Ventilator associated pneumonia in intensive care units of a tertiary care centre of Gujarat

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Abstract

Purpose: Healthcare associated pneumonia were reported to be the second most common healthcare associated infection in US intensive care units (ICUs). The mortality attributable to VAP was reported to range between 0 and 50%.

Aims: This study was conducted to determine ventilator associated pneumonia (VAP) rate from tracheal aspirates to improve the specificity of the diagnosis of VAP, to restrict antibiotic overuse and its associated problems in patients of Medical and Surgical intensive care units (ICUs).

Methods and Material: Study included 233 patients in the MICU or SICU subjected to mechanical ventilation for more than 48 hours. VAP was identified as per the definition of Centres for Disease Control and Prevention. Laboratory confirmation was done by quantitative culture of tracheal aspirates.

Results: In MICU, a total of 11 Similarly in SICU, a total of 20 positive samples were diagnosed of having ventilator associated pneumonia VAP rate per 1000 ventilator-days was higher in SICU (19.6) as compared to MICU (10.7). Overall ventilator utilization ratio during the study period for MICU was 0.65 and that for SICU was 0.53.

Conclusion: VAP rate in SICU was high compared to MICU in spite of a lower ventilator utilization ratio. Various risk factors contributing to higher VAP rates in SICU must be identified to implement specific preventive measures in SICU.

Keywords: Ventilator associated pneumonia, Medical intensive care unit, Surgical intensive care unit, Quantitative culture of tracheal aspirats, Mechanical ventilation

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Introduction

Healthcare associated infections occur worldwide and affect both developed and resource - poor countries. Ventilator associated pneumonia (VAP) is defined as pneumonia occurring after 48 hours of endotracheal intubation and initiation of mechanical ventilation.[1] VAP is the most frequent intensive-care-unit (ICU)-acquired infection, occurring in 8 to 28% of patients intubated for longer than 48 hours.[2] For the year 2011, National health care safety network (NHSN) facilities reported more than 3,525 VAP and the incidence for various types of units ranged from 0.0-4.9 per 1000 ventilator-days.[3] Published and unpublished data from Asian countries suggested an incidence of VAP varying from 3.5 to 46 per 1000 ventilator-days.[4] Lack of a gold standard for diagnosis is the major culprit of poor diagnosis and thus outcome of VAP. The clinical diagnosis based on purulent sputum may follow intubation or oropharyngeal secretion leakage around airway, chest X-ray changes suspected of VAP may also be a feature of pulmonary oedema, pulmonary infarction, atelectasis or acute respiratory distress syndrome. Fever and leukocytosis are non-specific and can be caused by any condition that releases cytokines. Although microbiology helps in diagnosis, it is not devoid of pitfalls. In fact, it was proven that colonization of airway is common and presence of pathogens in tracheal secretions in the absence of clinical findings does not suggest VAP.[5,6] To potentially improve the specificity of the diagnosis of VAP and the consequent unnecessary antibiotic use and its associated problems, numerous studies have investigated the role of quantitative cultures of respiratory secretions. These have included bronchoscopic sampling and non-bronchoscopic methods such as quantitative cultures of Endotracheal Aspirates (QEAs) and sampling of secretions from distal airways "blindly" via an endobronchial catheter. Bronchoscopy, being invasive, is commonly associated with complications, especially in patient with high respiratory support. This has paved the way for less invasive tests such as endotracheal aspirates (ETA) and quantitative ETA cultures with a threshold of 10^5 to 10^6 bacteria per millilitre of exudates that is considered as optimal for the microbiological confirmation of VAP.[7,8,9] The American thoracic society (ATS) guidelines recommend that quantitative cultures can be performed on ETA or samples collected either bronchoscopically or nonbronchosopically.[10] More

importantly, recent small trials have repeatedly shown that there is no advantage of bronchoscopic cultures over quantitative ETA cultures when mortality was considered as the end-point further strengthening the case for quantitative ETA as a diagnostic tool.[11,12] Hence present study was conducted to determine VAP rate using quantitative culture methods of tracheal aspirates from medical and surgical intensive care units.

Materials & Methods

This is a prospective type of study conducted from 1st May 2012 to 31st May 2013 after approval from institutional research and ethics committees. All patients admitted in the MICU or SICU who were subjected to mechanical ventilation for more than 48 hours**,** showed positive culture of tracheal aspirate with a significant colony count ($\geq 10^5$ CFU/ml) and clinical evidence of pneumonia as described in the definition provided by National Health Safety Network (NHSN), Centre for Disease Control and Prevention (CDC) guidelines were considered as confirmed cases of VAP and were included as a numerator in the study[3]. 91 cases screened for Ventilator associated pneumonia as per the inclusion criteria. Informed consent was obtained from each patient's next of kin.

Study excluded those patients who had evidence of infection being acquired from units other than medical and surgical intensive care units and/or positive quantitative tracheal aspirate culture within 48 hours of admission to Medical or Surgical Intensive Care Unit.

All patients whose quantitative culture had revealed a colony count of $< 10^5$ CFU/ml of tracheal aspirate and who did not show clinical evidence of pneumonia were also excluded.

Clinical diagnosis of VAP was defined as the presence of a new and/or progressive lung infiltrate in a chest X-ray, associated with at least two of the following criteria: (1) Purulent tracheal secretion; (2) White blood cell count > 12,000 or < 4,000/mm³ or bands count > 10%; (3) Axillary temperature > 38°C or < 36°C; with no other recognized cause and (4) worsening of PaO2/FiO2 ratio ≤ 240, increase oxygen requirements, or increased ventilator demand.(5) for adults ≥ 70 years old altered mental status with no other recognized cause in the previous 48 hours.[3]

Laboratory confirmation was done by quantitative culture of tracheal aspirate. Tracheal aspirates was serially diluted in sterile normal saline as 1/10, 1/100, 1/1,000, and with the help of 4mm diameter calibrated loop 0.01 ml of 1/1,000 diluted secretions were inoculated on the Nutrient Agar, 5% Sheep Blood Agar, MacConkey Agar and Chocolate agar and incubated overnight at 37^0c and identified as per Standard Operative Procedure including Gram's stain, colony morphology and biochemical reactions. Presence of one or more colonies over the streaking area signifies growth of $\geq 10^5$ cfu/ml. Colonizers were present in count of $\leq 10^4$ cfu/ml.[8] A positive tracheal aspirates culture was correlated clinically with findings of pneumonia as per the criteria mentioned.

VAP rates in MICU and SICU were calculated, Parameters like number of admissions, patient-days, ventilator-days and ventilator utilization ratio was also determined. Both MICU and SICU were contacted on daily basis at a specific hour of the day. Total numbers of patient & number of patients on mechanical ventilation were noted down at that particular hour on daily basis throughout the study period. Adding the total number of patients in MICU and SICU on each day gave us patient-days. Similarly ventilator-days were calculated.

Incidence rate and incidence density of VAP was calculated for each month of the study period for both MICU and SICU separately.

Ventilator utilization ratio was also calculated to determine the use in terms of frequency and duration of ventilator in the MICU and SICU and its effect on the VAP rate. Comparison of VAP in MICU and SICU was made on the basis of onset of VAP

Statistical analysis used: Descriptive statistics and Chi square test

Results

Out of total tracheal aspirates (n=**339**) received during the study period, **141**(41.5%) samples were received from MICU and **110**(32.4 %) from SICU, **88** (26%) samples were from other areas of hospital .Culture positivity from MICU and SICU was **86**(61%) and **69**(62.7%) respectively. In MICU, a total of **11** positive samples were diagnosed of having ventilator associated pneumonia.

Similarly in SICU, a total of **20** positive samples were reported of having ventilator associated pneumonia. In MICU, Ventilator days 1028, Patient-days 1576 and ventilator utilization ratio 0.65 were calculated.

Similarly in SICU, Ventilator days 1020, Patient-days 1892 and ventilator utilization ration 0.53 were calculated.

As shown in (Table 1), 8(25.8%) cases were from early onset of VAP, whereas 23(74.2%) cases were from late onset of VAP. There was no statistically significant difference in MICU and SICU on the basis of onset of VAP (**p = 0.890**).

A total of 10 cases of VAP expired during the entire study period with a crude mortality rate of 32.25%.

Male 23 (74%) was more common than female 8 (26%) in VAP cases. In SICU male were 90% of total VAP cases. VAP rate per 100 admissions was higher in SICU (2.87) than MICU (1.55).

Table 1: Cases of VAP with respect to onset of VAP

Time (Days)	MICU n(%)	SICU n(%)	Total n(%)
<4	3(27.3)	5(25)	8(25.8)
≥4	8(72.7)	15(75)	23(74.2)
Total	11(100)	20(100)	31(100)

Table 2: Outcome of cases of VAP with respect to early onset and late onset VAP

Time interval	Recovered	DAMA	Death	Total
<4 days	3	2	4	9
>4_days	10	6	6	22
Total	13	8	10	31

Table 3: Comparison of time to development of VAP

Studies	Time to development of VAP
Chien Liang *et al*[21]	5.1±3.7 days
Present study	**8.29 days**
Zeina A. Kanafani *et al*[22]	12.8 days
Joao Manoel da Silva Junior *et al*[16]	17 days

Table 4: Comparison of VAP rates amongst various studies

Studies	VAP/1000 ventilator-days
NHSN2011 report[23]	1.61
Mehta A [INICC Indian ICU][24]	10.46
Long MN et al[25]	13.2
Present Study	15.13
Finkelstein R. et al[26]	20
Joao Manoel de Silva Junior et al[16]	21.6
Noyal Mariya Joseph[27]	22.94
Fabian Jaimes et al[28]	29
Rosenthal V. et al[29]	50.87

Discussion

The respiratory tract is the most common site of nosocomial infections in the Intensive Care Unit (ICU)[13] and Ventilator associated pneumonia (VAP) is the most common nosocomial infection in patients who need mechanical ventilation.[14,15] The cumulative risk of developing pneumonia is 1% daily in mechanically ventilated patients.[16] VAP is frequently difficult to diagnose in ICU patients with an endotracheal tube or a tracheostomy.[17] The diagnosis of pneumonia in mechanically ventilated patients remains a difficult challenge because the clinical signs and symptoms lack both sensitivity and specificity and the selection of microbiologic diagnostic procedure is still a matter of debate.[18] The diagnosis of VAP is thus based upon a combination of clinical, bacteriological and radiological criteria.[19] In our study11 (12.7%) positive samples from MICU and 20 (28.9%) positive samples from SICU were labelled as being isolated from cases of VAP as per the definition NHSN, Centres for Disease Control and Prevention (CDC), America.

VAP as nosocomial infection: VAP is third most common healthcare associated infection in our institute accounting for about 14% of all healthcare associated infections preceded by Surgical Site Infections (30%) and Catheter Associated Urinary Tract Infections (27%). In EPIC (European prevalence of infections in intensive care) study, VAP was the most frequent infection acquired in intensive care unit accounting for 45% of all infections in European ICUs.[20] International Nosocomial Infection Control Consortium (INICC) study from seven Indian cities involving 16 ICUs described VAP constituting for about 29.6% of all healthcare associated infections. [INICC Indian] This diversity in rates of VAP throughout the globe could be due to a number of factors including difference in the epidemiology of developing and developed countries, patient load, management protocols, etc. Moreover criteria used for diagnosing VAP also varies amongst different studies conducted on VAP.

Incidence rate of VAP per 100 admissions: A total of 31 cases of VAP were detected from both ICUs and thus the combined incidence rate for both the ICUs was 2.20 per 100 admissions (2.2%). A previous study conducted by Luis Fernando *et al* (2001) described a VAP rate of 31.1% among 106 patients who were prospectively followed for VAP[15] which was much higher than the present study. However, incidence density is a more reliable indicator for assessing VAP rate compared to incidence rate which is being compared later in the discussion.

Duration of hospitalization and time to development of VAP: (Table 3) shows a comparison of time to development of VAP between various studies. In the present study time to development of VAP was 8.27 days for MICU whereas it was 8.30 days for SICU. Thus we did not observe any difference in time to development of VAP amongst patients of Medical and Surgical Intensive Care Units of our hospital. Factors like endemic organisms causing VAP, comorbid conditions in patients, choice of antimicrobial agents, etc. could affect the time to development of VAP. A further comparative study could be conducted to find out which of these factors significantly affect time to development of VAP.

Incidence density of VAP per 1000 patient-days: In present study incidence density of VAP for both ICUs was 8.93 per 1000 patient-days. This was 6.97 & 10.57 per 1000 patient-days for MICU and SICU respectively. This is because in SICU there were more road traffic accident patients who were critically ill and required more duration of treatment.

Incidence density of VAP per 1000 ventilator-days and Ventilator utilization ratio: Combined total ventilator-days for both ICUs were 2048 with an

incidence density of 15.13 per 1000 ventilator-days. Incidence density of VAP for MICU was 10.70 per 1000 ventilator-days. Similarly, SICU was 19.60 per 1000 ventilator-days. Thus VAP rate was found to higher in SICU when compared with MICU during the entire study period (Table 4), showing VAP rates in previous studies in ascending order including present study have ranged from 1.61 – 50.87 per 1000 ventilator days. To correlate the VAP rate with use of ventilator, a ventilator utilization ratio was also calculated for the entire study period. Combined ventilator utilization ratio for both ICUs was 0.59. Ventilator utilization ratio for MICU and SICU for the entire study period was 0.65 and 0.53 respectively, ventilator utilization ratio was also found to be higher in INICC study (0.78) compared to the present study.

In our study combined mean ICU stay for both ICUs for patients diagnosed of having VAP was 18.48 days. Mean ICU stay of VAP cases in MICU was 18.36 days whereas mean ICU stay of VAP cases in SICU was 18.55 days. In a previous study conducted by Zeina A. Kanafani et al in America(2001) mean ICU stay for patient diagnosed of having VAP was 24 days, which was much higher than present study.[22] In a previous study conducted by Joao Manoel da Silva Junior et al in Brazil (2003-04), mean ICU stay in VAP cases f*or* MICU was 6 days whereas for SICU was 7 days, which were far less compared to present study.[16] In present study, number of admissions in SICU were less (697 admissions) compared to MICU (708 admissions) whereas patient-days for SICU were more (1892 patient-days) compared to MICU (1576 patient-days) which implies that patients admitted in SICU had a longer duration of hospitalization and therefore risk of acquiring VAP would also increase.

In summary, VAP rates vary among different countries probably because of difference in epidemiology and lack of standard definitions. The same holds true while comparing rates between the ICUs of the same country. Important message that could be carried forward is that VAP rates could be reduced by reducing the use of mechanical ventilation when not required as well as by implementing care bundle approach. Care bundles not only ensure judicious use of mechanical ventilation but also look into various preventive measures for VAP including oral care and prevention of aspiration.

Conclusion

The VAP rates were found to be higher compared to western literature but were found to be parallel with some developing countries indicating that VAP continues to be a major concern in developing countries. The bacteriological approach for the management of VAP avoids the problem of overtreatment by separating colonizers from infecting pathogens. This study showed that quantitative culture of tracheal aspirates is a useful test for early diagnosis of VAP.

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