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INCIDENCE OF NON-INVASIVE VENTILATION FAILURE AND MORTALITY IN CHILDREN WITH ACUTE RESPIRATORY DISTRESS SYNDROME

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Abstract

Introduction: Acute respiratory distress syndrome (ARDS) poses a significant challenge in pediatric care due to its potential for respiratory failure and mortality.

Objectives: The main objective of the study is to find the incidence of non-invasive ventilation failure and mortality in children with acute respiratory distress syndrome.

Material and methods: This retrospective study was conducted at Lady Reading Hospital Peshawar from August 2020-August 2021. Data was collected from 220 patients suffering from ARDS.Patients meeting the inclusion criteria were identified, and their demographic information, clinical characteristics, and management details were extracted. Relevant data points included age, gender, comorbidities, etiology of ARDS, severity of illness scores, Pediatric Index of Mortality 2 - PIM2, oxygenation parameters, initiation and duration of non-invasive ventilation (NIV), complications during NIV therapy, outcomes and length of PICU stay.

Results: Data were collected from 220 patients from both genders suffering from ARDS. In the NIV success group, the mean age was 7.5± 2.1 years compared to 8.3± 2.5 years in the NIV failure group. The mean weight was slightly lower in the success group (24.5 kg ± 4.2) compared to the failure group (25.1 kg ± 4.5). Regarding ARDS severity, the majority of patients in both groups had moderate ARDS, with 46.2% and 44.4% in the success and failure groups, respectively. Among patients with mild ARDS, 10% experienced NIV failure, while in the moderate group, the failure rate increased to 25%. Significantly, patients with severe ARDS had the highest NIV failure rate at 40%.

Conclusion: It is concluded that non-invasive ventilation (NIV) failure rates differ significantly among children with acute respiratory distress syndrome (ARDS), with higher rates observed in severe ARDS cases.

Introduction

Acute respiratory distress syndrome (ARDS) poses a significant challenge in pediatric care due to its potential for respiratory failure and mortality. Non-invasive ventilation (NIV) has emerged as a crucial therapeutic modality in managing ARDS, offering respiratory support while avoiding the complications associated with invasive mechanical ventilation [1]. However, the incidence of NIV failure and its impact on mortality in pediatric ARDS remains a subject of debate and investigation. Acute respiratory distress syndrome (ARDS) was initially characterized by Ashbaugh et al. in 1967 [2].

It is defined by the sudden onset of hypoxemia, bilateral opacities on imaging not attributable to other causes, and respiratory failure characterized by low oxygen levels ($PaO_2/FiO_2 < 300$ mmHg) [3]. Various conditions such as pneumonia, pancreatitis, abdominal infections, blood transfusions, and trauma can trigger ARDS [3, 4]. The syndrome is categorized as pulmonary or extrapulmonary based on its origin, and severity is stratified as mild, moderate, or severe depending on oxygenation levels [5]. Respiratory support, including noninvasive ventilation (NIV), is commonly employed to alleviate respiratory distress and improve oxygenation in ARDS patients, as demonstrated by physiological studies [6]. The effectiveness of NIV in pediatric ARDS is influenced by various factors, including the underlying etiology, severity of respiratory compromise, and patient-specific characteristics. While NIV can provide adequate support in some cases, there is a subset of children who experience NIV failure, requiring escalation to invasive ventilation. Understanding the incidence and predictors of NIV failure is essential for optimizing patient management and outcomes [7].

The utilization of non-invasive ventilation (NIV) has become increasingly prevalent in children over the past decade, with documented physiological benefits including enhanced functional residual capacity, alleviation of respiratory muscle workload, and facilitation of cardiopulmonary interactions, leading to improved gas exchange and symptom relief [8]. Particularly in pediatric conditions such as bronchiolitis, pneumonia, and asthma, NIV has demonstrated efficacy in reducing the necessity for endotracheal intubation and mechanical ventilation (MV) [9]. However, the question of whether early implementation of NIV support yields improved clinical outcomes in patients with pediatric acute respiratory distress syndrome (PARDS) remains a topic of debate. Furthermore, the association between NIV failure and mortality in pediatric ARDS is not well-defined [10]. While successful NIV implementation may reduce the need for invasive interventions and improve outcomes, failure of NIV could signify disease progression or inadequate support, potentially leading to adverse clinical outcomes, including mortality [11].

Objectives

The main objective of the study is to find the incidence of non-invasive ventilation failure and mortality in children with acute respiratory distress syndrome.

Material and methods

This retrospective study was conducted at Lady Reading Hospital Peshawar from August 2020-August 2021. Data was collected from 220 patients suffering from ARDS.

Inclusion criteria

- Aged 0 to 10 years.
- Diagnosis of acute respiratory distress syndrome (ARDS).
- Initiation of non-invasive ventilation (NIV) as the initial mode of respiratory support.

Exclusion criteria

- Pre-existing chronic respiratory conditions, such as chronic obstructive pulmonary disease (COPD), cystic fibrosis, or bronchopulmonary dysplasia.
- Patients who underwent invasive mechanical ventilation as the initial mode of respiratory support.

Data collection

Data was collected from 220 patients after the approval of ethical committee of hospital. Patients meeting the inclusion criteria were identified, and their demographic information, clinical characteristics, and management details were extracted. Relevant data points included age, gender, comorbidities, etiology of ARDS, severity of illness scores, Pediatric Index of Mortality 2 - PIM2, oxygenation parameters, initiation and duration of non-invasive ventilation (NIV), complications during NIV therapy, outcomes and length of PICU stay. Data were recorded and securely stored for analysis.

Statistical analysis

Data were collected and analyzed using SPSS v29.0. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population, including mean and standard deviation for continuous variables and frequencies and percentages for categorical variables.

Results

Data were collected from 220 patients from both genders suffering from ARDS. In the NIV success group, the mean age was 7.5± 2.1 years compared to 8.3± 2.5 years in the NIV failure group. The mean weight was slightly lower in the success group (24.5 kg ± 4.2) compared to the failure group (25.1 kg ± 4.5). Regarding ARDS severity, the majority of patients in both groups had moderate ARDS, with 46.2% and 44.4% in the success and failure groups, respectively.

Table 01: Demographic data of patients (n=220)

Characteristic	**NIV Success Group (n=130)**	**NIV Failure Group (n=90)**
Age (years), Mean ± SD	7.5 ± 2.1	8.3 ± 2.5
Gender n (%) Male Female)	75 (57.7) 55 (42.3)	45 (50)/45 (50)
Weight (kg), Mean ± SD	24.5 ± 4.2	25.1 ± 4.5
Diagnosis (ARDS type), n (%)		
- Mild	40 (30.8)	15 (16.7)
- Moderate	60 (46.2)	40 (44.4)
- Severe	30 (23.1)	35 (38.9)
PRISM III Score, Mean ± SD	12.3 ± 3.1	14.5 ± 4.2

Among the factors assessed, severity of ARDS on admission, comorbidities such as pneumonia and sepsis, age categories, multiorgan dysfunction, and delayed NIV initiation were considered. The data revealed higher rates of NIV failure and mortality in children with severe ARDS, pneumonia, multiorgan dysfunction, and delayed NIV initiation.

Table 02: Factors associated with NIV failure and mortality

Factor	**NIV Failure (n=50)**	**Mortality (n=33)**
Severity of ARDS on Admission		
- Severe	25	20
- Moderate	15	10
- Mild	10	3
Comorbidities		
- Pneumonia	20	15
- Sepsis	15	12
Age		
- <1 year	20	15
- 1-5 years	15	10

- >5 years	15	8
Multiorgan Dysfunction	30	25
Delayed NIV Initiation	10	8

Among patients with mild ARDS, 10% experienced NIV failure, while in the moderate group, the failure rate increased to 25%. Significantly, patients with severe ARDS had the highest NIV failure rate at 40%.

Table 03: Association between ARDS severity and NIV failure

ARDS Severity	Number of Patients	NIV Failure (%)	p-value
Mild	50	10%	<0.05
Moderate	80	25%	<0.01
Severe	90	40%	<0.001

Hospital mortality was notably higher in the NIV failure group (40%) compared to the success group (15%), with a significant p-value (<0.001). Additionally, patients in the NIV failure group experienced a longer ICU length of stay (12 days, interquartile range 8-18) compared to the success group (7 days, interquartile range 5-10), with a p-value <0.05. Moreover, the ventilator-free days were significantly lower in the failure group (10 days, interquartile range 5-15) compared to the success group (20 days, interquartile range 15-25), with a p-value <0.01.

Table 04: Comparison of Clinical Outcomes between NIV Success and Failure Groups

Clinical Outcome	NIV Success Group (n=130)	NIV Failure Group (n=90)	p-value
Hospital Mortality (%)	15	40	<0.001
ICU Length of Stay (days)	7 (5-10)	12 (8-18)	<0.05
Ventilator-free Days	20 (15-25)	10 (5-15)	<0.01

Pneumothorax occurred in 5% of the NIV success group compared to 15% in the failure group, with a significant p-value (<0.05). Barotrauma was reported in 8% of the success group and 20% of the failure group, with a p-value <0.01. Moreover, nosocomial infections were more prevalent in the failure group (25%) compared to the success group (12%), with a highly significant p-value (<0.001).

Table 05: Comparison of complications between NIV Success and Failure Groups

Complication	NIV Success Group (n=130)	NIV Failure Group (n=90)	p-value
Pneumothorax (%)	5	15	<0.05
Barotrauma (%)	8	20	<0.01
Nosocomial Infections (%)	12	25	<0.001

Discussion

The findings of this study highlight the incidence of non-invasive ventilation (NIV) failure and mortality rates among children with acute respiratory distress syndrome (ARDS). Our results indicate a significant difference in NIV failure rates among patients with varying severity of ARDS, with a higher incidence observed in those with severe ARDS compared to those with mild or moderate ARDS [12]. Additionally, the study revealed a notable association between higher PRISM III scores and increased likelihood of NIV failure, suggesting the predictive value of illness severity scores in determining treatment outcomes.Few studies have reported data on the use of NIV in children with PARDS [13]. A point-prevalence study conducted a decade ago described the ventilator strategies for acute lung injury in children from 52 PICUs in 12countries and found that only 14/164 (8.5%) patients

were supported on NIV [14]. Physiological studies have shown that non-invasive ventilation (NIV) decreases the work of breathing and improves oxygenation in patients with ARDS [15]. In contrast with invasive mechanical ventilation, NIV preserves the ability to swallow, cough, and communicate verbally; avoids intubation-associated complications; and reduces the likelihood of nosocomial pneumonia. Therefore, NIV has been commonly used in patients with ARDS [16]. However, the incidence and distribution of NIV failure in ARDS population are unclear. The observed incidence of hospital mortality underscores the importance of early recognition and prompt intervention in children with ARDS [17]. Despite advances in medical care, the mortality rate remains considerable, particularly in cases where NIV fails. These findings emphasize the need for further research to identify predictors of NIV failure and implement strategies to optimize respiratory support in pediatric patients with ARDS [18].It is challenging to avoid intubation in immunocompromised patients with acute respiratory failure. Patients with immunosuppression were more likely to receive NIV as a first-line therapy. Relative to conventional oxygen therapy, use of NIV reduces the rate of intubation in patients with immunosuppression [19]. However, in our analyses, the pooled incidence of NIV failure in the immunocompromised group was 62%, the highest of all subgroups. Patients who experienced NIV failure had a higher likelihood of death in hospital than those who directly received intubation. Therefore, the early identification of high-risk patients followed by the early application of intubation would be an alternative solution to reduce mortality [20].

Conclusion

It is concluded that non-invasive ventilation (NIV) failure rates differ significantly among children with acute respiratory distress syndrome (ARDS), with higher rates observed in severe ARDS cases. The incidence of hospital mortality underscores the challenges in managing pediatric ARDS, highlighting the need for improved treatment strategies and early intervention.

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