

Ventilator Associated Pneumonia: Incidence, Etiology, and Preventive Strategies

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Abstract

Objective: To determine the incidence of ventilator associated pneumonia (VAP) in the intensive care unit, and to characterize most common causative pathogens and resistance pattern. To evaluate compliance to VAP prevention strategies and their documentation in order to identify areas for quality improvement.

Design: A retrospective single center study was performed in which medical records were reviewed from all patients on mechanical ventilator admitted to intensive care unit from January to December 2007. The Clinical Pulmonary Infection Score (CPIS) and problem list were used to identify VAP cases. Data on microbial isolates and antimicrobial resistance were collected as well as documentation of measures to prevent VAP.

Setting: A multidisciplinary, eight-bed Intensive Care Unit (ICU) at a metropolitan municipal hospital in Puerto Rico.

Patients and participants: A total of 60 patients that required mechanical ventilation for more than 48 hours.

Measurements and results: The overall estimated VAP rate was 37.15. There was an extremely low compliance to head of bed elevation, daily sedation interruption and oral care. The most common pathogens identified in early and late onset VAP were *Klebsiella* species, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*, all being multidrug resistant pathogens.

Conclusions: The lack of compliance to VAP preventive measures as part of the routine management of patients in mechanical ventilation may explain the high VAP rate. Multidisciplinary teams are needed to establish standardized protocols as well as periodic quality improvement reviews to prevent this complication.

Key words: pneumonia, nosocomial infections, mechanical ventilation, preventive, clinical pulmonary infectious score, intensive care unit.

Introduction

Ventilator associated pneumonia (VAP) continues to be an

important cause of morbidity and mortality, especially at the setting of Intensive Care Unit (ICU). It is the leading cause of death among nosocomial infections, (1,2) accounting for a hospital mortality ratio of 46%. (1) It has been estimated that VAP prolongs time patients remains on the ventilator and total length of hospital stay. (3) The economical impact has been tremendous, exceeding \$40,000 for every patient. (4)

VAP is defined as a pulmonary infection that develops in patients on mechanical ventilation after 48 hours of intubation. (5) A combination of clinical, radiographic and

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laboratory data should be considered for patients with suspected VAP. (6,7) If a ventilated patient develops a new or progressive infiltrate, with fever, leukocytosis, purulent sputum and hypoxemia, the diagnosis of VAP should be considered.

Important sources of infection include healthcare devices, general ICU environment and the transfer between patients-staff and then to other patients. (7,8,9) Pathogenesis has been mainly related to the access of nosocomial pathogens into the lower respiratory tract by aspiration of oropharyngeal pathogens or leakage around the endotracheal tube cuff. (7) For these reasons, all healthcare professionals should make efforts to practice effective preventive strategies to prevent this mortal complication.

The purpose of our study was to determine the incidence of VAP in the ICU, and to characterize the most common causative pathogens and resistance pattern. Since our institution has an Internal Medicine Residency and a recently developed Pulmonary fellowship, we also intended to evaluate compliance to VAP prevention strategies and their documentation in order to identify areas for quality improvement and consequently have a positive impact to decrease the rate of this complication.

Methods

Our study was approved by our Institutional Review Board. A retrospective single center study was performed at the ICU at a metropolitan municipal hospital in Puerto Rico. This is a multidisciplinary unit that combines medical, surgical, cardiac, gynecological and obstetrics patients, with a total of 8 beds. Medical records were reviewed for all patients on mechanical ventilator admitted to ICU from January to December 2007. Patients were excluded if they were intubated for less than 48 hours, or if the reason for intubation was suspected to be a hospital acquired pneumonia. The Clinical Pulmonary Infection Score (CPIS) as well as problem list documented by physicians were used to identify VAP cases. Data of microbial isolates and antimicrobial resistance were collected as well as documentation of measures to prevent VAP. Only medical patients were included in the study.

Results

Within the study period, a total of 60 patients at the ICU required mechanical ventilation for more than 48 hours. Of the above number of patients, 25 of them were diagnosed with VAP according to a CPIS greater than six, medical record problem list and clinical, laboratory, and radiographical criteria. The overall estimated VAP rate was 37.15. The most common reasons for intubation and mechanical ventilation were cerebrovascular accidents, community acquired pneumonia and cardiac complications (**Table 1**).

VAP cases were classified as early and late onset. The characteristics as well as compliance to VAP preventive measures are described for each group on **Tables 2** and **3**, respectively. An extremely low compliance to head of bed elevation, daily sedation interruption and oral care were identified. Among the 25 microbial isolates, the most common pathogens identified in both groups were *Klebsiella* species, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa* (**Table 4,5**). All of these were identified as multidrug resistant pathogens.

Discussion

In this single center observational study more than one third of patients receiving mechanical ventilation developed ventilator-associated pneumonia (41%), which is higher than the expected 10 to 25% incidence for VAP. (2) These findings may reflect the lack of compliance to VAP preventive measures as part of the routine management of patients in mechanical ventilation at this teaching institution. Most common pathogens found on sputum culture include *Pseudomonas*, *Klebsiella*, *Acinetobacter*, *Enterobacter*, *Serratia* and *E. coli*, which are expected for hospital acquired pneumonia microorganisms. (7) However, pathogen results differ from what is expected for early onset VAP. It has been established that early onset pneumonia is caused by pathogens such as *Pneumococci*, *Staphylococci*, *Enterobacteriaceae*, and *Haemophilus* species (10) that may gain access to the lower respiratory tract during the process of intubation. Our early onset patients were infected with pathogens common to late onset VAP as *Pseudomonas*,

Acinetobacter, Staphylococcus, and Klebsiella. This may respond to the fact that some of these patients received previous treatment with antibiotics due to another infectious process prior to the development of VAP. The risk for colonization and contamination with multidrug resistant pathogens is higher in this situation, for which their flora is similar to late onset VAP patients. These situations may also reflect the possibility that these patients had a hospital acquired pneumonia that was not identified at the time of intubation and was then diagnosed as a VAP.

The most common microbial isolates among early and late onset VAP cases were multidrug resistant pathogens. Although data about antimicrobial agents used are not shown, most of the patients were treated with three or more antibiotics. This finding may be in part the result of multiple medical staff interventions in a teaching hospital, as well as the delay in the timely availability of microbial isolates results. The use of multiple antimicrobial agents may be the contributing factor to multidrug resistance in this institution that lacks an antibiotic rotation program.

This study provided extremely valuable information regarding medical practice in our ICU. As part of a new

Pulmonary Fellowship program, quality improvement strategies are being developed and continuously evaluated. Our team pursues better documentation of preventive strategies among all healthcare professionals that have direct contact with patients, including nurses, respiratory therapists, residents, fellows and attending physicians. Endotracheal tube cuff pressure measure is being documented as well as head of bed elevation, by respiratory therapists twice per shift. Intensive care unit and ventilator order sets are also being created to ensure that every measure is being taken to prevent this dreadful complication. These orders include head of bed elevation, stress ulcer and thromboembolism prophylaxis and daily interruption of sedative medications.

Limitations of this study include a single center scenario as well as the retrospective assessment of VAP cases. Although data used to evaluate and identify every case involved clinical, laboratory, and radiography criteria, as well as the CPIS, these do not guarantee the real facts as when data is being collected in a prospective study. Thus, we intend to repeat this study after all quality improvement strategies are established and with a prospective evaluation. We will compare results from both studies to determine the impact of these in the VAP rate of our institution.

Table 1. Reason for Mechanical Ventilation Among Early and Late Onset VAP

Diagnosis	Early onset	Late onset
Cerebrovascular accident	2	2
Community acquired pneumonia	0	4
Cardiac (myocardial infarction, unstable angina, uncompensated congestive heart failure)	2	1
CNS* toxoplasmosis	0	2
Sepsis (soft tissue infections)	1	2
Upper gastrointestinal bleeding	0	2
Bacterial endocarditis	1	0
Delirium tremens	1	0
Diabetic ketoacidosis	0	1
Adrenal crisis	0	1
Uncompensated COPD*	0	1
Drug overdose, rhabdomyolysis	1	0
Acute renal failure	0	1

*CNS=central nervous system, COPD=chronic obstructive pulmonary disease.

Table 2. Characteristics of Early Onset Pneumonia Patients (n=8)

Characteristic	Result
Age, mean (range)	50 (30-71)
Women, no. (%)	3 (37.5)
Men, no. (%)	5 (62.5)
Days in MV, mean (range)	11 (5-15)
Preventive measures documentation, no. of patients (%) <ul style="list-style-type: none"> <li data-bbox="224 904 341 938">• NGT <li data-bbox="224 1002 560 1036">• Head of bed elevation <li data-bbox="224 1100 695 1134">• ETT cuff pressure measurement <li data-bbox="224 1198 987 1232">• DVT prophylaxis in patients without contraindications <li data-bbox="224 1295 586 1330">• Stress ulcer prophylaxis <li data-bbox="224 1393 391 1427">• Oral care <li data-bbox="224 1491 626 1525">• Daily sedation interruption 	8 (100)* 0 (0) 8 (100)** 7 (100) 7 (87.5) 0 (0) 4 (50)

*NGT documented as placed but not part of physicians' orders

**Exact measure not documented

Table 3. Characteristics of Late Onset Pneumonia Patients (n=17)

Characteristic	Result
Age, mean (range)	57 (37-81)
Women, no. (%)	9 (52.9)
Men, no. (%)	8 (47.0)
Days in MV, mean (range)	19.2 (6-40)
Preventive measures documentation, no. of patients (%)	
• NGT	17 (100)*
• Head of bed elevation	0 (0)
• ETT cuff pressure measurement	17 (100)**
• DVT prophylaxis in patients without contraindications (n=11)	10 (90.9)
• Compressive stocking ordered for patients with contraindications for prophylaxis (n=6)	4 (66.7)
• Stress ulcer prophylaxis	17 (100)
• Oral care	0 (0)
• Daily sedation interruption	8 (47)

*NGT documented as placed but was part of physicians' orders in 5 (29%) of cases

**Exact measure not documented

Table 4. Most Common Pathogens on Sputum Cultures of Early Onset VAP Cases

Pathogen	Number (%)
Klebsiella pneumoniae	3 (37.5)
Klebsiella ozaenae	1 (12.5)
Acinetobacter baumannii	4 (50)
Staphylococcus aureus	1 (12.5)

Table 5. Most Common Pathogens on Sputum Cultures of Late Onset VAP Cases

Pathogen	Number (%)
Klebsiella pneumoniae	6 (35.3)
Pseudomonas aeruginosa	4 (23.5)
Acinetobacter baumannii	7 (41.1)
Enterobacter cloacae	2 (11.8)
Escherichia coli	2 (11.8)
Serratia marcescens	1 (5.9)

References

1. Ibrahim EH, Tracy L, Hill C, Fraser VJ, Kollef MH. The occurrence of ventilator-associated pneumonia in a community hospital: risk factors and clinical outcomes. *Chest* 2001;120:555-61.
2. Craven DE. Preventing ventilator-associated pneumonia in adults: sowing seeds of change. *Chest* 2006;130:251-60.
3. Rello J, Ollendorf DA, Oster G, Vera-Llonch M, Bellm L, Redman R, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. *Chest* 2002;22:2115-21.
4. Tablan OC, Anderson LJ, Besser R, Bridges C, Hajjeh R; CDC, et al. Guidelines for preventing health-care-associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. *MMWR Recomm Rep* 2004;53:1-36.
5. Kollef MH. The prevention of ventilator-associated pneumonia. *N Engl J Med* 1999;340:627-34.
6. Center for Disease Control and Prevention. The National Healthcare Safety Network Manual. Patient Safety Component Protocol [Online]. 2008 Jan; Available from: URL:http://www.cdc.gov/ncidod/dhqp/pdf/nhsn/NHSN_Manual_PatientSafetyProtocol_CURRENT.pdf.
7. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. *Am J Respir Crit Care Med* 2005;171:388-416.
8. Chastre J, Fagon JY. Ventilator-associated pneumonia. *Am J Respir Crit Care Med* 2002;165:867-903.
9. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Infection Control Programme. Lancet* 2000;356:1307-12.
10. Giantsou E, Liratzopoulos N, Efrimidou E, Panopoulou M, Alepopoulou E, Kartaliki-Ktenidou S, et al. Both early-onset and late-onset ventilator-associated pneumonia are caused mainly by potentially multiresistant bacteria. *Intensive Care Med* 2005;31:1488-94.