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Original Research Article

Clinical profile of ventilator-associated pneumonia and its correlation between risk factor, morbidity and mortality in children

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ABSTRACT

Background: Mechanical ventilation (MV) is often necessary to manage critically ill pediatric patients admitted in the ICU. Nonetheless, it presents certain complications, including the potential risk of developing ventilator-associated pneumonia (VAP). The main objective of the present study was to evaluate the clinical profile and risk factor associated with the morbidity and mortality in children with VAP.
Methods: This was a cross-sectional observational study conducted on 120 children aged 1 month 12 years who were mechanically ventilated. All enrolled children were evaluated daily for the onset of ventilator-associated pneumonia (VAP). Chest radiography and microbiological sampling was performed in children suspected with VAP. Duration of hospital stays, ventilator days and reintubation were also recorded.
Results: Out of 120 children, 35 (29.2%) had developed VAP and the prevalence of VAP is estimated to be 29.2%. The most prevalent pathogen associated with VAP was K. pneumonia in 18 (51.4%) of the children. The duration of MV (28.65±12.76 vs 9.87±6.87, p<0.001 and hospital stay (35.87±8.15 vs 15.76±4.12; p=0.001) was higher in VAP as compared to no VAP and it was significant. Bivariate analysis revealed that use of steroids (p=0.004), sedative (p=0.01) and reintubation (p=0.003) was found to be significant risk factor for the development of VAP. The incidence of mortality in VAP was 4/35, i.e., 11.4%.
Conclusions: About one-third of the children developed VAP. Klebsiella was the most predominate isolate and duration of MV and hospital stay were important predictors for VAP.

Keywords: Children, K pneumonia, Mechanical ventilation, Steroid use, Ventilator associated pneumonia

INTRODUCTION

Mechanical ventilation (MV) is an essential life-saving therapeutic intervention to manage critically ill pediatric patients, particularly those with respiratory failure.[1] However, despite its life-saving potential, mechanical ventilation comes with substantial risks. One of the most severe and frequent complications associated with MV is ventilator-associated pneumonia (VAP).[2] VAP is pneumonia that occurs in a patient who has been mechanically ventilated for 48 hours or more and is considered a significant healthcare-associated infection in the PICU setting.[3] It is associated with prolonged hospital stays, increased morbidity and elevated mortality rates, making it a serious concern for both clinicians and patients.[4]

The pathophysiology of VAP is complex and multifactorial. The condition arises when the respiratory tract is colonized by pathogenic microorganisms that enter the lower respiratory tract, leading to infection.[5] VAP in pediatric patients poses unique challenges. Children, especially those in critical care, are at heightened risk due to factors such as prolonged mechanical ventilation, sedation and immune suppression.[6] Prolonged intubation, the use of sedatives

and paralytics, reintubation and poor nutritional status are all well-documented risk factors for the development of VAP.[7] These factors impair the immune response, compromise airway clearance and increase the likelihood of bacterial colonization, predisposing children to infections such as VAP. Additionally, the use of immunosuppressive therapies like corticosteroids further increases the risk of infection in these already vulnerable patients.[8]

The most common pathogens responsible for VAP in children include *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and Acinetobacter spp.[9] The microbiological profile of VAP in children can vary depending on regional factors. Still, the growing concern of multi-drug-resistant organisms has made treatment more challenging. The emergence of resistant pathogens has highlighted the need for more effective antimicrobial stewardship and tailored therapies to manage VAP effectively.

This study aims to evaluate the clinical profile, microbiological findings and risk factors associated with VAP in pediatric patients. Additionally, the study will assess the impact of VAP on patient outcomes, including morbidity and mortality.

METHODS

This cross-sectional observational study was conducted in a pediatric intensive care unit (PICU) over one year from August 2023-August 2024 at the Department of Pediatrics, Al-Ameen Medical College, Vijayapura and Karnataka, India.

The study included 120 pediatric patients aged between 1 month and 12 years who were mechanically ventilated for varying durations. These children were selected from those admitted to the PICU and required mechanical ventilation due to respiratory failure or other critical illnesses. The study was approved by the Institutional Ethical Review Board (IRB). Written informed consent was obtained from the parents or guardians of all participating patients.

Inclusion criteria

Children aged 1 month to 12 years and those requiring mechanical ventilation for at least 48 hours were included in the study.

Exclusion criteria

Children with pre-existing chronic respiratory infections or diseases, receiving non-invasive ventilation and with mechanical ventilation for less than 48 hours were excluded from the study.

Demographic data (age, gender), nutritional status, underlying conditions and primary diagnosis were collected from the patients' medical records. Additionally, details regarding the duration of mechanical ventilation, total hospital stay, sedative and steroid use and reintubation were recorded.

Ventilator-associated pneumonia (VAP) was diagnosed based on the case definition provided by the Centers for Disease Control and Prevention (CDC), which includes clinical, radiological and microbiological criteria. Chest radiography and microbiological samples (blood and tracheal aspirates) were collected for microbial cultures in children suspected of developing VAP.[10]

Microbiological sampling was performed by collecting tracheal aspirates and blood cultures to isolate pathogens responsible for the infection. The isolates were identified and tested for antibiotic susceptibility.

Data analysis

The data was shown mean±SD and frequency (%). The statistical analysis was performed using Chi-square tests and bivariate analysis to assess the association between various risk factors and the development of VAP. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The prevalence of VAP is estimated to be 29.2%. The duration of mechanical ventilation ($p<0.01$) and hospital stay ($p=0.001$) was higher in VAP when compared to no-VAP and it was significant. The incidence of reintubation ($p=0.001$), steroid use ($p=0.005$) and use of PPI ($p=0.01$) was higher in VAP when compared to No- VAP. The data is shown in Table 1.

The indication for mechanical ventilation is shown in *Table 2*. The most common indication was respiratory failure, which accounted for 54.1% of cases. Poor sensorium was the second most frequent reason, affecting 28.3% of the children. Shock and cardio-respiratory arrest were less common, occurring in 8.3% and 5.8% of patients, respectively. Airway protection was the least common indication, accounting for 3.3% of cases.

The distribution of causative organisms for VAP is shown in *Table 3*. The most common pathogen was *Klebsiella pneumoniae*, identified in 51.4% of the cases. *Pseudomonas aeruginosa* was the second most frequent organism in 20% of cases. *Staphylococcus aureus* was found in 14.3% of the VAP cases. Haemophilus influenzae and Enterococcus were also identified, accounting for 11.4% and 2.9% of cases, respectively.

Table 4 presents the risk factors for developing ventilator-associated pneumonia (VAP) in mechanically ventilated children. Among the risk factors, duration of mechanical ventilation was the most significant, with an odds ratio (OR) of 8.43 (95% CI, 2.13-14.76, p=0.001),

indicating a strong association with VAP. Reintubation also showed a significant relationship, with an OR of 5.32 (95% CI:1.76-11.65, p=0.003). The use of steroids (OR=3.65, 95% CI: 1.11-8.32, p=0.004), sedation (OR=4.39, 95% CI: 1.54-10.45, p=0.01) and proton pump inhibitors (PPIs) (OR=2.76, 95% CI: 0.98-7.34, p=0.04) were also significantly associated with VAP. These results indicate that these factors increase the likelihood of VAP development in pediatric patients on mechanical ventilation. However, age (OR=0.54, 95% CI: 0.19-1.98, p=0.43) and duration of hospital stay (OR=0.65, 95% CI: 0.12-2.14, p=0.08) were not statistically significant in the development of VAP. These findings underscore the critical role of managing ventilation duration, reintubation and using sedatives and steroids to mitigate the risk of VAP in pediatric ICUs. Table 5 presents the outcomes for the 35 children who developed ventilator-associated pneumonia (VAP). Among these children, 4 (11.4%) died, while 6 (17.1%) left against medical advice. Most children (25, 71.4%) recovered and were discharged. This highlights the varying severity of VAP and its impact on patient outcomes. The data also suggests that while recovery is the most common outcome, a substantial proportion of children either died or left the hospital prematurely.

Table 1: Comparison of demographics and clinical variables between VAP and No VAP children on mechanical ventilation.

Variables	VAP (n=35)	No VAP (n=85)	P value
Age in years (mean±SD)	4.45±0.87	5.21±1.43	0.87 NS
Gender (N, %)			
Male	21 (60%)	50 (58.8%)	0.72 b NS
Female	14 (40%)	35 (41.2%)	
Duration of mechanical ventilation in days (mean±SD)	28.65±12.76	9.87±6.87	P<0.01 a*
Duration of hospital stay in days (mean±SD)	35.87±8.15	15.76±4.12	0.001 a*
Reintubation (N, %)	22 (62.8%)	25 (29.4%)	0.001 b*
Steroid use (N, %)	27 (77.1%)	34 (40%)	0.005 b*
Use of proton pump inhibitors (N, %)	31 (88.5%)	18 (21.2%)	0.01 b*

The data was shown as mean±SD and n (%). The comparison between VAP and no VAP was done as follows a-unpaired student t-test; b-Chi-square test. *Indicates significant (p<0.05), NS-Non significant

Table 2: Indication of mechanical ventilation.

Indication for mechanical ventilation	No. of children (n=120) (%)
Respiratory failure	65 (54.1)
Poor sensorium	34 (28.3)
Shock	10 (8.3)
Cardiorespiratory arrest	7 (5.8)
Airway protection	4 (3.3)

Table 3: Distribution of causative organisms among the VAP cases (n=35).

Patterns of organisms identified	VAP children (n=35)
Klebsiella pneumonia	18 (51.40%)
Pseudomonas aeruginosa	7 (20%)
S. aureus	5 (14.30%)
Haemophilus influenza	4 (11.40%)
Enterococcus	1 (2.90%)

Table 4: Risk factors associated with ventilator-associated pneumonia in mechanically ventilated children.

Variables	Odds Ratio (OR)	95% CI	P value
Age in years (mean±SD)	0.54	0.19 -1.98	0.43 NS
Duration of mechanical ventilation	8.43	2.13-14.76	0.001 *
Duration of hospital stay in days	0.65	0.12-2.14	0.08 NS
Reintubation	5.32	1.76-11.65	0.003 *
Steroid use	3.65	1.11-8.32	0.004 *
Sedation use	4.39	1.54-10.45	0.01 *
Use of proton pump inhibitors	2.76	0.98-7.34	0.04 *

Bivariate analysis, *denotes significant, p<0.05, NS-Non-significant

Table 5: Final outcome among the VAP children (n=35).

Outcome	VAP Children (n=35)
Died	4 (11.4%)
Left against medical advice	6 (17.1%)
Recovered	25 (71.4%)

DISCUSSION

The overall prevalence of VAP in the study cohort was found to be 29.2%, which is consistent with previous studies that report a significant incidence of VAP in mechanically ventilated children ranging between 17% and 30% in pediatric ICU settings.[11]

Among the key findings, the duration of mechanical ventilation was identified as the most significant risk factor for the development of VAP. The children who developed VAP had a significantly longer duration of mechanical ventilation (28.65±12.76 days) than those without VAP (9.87±6.87 days). This finding supports the established understanding that prolonged intubation impairs the respiratory tract's natural defences, such as mucociliary clearance, thereby increasing the likelihood of infection. This finding aligns with a previous study by Kalita et al, where the duration of MV was higher in VAP compared to no VAP children (23.15±20.55 vs 11.32±12.27 days, p<0.00).[12]

The study identified several significant risk factors, with the duration of mechanical ventilation emerging as the most critical predictor for the development of VAP. The odds ratio (OR) for the duration of mechanical ventilation was found to be 8.43 (95% CI: 2.13-14.76, p=0.001), suggesting a strong association between prolonged ventilation and the increased likelihood of developing VAP. Likewise, in a study done by Aswati et al, a longer duration of MV (>4 days) is associated with VAP (OR: 3.76, P=0.008).[13]

Additionally, reintubation was a significant risk factor for VAP, with an OR of 5.32 (95% CI: 1.76-11.65, p=0.003). Reintubation often involves multiple procedures that can increase the chances of bacterial colonization and the introduction of pathogens into the airway, further complicating the risk of VAP. This finding emphasizes the importance of avoiding reintubation when possible and exploring alternatives to minimize the need for reintubation in pediatric ICU settings. In a meta-analysis by Tan et al, reintubation is a significant risk factor for VAP with an OR 9.18, p=0.000.[14]

The use of steroids (OR=3.65, 95% CI: 1.11-8.32, p=0.004), sedation (OR=4.39, 95% CI: 1.54-10.45, p=0.01) and proton pump inhibitors (PPIs) (OR=2.76, 95% CI: 0.98-7.34, p=0.04) were also significantly associated with VAP. Steroids suppress the immune system, making patients more susceptible to infections. Sedation, while necessary for patient comfort and ventilation, can reduce the ability to clear secretions from the airway, providing an opportunity for bacterial colonization. PPIs, often prescribed to prevent stress ulcers in critically ill patients, can alter gastric pH and potentially increase the risk of aspiration and subsequent infection in the respiratory tract. These findings suggest that careful use of sedatives, steroids and PPIs is essential to reduce the risk of VAP in critically ill children. In a meta-analysis by Liu et al, the use of steroids is a significant risk factor for VAP in MV children with an OR 1.87, p=0.03.[6] In Roberto et al, study the use of sedatives is associated with VAP with an OR of sedatives OR, 2.4 and it was significant.[15] In Albert et al, study, the use of PPI showed a significant association with the development of VAP in MV children (OR: 2.0, p=0.011).[16]

In contrast, age (OR=0.54, 95% CI: 0.19-1.98, p=0.43) and duration of hospital stay (OR=0.65, 95% CI: 0.12-2.14, p=0.08) were not found to be statistically significant in the development of VAP. The lack of significant association with age may be due to the broad age range of the study population and other more critical factors (such as ventilation duration) playing a more dominant role in VAP development. Similarly, while the duration of hospital stay is often associated with prolonged illness, it did not directly correlate with the risk of VAP in this study, potentially indicating that factors like the mechanical ventilation duration have a more substantial impact on infection risk.

The microbiological profile of VAP in our study revealed *Klebsiella pneumoniae* as the most common pathogen, identified in over half (51.4%) of the VAP cases. This finding is consistent with other studies that report *Klebsiella pneumoniae* as a frequent pathogen in pediatric VAP. Additionally, Pseudomonas aeruginosa and Staphylococcus aureus were also isolated in a notable proportion of cases. These organisms, particularly Klebsiella and Pseudomonas, are often associated with hospital-acquired infections and multi-drug resistance, which complicates treatment strategies. The high prevalence of these pathogens emphasizes the need for vigilant surveillance and appropriate antimicrobial stewardship to manage VAP effectively.[17] In a study by Bhattacharya et al, the most common organisms identified were *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, 21.60% and 29.80% of the VAP cases.[2] Regarding outcomes, the study found that 11.4% of children with VAP died, while 17.1% left against medical advice. The majority (71.4%) of children recovered and

were discharged. These results highlight the severe nature of VAP and its potential for high morbidity and mortality, particularly in cases with delayed diagnosis or complications. The relatively high recovery rate, however, indicates that timely interventions and appropriate management can lead to favourable outcomes for many children with VAP. In a study conducted by Mahantesh et al, the crude mortality rate calculated was 28.3% in VAP children.[9]

The impact of VAP on mortality and morbidity in pediatric ICUs is significant and our study provides further evidence that factors such as the duration of mechanical ventilation, reintubation and the use of immunosuppressive therapies like steroids and sedatives are critical determinants of VAP risk. While most children recover, the morbidity associated with prolonged ICU stays and the mortality in severe cases underscore the need for targeted prevention strategies, such as minimizing ventilator days, optimizing sedation protocols and monitoring for early signs of infection.

The main limitations of the study were less sample size and single center study.

CONCLUSION

This study confirms that VAP remains a significant complication in mechanically ventilated children. Prolonged mechanical ventilation, reintubation and the use of steroids and sedatives are key risk factors. Early identification, tailored antimicrobial treatment and preventive measures to limit ventilation duration and reintubation are critical in reducing the incidence and improving outcomes of VAP in pediatric ICUs.

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