

Risk factors associated to clinical deterioration during the transport of sick newborn infants

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SUMMARY

Adequate neonatal transport is a key component in the care of newborn infants that require transfer.

Objective. To determine the characteristics and risk of clinical deterioration during neonatal transport.

Material and Methods. This was an observational and prospective study that consecutively included newborn infants transferred to the Neonatal Intensive Care Unit (NICU) of the Hospital Garrahan. The TRIPS (Transport Risk Index of Physiology Stability) risk score was measured pre- and post-transport.

A diagnosis of clinical deterioration was made when the post-transport TRIPS score was higher than the pre-transport score. Newborns characteristics, transport distance, newborns status upon admission, need for immediate cardiorespiratory support (ICRS), and death before the 7th day and at discharge were recorded. Bivariate and multivariate analyses were used to assess the associations with clinical deterioration.

Results. A total of 160 transferred newborn infants were enrolled, gestational age (GA) was 35 ± 3 weeks; birth weight (BW) 2482 ± 904 g and median age 2 days. Most were referred due to cardiorespiratory (50%) or surgical (34%) illnesses. Of them, 91 (57%) had clinical deterioration and 46% hypothermia. Forty nine neonates required ICRS and 28 died (twelve before 7 days after admittance). Variables assessed were not associated with the risk of clinical deterioration. Mortality was higher in the group with clinical deterioration (OR: 3.34; 95% CI: 1.2-8.7), even when severity of the clinical picture was considered (OR_A: 3; 95% CI: 1.2-8.3). Clinical deterioration during transport was associated with the need for ICRS (OR: 2.4; 95% CI: 1.2-5).

Conclusions. In our experience transferred newborn infants often suffered loss of stability or clinical deterioration, regardless of their characteristics, and this was related to a higher mortality. Therefore, it is critical to optimize care strategies during all neonatal transports.

Key words: newborn infant care, neonatal transport, neonatal intensive care unit.

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INTRODUCTION

Adequate neonatal transport is a key component of care of the sick newborn infant who requires refer-

ral to tertiary care centers that provide higher levels of care. When a newborn infant is referred, transport may interfere with several aspects of his/her homeostasis, such as thermoregulation, metabolic stability, fluid and electrolyte balance, and cardiorespiratory status, among others. This interference may cause clinical deterioration, especially when the quality and continuity of monitoring and/or treatment is not ensured as during hospitalization.^{1,2} Instability or complications secondary to transport may result in greater morbidity and mortality in these vulnerable newborn infant.³

In our country, when a newborn infant needs to be transported to a tertiary care center, several options are possible: referral may be handled by referring institutions, by referral institutions, or by systems specifically dedicated to patient transport; these modalities are heterogeneous and generally do not respond to regionalization program requirements.

The neonatal intensive care unit (NICU) of Hospital "Prof. Dr. Juan P. Garrahan" is a reference health care center for severely ill newborn infants referred from other institutions of our country. Every year, an average of 650-700 newborn infants are admitted, of whom about 60% are patients accepted after referral is requested, from various institutions in Buenos Aires or from other provinces; the remaining newborn infants are admitted via spontaneous consultations to the hospital's emergency room or private pediatric offices, including various pediatric subspecialties.⁴ In a study conducted in our unit to assess risk factors for mortality and

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prolonged NICU stay, we saw that in more than one third of referred patients, monitoring failures had occurred during transport, with deficits in cardiorespiratory care and thermoregulation, which were not systematically reported by the physicians who admitted the infants.⁵ Similarly, our daily experience suggests that some newborn infants admitted to the NICU suffer worsening of their condition or become unstable during transport between institutions. In our country, no studies have been conducted to systematically assess the process of neonatal transport; hence we decided to evaluate the quality and impact of neonatal transport in a population of sick newborn infants referred to our NICU. To measure the consequences of transport on the newborn infant clinical stability, we used the TRIPS score (Transport Risk Index of Physiology Stability), which is based on four components of physiological stability that are easily recorded: temperature (0 to 8), blood pressure (0 to 26), response to stimuli (0 to 17) and respiratory status (0 to 14) (Figure 1).

The TRIPS score⁶ is a tool that evaluates the transport process and stability of the newborn infant during transport; it was validated in a cohort of 1723 newborn infants of various gestational ages (GA) and birth weights (BW). The TRIPS score allowed the discrimination of patients' mortality in the NICU with a relative response curve (ROC curve) of 0.83, regardless of their GA. In the original validation report, TRIPS was classified in 4 categories according to the measured value (higher numbers account for more critically ill newborn infants): low score (0-10), moderate score (11-20), high score (21-30) and very high score (> 30). Pre- and post- transport measurements allowed the detection of changes in the clinical condition during referral, an increase in score during refer-

ral was associated with higher neonatal mortality.

The objectives of this study were to describe the characteristics of neonatal transport and assess the risk of loss of stability or clinical deterioration during transport using the TRIPS score, analyze potential factors associated with clinical deterioration and determine their impact on the newborn infants' outcome.

MATERIAL AND METHODS

This is an analytic and observational study of a prospective cohort. All patients admitted to the NICU of Hospital Garrahan and transported from various institutions between July 1, 2009 and May 31, 2010 were included.

Sample selection was performed consecutively; newborn infants admitted without a request of referral or by spontaneous demand from the emergency room were excluded, as well as neonates with malformations or diseases not compatible with life.

Information on the following variables was collected: BW, GA, sex, mode of delivery, Apgar score (at 1 and 5 minutes), age at the moment of transport (days of life) and the presence of an antenatal diagnosis (defined as the presence of a malformation or congenital disease during pregnancy). For every referral, the following data were also recorded: transport distance in kilometers according to three ordinal categories (<60 km, 60-300 km, >300 km), place of referral, type of disease (according to the main organ or system involved), severity of the infant's condition according to the SNAP II risk score, use of respiratory assistance and/or administration of inotropic drugs during transport, professionals in charge of the transport. Selection of these variables was related to the assumption that more immature or severely compromised children,

FIGURE 1. TRIPS score

Parameter	Value	TRIPS score
Temperature	<36.1°C or >37.6°C	8
	36,1/36.4°C or 37.2/37.6°C	1
	36.5°C to 37.1°C	0
Respiratory status	Severe (apnea, gasping, intubated)	14
	Moderate (RR >60/min and/or O ₂ sat <85%)	5
	Normal (RR ≤60/min and/or O ₂ sat ≥ 85%)	0
Systolic blood pressure	<20 mmHg	26
	20-40 mmHg	16
	>40 mmHg	0
Response to painful stimuli	No response, seizures, on muscle relaxants	17
	Lethargic, no crying	6
	Crying and withdrawal	0

and/or longer distance (with longer duration of transport) could be predisposing factors for deterioration. Additional data recorded were: the use of an incubator, infusion pump, vascular accesses and type of monitoring (heart rate, saturimetry, and blood pressure). The dependent variable or the result measured for this study was primarily, clinical deterioration (CD) or infant loss of stability during transport, assessed by the change in the TRIPS score (measured at the beginning of transport and upon admission to the unit). Cases classified in the "CD" category were those in which the TRIPS score at admission was higher than before transport (regardless of the numerical difference, provided it was higher), and without "CD" when the TRIPS score at admission was equal or lower than the pre-transport score. Secondary measurements were: neonatal outcome such as mortality (before day 7 after admission and at discharge) and the need for cardiorespiratory support immediately post transport (ICRS), defined as the need for mechanical ventilation (MV) and/or increase in FiO_2 greater than 50% of the baseline concentration, or the administration of new inotropic drugs or an increase in dose greater than 50% in the first 60 minutes after admission; this variable (ICRS) was used to represent the child's clinical instability upon admission to the NICU. Adequate temperature at admission was defined as an axillary temperature between 36.2°C and 37°C, and normoglycemia as glycemia levels between 50 and 100 mg/dl.

All data were collected in a special worksheet. The initial TRIPS value was assessed immediately before transport by the referring physician (with the help of the neonatologist who accepted the referral to the NICU) and recorded on the referral sheet; the post-transport TRIPS score was assessed by the referral physician (who was unaware of the previous value), at the time when the newborn infant was admitted to the unit. All physicians in the unit were previously informed and trained in the use of the TRIPS score.

For statistical analysis, numeric data were expressed as means, medians and the respective standard deviations or quartiles according to their distribution; 95% confidence intervals (CI) were used to estimate the precision of results. Categorical data were described as proportions. To calculate the sample size, it was estimated that a total of 150 cases were required in order to obtain a 30% proportion of CD, the primary outcome (according to previous data), with a $\pm 5\%$ accuracy and an 80% statistical power. To compare numerical variables, the t-test or the Wilcoxon test were used

for paired or independent data, and the chi-square test was used for categorical variables. Logistic regression multivariate analysis was used to adjust effect measures, to assess the effect of confounding variables. The measures of effect, the OR and the adjusted OR (OR_A), were reported with their respective 95% CI. A two-tailed p value <0.05 was considered significant. The STATA 10.0 (Stata Corp Texas) software was used for statistical processing.

The study was approved by the Review and Ethics Committees of Hospital Prof. Dr. Juan P. Garrahan. In all cases, patients' data and referring centers were kept confidential.

RESULTS

A total of 160 newborn infants transported, who met the eligibility criteria, were included in the study. The main characteristics of the group and their origin are described in *Table 1*.

In all cases, patients were transferred by ground transportation and in 85% of the cases, the infant was assisted by a neonatologist during this stage.

The pre-transport TRIPS score was, in average, 17 ± 14 (median 20, 25-75 quartiles: 1-31). The post-

TABLE 1. Characteristics of the 160 transported patients included in the study

Gestational age (X \pm SD, weeks)	36 \pm 3
Birth weight (X \pm SD, g)	2482 \pm 904
Newborn infant < 1500 g	32 (20%)
Preterm infant	75 (47%)
Male sex	80 (50%)
Age at admission (days, median and IQI)	2 (1-13)
Main diagnosis	
Cardiovascular	29%
Respiratory	21%
Surgical	34%
Others	16%
Antenatal diagnosis	32 (20%)
Referred from	
CABA (City of Buenos Aires)	65 (41%)
Greater Buenos Aires Area	77 (48%)
Provinces	18 (11%)
Transport distance	
<60 km	130 (81%)
60-300 km	14 (9%)
>300 km	16 (10%)
Mechanical ventilation	66 (57%)
Use of inotropic drugs	42 (26%)
SNAP II (median and IQI)	6 (3-14)
SNAP II >14	23 (14%)

transport TRIPS score was 21 ± 15 (median 21, 25-75 quartiles: 6-32).

In the study population, risk according to the pre-transport TRIPS score was distributed as follows: 62 newborn infants (39%) with a low score (0-10), 25 newborn infants (16%) with a moderate score (11-20), 11 newborn infants (7%) with a high score (21-30) and 62 newborn infants (39%) with a very high score (>30). Table 2 depicts the mean values of pre- and post-transport overall TRIPS scores, and according to risk categories. In low, moderate and very high-risk categories, the post-transport value was significantly higher than pre-transport; in the high risk category, with fewer number of cases, the *p* value was 0.051 and, hence, did not reach statistical significance.

In 57% of referrals (91/160 newborn infants) CD was observed (TRIPS at admission to the NICU was higher than that measured pre-transport). The TRIPS score remained unchanged in 57 cases (36%) and decreased in 12 (7%). When analyzing the components of the score that were most affected in the 91 children with CD, we saw that loss of thermal and respiratory stability were the variables that most often became unstable.

Use of an incubator, infusion pump and pulse oximetry was almost constant (98%); only 4 newborn infants had their blood pressure checked during transport. Forty-six percent (73 newborn infants) of the infants had hypothermia on admission to the unit and 20% (32 newborn infants) had abnormal glycemia levels. As to vascular accesses, 77 newborn infants (48%) had a peripheral vascular access in place; in 25 the access was percutaneous, 10 had a catheter in the umbilical vessels, and the rest were peripheral; however, 12% of them were not patent at admission.

When factors most commonly associated with CD during transport were analyzed, no differences were found in any of the study variables; i.e., neither newborn infant GA, BW, age, status, treatment requirements nor transport distance, severity, treatment requirements or transport distance were associated with a higher frequency of CD (Table 3).

Thirty-one percent of the newborn infants (49) were unstable at admission and required ICRS (MV and/or FIO₂ > 50% or administration of inotropics or increase in dose greater than 50% of the admission level during the first hour post-admission); this need was associated with CD during transport (OR: 2.45; 95% CI: 1.2-5).

Of the 160 patients included in the study, 28 died (17.5%), 12 of them before day 7 after admission. Mortality was higher in the group with CD (24%) compared with the group without CD (9%) (OR: 3.34; 95% CI: 1.27-8.78) and this association persisted even after considering the severity of the newborn infant's condition (ORA: 3; 95% CI: 1.2-8.3); the relationship with death before day 7 after admission did not reach statistical significance (OR: 4.1; 95% CI: 0.9-19).

DISCUSSION

In this study we have assessed the problem of neonatal transport in our country, in a neonatal intensive care reference unit that receives referrals of critically ill newborn infants. As the experience and some prior studies suggested,^{4,5} we saw that newborn infants who required transport to access our unit frequently became unstable, and this deterioration was independent from the child's characteristics and the type or severity of their condition.

TABLE 2. Pre-transport and post-transport TRIPS overall scores and according to risk category (assessed according to pre-transport value)

	Pre-transport TRIPS, mean (95% CI)	Post-transport TRIPS, mean (95% CI)	p value *
Overall values, 160 newborn infants	17.57 (15.34 - 19.8)	21.38 (18.96 - 23.79)	< 0.001 [#]
Values according to risk category			
Low (0-10) 62 newborn infants	1.67 (1.03-2.32)	5.48 (3.69-7.27)	< 0.001 [#]
Moderate (11-20) 25 newborn infants	16.84 (15.55-18-12)	20.88 (18.08-23.07)	= 0.001 [#]
High (21-30) 11 newborn infants	21.90 (20.51-23.30)	27.36 (21.65-34.07)	0.05
Very high (> 30) 62 newborn infants	33 (31.96-34.03)	36.41 (34.53 - 38.30)	= 0.005 [#]

X (95% CI): mean value and 95% CI.

Significant.

* Wilcoxon's test for paired data.

It is not possible to state whether deterioration is secondary to progression of the condition leading to the patient's transport or whether it is related to the quality of neonatal care; however, in all cases another severity score, the SNAP, was measured, and deterioration occurred even in children with more stable conditions.

Additionally, the impact of this deterioration could be related with a worse outcome, measured through mortality rate, and secondarily by the need for intensive cardiopulmonary support close to admission.

Transport of a neonatal patient requires trained human resources, equipment and procedures that are protocol-based and subject to audit.

In developed countries, transport teams operating under the regionalized framework of neonatal care, are in charge of transporting newborn infants from lower level care centers to tertiary care centers, which ensures a homogenous and evaluable quality of care⁷.

Availability and assessment of neonatal care during transport has raised interest in several groups,^{9,10} and, generally, studies are based on measuring patients's stability during this period. Several scales have been designed to measure the impact of transport on newborn infants. The Neonatal Stabilization Score¹¹ evaluates the process in extremely low birth weight newborn infants, as well as Hermansen's transport score¹², validated only for very low birth weight (VLBW) infants. The NSST¹³ (Neonatal Status Score) and the ANTSS¹⁴ (Alberta Neonatal Transport Stabilization Score) are other tools that allow to calculate the weight of different variables based upon the local experience acquired. Finally, neonatal risk scores that are most used, such as the CRIB¹⁵ (Clinical Risk Index for Babies) and the SNAP II¹⁶ (Score for Neonatal Acute Physiology) seek to determine the stability and severity of newborn infants, but require to collect data for 12 hours, which hinders their use during transport.

The TRIPS¹ score was designed in 2001⁶ and systematically used¹⁷ by the Canadian Neonatal Care Network to assess newborn infants during transport, independently from GA and weight. The choice of this score for our study was also based on its simple measurement, since parameters used for this calculation are easy to be measured by the referring physician as well as the referral physician, and do not depend on laboratory tests or subjective impressions, thus avoiding inter-observer variability and hence, measurement bias.

Additionally, as in the original report⁶, we found that the increase in the TRIPS score after transport was associated with newborn infant mortality, emphasizing the importance of neonatal care during this stage.

In contrast to other studies, in which the status of the newborn infant before transport, together with GA, distance or duration of transport affected stability^{18,19}, no differences were found that could discriminate infants with higher risk of CD, indicating that even newborn infants who are less critically ill require safe care during transport to prevent complications such as hypothermia or hypoglycemia from occurring.

Our study has several limitations: although the score is simple, it was obtained by different physicians and hence, measurement bias may have occurred; also, because of the sample size, power was insufficient to estimate the risks associated to deterioration. Perhaps a study with more patients could have identified which children with CD are at greater risk.

TABLE 3. Comparison of patients with and without clinical deterioration (CD) during transport. Bivariate analysis

	With DC N: 91	Without DC N: 69	p value*
Days of life	10 ± 15 days	10 ± 18 days	0.88
Transport < 7 days of life	58 (64%)	51 (74%)	0.17
BW	2406 ± 926 g	2581 ± 870 g	0.22
VLBW infants (< 1500 g)	22 (24%)	10 (15%)	0.12
GA	35 ± 3 weeks	35 ± 4 weeks	0.76
SNAP	7.5 ± 5.6	6.1 ± 5.1	0.10
Pre-transport TRIPS	16 ± 13	19 ± 14	0.23
Critically ill newborn (SNAP > 14)	15 (16%)	8 (12%)	0.38
Distance > 60 km	19 (21%)	11 (16%)	0.42
Cardiorespiratory disease	48 (53%)	32 (46%)	0.42
Use of MV	50 (55%)	41 (59%)	0.57
Use of oxygen therapy	49 (54%)	29 (42%)	0.13
Use of inotropics	27 (30%)	15 (22%)	0.25
Central vascular accesses	48 (53%)	35 (51%)	0.80
Patent line	80 (88%)	60 (87%)	0.85
Antenatal diagnosis	17 (19%)	15 (22%)	0.63

t-test or Wilcoxon test- Chi-square test.

CD: clinical deterioration (post-transport TRIPS > pre-transport TRIPS).

In Argentina about 700,000 babies are born every year; it is estimated that 6-8% of them will require admission to a NICU. Some of these births take place in maternities where the type or complexity of the neonatal condition exceeds the institution's capability or the possibility of diagnosis or treatment. Fortunately, the detection of the disorder in the perinatal period allows to high risk pregnant women to maternities with tertiary neonatal intensive care, where newborn infants can be assisted and thus, transfer to other institutions is prevented. In such cases, the best "neonatal transfer", i.e., transport in the mother's womb, can be assured. However, due to many circumstances, such as the lack of appropriate follow-up during pregnancy and/or the lack of an antenatal diagnosis, newborn infants must often be transferred to a tertiary NICU after birth. Considering this setting, regionalizing the care of newborn infants who require intensive care and optimizing assistance during transport are key strategies to improve neonatal health outcomes in our country. Also, setting up teams of trained physicians and nurses with standardized procedures becomes a priority, since that strategy has been shown to optimize outcomes in the transport of critically ill children and newborn infants in other centers worldwide.²⁰⁻²²

Optimizing neonatal care during transport is important, even in its simpler albeit fundamental aspects, such as adequate thermoregulation and glycemia management. The use of tools or scores to systematically measure the quality of transport allows to audit and optimize quality of care, thus improving safety and efficiency of neonatal health care.

CONCLUSIONS

The data of our study show that a high percentage of referred newborn infants, regardless their clinical status, suffer deterioration during transport, which results in a higher risk of early neonatal mortality. ■

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