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Original Research Article

Incidence, determinants and outcomes of ventilator associated pneumonia in medical intensive care unit: a prospective cohort study from South Western India

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ABSTRACT

Background: Ventilators are being increasingly used in developing countries as a result of which complications like ventilator associated pneumonia is also increasing. Present study is being undertaken to evaluate the impact of risk factors and their changing trends for Ventilator associated pneumonia.
Methods: A prospective observational study was conducted in mechanically ventilated patients of medical intensive care unit from October 2013 to April 2015.
Results: In present study 166 patients receiving mechanical ventilation in a medical ICU were observed. Incidence of VAP in present study is 43.5 for 1000 days of mechanical ventilation. The risk factors that were significant in the study are organ failure (p=0.001), emergency intubation (p=0.001), reintubation (p=0.023) and COPD (p=0.026). The common organisms responsible for VAP were *Acinetobacter* (30%), *Klebsiella pneumoniae* (27.1%) and *Pseudomonas aeruginosa* (20%). The mortality was higher in VAP group (31.3%) compared to the non VAP group (15.7%).
Conclusions: There is high incidence of VAP in the developing countries. The risk factors that were found to be associated with VAP in the present study were the presence of COPD, reintubation, organ failure and emergency intubation. VAP is associated with significantly increased duration of hospital stay, morbidity and mortality.

Keywords: Ventilator associated pneumonia, Medical ICU, India

INTRODUCTION

Ventilator associated pneumonia (VAP) is a nosocomial infection which develops after 48 hours of mechanical ventilation. It is one of the most important complications of the modern day intensive care units (ICUs). The risk of pneumonia for patients on ventilator increases by 3-10 times.[1]

The incidence and organisms responsible for VAP vary according to intensive care units', duration of hospital stay and prior antibiotic use. According to NHSN/CDC surveillance report, incidence of VAP ranged from 0 to 4.4 per 1000 ventilator days but in the developing countries incidence of VAP are higher than developed countries.[2] Several risk factors were observed to contribute to the development of VAP, some of them are modifiable and if intervened reduces the incidence of VAP.[3] For every day of endotracheal intubation and mechanical ventilation (MV), crude rate of VAP increases and the risk of death increases multifold.[4]

VAP increases the morbidity, mortality, duration of the hospital stay and cost of treatment of the patient. It is

difficult to quantify the exact increased mortality due to VAP but approximately the attributable mortality to VAP can be as high as 13% as seen in various studies.[5] Morbidity is also increased as seen by increased mean duration of the hospital stay which is approximately 7 to 9 additional days on an average.[1] It is said that the attributed cost to VAP can be as high as $15,986 depending upon the setting.[6] It's very important to understand the risk factors and outcomes of VAP, which in turn help in the implementation of the preventive measures.

Present study was undertaken to determine the incidence of VAP in medical ICUs, identify the risk factors and organisms causing VAP and to assess the clinical outcome of the patients with VAP. Early onset VAP develops during the first four days of mechanical ventilation and late onset VAP usually develops from day five onwards.[7]

METHODS

A prospective observational study was conducted in the medical ICU of a large tertiary hospital (2030 bedded) in South Western India, from October 2013 to April 2015. Patients mechanically ventilated for more than 48hours in medical ICUs' and aged more than 18 years were included in the study. Patients with pneumonia prior to mechanical ventilation or within 48 hours of MV, presence of a previously established permanent artificial airway and patients intubated outside investigator's hospital were excluded from study. Patients were prospectively followed during the course of hospital stay. The patient's clinical data were recorded using a proforma. Ventilator associated pneumonia was diagnosed using CDC/NHSN criteria.[8] Those patients who developed ventilator associated pneumonia were grouped into VAP category and those who did not into non-VAP category. The two groups were compared for risk factors and outcomes.

Endotracheal tube (ET) aspirate samples were taken on clinical suspicion of VAP and transferred to microbiology lab within 30 minutes. Gram staining was done initially and only samples with epithelial cells <5 and pus cells >25 per high power field were taken up. Samples were then inoculated on 5% sheep blood agar; Mac-Conkey agar and chocolate agar and semi-quantitative cultures were done. Growth $>10^5$ CFU/ml was taken as the cut-off threshold for endotracheal aspirate samples. Samples showing growth less than these thresholds were assumed to be due to colonization or contamination. Organ failure in the present study is defined as failure of any one of the cardiac, renal and liver involvements. Cardiac failure is defined by AHA criteria (American heart association) and reduced ejection fraction <50 documented by 2d-echo or by elevated NT-pro BNP levels. Liver involvement is defined by two fold raise in AST/ALT levels above the baseline or with history of chronic liver disease/ documented by ultrasound abdomen. Renal failure is defined by RIFLE criteria in case of acute renal failure or if any previous documented chronic kidney disease is present.

Multi drug resistant (MDR), extensively drug resistant (XDR) and pan drug resistant (PDR) organisms were defined according to the European centre for disease prevention and control (ECDC) and the centers for disease control and prevention (CDC) criteria.[9] It was considered MDR when the organism is resistant to ≥1 agent in ≥3 antimicrobial categories as prescribed by the above guidelines. It was considered XDR when the organism is resistant to ≥1 agent in all but ≤2 antimicrobial categories as prescribed by the above guidelines. It was considered PDR (pan drug resistant) when non-susceptible to all the listed antimicrobials in the above guidelines. The patients were treated with antibiotics as per the clinician judgment guided by the local antibiotic policy.

Statistical analysis

Data collected was analyzed with SPSS v15 package. Incidence was calculated as the number of cases of VAP for 1000 days of mechanical ventilation. Chi square test for association was performed to identify the variables that significantly contribute to VAP (α=0.20). These significant variables were taken as the predictors in the logistic regression. Median hospital stay in patients with VAP and non VAP groups were compared using Mann Whitney U test. To check for association of VAP with mortality and people who required tracheostomy we performed chi square test. The results were considered statistically significant at the level of p=0.05.

RESULTS

Current study included 166 patients out of which 51 developed VAP. Total 26 patients were observed to developed early VAP (51%) and 25 patients late VAP (49%). The median time for onset of VAP in the present study was 4 days (IQR 4, 7). In case of early VAP it was 4 days (IQR 3, 4) and late VAP it was 7 days (IQR 6, 10). The mean age of the study group was 51.4±17.49 years. Most of the patients of VAP were present in the age group of more than 60 years (43.13%). The patients included in the study were admitted for various aetiologies, the most common admitting diagnosis of the patient is intentional self-harm/poisoning (37), sepsis/infectious causes (32) and cerebrovascular accidents (23) followed by acute exacerbation of COPD/bronchial asthma (19).

Risk factor of VAP

Organ failure (CI 1.545, 11.883; p<0.001**)**, emergency intubation (p=0.01), re-intubation (p=0.023) and COPD (CI 0.843, 10.257; p=0.026) were found to have a significant association with the development of VAP (Table 1).

Table 1: Univariate and multivariable logistic regression for the association of various risk factors.

Risk factors	VAP (N=51) Frequency (%)	NON VAP (N=115) Frequency (%)	OR Unadjusted	P value	OR adjusted (CI)	P value
Age >60 years	18 (35.3)	36 (31.3)	1.197 (0.596, 2.402)	0.613	-	-
COPD	12 (23.5)	17 (14.8)	1.774 (0.776, 4.055)	0.0171	2.94 (0.843, 10.257)	0.026
Diabetes mellitus	10 (19.6)	17 (14.8)	1.406 (0.594, 3.329)	0.437	-	-
Alcoholism	11 (21.5)	24 (20.8)	1.043 (0.466, 2.332)	0.919	-	-
Smoking	11 (21.5)	20 (17.3)	1.306 (0.573, 2.976)	0.524	-	-
Impaired consciousness	25 (49)	66 (57.3)	0.714 (0.368, 1.384)	0.317	-	-
Immune suppressive therapy	11 (21.5)	16 (13.9)	1.702 (0.727, 3.985)	0.218	-	-
MV >7 days	14 (27.45)	22 (19.1)	1.60 (0.740, 3.457)	0.230	-	-
Organ failure	29 (56.9)	34 (29.8)	3.14 (1.585, 6.222)	<0.001	4.285 (1.545, 11.883)	<0.001
Emergency intubation	23 (45.1)	22 (19.1)	3.47 (1.688, 7.142)	0.001	4.068 (1.385, 11.954)	0.001
Re-intubation	6 (11.7)	2 (1.7)	7.73 (1.465, 38.726)	0.023	8.169 (0.761, 87.646)	0.023

Organisms

Microbiological profile of the isolated organisms show that the common organisms reported were *Acinetobacter* (30%), *Klebsiella pneumoniae* (27.1%) and *Pseudomonas aeruginosa* (20%). The most common organism in both early and late VAP was *Acinetobacter*. *Stenotro-phomonas maltophilia* and *Enterobacter* were seen only in the early group (Table 2).

Table 2: Microbiological profile of organisms.

Pathogen	Early VAP N (%)	Late VAP N (%)	Total N (%)
Acinetobacter	10 (31.25)	11 (28.94)	21 (30.0)
Klebsiella pneumoniae	9 (28.12)	10 (26.3)	19 (27.1)
Pseudomonas aeruginosa	6 (18.75)	8 (21.05)	14 (20.1)
Stenotro-phomonas maltophilia	2 (6.25)	-	2 (2.85)
MRSA	1 (3.12)	4 (10.52)	5 (7.14)
MSSA	1 (3.12)	1 (2.63)	2 (2.85)
E. coli	2 (6.25)	1 (2.63)	3 (4.28)
Enterobacter	1 (3.12)	-	1 (1.42)

Drug resistant patterns

Antibiotic sensitivity pattern shows *Acinetobacter* species were sensitive to colistin (95.2%), tigecycline (80.9%) and cefoperazone sulbactam (80.9%). *Klebsiella pneumoniae* was sensitive to colistin (100%), tigecycline (100%), imipenem (52.6%) and cefepime (52.6%). *Pseudomonas aeruginosa* was sensitive to colistin (100%), gentamicin (50%), cefepime (50%), imipenem (42.8%) and amikacin (42.8%) (Table 3). In the isolates of *Acinetobacter* species MDR strains (61.94%) were more common followed by sensitive strains (19.04%), XDR strains (14.28%) and only 1 strain was PDR. In *Klebsiella pneumoniae* 47.3% strains are XDR, 42.1% strains are sensitive isolates and 10.5% strains are MDR. In *Pseudomonas aeruginosa* 42.85% strains are sensitive isolates, 35.71% are XDR and 21.4% are MDR. In the isolate of *S. aureus*, all the strains (100%) were MDR (Table 4).

Outcome

The median duration of mechanical ventilation after the onset of VAP in early VAP group is 4 (IQR 1, 5) days and late VAP group is 3 (IQR 1, 5.5) days (p=0.887). There is no significant difference in the duration of mechanical ventilation after the onset of VAP in early and late groups. Duration of mechanical ventilation in a patient with VAP and non VAP are 8 (IQR 6, 10) days and 5 (IQR 4, 7) days respectively. Duration of mechanical ventilation in a patient with early VAP and late VAP are 7 (IQR 5, 8.25) days and 10 (IQR 8, 18) days respectively.

Table 3: Antibiotic sensitivity pattern showing the number of sensitive strains.

Antibiotic	Acinetobacter N=21 Frequency (%)	*Klebsiella pneumoniae* N=19 Frequency (%)	*Pseudomonas aeruginosa* N=14 Frequency (%)
Amikacin	2 (9.5)	9 (47.36)	6 (42.8)
Amoxiclav	-	4 (21.0)	-
Cefazolin/cefadroxil	-	4 (21.0)	-
Cefotaxime/ceftriaxone	-	4 (21.0)	-
Ceftazidime	-	-	5 (35.7)
Cefuroxime	-	4 (21.0)	
Trimethoprim/sulfamethoxazole	3 (14.28)	5 (26.3)	1 (7.14)
Gentamicin	1 (4.76)	8 (42.1)	7 (50)
Netilmycin	3 (14.28)	9 (47.36)	6 (42.8)
Tobramycin			5 (35.7)
Ciprofloxacin/ofloxacin	1 (4.76)	6 (31.57)	5 (35.7)
Aztreonam			
Cefoperazonesulbactum	17 (80.9)	9 (47.36)	2 (14.3)
Cefpirome/cefepime	1 (4.76)	10 (52.6)	7 (50.0)
Imipenem	14 (66.7)	10 (52.6)	6 (42.8)
Piperacillin-tazobactam			5 (35.7)
Colistin	20 (95.2)	19 (100)	14 (100)
Tigecycline	17 (80.9)	19 (100)	-

Table 4: Drug resistant patterns of most common organism isolates.

Sensitivity pattern	Acinetobacter species (N=21) Frequency (%)	*Klebsiella pneumoniae* (N=19) Frequency (%)	*Pseudomonas aeruginosa* (N=14) Frequency (%)	*S. aureus* (N=5) Frequency (%)
MDR	13 (61.94)	2 (10.5)	3 (21.4)	5 (100)
XDR	3 (14.28)	9 (47.3)	5 (35.71)	-
PDR	1 (4.78)	-	-	-

Table 5: Outcomes in VAP groups.

Groups	VAP (N=51) Frequency (%)	Non-VAP (N=115) Frequency (%)	Early VAP (N=26) Frequency (%)	Late VAP (N=25) Frequency (%)
Recovered	21 (42.0)	80 (69.56)	7 (27.0)	14 (56.0)
Expired	16 (31.37)	18 (15.65)	11 (42.3)	5 (20.0)
Lost of follow-up	14 (27.45)	17 (14.78)	8 (30.7)	6 (24.0)

Median duration of hospital stay in a case of VAP and non VAP are 15 (IQR 10, 21) and 10 (IQR 7, 15) days respectively. Median duration of hospital stay in a case of early and late VAP are 11.5 (IQR 8, 17.25) and 19 (IQR 10, 23) days respectively.

The patients those who undergoes tracheostomy out of them 13.7% had developed VAP and 4.3% does not developed VAP. Out of 51 cases in VAP 42% of the patients recovered, 31.37% of patients expired and 27.4% patients were lost to follow up. In non-VAP group 69.56% patients recovered, 15.65% patients expired and 14.78% patients were lost to follow up. In early VAP group 27% of the patients recovered, 42.3% of patients expired and 30.7% patients were lost to follow up. In late VAP group 56% patients recovered, 20% patients expired and 24.0% patients were lost to follow up (Table 5).

DISCUSSION

Incidence of VAP in the present study is 43.5 for 1000 days of mechanical ventilation. In a study by International nosocomial infection control consortium (INICC) the incidence was around 12-17.8 for 1000 days of mechanical ventilation.[10] The incidence in one of the Indian study by Charles et al had an incidence rate of 53.25 per 1000 ventilator days.[11] 30.7% patients in the present study developed VAP. This was almost comparable to other studies in developing countries which is in the range of 6-52%.[12] Based on this observation there is an urgent need for better infection

control in care of ventilated patients. Among patients who developed ventilator associated pneumonia, 26 (51%) developed early VAP and 25 (49%) developed late VAP. Majority of the patients in the present study developed VAP in the initial 10 days of mechanical ventilation with 28 (54.9%) patients in the first 5 days and 47 (92.1%) in the first 10 days of mechanical ventilation. Apostolopoulou et al also had documented in their study, the increased risk of developing VAP during the first two weeks of mechanical ventilation. Probably the interaction of several risk factors during the first two weeks of mechanical ventilation keeps the patient at increased risk of developing VAP and also the most sick patients usually expire in the early days and hence decrease in the number of cases of ventilator associated pneumonia during later days.[13]

In the present study the median duration of mechanical ventilation before the onset of VAP was 4 (IQR 4, 7) days. This was comparable to study by Rello et al where the mean duration between the time of ventilation and onset of VAP was around 3.3 days.[14] The median duration of mechanical ventilation before the onset of early VAP was 4 (IQR 3, 4) days and late VAP was **7** (IQR 6, 10) days.

Risk factors in the development of VAP

In the present study COPD was found to be significant, it was similar to other study by Hadda et al. Increased airway secretions, bronchospasm and mucosal oedema results in exacerbation of COPD which occurs because of establishment and proliferation of the microbial pathogens in airways.[15]

Organ failure in the present study was found to be significant. Presence of organ failure predisposes the patient to increased incidence of VAP as seen in various other studies.[16] Although organ failure scoring systems were not used, presence of organ failure at the time of admission is definitely a risk factor in the development of VAP in the current study also.

Emergency intubation increases the chance of VAP probably because patients who underwent planned intubations were usually kept nil per oral and proper suctioning was done prior to intubation compared to patients who underwent emergency intubation so they were less prone for aspiration and hence less chance of VAP. Re-intubation was found to be significant risk factor. Re-intubation is associated with transfer of organisms from upper respiratory tract to lower respiratory tract, which could be reason for the higher incidence of VAP in them.[17]

Microbiology

The microbiological profile of organisms varies geographically and hence the microbiological profile of local ICU is very important as it helps in deciding empirical antibiotic therapy.[18] The common organisms seen in the present study were *Acinetobacter* (30%), *Klebsiella pneumoniae* (27.1%) and *Pseudomonas aeruginosa* (20%). This was similar to other studies done by Kant et al where *Acinetobacter* was the most common organism.[19] Out of the total isolates in patients with VAP 39.2% cultures were mono microbial whereas 43.1% were polymicrobial and there was no growth in 17.6%. The increased incidence of *Acinetobacter* species could be due to its ability to grow in any kind of environment and to develop resistance to antibiotics and spread by aerosols.[20]

Traditionally it was considered that early VAP grew drug sensitive organisms and late VAP grew multidrug resistant organisms but all recent studies like Saravu et al had MDR organisms in both early and late VAP groups, similar to that of the present study.[17] 61.94% of the *Acinetobacter* species grown is MDR and 14.28% is XDR. Most of the *Acinetobacter* species grown are sensitive to cefoperazone sulbactam (80.9%), colisitn (95.2%) and tigecycline (80.9%). The sensitivity pattern of *Acinetobacter* was similar to study by Dizbay M et al which showed increased sensitivity to colistin[21]. *Pseudomonas aeruginosa* showed 35.27% XDR strains while 21.4% strains are MDR. Most of these are sensitive to colistin, amikacin, gentamicin and imipenem. In *Klebsiella pneumoniae* strains 47.3% are XDR and 10.5% are MDR. Most of these organisms are sensitive to colistin, imipenem, aminoglycosides and piperacillin tazobactum. In view of higher number of multi drug resistant organisms in the present study and it is advisable to start empirically antibiotic as soon as diagnosis of VAP is made and depending upon the subsequent culture sensitivity antibiotic can be modified.

Outcomes

The median (interquartile range, IQR) duration of mechanical ventilation was 5 (IQR 4, 8) days with range of 28 varying from 3 days to 31 days. Median duration of mechanical ventilation in patients with VAP was 8 days (IQR 6, 10) which was ($p<0.001$) significantly high compared to patients without VAP 5 days (IQR 4, 7). Median duration of mechanical ventilation in early and late onset VAP was 7 (IQR 5, 8.25) days and 10 (IQR 8, 18) days respectively ($p<0.001$). There is a significant difference in the duration of mechanical ventilation in early and late onset VAP and between VAP and non VAP groups. This was similar to study by Mariya et al which had significant increased duration in a case of VAP (mean: 16.61 days) compared to non VAP (mean: 8.21 days).[22]

The morbidity and mortality of the patients with VAP are definitely higher compared to that of patients without VAP. This can be seen by the increased duration of hospital stay in VAP group (median of 15, IQR 10, 21) as compared to non VAP group (median of 10, IQR 7, 15). Other studies also showed similar results of increased

duration of hospital stay on an average of up to 7-9 days as seen in study by Fagon et al.[23]

The mortality was higher in VAP group (31.3%) compared to the non VAP group (15.7%). Probably because of the multiple interaction of the risk factors in the first one week leading to increased mortality in the early group. The mortality rate of VAP can range from 24% to 50% depending upon the setting and sometimes can be as high as 76%.[1] This high mortality compared to the international standards can be explained probably due to a study done in a pure medical ICU. Higher mortality rates were recorded in medical ICU compared to a surgical ICU as seen in study by Rotstein et al.[24]

CONCLUSION

Ventilator associated pneumonia is an important problem in our ICU with an incidence of 43.5 for 1000 days of mechanical ventilation, with equal proportions of early and late VAP. Presence of organ failure, COPD, Emergency intubation and re-intubation were found to be significant risk factors in the development of ventilator associated pneumonia. Notably *Acinetobacter* species, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* have been identified as the most common etiological agents of VAP both in early and late groups. Ventilator associated pneumonia is associated with significantly increased morbidity and mortality.

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