www.jpnim.com Open Access eISSN: 2281-0692
Journal of Pediatric and Neonatal Individualized Medicine 2018;7(2):e070211
doi: 10.7363/070211
Received: 2017 Sept 02; revised: 2017 Oct 20; accepted: 2017 Oct 29; published online: 2018 Jun 25

Original article

Using information technology during the transport of the critically ill newborn: preliminary data from Slovakia

Peter Krcho[1], Oto Mihalčo[1], Simona Rusnáková[2]

[1]Neonatal Clinic and Neonatal Intensive Care Unit, Medical Faculty UPJŠ Košice, Košice, Slovakia
[2]Institute of Pathological Physiology, Medical Faculty UPJŠ Košice, Košice, Slovakia

Abstract

Background: Infants born outside perinatal centres may have compromised outcomes due to unsatisfactory speed and efficiency of transfer to an appropriate tertiary centre. Newborns are among the most sensitive patients during the transition period after delivery. Adequate pre-transfer stabilization, safety during transport and ongoing intensive care in the Neonatal Intensive Care Unit (NICU) are essential to improve the outcome of transported neonates. This paper aims to show new possibilities of closely monitoring the critically ill newborns requiring transport to a NICU. The authors present a communication tool for sharing information before, during and after the transport of critically ill neonates. The system is able to transfer digital data of the ultrasonographic scans, medical data, videos and photos of critically ill newborns. Physicians with limited training and diagnostic and therapeutic tools in regional hospitals can find it difficult to formulate a reliable clinical picture of the disease or abnormality. This information-sharing technology can prevent complications and the progression of particular disorders and can support surveillance.

Results: During a period of three years, 38 newborns were transferred with the help of information technology (IT). The average birthweight was 2,024 g (min 650 g, max 4,150 g), average GA was 34.7 weeks (min 24, max 41). The most common diagnosis for transferring the newborns postnatally was respiratory distress syndrome or pulmonary maladaptation (23 cases, 61%).

Conclusions: High-risk births inevitably occur in non-tertiary hospitals, despite committed attempts to transfer at-risk women to perinatal centers before delivery by obstetrics teams. Therefore, modifications to prenatal advice, together with improvements in neonatal transport network services and intensive care facilities, could significantly improve the survival of transported neonates and minimize morbidity.

Keywords

Newborn, transport, IT, information technology, equipment, morbidity, intensive care.

Corresponding author

Peter Krcho, Neonatal Clinic and Neonatal Intensive Care Unit, Medical Faculty UPJŠ Košice, Košice, Slovakia; email: peter.krcho@upjs.sk.

How to cite

Krcho P, Mihalčo O, Rusnáková S. Using information technology during the transport of the critically ill newborn: preliminary data from Slovakia. J Pediatr Neonat Individual Med. 2018;7(2):e070211. doi: 10.7363/070211.

Introduction

Neonates, soon after delivery, go through a transition process, changing the functions of the organs, especially lungs and circulation. During this transition phase they are at high risk of brain hypoxia and other complications with severe consequences. Significant advances in perinatal and neonatal care and changes in the approach to immediate resuscitation have resulted in improved survival rates among preterm infants [1, 2].

However, decreases in neonatal morbidity and mortality rates depend not only on technological progress, but also on the way in which perinatal care is organized [3, 4]. The most effective is high-quality prenatal care, with early evaluation of the condition of the fetus and intrauterine transport of the mother to a perinatal centre. Here, higher-quality care is provided by specialists before and after delivery, increasing the likelihood of trouble-free transition with the best outcome. Evidence has also suggested that perinatal outcomes of infants are better following maternal transport before delivery compared to infants transported after birth [5-7].

However, preterm delivery, perinatal illness and congenital malformations cannot always be anticipated, resulting in a continuing need for *ex-utero* transfer of neonates after delivery [8, 9]. For this reason, all hospitals that provide obstetric services must be prepared for the birth, resuscitation, stabilization, and treatment of premature or term sick infants. When the medical needs of the mother and/or fetus are beyond the scope of the current facility, antepartum maternal referral to a tertiary care centre is necessary.

Transport

Stabilization of patients and preparation for transport should begin before the transport team arrives. In consultation, the referring centres may address additional areas of attention based on specific patient clinical assessment and presumptive diagnosis. The reasons for neonatal referral are diverse and based on the needs of infants relative to the capability of the referring centre. The most common indications include respiratory distress, premature or extremely premature newborns with birth weight less than 750 g, sometimes term or post-term newborns with birth weight > 4,000 g or newborns with unpredictable congenital abnormalities of various organs. One specific group of transported newborns are neonates with congenital heart abnormalities and newborns with congenital abnormalities of the gastrointestinal system. Stabilization and support of these infants may require frequent inter-hospital communication to identify specific medical interventions. The importance of this form of continuing dialogue with respect to accuracy in diagnosis, management, and changes in patient status cannot be stressed enough. Use of technology that allows the sharing of X-rays, photos of newborns and other additional information may facilitate the accuracy of these interactions.

The transport of the critically ill newborns needs special, sophisticated equipment, skilled staff, rapid communication and excellent logistics backup. Collaboration between physicians before transport is crucial. The paediatricians and neonatologists are usually the first to detect problems during the transition process or are directly involved in the resuscitation of the newborns in the first minutes after delivery.

The equipment and medications necessary for neonatal transport are similar to those used in the Neonatal Intensive Care Unit (NICU). Equipment must be light, compact, durable, and motion and g-force tolerant. All electronic equipment should have its own independent power supply, adequate visual and audio alarms, and no electromagnetic interference [10]. There is a need for special hardware, incubator, monitoring systems (pulse oximeter, skin temperature probes, blood pressure cuffs); equipment supporting ventilation (ventilator, self-inflating bag, oxygen mask, infant nasal cannula, CPAP prongs); commercial medical gases; airway and suction equipment (laryngoscope, endotracheal tubes, suction catheters, nasogastric tubes); medications and other tools for resuscitation and

specialized intensive care. The weight of the whole set of equipment could be in excess of 150 kg. A special medical vehicle is also used for quick transfer of the staff and equipment. One of the most important elements of the entire process is the availability of skilled staff, consisting of a nurse and physician specialized in neonatal transport and having a basic understanding of neonatal pathophysiology, resuscitation and stabilization techniques, ventilator management and radiographic interpretation. An integral part of the transport team are the ambulance driver and paramedics, who are responsible for safe and quick transport of the whole crew from the regional hospital to the perinatal centre.

Material and methods

The authors have developed a hardware solution using internet for data transfer, based on the previously installed system for sharing the digital data of ultrasonographic scans of patients in the NICU in Košice. It is a local communication tool between the ultrasound, notebook, tablet and big screen installed next to the incubator (**Fig. 1**). The system is used to store and visualize the scans of the organs on the databases and the screens for evaluation purposes. The experience gained with the hardware mentioned led to the idea of using a similar, cloud-based system during transport. The hardware consists of tablets in the receiving unit and a tablet for transport. The data are shared continuously between the tablets in real time. The communication process starts with the phone call to the regional NICU requesting transport of the critically ill newborn. After initial communication using this technology, physicians can share useful information about the baby's actual condition and subsequently decide initial steps for its effective stabilization. Physicians with limited training and diagnostic and therapeutic tools in regional hospitals can find it difficult to formulate a reliable clinical picture of the disease or abnormality. This technology can prevent complications and the progression of particular disorders and support surveillance.

Description of the equipment

Tablets

For data processing, editing and photo and video recording, regular tablets with detachable

Figure 1. Viewing the ultrasound scans at the bedside.

keyboards are used. They are shock resistant and have two batteries.

Software

The special software was created for collecting administrative and medical data, photo and video files and ultrasound scans in formats enabling cloud-based real time sharing. This software allows participants to be connected to the cloud in real time and view the stored information from different places.

The platform

All the connected equipment uses Microsoft OS Windows 10 and Microsoft Azure with Cloud.

The process

Data editing

The main administrative and medical data are edited directly in the database during the initial phone call between the regional hospital and the NICU. The patient's condition is assessed and directions for diagnostic and therapeutic interventions are given. The emergency ambulance is called and all necessary equipment is installed for the transport.

In the ambulance

The neonates are transported from a distance ranging from 4 to 120 km. Some transfers might cover a distance of 450 km. During transport, the regional hospital may send X-rays, biochemical data, photos or videos of the baby requiring intensive support (**Fig. 2**). This additional information can lead to clearer communication and the actual condition of baby can be consulted.

Initial steps

After the arrival of the emergency ambulance at the regional hospital, all the necessary equipment is moved to the bedside at the neonatal unit. The initial emergency assessment of the newborn is performed and all necessary interventions are processed. The airway is secured or, in the most severe cases, the newborn is intubated and connected to the transport ventilator. Based on the condition of the newborn, emergency treatment is performed (airway suctioning, lung stabilization with artificial surfactant, support of perfusion with inotropes or fluid bolus). After the first interventions, all data

Figure 2. Initial screen for data management.

are edited or recorded in the database using the preformatted screens.

More detailed investigation

Transport ultrasound can be performed, based on the patient's condition. This is very useful to evaluate and scan the various organs, investigate the morphology of the heart, evaluate circulation and visualize the abdominal organs. All the recorded data are transferred to the tablets and cloud at the end of the investigation (**Fig. 3**).

The mother or parents are informed about the condition of the baby before transport to the teritiary center. Detailed investigation allows the physicians and nurses to provide more precise information about the prognosis of the baby. In some cases this investigation may discover the definitive solution for staff and parents.

Results

Over a period of three years, 38 newborns were transported with the help of information technology (IT). The average birthweight was 2,024 g (min 650 g, max 4,150 g), average GA was 34.7 weeks (min 24, max 41). The most common diagnosis for the transport of the newborns postnatally was respiratory distress syndrome or pulmonary maladaptation (23 cases, 61%). All the babies needed some kind of respiratory support, mainly intubation.

Fifteen newborns (39%) were transported for other reasons, 4 for congenital heart disease, 4 transfers were made to the neonatal cardiosurgery unit for surgical PDA ligation. In the group studied, 3 cases of twins were transported for respiratory problems. In 2 cases infection complication was present: 1 had sepsis and the second had congenital syphilis. One newborn had Potter syndrome, with renal agenesis and the transport was canceled. One transport concerned a newborn with an extremely rare congenital abnormality, thoracoschisis, for special surgical intervention.

Discussion

High-risk births inevitably occur in non-tertiary hospitals, despite committed attempts to transfer at-risk women to perinatal centres before delivery by obstetrics teams. Therefore, modifications to prenatal advice, together with improvements in neonatal transport network services and intensive care facilities, could significantly improve the survival of transported neonates and minimize morbidity. Adequate pre-transfer stabilization, safety during transport, and ongoing intensive care in the NICU are essential to improve the outcome of transported neonates [11-13].

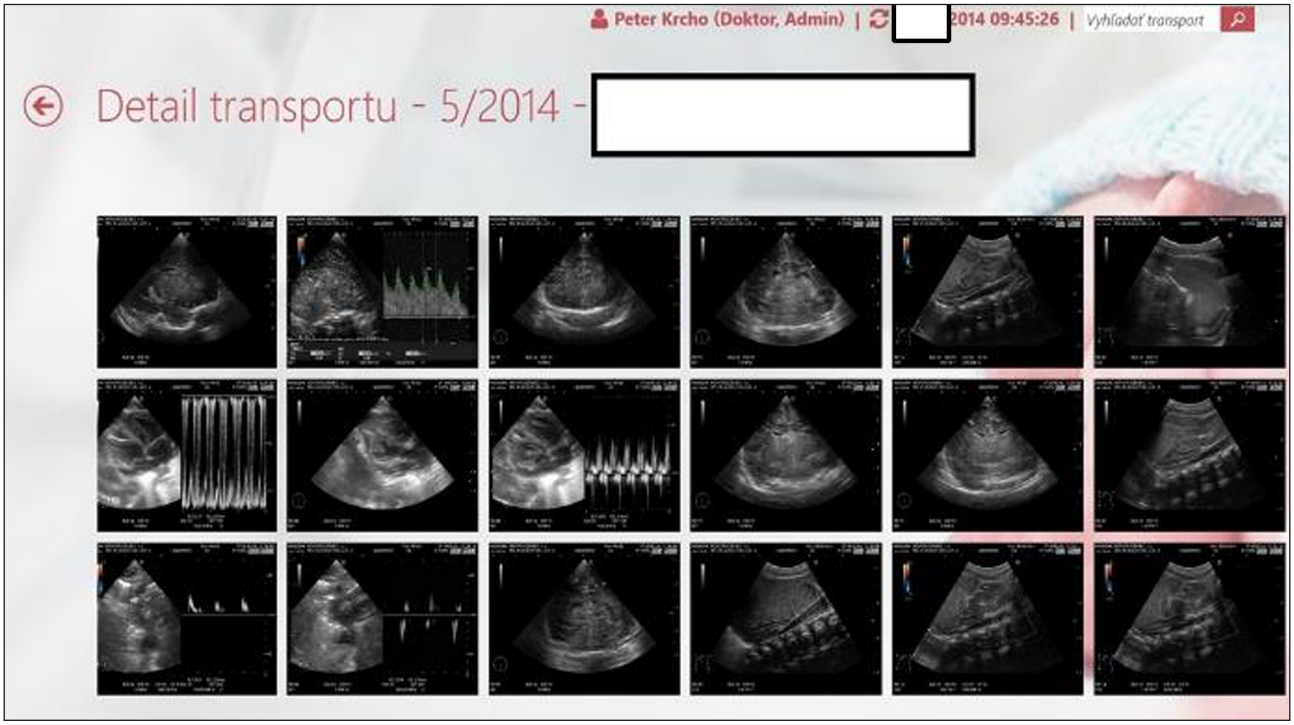

Figure 3. Screen of the recorded ultrasound scans.

This paper shows a new possibility for monitoring more closely the critically ill newborns requiring transport to the NICU. Due to the lack of adequate prenatal centralization in the region, many cases still need urgent specialised diagnostic interventions to select the most appropriate approach. It is extremely important to increase the speed of the final diagnosis. This IT solution was developed to meet this need (**Fig. 4**).

There are several advantages to the system. The most important is the possibility of evaluating the condition of the newborn before transport, assessing the severity of deterioration and the level of urgency or the type of intervention to be performed at the regional hospital before the arrival of the neonatal staff from the NICU. The stored data are shared in real time between the regional hospital, the NICU and the ambulance. After the arrival of the team of intensivists, the newborn is stabilized, in some cases intubated, and the most important drugs are given (surfactant) to prevent respiratory failure. The next step is a more detailed evaluation of the baby's condition, mainly by means of ultrasound of the brain, heart, kidney and all abdominal organs. The scans are recorded and can be seen at the three different locations in real time. An important part of the system is imputing of the data in the database. This includes administrative data but also scoring and detailed evaluation of the biochemical investigation of blood gases and biochemistry. Photos and video files can also be recorded. All the staff at the three different locations can monitor in real time the condition of the newborn: at the NICU before admission, at the regional hospital for re-evaluation and analysis of the procedure performed before the transfer, and the transport team who is responsible for all necessary interventions. The majority of the cases were successfully transported, treated and then discharged from the neonatal centre. One case was not treatable, but the parents received detailed information, with the final diagnosis performed by ultrasound evaluation of the organs. In all the cases it was possible to discuss the scans with specialists and consultants to identify the best logistic approach to the diagnosed abnormality. Especially in congenital heart disease, the possibility of evaluating the morphology of the heart is extremely important for the paediatric cardiologist, and some of the scans could be quickly added to the database. The stored data are an excellent tool for the ongoing education of physicians in the regional hospital and for postgraduate students and they are extremely important for the staff in the NICU before admission to the unit.

Conclusions

Our preliminary experience is the first in Slovakia. Our data are encouraging. We believe

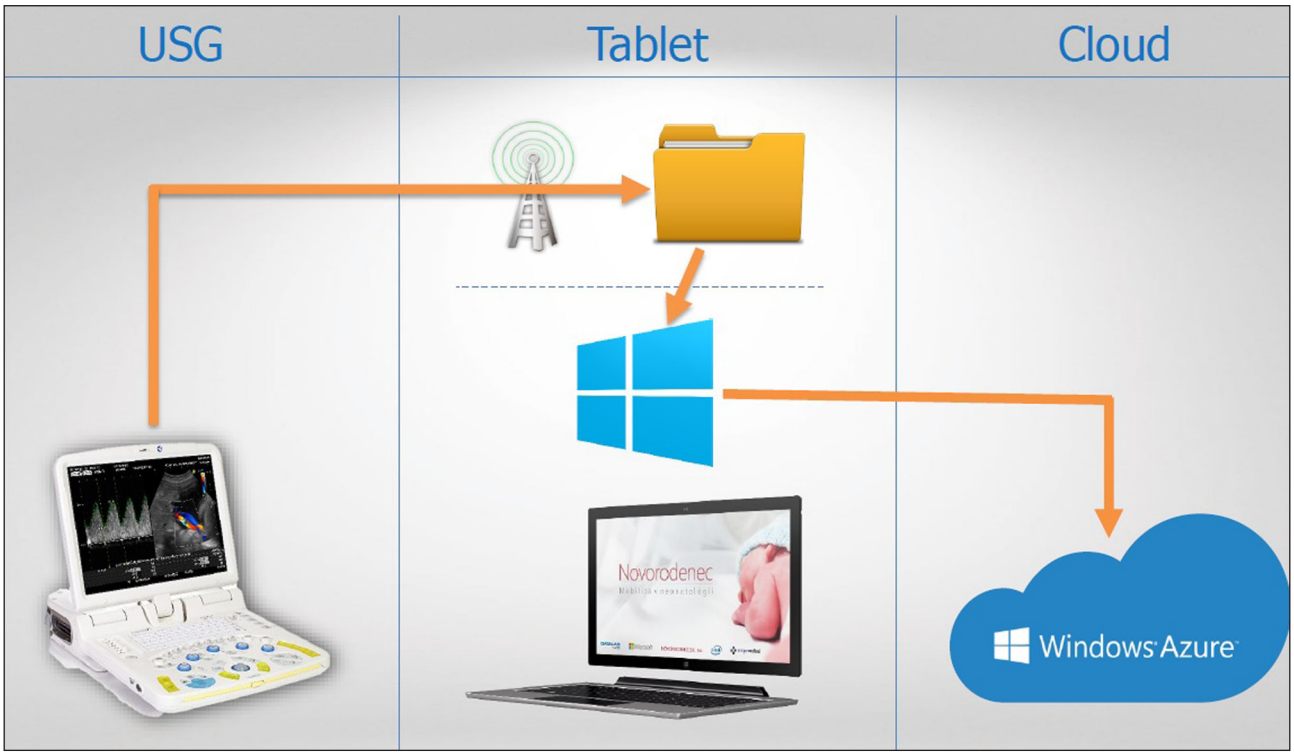

Figure 4. Data sharing between the hardware used in the project.

that research, innovation, and maintenance of regionalization represent the future of perinatal transport. The mandate for highly motivated leadership able to apply epidemiologic, research, and quality-improvement methodology to the area of perinatal transport is essential for progress. The inclusion of continuous quality improvement at the top leadership level of the organizational structure of the perinatal transport system and systematic collection of relevant data within an identified perinatal region represent the backbone for applying new technologies helpful for the patients.

Declaration of interest

The Authors declare that the work was supported by "Novorodenec.sk" N.G.O. The project we developed received few awards, Microsoft Industry Award in 2014 and a special prize in the conference in Orlando in 2015.

Disclosure

Pictures were used with the parents' permission.

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