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Importance of stabilization of the neonatal transport network in critically ill neonates

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Abstract

Objective: This study aimed to investigate how to stabilize the condition of critically ill neonates within the neonatal transport network.

Methods: A total of 243 critically ill newborns in four hospitals involved in the transport network were enrolled. The newborns were divided into the research and control groups. In the research group, medical staff underwent theoretical training, and neonatal intensive care unit (NICU) professionals participated and provided on-site guidance on delivery of high-risk infants. Delivery of high-risk neonates in the control group was conventionally managed in local hospitals, and neonates were transferred after a phone call to the NICU.

Results: Gestational age and body weight were lower, and dexamethasone use was higher in the research group than in the control group. The proportions of neonates who underwent mask pressure, endotracheal intubation, pulmonary surfactant application, and chest compressions were higher, and those with dyspnea and nervous system abnormalities were lower in the research group than in the control group. Blood gas and sugar levels were better in the research group than in the control group.

Conclusion: Strengthening professional training and participation of professional NICU staff in childbirth can improve the conditions of high-risk neonates and increase safety of their transportation.

Keywords

Transportation network, hospital exchange, training, high-risk neonates, blood gas, neonatal intensive care unit

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Introduction

The neonatal transport system was first founded in the United States in 1950.[1] The neonatal transport system in China was initiated in the early 1990s. After more than 20 years, this system has made huge progress.[2] However, there are multiple steps involved in the transfer process, and the resources possessed by various local medical units differ. Therefore, inter-hospital communication, transport processes, and systems affect the transport system.[3] Stability of critically ill children before transfer is the initial step to determine whether transfer can be conducted. Additionally, timely and appropriate management of high-risk neonates after delivery are important for successful transfer.[4] Well-developed neonatal transport network services and intensive care facilities could significantly improve survival of transported neonates and minimize morbidity.[5,6] To determine a method of stabilizing the condition of critically ill children within the neonatal transport network, for nearly 3 years, our hospital has strengthened communication between hospitals involved in the neonatal transport network. Furthermore, various medical training has been carried out and many staff have participated in managing the delivery process of critically ill newborns. This has obtained good results, and provided a feasible method of improving the efficiency of transport and the success rate. We report the details of our investigation on stabilizing the condition of critically ill newborns within the neonatal transport network.

Materials and methods

This study was conducted in accordance with the declaration of Helsinki. This study obtained approval from the Medical Ethics Committee of The First Hospital of Tsinghua University. Written informed consent was obtained from the guardians of all participants.

Study subjects

From 1 January 2012 to 31 December 2014, all high-risk neonates who were transferred by the transport network were included in this study. The transport network involved four hospitals, and the neonatal intensive care unit (NICU) of our hospital was the main center. Neonates were assigned into one of two groups, according to the level of perinatal care as follows:[7] the research group and control group. Neonates with congenital birth defects were excluded.

Research methods

Identification and evaluation of high-risk pregnant women and high-risk neonates were unified by a centralized teaching mode,[8] as well as basic treatment methods for critically ill children. Specific training content included understanding and evaluating fetal distress,[9,10] identification of high-risk pregnancy and high-risk neonates,[11–13] the neonatal critical illness score;[14,15] neonatal asphyxia resuscitation technology,[16,17] central venous catheters, and premature management.[18]

The team in the research group contacted the NICU of our hospital by phone before delivery of high-risk pregnant women. After preliminary understanding of the patient's condition and communications, medical staff and an ambulance were sent by the NICU and arrived before childbirth, and participated in the whole process of childbirth. NICU medical personnel offered on-site guidance for rescue and treatment of critically ill newborns.

In the control group, delivery of high-risk newborns was managed by medical staff in local hospitals. The local hospital contacted the NICU of our hospital after birth of the neonate and described the

situation of the newborn. The NICU then sent medical staff and an ambulance to transfer the neonate to our hospital.

Statistical methods

An Epidata data file was established. Data were statistically analyzed using the statistical software program SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Count data are expressed as the number of cases and rates, and intergroup comparison was conducted by the chi-squared test or Fisher's exact probability test. Normally distributed measurement data are expressed as mean $\pm$ standard deviation, and intergroup comparison was conducted using the *t*-test. Non-parametric tests were used to compare measurement data that did not conform to a normal distribution and homogeneity of variance. $P < 0.05$ was considered statistically significant.

Results

The research group comprised 111 high-risk neonates and the control group comprised 132 high-risk neonates. Gestational age was significantly shorter and body weight was lower in the research group than in the control group (both $P < 0.001$, Table 1). The number of cases with administration of dexamethasone was higher in the research group than in the control group ($P < 0.001$, Table 1). Sex, delivery mode, placental abnormality, abnormal amniotic fluid, an abnormal umbilical cord, maternal diabetes rate, pregnancy-induced hypertension rate, maternal infection rate during pregnancy, and congenital heart disease rate were not significantly different between the two groups (Table 2).

Measures for the delivery of neonates in the two groups were as follows. The numbers of cases with application of mask pressure, endotracheal intubation, and T-piece use were significantly higher in the research group than in the control group (all $P < 0.05$). The numbers of cases with pulmonary surfactant application and chest compressions were significantly higher in the research group than in the control group (both $P < 0.001$). Additionally, the

Table 1. Comparison of general characteristics during the perinatal stage between the two groups.

Characteristic	Research group (n = 111)	Control group (n = 132)	χ^2/t	*P*
Sex, male/female (%)	56/55 (50.5/49.5)	66/66 (50/50)	0	0.953
Gestational weeks	32.63 ± 2.34	34.89 ± 1.53	8.97	<0.001
Birth weight (g)	1828.7 ± 489.4	2397.3 ± 398.4	9.98	<0.001
Cesarean delivery, n (%)	82 (73.9)	83 (62.9)	2.86	0.09
Placental abnormality, n (%)	11 (9.9)	17 (12.9)	0.27	0.63
Abnormal amniotic fluid, n (%)	13 (11.7)	13 (9.8)	0.02	0.886
Abnormal umbilical cord, n (%)	16 (14.4)	21 (15.9)	0.07	0.795
Premature rupture of the membranes, n (%)	19 (17.1)	30 (22.7)	0.86	0.355
Intrauterine fetal distress, n (%)	38 (34.2)	49 (37.1)	0.47	0.116
Diabetes, n (%)	37 (33.3)	52 (39.4)	0.41	0.52
Pregnancy-induced hypertension syndrome, n (%)	29 (26.1)	30 (22.7)	0.22	0.642
Infection, n (%)	17 (15.3)	15 (11.3)	0.57	0.109
Heart disease, n (%)	27 (24.3)	28 (21.2)	0.18	0.672
Dexamethasone, n (%)	92 (82.9)	63 (47.7)	30.76	<0.001

Values are mean ± standard deviation of n (%).

Table 2. Comparison of fetal problems, disease, and dexamethasone treatment during the perinatal stage between the two groups.

	Premature rupture of the membranes, n (%)	Intrauterine fetal distress, n (%)	Diabetes, n (%)	Pregnancy-induced hypertension syndrome, n (%)	Infection, n (%)	Heart disease, n (%)	Dexamethasone, n (%)
Research group (n = 111)	19 (17.1)	38 (34.2)	37 (33.3)	29 (26.1)	17 (15.3)	27 (24.3)	92 (82.9)
Control group (n = 132)	30 (22.7)	49 (37.1)	52 (39.4)	30 (22.7)	1 5 (11.3)	28 (21.2)	63 (47.7)
χ^2	0.86	0.47	0.41	0.22	0.57	0.18	30.76
P	0.355	0.116	0.52	0.642	0.109	0.672	<0.001

Table 3. Comparison of treatment measures between the two groups.

	Nasal catheter oxygen inhalation, n (%)	Mask pressure, n (%)	Tracheal intubation, n (%)	T-piece use, n (%)	Salt water (vasoactive drug), n (%)	External chest compression, n (%)	PS use, n (%)	Meconium aspiration, n (%)
Research group (n = 111)	50 (45)	61 (55)	57 (51.4)	54 (48.6)	8 (7.2)	34 (30.6)	34 (30.6)	5 (4.5)
Control group (n = 132)	87 (65.9)	54 (40.9)	8 (6.1)	15 (11.4)	1 (0.8)	6 (4.5)	7 (5.3)	1 (0.8)
χ^2	9.84	4.23	60.83	15.17	–	23.89	25.8	–
P	0.002	0.04	<0.001	<0.001	0.013	<0.001	<0.001	0.096

P values were obtained by Fisher's exact probability test.
PS: pulmonary surfactant.

proportion of cases with nasal catheter oxygen inhalation was higher in the control group compared with the research group ($P = 0.002$) (Table 3).

We compared the clinical situation of the two groups of neonates upon admission to the hospital. The respiratory rate, amount of groaning (sound emitted by a semi-closed glottis as an extended exhalation after deep inhalation), and inspiratory depression performance were lighter in the research group than in the control group (all $P < 0.05$). There were significantly fewer neonates with neural inhibition and those who were fidgety in the research group than in the control group (both $P < 0.001$). Transcutaneous oxygen saturation was significantly higher in the research group than in the control group ($P < 0.001$). Differences in heart rate, cyanosis, and pale appearance were not significantly different between the two groups (Table 4).

Blood gas results, such as pH, arterial carbon dioxide pressure, base excess, and bicarbonate values, were significantly better in the research group than in the control group (all $P < 0.05$). Blood sugar levels were significantly better in the research group than in the control group ($P < 0.05$, Table 5).

Discussion

Neonatal transport can be divided into three steps of before transport, during transport, and after transport. Stability of conditions before transport, close monitoring during transport, and active treatment

Table 4. Comparison of clinical manifestations in neonates of the two groups at admission.

	Respiration (breaths/ minute)	Groaning, n (%)	Reflection: inhalation dyspnea, n (%)	Heart rate, (beats/ minute)	Cyanosis, n (%)	Pale appearance, n (%)	$TCsO_2$ (%)	Inhibition, n (%)	Fidgety, n (%)
Research group (n = 111)	45.33 ± 7.64	30 (27)	7 (65.8)	133.73 ± 7.64	109 (98.2)	5 (4.5)	91.22 ± 4.09	19 (17.1)	24 (21.6)
Control group (n = 132)	49.42 ± 10.58	86 (65.2)	109 (82.6)	131.4 ± 17.30	123 (93.2)	5 (3.8)	87.51 ± 4.61	64 (48.5)	63 (47.7)
Z/χ^2	2.54	33.62	8.19	1.05	2.45	2.55	3.57	25	18.62
P	0.015	<0.001	0.004	0.31	0.118	0.120	<0.001	<0.001	<0.001

Values are mean ± standard deviation of n (%). $TCsO_2$: transcutaneous oxygen saturation. "Inhibition" means after receiving stimulation, tissue or body activity weakened or became relatively static.

Table 5. Blood gas and blood sugar measurements in the two groups after admission.

	pH	$PaCO_2$ (mmHg)	PaO_2 (mmHg)	SaO_2 (%)	BE (mmol/L)	$HCO3^-$ (mmol/L)	Blood sugar (mmol/L)
Research group (n = 111)	7.30 ± 0.08	41.34 ± 3.16	71.34 ± 32.95	83.69 ± 15.33	−4.21 ± 2.19	21.19 ± 2.63	3.44 ± 0.99
Control group (n = 132)	7.18 ± 0.10	45.65 ± 7.69	71.75 ± 23.58	79.91 ± 17.55	−5.65 ± 2.77	18.48 ± 3.63	3.0 5 ± 2.16
t	2.853	2.109	1.062	1.712	2.593	2.541	2.072
P	0.008	0.037	0.328	0.061	0.013	0.019	0.035

Values are mean ± standard deviation. $PaCO_2$: arterial carbon dioxide pressure; PaO_2: arterial oxygen pressure; SaO_2: arterial oxygen saturation; BE: base excess; $HCO3^-$: bicarbonate.

after transport cannot be separated. Understanding every step plays a decisive role in the occurrence and development of disease in children.[19,20] In particular, stability of the patient's condition is a prerequisite for a safe transport. Good transition of the respiratory cycle in critically ill children after delivery depends on timely and effective establishment of autonomous respiration after birth. Asphyxia, premature birth, maternal diabetes, high blood pressure, and infection are common causes and risk factors that make establishing respiration difficult after birth in ill children.[21] Management of the first few minutes after birth is not only key to survival of ill children, but is also key to success or failure of the whole transport process. Furthermore, this management improves safety and ensures quality of transport.

Since 2012, on the basis of summing up the experience of transport for longer than 10 years, our hospital enhanced its regional transport, and improved the transport range to more than 10 hospitals surrounding our hospital. In our study, four hospitals that have certain midwifery levels in the transport area were chosen to be included. Two hospitals were assigned into one group and two hospitals were assigned into the other group according to the level of perinatal care. In the form of concentrated teaching, inter-hospital training within the transport network was enhanced, and understanding of identification and treatment of critically ill children by health care staff in the research group were unified. Furthermore, combined with cooperation of experience of the Pediatrics Department of our hospital, communication between

these two hospitals was strengthened, and communication and cooperation between our NICU and the other hospitals were strengthened. Additionally, our hospital participated in field treatment for delivery of critically ill neonates, and provided on-site treatment guidance for hospitals in the research group. This enabled ill neonates to receive pre-hospital treatment after delivery and before transport. Our study showed that gestational age and body weight were lower in high-risk neonates in the research group than those in the control group. Furthermore, the number of patients who received dexamethasone was higher in the research group than in the control group (Table 1). These findings suggest that the critical degree of illness in neonates was higher in the research group than in the control group. High-risk neonates in the research group were escorted in the whole process of delivery by professional staff in the NICU of our hospital.

Before delivery, there was full exchange and communication regarding perinatal conditions of the ill neonates between the NICU and obstetric doctors in the local hospital. However, staff at the NICU fully assessed the possible situation of ill neonates after birth and made full preparations before birth for ill neonates. These staff then participated in the whole process of delivery. After delivery, the measures taken by the NICU staff for ill neonates were not only simple oxygen inhalation, but also included mask pressure ventilation. Furthermore, application of T-piece resuscitation combined with a tracheal cannula, pulmonary surfactant, vasoactive drugs, and other measures were more frequently applied in the research group than in the control group (Table 3). Because active measures were taken for ill neonates in the research group after birth, the incidence of dyspnea, neurological abnormalities, acidosis, and hypoglycemia was lower than that in the control group. Furthermore, the respiratory rate and percutaneous oxygen saturation were better in the research group than in the control group (Tables 4 and 5). These results were closely associated with adequate preparations before delivery and active and appropriate measures after delivery. In this study, through theoretical training for pediatric medical staff in the research group, identification of high-risk neonates and treatment after delivery were strengthened. Through timely contact and communication between the hospitals, and full cooperation and collaboration with the medical staff in local hospitals, NICU professionals participated in the whole process of delivery of high-risk neonates, and provided accurate and timely treatment. This not only improved the treatment level of the local hospitals for critically ill neonates, but also improved stabilization of the condition of ill neonates, which ensured the safety of transport.

There are some limitations of this study. First, there were differences in the initial characteristics of the groups, such as gestational weeks, birth weight, and dexamethasone use. Second, there were no data on pH after admission. Third, this was not a randomized, controlled trial. This study included critically ill neonates. In view of the special nature of premature pathological conditions, further studies should divide critically ill neonates into preterm and full-term infants to obtain more accurate results.

In conclusion, establishment of unified identification and disposal measures for critical illness and medical training in hospitals that involve the transport network combined with on-site treatment guidance can consolidate the quality of medical staff in our NICU. Furthermore, this process can improve understanding, evaluation, and emergency treatment abilities of related medical staff who treat high-risk pregnant women and neonates in the hospitals involved in the transport network, stabilize the conditions of sick neonates, and provide security for successful transfer.

The combination of professional training and on-site treatment guidance is a feasible method of improving the efficiency of transport in the network and the success rate of treatment.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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