Section 1

Organization of neonatal transport

History and challenges of neonatal emergency transport services (NETS)

Alan C. Fenton and Georg Hansmann

History of neonatal emergency transport services

Services for neonatal transport have evolved alongside in-hospital services for neonatal care. Early portable incubators were used to transport infants to hospitals that were designated to provide neonatal care, from either home or maternity hospitals. The treatments offered during transfer were limited to thermal support and supplemental oxygen, although interestingly early reports acknowledged the need for accompanying staff (invariably nurses) to have expertise in handling sick infants and administering emergency treatment while in transit.

The development of specialized neonatal intensive care units (NICUs) providing an evolving "package" of care began in **North America, Europe, and Australia in the late 1960s**. Regionalization of care[1,2] that paralleled the establishment of tertiary centers influenced the pattern of infants transported, with increases in the number of in-utero transfers, particularly in North America. The majority of these are for fetal rather than maternal reasons. It is as yet uncertain whether the more recent development of formal neonatal networks in other countries such as the UK will have similar effects on the profile of postnatal transfers. What is clear, however, is that neonatal transport services will remain an essential component of perinatal care.

In 1966, the first newborn with respiratory distress syndrome was transported to University of California San Francisco by its NICU staff, and the first recorded transport of a mother in preterm labor from another city was undertaken in 1969. Several other centers such as Phoenix, Utah, Wisconsin, and Toronto were instrumental in developing transport opportunities for newborn infants. In 1970, the Stanford/Lucile Packard Children's Hospital Neonatal Transport Program began with the development of a regional perinatal access program that initially covered several counties of **Northern California**. Transport of critically ill infants for longer than 30 minutes was not feasible because of the inability to provide life support and an adequate thermal environment. At the same time, there was clinical evidence that the transport of such infants led to a significant reduction in morbidity and mortality. A perinatal outreach program was created with the main goal of training health care providers in community hospitals in neonatal resuscitation and the pretransport early care of critically ill infants. A resource management (dispatch/communications) center was created and connected to newly formed networks of NICUs. The program expanded and a mutual relationship with a similar program in Paris, **France**,

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led to advances in both, ultimately leading to the creation of the *California Perinatal Transport System* (http://www.perinatal.org, accessed 13 October 2008).

Neonatal intensive care practices in **Europe** – especially for very preterm infants[3,4] – vary widely, and the majority of transfer services have evolved in an ad hoc way. For example, neonatal transport services in the **northern region of the UK** developed in parallel with the establishment of the Northern Neonatal Network (1991), a collaborative consortium of tertiary-level NICUs, from an initial single regional center in Newcastle (1972) over a 20-year period. The consortium oversees that intensive care beds (UK: cots) are utilized appropriately and that return transfers are suitable. Staffing for this transfer service is a mixture of neonatal nurses and either neonatologists or pediatric/neonatal trainees. More recently paramedic neonatal transport practitioners (similar to the British Columbia model in **Canada**) have been introduced.

In 1978 a local neonatal emergency transport service (NETS) was established at the German Heart Center **Munich** in cooperation with the city's local fire department. Other cities followed so that NETS became available 24 hours a day, 7 days a week in many, but not all, regions of Germany. In the last 30 years, survival rates and outcome of critically ill neonates – not least because of NETS – have considerably improved: 3 years after the establishment of NETS in Munich, the perinatal mortality rate in the region had decreased by 50%. A more recent study from **Toronto** showed that dedicated neonatal retrieval teams significantly improve delivery room resuscitation of outborn preterm infants[5]. Such success and high quality of neonatal care can only be guaranteed by a 24-h on-call service provided by well-trained nurse practitioners (NP), nurses (RN), paramedics, midwives, and doctors (pediatricians, emergency physicians, obstetricians, and anesthesiologists). The frequency of annual NETS calls, however, is dependent on many factors, including: (1) term and preterm birth rates; (2) early antepartum transports for high-risk pregnancies; and (3) the establishment of small neonatal units in hospitals with obstetric departments (counteracting earlier efforts to centralize neonatal intensive care in tertiary centers). Hence, both limited clinical exposure and increasing requests for retrievals, such as in the UK, underline the need for ongoing training of NETS health care providers.

In the US, hospitals are classified by the **level of NICU care** available:

- No NICU: level I
- Intermediate NICU: level II
- Expanded intermediate NICU: level II+
- Tertiary NICU: level III

The American Academy of Pediatrics recommends that deliveries that occur before 32 weeks of gestation take place in level III (i.e., highly specialized) units[6], and most European countries have passed laws or issued recommendations based on this premise. However, no consensus exists in Europe about size or other criteria for NICUs[7].

- There is an abundance of literature showing a decrease in infant morbidity and mortality by maternal (i.e., prenatal) transport of high-risk pregnancies when compared to emergency transport of sick newborn infants. Hence, the best transport incubator is the uterus.
- In a recent Californian study (2007)[2], mortality among very-low-birth-weight (VLBW) infants was lowest for deliveries that occurred in hospitals with NICUs that had both a high level of care and a high volume of such patients. Increased use of such facilities most likely reduces mortality among VLBW infants[2].

- In contrast, a study from the UK (1999)[8] showed that actual survival rates for infants ≤32weeks' gestation and for the group of babies ≤28 weeks' gestation fell within the 95% confidence interval of the rate predicted by the clinical risk index for babies (CRIB) score (see Table 2.5, page 146) for both the larger referral units and the smaller district units[8]. Given the improved levels of specialist medical and nursing input since 1987, the authors of this study feel it is plausible that differences in survival should have disappeared between both types of NICUs. However, they do see such a new structure as a potential threat to the teaching, training, and research base of the neonatal service as a whole.

Challenges of neonatal emergency transport services

For those infants requiring intensive care, the members of a transport team should be able to provide intensive care during that transfer at a quality that is similar to that in the receiving intensive care unit itself. Developments in equipment now enable the majority of intensive therapeutic measures (for example inhaled nitric oxide or extracorporeal membrane oxygenation (ECMO)) and intensive monitoring (including blood gas analysis) used within the NICU setting to be delivered during transfer. It is however important to appreciate that caring for sick infants in the transport environment poses numerous additional challenges compared to working within the NICU setting[9]. These include movement, noise, vibration, temperature, and (in the case of air transfer) changes in atmospheric pressure, all of which may adversely affect both the patient and the transport team. Access to the patient may also be poor, lighting less than optimal, and equipment relatively unfamiliar. In summary the environment is extremely stressful and potentially hostile.

For the above reasons it should be recognized that individuals who function well within the NICU environment may not function as effectively within the transport setting where additional support is not immediately available. Skills highly desirable in the transport environment therefore include both the ability to act decisively and independently in addition to solving problems in acutely stressful situations within a team setting.

Neonatal transport units may be staffed by a variety of health care professionals including physicians, nurse practitioners (NP), neonatal-trained nurses, respiratory therapists, and specialized paramedics. Paramedics have the advantage of being familiar with working in a moving environment, though they require additional training to be able to assist in delivering "hands on" care to the infant. Acutely sick infants should be transported by a minimum of two trained personnel. There are potential advantages and disadvantages with each combination of personnel: the final choice should be dictated by the clinical problems that an individual patient presents, although in reality availability and cost are also major factors. While highly specialized NP used to run neonatal transport units in North America and the UK, it is commonly medical doctors certified in neonatal emergency medicine in continental Europe.

Whatever team composition is used, its members must work effectively to:

- Deliver appropriate neonatal care within both the hospital and the transport environment
- Manage the range of anticipated problems for the types of transport undertaken
- Manage emergencies appropriately as they arise
- Communicate effectively with each other, with referring and receiving unit staff, and with the infant's family

Expectations and demands placed upon neonatal transport teams cannot be exactly the same as those experienced by NICU teams. The transport team and the obstetric staff, as well as the difficulties of individual transport situations, vary greatly in quality and quantity (e.g., equipment, transport distance). However, the priority (and challenge) for the NETS team should be to transport the neonate in optimum condition to the nearest appropriate intensive care unit.

! Blood gas, blood glucose, body temperature, and transportation time – among other criteria – document the quality of care provided by the neonatal emergency transport service (NETS).

Successes in some areas of neonatal care have resulted in new problems. The improvements in survival rates have had an impact on resources, particularly intensive care bed (cot) availability, and no area of medicine is currently free from budget constraints. For example, the cost-effectiveness of senior medical personnel during "routine" neonatal transfer has been questioned. These problems are compounded by heightened public expectation of a favorable outcome for even the sickest and extreme preterm infants. It is therefore essential that neonatal transfer services continually assess the quality of service that they deliver and strive to improve. This process must include appropriate support for those who access those services.

Interdisciplinary approach for neonatal emergencies

Georg Hansmann

Team work of paramedics, nurse practitioners, and neonatologists in the neonatal emergency transport service

In the neonatal emergency transport service (NETS), effective coordination between paramedics, highly specialized neonatal intensive care unit (NICU) nurses or nurse practitioners (NP), and neonatal emergency doctors (NETS-MD) is essential. The NETS-MD – especially in the first weeks in service – is well advised to take advantage of the experience of paramedics and NP, particularly in terms of transport logistics. That said, the NETS-MD, preferably with a minimum of 12 months of NICU experience, should lead the initial care/neonatal resuscitation and subsequent transport (i.e., runs code and transport). Depending on their experience level, two paramedics or one experienced NICU nurse or NP may go with the NETS-MD to the emergency site, in order to perform initial care/neonatal resuscitation. This particularly applies to emergent deliveries of extremely premature or sick infants, or preterm twins (32 + 0/7 till 35 + 0/7 weeks' gestation), who need simultaneous initial care (see Table 1.1).

- In uncomplicated cases, the common goal is for active initial care (including neonatal resuscitation) to be provided by the least experienced paramedic, RN, NP or doctor under the supervision of highly qualified and experienced health care providers. Nobody gets better just by watching, and there is no learning by osmosis.
- If problems occur at the emergency site, e.g., after a cesarean (c-section) section of twins, the NETS-MD should either call the anesthesiologist on service for help, or, if available, additional neonatal or pediatric emergency transport services.

Team work of obstetricians, midwives, anesthesiologists, neonatal intensive care unit nurses and nurse practitioners, and neonatologists

With an increasing number of emergency calls, the new NETS team members get to know the obstetricians, midwives, and NP/RN working in each local district and county.

However, since NETS personnel may change frequently, established care providers may need to rely on their own expertise, risk aversion, and stress tolerance during decision making.

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Table 1.1 Suggestions on how to coordinate a neonatal transport right after an emergency call.

Gestational age (weeks p.m.)/birth weight	Emergency transport of pregnant women	Personnel needed in the delivery room/OR	Take with you from NICU (plus standard equipment)	Admitting unit
<28+0/7 or <1000 g	Yes, if possible	1 (−2) pediatrician(s) (call for additional NETS, if needed!) + 2 experienced Peds-MD (alternative: 1 PARAM + 1 RN/NP)	1 vial of surfactant, straight blades (size 00), ET tubes (size 2.0 and 2.5), preterm ECG electrodes	NICU
<28+0/7 or <1000 g, and twins	Yes, if possible	2 (−4) pediatricians (ask for additional NETS!) + 2 experienced Peds-MD (alternative: 1 PARAM + 1 RN/NP)	2 vials of surfactant, 2 straight blades (size 00), ET tubes (size 2.0 and 2.5), preterm ECG electrodes	NICU
28+0/7 to 32+0/7 or 1000–1500 g	Yes, if possible	2 pediatricians (or: 1 pediatrician and 1 RN/NP) + 1 senior PARAM (alternative: 1 RN)	1 vial of surfactant, straight blades (size 00), ET tubes (size 2.5), preterm ECG electrodes	NICU
28+0/7 to 32+0/7 or 1000–1500 g and twins	Yes, if possible	2 (−4) pediatricians (eventually call for NETS-MD) + 1 senior PARAM/NP/RN + 1 PARAM (or: 1 PARAM + 1 RN/NP)	2 vials of surfactant, straight blades (size 00), ET tubes (size 2.5), preterm ECG electrodes	NICU
32+0/7 to 35+0/7 or 1500–2500 g	If applicable	1 pediatrician + 1 PARAM (or + 1 RN/NP)	Preterm ECG electrodes	see p. 179
32+0/7 to 35+0/7 or 1500–2500 g and twins	If applicable	1 pediatrician and 1 senior PARAM/NP/RN + 1 PARAM (or 1 pediatrician + 1 RN/NP + 1 PARAM; optimum 2 pediatricians + 2 PARAM/NP/RN)	Preterm ECG electrodes	see p. 179
>35+0/7 or >2500 g	Normally no	When indicated (see p. 179): 1 pediatrician/MD + 1 PARAM (or: 1 NP/RN)	Standard equipment	see p. 179
>35+0/7 or >2500 g and twins	Normally no	1 (−2) pediatrician/MD, 2 senior PARAM (or: 1 pediatrician + 1 NP/RN + 1 PARAM; optimum: 2 pediatricians + 2 PARAM/RN/NP)	Standard equipment	see p. 179

Suspected congenital heart disease	Yes (elective)	1 pediatrician + 2 PARAM/NP/RN (or: 1 PARAM + 1 NP/RN)	1 vial PGE_1	Pediatric Heart Center
Suspected hemorrhage/asphyxia	No	1 pediatrician and 1 senior PARAM + 1 PARAM (or 1 pediatrician and 1 NP/RN; optimum: 2 pediatricians + 1 PARAM/NP/RN)	Type O rhesus-negative blood, as indicated; prepare 50 ml volume (NS, human albumin 5%) with tubing and store in an incubator (37°C)	NICU
Anticipated hypoxic ischemic encephalopathy	No	1 pediatrician and 1 senior PARAM + 1 PARAM (or 1 pediatrician and 1 NP/RN; optimum: 2 pediatricians + 1 PARAM/NP/RN)	Eventually cooling device (cap or blanket); safety and efficacy data on cooling during transport limited	NICU

Estimated birth weight and calculated weeks of gestational age post menstruation (p.m.) may be inaccurate. Hence, the birth weight range given in the table is between the 10th and 50th percentile of the corresponding gestational age. Always assume that the NETS-MD emergency bag is incomplete (e.g., surfactant, ET tubes 2.0 for birth weights <750 g and small larynx, straight blades 00; preterm ECG electrodes, plastic wrap/bag), and take drugs you might need with you in a cooling mini case (e.g. surfactant, PGE_1). While 2 pediatricians would be favorable for the management of singletons of 28–32 weeks' gestation in the delivery room, this is rarely achieved in a real-life NETS emergency call. Resuscitations of those preterm and SGA infants are generally well manageable by a team of 1 pediatrician plus 1 experienced NP, RN or PARAM. However, depending on the status of the neonate and additional risk factors, the attendance of a second pediatrician may be indicated, regardless of the birth weight and gestational age, and even in the absence of multiple gestations. MD, medical doctor; NP, nurse practitioner; PARAM, paramedic; RN, registered nurse; PGE_1, prostaglandin E_1; peds-MD, pediatrician.

The in-patient doctor in charge is responsible for clinical assessment and urgent treatment of the fetus or newborn in the delivery room. When the newborn shows signs of postnatal deterioration, the midwife or nurse informs the obstetrician (or pediatrician – if available), who must then decide whether to notify the NETS team.

! General guidelines

- Call the NETS with your initial concerns (don't wait until the fetal heart sounds or SpO_2 and blood gas are really bad). Call too early rather than too late!.
- Immediate and appropriate neonatal resuscitation by obstetricians, anesthesiologists, NP, RN, and midwives is essential for a good outcome of the neonate. The obstetrician or anesthesiologist on service carries full responsibility while awaiting the NETS.
- Pregnant women in labor with additional risk factors must be transported immediately to a tertiary perinatal center. If prepartal transport is no longer possible, call the pediatrician/ NETS as soon as possible.

Interdisciplinary training workshops, unlike the less hands-on neonatal emergency seminars, are still rare (e.g., Center for Advanced Pediatric and Perinatal Education at www.lpch.org/cape/, and American Academy of Pediatrics at www.aap.org/nrp). This handbook has an interdisciplinary approach (obstetrics, anesthesiology, neonatology, emergency medicine). Its overall goals include maximizing efficiency and optimal care for just-delivered infants prior to and after arrival of the NETS (see pp. 9–15, pp. 124–72, and p. 511).

Principles of crisis resource management (CRM)

1. Know your environment
2. Anticipate and plan for crises
3. Assume a leadership role
4. Communicate effectively
5. Call for help early enough
6. Distribute workload optimally
7. Allocate attention wisely
8. Utilize all available resources
9. Utilize all available information
10. Maintain professional behavior

Neonatal emergency call: what the neonatology team would like to know from obstetricians and midwives

Georg Hansmann

Important information for the neonatal emergency transport service

- Name and role of the person calling doctor, midwife, nurse practitioner, neonatal intensive care unit nurse
- Name and location of referring hospital
- Indication for referral (i.e., emergency call), for example:
  - "Emergency cesarean section (C-section) due to pathological cardiotocogram/fetal heart sounds," or
  - "Transfer of newborn for evaluation of nasal flaring and gray skin color, etc."
- Time and place of birth, for example:
  - "Plan urgent C-section in 30 min, operating room (OR) no. 3, second floor," or
  - "C-section in delivery room 2, first floor"
- Gestational age in postmenstrual weeks
- Estimate of lung maturity
- Antenatal corticosteroids given? Yes/no, when, how many doses, how far apart?
- Birth weight (prenatal estimation or postnatal weight), small/large for gestational age (SGA/LGA)
- Rupture of membranes (ROM) ($\geq$18 hours before birth?), mother with signs of infection (high white blood cell count, C-reactive protein, fever, fetal tachycardia, uterine tenderness)? Bacterial smears, blood cultures taken? Antibiotic treatment – yes/no, when started, how many doses? Color/smell of the amniotic fluid? Maternal risk factors (group B streptococcus status, antibiotic coverage $>$ 4 h, ROM $>$ 18 h, herpes simplex virus lesions, etc.)
- High-risk pregnancy (see p. 231, pp. 504–5)?, e.g. impending preterm delivery:
  - Can the pregnant woman be transferred to a hospital with a tertiary neonatal intensive care unit?
  - Arterial hypertension/preeclampsia/HELLP syndrome (hemolysis, elevated liver enzymes plus low platelet count)
  - Diabetes mellitus?

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  - Vaginal bleeding/placental anomaly?
  - Pathological cardiotocogram/fetal heart sounds?
  - Fetus SGA?
  - Previous miscarriages or premature births?
  - Prenatal diagnosis (malformations, amniocentesis/chromosomes)?
- If the birth has taken place:
  - Grunting, retractions, nasal flaring?
  - Skin color?
  - SO_2 per pulse oximeter (S_pO_2)?
  - Oxygen requirement (F_iO_2)?
  - Blood gases (arterial, capillary, venous, umbilical arterial pH)?
  - Blood glucose?
  - Body temperature?
  - Malformations/deformities?
- In case of life-threatening neonatal condition:
  - Who is currently performing the resuscitation of the newborn infant?
  - Is a pediatrician or anesthesiologist at the bedside or readily available?
- Is any incubator or cot with radiant warmer organized in the NICU?

! If the complete information has not been obtained at the time of the emergency call, the NETS-MD/-NP should be provided with all necessary information on arrival. If the midwife does not have enough time to gather all relevant data (e.g., due to an approaching C-section), help must be provided by the midwife/nursery staff to: (1) obtain all birth-related information; and (2) to check on or even prepare the resuscitation unit for immediate use (e.g., running suctioning, oxygen source, and radiant warmer "on"; see checklist p. 136). Information can often be obtained by a transport operator/clerk while the team is being dispatched. The resuscitation unit should be functional at all times; daily checks by the staff in charge of the delivery room are mandatory.