# A study to assess the correlation co-efficient between Microorganisms of Subglottic Secretions and Bronchoalveolar Lavage among Patients with Ventilator Associated Pneumonia in ICUs

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**ABSTRACT**

**Introduction :** Ventilator-associated pneumonia (VAP) is a well-known complication affecting up to 27% of mechanically ventilated patients. It accounts for approximately 25% of all ICU-acquired infections and for >50% of all antibiotic use in ICU patients. Hence the purpose of the current study was to assess the effectiveness of subglottic suctioning for prevention of VAP.**Methods:** This was a Cross Sectional study design . The patients were randomly divided into two groups: Group A - No subglottic secretion drainage (NSSD) where they were intubated with ETT of without provision of suction above cuff and Group B- Continuous subglottic secretion drainage (CSSD). *The coefficient of correlation for the microorganisms cultured from subglottic and BALF in each group was calculated using Pearson's correlation.***Results:** The incidence of VAP among NSSD group was 41% and in CSSD group was 24% . The odds ratio was 0.457 with a relative risk reduction of 0.378. The most common microorganisms among the patients who were diagnosed with early onset VAP (EOVAP) was *Klebsiella pneumoniae. In the total study population, the correlation coefficient was 0.76 . In the NSSD group, the correlation coefficient was 0.83 . In the CSSD group, correlation coefficient was 0.77 .The average number of days of mechanical ventilation at the time of VAP diagnosis was more in CSSD group with 5.76 ± 0.71 days.***Conclusion:** The use of continuous subglottic suction reduces the incidence of VAP and the number of days of mechanical ventilation and duration of ICU stay. A greater concordance of organisms grown in subglottic and BALF cultures, when subglottic suction is not used, suggests a reduction of aspiration of subglottic secretions as a factor contributing to VAP when ETTs with subglottic suction are used.

**Keyword :** Correlation , VAP , ETT , Subglottic secretion suction , ICU

## Introduction

Nosocomial pneumonia is a common complication in critically ill patients. Ventilator-associated pneumonia (VAP) is a well-known complication affecting up to 27% of mechanically ventilated patients. It accounts for approximately 25% of all ICU-acquired infections and for >50% of all antibiotic use in ICU patients.[1,2] It is also the most common nosocomial infection with an overall prevalence of 10%.[1] The greatest risk factor identified for the development of nosocomial pneumonia is mechanical ventilation.[2–6] In some studies it has been shown that in Intensive Care Unit (ICU) patients, 80%–90% of cases of nosocomial pneumonia are ventilator-associated pneumonia (VAP).[4,7,8] The risk of VAP is highest in the first few days of intubation, with a daily hazard rate of approximately 3% at day 5 of intubation, decreasing to 1% day 9.[9,10] Many clinical entities, such as alveolar hemorrhage, drug-induced lung toxicity, cardiogenic pulmonary edema, primary or secondary ARDS, collagen vascular diseases, and primary or metastatic lung cancer may mimic lower respiratory tract infections, but they differ from VAP in terms of management and overall prognosis.[8-10] The diagnosis of VAP is made when a patient who has been mechanically ventilated for ≥48 h develops a new or progressive infiltrate, and the respiratory specimens are positive. However, VAP cannot be confirmed or ruled out until the completion of culture results, which generally takes 2–3 d. Furthermore, pure clinical

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approaches, such as modified CPIS and Johanson criteria, are characterized by a wide variance in sensitivity and specificity among different studies and a relatively moderate overall performance in early VAP diagnosis.[8-10]Endotracheal intubation predisposes to nosocomial pneumonia through several possible mechanisms:

1. Aspiration of oropharyngeal secretions during tracheal Intubation[10-12]
2. Loss of mucosal integrity due to intubation-related trauma
3. Reduced mucociliary clearance of secretions
4. Microaspiration of secretions around the inflated endotracheal tube (ETT) cuff
5. Biofilm formation and bacterial colonization inside the ETT lumen.[9-12]

Thus, measures to prevent VAP include preventing aspiration of secretions, minimize trauma, reduce the duration of invasive mechanical ventilation, reducing bacterial colonization of aerodigestive tract, minimizing secretions above cuff with the use cuffed ETT with inline or subglottic suctioning, preventing contamination of lower airway, and preventing exposure to contaminated equipment. The purpose of the current study was to assess the effectiveness of subglottic suctioning for prevention of VAP.

**Methodology**

This Cross Sectional Analytical study involved Prior Consent from Hospital Authorities / Medical Superintendents of the Local Randomly selected Secondary & Tertiary care hospitals having ICU for the study. The study was conducted within ethical standards. The Patients who were admitted in randomly selected tertiary care hospitals including Our Teaching Hospitals in the city were selected for the study . Randomization was done using computer tables in selecting data. It was observed in the records that all Patients underwent standard clinical examinations, routine biochemical and haematological investigations, Medical record numbers were used to generate the data for analysis. Patients in the age group between 18 and 80 years admitted to the ICU who developed VAP after receiving mechanical ventilation (fulfilling criteria of VAP definition as per Centre for Disease Control and Prevention) were recorded & assessed in the study. The study population was from both rural and urban areas near the hospital and was from all socioeconomic classes.The patients were randomly divided into two groups: Group A - No subglottic secretion drainage (NSSD) where they were intubated with ETT of Portex® brand without provision of suction above cuff and Group B- Continuous subglottic secretion drainage (CSSD) where ETT of Portex® brand with provision of suction above cuff was used.Patients with acute myocardial infarction or unstable angina, cardiac arrhythmias, refractory hypoxemia, pulmonary hypertension, lung abscess, hemodynamically unstable patients, requirement of high levels of positive end-expiratory pressure, cultures showing growth of fungus, and patients referred from another hospital diagnosed as VAP were excluded from the study.A total of 200 critically ill patients were enrolled in this period, 100 patients in NSSD group and 100 in the CSSD group. Fifty patients in each group developed VAP on follow-up. Thus, the total population in this study was 100.It was noted in records that The ETT cuff pressure was maintained in a range of 18–24 cmH2O and was regularly monitored in both the groups. Continuous subglottic suctioning was accomplished with a special ETT with a suction port in the dorsal lumen that resides just above the inflated balloon. This permits aspiration of secretions in the subglottic space,[13,14] thus preventing pooling of these secretions above inflated cuff which could lead to aspiration.It was noted that Subglottic secretions were collected under strict aseptic precautions into mucous extractor using a suction pressure of 20–30 cmH2O and were immediately transported to the laboratory for microbiological examination (for aerobic bacterial culture). It was noted that Bronchoalveolar lavage fluid (BALF) specimens were collected under strict aseptic precautions. A volume of 50–200 mL of sterile saline was infused into the distal bronchoalveolar tree. Suctioning was done and immediately transported to the laboratory for microbiological examination (for aerobic bacterial culture). Both the subglottic and BALF samples were collected at the same time and were subjected to microbiology laboratory within half an hour for culture and identification of microorganisms. The samples were inoculated on blood agar and MacConkey's agar and incubated for a period of 48–72 h for the growth of the bacteria. The colony morphology was studied. Preliminary identification tests such as Gram stain, motility, catalase, and oxidase test were performed. The samples were then subjected for aerobic bacterial cultures. Identification of the bacteria was done by the card (Gram-positive and Gram-negative) .Data of continuous variables were reported as means ± standard deviation whereas categorical data were expressed as percentages or frequency tables. Correlation analysis was done to evaluate the association between various measured variables. Student's t-test was used to compare the incidence of VAP in both groups. Odds ratio was calculated using Chi-square test, from which relative risk reduction was estimated. A value of $P < 0.05$ was considered to be

statistically significant. All statistical analyses were done using SPSS version 17.0, IBM Computers (SPSS Inc. Released 2008. SPSS Statistics for Windows, Version 17.0. Chicago).

**Results**

The mean age of the patients was 54 ± 12 years. Fifty-eight patients were males. The incidence of VAP among NSSD group was 41% and in CSSD group was 24% [Table 1]. The odds ratio was 0.457 with a relative risk reduction of 0.378.Among the various comorbidities, hypertension (29%) was the most common and seizure disorder (2%), the least. Other comorbidities are mentioned in Table 2. Respiratory failure (type 1 and type 2) and airway protection were the two reasons for intubation, Type 2 respiratory failure was seen in 88% of patients in the NSSD group and 80% of patients in CSSD group. Majority of the patients were suffering from chronic obstructive pulmonary disease (COPD) and presented with acute exacerbation of underlying COPD.The most common microorganisms among the patients who were diagnosed with early onset VAP (EOVAP) was Klebsiella pneumoniae (approx. 43%). Among the patients with late onset VAP (LOVAP), Acinetobacter baumannii was the most common (approx. 30%). The most common microorganism in the NSSD group was K. pneumoniae (approx. 44%), and in CSSD group, A. baumannii ( approx. 32%). The prevalence of various other microorganisms as a causative agent in this study population is depicted in Table 3. The coefficient of correlation for the microorganisms cultured from subglottic and BALF in each group was calculated using Pearson's correlation. In the total study population, the correlation coefficient was 0.76 . In the NSSD group, the correlation coefficient was 0.83 . In the CSSD group, correlation coefficient was 0.77 The average number of days of mechanical ventilation at the time of VAP diagnosis was more in CSSD group with 5.76 ± 0.71 days, whereas, in NSSD group VAP was diagnosed within 3.42 ± 0.62 days (P = 0.0001). The average duration of mechanical ventilator support in CSSD group was 7.6 ± 1.1 days compared to 10.6 ± 1.38 days in the NSSD group (P = 0.0001). The mean ICU stay was also higher in the NSSD group (13.1 ± 1.91 days) compared to CSSD group (9.1 ± 1.12 days) (P = 0.0001)

**Table 1: Incidence of ventilator-associated pneumonia *n* (%)**

| | No VAP | VAP | *P* |
|---|---|---|---|
| Group NSSD | 59% | 41 % | 0.002 |
| Group CSSD | 76% | 24% | |
| Total | n=200 | n=100 | |

Chi-square test. VAP: Ventilator-associated pneumonia, NSSD: No-subglottic secretion drainage, CSSD: Continuous subglottic secretion drainage.

**Table 2: Underlying comorbidities of patients in no-subglottic secretion drainage and continuous subglotticsecretion drainage group**

| Diagnosis | Group NSSD, *n* (%) | Group CSSD, *n* (%) |
|---|---|---|
| Acute exacerbation of COPD | 34% | 35% |
| Acute exacerbation of bronchial | 31% | 30% |
| Asthma | | |
| Obstructive sleep apnea | 21% | 20% |
| Systemic lupus erythematosus | 06% | 07% |
| Coronary artery disease | 04% | 03% |
| Interstitial lung | 02% | 0 |
| disease (infective exacerbation) | | |
| Tubercular lymphadenitis | 0 (0) | 2% |

**COPD: Chronic obstructive pulmonary disease, NSSD: No-subglottic secretiondrainage, CSSD: Continuous subglottic secretion drainage**

**Table 3: Prevalence of various microorganisms ascausative agent in both groups**

| Bacteria cultured | NSSD (%) | | CSSD (%) | |
|---|---|---|---|---|
| | EOVAP | LOVAP | EOVAP | LOVAP |
| *Acinetobacter baumannii* | 16 (34) | 2 (66.7) | 0 | 16 (32) |
| *Escherichia coli* | 4 (8.5) | 0 | 0 | 5 (10) |
| *Klebsiella pneumoniae* | 20 (42.5) | 0 | 0 | 12 (24) |
| *Proteus mirabilis* | 0 | 0 | 0 | 3 (6) |
| *Pseudomonasaeruginosa* | 7 (14.9) | 1 (33.3) | 0 | 12 (24) |
| *Serratia marcescens* | 0 | 0 | 0 | 2 (4) |
| Total | 47 (100) | 3 (100) | 0 | 50 (100) |

NSSD: No-subglottic secretion drainage, CSSD: Continuous subglottic secretion drainage, VAP: Ventilator-associated pneumonia,EOVAP: Early-onset VAP, LOVAP: Late onset VAP

## Discussion

The diagnosis of VAP is made when a patient who has been mechanically ventilated for ≥48 h develops a new or progressive infiltrate, and the respiratory specimens are positive. However, VAP cannot be confirmed or ruled out until the completion of culture results, which generally takes 2–3 d. Furthermore, pure clinical approaches, such as modified CPIS and Johanson criteria, are characterized by a wide variance in sensitivity and specificity among different studies and a relatively moderate overall performance in early VAP diagnosis.VAP is a prevalent and costly nosocomial infection related to instrumentation of the airway with an ETT, enabling microaspiration of contaminated secretions.In our study, the incidence of VAP in NSSD group was 41% and in theCSSD group was 24%. Compared to study done by Ranjan et al., overall incidence of VAP was 57.14%.[15] The lower incidence in the present study may be due to differences in study population, definition of VAP itself (clinically vs. microbiologically oriented) and possibly, to the use of preventive strategies.The relative risk reduction in the incidence of VAP was significant with the adoption of subglottic suction ETTs.The proportion of EOVAP and LOVAP was similar to that in the study by Golia et al.[16] In their study, 44.23% had EOVAP and 55.77%, LOVAPAmong other factors, age is an important factor. As age increases, the immune response and mucociliary clearance decrease increasing the susceptibility for VAP development. Bonten et al.found that age>60 years was a nonmodifiable risk factor with an odds ratio of 5.1.[17] VAP also has a male preponderance as seen by Jaimes et al.[18] (58%) and Huang et al.[19](67%) of VAP patients. The incidence of comorbidities is similar to that seen in the study by Huang et al. with hypertension being the most common (28.57%) followed by diabetes mellitus (20.16%) and chronic kidney disease 7.56%.[20] The onset of VAP was delayed in the CSSD group versus NSSD group . These findings are similar to that of Yang et al.[20] Patients with continuous aspiration of subglottic secretions had delayed onset of VAP (7.3 ± 4.2 days) as compared to No aspiration of subglottic secretions (5.1 ± 3.0 days) . In another randomized study that included 714 patients undergoing cardiac surgery, subglottic secretions removal demonstrated a significant reduction in the incidence of VAP, ICU length of stay, antibiotic use, and overall mortality.[11] In our study, The average number of days of mechanical ventilation at the time of VAP diagnosis was more in CSSD group with 5.76 ± 0.71 days, whereas, in NSSD group VAP was diagnosed within

3.42 ± 0.62 days (P = 0.0001). The average duration of mechanical ventilator support in CSSD group was 7.6 ± 1.1 days compared to 10.6 ± 1.38 days in the NSSD group (P = 0.0001). The mean ICU stay was also higher in the NSSD group (13.1 ± 1.91 days) compared to CSSD group (9.1 ± 1.12 days) (P = 0.0001)In the study conducted by Ahmed A Alsaddique, the use of continuous subglottic suction was beneficial even in the case of established VAP. It prevents further soiling of the airways, hastens recovery, and shortens the ICU stay. They suggested that subglottic suction is instituted early in case of prolonged mechanical ventilation to prevent VAP.[21] The most common microorganism cultured from BALF was K. pneumoniae followed by A. baumannii in the current study. Ranjan et al. identified A. baumannii followed by Pseudomonas aeruginosa were the most common microorganisms in their study.[15] In our study, the microorganisms cultured in EOVAP was K. pneumoniae most common followed by A. baumannii in EOVAP, but it was reversed in LOVAP. Golia et al. isolated P. aeruginosa, Escherichia coli, and A. baumannii in EOVAP and LOVAP.[16]Colonization of the oropharynx is an independent predictor for tracheobronchial colonization. Aspiration of these bacteria-containing secretions is the main mechanism of acquiring VAP in mechanically ventilated patients.[22] In our study, the correlation coefficient between microorganisms isolated from subglottic and BALF cultures showed that the microorganism present in subglottic secretions might have been microaspirated into lower respiratory tract leading to VAP. In the total study population, the correlation coefficient was 0.76 . In the NSSD group, the correlation coefficient was 0.83 . In the CSSD group, correlation coefficient was 0.77 .This shows that concordance of bacteria in subglottic and BALF is more in NSSD group when compared CSSD group.

**Conclusion**

The use of continuous subglottic suction reduces the incidence of VAP and the number of days of mechanical ventilation and duration of ICU stay. A greater concordance of organisms grown in subglottic and BALF cultures, when subglottic suction is not used, suggests a reduction of aspiration of subglottic secretions as a factor contributing to VAP when ETTs with subglottic suction are used.

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**References**

1. Vincent JL, Bihari DJ, Suter PM, Bruining HA, White J,Nicolas-Chanoin MH, et al. The prevalence of nosocomial infection in Intensive Care Units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. JAMA 1995;274:639-44.
2. Celis R, Torres A, Gatell JM, Almela M, Rodríguez-Roisin R,Agustí-Vidal A. Nosocomial pneumonia. A multivariate analysis of risk and prognosis. Chest 1988;93:318-24.
3. Langer M, Cigada M, Mandelli M, Mosconi P, Tognoni G. Early onset pneumonia: A multicenter study in Intensive Care Units. Intensive Care Med 1987;13:342-6.
4. Chevret S, Hemmer M, Carlet J, Langer M. Incidence and risk factors of pneumonia acquired in intensive care units. Results from a multicenter prospective study on 996 patients. European Cooperative Group on Nosocomial Pneumonia. Intensive Care Med 1993;19:256-64.
5. Cross AS, Roup B. Role of respiratory assistance devices in endemic nosocomial pneumonia. Am J Med 1981;70:681-5.
6. Cunnion KM, Weber DJ, Broadhead WE, Hanson LC, Pieper CF,Rutala WA. Risk factors for nosocomial pneumonia: Comparing adult critical-care populations. Am J Respir Crit Care Med 1996;153:158-62.
7. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in medical Intensive Care Units in the United States.National Nosocomial Infections Surveillance System. Crit Care Med.1999;27:887-92.
8. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in combined medical-surgical Intensive Care Units in the United States. Infect Control Hosp Epidemiol 2000;21:510-5.
9. Eggimann P, Hugonnet S, Sax H, Touveneau S, Chevrolet JC, Pittet D.Ventilator-associated pneumonia: Caveats for benchmarking. IntensivE Care Med 2003;29:2086-9.
10. Cook D, Guyatt G, Marshall J, Leasa D, Fuller H, Hall R, et al. A comparison of sucralfate and ranitidine for the prevention of upper gastrointestinal bleeding in patients requiring mechanical ventilation.Canadian Critical Care Trials Group. N Engl J Med 1998;338:791-7.
11. Bouza E, Pérez MJ, Muñoz P, Rincón C, Barrio JM, Hortal J.Continuous aspiration of subglottic secretions in the prevention of ventilator-

associated pneumonia in the postoperative period of major heart surgery. Chest 2008;134:938-46.
12. Torres A, Gatell JM, Aznar E, el-Ebiary M, Puig de la Bellacasa J,González J, et al. Re-intubation increases the risk of nosocomial pneumonia in patients needing mechanical ventilation. Am J Respir Crit Care Med 1995;152:137-41.
13. Berra L, De Marchi L, Panigada M, Yu ZX, Baccarelli A, Kolobow T.Evaluation of continuous aspiration of subglottic secretion in an in viVOstudy. Crit Care Med 2004;32:2071-8.
14. Ramirez P, Ferrer M, Torres A. Prevention measures for ventilator-associated pneumonia: A new focus on the endotracheal tube.Curr Opin Infect Dis 2007;20:190-7.
15. Ranjan N, Chaudhary U, Chaudhry D, Ranjan KP.Ventilator-associated pneumonia in a tertiary care Intensive CareUnit: Analysis of incidence, risk factors and mortality. Indian J Crit Care Med 2014;18:200-4.
16. Golia S, Sangeetha KT, Vasudha CL. Microbial profile of early and late onset ventilator associated pneumonia in the Intensive Care Unit of a tertiary care hospital in Bangalore, India. J Clin Diagn Res 2013;7:2462-6.
17. Bonten MJ, Kollef MH, Hall JB. Risk factors for ventilator-associated pneumonia: From epidemiology to patient management. Clin Infect Dis 2004;38:1141-9.
18. Jaimes F, De La Rosa G, Gómez E, Múnera P, Ramírez J,Castrillón S. Incidence and risk factors for ventilator-associated pneumonia in a developing country: Where is the difference? RespirMed 2007;101:762-7.
19. Huang KT, Tseng CC, Fang WF, Lin MC. An early predictor of the outcome of patients with ventilator-associated pneumonia. Chang Gung Med J 2010;33:274-82.
20. Yang CS, Qiu HB, Zhu YP, Huang YZ, Xu XT, Gao L. Effect of continuous aspiration of subglottic secretions on the prevention Of ventilator-associated pneumonia in mechanically ventilated patients: A prospective, randomized, controlled clinical trial. Zhonghua Nei Ke Z Zhi 2008;47:625-9.
21. Alsaddique AA. Use of continuous subglottic suction in established ventilator associated pneumonia. Saudi J Anaesth 2009;3:20-4.
22. Safdar N,CrnichCJ, Maki DG.The pathogenesis of ventilator-associated pneumonia: Its relevance to developing effective strategies for prevention. Respir Care 2005;50:725-39.

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