**Original Article**

# The Combination Strategy to Reduce Early Ventilator-Associated Pneumonia

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## Abstract

**Background**: Ventilator-associated pneumonia (VAP) is the most common nosocomial infection in intensive care units (ICUs), leading to increase in mortality and length of ICU and hospital stay as well as duration of mechanical ventilation and hospital charges .

**Aim**: The present study was conducted to investigate the effect of combination strategy on early VAP .

**Methods**: In a controlled clinical trial, 117 patients undergoing mechanical ventilation were evaluated in ICU in two groups comprising control (n=71) and intervention (n=46); the former received the ward's routine care, and the latter received planned nursing care protocols. Incidence of pneumonia was investigated using clinical pulmonary infection score system (CPIS) and Mini-BAL method .

**Results**: The incidence of early VAP was 19.6% and 40.8% in the intervention and the control groups respectively (P <0.001). The early VAP rate was 22.8 and 14.41 per 1000 ventilator days in control and the intervention groups. respectively. Length of ICU (P <0.02) and hospital (P<0.001) stay and also duration of mechanical ventilation (P<0.001) showed significant reduction in the intervention group compared to the controls.

**Conclusions**: Precise implementation of planned and evidence-based nursing care is effective in reducing incidence, duration and hospital stay associated with early VAP .

**Key Words**: ventilator-associated pneumonia, nursing care, prevention.

## Introduction

According to the Center of Disease Control and Prevention, 1.7 million nosocomial infections occur annually in the United States which cause about 99000 cases of death. Additionally, the financial burden is profound and the annual direct medical costs for HAIs range from $28- $45 billion in the US alone (1). In Asian countries, incidence of ventilator-associated pneumonia (VAP) has been reported to be 7.5% (2), while in Iran, it varies from 15.4% to 32.2% (3,4).

Ventilator-associated pneumonia is the most common nosocomial infection in ICUs, developed in patients with more than 48 hours of mechanical ventilation, and is considered as the most leading factor in patients' lack of well-being and increased morbidity, mortality, and healthcare cost in these sectors (5).

The increasing incidence of resistance to third and fourth generations of cephalosporins among gram negative bacilli that has occurred in parallel with increasing use of these drugs in ICUs (6), …

In 2002, National Nosocomial Infections Surveillance of America reported pneumonia-associated mechanical ventilation rate from 2.2% in pediatric ICUs to 14.7% in trauma critical care units (7). In other reports, patients undergoing mechanical ventilation have been shown to be 6 to 12 times more susceptible to develop nosocomial infections than other patients (8).

The incidence of ventilator-associated pneumonia is 8% to 68%with the mortality rate varying from 24% to 50% (9). VAP leads to increase in hospital charges between 10000 to 12000 dollars per each episode as well as addition of five extra days to mechanical ventilation, six days to length of ICU stay and seven days to total hospital stay (10). Therefore, the prevention should be taken into consideration as a top priority.

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Hence, in all quality control programs, a great importance has been given to VAP prevention, as it can lead to cost reduction and promotion of clinical prognosis (11). Due to increased incidence of ventilator-related infections and subsequent complications resulting in shortage of beds in ICUs in IR Iran, there is high cost and high mortality. VAP is one of the factors that increases duration of hospitalization.

In this study, we investigated the effect of combination strategy on reducing ventilator-associated infection with an assumption that it leads to reduction in incidence and severity of VAP.

## Materials and Methods

**Study design:** The present controlled clinical trial has been carriedout in ICUs of two university hospitals in Tehran and Kerman (Southeast of Iran), from July 2010 to July 2011. The study was approved by Research Ethics Committee number 25 of Baqiyatallah University of Medical Sciences. Also Informed consent was obtained from the relatives of patient. The primary purpose of the study was to investigate the effect of combination strategy on reducing early VAP rate, while, reducing the length of ICU and hospital stay as well as time needed to connect to ventilator were considered as the second objectives. Patients were monitored for 96 hours (four days) in the mentioned units. To provide combination strategy, the CDC instructions and evidence-based clinical guidelines (12-19) were used.

**Patients:** All patients, ranging in age from 18 to 65 years, admitted to ICUs and intubated were entered in to the study if no symptoms indicative of pneumonia (high fever, leukocytosis or leukopenia, lung infiltration, and purulent discharge) and underlying lung problems (chronic obstructive pulmonary disease, lung cancer, and chest trauma) were observed and then monitored for 96 hours after intubation to be under the ventilation for more than 48 hours. Exclusion criteria comprised having no teeth, suspected pneumonia during intubation, pregnancy and lack of consent for participation by patients and their families, FiO2 >90 and/or PEEP >14cm H2O, cardiopulmonary arrest and resuscitation.

**Control group:** This group was selected using the objective-based sampling method. First, sampling was performed in the control group (n=76), based on which the ward's routine care was afterwards implemented. In IR Iran, the routine care currently undertaken in ICUs is not based on any particular protocol, principal or standard and is even sometimes substantially ignored. On the other hand, the care depends on the individual, and without any regular or special program in these units.

Such a care vacuum can be a major risk factor in VAP development. Following intubation, patients were observed for 96 hours (4 days) and study parameters including vital signs, mode of ventilator, ABG, laboratory tests, medications, history of blood transfusion and chest X-Ray were recorded in the 24 h and 96 h after intubation. On the fourth day, mini-BAL culture was sent for each patient and the result was recorded. Chest X-Ray interpretation was done concurrent and independently by a sub specialist in critical care and a Radiologist

**Intervention group:** The intervention group (n=46) received planned and evidence-based nursing care. An evidence-based clinical guidelines protocol was designed in form of a poster and mounted in ICUs. Various training sessions were held several times in different shifts for staff notification and preparation. They were also provided educational pamphlets and protocol-implementing procedures. Materials and equipments needed including chlorhexidine, toothbrush and toothpastes were provided in units. Additionally, a checklist was prepared on the time and the manner of protocol implementation and filled out during 96 hours separately for each patient. In addition to completing the nursing-care checklist, all the same items were recorded for the intervention group as they for the control, and mini-BAL culture was sent at the end of the care. The standard VAP prevention protocol comprised the following: Oral hygiene using 0.2% chlorhexidine mouthwash every eight hours (5, 11,20,21), teeth brushing every 12 hours (5, 20, 22, 23), elevating the head of bed to 30-45 degrees especially while gavaging in cases of no contraindications (24-26), maintaining the cuff pressure between 20-30 cm H2O (27), continuous subglottic suctioning (28,29), nurses' personal hygiene (hand washing) before and after contact with patients (29-32), sterilization observation (12) and ventilator tube's replacement in cases of significant contamination (13,33).

**VAP definition:** Early VAP is defined as development of ventilator-associated pneumonia within 48 to 72 hours after intubation, in which microorganisms such as Staphylococcus aureus, Haemophilus influenzae and Streptococcus pneumonia have the highest prevalence. On the contrary, late-onset VAP occurs usually 96 hours after ventilation, in which methicillin resistant staphylococcus aureus (MRSA), Pseudomonas aeruginosa and Enterobacter are generally involved. The results of some studies have also pointed to VAP development by multiple organisms in most patients (5, 34).

**Diagnosis of pneumonia based on clinical pulmonary infection score system (CPIS):** Six main criteria are used in this scoring method and higher-than-six score are consistent with the diagnosis of pneumonia (17).

**Diagnosis based on Mini-BAL culture**: Results of pulmonary secretion's culture >105 are in accordance with diagnosis of pneumonia. In this study, two methods including CPIS and Mini-BAL respiratory secretion cultures were applied.

VAP rate is calculated based on per 1000 ventilator days, which is the standard criterion for its evaluation presented by the Center for Disease Control and Prevention (35).

(Total no. of VAP Cases / Ventilator Days) x 1000 = VAP Rate.

**Statistical analysis:** Data was analyzed by SPSS version 16 statistical software using chi-square and independent t-test for qualitative and quantitative variables respectively.

## Results

In a 12-month period, 117 eligible patients were studied in ICUs, among whom 71 patients had been allocated to the control and 46 patients to the intervention groups. The early VAP rate was 40.8% in the control and was reduced to 19.6% after receiving the planned nursing care ($p<0.001$) (Table II). The mean CPIS was 5.4 ± 3 and 3.5 ± 2.6 in the control and the intervention group, equivalent to 22.8 and 14.41cases per 1000 ventilator days respectively in these groups. Spearman's correlation test demonstrated a direct correlation between the two methods of VAP calculation ($r = 0.78$, $p <0.001$).

| Colony count | Case group N(%) | Control group N(%) | Chi-Square Tests |
|---|---|---|---|
| $10^3$ | 26 (56.5%) | 19 (26.8%) | |
| $10^5$>count>$10^3$ | 11(23.9%) | 23(32.4%) | $x^2$11/1 |
| $10^5$ | 9 (19.6%) | 29 (40.8%) | p<0/0001 |

Table II. Comparison of VAP rate based on mini-BAL method

**Patients' characteristics:** Of total 117 patients, 85.5% were male and 14.5% were female (Table I). There was no significant difference between gender and VAP rate in the two groups (P=0.2). Moreover, the mean age of participants was 37.1, ranging from 18 to 65 years and no statistical difference was observed in terms of the mentioned variable and VAP rate between the two groups (P=0.3).

| parameters | Control group mean±SD | Case group mean±SD | p.val |
|---|---|---|---|
| Age | 38.1±15.6 | 35.5±16.1 | 0.391 |
| APATCH II | 13.8±5.2 | 12.6±5.6 | 0.265 |

Table I. Demographic characteristic of patients

**Cost-benefit criteria:** The mean length of ICU stay was 22.7 days in total study population, which was significantly different between the two groups (P=0.02). The mean duration of ventilation was 15.5 days and significantly meaningful between the two groups (P=0.009) and the mean length of hospital stay was 31.8 days indicating a statistically significant difference between the study groups (P=0.004) (TableIII).

| Cost – benefit criteria | Control group | Case group | Independent t-test Pvalue |
|---|---|---|---|
| Ventilator Day(day) | 17.8±12.8 | 12.6±9.07 | t=2.6 P=0.009 |
| ICU stay(day) | 25.3±15.5 | 18.6±16.3 | t=2.22 P=0.028 |
| Hospital stay(day) | 36.1±21.3 | 25.1±17.5 | t=2.89 P=0.004 |

Table III.compare Cost-benefit criteria in two groups

## Discussion

In the present study, a significant reduction was observed in VAP rate through implementation of planned nursing care, by which length of ICU and hospital stay as well as duration of ventilation were declined.

Approximately 300 000 cases of VAP occur in the United States each year, from which more than 14000 are related to patients admitted to the ICUs (13).

In a study by Bouza et al., it was shown that continuous suctioning of subglottic secretions can diminish 30% of daily doses of antibiotics (36). Organisms responsible for VAP, especially gram-negative bacilli and Staphylococcus aureus, exist in hospitals and are often transferred to patients after colonization in healthcare providers' hands. Hand washing with alcoholic solutions has been more acceptable and decreased nosocomial infections from 17 to 9.9 percent (31).

Findings of Han et al. study revealed that frequent replacement of ventilator tubes is accompanied by increased risk of VAP, and the replacement is merely safer in cases of significant contamination, causing cost savings between 4900-111530 dollars depending on the hospital (33, 37).

In an investigation by Al-Tawfiq et al., the mean frequency of VAP declined from 9.3 cases per 1000 ventilator days in 2006 to 2.3 cases in 2007 and 2.2 cases in 2008 after application of a five-item instruction. Each case of VAP, augmented duration of hospital stay by 10 days and the mean cost by 40000 dollars (38).

In the present research, there was 21% decrease in the VAP rate, while it was 80% in Al-Tawfiq's study (38).

In another survey by Bird et al., incidence of VAP was reduced from 10.2 to 3.4 per 1000 ventilator days after following the guidelines which brought 1.08 million dollars cost savings (39).

Likewise, in a study by Wip et al., using a four-item prevention program was found to be effective in VAP decrement. This program included head-of-the-bed elevation to 30-45 degrees. Daily examination included preparation for extubation, peptic ulcer prophylaxis and deep vein thrombosis prophylaxis. However, other VAP preventive methods, such as oral health care, use of chlorhexidine and continuous suctioning of subglottic secretions were not investigated (40).

In this regard, BerenHoltz et al. evaluated the effect of multilateral interventions on VAP and acceptance of five evidence-based suggestions in relation to the patients under ventilation and reported a reduction in VAP incidence from 5.5 cases (mean= 6.9) per 1000 ventilator days to zero (mean=3.4) case after the 16-18 months intervention period (41).

For prevention of VAP, a surveillance program was applied by Rello et al., including no ventilator tubes replacement except in case of contamination, hand washing with alcoholic solution, proper education for the staff, combination of awareness protocol and sedation management and chlorhexidine-based oral care that resulted in decreased length of hospital stay in addition to VAP prevention (42).

In another study, other care programs such as hand washing, wearing gown and gloves, head of bed elevation, maintenance of endotracheal tube cuff pressure, use of oral gastric tube, avoiding excessive stomach bloating and good oral health (18) were illustrated to lessen the VAP incidence to 51% (43).

Prevention of VAP in ICUs is a matter of high significance and necessity for healthcare providers. Several strategies and guidelines have been provided for prevention of VAP, following and observing of which is under the influence of various factors such as lack of

requisite knowledge and proper infection control program and unawareness of these guidelines (44).

Diagnosis of VAP has been discussed as a challenge because clinical signs and symptoms have no sensitivity and specificity and selecting a microbiological diagnosis is still a matter of controversy. There are several quantitative and qualitative methods available for diagnosis of VAP. As bronchoscopy requires a skilled technician and high cost in one side and is not 24 h available on the other, using the non-Bronchoscopic Alveolar Lavage has been suggested due to inexpensiveness, simplicity and usefulness for this purpose. Besides, application of the CPIS is also beneficial with 93% sensitivity and 100% specificity (45). In mini-BAL method, the mini-BAL specific steel sample-collecting container was used comprising of two interfaces, one connected to the suction apparatus and the other to the sterile suction catheter No. 14. Twenty ml normal saline was then injected into the lower part of the airway and was aspirated into the special container afterwards. The samples collected were immediately transported to the laboratory and the procedure was repeated if the aspirated fluid was less than 5 ml.

Another finding of the present study is the consistency of mini-BAL results with those of CPIS in diagnosis of VAP. Spearman's correlation test demonstrated a direct relationship between the two methods of VAP calculation ($r=0.78$, $p<0.001$), which is in accordance with the results obtained by Chastre et al., Luyt et al. (46) and Schurink et al. (47), indicating CPIS application as a non-invasive method for diagnosis of VAP.

Findings of the present research and other similar studies reported in the scientific literature suggest that using guidelines presented on VAP prevention can have dramatic impact on reduction of VAP rate and cost. However, implementation of the planned nursing care in this regards necessitates instructing guidelines, notification to the personnel of intensive care, continuous monitoring on instructions, persistent control over incidence of VAP and feedback to the staff in the related fields.

## Conclusion

Precise implementation of planned and evidence-based nursing care is effective in reducing incidence, duration and hospital stay associated with early ventilator-associated pneumonia.

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