Original Article

Prognostic Role of Temperature Oxygenation Perfusion Sugar (TOPS) score in Outborn Transported Neonates in a Tertiary Care Center—A Prospective Cohort Study

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Abstract

Background: Neonatal outcomes are affected by the acute physiologic derangements of neonatal vitals, such as temperature, blood sugar (GRBS), perfusion, and oxygenation. The aim was to correlate the temperature oxygenation perfusion sugar (TOPS) score of outborn neonates transported with the morbidity and mortality during hospitalization in the neonatal intensive care unit (NICU).

Methods: Five hundred transported neonates were enrolled in this prospective cohort study by scoring TOPS vitals within an hour of NICU admission, and the outcomes were assessed after 72 hours of hospitalization.

Results: Among 500 neonates, hypoglycemia, hypoperfusion, hypoxemia, and hypothermia were found in 13%, 32%, 30%, and 37%, respectively. One hundred five (21%) neonates did not survive. Hypoxemia (82%) was the most common parameter, followed by hypoperfusion (78%) among the nonsurvivor neonates. Neonates with a TOPS score of zero survived, whereas neonates with a TOPS score of four had 100% mortality. TOPS SCORE's overall sensitivity and specificity were reported at 87% and 84%, respectively, with 59% positive and 96% negative predictive values. TOPS score ≥2 had a receiver operating characteristic (ROC) curve at 0.91. Hypoxemia (82%) was the most sensitive parameter to predict mortality, followed by poor perfusion (77%).

Conclusion: The prognostication of mortality in transported neonates can be assessed by the TOPS score, as mortality notably increases with an increase in the TOPS score. A TOPS score of ≥2 was a good predictor of morbidity and mortality in transported neonates.

Keywords:

Outborn neonates, transport, TOPS score, mortality, hypoglycaemia

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Introduction

United Nations International Children's Emergency Fund (UNICEF) reported over 50 lakhs under-5 children death in 2020, including 24 lakhs neonates.[1] Over the last three decades, under-5 mortality has seen a significant reduction, whereas neonatal mortality is comparatively high.[1]

In low- and middle-income countries, most births occur in rural settings or at home. Peripheral health centers with basic infrastructure, equipment, and healthcare professionals with inadequate formal training cater to these births. Hence, sick babies require transport to a tertiary unit.[2] Thereby, neonatal transport plays a prime role in the perinatal care of these preterm or ill neonates.[3]

India contributes to more than 25% of global neonatal mortality despite progress in perinatal care over the last decade.[4] The early neonatal period contributes to three-fourths of neonatal deaths and about 10 lakh deaths in the first 24 hours of life.[5] The government of India provides financial assistance to mothers to promote institutional delivery. During 2015-2016 and 2019-2021, noninstitutional deliveries constituted 8.9% and 11.4%, respectively.[6,7]

The neonatal transport system in India is currently inefficient and only available in major cities. Most of the neonates are self-transported without pretreatment stabilization by

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parents by their private or public vehicle with inadequate care during transport, leading to hypothermia, hypoxia, and hypoglycemia in vulnerable neonates, which directly contributes to high mortality.[8–10]

Various scoring systems have been used in developed countries to prognosticate sick neonates, which are not feasible in resource-limited settings as most are time-consuming and need sophisticated equipment.[11–15]

Mathura et al. devised the temperature oxygenation perfusion sugar (TOPS) score, a simple scale that healthcare professionals can apply in resource-limited settings. TOPS score is based on the acute physiology of neonates, which stands for temperature, oxygen saturation, perfusion, and sugar.[16]

This study was conducted to assess the TOPS parameters in transported neonates and to correlate with the outcomes of these transported neonates during hospitalization in the neonatal intensive care unit (NICU).

Methods

This prospective cohort study was conducted in Level III A NICU of Vijayapura District of North Karnataka, on outborn transported neonates admitted to the NICU over a period of two years from April 2022 to May 2024. All outborn neonates transported to the NICU were admitted in separate cubicles as per NICU protocol.

Inclusion Criteria

All outborn neonates transported to Level III A NICU were enrolled.

Exclusion Criteria

Neonates with lethal congenital malformations and surgical emergencies were excluded. Institutional Ethical Committee was taken before the commencement of research and informed valid written consent from parents of enrolled neonates.

Sample Size

Sample size was calculated as 478 cases, using a 95% confidence interval with a precision of 10% using the formula of n = z2α p (1-p)/d^2 with the anticipated proportion of 43% transported neonates.

Predefined structured proforma was used to document transported neonates' data following NICU admission. Data collection included birth weight, gestational age, mode of delivery, Apgar score, mode of transport, referral hospital, and TOPS parameters within an hour of NICU admission. The temperature was assessed using a digital thermometer (EC-5004) by keeping it under the armpit of the neonate for one minute. The lowest documented temperature reading was considered among the minimum two readings taken for this study. To measure the oxygen saturation of the transported neonate at room air, a pulse oximeter (MD300C53) was connected to the right upper limb, and the mean of the two values taken was documented. Capillary refill time (CRT) at the sternum was assessed to determine the perfusion of the transported neonate. A glucometer (AccuSure: TD-4183) was used to determine blood sugar levels. TOPS parameters were defined as follows—hypothermia: Axillary temperature of <36.5 °C. CRT at the sternum >3 seconds was considered poor perfusion. Right upper limb saturation of <90% was defined as hypoxia. Hypoglycemia was documented if GRBS <45 mg%. TOPS parameters were assigned a score of "0" if normal and "1" if abnormal. All transported neonates were treated according to the NICU protocol. Neonatal outcomes were determined after 72 hours of hospitalization in the form of discharge or death.

Statistical Analysis

Documented data was analyzed in SPSS software 29. The *P* value of <.05 was considered statistically significant. Continuous variables were presented as mean ± SD (standard deviation), whereas categorical variables were expressed in frequency. Pearson's chi-squared test was used to determine the differences in proportions of the two comparison groups and to find a trend in mortality of the predictor variable. Multivariable analysis used the binary multiple logistic regression model to predict mortality with the TOPS total score as the primary predictor variable.

Results

Five hundred transported neonates were enrolled in the study with the male-to-female ratio of 1.5:1. Enrolled neonates had a mean gestational age of 35.72 ± 2.66 weeks and a mean birth weight of 2152.13 ± 598.97 grams at presentation. Transported neonates presented to NICU at 79.33 ± 122.95 hours of life (mean), with the mean traveling distance from referral hospitals of 27.41 ± 16.32 km. The most common cause of admission to NICU in these transported neonates was sepsis (30%), followed by asphyxia and meconium aspiration syndrome (28%) and prematurity (19%) (Figure 1 and Table 1).

Thirty-seven percent of transported neonates had hypothermia, whereas hypoxemia, hypoperfusion, and hypoglycemia were found in 30%, 32%, and 14% of neonates, respectively. Twenty-one percent (105) of neonates did not survive out of 500 enrolled neonates. Hypoxemia (82%) was the most common abnormality noted in nonsurvivor neonates, followed by hypoperfusion (78%), hypothermia (67%), and hypoglycemia (23%). In 190 (38%) neonates, no abnormal parameters were

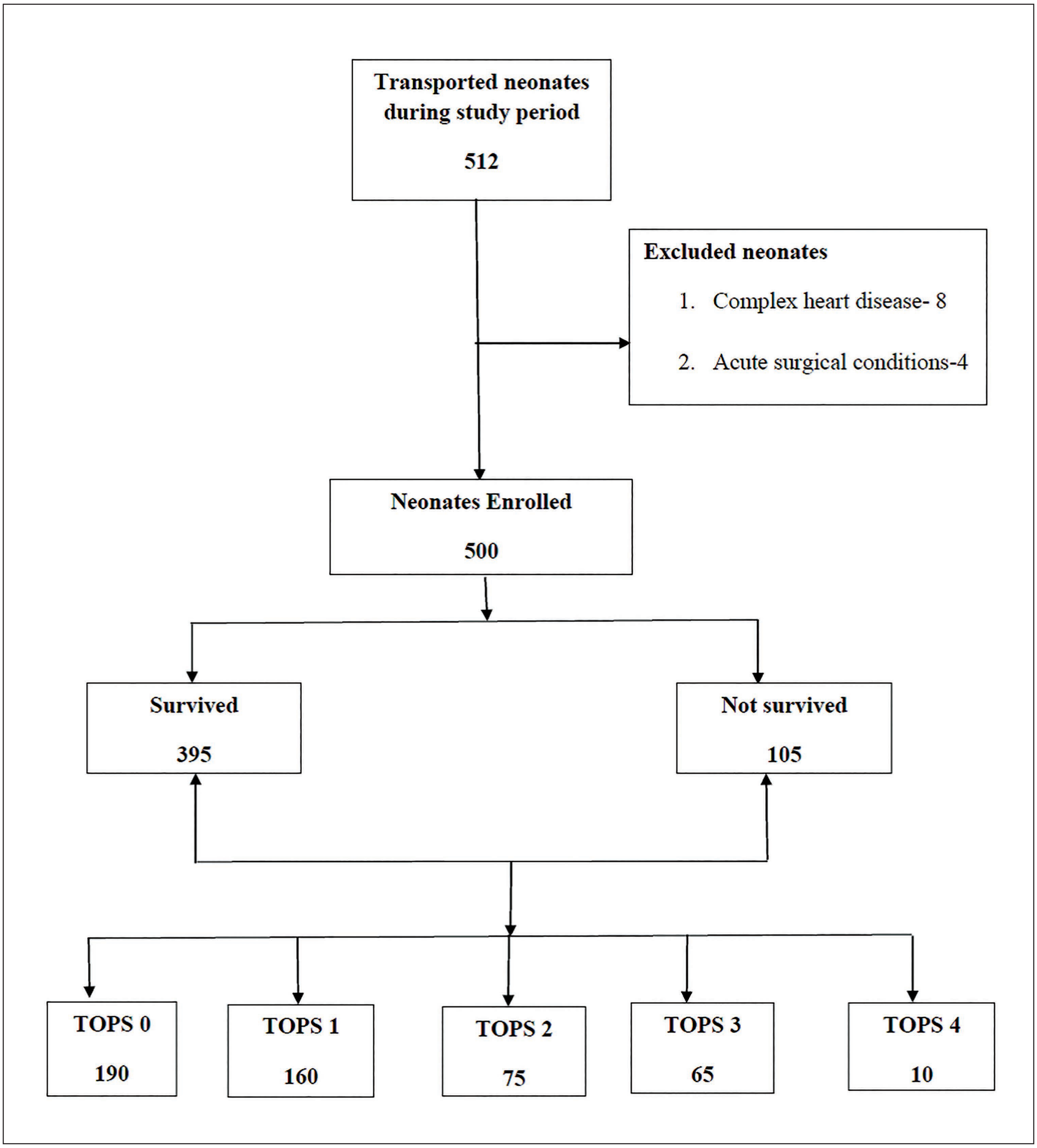

Figure 1. Flow Diagram of Study Population.

found (score 0), whereas 160 neonates (32%), 75 neonates (15%), 65 neonates (13%), and 10 neonates (2%) obtained a score of 1, 2, 3, and 4, respectively. All the neonates with all normal parameters survived, whereas those with all abnormal parameters (score 4) showed 100% mortality. An increase in TOPS score parameters was associated with increased mortality, which was statistically significant ($P = .001$; Table 2).

The overall sensitivity and specificity of TOPS score were 87 and 84% with positive and negative predictive values of 59% and 96% respectively. The area under the receiver operating characteristic (ROC) curve plotted was 0.91 (95% confidence interval).

In transported neonates, TOPS score of ≥2 was found to be a good predictor of mortality. Hypoxemia (82%) was the

Table 1. Baseline Characteristics of the Enrolled Neonates.

Characteristics	Frequency (*n* = 500)	Percentage
Gestational age		
Preterm	283	56.67
Term	217	43.33
Weight on admission (grams)		
≤2,500	312	62.33
>2,500	188	37.67
Morbidity profile		
Sepsis	150	30
Jaundice	80	16
Birth asphyxia	49	9.67
Meconium aspiration syndrome	90	18
Prematurity	93	18.67
Hypernatremic dehydration	38	7.66
Mode of delivery		
Vaginal	270	54
Cesarean section	230	46
Referral hospital		
District hospital	320	64
Private hospital	170	34
Home	10	2
Age at admission (hours)		
Mean ± SD	79.33 ± 122.95	
Traveling distance (km)		
Mean ± SD	27.41 ± 16.32 km	

Table 2. Distribution of TOPS Scores Among Survived and Nonsurvived Neonates.

Vitals	TOPS score	Neonates (*n* = 500)	Survived (*n* = 395)	Nonsurvived (n = 105)	*P* Value
Axillary temperature	0	315 (63)	280 (71)	35 (33)	.001
	1	185 (37)	115 (29)	70 (67)	
Preductal oxygen saturation (on room air)	0	350 (70)	331 (84)	19 (18)	.001
	1	150 (30)	64 (16)	86 (82)	
Capillary refill time	0	340 (68)	317 (80)	23 (22)	.001
	1	160 (32)	78 (20)	82 (78)	
Blood sugar	0	430 (86)	349 (88)	81 (77)	.001
	1	70 (14)	46 (12)	24 (23)	
Total TOPS score	0	190 (38)	182 (46)	0	.001
	1	160 (32)	150 (38)	16 (15)	
	2	75 (15)	43 (11)	32 (30)	
	3	65 (13)	20 (5)	47 (45)	
	4	10 (2)	0	10 (10)	

most common abnormality noted in nonsurvivor neonates, followed by hypoperfusion (78%), hypothermia (67%), and hypoglycemia (23%). Parameter with highest specificity was hypoglycemia (89%). Negative predictive value was 94% in hypoxemic neonates, whereas positive predictive value was 57% (Table 3).

Discussion

Despite the promotion of institutional births in low- and middle-income countries, the inadequate infrastructure in peripheral health centers results in the transfer of high-risk neonates to tertiary referral centers.[2] This study showed that the most

Table 3. Predictive Values of TOPS Parameters.

	Hypothermia	Hypoxia	Hypoperfusion	Hypoglycemia
Sensitivity (%)	67	82	78	23
Specificity (%)	71	84	79	89
Negative predictive value (%)	89	94	93	82
Positive predictive value (%)	39	57	49	34
Odds ratio	5.60	25.65	17	3.17

common cause of admission to NICU in these transported neonates was sepsis (30%), followed by asphyxia and meconium aspiration syndrome (28%) and prematurity (19%), which were in comparison to the current literature.[2]

Government hospital units such as primary health center/community health center or district hospitals referred 64% of neonates to our tertiary referral unit, whereas 34% of neonates were referred from private hospitals, and 2% of neonates came from home delivery. Verma et al.[17] stated in their study that 66% of neonates came from government hospitals, similar to our data. In this study, 87% of neonates were transported by government ambulance (108 ambulance/Nagu Magu Program), whereas 10% were transported by private ambulance, and the remaining 3% were in private vehicles. Nineteen percent of the transported neonates had healthcare professionals with formal training during transport, whereas parents/guardians accompanied the remaining 81% of neonates. Punitha et al. reported that 75% of the neonates were transported by neonatal ambulance in Tamil Nadu, a state of India.[9]

Assessing the severity of illness on admission to the NICU determines the risk of neonatal mortality. Various scoring systems are available for evaluating transported neonates, but none are easily applicable in low-resource settings for routine use. Acute neonatal physiology is adversely affected by the derangements in neonatal vitals like temperature, oxygen saturation, skin perfusion, and blood sugar.

Hypothermia (37%), hypoperfusion (32%), and hypoxemia (30%) were the most common abnormal parameters noticed among transferred neonates in this study. Cavallin et al.,[18] Baghel et al.,[19] and Sen et al.[20] reported suboptimal warming care of the neonates before and during transport with high rates of hypothermia, 75.8%, 74.6%, and 65%, respectively, at admission to the tertiary center, hence highlighting the necessitate for improvements in thermal management before and during transport.

The most common reasons observed for hypothermia of transported neonates include unavailability of warm, clean clothes, lack of awareness of kangaroo care during transport and the need for formal training of healthcare professionals about the importance of a thermoneutral environment.

In concurrence with our study (37%), Begum et al.[21] reported hypothermia in 39% of the neonates. Factors attributing to decreased incidence of hypothermia in our study include 97% of neonates being transported by government/private ambulance and usage of Embrace Nest during the transport. Hypothermia in neonates at admission is one of the strong predictors of mortality, which has a considerable clinical association with sepsis and hypoxia. In this study, we observed hypothermia contributed to a seven-time increase in the risk of neonatal mortality, which was statistically significant ($P = .001$).

Hypoxemia in neonates is determined by sentinel events, such as spontaneous respiration at birth, the Apgar score, and maintaining targeted oxygen saturation during transport. Hypoxemia was documented in 30% of the neonates on the first hour of admission to the NICU in this study. Studies by Baghel et al.[19] and Chheda et al.[22] quoted 74.6% and 47.6% hypoxemia in transported neonates, whereas Cavallin et al.,[18] Seth et al.,[23] Pathak et al.,[24] and Mehta and Sharma[25] hypoxemia reported 33%, 29.59%, 27.8%, and 28.4%, respectively, which was in concurrence with our data. As per our study, there was significantly higher mortality in transported neonates whose preductal oxygen saturation was <90% at admission to NICU compared to those who had an oxygen saturation of >90% ($P = .001$).

Hypoperfusion (32%) and hypoglycemia (14%) were the other abnormal parameters in this study's TOPS score among transferred neonates. Hypoperfusion results in a lack of blood flow to a tissue, thereby determining oxygenation. Chheda et al.,[22] Pathak et al.,[24] and Mehta and Sharma[25] quoted 43.5%, 39.8%, and 35% poor perfusion in their respective studies, which was similar to our documentation. Vijayapura, Karnataka, India, has a subtropical steppe climate, resulting in dehydration and increased mortality in transported neonates. Neonates delivered at government hospitals are often shifted alone without their mothers. During transport, the majority of neonates do not receive maintenance intravenous fluids and are shifted without securing intravenous lines, thereby resulting in hypoperfusion and hypoglycemia.

Preemie-transported neonates without pre-transport stabilization or intravenous fluid supplementation have a higher risk of hypoglycemia. In parallel with our data (13.3%), Sen et al.[20] and Chheda et al.[22] reported hypoglycemia in 16% and 14.7% neonates, whereas Cavallin et al.[18] and Baghel et al.[19] reported low incidence rates of hypoglycemia.

A TOPS score of ≤1 was observed in 70% of transported neonates in this study, similar to Pathak et al.[24] who reported 56.1%. A TOPS score of 4 (all parameters were abnormal) was recorded in 2% of the neonates. According to the current study, a TOPS score of ≥2 was associated with nine times higher mortality in transported neonates (P = .001).

TOPS score of ≥2 had the sensitivity, specificity, positive predictive value, and negative predictive value of 87.1%, 84.08%, 58.7%, and 96.7%, respectively, for predicting mortality, and the area under the ROC curve was 0.91.

Shah et al.[26] showed that hypoxemia and hypoperfusion with a sensitivity of 92.2% and 81.7%, respectively, and negative predictive values of 97% and 93% were the most sensitive parameters for predicting mortality in concurrence with our study. Among all the TOPS parameters observed, hypoglycemia had the highest specificity (88%) but with low sensitivity.

Limitations

One of the study's limitations was the lack of comparison of data on inborn and outborn neonates with baseline characteristics, and the other was the single-center nature of the project.

Conclusion

Neonatal transport is organized teamwork with a dedicated transport team in a well-equipped designated transport vehicle. Pre-transport stabilization plays a vital role before transport, along with care during transport and post-transport management. Transport of sick neonates comprises effective communication and timely referral to tertiary centers. The TOPS score is a reliable indicator of morbidity and mortality in transported neonates. Neonatal mortality was higher when all four TOPS parameters were abnormal, while a TOPS score of zero showed better chances of survival. TOPS can be used to identify neonates at high risk of mortality and thereby concentrate efforts of healthcare professionals in interventions to prevent hypothermia and oxygen desaturation during transport. Despite the availability of 108 ambulances, quality interventions such as implementation and awareness about kangaroo care, along with maintenance of intravenous fluids and appropriate respiratory support to transported neonates, can reduce the risk of morbidity and mortality.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

Ethical clearance has been obtained from Institutional Ethical Committee [BLDE (DU)/IEC/156/2022)].

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Informed Consent

Informed written consent was taken from parents/guardians of all enrolled neonates.

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