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Original Article

Correlation of TOPS Score with the Short-term Outcome of Transported Neonates: An Experience from Resource-limited Settings: A Prospective Observational Study

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ABSTRACT

Background: Acute derangements of neonatal physiological parameters, such as temperature, oxygen saturation, skin perfusion, and blood sugar (TOPS parameters), can adversely affect the neonatal outcome. To correlate the TOPS parameter with the short-term outcome of transported neonates.

Methods: This prospective observational study was carried out on 300 transported neonates by applying TOPS parameters within an hour of admission, and the outcome was assessed after 72 h of hospitalization.

Results: Hypothermia, hypoxemia, hypoperfusion, and hypoglycemia were found in 37%, 30%, 32%, and 13.33% of the neonates, respectively. The neonatal mortality rate was obtained at 20.67%. Among the non-survivors, hypoxemia was the most prevalent abnormality, followed by hypoperfusion in 77.42% of the neonates. All the neonates with all normal parameters (score 0) survived, while those with all abnormal parameters (score 4) showed 100% mortality. It was observed that an increase in the score led to an increase in the mortality rate, and it was statistically significant (P=0.001). The overall sensitivity and specificity were estimated at 87.1% and 84.03%, respectively, with a positive predictive value of 58.7% and a negative predictive value of 96.15%. The area under the receiver operating characteristic curve was 0.913 when the TOPS score was ≥ 2. The prediction of mortality was most sensitive with hypoxemia, followed by hypoperfusion, with sensitivities of 82.26% and 77.42% and negative predictive values of 94.76% and 93.14%, respectively.

Conclusion: The TOPS score was a reliable tool to predict mortality in transported neonates as mortality significantly increased by an increase in the TOPS score. Mortality was high when the scores of all four parameters were abnormal, while there was a better chance of survival with a score of zero.

Keywords: Neonatal transport, Oxygenation, Perfusion, Sugar, Temperature, TOPS score

Introduction

Neonates are the most vulnerable members of society as they face the highest risk of death in this phase than any other phase of life. Despite improvement in obstetrics and neonatal health services over the last two decades, India contributes to more than one-fourth of global neonatal mortality (1). Around 75% of neonatal deaths occur in early neonatal life and about one million deaths in the first 24 h (2). As per the recent Family Health Survey, the neonatal mortality rate in India is 24.9 per 1,000 live births with interstate and rural-urban variations (3).

Though in-utero transport and institutional delivery are the safest, preterm birth and unexpected perinatal life-threatening events cannot always be anticipated. Despite financial assistance by the Government of India to mothers for institutional delivery, 18.9% and 11.4 % of deliveries were non-institutional during 2015-16 and 2019-2021, respectively (3, 4). Such non-institutional and institutional births in limited-facility centers for neonatal care require transfer to a higher center. In India, the neonatal transport system is still in its infancy, not efficient, and only available in larger cities. As a result, most of the neonates are self-transported by parents by

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their own/private or public vehicle without pretreatment stabilization or poor or no care during transport leading to increased risk of hypothermia, hypoxia, and/or hypoglycemia in already sick neonates, which would eventually result in high mortality compared to the intramural neonate (5-7).

A simple, reproducible, and easily applicable tool helps explain prognostication to parents and reduce mortality. Various scoring systems have been devised and are used in developed countries; however, most of them are time-consuming and need sophisticated equipment, and therefore, not feasible in resource-limited settings (8-12). It is a well-known fact that acute derangement of such parameters as temperature, oxygen saturation, skin perfusion, and blood sugar can adversely affect neonatal physiology and neonatal outcome. Therefore, Mathur et al. devised a scale that is simple and easy to use, does not require sophisticated instruments, and can be applied by paramedical persons also in resource-limited settings. This was based on a simplified assessment of neonatal acute physiology and given the acronym TOPS, which stands for temperature, oxygen saturation, perfusion, and sugar (13). This study was conducted to correlate the TOPS parameter and short-term outcome of transported neonates in resource-limited settings.

Methods

This prospective observational study was carried out at a tertiary care teaching government referral hospital in India on extramural (outborn) transported neonates admitted to either outpatient or emergency departments over one year. As per hospital policy, extramural neonates were treated in a separate neonatal cubicle in the general pediatric ward with such facilities as central oxygen pipes, phototherapy units, warmers, and bubble continuous positive airway pressure machines. The sample size was calculated by considering the expected proportion of 37.6%, relative precision of 15%, and desired confidence level of 95% as well as using the formula of n=z2α p(1-p)/d2. The calculated sample size was determined at 283 cases; however, we recruited 300 extramural neonates by convenience sampling technique. The included neonates were of both genders with a gestational age of > 28 weeks and a weight of > 1 kg. on the other hand, neonates who had extremely preterm and extremely low birth weight, had lethal congenital malformation and acute surgical emergencies, left the hospital against medical advice, and whose parents were unwilling to participate in the study were excluded. Approval was obtained from the Institutional Ethical Committee of Government Medical College, Nagpur, Maharashtra, India, and informed valid consent was taken from parents. Data were collected following admission from either the mother or caregiver in a specially designed profile for study. Sociodemographic data and transport details were gathered from the mother or caregiver. Apgar scores were recorded from the available referral documents. Detailed clinical examination and TOPS parameters were documented within an hour of hospitalization.

The temperature was assessed using a digital thermometer (EC-5004) by keeping it under the armpit of the baby for 2 min. Minimum two readings were recorded and the lowest temperature reading was considered for this study. Oxygenation was assessed by measuring oxygen saturation at room air with a pulse oximeter (MD300C53). Two values were recorded and the mean of the two values was considered for the study. Perfusion was assessed by measuring capillary refill time (CRT) at the sternum by simultaneously activating a stopwatch and applying gentle pressure until the skin is blanched. When skin color returned to baseline the stopwatch was inactivated. If for any reason measurement had to be repeated, a period of 30 s was allowed before the next attempt. Blood sugar level was measured by glue strips read by glucometer (made by AccuSure simple Model No: TD-4183).

A temperature of < 36.5°C was regarded as hypothermia, oxygen saturation of < 90% as hypoxia, CRT of > 3 s as prolonged CRT, and blood sugar of < 45 mg% as hypoglycemia. Each parameter was assigned a score of "1" if abnormal and "0" if normal. The total TOPS score (an aggregate score of all four parameters) for each neonate was calculated.

Relevant hematological, biochemical, and radiological investigations were done. The diagnosis was made on the basis of clinical findings and investigations. All the cases were managed according to the standard treatment protocol of our hospital, and outcome in the form of discharge or death was noted after 72 h of hospitalization.

Statistical Analysis

Collected data were entered into an Excel spreadsheet and coded and analyzed in STATA statistical software (version 14.0). Continuous variables were presented as mean±SD, and categorical variables were expressed in frequency and percentages. Two independent samples t-test or one-way ANOVA was used to compare the means in the two groups (outcome with and without mortality). Differences in proportions in the two comparison groups were assessed with Pearson's chi-squared test. Fisher's exact test was used for data with a small frequency. The Chi-square test for linear trend (Extended Mantel-Haenszel method) was also used to find the significance of the trend in mortality by ordinal categories of the predictor variable. Multivariable analysis was performed using the binary multiple logistic regression model to predict dichotomous outcome (mortality) with the TOPS total score as the main predictor variable, adjusting the effect of other factors. The p-values of < 0.05 were considered significant.

Results

A total of 182 (60.67%) participants were male, and the male to female ratio was 1.5:1. Mean gestational age was obtained at 35.72±2.66 weeks, while 62.33% of the neonates had a low birth weight with a mean weight of 2152.13±598.97 g on admission. The mean age at admission was 79.33±122.95 h, and the mean traveling distance was 67.41±57.32 km. Sepsis was the most common cause of admission (n=90, 30%) followed by prematurity (Table 1).

The incidence rates of hypothermia, hypoxemia, hypoperfusion, and hypoglycemia were found to be 37%, 30%, 32%, and 13.33% in neonates, respectively. Out of 300 neonates, 62 cases passed away, giving a mortality rate of 20.67%. Among the non-survived neonates, hypoxemia was the most prevalent abnormality in 51 (82.26%) subjects, followed by hypoperfusion, hypothermia, and hypoglycemia in 48 (77.42%), 43 (69.35%), and 14 (22.58%) neonates, respectively. In 110 (36.67%) neonates, no abnormal parameters were found (score 0), while they were reported in 98 (32.67%), 46 (15.33%), 39 (13%), and 7 (2.33%) cases obtaining 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. It was also observed that as the score increased mortality increased as well, and it was statistically significant (P=0.001).

Table 1. Baseline characteristics of studied population

Characteristics	Frequency (n=300)	Percentage
Gender		
Male	182	60.67
Female	118	39.93
Gestational age		
Preterm	170	56.67
Term	130	43.33
Age at admission (hours) (mean±SD)	79.33±122.95	
Weight on admission (g)		
≤ 2,500	187	62.33
>2,500	113	37.67
Mode of delivery		
Vaginal	213	71.0
Caesarean	85	28.33
Forceps/vacuum application	2	0.67
Referring hospital		
Private hospital	54	18.0
Primary health center	103	34.33
Rural hospital	7	2.33
District hospital	118	39.33
Home	18	6.01
Traveling distance (Km) (mean±SD)	67.41±57.32	
Morbidity profile (not exclusive)		
Sepsis	90	30.0
Jaundice	48	16.0
Birth asphyxia	29	9.67
Respiratory distress	54	18.0
syndrome	9	3.0
Convulsion	56	18.67
Prematurity	14	4.66
Non-specified		

Table 2. Distribution of TOPS scores in subjects

Parameter	Score	All cases (n=300)	Survived (n=238)	Non-survived (n=62)	P-value
Axillary temperature	0	189 (63.0)	170 (71.43)	19 (30.65)	0.001
	1	111 (37.0)	68 (28.57)	43 (69.35)	
Oxygen saturation (on room air)	0	210 (70.0)	199 (83.61)	11 (17.74)	0.001
	1	90 (30.0)	39 (16.39)	51 (82.26)	
Capillary refill time	0	204 (68.0)	192 (80.67)	14 (22.58)	0.001
	1	96 (32.0)	46 (19.33)	48 (77.42)	
Blood sugar	0	260 (86.67)	212 (89.08)	48 (77.42)	0.01
	1	40 (13.33)	26 (10.92)	14 (22.58)	
Total TOPS score	0	110 (36.67)	110 (46.22)	0	0.001
	1	98 (32.67)	90 (37.82)	8 (12.90)	
	2	46 (15.33)	27 (11.34)	19 (30.65)	
	3	39 (13.00)	11 (4.62)	28 (4516)	
	4	7 (2.33)	0	7 (11.29)	

Table 3. Test characteristics of individual abnormal parameters

	Individual abnormal parameters			
	Hypothermia	Hypoxia	Hypo-perfusion	Hypoglycemia
Sensitivity (%)	69.35	82.26	77.42	22.58
Specificity (%)	71.43	83.61	79.83	89.08
Negative predictive value (%)	89.95	94.76	93.14	81.54
Positive predictive value (%)	38.74	56.67	50	35
Odds ratio	6.60	27.07	18.0	2.34

The overall sensitivity and specificity were 87.1% and 84.03% with positive and negative predictive values of 58.7% and 96.15%, respectively, and the area under the receiver operating characteristic (ROC) curve was 0.913 (95% confidence interval: 4.99-15.00) (Figure 1). Therefore, a TOPS score of ≥ 2 was found to be a good predictor of mortality in transported neonates. Considering an individual parameter of TOPS, the mortality rate was significantly higher in neonates with an abnormal parameter compared to the score of 0. The prediction of mortality was most sensitive with hypoxemia followed by hypoperfusion with scores of 82.26% and 77.42% and negative predictive values of 94.76% and 93.14%, respectively. Hypoglycemia had the highest specificity (89.08%), however, low sensitivity (Table 3).

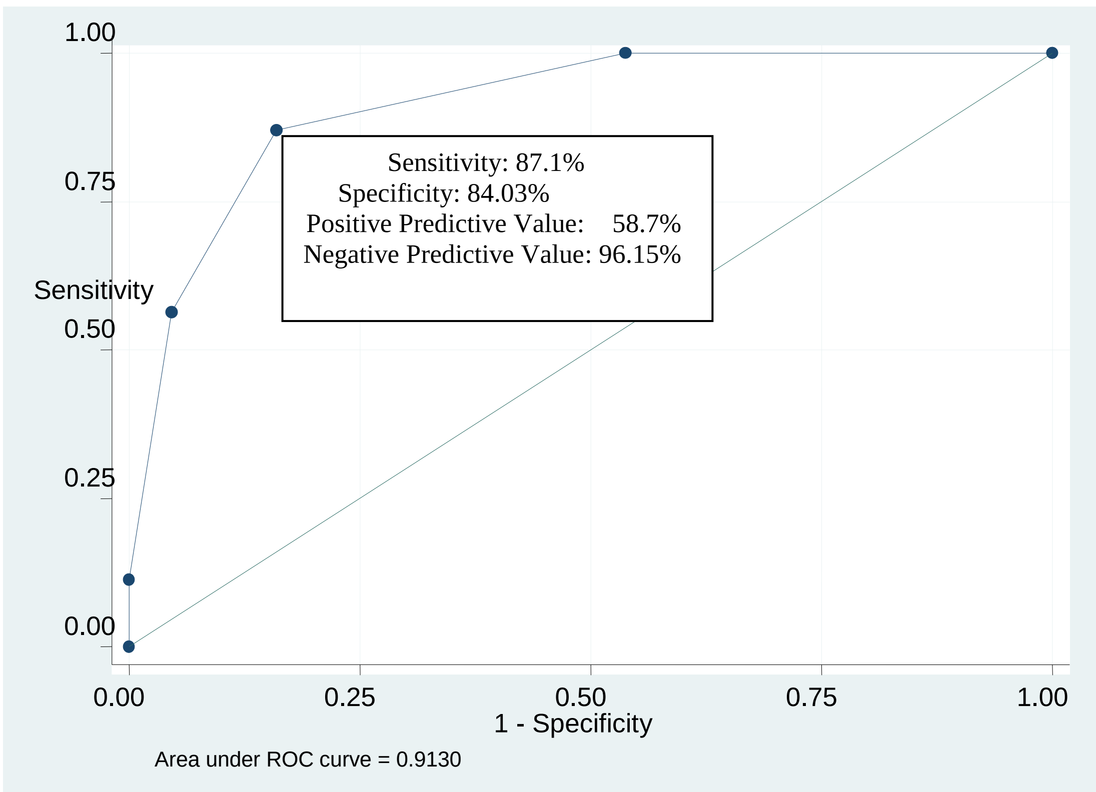

Figure 1. Receiver operating characteristic curve for predicting mortality with TOPS

Discussion

Based on the results of the study, 90% of the neonates were transported by ambulance due to an effect of Janani-Shishu Suraksha karyakram (an incentive-based scheme launched by the Government of India) and an effect of 108 Ambulance service; however, only 28.66% of the cases were accompanied by health assistants, and mortality was significantly higher in neonates transported by a private vehicle/auto-rickshaw and in an ambulance but without health assistants (P=0.04). Our results were in agreement with the observation of other authors; nevertheless, some researchers reported more use of public transport, private vehicles, and self-transportation (14-18). The findings of a study conducted by Punitha et al. in Tamil Nadu, a state of India, showed that 75% of the neonates were transported by neonatal ambulance and fewer life-threatening events happened in such neonates, compared to self-transported ones (6).

In this study, two-thirds (76%) of the neonates were referred by government facilities of either a primary/secondary health center or district hospital as our hospital is the largest referral center in this geographic area. Our findings were consistent with those of the study by Verma et al., according to which most neonates (65.89%) were referred by government health care setups; nonetheless, based on the findings of studies, the majority of referrals were from private hospitals (16, 17, 19, 20). In the present study, 6% of the neonates were directly brought from home who had a significantly higher mortality rate. The reason for this issue might be due to such factors as delivery by untrained persons without proper care, referral to hospitals without stabilization, and lack of care during transport.

The assessment of the severity of illness is central to assessing the risk of fatality. Although numerous scoring systems have been developed for the assessment of illness severity in neonates, none of them are simple enough to be operated routinely. Acute derangements in parameters like temperature, oxygen saturation, skin perfusion, and blood sugar (given the acronym TOPS) are known to affect neonatal physiology adversely. Hypothermia is usually common among referral neonates due to absent parental kangaroo care during transport, unavailability of warm clothes, and ignorance of temperature care. In the present study, 37% of the neonates had hypothermia. Most authors reported higher incidence rates of hypothermia on admission (Seth et al. 50%, Pathak et al. 47.8%, Sen et al. 65%, and Bagel et al. 74.6%), while the results of a study by Begum et al. revealed that 39% of the neonates had hypothermia (14, 15, 21-23). The reason for the low incidence of hypothermia in our study might be attributed to the fact that most of the neonates (90%) were transported by an ambulance within an hour and 45% of the neonates received care during transfer. Hypothermia has a significant clinical association with sepsis and hypoxia and is one of the strong predictors of mortality. Similar to the observations by other authors, we also observed significantly higher mortality in neonates having hypothermia (P=0.001) and a seven-times increase in the risk of mortality (16, 17, 19).

Oxygen saturation is determined by perinatal events, such as the immediate establishment of respiration, the Apgar score, and proper oxygenation of sick neonates during transport. In the present study, 30% of the neonates had hypoxia (oxygen saturation less than 90%) on the first hour of arrival, and our results were in line with those of a study by Seth et al. (29.59%), Pathak et al. (27.8%), and Mehata et al. (28.4%); nevertheless, higher incidences of hypoxia were reported by Chedda et al. (47.6%) and Bagel et al. (74.6%) (15, 21, 22, 24, 25). Organ survival is best correlated with oxygen delivery to the tissues. Cortical neurons of the brain and tubular cells of the kidneys are most sensitive to hypoxia, and therefore, hypoxic-ischemic encephalopathy and acute kidney injury are contributory factors to mortality. Similar to the reports of other studies, it was also found in the current study that there was significantly higher mortality in neonates whose oxygen saturation was less than 90% on arrival, compared to those who had an oxygen saturation of more than 90% (P=0.001) and higher odds for mortality (27.07) (13, 16, 21, 25).

Perfusion, the flow of blood to a tissue, and oxygenation determine the oxygen delivery to the tissues. Estimation of skin perfusion by CRT as a marker for vital organ perfusion is based on the assumption that skin and muscle tissue are sacrificed to vital organ tissues in low flow states. In our study, poor perfusion (CRT>3 s) was observed in 32% of the transported neonates, which was consistent with those of studied by Mehta et al. and Pathak et al.; however, a higher incidence of poor perfusion was reported by Chedda et al. (43.5%), while low incidence rates were noted by Begum et al. (11%) and Seth et al. (16.33%) (21-25). Transported neonates are deprived of breastfeeding and/or suffer from inadequate administration of fluid and high temperature in our geographic area leading to dehydration and an increase in mortality. In the present study significantly higher mortality and higher odds ratio (OR 18) was observed in neonates with poor perfusion than in those with normal CRT (P=0.001); similar to our finding, Mathur et al. revealed that hypoperfusion was the strongest predictor of mortality with the highest odds ratio (13).

Glucose is an important substrate to provide calories to the tissues, and preterm neonates have fewer stores in the liver compared to term ones and are prone to hypoglycemia if feeding is not initiated. Sick transported neonates have a higher chance of hypoglycemia due to the unavailability of mothers' breastfeeding or because sick neonates are unable to accept breast feeding;

moreover, most of the transported newborns are referred without stabilization or intravenous fluid supplementation. Similar to the observation of Chedda et al. (14.7%) and Sen et al. (16%), we observed hypoglycemia in 13.33% of the neonates, while Mehata et al. and Verma et al. revealed higher incidence rates of hypoglycemia; however, Bagel et al. and Begum et al. reported low incidence rates of hypoglycemia (14-16, 23-25). Hypoglycemia and hypothermia set up a perpetuating cycle and are complicated by septicemia and hypoxic-ischemic encephalopathy. The present study shows mortality was significantly more in hypoglycemic neonates compared to normoglycemic (P=0.01) and our findings are concomitant with Mathur et al, Chedda et al. (13, 25).

In the current study, the majority of the neonates (69.34%) had a TOPS score of ≤1 (including TOPS scores of 0 and 1 in 36.67% and 32.67% of the cases, respectively), while a TOPS score of 4 (all parameters were abnormal) was recorded in 2.33% of the subjects. The results of a study by Pathak et al. demonstrated a normal score of 0 in 43.5% of the neonates, and scores of 1, 2, 3, and 4 in 12.6%, 13%, 18.9%, and 12% in the neonates, respectively, which was in line with those of the present study those reported in other pieces of research (16, 19, 22). In the current study, none of the neonates succumbed to death when the TOPS score was 0; however, mortality increased by an increase in the TOPS score (P=0.001) and mortality was 9 times higher when the TOPS score was ≥ 2. Moreover, based on the findings, the sensitivity, specificity, positive predictive value, and negative predictive value of the TOPS score of ≥ 2 for predicting mortality were 87.1%, 84.08%, 58.7, 96.7%, and 84.67%, respectively, and the area under the ROC curve was 0.91. Our findings were in agreement with the results of other researchers (14, 16, 19, 22).

In the present study, sensitivity and specificity to predict mortality for abnormal temperature, hypoxemia, hypoperfusion, and hypoglycemia were 69.35%, 71.43%; 82.26%, 83.61%; 77.42%, 79.83%; and 22.58%, 89.08%, respectively. These results were consistent with those of a study conducted by Verma et al. reporting the sensitivity and specificity of hypothermia, hypoxia, hypoperfusion, and hypoglycemia to predict mortality as 77.78%, 61.49%; 74%, 69%; 44%, 93%; and 33%, 81%, respectively (16). Nonetheless, Shah et al. showed that hypoxemia and hypo perfusion were the most sensitive parameters for predicting mortality with a sensitivity of 92.2% and 81.7% and negative predictive values of 97% and 93%, respectively (20). Hypoglycemia had the highest specificity (88%), however, low sensitivity.

In the present study, the mortality rate was 20.67%, which was in agreement with the reports of the studies performed by Verma et al. (20.76%), Parekh et al .(24.7%), and Dalal et al. (23.66%), while slightly a higher rate was reported by Mathur et al. (13, 16, 19, 26). Similar to the reports by Pathak et al., we observed the highest neonatal mortality in neonates who presented with hypoxemia (56.67%), followed by hypoperfusion (51.06%), hypothermia (38.74%), and hypoglycemia (35%), and all the parameters were associated with significantly higher mortality. Nevertheless, Verma et al. and Hapani et al. reported relatively higher mortality among neonates with hypoperfusion (63.16%), compared to neonates with hypoxemia (39.22%), hypothermia (34.62%), and hypoglycemia (32.53%) (16, 18, 22).

Limitations

One of the limitations of the study was related to the single-centered nature of the study in central India. In this regard, our findings may not be representative of the entire country. Therefore, it is necessary to conduct studies with larger sample sizes, in several centers, and with a longer duration of follow-up to identify the other conditions causing neonatal mortality. Furthermore, due to the nature of the study, a long-term follow-up was not possible to recognize the long-term complications and outcomes. The other limitation of this study was regarded to not considering the no head-to-head comparison of outborn and inborn data and other factors, such as gestational age and birth weight.

Conclusion

Based on the results, all parameters of the TOPS score were vitally important and each abnormal parameter was associated with an increased risk of mortality. Mortality significantly increased by an increase in the TOPS score. Neonatal mortality was high when all four parameters of the TOPS score were abnormal, while a better chance of survival was revealed with a score of 0. Consequently, it is a reliable tool to predict mortality in transported neonates.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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Authors' contributions

Concepts, design, clinical studies, data analysis, data acquisition, manuscript preparation, and manuscript review: both authors. Definition of intellectual content, statistical analysis, manuscript editing, respondence: R. M. M. Literature search: R. A. Ch.

The manuscript was read and approved by all the authors to ensure that the requirements for authorship, as stated earlier in this document, were met. The authors believed that the manuscript represented honest work.

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