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# Comparison of the Use of Conventional and Antibiotic-Coated Tracheal Tubes and EVAC on the Incidence of Ventilator-Associated Pneumonia (VAP)

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## Abstract

Ventilator-associated pneumonia (VAP) is one of the most important hospital infections in hospitalized patients, which is associated with increased mortality and patient costs. The tracheal tube itself seems to be a major risk factor for VAP. Contaminated secretions pass through the endotracheal tube and reach the lungs. Also, bacteria form a bacterial biofilm on the tracheal tube and are transferred from there to the lungs. Different tracheal tube designs have been produced to overcome these cases. The purpose of this study is to investigate the effect of an Evac tracheal tube covered with antibiotics and normal on the incidence of pneumonia caused by the ventilator. Research method: 180 patients were randomly intubated in three groups of 60 people with three types of tracheal tubes, Evac and Bactiguard. Clinical examinations, endotracheal tube aspiration culture, and chest radiography were obtained from the patients and the incidence of VAP was calculated based on the CPIS standard. The relationship between the type of endotracheal tube and the incidence of VAP and the length of stay in the intensive care unit (ICU) and being discharged alive from the ICU were investigated. Findings and conclusions: The average incidence of VAP for the group of patients in-

tubated with a conventional tracheal tube was 50%, EVAC was 45% and Bactiguard was 40%. The results showed that there is no significant relationship between the incidence of ventilator-induced pneumonia and the type of tracheal tube. The incidence of ventilator-induced pneumonia was not significantly reduced by suctioning subglottic secretions and Bactiguard tracheal tubes. It seems that using one method alone is not effective in reducing ventilator-induced pneumonia.

## Keywords

Intensive Care Unit, Pneumonia, Suction, Ventilator

## 1. Introduction

Endotracheal tube placement is necessary to control the airway of patients who need mechanical ventilation. However, long-term use of these tubes can lead to ventilator-associated pneumonia (VAP) [1]. VAP refers to pneumonia that occurs after 48 hours of intubation and mechanical ventilation of the patient and develops pneumonia [2]. VAP is the most common fatal infection among patients, treated in the intensive care unit [1].

The second most common hospital infection in acute patients is pneumonia, which affects 27% of critically ill patients [2].

Mortality due to VAP is reported to be 50%, depending on various factors such as chronic liver disease, problems, and trauma caused by enitobicin and micro-organisms colonized in the lower airway. Despite the progress that has been made in the field of recovery and control of intubated patients, VAP remains a common and sometimes fatal factor in the ICU. Another complication of VAP is the increase in the number of days the patient is hospitalized in the intensive care unit (ICU), and the subsequent increase in the patient's expenses [2] [3].

## 2. Mechanisms to Reduce the Occurrence of VAP

Efforts to reduce the microaspiration of contaminated secretions and the formation of biofilm inside the endotracheal tube (ETT) lumen can lead to the prevention of VAP [4].

### 2.1. Suction of Subglottic Secretions

Installing an orifice above the tube cuff, connected to an external tube was an innovation in ETT design that continuously or intermittently suctions subglottic secretions [4].

The principle behind this technique is that removing the secretions in the space between the laryngeal diaphragm and the ETT cuff can lead to the reduction or elimination of microaspiration and colonization of bacteria in the trachea and ultimately reduce the incidence of VAP [4].

### 2.2. Changes in the Cuff of the Tracheal Tube

Recently, changes have been made in the design or composition of the ETT cuff to prevent microaspiration, and studies have shown the success of this type of endotracheal tube that has a polyurethane or silicone cuff [4].

### 2.3. Reduction of Biofilm Formation

The combination of an antimicrobial substance with polymer-forming medical equipment is an accepted method to reduce infections associated with medical equipment. This method can prevent microbial adhesion to the equipment by using the antimicrobial surface or by releasing the drug to the extent that it can kill microbes. Recently, researchers are trying to prevent bacterial colonization by covering the ETT with new materials [5].

In this regard, the antimicrobial substance used and its release speed are important factors. The selected antimicrobial substance should be broad-spectrum and have lower degrees of bacterial resistance and have anti-microbial adhesion properties [5].

Due to the widespread development of antibiotic resistance, efforts are being made to use non-antibiotic antimicrobial substances [5].

Silver has antimicrobial properties with broad coverage against gram-positive and negative bacteria, fungi, parasites, and viruses [5].

Considering the high prevalence of VAP and the cost of treatment and complications related to it, its prevention seems essential. Based on this, we decided to investigate two types of EVAC tracheal tube, which has a different cuff shape and suction of subglottic secretions, and Bactigaurd, which has gold, palladium, and silver coating. This study aims to compare the use of conventional tracheal tubes with antibiotic coating and EVAC on the incidence of VAP.

## 3. Materials and Methods

Patients transferred to the special care units of Loghman Hakim Hospital, who needed intubation for more than 48 hours and did not meet the exclusion criteria, were included in the study. Exclusion criteria included the following: patients who were converted but before According to the treating physician, the initial assumption was that they would be extubated within 48 hours, patients who developed fever within 48 hours and needed antibiotics, patients who died within 48 hours, patients who were transferred from ICU to other centers within 48 hours. Transferred patients who were extubated less than 48 hours, pregnant women, with human immunodeficiency virus (HIV), lung cancer, people who were under immunosuppressive treatments, received antibiotics in the last 24 hours, need intubation other than the oral route.

On the first day of the study, the 180 endotracheal tubes were randomly divided between three ICUs, in a way that 60 groups marked with letters A, B, and C were randomly assigned to each ICU from a lottery box. If the patient withdraws from the study due to the withdrawal criteria, another endotracheal tube

related to the same group was replaced.

The operator was not aware of the assignment of the patient to each group, after the patient entered the study, the assignment of the patient was determined based on the announcement letter from the box.

The studied groups were as follows: Group A was intubated using Mallimckrodt HiLo oral/nasal tracheal tube (Medtronic). Group B was intubated using Evac tracheal tube (Mallimckrodt oral/nasal tracheal tube taper guard Medtronic, Dubin, Ireland). Group C was intubated using Bactigaurd tracheal tube (Bactigaurd AB oral/nasal cuffed Sweden).

In this way, 60 patients were studied in each group. Baktiguard tracheal tube cuffs were cylindrical, while Evac tracheal tube cuffs were tapered and conical in shape. Every three hours, cuff pressure was monitored in all patients of all three groups until it was 20 - 30 cm of water.

The Evac tracheal tube was also capable of suctioning subglottic secretions, which were removed every three hours by a 5 - 10 ml syringe.

In the other two groups, secretions were suctioned at least 8 times a day by open method and aseptic technique. Then these secretions were sent to the microbiology laboratory for culture.

In the laboratory, the samples were cultured on specific microbial culture media, and after 24 hours, an antibiogram test was performed for the samples containing pathogenic bacteria, and according to the antibiogram answer, the effective antibiotic type for the infection was determined.

The inner diameter of all tubes was 7 × 7.5 mm for women and 8 × 8.5 mm for men, and the tracheal tube was placed 21 cm long in women and 23 cm long in men. Chlorhexidine or antibiotics were not prescribed for patients at this stage. But H2 blocker was prescribed for all patients due to someone's stress profile.

All patients were monitored by a trained nurse during their stay in the ICU.

The head patients were placed 30 - 45 degrees higher unless they had orthopedic or hemodynamic problems. And all patients were sedated using Fentanyl, Rinfentanil, and Midazolam to reach RASS +1 to −2 stage (Richmond Agitation Sedation Score).

All patients had a positive end-expiratory pressure (PEEP) of 5 mmHg during the mechanical ventilation phase. And they were hospitalized in ICU until extubation or death or discharge. Chest X-rays were also prepared from the patients, which were first interpreted by the ICU specialist and then reported by a radiologist with the rank of assistant professor, and in cases of conflicting reports, the third radiologist made a report without knowing about the previous reports, and his opinion was the index of the report, it is registered. Patients' fever, subglottic secretions, leukocytosis, changes in breathing, and gas exchange were checked daily and scored based on clinical pulmonary infection score (CPIS). If the CPIS of the disease was equal to or greater than 6, it was considered pneumonia.

The start date of antibiotic therapy in all three groups was within the first

twenty-four hours of the onset of fever or purulent discharge.

The incidence of VAP, duration of intubation and hospitalization in ICU, and the mortality rate of patients were also recorded.

Finally, the data were entered into a statistical package for the social science (SPSS). The Ki2 test was used to check whether the default assumptions were correct and the Fisher's Exact Test was used to check the relationship between the incidence of VAP and the variables. In addition, we used the Student t-test in certain cases.

## 4. Results

180 studied patients were divided into three groups of 60 people. Group A was intubated with a normal endotracheal tube, Group B with an EVAC endotracheal tube, and Group C with a Bactiguard endotracheal tube. The average age of the subjects studied was 45.79 years, which was 36.176 in Group A, 53.13 in Group B, and 46.32 in Group C (Table 1).

In terms of gender, there were 107 men and 73 women, respectively, in Groups A, B, and C, 66.74%, 55%, 56.7% were men and 33.26%, 45%, and 43.3% were women. There was no significant difference between gender and age (Table 1).

The incidence of VAP was in 81 patients, of which 30 members of Group A (50%), 24 members of Group B (40%), and 27 members of Group C (45%) patient's had VAP, and no significant difference was observed between the three study groups (Table 2).

Mortality in the three groups was 13.3%, 55%, and 43.3% respectively, which was significantly lower in the conventional endotracheal tube group than the

Table 1. Statistical society.

| | | ETT<br>Group A | EVAC<br>Group B | Bactiguard<br>Group C |
|---|---|---|---|---|
| Age Average | | 36.176 | 53.13 | 46.32 |
| Sex | Men | 66.74% | 55% | 56.70% |
| | Women | 33.32% | 45% | 43.30% |

Table 2. Incidence of VAP.

| | ETT | EVAC | Bactiguard |
|---|---|---|---|
| | Group A | Group B | Group C |
| Average length of stay in ICU (days) | 7.6167 | 12.4 | 11.75 |
| Average length of stay in the hospital (days) | 9.5176 | 18.57 | 16.78 |
| Mortality | 13.30% | 55% | 43.30% |
| Vap | 50% | 40% | 45% |

other two groups (P < 0.001). There was no significant difference between VAP and being discharged alive from ICU and age (Table 2).

86% of the patients who were discharged alive were intubated with a conventional endotracheal tube and this difference was significant (P < 0.001). Also, 45.2% of the patients who stayed in the ICU for less than 8 days were intubated with a conventional endotracheal tube. (P < 0.0002) The average length of stay in the ICU was 7.61 days in Group A and 12.40 days in Group B. And 11.75 days were in Group C (Table 2).

In general, the table shows that 46.6% of women and 43.9% of men have suffered from VAP, and there is no significant difference between the two sexes in the incidence of this disease. (Table 3)

Regarding VAP and the type of endotracheal tube used, it can be seen that 50% of patients intubated with a conventional endotracheal tube, 40% of patients intubated with an EVAC endotracheal tube, and 45% of those intubated with Baktiguard endotracheal tube have developed VAP, and it is clear that EVAC endotracheal tube reduces the incidence of VAP in patients hospitalized in ICU but it was not the meaningful difference. (Table 3)

Regarding the length of stay in the ICU and being discharged from there alive, 32.1% of people with VAP meters stayed in the ICU for more than 8 days, and more than half of them, 67.9%, stayed in the ICU for a period equal to or more than 8 days. These findings indicate the seriousness of complications caused by VAP for patients and their need for special hospital care. (Table 3)

Finally, the observations have shown that 45.8% of the patients with VAP examined alive were discharged from the ICU, and this result was a sign of the controllability of this complication, but because no significant difference was found in all the examined cases, it is suggested that more factors be examined simultaneously in future research. (Table 3)

**Table 3.** Comparison of the incidence of VAP in various tube types and its link with other factors.

| | | VAP | | P Value |
|---|---|---|---|---|
| | | + | − | |
| Sex | Women | 46.60% | 53.40% | 0.1 |
| | Men | 43.90% | 56.10% | |
| tube type | Conventional endotracheal tube | 50% | 50% | 0.545 |
| | EVAC | 40% | 65% | |
| | Bactiguard | 45% | 55% | |
| Length of stayin ICU | Less than 8 days | 32.10% | 67.70% | 0.001 |
| | More than or equal to 8 days | 67.90% | 32.30% | |
| Discharged alive from ICU | | 45.80% | 54.20% | 0.751 |

## 5. Discussion

There are many disagreements about the causes of VAP in medical literature, and many of these studies emphasize the role and type of tube, microaspiration, and bacterial biofilm in causing VAP.

This study was also conducted to compare the use of conventional tracheal tubes and antibiotic-coated and Evac on the incidence of ventilator-induced pneumonia.

The results showed that there was no significant difference between VAP and the type of tracheal tube, although better results were obtained with Evac tracheal tube, this difference was not significant.

Quchani and Steven Deem generally achieved the same results as our study [6] [7]. Guchani investigated specifically the effect of the Hi-lo Evac tracheal tube on the reduction of VAP and concluded that the Evac tracheal tube is ineffective in reducing the incidence of VAP. However, it leads to a reduction in ICU length of stay and mortality [6]. In contrast with their study, we found that EVAC endotracheal tube reduces the incidence of VAP in patients hospitalized in ICU however it was not so significant.

The results of the present study also showed that there is a significant difference between VAP and the length of stay in the ICU. Also, there was a significant difference between endotracheal tube and mortality and it was shown that patients who were intubated with conventional endotracheal tube were discharged alive from ICU with a higher proportion. This result confirms the results of Hadda's study. They showed that VAP infection does not affect mortality, although the length of stay in the ICU and hospital is affected by this disease [8].

Chastre also stated that having VAP increases the average length of stay in the hospital by 7 - 9 days, and in the present study, we concluded that having VAP leads to an increase in the length of stay in the ICU for 8 days and it becomes more [9].

Bekaert's recent study also indicated that VAP itself causes only one percent of mortality in the ICU [10].

One of the positive features of the Taper guard Evac tracheal tubes used in this study is the shape of the cuff, which is a tapered shape, and at least one place in the trachea is completely fitted with this cuff, and leakage does not occur from this area, and therefore microaspiration Also, these tubes suck subglottic secretions and probably for these reasons, the relative success of this group was achieved in this study. However, the higher mortality in this group is probably related to the design of this tracheal tube, which has a separate lumen for suctioning secretions, but this lumen has led to an increase in the thickness of the tube and its hardness, and as a result, mucosal damage to the trachea increases [11] [12].

The efficiency of aspiration of subglottic secretions is affected by many factors. including the viscosity and consistency of secretions, interrupted versus

continuous aspiration, and the position of the patient and the position of the endotracheal tube in the patient's airway, the presence or absence of swallowing. Same as our findings there is no study has investigated the effect of these factors on the prevalence of VAP [13].

According to Rello's study, in one-third of the cases, there is a failure in the suction of subglottic secretions, which can be one of the risk factors of VAP. According to their theory, the blockage of the subglottic suction port occurs due to the suction of the tracheal mucus, and this problem leads to the failure of the suction of the secretions and ultimately the increase in the incidence of VAP [14] [15].

In this study, we intermittently suctioned subglottic secretions with the Evac endotracheal tube, which according to studies, caused mucosal damage less than continuous suction, because continuous suction causes drying of the mucosa, followed by tracheal damage [15].

Some studies consider the use of continuous suction to be more effective than intermittent suction in reducing VAP [5] [16]. But recent studies consider the use of interrupted suction to be safer [17] [18]. All sheep that were intubated with a tracheal tube with continuous suction of subglottic secretions for three days showed severe damage to the tracheal mucosa such as mucosal necrosis or tracheal cartilage exposure [19] These problems related to the Evac tracheal tube can be the reasons for the difference. The present study is similar to the studies of Dezfulian and Damas [16] [20] [21].

Damas also emphasized in his study that the suction of secretions is related to VAP, but it has nothing to do with ventilator-associated conditions (VAC) [20] and according to studies (Infection-related Ventilator-Associated Complications), IVACs and VACs are more related to are associated with high mortality [22].

Tracheal tubes with subglottic suction with the same internal diameter as normal tracheal tubes often have an average of one millimeter larger external diameter, which increases the risk of pharyngeal and laryngeal damage [23] [24].

Girou also reported that 25% of patients with a tracheal tube with suction of subglottic secretions required re-intubation due to laryngeal edema [20].

These issues can justify the limited beneficial effects of the subglottic secretion drainage (SSD) endotracheal tube [4].

Berra's study showed that the use of a silver-coated tracheal tube significantly reduced VAP. While he conducted the study on sheep and considering the difference between the normal flora of the mouth in sheep and humans and the different conditions of the patients, the difference between the results of the present study and Berra's study can be justified.

Studies have shown that the effectiveness of tracheal tubes impregnated with antiseptic substances in preventing the growth of pathogenic bacteria with different organisms associated with VAP can be variable [25].

Rello's study showed that tracheal tubes with silver coating had fewer Enterobacteriaceae. Also, the colonization of Pseudomonas aeruginosa was observed

less in the tracheal tube, but this amount was not significant [13] [26].

As we know, the most pathogenic bacteria associated with VAP are Staphylococcus aureus and Pseudomonas aeruginosa [6]. According to Rello's study, these bacteria did not decrease significantly due to the use of tracheal tubes with silver coating [13].

Juan also concluded in his study that it is important to use several methods at the same time to reduce VAP. This is because the intervention is not a successful method [15] and all VAP prevention factors should be applied to the patient from the beginning of the patient's intubation. These factors include reducing the amount of aspiration and bacterial colonization [15], and the findings of our study also confirm this point. It seems that no risk assessment criteria for VAP related to emergency intubation is acceptable, and this case is included in all cases of emergency intubation [15]. This study showed that intermittent suction of subglottic secretions and tracheal tubes coated with silver did not have a decisive role in reducing ventilator-induced pneumonia, and according to the results obtained in this study, it does not seem that using one method alone is effective in reducing ventilator-related lung infection.

## 6. Conclusions

The average incidence of VAP for all groups of patients intubated with every kind of these 3 endotracheal tubes was around 50%. The results showed that there is no significant relationship between the incidence of ventilator-induced pneumonia and the type of tracheal tube. The incidence of ventilator-induced pneumonia was not significantly reduced by suctioning subglottic secretions and Bactiguard tracheal tubes. It seems that using one method alone is not effective in reducing ventilator-induced pneumonia.

Despite a lot of research, VAP remains one of the most frequent ICU-acquired infections and is associated with increased mortality. Which sampling method to use is still a matter of controversy. Emerging microbiological tools will likely modify our routine approach to diagnosing and treating VAP in the next future. Larger randomized trials are needed to confirm that bundles that combine multiple prevention strategies may improve outcomes. Further research is needed to identify and assess new therapeutic approaches.

## Ethical Standards

The study was approved by the Ethics Board of the Research and Development Center of Loqhman Hakim Hospital on April 28, 2021, and conducted in accordance with the Declaration of Helsinki. Since this study did not involve any patient's personal information and only medical record has been used in this study, informed consent is not required in this study.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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