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ORIGINAL ARTICLE

Ventilator associated pneumonia and its outcome in children admitted at pediatric intensive care unit of a tertiary care hospital.

Mehak Siddiquie[1], Muhammad Zahid Farooq[2], Asim Khurshid[3]

ABSTRACT… Objective: To determine the frequency of VAP and its outcome in children admitted to the pediatric intensive care unit (PICU) of a tertiary care hospital. **Study Design:** Cross-sectional study. **Setting:** Department of Pediatric Intensive Care, Children Hospital Multan, Pakistan. **Period:** February 2024 to July 2024. **Methods:** A total of 139 patients of both genders, ages 6 months to 12 years, admitted to the ICU for MV were included. All of the relevant information was noted, and the patients were followed until the final outcome, which included discharge from ICU or expiry. **Results:** In a total of 139 children, 87 (62.6%) were male. The mean age was 5.94±2.47 years. The development of VAP was observed in 45 (33.1%) patients. Age between 7 to 12 years (p=0.0158), and weight > 20kg (p=0.0053) were having significant association with the development of VAP. Age between 7-12 years (p<0.0001), female gender (p=0.0491), and weight > 20kg (<0.0001) were having significant association with mortality. Mortality was significantly associated with VAP (67.7% vs. 26.4%, p<0.0001), duration of MV > 7 days (p<0.0001), and duration of PICU stay > 10 days (p<0.0001). **Conclusion:** This study found a relatively high incidence of VAP in the PICU, with significant associations between VAP and age, weight, and mortality.

Key words: Expired, Mechanical Ventilation, Ventilator-associated Pneumonia.

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INTRODUCTION

The term ventilator-associated pneumonia (VAP) describes nosocomial pneumonia that develops at least 48 hours following the start of mechanical ventilation (MV).[1] In Intensive Care Units (ICUs), VAP is the most prevalent hospital-acquired infection (HAI) among adults with a frequency ranging from 15-45%.[2] VAP accounts for almost 20% of all HAIs in pediatric intensive care units (PICUs), with a prevalence between 3-22 per 1000 ventilator days. In the pediatric age groups, VAP is the 2nd most prevalent HAI after blood stream infections.[3] VAP is linked to higher rates of hospital morbidity, mortality, and higher health care cost.[4]

The use of mechanical ventilators has brought a revolution in the management of critically ill patients, especially the neonates; however, the use is not without certain limitations and complications.[5] A number of factors have been documented that increase the risk of developing VAP in neonates' ventilation in neonatal intensive care units (NICUs). These include low birth weight, prematurity, increased length of stay in the NICU, enteral feeding, re-intubation, neonates under extracorporeal membrane oxygenation (ECMO), bronchopulmonary dysplasia, the presence of concomitant infections, neonatal sepsis, and neonates receiving transfusions.[3,5-8] VAP can either be classified as early (occurs within 72 hours after intubation) or late (occurs after 72 hours after intubation).[6] In terms of pathophysiology, antibiotic sensitivity, causation, therapy, and outcome, early and late VAP may differ from each other.[7] A retrospective cohort study by Gadappa et al in critically ill children on MV disclosed that 40% of children developed VAP, out of which, 77% died.[8] Amanati A et al from Iran observed that VAP was developed in 22.9% of critically ill children undergoing MV, and mortality was recorded in 47.7% of cases with VAP.[9]

There is variability in the VAP occurrence according to the international statistics, and the local data is also insufficient for a precise assessment of the incidence rates of VAP.

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Considering all this, we planned the current study, aiming to determine the frequency of VAP and its associated outcomes. The study findings would be helpful in knowing the magnitude of VAP and associated outcomes in children admitted to the PICU. The findings of this study may also pave the way for the implementation of improved ways of prevention and treatment of VAP in children in similar settings.

METHODS

This cross-sectional study was executed at PICU of The Children's Hospital and Institute of Child Health, Multan, Pakistan, from February 2024 to July 2024. Permission from the institutional ethical committee was obtained (letter number: 135, dated: 08-01-2024). A sample size of 139 was calculated considering the expected frequency of VAP as 22.9%[9], with a confidence level of 95% and a margin of error of 7%. Non-probability, consecutive sampling technique was used. The inclusion criteria were children of either gender, aged 6 months to 12 years and admitted to the PICU for MV. The exclusion criteria were patients with chronic lung disease like cystic fibrosis or post TB bronchiectasis (assessed on history and medical record). Post-cardiac surgery patients or those who discontinued ventilation (discharged, LAMA, expired) before 48-hours were also excluded. Parents/caregivers were briefed about the objective and safety related to this study, and were assured about the confidentiality of the information they provided. Informed and written consents were obtained.

Baseline information like age (years), gender (male/female), and weight (kg, measured using a digital weighing scale), were noted. The presence of nasogastric tube (yes/no), parenteral nutrition (yes/no), and the length of ICU stay (days) were also recorded. VAP was suspected as any one or more of the following: i) new onset fever (temperature>100.4 F); ii) increased oxygen requirement; iii) change in tracheal secretion amount and consistency. Confirmation of the VAP was labeled as per PNEU criteria assisted by radiological examinations, microbiological tests and chemistry investigations.[10] All radiological and laboratory studies were performed at the institutional facilities. The final outcome was noted in the form of discharge from ICU, or expiry. Children who left against medical advice (LAMA) were excluded from the final outcome analysis. All the children were managed according to the standard departmental protocol. A specifically pre-designed proforma was used to record the relevant information.

The statistical analysis was performed using "IBM-SPSS Statistics" version 26.0. The quantitative variables like age, weight, and the length of ICU stay were shown in the form of mean and standard deviation. For the qualitative variables like gender, NG tube administration, parenteral nutrition, VAP, and outcome, frequency and percentages were calculated. The data was stratified for age groups, gender, weight, NG tube administration, and parenteral nutrition to determine the effect of these on the frequency of VAP and outcomes. Post-stratification, chi-square test was applied. Quantitative data like duration of MV, and duration of PICU stay were compared employing independent sample t-test. P-value < 0.05 was taken as significant.

RESULTS

In a total of 139 children, 87 (62.6%) were male, and 52 (37.4%) females, showing a male-to-female ratio of 1.7:1. The mean age was 5.94±2.47 years (ranging between 6 months and 12 years). The mean weight was 15.60±5.79 kg. Table-I is showing characteristics of children at the time of enrollment.

TABLE-I

Characteristics of children (n=139)

Characteristics		Frequency (% age)
Age groups	6 months-6 years	82 (59.0%)
	7 to 12 years	57 (41.0%)
Gender	Male	87 (62.6%)
	Female	52 (37.4%)
Weight (kg)	≤20	104 (74.8%)
	>20	35 (25.2%)
NG tube		52 (37.4%)
Parenteral nutrition		41 (29.5%)

The development of VAP was observed in 45 (33.1%) patients. Stratification of VAP with respect to age groups, gender, weight, presence of NG

tube, and parenteral nutrition is shown in Table-II. Age between 7 to 12 years was found to have significant relationship with the development of VAP (p=0.0158). Weight > 20kg was significantly associated with the development of VAP (40.0% vs. 18.1%, p=0.0053). Gender (p=0.9506), presence of NG tube (p=0.2883), or parenteral nutrition (p=0.6127) were not having any notable associations with the development of VAP and the details are shown in Table-II.

There were 91 (65.5%) patients who were successfully discharged from the ICU, 17 (12.2%) LAMA, and 31 (22.3%) expired. Patients who were LAMA were excluded from the final outcome analysis and the details are given in Table-III. Age between 7-12 years (p<0.0001), female gender (p=0.0491), and weight > 20kg (<0.0001) were having significant association with mortality. Mortality was significantly associated with VAP (67.7% vs. 26.4%, p<0.0001). Mortality was significantly associated with duration of MV > 7 days (p<0.0001), and duration of PICU stay > 10 days (p<0.0001). The mean duration of MV among patients who were discharged, and died were 6.2±2.8 days vs. 10.4±4.1 days (p<0.0001). The mean duration of PICU Stay among children who were successfully discharged and those who died were 8.5 ± 3.2 days vs. 13.7±5.4 days (p<0.0001). Table-III is showing details about the stratification of study variables with respect to outcomes.

DISCUSSION

In this study, the development of VAP was observed in 33.1% patients. A study by Khattab et al from Egypt reported that the frequency of neonates developing VAP was 55.2%.[11] Osman et al revealed that 35% children in PICU developed VAP following the initiation of MV support.[12] Vijay et al found the incidence of VAP in PICU as 38.4%.[13] A recent study by Bhattacharya et al also found relatively similar incidence of VAP in PICU as 36.2%.[14] A local study by Haque et al from Karachi reported the incidence of VAP in PICU as 0.7% which could be due to the strict implementation of ventilator bundle in PICU.[15] All these findings highlight the critical need for effective VAP prevention and management strategies in PICU settings, particularly in resource-limited regions. There is also a need of adhering to stringent preventive measures, such as the ventilator bundle, which has been shown to significantly reduce VAP rates even in resource-constrained settings. Bhattacharya et al identified prolonged mechanical ventilation as a significant risk factor for VAP[14], a finding that aligns with our data, where patients who developed VAP had a notably higher mean duration of mechanical ventilation, and PICU stay. This correlation indicates that prolonged ventilation could serve as an indicator for heightened surveillance and early intervention to prevent VAP in pediatric patients.

TABLE-II

Stratification of ventilator-associated pneumonia with respect to study variables (N=139)

Variables		Ventilator-Associated Pneumonia		P-Value
		Yes (n=45)	No (n=94)	
Age groups	6 months-6 years	20 (44.4%)	62 (66.0%)	0.0158*
	7 to 12 years	25 (55.6%)	32 (34.0%)	
Gender	Male	28 (62.2%)	59 (62.8%)	0.9506
	Female	17 (37.8%)	35 (37.2%)	
Weight (kg)	≤20	27 (60.0%)	77 (81.9%)	0.0053*
	>20	18 (40.0%)	17 (18.1%)	
Presence of NG tube	Yes	14 (31.1%)	38 (40.4%)	0.2883
	No	31 (68.9%)	56 (59.6%)	
Parenteral nutrition	Yes	12 (26.7%)	29 (30.9%)	0.6127
	No	33 (73.3%)	65 (69.1%)	

Chi-square test applied; *p<0.05

TABLE-III

Stratification of study variables with respect to outcomes (N=122)

Variables		Outcome		P-Value
		Discharged (n=91)	Expired (n=31)	
Age groups	6 months-6 years	59 (64.8%)	6 (19.4%)	<0.0001
	7-12 years	32 (35.2%)	25 (80.6%)	
Gender	Male	62 (68.1%)	15 (48.4%)	0.0491
	Female	29 (31.9%)	16 (51.6%)	
Weight (kg)	≤20	74 (81.3%)	13 (41.9%)	<0.0001
	>20	17 (18.7%)	18 (58.1%)	
Presence of NG tube	Yes	37 (40.7%)	9 (29.0%)	0.2487
	No	54 (59.3%)	22 (71.0%)	
Parenteral nutrition	Yes	31 (34.1%)	6 (19.4%)	0.1238
	No	60 (65.9%)	25 (80.6%)	
Ventilator associated pneumonia	Yes	24 (26.4%)	21 (67.7%)	<0.0001
	No	67 (73.6%)	10 (32.3%)	
Duration of mechanical ventilation	≤7	68 (74.7%)	11 (35.5%)	<0.0001
	>7	23 (25.3%)	20 (64.5%)	
Duration of PICU stay	≤10	75 (82.4%)	14 (45.2%)	<0.0001
	>10	16 (17.6%)	17 (54.8%)	

The demographic distribution of our study revealed a male predominance (62.6%), with a male-to-female ratio of 1.7:1. This gender distribution is consistent with the findings of Balasbramanian and Tullu[16], who also reported a higher proportion of male patients (58.6%) in their cohort. However, gender did not have a significant association with the development of VAP in our study (p=0.9506), indicating that factors other than gender may play a more critical role in the pathogenesis of VAP in pediatric patients. This finding suggests that preventive strategies should focus more on clinical and procedural risk factors rather than demographic variables. Age was a significant factor associated with VAP in our study, particularly in the age group of 7 to 12 years (p=0.0158). This finding is noteworthy because it contrasts with some studies where younger age groups, such as neonates and infants, were more vulnerable to developing VAP. For instance, the median age in the study by Vijay et al.[13], was 30 months, indicating a younger cohort compared to our population. This variation could be attributed to different demographic and clinical characteristics of the study populations or differences in healthcare practices and protocols. Weight was another significant factor, with children weighing more than 20 kg showing a significantly higher frequency of VAP (40.0% vs. 18.1%, p=0.0053). This observation could be due to the increased challenges in managing ventilation in larger children, including difficulties in maintaining adequate respiratory mechanics and the potential for higher sedation requirements, which may predispose them to VAP. Similar findings were reported by Bhattacharya et al., who found that children with prolonged ventilation, who were more likely to be older and heavier, had a higher incidence of VAP.[14] This suggests that weight management and careful consideration of sedation protocols may be crucial in reducing VAP risk in this demographic.

The overall mortality rate in our study was 22.3%, with a significant association between mortality and age (p<0.0001), female gender (p=0.0491), and weight (p<0.0001). These findings are in partial agreement with the study by Balasbramanian and Tullu[16], which found a VAP-related mortality rate of 42.8%, although they did not find a higher mortality rate compared to non-VAP patients. The differences in mortality rates could be due to variations in the baseline health status of the patients, the severity of underlying conditions, and differences in healthcare resources and practices between the study

settings. Our study's findings emphasize the need for targeted interventions to reduce VAP rates, particularly in children with prolonged ventilation or higher body weights. The implementation of VAP prevention bundles, as demonstrated by Haque et al.[15], could significantly reduce VAP incidence and should be a priority in our PICU. The implementation of standardized diagnostic algorithms and training for healthcare providers could help reduce variability and improve the accuracy of VAP diagnosis in clinical practice.[17-19] The high mortality rate observed in older children and those with higher body weights suggests that these groups may benefit from more aggressive monitoring and early intervention strategies.[20-22] The variability in VAP incidence and outcomes across different studies highlights the need for standardized diagnostic criteria and robust infection control practices. While our study used clinical and radiological criteria to diagnose VAP, similar to the CDC/NNIS guidelines used by Balasbramanian and Tullu[16], there may still be discrepancies in the interpretation and application of these criteria.

This study had some limitations. Being a single center study, conducted on a limited number of patients were some of the limitations of this study. We were unable to not various causes behind the need for MV. Laboratory parameters were not evaluated in the study which should be assessed in the future studies to their impact on the outcomes in these children.

CONCLUSION

This study found a relatively high incidence of VAP in the PICU, with significant associations between VAP and age, weight, and mortality. These findings underscore the urgent need for effective VAP prevention strategies, including the adoption of ventilator bundle care protocols and the implementation of stringent infection control measures. Future research should focus on identifying additional modifiable risk factors for VAP and evaluating the impact of targeted interventions on VAP incidence and outcomes in pediatric populations. There is also a need for multicenter studies to provide a broader perspective on VAP epidemiology and to develop universally applicable guidelines for VAP prevention and management in PICUs.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Mehak Siddiquie:** Data collection, drafting.
2	**Muhammad Zahid Farooq:** Study concept, methodology.
3	**Asim Khurshid:** Proof reading, critical revisions.