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Original Research Article

Comparative study of incidence, risk factors, etiological agents and outcome of early and late ventilator associated pneumonia in paediatric intensive care unit at a tertiary care centre

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ABSTRACT

Background: Ventilator Associated Pneumonia (VAP), the nosocomial pneumonia developing in mechanically ventilated patients after 48 hours of mechanical ventilation, is the second most common nosocomial infection in the paediatric intensive care unit (PICU). VAP occurring within 96 hours of initiation of mechanical ventilation is termed as early VAP and later than that is known as late VAP. The aim of this study was to determine the incidence rate, risk factors and bacteriological profile and outcome of early and late ventilator associated pneumonia in PICU.
Methods: The study was conducted from December 2015 to November 2017 in which 89 children beyond 1 year of age were ventilated for more than 48 hours of which those who developed VAP as per CDC criteria were enrolled in the study. The endotracheal secretions were collected, processed and recorded as per standard microbiological methods. Statistical associations were further evaluated between various parameters of VAP and time of development of VAP.
Results: Of all the mechanically ventilated patients, 33.7% developed VAP. Incidence of Early VAP was 23.3% and that of Late VAP was 76.67%. Duration of mechanical ventilation and re-intubation were significantly associated with the time of development of VAP. Micro-organisms identified by culture, involved in the aetiology of VAP were: gram-negative bacteria in 74.9% and gram-positive bacteria in 25.1%. The overall mortality rate was 43.33%.
Conclusions: Re-intubation and duration of mechanical ventilation are a significant risk factor for development of late VAP. Overall the most common Gram-negative bacteria associated with VAP was *Acinetobacter baumanii*. The most common isolate in early VAP was *Acinetobacter baumanii* whereas infections by *Pseudomonas* and *E. coli* are common in late VAP. population.

Keywords: Gram negative bacteria, Intubation, Nosocomial, Peadiatric intensive care unit, Ventilator associated pneumonia

INTRODUCTION

Ventilator associated pneumonia (VAP) is defined as pneumonia in mechanically ventilated patients, that develops at 48 hours or later after the patient has been placed on ventilator. It is the second most common hospital acquired infection among paediatric intensive care unit patients.[1,2] VAP is further classified as early onset or late onset pneumonia.

Early-onset pneumonia occurs within the first 4 days of initiation of mechanical ventilation (<96 hours), whereas late-onset VAP develops after 4 or more days (>96 hours).[3]

Overall, VAP occurs in 3 to 10% of ventilated paediatric patients.[4-6] Incidence of late VAP reported in literature is as high as 63.5%.[7] According to data published by the National Nosocomial Infection Surveillance System (NNIS) program sponsored by the Centre for Disease Control and Prevention (CDC), VAP rates in PICU oscillate from 1.4 to 7 episodes per 1,000 ventilator days.[8-10] Incidence of paediatric VAP as mentioned in western literature varies from 5.1% to 33%.[5,9,11] However, in developing countries the reported rates are significantly higher, ranging from 16.1 to 89 episodes per 1,000 ventilator days.[12-14] The incidence of VAP increases with the duration of mechanical ventilation. Estimated rates are 3% per day for the first 5 days, 2% per day for days 6-10, and 1% per day after day 10.[15]

Ventilator-associated pneumonia (VAP) results from the invasion of the lower respiratory tract and the lung parenchyma by microorganisms. Intubation compromises the integrity of the oropharynx and trachea and allows oral and gastric secretions to enter the lower airway compromising its integrity and increasing risk of VAP.

Contrarily, blood borne seedling of the lung constitutes a rare cause of VAP.[8] Moreover, pathogens can reach the lung from exogenous sources such as hands of healthcare workers, ventilator circuits, and the biofilm of endotracheal tube.[17]

As children differ greatly from adults in their anatomy, physiology and underlying disease, specific aetiology for VAP in them is described. In neonates and paediatric patients, microbial diagnosis of VAP is based on the culture of samples obtained from the lower respiratory tract by tracheal aspirate, which is considered a less invasive method and may have an acceptable diagnostic accuracy.

VAP in PICU is governed by various risk factors. Various factors associated with increased risk of developing VAP are: reintubation, prior antibiotic use, central nervous disorders, mechanical ventilation for >3 days and chronic obstructive pulmonary disease. VAP is also an important cause of morbidity and mortality in patients in the ICU.[12]

Due to a strong evidence of the adverse effects of inadequate empirical antibiotic treatment on outcome, the detection of the causative organism in VAP becomes imperative in guiding appropriate therapy.[17,18] Early, aggressive, empirical therapy with broad spectrum agents targeted at likely pathogens followed by a regimen driven by microbiological documentation is an effective strategy for the management of VAP and other serious infections.[19]

However, inappropriate use and overuse of antibiotics can lead to increased hospital expenditures and could potentially promote antibiotic resistance. Thus, prescribing patterns for empirical therapy for suspected VAP should maintain a balance between adequately covering patients who are potentially infected and minimizing unnecessary and prolonged exposure to antimicrobials.[12,20-22]

The aim of the present study was to determine the incidence, risk factors of late VAP in paediatric ICU, the pathogens involved & their outcome.

METHODS

Present study is a prospective observational study conducted on children aged between 1- 14 years, who were admitted and ventilated for more than 48 hours and developed VAP as per CDC criteria, in the Paediatric Intensive care unit, of Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar from December 2015- November 2017. Total 30 subjects were enrolled in the present study.

- Clinically, patients must have at least three of the following criteria:
- Fever (>38.4°C or >101.1°F) or hypothermia (<37°C or 97.7°F) with no other recognized cause;
- Leukopenia (<4,000 WBC/mm^3) or Leucocytosis (≥15,000 WBC/mm^3);
- New onset of purulent sputum, change in character of sputum, increased respiratory secretions, or increased suctioning requirements;
- Rales or bronchial breath sounds;
- Worsening gas exchange (O_2 desaturations (pulse oximetry of <94%), increased oxygen requirements, or increased ventilation demand)

Endotracheal/tracheostomy tube secretion culture were collected with all aseptic and antiseptic precautions, by adding 1-2 ml of sterile normal saline into the endotracheal tube and then sucking it with help of a sterile mucous trap.

The sample collected was transported within one hour of collection to the bacteriology laboratory for culture and sensitivity using both conventional and Vitek II techniques. Samples collected at night were stored at 4 degrees centigrade and were sent to the laboratory by 10:00am the next morning. For culture, a colony count of 105 CFU/ml of endotracheal aspirate was taken as cut off between organisms causing VAP and colonization.

The data of VAP patients was tabulated into various categorical variables which were presented in number & percentage (%) and continuous variables as mean ± SD & median. Qualitative variables were correlated using Chi-Square test /Fisher's exact test. A p value of <0.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS

In the study majority of the patients i.e. 46.67% were between 5 to 10 years of age. Out of the total 30 patients studied 24 (80%) were male. Most common indication of ventilation in the study group was low GCS as seen in 30% cases followed by respiratory distress in 26.67%, seizures in 16.67%, cardiac arrest in 13.33% and desaturation in 13.33% cases. 21 patients (70%) required re-intubation and 76.67% patients developed VAP after 96 hours of initiation of mechanical ventilation whereas 23.3% developed VAP before 96 hours of initiation of mechanical ventilation. VAP was confirmed radiologically as presence of consolidation in 53.3% cases and as presence of new or progressive or persistent infiltrates in 46.67% cases. Mortality rate in the study was 43.3%.

Gender had no statistical significance to time of development of VAP. 90.48% who were re-intubated were developed Late VAP whereas only 9.52% developed Early VAP. Re-intubation and duration of Mechanical ventilation were significantly associated with the development of late VAP (p=0.014 and p=0.0004 respectively). Growth on endotracheal tube secretions culture had no statistical significance to time of development of VAP (p=0.060). Outcome had no statistical significance to time of development of VAP (p=0.188). 22 patients out of total 30 cases had growth on tracheal secretions and 24 VAP events were reported. Most of the patients i.e. 33.33% had growth of *Acinetobacter baumanii* complex, followed by *E. coli* in 20.83%, *Pseudomonas aeruginosa* in 20.83%, *Kliebsiella pneumoniae* in 8.3%, *Staphylococcus aureus* in 4.16% and *Staphylococcus haemolyticus* in 12.5% cases. Out of the total 30 patients, 7 developed early VAP, out of which 42.8% had no growth on ET secretion culture.

Table 1: Demographic variables.

		Percentage (n)
Age	1-5 year	26.67 (8)
	5-10 year	46.67 (14)
	>10 years	26.67 (8)
Sex	Male	24 (80)
	Female	6 (20)
Indication of Ventilation	Low GCS	30 (9)
	Respiratory distress	26.67 (8)
	Seizures	16.67 (5)
	Cardiac arrest	13.33 (4)
	Desaturation	13.33 (4)
Re-intubation	Yes	70 (21)
	No	30 (9)
Time of Development of VAP	<4 days (Early VAP)	23.3 (7)
	>4 days (Late VAP)	76.67 (23)
Total leucocytic Count	Leucocytosis	66.67 (20)
	Leucopoenia	26.67(8)
Radiological findings	Consolidation	53.3 (16)
	New or progressive or persistent infiltrates	46.67 (14)
Outcome	Death	43.3 (13)
	Discharge	56.6 (17)

Table 2: Association of Time of development of VAP with various variables.

		Early vap	Late vap	P value
Sex	Male	20.83% (5)	79.17% (19)	0.603
	Female	33.33% (2)	66.67% (4)	
Re-intubation	Yes	9.52% (2)	90.48% (19)	0.014
	No	55.5% (5)	44.44% (4)	
Duration of mechanical Ventilation	<4 days	100% (4)	0% (0)	0.0004
	4-7 days	30% (3)	70% (7)	
	7-10 days	0 (0%)	6 (100%)	
	>10 days	0 (0%)	10 (100%)	
ET culture results	Growth	13.64% (3)	86.36% (19)	0.060
	No growth	50% (4)	50% (4)	
Outcome	Death	28.57% (2)	47.83% (11)	0.188
	Discharge	71.43% (5)	52.17% % (12)	

Amongst the rest, 28.57% showed growth of *Acinetobacter baumanii*, 14.2% of *Staphylococcus aureus* and 14.2% of *Staphylococcus haemolyticus*.

Out of the total 30 patients, 23 patients developed Late VAP. 20% patients had sterile ET culture. 2 patients had polymicrobial growth. Most common isolate was *Acinetobacter baumanii* seen in 24% cases followed by *Pseudomonas aeruginosa* in 20%, *E. coli* in 20%, *Kliebsella pneumonia* in 8% and *Staphylococcus haemolyticus* in 8%.

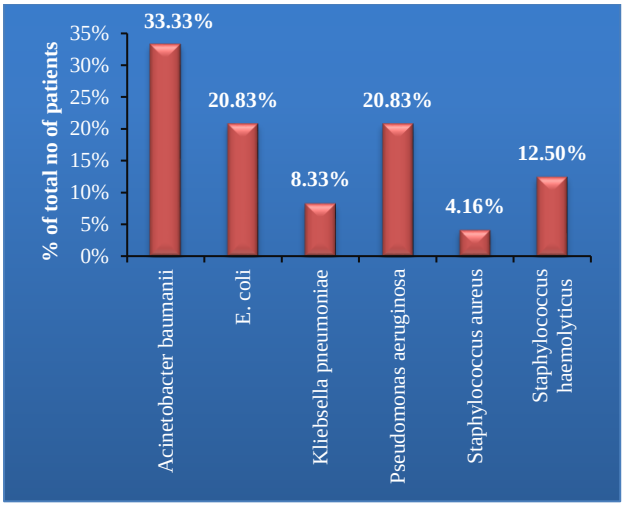

Figure 1: Endotracheal tube culture results.

22 patients out of total 30 cases had growth on tracheal secretions and 24 VAP events were reported. Most of the patients i.e. 33.33% had growth of *Acinetobacter baumanii* complex, followed by *E. coli* in 20.83%, *Pseudomonas aeruginosa* in 20.83%, *Kliebsiella pneumoniae* in 8.3%, *Staphylococcus aureus* in 4.16% and *Staphylococcus haemolyticus* in 12.5% cases.

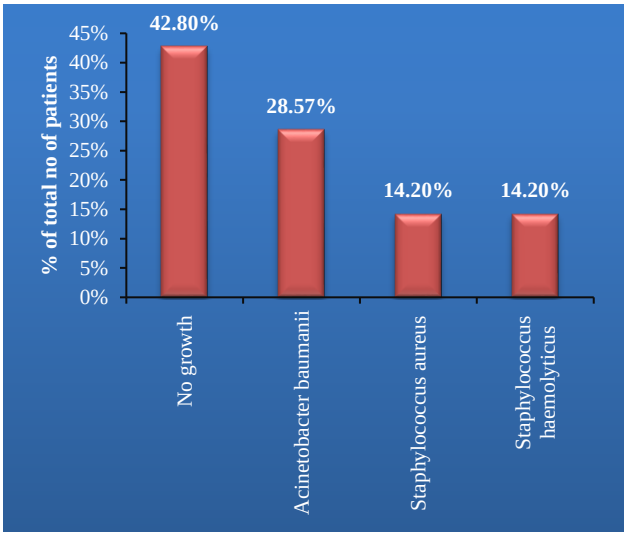

Figure 2: Micro-organisms in early VAP.

Out of the total 30 patients, 7 developed early VAP, out of which 42.8% had no growth on ET secretion culture. Amongst the rest, 28.57% showed growth of *Acinetobacter baumanii*, 14.2% of *Staphylococcus aureus* and 14.2% of *Staphylococcus haemolyticus*.

Out of the total 30 patients, 23 patients developed Late VAP. 20% patients had sterile ET culture. 2 patients had polymicrobial growth. Most common isolate was *Acinetobacter baumanii* seen in 24% cases followed by *Pseudomonas aeruginosa* in 20%, *E.coli* in 20%, *Kliebsella pneumonia* in 8% and *Staphylococcus haemolyticus* in 8%.

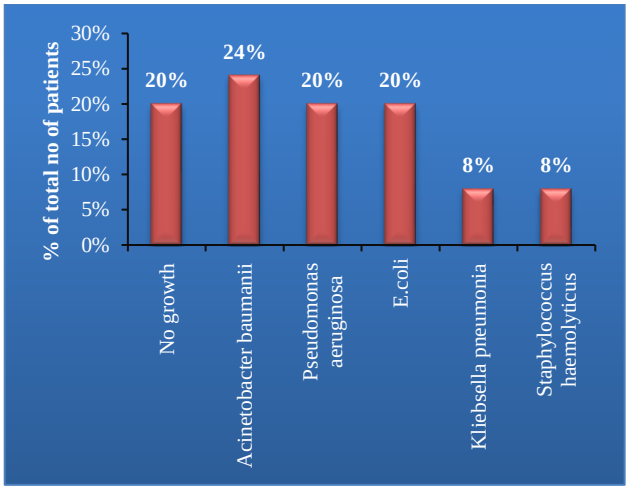

Figure 3: Micro-organisms in Late VAP.

DISCUSSION

Total 522 patients were admitted in the PICU during the study period of which 89 (56 males and 33 females) were ventilated for more than 48 hours. Out of this, 30 patients developed VAP as per CDC criteria were further studied. Incidence of VAP was 33.7%. Incidence of VAP is differs greatly based on setting and location in critically ill children in PICU. Our study showed an incidence of 33.7% in paediatric VAP patients which is comparable with the incidence of 31% reported by Galal Y et al.[23] However, Chiru D et al have reported an incidence of 43.13% in all children aged 0-18 years.24 In a 30-month prospective study in a PICU in Saudi Arabia the VAP incidence was 10.3%. [5]

Admissions of male patients in the study was more as compared to females contributing in higher incidence of VAP in males. In a developing country like ours, such a vast difference based on sex can be attributed to uneven male to female ratio, male preference and female neglect. Moreover, the X chromosome in females contains 10% of all the microRNA's detected so far in the genome some of which have an important function in immunity. Similarly, Chiru D et al reported an incidence of 79.3% males and 20.7% females in their study on VAP paediatric patients.24 In contrast a study conducted by Galal Y et al, on children >1 month of age, females were higher in number (56.1%).[23]

Most common clinical diagnosis leading to ventilation in the study was neurological disease (36.65%) in form of low GCS. Our findings were similar to that of Galal YS et al wherein neurological cause was seen in 39.4% cases ventilated.[23] On the contrary, in the study done by Hamid M et al, the most common indication of ventilation was respiratory failure in 72% cases, neuromuscular blockade and paralysis in 24% cases.[25] Chiru D et al reported acute

respiratory failure in 63.6% and severe sepsis in 22.8% cases in VAP patients of 0-18 years.[24]

Re-intubation was required in 70% of the patients who developed VAP and it was a significant risk factor for development of Late VAP. (p=0.014). Re-intubation has been described as a significant risk factor for development of VAP but not for late VAP. Elward MA et al reported re-intubation in 56.7% cases.[4] Sonmez et al studied VAP in paediatric patients and reported re-intubation as a significant risk factor for development of VAP (p=0.033).[26] Similarly, Chiru D et al reported re-intubation as a significant risk factor for development of VAP in children 0-18 years of age. (p=0.001).[24]

Prolonged duration of mechanical ventilation increases the risk of infection. Late VAP was predominant in the study accounting for 76.67% (n=23) paediatric patients. In the study conducted by Mahantesh et al, late VAP was more common and was seen in 63.51% cases.[27] In a study done by Amanati et al on paediatric cases, early VAP events were reported in 69.5% patients and late in 30.43%.[28] Microbiologically, 22 patients had VAP with 24 VAP events reported, out of which 83.33% (n=20) had growth of gram negative organisms and gram-positive organisms was seen in 16.66% cases (n=4). Most common organism isolated was *Acinetobacter baumanii* in 8 (33.3%) followed by *E.coli* in 5 (20.83%) and *Pseudomonas aeruginosa* in 5 (20.83%) cases. Our study results were in concordance with results obtained by Mahantesh et al where *Acinetobacter* was the predominant isolate in 62.1% cases followed by Pseudomonas aeruginosa in 31%.[7] The predominance of gram negative bacterial isolation, with the most common organism being *Acinetobacter spp* (54.5%), was observed in study conducted by Patra et al.[29] Sneka et al showed 41.1% growth of *Acinetobacter spp*, 23.5% *Kliebsella pneumoniae*, 11.7% cases of *Pseudomonas aeruginosa* and 11.7% cases of CONS.[30] Srinivasan et al reported growth of gram-negative bacteria (42%), *Staphylococcus aureus* (22%) and *Haemophilus influenzae* (11%).[27] In the study done by Meenakshi Sharma et al *Acinetobacter* was reported in 37.5% cases and *Kliebsella* in 27.5% cases.[31]

In early VAP most common isolated organism was Acinetobacter in 28.57% followed by *Staphylococcus aureus* and *Staphylococcus haemolyticus* in 14.2% cases respectively whereas in late VAP the most common organism was *Acinetobacter* in 24% cases followed by *Pseudomonas* in 20%, *E.coli* in 20%, *Kliebsella pneumonia* and *Staphylococcus haemolyticus*. These findings were comparable with the results observed by some authors, that community acquired organisms such as *Streptococcus pneumoniae*, *H. influenzae* and methicillin sensitive Staphylococcus aureus (MSSA) were frequent causes of early onset VAP and *Enterobacter*, *Pseudomonas* and *Acinetobacter* species were encountered in late onset VAP.[32]

Mortality was seen in 43.33% (n=13) paediatric cases while, the rest were discharged. Outcome had no statistical significance to time of development of VAP. Overall mortality in paediatric patients having VAP as reported by Galal Y et al was 68.2%.[23] Mortality rates were also higher in VAP patients in a study done by Patri MF et in Italy.[33] In the study conducted by Payal J et al the mortality was rate was high up to 52%.[34] Mortality rate of 22.8% was reported with the study done by Chiru D et al.[24]

CONCLUSION

The present study concludes that reintubation and duration of mechanical ventilation were significant risk factors for development of VAP, especially late onset VAP. Among the various etiological agents responsible for VAP, gram negative organisms were the leading cause. However, in late VAP, gram positive were commoner. Time of development of VAP had no statistical significant association to outcome.

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