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Original Article

Evaluation of Clinical Parameters for the Prediction of Hospital Stay in Neonates admitted in a Tertiary Referral Hospital in a Developing Country

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ABSTRACT

***Background*:** The present study aimed to evaluate different clinical parameters on admission for the prediction of hospital stay in neonates.

***Methods*:** This prospective observational study was conducted during one year (Jan-Dec 2010) in a tertiary referral hospital in North India. Out of 344 neonates admitted at the hospital, 41 were discharged against medical advice and excluded from the study. At the time of admission, initial vital signs and basic information of the neonates were recorded. Subjects were evaluated based on clinical parameters and followed-up until discharge/death. Final outcomes were recorded in terms of total length of hospital stay in surviving and non-surviving neonates. In the statistical analysis, odds ratio with 95% confidence interval were calculated for each parameter, and significant associations were investigated between the variables (P≤0.05).

***Results*:** Of 30 clinical variables, 18 were found to be significantly associated with prolonged hospitalization (>7 days) in surviving neonates. These parameters included abnormal heart rate (>160/min or <100/min), abnormal respiratory rate (>60/min or <30/min), abnormal SpO2 (<90%), prolonged capillary refill time (≥3 seconds), moderate hypothermia or hyperthermia, decreased consciousness, abnormal crying, reduced or lack of physical activity, presence of pallor, icterus involving soles, central cyanosis, dehydration, chest recessions, respiratory distress, abdominal distension, hypotonia, incomplete or absent Moro reflexes in term neonates, and absent or sluggish deep tendon reflexes. Additionally, three parameters were found to be significantly associated with the mortality of non-surviving neonates within 7 days of hospital stay, including abnormal respiratory rate (>60/min or <30/min), abnormal SpO2 (<90%) and prolonged capillary refill time (≥3 seconds).

***Conclusion*:** According to the results of this study, length of hospitalization in neonates could be predicted at the time of admission using simple, easily-assessed clinical parameters.

***Keywords*:** Clinical Parameters, Hospital Stay, Neonates, Tertiary Referral Hospital

Introduction

In some developing countries, such as India, it is necessary to evaluate patients based on physical variables or clinical parameters due to the limited medical resources. Identification of high-risk variables could contribute to the prediction of medical outcomes among neonates. On the other hand, accurate prognosis is required for physicians so that they could have guidance in their clinical decision-makings, including the selection of the appropriate therapy for different patients. In this regard, different parameters could be investigated in order to predict patient outcomes, while assessing policy formulations and resource associations.

Although severity scores of neonatal illnesses have been widely used for the prediction of clinical outcomes, these scores primarily aim to adjust the rate of mortality and morbidity among neonates in a particular hospital or population, allowing standardized comparisons. Despite the fact that risk correction analysis has become relatively commonplace in the examination and research about infant populations, use of such scores has been quite rare in providing parents with the prognostic information of neonates (1).

This is a common problem with the use of different scores; as such, clinical risk index for babies (CRIB) and the score for neonatal acute

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physiology (SNAP), which are restricted to 12 and 24 hours after birth, respectively, are considered as poor predictors for individual outcomes (1). Moreover, none of the scoring systems available currently are able to predict neonatal outcomes by assessing only clinical parameters and not involving any laboratory investigation.

The main difference between the present study and those conducted previously in this regard is that neonatal evaluation was performed at the time of admission, so that the prognosis of the condition could be evaluated through the identification of high-risk clinical variables. To the best of our knowledge, no such prospective study has been formerly conducted, in which only clinical variables were used to predict clinical outcomes in both surviving and non-surviving neonates. Furthermore, we considered the length of hospital stay as a major predictor of clinical outcomes, disregarding any laboratory investigation and/ or scoring systems. This study mainly aimed to identify various clinical parameters used for the prediction of different clinical outcomes among neonates.

Since only clinical parameters were taken into account and no laboratory investigation was included in the present study, our findings could be useful in peripheries where laboratory facilities are not available and clinical assessment is of great significance. In addition, this study was cost-efficient, as no expenses were involved in laboratory investigations or other procedures. Therefore, the obtained results could also be helpful in strengthening the clinical skills of physicians.

Method

This study was conducted on out-born neonates admitted at a tertiary referral hospital during one year (Jan-Dec 2010). In total, 344 neonates were enrolled in this study, and 41 were discharged against medical advice and excluded from the study. As a result, final sample size of the study was determined to be 303.

At the time of admission, neonates were evaluated based on different clinical parameters and their medical history (Table 1). Heart rate and respiratory rate were recorded for one minute, and temperature was measured in ^{0}F after adjusting the axillary mercury–in-glass thermometer for three minutes. In addition, oxygen saturation was scanned using a pulse oximeter, and capillary refill time was measured on sternum after applying blanching pressure for 5 seconds during the required time for the full re-perfusion of the blanched area.

A temperature between 36.50-37.50°C (97.70-99.50°F) was considered as normal, between 36.00-36.49°C (96.80-97.7°F) represented mild hypothermia, 32.00-35.90°C (89.60-96.6°F) was indicative of moderate hypothermia, below 32.00°C (89.60°F) represented severe hypothermia and above 37.50°C (99.50°F) was interpreted as the presence of hyperthermia (2, 40).

In this study, circulatory dysfunction was detected in the presence of tachycardia (heart rate: >160/minute), bradycardia (heart rate: <100/minute) or capillary refill time of more than 3 seconds. Abnormal respiratory rate was defined in the rates above 60/minute or less than 30/minute, and oxygen saturation of less than 90% was considered as hypoxemia (3, 4) (Table 2).

Various functional and behavioral responses were evaluated in terms of the wakefulness of neonates, including their physical movements and type of crying (5). Among other variables investigated in the general physical examination

Table 1. Clinical Parameters Studied on Admission

General	Vital Signs	Functional and Behavioral Responses	GPE Variables	Systemic Examination
Age	Heart Rate	Consciousness Level	Pallor	Respiratory Efforts
Gender	Respiratory Rate	Type of Crying	Icterus	Additional Respiratory Sounds
Birth Weight	Oxygen Saturation	Spontaneous Activity Level	Cyanosis	Murmur
Gestation	Capillary Refill Time		Bleeding on Any Site	Abdominal Distension
Appropriateness for Gestation	Temperature		Anterior Fontanel	Hepatosplenomegaly
Ponderal Index			Hydration Status	Tone
			Congenital Malformations	Moro Reflexes
				Deep Tendon Reflexes
				Seizures

Table 2. Normal Reference Range of Vital Signs

Vital Signs	Normal Ranges
Heart Rate	100-160/min
Respiratory Rate	30-60/min
Temperature	97.70-99.50 F
Capillary Refill Time	<2 Seconds
Oxygen Saturation	>90%

of the neonates were the presence and severity of pallor, icterus and cyanosis, which were evaluated through recording the skin color and complexion, mucosa and nail beds, respectively. Moreover, presence of any bleeding areas and bulging anterior fontanel was recorded for the subjects.

To assess the dehydration status of neonates, we recorded variables such as the presence of depressed fontanel, dry mucosa and sunken eyes. Additionally, presence of any congenital malformations was noted and further classified into major and minor abnormalities in accordance with the Australian Congenital Anomalies Monitoring System (ACAMS) (6).

After performing detailed systemic examinations on the neonates, respiratory distress was evaluated based on the presence of any two of the following parameters: 1) respiratory rate of more than 60/min; 2) chest retractions and 3) grunting. Additional respiratory sounds, such as stridor, wheezes (rhonchi) and crepts, were recorded as well.

In neonatal examinations, presence of heart murmur was recorded in terms of type, grade and location. Moreover, abdominal distension and organomegaly were documented if present.

In this study, significant hepatomegaly was diagnosed if the lower border of the liver was palpable at more than 2.5 cm below the right costal margin to the midclavicular line. Term neonates were evaluated in terms of the Moro reflexes by examining variables such as the deep tendon reflexes, tone and any seizure activity at the time of admission.

In this study, gestational age of the neonates was presented in weeks and categorized in different groups, including ≤28, 28-31+6, 32-36+6 and 37-41+6 weeks. In addition, the neonates were classified into the following groups regarding their birth weight: 1500-2499 g, as low birth weight (LBW), 1000-1499 g, as very low birth weight, ≤999 g, as extremely low birth weight and 2500-3999 g, as normal birth weight.

Anthropometric measurements of the neonates were performed upon admission, and the Ponderal index was calculated in small-for-gestational-age infants in order to differentiate between symmetrical and asymmetrical intrauterine growth restriction (IUGR).

All the aforementioned parameters were determined and recorded by the same specialist, which was dually countersigned by the senior consultant as to avoid observer bias.

Studied neonates were followed-up until discharge/death, and total length of hospital stay was determined in both surviving and non-surviving infants. Furthermore, clinical parameters significantly associated with prolonged hospital stay in surviving and non-surviving neonates, as well as the infants with early death (within 7 days), were identified.

For the statistical analysis of the obtained data, mean and standard deviation (SD) were calculated, and comparison between the means was performed using the analysis of variance (ANOVA). In addition, odds ratios with 95% confidence intervals were calculated for each parameter. Also, abnormal parameters responsible for prolonged hospital stay (more than 7 days) in surviving neonates and for inadequate stay (less than 7 days) in non-surviving neonates were investigated in this study.

Multiple logistic regression analysis was used to evaluate the magnitude of association between the study variables; regression coefficients associated with each variable were considered as the respective weight for that variable. In data analysis, $P \leq 0.05$ was considered as significant.

Results

This study was conducted on 303 neonates admitted at the out-born section of a tertiary referral hospital in India. Among the subjects, 73.6% were male, and 26.4% were female. At the end of the study, surviving neonates accounted for equal proportions of male and female.

Different characteristics and vital signs of the study population upon admission are presented in Table 3. According to the results of the study, lower gestation and birth weight were associated with longer hospitalization in surviving neonates.

In total, 268 neonates (88.4%) survived, while 35 (11.6%) died. In addition, 58.6% of the surviving neonates were discharged after more than 7 days of hospitalization, and 91.4% of the non-surviving neonates died within 7 days of hospitalization (Figure 1).

In the present study, 66.9% of the neonates were admitted within 3 days after birth, 22.7%

Table 3. Basic Characteristics and Vital Signs on Admission

	Mean±SD		F-value	P-value
	Surviving	Non-surviving		
Age (days)	3.19±2.78	2.77±2.76	0.714	0.399
Birth Weight (gm)	2508.51±617.16	2245.71±632.45	5.581	0.019
Gestation (weeks)	37.20±2.34	36.68±3.37	1.354	0.245
Heart Rate	143.03±19.82	142.11±37.11	0.052	0.820
Respiratory Rate	56.62±20.49	45.71±37.49	6.931	0.009
SpO2	89.10±14.74	58.51±29.68	99.100	0.000
Capillary Refill Time	2.49±0.67	3.97±1.22	119.912	0.000
Temperature	97.77±1.22	96.560±1.11	30.962	0.000

were admitted within 4-7 days, 9.2% within 8-10 days and 1.2% were hospitalized within 11-15 days after birth. Among these subjects, 73.6% were male, and 26.4% were female, and survival rate was almost equal between these two groups.

In this study, 35% of the admitted neonates were preterm, and 38% were LBW (>2500 g). Additionally, 25.1% of the neonates were small for gestational age, 27.6% of whom had symmetrical IUGR. Percentage of the contribution of different neonatal diseases in our neonatal set-up is shown in Figure 2.

Out of 30 clinical variables investigated in our study, 18 were found to be significantly associated with prolonged hospitalization (more than 7 days) in surviving neonates. These variables are as follows: heart rate (>160/min or <100/min), abnormal respiratory rate (>60/min or <30/min), abnormal SpO2 (<90%), prolonged capillary refill time (≥3 seconds), moderate hypothermia or hyperthermia, decreased consciousness level, abnormal crying, reduced or lack of physical activity, presence of pallor, icterus involving soles, central cyanosis, dehydration, chest recessions, respiratory distress, abdominal distension,

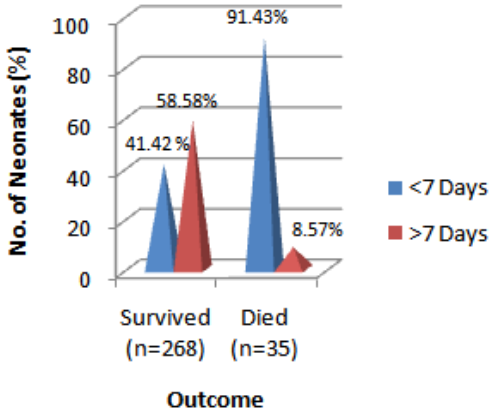

Figure 1. Data Distribution based on the Length of Hospital Stay

hypotonia, incomplete or absent Moro reflexes in term neonates, and absent or sluggish deep tendon reflexes.

Odds ratios with 95% confidence interval for statistically significant variables are presented in Table 4, Figure 3a and 3b. Accordingly, dehydration at the time of admission had the highest odds ratio (4.66) compared to other variables. Moreover, three clinical variables were found to be significantly associated with early death (within 7 days of hospitalization) in non-surviving neonates (Table 5).

Discussion

Prognostication plays a pivotal role in determining the efficacy of health care programs and medical policies. This is especially important in the triage of seriously ill neonates referred to emergency departments in developing countries, where health care facilities are extremely limited.

In this regard, identification of different factors for the prediction of clinical outcomes and length of hospital stay could contribute to the proper prioritization of neonatal care. In the current study, we attempted to evaluate the clinical outcomes and length of hospitalization among surviving and non-surviving neonates.

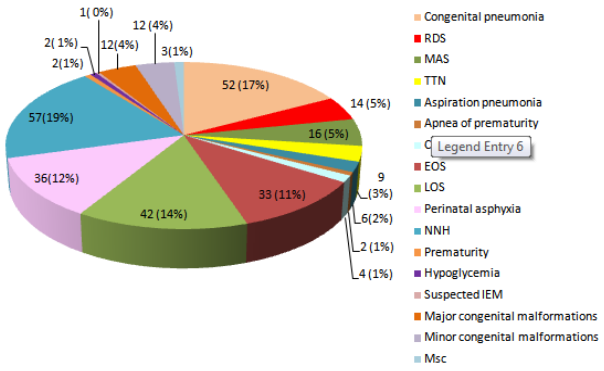

Figure 2. Primary Diagnosis

Table 4. Significant Clinical Parameters Responsible for Prolonged Hospitalization in Surviving Neonates

Clinical Variables	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Abnormal Heart Rate (>160/min or <100/min)	2.63	1.31-5.31	0.006
Abnormal Respiratory Rate (>60/min or <30/min)	2.18	1.32-3.59	0.002
Abnormal SpO2 (<90%)	3.19	1.80-5.64	0.0001
Prolonged Capillary Refill Time (≥3 Sec)	2.55	1.52-4.28	0.0004
Moderate Hypothermia/ Hyperthermia	3.04	1.34-6.92	0.008
Decreased Consciousness Level	2.70	1.34-5.44	0.005
Abnormal Crying	3.17	1.90-5.30	<0.0001
Reduced/No Activity	3.27	1.94-5.52	<0.0001
Presence of Pallor	0.52	0.30-0.91	0.022
Icterus Involving Soles	1.82	1.11-2.99	0.017
Central Cyanosis	0.10	0.01-0.78	0.028
Dehydration	4.66	1.34-16.24	0.015
Chest Recessions	0.38	0.23-0.63	0.0002
Respiratory Distress	2.21	1.29-3.76	0.003
Abdominal Distension	0.24	0.09-0.64	0.004
Hypotonia	2.93	1.62-5.32	0.0004
Incomplete/Absent Moro Reflexes in Term Neonates	2.36	1.15-4.82	0.018
Absent/Sluggish DTR	2.91	1.55-5.46	0.0009

3a 3b

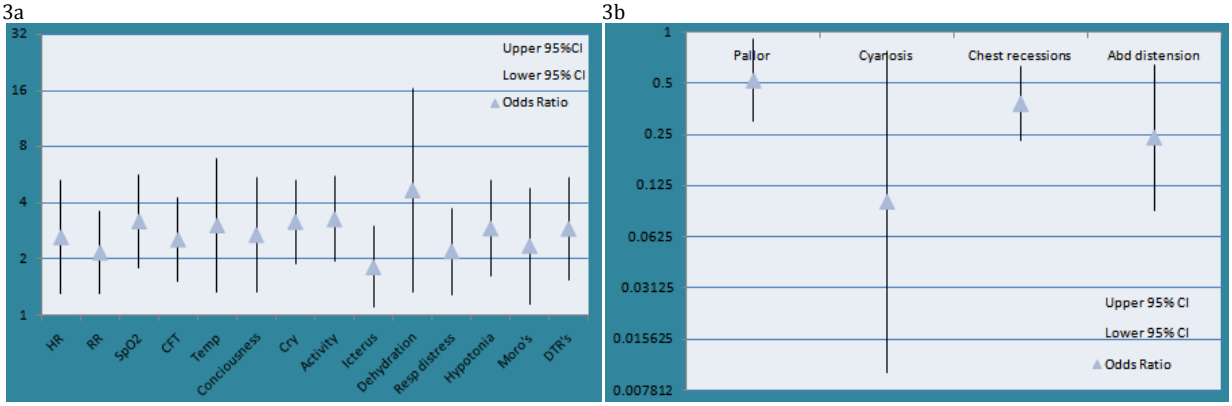

Figure 3a-3b. Significant Parameters associated with Long Hospitalization in Surviving Neonates

In the present study, univariate analysis of various clinical parameters was performed in order to determine the significant parameters associated with prolonged hospitalization (more than 7 days) in surviving neonates. Out of 30 investigated variables, 18 were found to be significant in the prediction of neonatal outcomes, including abnormal heart rate and respiratory rate, low oxygen saturation, prolonged capillary refill time, moderate hypothermia or hyperthermia, decreased consciousness level, abnormal crying, reduced or lack of physical activity, presence of pallor, icterus involving soles, central cyanosis, dehydration, chest recessions, respiratory distress, abdominal distension, hypotonia, incomplete or absent Moro reflexes in term neonates, and finally, absent or sluggish deep tendon reflexes.

In the current study, 88.4 % (268/303) of the studied neonates survived, 58.6% of whom had prolonged hospitalization (more than 7 days), while 91.4% of non-surviving neonates died within 7 days of hospital stay. It is also noteworthy that neonates with shorter

Table 5. Significant Clinical Parameters Responsible for Short Hospital Stay in Non-surviving Neonates

Clinical Variables	OR	95% CI	P-value
Abnormal Respiratory Rate (>60/min or <30/min)	0.07	0.00-0.98	0.0483
Abnormal SpO2 (<90%)	0.05	0.00-0.75	0.0302
Prolonged Capillary Refill Time (≥3 Sec)	0.05	0.00-0.75	0.0302

hospitalization had higher mortality compared to the neonates with long hospital stay. As such, a statistically significant association was observed between the length of hospital stay and clinical outcomes of the surviving and non-surviving neonates.

According to the literature, several studies have been performed on the association between various clinical and laboratory parameters and prediction of mortality among neonates. However, no studies have been conducted on the evaluation of these parameters and their association with length of hospital stay among infants.

According to the findings of the present study, prediction of clinical outcomes in terms of mortality, as well as length of hospital stay, could be achieved entirely based on physical criteria. This could make remarkable contributions to the triage of different patients and accurately define their prognosis, which distinctly concerns the patients and their family, as well as policy formulations and resource associations in a health care facility. The findings of the current study could be useful in peripheries where laboratory facilities are not available, while contributing to the improvement of clinical skills in health care staff engaged in different sectors.

Conclusion

According to the results of this study, length of hospitalization and survival rate of neonates could be predicted at the time of admission using simple and easily assessed clinical parameters.

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