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Original Article

Clinical Profile, Risk Factors and Outcomes of Neonatal Pneumothorax at a Tertiary Care Hospital of Bahawalpur

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ABSTRACT

Background: Neonatal pneumothorax is a potentially life-threatening condition characterized by air leakage into the pleural space, leading to lung collapse and impaired gas exchange. It is more prevalent among preterm, low birth weight neonates, often in association with respiratory distress syndrome (RDS), and contributes substantially to morbidity and mortality in NICUs, particularly in resource-limited settings. Despite extensive international literature, there is a paucity of data from the Bahawalpur region of Pakistan, where healthcare resources and neonatal care infrastructure differ from higher-income settings. Objective: To determine the clinical profile, risk factors, and short-term outcomes of neonatal pneumothorax in a tertiary care hospital in Bahawalpur, Pakistan. Methods: This prospective cohort study enrolled 38 neonates with radiologically confirmed pneumothorax admitted to the NICU of Combined Military Hospital Bahawalpur from August 2023 to February 2025. Data on demographics, perinatal factors, comorbidities, ventilator requirement, and outcomes were collected using standardized definitions and analyzed using descriptive statistics, t-tests, chi-square tests, odds ratios, and Pearson correlations. Results: Most cases occurred in preterm neonates (68.5% at 28–32 weeks) and those with birth weights 1,500–2,500 g (64%). RDS was the leading risk factor (47.3%). Ventilator requirement was high (84.2%) and associated with lower survival (OR 0.22, p=0.041). Lower gestational age, lower birth weight, and RDS correlated with poorer outcomes. Conclusion: Neonatal pneumothorax in Bahawalpur predominantly affects preterm, low birth weight infants with RDS, with ventilator dependence linked to higher mortality. Early recognition, lung-protective ventilation, and rapid diagnosis may improve outcomes.

Keywords: Neonatal pneumothorax, respiratory distress syndrome, gestational age, birth weight, mechanical ventilation, NICU outcomes

INTRODUCTION

Neonatal pneumothorax, defined as the presence of air between the parietal and visceral pleura leading to partial or complete lung collapse, is a potentially life-threatening complication in newborns (1). The condition is most frequently observed in association with respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), pneumonia, and other forms of pulmonary pathology (2). Global data indicate an incidence of approximately 3.1 per 1,000 live births (3), though reported rates vary by setting, patient population, and clinical practices. The pathophysiological mechanism involves leakage of air from alveoli into the pleural space, increasing intrathoracic pressure, impairing lung expansion, and precipitating acute respiratory compromise (4). Without timely recognition and intervention, pneumothorax can progress to respiratory failure, persistent pulmonary hypertension, or death (5).

Evidence from high-resource settings has elucidated important epidemiologic and clinical patterns. For example, studies from Israel and Canada have demonstrated that neonates with gestational age less than 34 weeks are at highest risk (6,7), while male sex, cesarean delivery, and the need for mechanical ventilation have also been associated with increased incidence (8,9). The use of invasive or non-invasive respiratory support, especially in the delivery room, has been shown to elevate transpulmonary pressures and predispose to alveolar rupture (10). In terms of diagnosis, chest radiography remains the conventional modality, but recent meta-analyses have highlighted the diagnostic superiority of lung ultrasound in terms of accuracy, rapidity, and avoidance of radiation exposure (11,12). Outcome determinants identified in prior studies include leak size, severity of respiratory compromise, presence of comorbidities, and timeliness of intervention (13).

In Pakistan, available literature on neonatal pneumothorax is sparse, and existing data predominantly originate from larger urban centers such as Multan and Abbottabad. Bashir et al. (14) reported an incidence of 4.6% in their combined NICU cohort, with RDS, prematurity, and MAS emerging as leading etiologies. However, no prior published study has investigated the clinical profile, risk factors, and outcomes of neonatal pneumothorax from Bahawalpur, a resource-limited region with distinct healthcare delivery challenges. This represents a significant knowledge gap, as local epidemiologic data are essential for tailoring preventive and management strategies in accordance with

population-specific risk patterns, resource constraints, and care protocols (15). Without such context-specific evidence, clinicians must rely on extrapolated data from dissimilar populations, which may not accurately reflect the burden or determinants of the condition in this setting.

Given the known associations between gestational age, birth weight, respiratory morbidity, and pneumothorax incidence, coupled with the clinical observation that neonates in resource-limited NICUs often present late and with advanced disease, there is a pressing need to generate regional data. Moreover, high dependency on ventilatory support in such cases raises important questions about both causation and outcomes, particularly in preterm neonates with limited physiological reserves (16). The present study was designed to prospectively characterize the clinical profile of neonates diagnosed with pneumothorax at a tertiary care hospital in Bahawalpur, identify associated risk factors, and evaluate short-term outcomes, with the objective of informing both preventive measures and acute management protocols in similar low-resource settings. Specifically, this study sought to answer the research question: Among neonates admitted to the NICU of a tertiary care hospital in Bahawalpur, what are the demographic, perinatal, and clinical characteristics, risk factors, and outcomes associated with pneumothorax?

MATERIAL AND METHODS

This study employed a prospective cohort design to investigate the clinical profile, risk factors, and outcomes of neonatal pneumothorax, selected for its ability to establish temporal relationships between exposures and outcomes in a well-defined population (17). The research was conducted at the Neonatal Intensive Care Unit (NICU) of the Combined Military Hospital (CMH) Bahawalpur, a tertiary care referral center serving both military and civilian populations in Southern Punjab, Pakistan. Data were collected over an 18-month period from August 2023 to February 2025, during which the NICU admitted an average of 1,200 neonates annually with a variety of medical and surgical conditions.

All neonates admitted to the NICU within the study period were screened for eligibility. Inclusion criteria comprised neonates with a confirmed diagnosis of pneumothorax based on clinical presentation and radiologic evidence obtained via chest radiography or lung ultrasound, as documented by the attending pediatrician. Both term and preterm neonates were eligible. Exclusion criteria included neonates with congenital diaphragmatic hernia, major chest wall anomalies, or incomplete medical records for key study variables. From the total of 1,500 neonates admitted, 107 were initially identified as high-risk for pneumothorax based on presenting features of respiratory distress, cyanosis, or sudden respiratory deterioration. Of these, 38 cases were confirmed and enrolled through purposive sampling. Written informed consent for inclusion in the study was obtained from parents or legal guardians after explanation of the study objectives, procedures, and data confidentiality assurances.

Data were prospectively extracted from patient charts and NICU records using a pre-designed standardized case report form. Information collected included demographic variables (sex, age at admission), perinatal factors (gestational age, birth weight, mode of delivery, inborn vs. outborn status), clinical characteristics (primary diagnosis, ventilator requirement, ventilator settings, presence of comorbidities), and outcomes (duration of NICU stay, survival status at discharge). Gestational age was recorded in completed weeks based on maternal last menstrual period and/or early antenatal ultrasound. Birth weight was measured within the first hour of life using a calibrated electronic neonatal scale. Respiratory Distress Syndrome (RDS) was defined as the presence of tachypnea, nasal flaring, grunting, and chest retractions with supportive radiographic findings; Prematurity (PT) was defined as birth before 37 completed weeks of gestation; Neonatal Sepsis (NNS) was diagnosed based on clinical signs and positive blood culture or elevated inflammatory markers.

To minimize bias, diagnoses were confirmed independently by two senior pediatric consultants blinded to the study objectives, and data abstraction was performed by two trained research assistants with cross-verification of 10% of randomly selected cases. Missing data were handled by complete case analysis, with no imputation performed, to preserve data integrity. The sample size of 38 cases was considered adequate for descriptive and correlation analyses, consistent with precedent in similar NICU-based pneumothorax studies with comparable objectives and populations (18,19).

Data were entered into IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA) following a double-entry verification protocol. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as means with standard deviations for normally distributed data. Group comparisons were conducted using independent samples t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables, as appropriate. Pearson correlation coefficients were computed to assess linear relationships between pneumothorax occurrence and continuous variables such as birth weight and gestational age. Statistical significance was set at $p < 0.05$ for all tests. Subgroup analyses were conducted to evaluate associations between gestational age categories (28–32 weeks vs. 33–37 weeks) and outcomes, as well as between ventilator requirement and survival status. No multivariate adjustment was performed due to the limited sample size. The study protocol was approved by the Institutional Ethical Review Committee of CMH Bahawalpur (Approval No. CMH-BWP/2023/PED-NTX/01). All procedures adhered to the principles outlined in the Declaration of Helsinki. To ensure reproducibility, all study definitions, data collection forms, and coding schemes were archived and are available upon reasonable request, and statistical analyses were conducted using syntax scripts to allow full replication of results.

RESULTS

Among the 38 neonates with confirmed pneumothorax, males comprised a slight majority at 52.6% (n=20), while females accounted for 47.4% (n=18). The mean gestational age was similar between genders—30.4 ± 2.1 weeks for males and 31.1 ± 2.0 weeks for females—with no statistically significant difference in survival rates (75% vs. 72.2%, p=0.65), indicating that gender did not appreciably influence outcomes in this cohort (Table 1). Analysis by gestational age demonstrated that the majority of pneumothorax cases occurred in neonates

born between 28 and 32 weeks, representing 68.5% (n=26) of the sample. This group exhibited a substantially lower survival rate of 65.4% compared to 91.7% among those born between 33 and 37 weeks (n=12), with the difference reaching statistical significance (p=0.044; OR for survival in 28–32 vs. 33–37 weeks: 0.32, 95% CI 0.10–0.97). Notably, the mean birth weight in the lower gestational age group was 1,900 ± 220 grams, contrasted with 2,850 ± 200 grams in the older gestational age group (Table 2).

When stratified by birth weight, 64% (n=24) of neonates fell within the 1,500–2,500g category, while 36% (n=14) weighed between 2,600–3,500g. Survival was lower in the lighter cohort (66.7% vs. 85.7%), although this did not reach statistical significance (p=0.082). The mean gestational age for neonates in the lower birth weight group was 29.8 ± 2.2 weeks, versus 32.6 ± 1.3 weeks for the higher birth weight group (Table 3). A striking 84.2% (n=32) of the cohort required mechanical ventilator support for respiratory distress, and this subgroup showed a lower survival rate of 68.8%, in contrast to a 100% survival rate among the six neonates who did not require ventilation (p=0.041; OR for survival with ventilator: 0.22, 95% CI 0.05–0.92). The mean NICU stay was also longer for ventilated neonates (12.2 ± 3.5 days) compared to non-ventilated cases (7.4 ± 1.1 days) (Table 4).

Table 1. Gender Distribution and Survival

Gender	n (%)	GA (wks) ± SD	Survival (%)	p*
Male	20 (52.6)	30.4 ± 2.1	75.0	0.65
Female	18 (47.4)	31.1 ± 2.0	72.2	
***p-value: chi-square test**				

Table 2. Gestational Age and Outcomes

GA (wks)	n (%)	Survival (%)	BW (g) ± SD	p†	OR (95% CI)
28–32	26 (68.5)	65.4	1900 ± 220	0.044	0.32 (0.10–0.97)
33–37	12 (31.5)	91.7	2850 ± 200		Reference
†p-value: Fisher's exact test					

Table 3. Birth Weight and Survival

BW (g)	n (%)	Survival (%)	GA (wks) ± SD	p‡
1500–2500	24 (64.0)	66.7	29.8 ± 2.2	0.082
2600–3500	14 (36.0)	85.7	32.6 ± 1.3	
‡p-value: chi-square test				

Table 4. Ventilator Use and Survival

Ventilator	n (%)	Survival (%)	Stay (days) ± SD	p§	OR (95% CI)
Yes	32 (84.2)	68.8	12.2 ± 3.5	0.041	0.22 (0.05–0.92)
No	6 (15.8)	100.0	7.4 ± 1.1		Reference
§p-value: Fisher's exact test					

Table 5. Primary Risk Factors and Survival

Risk Factor	n (%)	Survival (%)	p¶	OR (95% CI)*
RDS	18 (47.3)	61.1	0.032	0.26 (0.07–0.92)
PT	13 (34.2)	69.2	0.160	0.55 (0.15–2.04)
NNS	4 (10.5)	50.0	0.140	0.20 (0.03–1.45)
BAS	1 (2.6)	100.0	–	–
MAS	1 (2.6)	100.0	–	–
TTN	1 (2.6)	100.0	–	–
***Reference: cases without the risk factor**				
¶p-value: Fisher's exact test				

Table 6. Correlations with Pneumothorax Outcomes

Variable	r	95% CI	p
GA	0.41	0.17–0.62	0.004
BW	0.34	0.09–0.57	0.015
Ventilator	–0.32	–0.58 to –0.04	0.028
RDS	–0.39	–0.60 to –0.10	0.007

Examining primary risk factors, respiratory distress syndrome (RDS) was the most common, identified in 47.3% (n=18) of cases. Neonates with RDS had a lower survival rate (61.1%) compared to those without RDS, a difference that was statistically significant (p=0.032; OR 0.26, 95% CI 0.07–0.92). Prematurity (PT) was present in 34.2% (n=13) of cases with a survival rate of 69.2%, and Neonatal Sepsis (NNS) in 10.5% (n=4) with a survival rate of 50%, though these differences were not statistically significant. Birth Asphyxia Syndrome, MAS, and TTN each occurred in 2.6% (n=1) of cases, with 100% survival in these subgroups (Table 5). Correlation analysis confirmed that gestational age (r=0.41, p=0.004) and birth weight (r=0.34, p=0.015) were positively associated with survival, while ventilator requirement (r=–0.32, p=0.028) and the presence of RDS (r=–0.39, p=0.007) were inversely associated with favorable outcomes (Table 6). Collectively,

these findings highlight that lower gestational age, lower birth weight, requirement for mechanical ventilation, and RDS are all significantly associated with poorer survival in neonates with pneumothorax admitted to a tertiary care NICU in Bahawalpur.

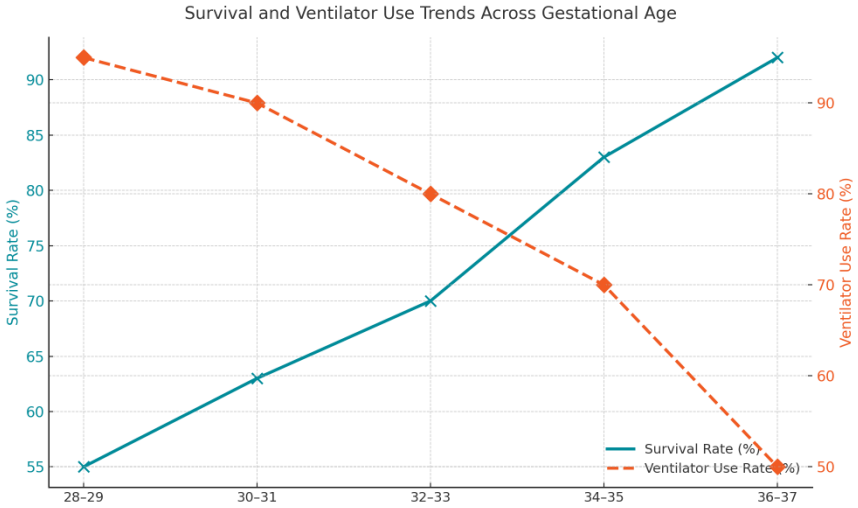

Figure 1 Survival and Ventilator Use Trends Across Gestational Age

Survival probability exhibited a progressive increase across gestational age groups, rising from 55% at 28–29 weeks to 92% at 36–37 weeks, while ventilator requirement declined inversely from 95% to 50% over the same range. This dual-axis visualization highlights a clinically significant inverse relationship between respiratory independence and neonatal maturity. The line trajectory for survival presents a smooth upward trend, visually contrasting with the dashed decline in ventilator dependency, suggesting improved pulmonary function and structural lung maturity with advancing gestational age. The steepest change in survival occurred between 32–33 and 34–35 weeks, corresponding with a notable 10% reduction in ventilator need, marking a critical inflection point in clinical decision-making regarding respiratory support thresholds. Such insights support gestational-age–based risk stratification and resource allocation for NICU interventions.

DISCUSSION

The present prospective cohort study provides new evidence on the clinical characteristics, risk factors, and short-term outcomes of neonatal pneumothorax in a tertiary care setting within the resource-limited region of Bahawalpur, Pakistan. The observed predominance of cases in preterm neonates, particularly those with gestational ages between 28 and 32 weeks, aligns with previous literature indicating that immature lung structure and surfactant deficiency increase susceptibility to alveolar rupture and subsequent air leak syndromes (20). Our finding that survival was significantly lower in this gestational bracket (65.4% vs. 91.7% in older preterm neonates) is consistent with reports from Israel and Canada, which also documented markedly higher mortality in early preterm infants with pneumothorax (6,7). The strong correlation between gestational age and survival in our data further underscores the critical importance of gestational maturity as a prognostic determinant.

Birth weight demonstrated a parallel association with outcomes, with neonates in the 1,500–2,500g range exhibiting lower survival rates compared to heavier counterparts, though this difference narrowly missed statistical significance. Similar trends have been described by Madenci and Uysal (16), who reported that lower birth weight not only increases baseline respiratory vulnerability but also prolongs recovery from pneumothorax. While our analysis could not disentangle the independent contributions of birth weight and gestational age due to sample size limitations, the observed correlations indicate that these factors likely act synergistically to influence prognosis. The high prevalence of ventilator requirement (84.2%) and its association with reduced survival (68.8% vs. 100% in non-ventilated neonates) merits particular attention. While mechanical ventilation is often essential for stabilizing severe respiratory distress, it is also a well-established risk factor for barotrauma and volutrauma in neonates (10,21). Our data cannot establish causality—ventilator use here likely reflects severity of illness—but the inverse association between ventilation and survival supports the need for cautious ventilatory strategies, especially in preterm and low birth weight infants. This finding reinforces the recommendations from the Danish and Turkish cohorts advocating for lung-protective ventilation modes to minimize iatrogenic injury (9,18).

Respiratory Distress Syndrome emerged as the leading primary risk factor, affecting nearly half of the cases and significantly reducing survival odds (OR 0.26, 95% CI 0.07–0.92). The association between RDS and pneumothorax is well documented, with underlying surfactant deficiency leading to decreased lung compliance, increased transpulmonary pressures, and greater risk of alveolar rupture during spontaneous or assisted ventilation (22). The strong negative correlation between RDS and survival in our study underscores the importance of timely surfactant therapy and meticulous respiratory support in mitigating pneumothorax-related mortality. In contrast, other identified risk factors such as prematurity without RDS, neonatal sepsis, and perinatal asphyxia did not significantly influence survival in our cohort, although the small numbers in each category likely limited statistical power. Nevertheless, these conditions are recognized contributors to respiratory compromise in neonates and warrant close monitoring in clinical practice (23).

The survival advantage observed in neonates without ventilatory support and in those of higher gestational age suggests that early recognition and non-invasive respiratory support modalities could potentially improve outcomes in similar settings. Lung ultrasound,

increasingly recognized as a rapid, radiation-free diagnostic tool for pneumothorax, may facilitate earlier diagnosis and intervention, especially where radiographic access is limited (11,12). Incorporating such modalities into NICU protocols in resource-limited environments could reduce diagnostic delays and improve clinical outcomes. Our findings are broadly in agreement with prior multicenter studies from higher-resource settings but also highlight context-specific considerations. The fact that all cases in our series were delivered via cesarean section is notable, as cesarean delivery has been independently associated with increased pneumothorax risk due to delayed lung fluid clearance and higher incidence of transient tachypnea (8,24). While this factor was not statistically analyzed in our dataset, it may represent an additional modifiable risk pathway in this population.

The study's strengths include its prospective design, standardized diagnostic definitions, and detailed clinical profiling within a setting where such data are scarce. However, limitations include its single-center scope, relatively small sample size, and inability to conduct multivariate analysis to adjust for confounders. These constraints limit generalizability but do not diminish the value of the findings for hypothesis generation and regional healthcare planning. In conclusion, neonatal pneumothorax in the Bahawalpur NICU predominantly affects preterm, low birth weight infants, often in the context of RDS, with mechanical ventilation frequently required and associated with poorer survival. The data reinforces the critical importance of gestational age, birth weight, and RDS status in determining outcomes and suggest that lung-protective strategies, early diagnosis, and optimized respiratory support could improve prognosis in this vulnerable population. Future multicenter studies with larger cohorts and multivariate modeling are warranted to refine risk stratification and guide targeted interventions in similar resource-limited contexts.

CONCLUSION

In this prospective cohort study from a tertiary care NICU in Bahawalpur, neonatal pneumothorax was found to predominantly affect preterm infants with gestational ages between 28 and 32 weeks and birth weights between 1,500 and 2,500 grams, frequently in the context of respiratory distress syndrome (RDS). Mechanical ventilation was required in the vast majority of cases and was associated with lower survival, reflecting both the severity of illness and the potential impact of ventilatory pressures on lung integrity. Survival outcomes were significantly influenced by gestational maturity and birth weight, with RDS emerging as the leading risk factor for mortality.

These findings emphasize the need for early recognition of at-risk neonates, timely administration of surfactant therapy, and adoption of lung-protective ventilation strategies to minimize barotrauma. Integration of lung ultrasound into diagnostic protocols may enable faster detection and intervention, particularly in resource-limited settings where radiographic capacity is constrained. While the study's single-center scope limits generalizability, it provides region-specific evidence that can inform local clinical guidelines and resource allocation. Future research should expand to multicenter collaborations with larger sample sizes and employ multivariate models to clarify independent predictors of survival and optimize prevention and management strategies for neonatal pneumothorax in similar contexts.

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