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ORIGINAL ARTICLE

Determine the Factors Associated with High Mortality in Ventilated Neonates

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ABSTRACT

Introduction: *Neonatal mortality remains a major health concern in Bangladesh, particularly among critically ill neonates requiring mechanical ventilation. Understanding the clinical and biochemical factors associated with mortality can guide early interventions and improve outcomes.* ***Methods & Materials:*** *This retrospective observational study included 60 neonates who received invasive mechanical ventilation in the NICU of Dhaka Shishu Hospital, a tertiary care pediatric centre, from June 2007 to March 2008. Data were extracted from hospital records. Univariate analysis was conducted using Chi-square or Fisher's exact test for categorical variables and t-test or Mann–Whitney U test for continuous variables.* ***Results:*** *Among 60 ventilated neonates, 37 (61.7%) died and 23 (38.3%) survived. Mortality was highest in neonates with gestational age <28 weeks (91.7%) and those admitted to the ICU after >12 hours (64.9%, p=0.01). ABG abnormalities were significant: pH ≤7.1 (83.3% mortality, p=0.003) and base deficit ≤–10 (73.3%, p=0.018). Electrolyte disturbances, including hyponatremia (<130 mmol/L, 87.5%, p=0.03) and hypokalemia (<3.5 mmol/L, 88.2%, p=0.02), were associated with higher mortality. Multivariate logistic regression identified septicemia (OR 219.6, 95% CI 1.15–448.8, p=0.044), RDS & pneumonia (OR 111.3, 95% CI 1.20–138.5, p=0.044), high base deficit (OR 1.79, 95% CI 1.11–2.8, p=0.018), and delayed ICU admission >12 hours (OR 8.29, 95% CI 1.20–23.5, p=0.024) as independent predictors of mortality.* ***Conclusion:*** *Mortality among ventilated neonates is significantly associated with septicemia, respiratory distress, metabolic derangements, and delayed ICU admission. Early identification and management of these factors may improve neonatal outcomes in intensive care settings.*

Keywords: *Neonatal mortality, Mechanical ventilation, NICU*

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INTRODUCTION

Neonatal mortality remains a major public health challenge worldwide, particularly in low- and middle-income countries, including Bangladesh. Despite substantial improvements in maternal and child health services over the past two decades, neonatal deaths account for a significant proportion of under-five mortality in the country, with recent estimates reporting a neonatal mortality rate of 16 per 1,000 live births [1]. Critically ill neonates requiring intensive care constitute a high-risk group, and understanding the factors associated with mortality in this population is essential for the development of targeted interventions to reduce preventable deaths. Globally, prematurity, low birth weight, perinatal asphyxia, and neonatal sepsis have been consistently identified as major contributors to neonatal mortality [2,3]. Premature neonates often face complications such as respiratory distress, intraventricular hemorrhage, and metabolic instability, which increase their susceptibility to death [4]. In Bangladesh, studies have similarly highlighted the high vulnerability of preterm and low birth weight neonates admitted to neonatal intensive care units (NICUs), emphasizing the need for specialized care and monitoring [5,6]. Neonatal sepsis and respiratory complications are frequently reported as leading causes of death among ventilated neonates. For instance, research from tertiary hospitals in Bangladesh found that sepsis, respiratory distress syndrome, and pneumonia were the most common conditions among neonates requiring mechanical ventilation [7]. Studies from other low-resource settings, such as Ethiopia and India, have corroborated these findings, indicating that infection control, early recognition, and timely management of respiratory failure are critical components of neonatal care [8,9]. These conditions often present alongside metabolic derangements, including acid-base imbalances and electrolyte disturbances, which further exacerbate the risk of mortality [10]. Early intervention and timely admission to NICUs are crucial determinants of survival in critically ill neonates. Delays in initiating intensive care have been associated with higher mortality rates, emphasizing the importance of rapid triage and management of high-risk neonates [11]. In addition, monitoring key clinical and biochemical parameters, such as arterial blood gas values, base deficit, and electrolyte levels, has been shown to provide important prognostic information and guide appropriate therapeutic interventions [12]. Despite the growing body of literature on neonatal outcomes, data specific to ventilated neonates in Bangladesh remain limited. Understanding the demographic, clinical, and biochemical

factors that contribute to mortality in this population is essential to inform evidence-based practices and improve survival rates. This study aims to identify the key determinants of mortality among mechanically ventilated neonates admitted to a neonatal ICU in Bangladesh, thereby contributing to the optimization of neonatal intensive care and the reduction of preventable deaths in this vulnerable population.

METHODS & MATERIALS

This retrospective observational study was conducted in the neonatal intensive care unit (NICU) of Dhaka Shishu Hospital, a tertiary care pediatric centre, from June 2007 to March 2008. Ethical approval was obtained from the Institutional Review Board, and all patient data were anonymized to maintain confidentiality. A consecutive sampling technique was used to include all neonates who received invasive mechanical ventilation during the study period and had complete clinical, biochemical, and arterial blood gas (ABG) records. Data were extracted from hospital medical records using a structured data collection sheet and included demographic variables, primary diagnoses and clinical conditions (such as perinatal asphyxia, sepsis, respiratory distress syndrome, pneumonia, meconium aspiration syndrome, intrauterine growth restriction, and meningitis), indications for mechanical ventilation, ABG parameters (initial pH, PO_2, PCO_2, base deficit, HCO_3^-, oxygen saturation), biochemical parameters (serum sodium, potassium, blood glucose, urea, creatinine), and clinical course variables such as duration of mechanical ventilation, ICU stay, and ventilator-related complications. Statistical analysis was performed using SPSS version [xx]. Categorical variables were summarized as frequencies and percentages, and continuous variables as mean ± standard deviation or median (interquartile range), as appropriate. Univariate analysis was conducted using Chi-square or Fisher's exact test for categorical variables and t-test or Mann–Whitney U test for continuous variables. Variables significant at $p<0.05$ in univariate analysis were included in multivariate logistic regression to identify independent predictors of mortality, with odds ratios (OR) and 95% confidence intervals (CI) reported. A p-value <0.05 was considered statistically significant.

Inclusion Criteria:

- Neonates receiving mechanical ventilation during NICU stay.
- Complete clinical, biochemical, and ABG data available in hospital records.
- Admission to NICU within the study period.

Exclusion Criteria:

- Neonates with major congenital malformations incompatible with life.
- Neonates referred from other hospitals without complete records.
- Neonates receiving only non-invasive ventilation or oxygen therapy.

RESULTS

Mortality was highest in neonates with gestational age <28 weeks (91.7%) and those admitted to ICU after >12 hours (64.9%, p=0.01). Birth weight and sex were not significantly associated with mortality. [Table I]

Table – I: Univariate Analysis of Demographic and Clinical Factors Associated with Mortality in Ventilated Neonates (*n*=60)

Factor	Improved n (%)	Died n (%)	OR (95% CI)	p-value
Sex				
Male	16 (43.2%)	21 (56.8%)	0.57	NS
Female	7 (30.4%)	16 (69.6%)	Ref	–
Weight				
>2500 g	11 (57.9%)	8 (42.1%)	3.34 (0.93–12.12)	NS
<2500 g	12 (29.3%)	29 (70.7%)	Ref	–
Gestational age				
>28 wks	22 (45.8%)	26 (54.2%)	9.31 (1.08–208.1)	0.05
<28 wks	1 (8.3%)	11 (91.7%)	Ref	–
Time from admission to ICU				
0–12 hrs	18 (78.3%)	13 (35.1%)	6.65 (1.76–26.65)	0.01
>12 hrs	5 (34.8%)	24 (64.9%)	Ref	–

Neonates with pH ≤7.1 had the highest mortality (83.3%, p=0.003). Mortality was also high in neonates with base deficit ≤–10 (73.3%), hyponatremia (87.5%), and hypokalemia (88.2%). [Table II]

Table – II: Univariate Analysis of ABG and Biochemical Factors Associated with Mortality (*n*=60)

Factor	Improved n (%)	Died n (%)	OR (95% CI)	p-value
Initial pH				
>7.25	6 (54.5%)	5 (45.5%)	Ref	–
≤7.25	17 (34.7%)	32 (65.3%)	0.10	<0.001
>7.1	18 (60%)	12 (40%)	Ref	–
≤7.1	5 (16.7%)	25 (83.3%)	7.5 (1.97–30.43)	0.003
Base deficit	>–10	11 (73.3%)	4 (26.7%)	7.56
≤–10	12 (26.7%)	33 (73.3%)	Ref	–
Hyponatremia (<130 mmol/L)	2 (12.5%)	14 (87.5%)	6.39 (1.16–46.28)	0.03
Hypokalemia (<3.5 mmol/L)	2 (11.8%)	15 (88.2%)	7.16 (1.30–51.67)	0.02

A shorter duration of ventilation (42.8 ± 24.6 hours) and ICU stay (5.5 ± 11.6 days) were associated with death (p = 0.001 and p = 0.01, respectively). Complications and ventilator-associated pneumonia were not significant. [Table III]

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Table – III: Univariate Analysis of Clinical Course and Complications Associated with Mortality (*n*=60)

Factor	Improved Mean ± SD / n (%)	Died Mean ± SD / n (%)	OR / t	p-value
Duration of ventilation (hours)	64.45 ± 19.63	42.78 ± 24.64	t=3.511	0.001
Duration of ICU stay (days)	13.05 ± 10.00	5.49 ± 11.61	t=2.54	0.01
Complications	16 (45.7%)	19 (54.3%)	OR=0.46	NS
Ventilator-associated pneumonia	5 (31.3%)	7 (36.8%)	–	–

Independent predictors of mortality were septicemia (OR 219.6, p=0.044), RDS & pneumonia (OR 111.3, p=0.044), high base deficit (OR 1.79, p=0.018), and delayed ICU admission >12 h (OR 8.29, p=0.024). Other factors were not significant. [Table IV]

Table – IV: Multivariate Logistic Regression Analysis of Independent Predictors of Mortality (*n*=60)

Predictor	OR	95% CI	p-value
Septicemia	219.59	1.15–448.8	0.044
RDS & Pneumonia	111.28	1.20–138.5	0.044
Base deficit	1.79	1.11–2.8	0.018
Time of ICU admission (>12 h)	8.29	1.20–23.5	0.024
Perinatal asphyxia	50.26	0.19–132.0	0.169
LBW	0.048	0.01–3.6	0.168
PH	0.577	0.04–8.6	0.690
Hyponatremia	1.136	0.86–1.5	0.356
Hypokalemia	1.937	0.45–8.3	0.375

DISCUSSION

In our study of 60 ventilated neonates, we observed that gestational age <28 weeks was associated with the highest mortality at 91.7%, compared to 54.2% in neonates >28 weeks. This indicates extreme prematurity is a critical determinant of death in ventilated neonates. Similarly, Kong et al. (2016) reported mortality rates exceeding 90% among neonates <28 weeks, and Markestad et al. (2015) observed mortality rates of 85–90% in extremely preterm infants requiring mechanical ventilation [13,14]. We also found that delayed ICU admission (>12 hours) was associated with 64.9% mortality, whereas admission within 12 hours had 35.1% mortality (p=0.01). This highlights the importance of timely ICU transfer. Cardoso et al. (2011) reported that delayed ICU admission increased mortality risk by 2–3 times, and Demisse et al. (2017) similarly emphasized that early intensive care significantly reduces neonatal deaths [15,16]. Regarding ABG parameters, neonates with an initial pH ≤7.1 had 83.3% mortality, while those with pH >7.1 had 40% mortality (p=0.003). Base deficit ≤–10 was associated with 73.3% mortality versus 26.7% for base deficit >–10. These findings indicate that severe acidosis strongly predicts poor outcomes. Hossain et al. (2009) reported that neonates with pH <7.1 had 70.6%% mortality, and Brown et al. (20118) also found low pH and high base deficit to be significantly associated with death, consistent with our observations [5,17]. Electrolyte disturbances were also associated with high mortality. In our cohort, hyponatremia (<130 mmol/L) had 87.5% mortality, and hypokalemia (<3.5 mmol/L) had 88.2% mortality. These results align with findings by Brown et al. (2018), where hyponatremia and hypokalemia were linked to mortality rates of 80–85% in ventilated neonates, confirming the importance of early correction of electrolyte imbalances [17]. Analysis of clinical course showed that neonates who died had shorter mean duration of ventilation (42.8 ± 24.6 hours) compared to survivors (64.5 ± 19.6 hours, p=0.001). Similarly, mean ICU stay was shorter in non-survivors (5.5 ± 11.6 days) than in survivors (13.1 ± 10.0 days, p=0.01). These findings suggest rapid deterioration in critically ill neonates. Russell et al. (2023) also reported that neonates who died had shorter ICU stays due to early mortality [18]. Ventilator-associated pneumonia was not significantly associated with death in our cohort (mortality 36.8% vs 31.3% in survivors), while other studies have shown VAP as a significant risk factor, suggesting differences in infection control practices [19]. In multivariate logistic regression, septicemia was the strongest independent predictor of mortality (OR 219.6, 95% CI 1.15–448.8, p=0.044). RDS & pneumonia were also significant (OR 111.3, 95% CI 1.20–138.5, p=0.044), along with base deficit (OR 1.79, 95% CI 1.11–2.8, p=0.018) and delayed ICU admission >12 hours (OR 8.29, 95% CI 1.20–23.5, p=0.024). Perinatal asphyxia, low birth weight, pH, hyponatremia, and hypokalemia were not significant in multivariate analysis. Gebreheat et al. (2022) and Wichterich et al. (2024) similarly identified septicemia and respiratory distress as independent predictors, with ORs ranging from 50 to 200, confirming the robustness of our findings [20,21]. Overall, our study demonstrates that gestational age <28 weeks (91.7% mortality), delayed ICU admission >12 hours (64.9%), severe acidosis (pH ≤7.1, 83.3%), high base deficit (≤–10, 73.3%), septicemia (OR 219.6), RDS & pneumonia (OR 111.3), and electrolyte imbalances (hyponatremia 87.5%, hypokalemia 88.2%) are critical determinants of mortality among ventilated neonates. These findings are consistent with international studies, highlighting the need for early ICU admission, prompt management of infections and respiratory complications, and meticulous correction of metabolic disturbances to improve survival.

LIMITATIONS OF THE STUDY

This study was conducted in a single tertiary care NICU, which may limit the generalizability of the findings to other hospitals or regions.

CONCLUSION

In ventilated neonates, septicemia, respiratory distress syndrome, high base deficit, and delayed ICU admission were identified as independent predictors of mortality. Early recognition and aggressive management of these factors are crucial for improving survival in critically ill neonates.

RECOMMENDATIONS

Based on our findings, it is recommended that NICUs implement protocols for early recognition and prompt

admission of critically ill neonates to minimize delays in intensive care. Regular monitoring and timely correction of metabolic derangements, such as acid-base and electrolyte imbalances, should be prioritized. Strengthening infection prevention measures and ensuring prompt management of sepsis and respiratory complications are essential. Future multicenter prospective studies with larger sample sizes are warranted to validate these findings and guide evidence-based interventions to improve neonatal survival.

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