır. Kamusal alanda değişimlerin yaklaşımları da değiştireceği ve her bebeğin naklinin kendi içinde özellikli durumlar eşliğinde değerlendirilmesi gerektiği unutulmamalıdır.

**Anahtar sözcükler:** Nakil, organizasyon, yenidoğan

## Introduction

The transport of newborns is one of the most important issues in the neonatal period. In utero transport of newborn is the best and the safest way to transport a sick neonate. It is a known fact that the best transport incubator is the uterus. However, neonatal transport may be inevitable because of factors including inability to predict risk, the occurrence of risk at the time of delivery, and the fact that the center where the delivery takes place is inappropriate for the baby's risk status (1).

The quality of stabilization, resuscitation, and care given

during neonatal transport affects the mortality and morbidity of the sick newborn. In a successful transport, the objective is to enable the baby to receive care under the best conditions like to Neonatal Intensive Care Unit (NICU) during transport.

Transport of pregnant women and newborns is far from being ideal in our country and continues to be an important problem of perinatology and neonatology. Therefore, this guide was prepared considering our country's conditions in accompaniment with the opinions of the Ministry of Health 112 service author-

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ities, previous workshops (the workshop held in April 2016 in Gölbaşı, Ankara, March 2017 Erzurum Protocol Meeting, and the 2<sup>nd</sup> Ankara Transport Workshop held in June 2017), organizations of different countries, and studies published in the literature (2-4). It should be kept in mind that this guide will be updated as our country's conditions change, and the transport of each baby should be sensitively regulated considering its own special conditions.

### Definition

**Perinatal transport:** Transport of a pregnant woman before delivery or a newborn after delivery for a risky pregnancy, delivery or newborn to a center where risk-related diagnosis can be made and treatment can be applied.

**Prenatal transport (in utero transport):** Transport of baby in utero before delivery to a center where postnatal diagnostic, therapeutic, and follow-up approaches can be applied, if there is any risk factor that could negatively affect the mother's or baby's health during pregnancy. The most appropriate transport incubator is the uterus.

**Neonatal transport:** Transport of a sick newborn whose status is critical to another appropriate center for follow-up, care, and treatment.

**In-hospital transport:** Transport of a newborn baby from one unit to another inside hospital because of any reason (e.g., imaging, invasive interventions, consultation).

**Transport between hospitals:** Transport of a newborn to another institution in the same city, in another city or in another country using ground or air ambulances.

**Back transport:** Back transport of patients to a unit with less competence or less resource after a critical condition is over or stabilization is achieved. This is a cost-effectiveness approach that provides use of the beds in regional reference centers by patients who really need advanced specialized care, strengthens the relations between the advanced level centers and centers that accept the baby transported back, increases the contribution of parents to patient care, and increases the experience of the center that will participate in the follow-up of the baby before discharge (5, 6).

### Indications and contraindications

The rules concerning the issue as to which pregnant women need perinatal transport in the intrauterine period and which infants need neonatal transport in the

postnatal period are not clear. These rules vary depending on the level of care in the healthcare institution in which the pregnant woman who has a high probability of delivery in the short term or the newborn is found, the presence of advanced specialized care opportunities, the presence of an appropriate number of available beds, the socioeconomic status of the family, health insurance, and the parents' wish (7). The indications and contraindications for neonatal transport according to 2<sup>nd</sup> and 3-4<sup>th</sup> level services are classified in Table 1-3 considering our country's conditions.

### Transport management and organization

Neonatal transport organization requires a very good communication network between institutions, advanced technology, and experienced personnel. In developed countries, neonatal mortality has decreased to a great extent with regionalization of perinatal care and improvement of neonatal transport systems. In this context, four

**Table 1. Transport indications for 3<sup>rd</sup> and 4<sup>th</sup> level neonatal intensive care unit**

- Very-low (<1500 g) and extremely-low (<1000 g) birth-weight infants
- Extreme prematurity: <30<sup>th</sup> gestational week (may also include infants with a gestational age of 30-32 weeks)
- Severe respiratory failure requiring assisted respiratory support
- Recurrent apnea requiring positive pressure ventilation support
- Jaundice requiring exchange transfusion
- Moderate/severe hypoxic ischemic encephalopathy (medical hypothermia+aEEG monitoring)
- Multi-organ failure
- Need for major surgery (e.g., congenital *Diaphragmatic* hernia, *gastroschisis*, *meningomyelocele*, *bilateral choanal atresia*, cardiac surgery)
- Heart failure or symptomatic arrhythmia
- Active hemorrhage requiring transfusion
- Patients whose clinical conditions are not suitable for follow-up in 2<sup>nd</sup> level NICU and who need a special diagnostic approach, care, application and treatment (e.g., diseases, severe or uncorrected electrolyte disorders, severe hematologic problems requiring intervention, severe congenital malformations compatible with life)
- Characteristics requiring advanced examinations related to ROP examination and/or treatment

ROP: retinopathy of prematurity; NICU: neonatal intensive care unit

**Table 2. Transport indications for 2<sup>nd</sup> level neonatal intensive care unit**

- Low-birth-weight infants (1500-2500 g), preterm infants with a gestational age of 32-36 weeks
- Persistent cyanosis despite oxygen treatment
- Need for short-term intubation and assisted respiratory support
- Convulsion (seizure activity)
- Sepsis showing symptoms of systemic infection
- Suspicion of hemorrhage and hemorrhage control
- Hypoglycemia unresponsive to treatment, electrolyte disorder
- Need for minor surgical intervention
- Congenital heart disease (with antenatal diagnosis or suspicious)
- Suspicion of metabolic disease
- Mild hypoxic ischemic encephalopathy
- Anemia and Polycythemia (Hct>65%, asymptomatic)
- Minor congenital malformations

**Table 3. Contraindications for neonatal transport**

- Congenital anomalies incompatible with life
- Immature infants who are non-viable (<400 g and <23<sup>th</sup> gestational week)
- Infants who cannot be stabilized, do not respond to resuscitation, and are predicted to be lost during transport
- Inappropriate transport conditions in terms of personnel, equipment, medical devices and materials, medications and competence of the referral hospital

different transport organizations emerge when neonatal transport systems are examined (8, 9).

**1. Regional emergency medical services (Three-way):** Phone call (On-Call) system - Emergency center call (112 for our country); transport of patients by random teams or educated teams (dedicated team).

**2. Center accepting the newborn (Two-way):** The hospital's or neonatal unit's own team: When a patient is to be referred to the relevant hospital, the hospital's educated and full-equipped team receives and brings the patient.

**3. Hospital referring the patient (One-way):** Transport of the baby to the center where he/she is to be followed up by the hospital referring the patient.

**4. Private transport systems (Private sector carriers):** These provide transport of infants under appropriate conditions

for a certain fee for families who request a neonatal transport service. Some private healthcare insurance systems can cover this transport fee.

### Neonatal transport in our country

Currently, the three-way e-mail/phone call (On-Call) system is being applied. Accordingly, the physician who wishes to refer their patient should call the regional 112 Emergency Service command center and/or send a patient transport request form to the mail address specified for the relevant region. The officer in the command center finds an available place primarily in a public institution where a neonatologist works and subsequently in private healthcare centers, if necessary, considering available bed status in accordance with the letter "Neonatal Transports" of the Directorate General for Health Services dated 21.06.2016 (Number 83913885-649.99-E99-364) and informs the physician who wishes to refer their patient by e-mail and/or phone.

Although some regional differences exist, neonatal transports between public healthcare institutions are realized by way of ground (mostly vehicles with red bands) and air ambulances affiliated to the 112 head physicians who are employed by the Turkish Republic Ministry of Health Emergency Health Services Branch Office. There is no standard definition related to the necessary personnel, medical devices, and consumable materials required only for neonatal transport for ambulances. A standard informed consent form is being used for neonatal transport. 112 command control centers exist for local or regional transport of all patients. However, a separate central system established for organization of neonatal transport does not exist. Private healthcare institutions carry newborns with their own ambulances. Standards for the personnel, medical devices, consumable materials, communication, and informed consent form to be used during neonatal transport do not exist and the process is limited with individual or institutional practices (10-12).

The legal framework for neonatal transport in our country has been specified with the "Emergency Health Services Code, Provincial Ambulance Service Operation Instructions, Ambulances and Emergency Health Vehicles and Ambulance Services Code and attachments, Rules and Procedures related to Ambulance Air Vehicle Operation and Heliports, Declaration related to the Rules and Procedures for Operation of Ambulance and Emergency Care Technicians and Emergency Medical Technicians," the referral and transport subtitle included in the sixth part of the Declaration of the Rules and Proce-

dures for Application of Intensive Care Services in Inpatient Care Institutions (Duty Services, Patient Admission and Hospitalization Procedures, Patient Referral and Transport in Intensive Care Units) [(R.G. Amendment: 29/05/2013-28661) article 22], the paper titled "Neonatal Transport" of the Turkish Republic Ministry of Health Directorate General for Health Services dated 21.06.2016 (Number 83913885-649.99-E99-364) and the decisions of the Provincial Emergency Health Services Coordination Commission.

### Employees in charge in neonatal transport

Neonatal transport requires team work. Unfortunately, adequately qualified teams do not exist in our country. The team members should have experience and qualifications in the subject of care of sick infants. The team should be able to perform all standard emergency and stabilization interventions required in the care of critically ill newborns. The team members should be able to correctly and efficiently use all devices and equipment used in the process of transport and in care of the newborn baby. The quality and composition of the team members is very important in terms of the success of transport (13). Therefore, they should receive education for neonatal resuscitation programs (NRP) and neonatal transport. The transported baby must be brought to the NICU and not to the emergency department. The team composition that we recommend for our country, from the most preferred to the least preferred, physician (neonatologist, Pediatrician, neonatology resident, pediatrics resident, general practitioner), respiratory therapist, transport nurse, NICU nurse, emergency medical technician or paramedic, technical staff, and driver.

### Neonatal transport vehicles and their characteristics

One or multiple vehicles may be used in the transport process. The patient's status, the distance and meteorologic and geographic conditions are important in specifying the type of vehicle. As the transport distance increases and the time outside hospital becomes more important, air transport should be considered depending on the severity of the status and the disease process. Generally, air transport is the quickest way of transport above 50 miles (80 km). Helicopter is preferred for distances between 50 and 150 miles (80-240 km) and airplane is considered more appropriate for distances of more than 150 miles (240 km) (2, 3, 6). These distance thresholds may be considered differently for our country (14, 15).

**A. Ground transport;** Ground ambulance is the most commonly used vehicle in the transport of patients between institutions.

**Advantages;** Ground vehicles have more advantages compared with air ambulances. Ground ambulances can operate even in unfavorable weather conditions, which frequently hinder safe air operations. Another advantage is the ability to interrupt transport and stop the vehicle in the event of an emergency to enable assessment of the patient and intervention. Training of personnel is much easier compared with transport by air ambulance. When the cost is compared with the costs of helicopters and airplanes, the expenses of ground ambulance related to operation, purchasing, renting, care and insurance are considerably lower.

**Disadvantages:** Shaking of the vehicle may negatively affect preterm infants in particular, and the problem of motion sickness may occur in patients, relatives, and members of the transport team. Ground ambulances have substantial time, distance, and access limitations. Ground ambulances have limited speed and the transport may be delayed or become impossible because of heavy traffic, road construction, service roads, unfavorable air conditions, and inaccessible land roads.

**B. Transport by air:** Transport by air has characteristics related to altitude physiology, which may affect patients with respiratory problems and air trap and equipment containing air (e.g., endotracheal tube cuff/balloon, laryngeal mask) (3, 5).

**B.1. Helicopter: Advantages;** Helicopters enable transport with a speed ranging between 190 and 280 km/h depending on air conditions, type of helicopter, flight altitude, and load weight. Travelling with an ambulance helicopter lasts one-third or one-fourth that of travelling the same distance in a ground ambulance. A helicopter requires only a small and flat area (30 m x 30 m) cleared of obstacles for landing. Helicopters have the advantages of not being affected by common traffic delays and the ability to reach areas that cannot be accessed.

**Disadvantages;** The patient cabin is smaller compared with ground ambulances and may pose a disadvantage for appropriate patient care. The need for a landing area for helicopters is a disadvantage when compared with ground ambulances. Air conditions may limit patient transport. Earplugs should be used in infants. Transport by way of helicopter is significantly more expensive compared with transport on a highway.

**B.2. Fixed-wing air ambulances (airplanes): Advantages;** Airplanes are faster and have a larger area compared with ground ambulances and helicopters. The patient cabin is



generally larger in ambulance airplanes compared with helicopters. During long-distance transports, airplanes can fly above or around unfavorable air conditions. For long distances, cost per kilometer is lower with transport by fixed-wing vehicles compared with helicopters.

**Disadvantages;** The most important limitation of using airplanes for patient transport is the necessity to land at an airport far from health institutions that refer or admit patients. In addition, transports via airplane ambulances require multiple transfers “from healthcare institution to ambulance and from ambulance to healthcare institution.”

**B.3. Causes of stress in air transport:** Hypoxia, noise, vibration, changes in pressure and temperature, decreased humidity, dehydration, gravity, fluid leak outside intravascular spaces, fatigue, spatial disorientation, vibrational vertigo, and exposure to fuel vapor and exhaust fumes. Both patients and the transport team and pilot may be affected by flight stress.

**B.4. Points to consider during air transport:** Understanding the unique characteristics of high-altitude physiology is necessary to enable the most appropriate patient care during transport via airlines. Patients, members of the flight team, members of the transport team, and some medical equipment may be affected by partial pressure changes of gases at altitudes above sea level. The precautions to be taken to prevent the development of complications in air transport according to high-altitude physiology are shown in Table 4.

In cardiac patients, the procedure of positioning the patient's head towards the back of the airplane (upside down position) during speed up increases myocardial function. As the negative gravity forces increase, the blood accumulates in the upper parts of the body. In patients with fluid load, the increase in positive gravity forces, which would provide accumulation of the blood in the lower extremities, may be a desired condition. This can be achieved by placing the patient's head towards the front part of the airplane (heads up position). These positions given at the time of lift-off according to the patient's characteristics will be changed in the opposite direction, if applicable.

#### Materials and medications used during neonatal transport

The transport team is responsible of the supply of transport devices. If some devices are used mutually by the hospital and transport vehicle, these devices should be

**Table 4. Strategies to prevent complications during air transport**

#### Directed to gas distribution

- Orogastric or nasogastric tube should be placed and the tip should be left open in infants who have a risk of vomiting or gastrointestinal symptoms
- Chest tube, endotracheal tube and other similar materials should be available
- Airway should be secured during and before transport
- Portable transillumination device should be carried to check presence of extrapulmonary air
- Appropriate thoracentesis needle kit should be available
- Flying should be maintained at low altitude, if possible or the cabin pressure should be increased during transport of patients with air trap (e.g., pneumothorax, pneumoperitoneum or intestinal obstruction)

#### Directed to reduced $pO_2$

- Before leaving hospital:
- The best oxygenation of the child should be enabled.
- Arterial  $PO_2$  and  $CO_2$  should be evaluated by way of pulse oxymeter and end-tidal  $CO_2$  or blood gases measurements
- The place and fixation of endotracheal tube should be checked
- En route:
- Transcutaneous oxygen saturation should be monitored in all patients who need oxygen and who are connected to ventilator
- $FiO_2$  should be increased, when necessary, in order to maintain adequate oxygen saturation

kept in a constant place and accessed easily, when necessary (2, 3, 5, 16). The materials should be checked daily and not only before and after each transport.

**Ambulance:** It is recommended not to use the same equipment and ambulance for the transportation of newborns and adults. The detailed guide should be examined for additional characteristics.

**Transport incubator:** A power-controlled mechanism that can easily be reached and read whenever required, should be preferred for heat control. Incubators should be able to warm up safely in motion and an open bed should not be used. When continuous measurements are required, soft, flexible probes should be used for axillary skin measurements. The baby should be visualized easily, and one should be able to reach the baby at least by two sides. The incubator should have a double wall and the

internal part should be warmed up as required. Adaptors that can operate in accordance with the necessary power sources should be available in the ambulance and hospital. Safety locks required during transport should be available.

**Respiratory support devices:** Ventilators should be portable, durable, and easy-to-use. They should alarm at high pressure and in case of impaired connection. Most ventilators need gas and not electricity for operation. Ventilators with synchronized mode should be preferred. Pressure-limited, time-cycled ventilators are used more commonly. Devices that can only apply continuous positive airway pressure (CPAP) should not be preferred because transport of patients with respiratory arrest may come into question.

**Aspirator:** Aspirators are needed at all points of transport. An independent battery power unit will be required for cleaning of the airway and tracheostomy tube. The vacuum pressure should be adjustable.

**Monitor devices:** Multifunctional monitors that can provide monitoring of the cardiac rhythm and oxygen saturation and invasive and noninvasive blood pressure monitoring should be preferred. If possible, two pulse oximeters should be available because preductal and postductal measurement may be required. Pulse oximeters used in airplanes should have passed electromagnetic intervention tests. Pulse synchronization is important to prevent erroneous readings when patient movement and vibrations occur during transport. Cuffs with appropriate sizes for different patients should be available for noninvasive blood pressure monitoring.

**Parenteral infusion materials:** Sensitive pumps that can give 0.1 mL fluid per hour and operate with a battery should be preferred. Intravenous infusion pumps should have the ability to stand unsupported, be controllable, and applied with intravenous and umbilical devices.

**Phototherapy device:** Phototherapy devices may also be added in the transport of infants who are at the exchange transfusion limit. It is appropriate to include phototherapy devices in transport vehicles in conditions where it should be provided in command and control centers.

**Transport bag:** The transport team should place the materials and drugs to be used during transport on the shelves inside the ambulance by listing. If it is not possible to carry it in the ambulance, a transport bag, which could be used during transport, should be prepared.

**Transport laboratory:** Currently, many transport teams use portable test devices that can measure electrolyte and/or blood gas values accurately or almost accurately. It is not absolutely mandatory to provide the recommended devices in the transport vehicle. They can be kept in the regional command and control center and provided in the transport vehicle depending on the patient's clinical characteristics.

**Drugs:** All drugs used in the resuscitation of newborns and might be needed for stabilization should be prepared before transport and kept ready in a portable bag. Appropriate storage and safe drug distribution are very important for the efficiency of transport. Appropriate storage and cooling should be provided for special drugs including surfactant and prostaglandin E1. Information related to drug dose by body weight, practical application notes, important indications and contraindications for use of drugs, and special conditions should be available in writing inside the vehicle.

### Stabilization before and d during transport

Before transport, the newborn must be medically stable and prepared legally and administratively. Stabilization of the newborn patient should be evaluated by the physician who sees the baby in the referring hospital (a neonatologist, if possible, and pediatrician with experience in neonatology, if not possible) and specified by consulting with the neonatologist in the center accepting the patient. Newborns who cannot be stabilized or who have not been confirmed by the appropriate center that is considered to admit the patient, must not depart (3, 5, 10, 17).

Operations to be performed according to the recommendations of the physician (preferably a neonatologist) managing the organization of the patient until transport occurs may decrease potential mortality and morbidity by enabling the patient's stabilization and safe transport. Stabilization criteria before transport are summarized in Table 5.

### Preserving body temperature

Newborns including mainly preterms and infants with low birth weight are vulnerable to cold. Hypothermia in transported infants is an important risk factor that has a negative effect on mortality and morbidity. Precautions directed to hypothermia are discussed in detail in Part of, Transport of Preterm Infants.

### Respiratory system

With regards to the respiratory system, tachypnea, groaning, intercostal and subcostal retractions, apnea, and de-

**Table 5. Stabilization criteria before neonatal transport**

Criteria	Stabilization status
Thermoregulation	Body temperature: 36.5 -37.5°C
Respiration	Presence of spontaneous respiration (40-60/min), or providing adequate airway patency or efficient ventilation
Oxygenation	Target oxygen saturation level: 90-94%, excluding special cases
Circulation	Adequate tissue perfusion (trouble-free perfusion index monitoring and/ or capillary fillin time <3 s) Heart rate 120-160/min Blood pressure within the normal limits (protection against hypotension)
Fluid	Presence of at least one usable intravascular access in stable patients, presence of one central access or 2 intravascular accesses in infants with multi-organ disorder
Metabolic status	Metabolic disorders should have been corrected Protection from acidosis (blood pH >7.25-7.40) Blood glucose level >40-50 mg/dL
Confirmation and consent	Confirmation of identity and gender The "Informed Consent and Approval Document" should have been filled
Family	Informing the family Providing emotional support for the family

saturation should be monitored and oxygen requirement and assistive respiratory support should be evaluated. The need for intubation should be considered with the accompaniment of findings of respiratory failure with blood gases, pulse oximetry, and chest radiography. The endotracheal tube should be fixed securely as a precaution for the possibility of displacement during transport and the place of the tube in reference to the upper lip level should be recorded.

Aspiration of the internal part of the tube must be performed before transport in order to apply surfactant and to provide airway patency. It should be ensured that these infants stay intubated at least throughout the transport. Adjustment of ventilator parameters should be made before transport considering that most ventilators used during transport do not have triggered modes. The objective before transport should be to ensure the following parameters: pH 7.25–7.4, pCO<sub>2</sub> 30-45 mmHg, and PaO<sub>2</sub> 45-75 mmHg.

### The circulatory system

Parameters including heart rate, color, capillary refilling time, peripheral perfusion index, and blood pressure are helpful in specifying peripheral circulatory disorder and/ or shock. In practice, it is adequate to have a mean blood pressure above the gestational age. Hypotension should be corrected before transport (by giving volume expander agents at a dosage of 10-20 mL/kg in 30-60 minutes). If response to volume expanders is inadequate, inotropic

agents may be used by way of the central venous route, if necessary. Transfusions must be performed before transport in accordance with the Turkish Neonatal Society "Blood Products Transfusion Guide" recommendations considering the hemoglobin/hematocrit values and clinical findings in infants who have indications for transfusion.

### Fluid-electrolyte-nutrition

Intravenous access should be implemented in sick newborns before transport with the objective of ensuring fluid balance and applying interventions and treatments. It is important that at least one vascular access is available in stable newborns and one central and at least two peripheral vascular accesses are available in infants with multi-organ dysfunction. In newborns, the blood glucose level should be checked, kept within the normal limits, and hypo/hyperglycemia should be avoided. Serum electrolytes and other biochemical parameters should be checked, when necessary. Fluid containing dextrose at a dose of 60-80mL/kg should be given on the first day according to the gestational week and present problem, and the amount and content of the fluid should be specified according to the postnatal day, weight, and clinical condition. Distension, tenderness or discoloration should be evaluated on abdominal examination and the time and type of the final feeding should be reviewed. Enteral feeding should be discontinued and a nasogastric-oro gastric tube should be placed and drained.

**Table 6. Risks which emerge during neonatal transport and preventive strategies**

Risk	Explanation related to prevention
Hypothermia (Body temperature <36°C)	To maintain axillary body temperature between 36.5 and 37.5°C; <ul style="list-style-type: none"> <li>• The ambulance cabin and transport incubator should have appropriate temperature and humidity,</li> <li>• A cap should be applied, especially in preterm infants and infants with a body weight of &lt;1000 g should be carried with a plastic transparent bag inside the incubator,</li> <li>• Under inappropriate conditions, kangaroo method should be selected alternatively,</li> <li>• Body temperature should be monitored closely,</li> <li>• One should not lead to hyperthermia while trying to prevent hypothermia,</li> <li>• Hot water bags or medical gloves should never be used to warm infants,</li> </ul>
Hypoglycemia (blood glucose level <40-50 mg/dL)	Breastfeeding, intravenous dextrose infusion, if necessary
Hypotension (Systemic blood pressure <2SD)	Appropriate fluid treatment, inotropic drugs
Hypoxia /Hyperoxia	The SpO <sub>2</sub> levels should be maintained between 90% and 94% in infants monitored with pulse oxymeter (especially preterm infants) and fluctuations should be avoided
Hypercarbia /Hypocarbia (pCO <sub>2</sub> >60 and <35 mmHg)	Mechanical ventilation settings should be changed according to values as a result of blood gas assessments

### Central nervous system

Central nervous system (CNS) disorders frequently emerge with the presence of hypoxic ischemic injury in the neonatal period. Medical hypothermia or passive hypothermia should be initiated and continued during transport in a controlled manner. Transport should be realized after convulsions stop and the patient becomes stable. Anticonvulsant agents may be needed in prolonged seizures, but these agents may render transport difficult by leading to respiratory depression. Under these circumstances, transport can be realized by intubating the patient in order to ensure airway for a safe transport.

The risks that may emerge in relation to stabilization during transport of newborns are considered with the 5 H rule. These risks have been defined and their preventive strategies are summarized in Table 6. Vital signs must be checked and monitored during transport.

### Transport in special conditions

#### Transport of preterm infants

Transport of preterm infants needs a special approach (4, 5, 18, 19).

#### Precautions directed to hypothermia

Immature and low-birth-weight infants are vulnerable to cold. Humidification of incubators and ventilator sys-

tems during transport of preterm infants is important to ensure thermoregulation. Additional precautions including chemical gel packs and polyethylene plastic sheets are helpful in preserving the temperature of a very-low-birth-weight baby. Hypothermia is an important problem during transport and all efforts should be directed to preserve normothermia. The following principles should be applied for all infants to be transported including, especially very-low-birth-weight infants:

- Transport incubators should always be prepared at the appropriate temperature;
- The baby's head should be wrapped with a bonnet or plastic sheet before transport (especially infants with a weight of <1000 g);
- The humidity unit of the ventilator should be opened, the incubator should be kept closed, and its damping valve should be opened;
- Temperature monitoring should be enabled with a power-controlled system by placing heat sensor on the baby's skin. If hypothermia is present, it should be corrected before departure;
- Severe heat loss may occur during transfer of a baby from a hospital incubator to a transport incubator. Therefore, this transfer procedure should be completed in 15 seconds at most;
- The ambulance cabin should be preheated;
- Interventions should be kept to a minimum during transport and the incubator window should not be opened, if possible. If an intervention is needed



and the baby becomes hypothermic and cannot be warmed during transport, transport should be interrupted and the baby should be brought to a nearby hospital in order to make necessary interventions and perform treatment for hypothermia.

### Precautions directed to noise and vibration

Earflaps should be used routinely because noise leads to increased heart rate and peripheral vasoconstriction in preterm infants. Vibration may lead to intracranial hemorrhage in preterm infants. Direct connections of vehicles should be decreased and their structures should be adjusted in order to minimize the effects of vibration. Soft underlay made of special material may be placed underneath the baby.

### Respiratory support and surfactant

The intubation threshold is increased in order to decrease need for intubation during transport. Intubation indications before transport of infants: if the baby is unstable, if  $O_2$  requirement is  $>50\%$ , if signs of respiratory distress are present, if  $pCO_2$  is high, if the saturation is below the preductal target pulse oximeter values (90-94%), if recurrent apnea is present, and the gestational week is below 30 GH.

Surfactant must be administered before transport in infants with specified indications. Time should be gained for stabilization by giving the decision of administration of surfactant in the early period. Tracheal aspiration should not be performed up to six hours after administration of surfactant, if possible. Appropriate sedation should be ensured in all intubated infants. There is no routine indication for muscle relaxants for transport.

### Transport of a discharged preterm baby to home

Transfer of infants whose treatments have been completed and who have been discharged should be performed in accordance with the correct technique and in a safe manner (20, 21). Position during transport should be calculated well and an appropriate seat should be provided.

The most appropriate sitting position and angle should be found preferably by the family by observing the baby before departure from hospital for at least 90-120 minutes in the car seat because there may be a risk of increased frequency of oxygen desaturation and increased apnea and bradycardia attacks. A half-vertical position in the car seat is appropriate for safe transport. The supine or prone position may be preferred if there is an increase in the frequency of desaturation and in apnea and bradycardia attacks during observation before transport. The car seat should be placed such that the baby faces the rear of the

car. In this way, the baby will be monitored and affected less by any potential accident (Figure 1).

If a cardiac monitor and apnea monitor are required, monitors with battery power that can last at least twice the travel time should be used.

### Transport of infants with hypoxic ischemic encephalopathy

The efficiency of treatment decreases as the time from hypoxic injury to initiation of cooling increases. Therefore, hypothermia treatment should be initiated as soon as possible (in the first six hours) (22). If a hypothermia device is unavailable, active (materials that are not products of technology, "ice batteries or packages applied on the head and/or body") or passive (open bed or closing the heater of the incubator) hypothermia treatment should be initiated. After rectal temperature is stabilized, the baby is transferred to the transport incubator such that the heater is closed and cooling treatment is applied such that a rectal temperature of  $33-34^{\circ}C$  is maintained. If a cooling device is available in the ambulance, treatment initiated with active or passive hypothermia using low technology tools is continued using a hypothermia device after the baby is transferred into the ambulance. If a hypothermia device is not available in the transport ambulance, the transport is implemented using active/passive cooling with low technology tools. Rectal temperature should be monitored using a power-controlled system and deep hypothermia must be avoided. The passive hypothermia method recommended to be applied in the initial center and during transport with ambulance and example follow-up form and protocol directed to be applied during transport have been presented by Öncel et al. (23).



**Figure 1.** Placement of car seat on the way home for preterm infants

### **Transport of surgery patients**

Points to be considered during transport of infants who need surgical intervention (4, 5).

### **Pneumothorax**

Pneumothorax may develop spontaneously. However, the risk of pneumothorax is higher during positive pressure ventilation, especially in preterm infants and in infants with meconium aspiration and lung anomalies. A small pneumothorax may be asymptomatic or only lead to mild respiratory distress. If the pneumothorax is larger, the pressure of the trapped air leads to collapse of the lung, blood flow is disrupted, and this causes severe respiratory distress, reduced oxygen saturation, and bradycardia. This condition is called tension pneumothorax. This is a life-threatening condition and urgent intervention is needed to drain the air away. Transillumination of the chest is a rapid assessment test and may be helpful. Urgent interventional treatment may also be performed based on clinical suspicion. If the baby is stable, a definite diagnosis of pneumothorax is made with chest X-ray. If needle aspiration or chest tube placement is to be performed during transport, the transport should be interrupted.

### **Necrotizing enterocolitis**

Supportive care is performed during transport of infants with necrotizing enterocolitis or suspicion of necrotizing enterocolitis. This comprises intravenous fluid, broad spectrum antibiotic treatment, correction of metabolic disorders, and gastric decompression.

### **Congenital diaphragm hernia**

Tracheal intubation should be performed before transport and a wide, cannulated nasogastric or orogastric tube should be placed for continuous aspiration. Peak airway pressure (PIP) should be limited, low tidal volume should be used, appropriate sedation should be performed, and adequate systemic blood pressure should be ensured with inotropic treatment during transport.

### **Esophageal atresia and tracheo-esophageal fistula**

Orogastric tube should be placed for continuous aspiration of the proximal esophageal pouch during transport and supine position should be given by elevating the bed-head. Ventilation with a bag valve mask and CPAP should be avoided.

### **Abdominal wall defects**

These infants carry a risk for hypothermia and hypoglycemia. Heat loss will be great because of the large surface area of the protruding intestines. This will also lead to very severe fluid loss. The lower part of the trunk includ-

ing the intestines should be wrapped with a colostomy bag before transferring the baby into a heated transport incubator. The baby should be transported in the lateral position by supporting the exposed intestines to prevent stretching and bending. An orogastric tube should be placed during transport. Umbilical catheterization should generally not be performed unless other vascular access methods are unsuccessful.

### **Volvulus**

During transport of infants with a suspicion of volvulus, primary supportive applications including intravenous circulatory support, correction of metabolic disorders and gastric decompression with wide cannulated nasogastric or orogastric tube should be implemented.

### **Congenital vertebral defects**

The baby should be put in the prone position paying regard to protecting neural tissues during transport and the necessary precautions should be taken to keep the vertebral defect damp (sterile cloths and plastic sheets with the condition of protecting the defect area). If there is disruption in the skin covering the defect, the risk of infection is increased and empiric antibiotic treatment should be considered.

### **Transport of infants with congenital heart disease**

Advanced life support should be initiated before transport in cases of hypoxemia unresponsive to oxygen, congestive heart disease or shock status. A stable airway should be ensured to provide appropriate ventilation. Intubation should be performed after premedication in critically ill newborns with congenital heart disease (CHD) with severe cyanosis or circulatory collapse. A safe venous access is important and arterial vascular access is helpful in evaluating blood pressure and acid-base status and gas exchange. Volume and inotropic support and correction of metabolic acidosis may be needed to correct cardiac output and tissue perfusion (4-6).

Oxygen support: it should be kept in mind that oxygen should be given constrictedly or should not be given in ductus-dependent CHD.

Prostaglandin E1 (PGE1) treatment; PGE1 infusion should be initiated before transport if dependence to ductus for systemic or pulmonary blood flow (pulmonary atresia with intact ventricular septum, transposition of the great arteries, hypoplastic left heart, severe coarctation) is considered. For stabilization, PGE1 is administered at a dosage of 0.01-0.025 µg /kg/min by intravenous infusion. Response to prostaglandin is generally rapid when ductal

flow is important in terms of the baby's hemodynamics. Inability to obtain response may imply erroneous initial diagnosis of ductus-dependent CHD, unresponsiveness of the ductus to PGE1, which may occur in older infants, or absence of ductus arteriosus.

Intubation and ventilation; presence of deep hypoxemia, respiratory failure or hemodynamic instability may require airway intervention. In most cases, intubation should be performed in association with sedation (narcotic or benzodiazepine) following premedication. Premedication with atropine (0.02 mg/kg) may decrease the vagal effects of laryngoscopy. Fentanyl (1-2 µg/kg) or midazolam (0.05-0.1 mg/kg) may be given for sedation. Chest wall rigidity may occur with low-dose fentanyl (more probable with administration of rapid-acting doses) and neuromuscular blockade may be needed for appropriate ventilation.

In most cases, preoxygenation of the newborn is provided with 100% FiO<sub>2</sub> and the concentration may be reduced to obtain an acceptable oxygen saturation because of the underlying CHD after intubation.

Inotropic treatment; newborns with undiagnosed CHD may develop congestive heart failure or circulatory collapse. In these infants, the ductus arteriosus should be opened urgently to provide systemic or pulmonary blood flow and inotropic treatment may be needed to improve the adverse effects of the myocardium with increased afterload (obstructive left side lesions requiring ductal flow for systemic blood flow) or hypoxemia (obstructive right side lesions requiring ductal flow for pulmonary blood flow).

### **Transport of newborns who need high-frequency oscillatory ventilation (HFOV) and inhaled nitric oxide (iNO)**

In recent years, it has become a common approach to apply HFOV and mostly iNO in association in newborns with increased oxygenation index who cannot tolerate hypoxia. In cases of severe respiratory distress in small preterm infants and in cases of severe meconium aspiration syndrome (MAS) and/or MAS in association with pulmonary hypertension, HFOV and iNO treatments are frequently required. Transport of such infants occurs because such sophisticated treatments are performed in a limited number of centers (2, 4-6).

In standard ambulances, ventilator enabling HFOV and devices providing nitric oxide are not available. In addition, these devices are very expensive and their use requires experience. Therefore, transport of such patients should be provided by teams experienced in this issue.

The team that should be available in transport requiring HFOV and/or iNO includes a neonatologist who can use HFOV and/or nitric oxide devices, a biomedical technician who can understand these devices, an experienced neonatal nurse, and allied health personnel. An HFOV device, iNO device, oxygen mixers, nitric oxide tank, connection cables and pipes will also be needed in addition to standard ambulance equipment in transport requiring HFOV and/or iNO.

The newborn to be transported should primarily be seen in the relevant unit, all devices and equipment should be connected to the patient there and the values at which the baby will be stabilized should be adjusted. The baby, who is thought to be stabilized for a period for which the neonatologist can make the decision, should later be transferred to the transport ambulance and safe transport of the baby, who continues to receive HFOV and/or iNO, should be provided.

### **Transport of newborns with extracorporeal membrane oxygenator (ECMO)**

In recent years, an increase in the use of mechanical cardiac assist devices has been observed due to technological advances and increased experience in patients with advanced stage respiratory and cardiac failure (2, 6, 24). Extracorporeal membrane oxygenator (ECMO) is one of these devices. Transport of these patients also comes up because neonatal ECMO treatments are successfully applied in some centers in our country. Installation and cannulation of extracorporeal membrane oxygenator; there are roughly two types of ECMO according to the mode of installation. These include venoarterial and veno-venous bypass techniques. Right internal jugular vein and carotid artery cannulation are preferred, especially in newborns and in patients below the age of 1 year.

Transport of a newborn with ECMO is considerably difficult. An ECMO team should also be added to the standard transport team. The following equipment should be available at least in a newborn-compatible mobile ECMO system: blood pump with appropriate size, medical gas tanks in association with ECMO device and blood heater, pipes and mixers, venous and arterial pressure monitors, anticoagulation monitoring equipment, uninterrupted power supply, and portable ultrasonography.

Ground ambulances and air ambulances with adequate sizes should be selected to transport newborns under appropriate conditions. The incubator in which the baby is transported, ECMO device, and other equipment should be tightly fixed and balanced so that they are not displaced

with shaking, vibrations, and accelerations and decelerations. A setting where neutral ambient temperature of the newborn is provided should be generated. In this way, heat regulation of the circulating blood will be easier.

### Communication in transport

Centralization of communication in the transport system is important (a communication system that can easily be remembered, monitored, and operates 24 hours a day and seven days a week). Specification and widespread use of a centralized access number for instant access to the transport system or the personnel of the referral center is ideal for communication and efficiency (2, 3, 5). The 112 call system is available in our country and this system should be performed more efficient with regional perinatal organizations. Close communication should be present at each step between the referring institution and the referral center and all information should be recorded, if possible.

Communication with the family should be provided at each step. In neonatal transport, care and treatment may be needed in two different places. Transport teams should be sensitive in terms of the family's opportunities and difficulties and involve the family in the process as far as possible. The family should be informed about the reason of referral and potential complications before transport. Written informed consent must be obtained from the family in addition to verbal consent.

Another question is participation of one of the parents in the process of transport together with the newborn. Participation of relatives other than the parents in the transport process should be prevented. Other than this, the mother or the father or both should be allowed to participate in the process of transport and accompany their baby.

### Documents used in transport

**ATTACHMENT-7 document:** In our country, it is a legal obligation to use the Republic of Turkey Ministry of Health Neonatal Referral and Transport Form included in Attachment-7 of the Notification about the Methods and Principles of the Intensive Care Services in Inpatient Treatment Institutions (Amendment: RG-16/8/2015-29447) during neonatal transport.

**Informed consent and approval document:** The ethical and legal aspects of transport should be kept in mind, the baby must be shown to the family, consent related to transport should be obtained, and family members should be enabled to accompany transport, if possible.

The informed consent and approval document should include the following information: possible causes and prognosis of the disease, the person to perform medical intervention, how and where medical intervention will be performed, predicted time of medical intervention, other diagnostic and therapeutic options, benefits and risks of these options and the potential effects of these options on the patient's health, potential complications, potential benefits and risks in case of refusal of medical intervention, important characteristics of the drugs to be used, lifestyle recommendations critical for the patient's health, how to reach medical assistance if required in the same issue, name and surname of the patient and their legal representative, the statement of "I have read and understood" written with own handwriting and signature, the name, surname, title and signature of the physician who made the informing and interventional procedure, and the date and time of the informed consent.

The Informed Consent Document should be signed as two copies, one copy should be included in the patient's file and the other copy should be given to the patient or the legal representative. In the copy left in the healthcare institution, there should be a signature indicating that one copy has been given to the patient or legal representative and the related document should be archived appropriately.

### Assessment of the transport process

The scoring systems used in the assessment of changes in the baby's status before and after transport are very important to assess the efficiency of the care given to the baby during the process of transport. The advantages of the Transport Risk Index Physiologic Stability (TRIPS), which is used most commonly, are that this scoring system can assess the total NICU mortality in addition to the mortality in the first seven days, it can assess the mortality and morbidity risk, it can be used before, during or after transport, and it can be easily applied by the transport team in a short time. Risk severity and mortality is predicted according to the scores obtained with four variables (body temperature, respiratory distress, systolic blood pressure, and response to stimulus) (25). It is recommended that it should be applied and recorded at least twice including the time when the transport team arrives to take the baby (in 15 minutes by the transport team) and the time when the baby is delivered to NICU (in 15 minutes by the NICU team).

### Neonatal transport checklists

The operational checklists, which are completed by the teams participating in the processes before neonatal



transport, during neonatal transport and at the end of neonatal transport, are very helpful in terms of noticing deficient applications, increasing the teams' awareness, and standardizing applications (2, 3).

### List of materials that should be carried together with the newborn baby during transport

Materials that should be carried during neonatal transport include laboratory tests (blood glucose, electrolytes, hematocrit, blood gases), records of the treatments applied and care given, information related to cord blood sample, maternal blood sample (5-7 mL) and placenta, copy of pregnancy recordings, all radiologic examinations, states of urination and defecation, and a neonatal card, which indicates administration of vitamin K, eye prophylaxis, hepatitis B vaccine, and other treatments (2, 3).

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