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A COMPARATIVE STUDY OF THE EFFICACY OF THE ENDOTRACHEAL TUBE WITH A SUBGLOTTIC SUCTION SYSTEM TO MINIMIZE THE RISK OF VENTILATOR-ASSOCIATED PNEUMONIA

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is a common condition in patients who are endotracheally intubatedin intensive care units (ICU). Subglottic secretion drainage (SSD) has been shown to be associated with a lower incidence of ventilator-associated pneumonia (VAP). **Objective:** The main objective of this prospective study is to establish the effect of endotracheal tube (ETT) with a subglottic suction device in reducing the risk of VAPin patients receiving mechanical ventilation. **Method:** This prospective observational study included 80 adult patients on mechanical ventilation from the ICU of Bangabandhu Sheikh Mujib Medical University, Dhaka from July 2017 to June 2019. Patients were divided into two groups: one with an endotracheal tube with a subglottic suction device(SSD) (Group-A, n = 40) and the other with a conventional endotracheal tube (Group-B, n = 40). Data were collected by taking a comprehensive history, clinical review, investigation, including tracheal aspiration culture, to determine the presence or absence of ventilator-associated pneumonia (VAP) in mechanically ventilated patients. The occurrence of VAP was compared between Group-A and Group-B and the relative risk (RR) of developing VAP was estimated in patients with SSD. **Results:** Group-A and Group-B were almost the same in terms of demographic characteristics (age and sex). Smoking practices were almost similar between classes. The purpose of admission to the ICU was not different between groups (p = 0.294). The mean length of mechanical ventilation was also statistically comparable. Related co-morbidities in the distribution between groups were also similar. 10 of the 40 (25%) patients in Group-A and 22 (55%) of the 40 patients in Group-B developed VAP. The probability of developing VAP in Group-A was lower than in Group-B. The predominantly cultivated microorganisms were acinatobacter (in both groups). **Conclusion:** Endotracheal tube with intermittent SSD on mechanical ventilator helps to reduce ventilator-associated pneumonia.

KEYWORDS: Subglottic secretion, Ventilator-associated pneumonia, Intensive care unit, Mechanical ventilator and Endotracheal tube.

INTRODUCTION

Pneumonia is the most common infectious cause of death and one of the top ten causes of death worldwide.[1] Ventilator–associated pneumonia (VAP) is a common complication in patients who are endotracheally intubated and is defined as pneumonia arising in a patient intubated for greater than 48 hours.[2] The clinical definition of VAP requires the presence of a new radiographic infiltrate and at least two of three major clinical findings – fever > 38°C, purulent tracheal secretions, and leukocytosis or leucopenia.

The leakage of contaminated secretions around the endotracheal tube cuff allows bacterial entry into the trachea.[2,3] VAP is thought to be caused by pooling of oral secretions above the endotracheal tube (ETT) cuff and subsequent microaspiration of these secretions.[4,5] Pooling of secretions can be reduced by the use of ETTs equipped with subglottic suction. These specialized ETTs have a separate suction port that allows suctioning below the glottis and above the ETT cuff.The conventional ETT limits the draining of secretions that

leak around the cuff favors bacterial multiplication and offers a focus for bacterial adherence and colonization.

The time of onset of VAP suggests the etiology of VAP, making it useful to distinguish early-onset VAP from late-onset VAP. In the recent American Thoracic Society/Infectious Disease Society of America (ATS/IDSA) Guidelines, Ventilator-associated pneumonia which developed within 4 days of intubation and mechanical ventilation is early-onset VAP and which developed after 4 days of intubation and mechanical ventilation is late-onset VAP.

According to the Centers for Disease Control and Prevention published guidelines on the prevention of VAP,[6] VAP can be reduced by (a) changing the breathing circuits of ventilators only when they malfunction or are visibly contaminated, (b) preferential use of oro-tracheal rather than naso-tracheal tubes, (c) use of noninvasive ventilation, (d) use of an endotracheal tube with a dorsal lumen to allow drainage of respiratory secretion.

Previous studies involving primarily medical patients, including multiple randomized controlled trials, have shown significant reduction in VAP rates in patients intubated with endotracheal tubes with subglottic secretion drainage (ETT-SSD).[7–11] Despite these benefits, these tubes are not widely used.We hypothesized that the use of ETT-SSD would reduce VAP who are high risk for VAP.

OBJECTIVES

General Objective

Observation of the effectiveness of the endotracheal tube with a subglottic suction device (for intermittent subglottic secretion drainage) in reducing the risk of ventilator-associated pneumonia.

Specific Objectives

- Observing the rate of ventilator-associated pneumonia in patients using an endotracheal tube with subglottic secretion drainage.
- Observing the rate of ventilator-associated pneumonia in patients using the endotracheal tube without subglottic secretion drainage.
- Comparison of the rate of ventilator-associated pneumonia in both groups.
- To isolate and identify bacterial agents of ventilator-associated pneumonia in the sampled population.
- Comparison of organisms between the groups.

METHODS

Study design: Prospective observational study.

Place of study: Department of Anesthesia, Analgesia, and Intensive Care Medicine, Bangabandhu Sheikh Mujib Medical University, Dhaka.

Study population: 80 patients.

Study period: July 2017 to June 2019.

Inclusion criteria

All adult patients were placed on a mechanical ventilator for more than 48 hours.

Exclusion criteria

- Diagnosed case of pneumonia
- Chest trauma patients
- Time interval of onset of pneumonia less than 48 hours after placement on a mechanical ventilator
- Patients on NIPPV (Non-invasive positive pressure ventilation)
- Severely immunocompromised patients (HIV infection, cancer patients on chemotherapy or radiotherapy)

Study procedure

In this study, 80 adult mechanically ventilated patients from Intensive care unit of Bangabandhu Sheikh Mujib Medial University were successively included. Patients were subdivided into two classes, one with endotracheal tubewith a subglottic suction device (SSD) (Group-A, n = 40) and another with a standard endotracheal tube (Group-B, n = 40). The occurrence of VAP was contrasted between group A and group B, and the relative risk (RR) was estimated for the production of VAP in patients with SSD. Data were collected to find the presence or absence of ventilator-associated pneumonia (VAP) in ventilated patients by taking a comprehensive history, clinical review, investigation including tracheal aspirate culture. Questionnaire data collection included symptoms, signs, primary reason for ICU admission,associated comorbidities, GCS score, bacterial growth on quantitative culture, the pattern of bacteria isolated from the cultured specimen, period of MV including results such as VAP production with its form.

SPSS [Statistical Package for Social Sciences for Windows, Version 20 (SPSS, Inc., Chicago, IL) was used to analyze the collected data. Descriptive statistics (frequency, mean, and SD), Chi-Square Test and Unpaired t-Test were the test statistics used to evaluate the results.The significance level was set at 0.05 and $p < 0.05$ was considered significant.

RESULTS

Demographic data were almost identically distributed between classes, such as age and sex and smoking habits ($p= 0.739$, $p= 0.642$, and $p= 0.370$, respectively). The following table 1 shows that the explanation for ICU admission between groups was not different ($p = 0.253$). Although the mean period of mechanical ventilation was lower in Group-A than in Group-B, the difference was not statistically significant ($p = 0.301$).

Table 1: Comparison of patients by their baseline characteristics.

Patients characteristics	Groups		P-value
	Group-A (n = 40)	Group-B (n=40)	
Age (years)	45.9 ± 14.5	44.5 ± 19.6	0.739
Sex			
Male	26 (65%)	28 (70%)	
Female	14 (35%)	12 (30%)	0.642
Smoking habit	20 (50%)	14 (35%)	0.370
Reason of ICU admission			
Type II Respiratory failure	15 (37.5%)	15 (37.5%)	
Grade IV unconsciousness	4 (10%)	4 (10%)	
Post OP haemodynamic instability	17 (42.5%)	9 (22.5%)	0.253
Electrolyte imbalance	0 (0%)	4 (10%)	
Labored breathing	4 (10%)	4 (10%)	
Type I Respiratory failure	0 (0%)	4 (10%)	
Duration of mechanical ventilation(days)	9.3 ± 6.7	12.7 ± 11.2	0.301

In distribution among the study groups, related co-morbidities were identical ($p > 0.05$ in each case). However, Table 2 shows that the APACHE II entry score was slightly lower in Group-A than in Group-B ($p = 0.012$), but the GCS did not differ between groups ($p = 0.142$).

Table 2: Comparison of patients by their comorbid conditions.

Co-morbid conditions	Groups		P-value
	Group-A (n = 40)	Group-B (n=40)	
COPD	3	5	0.500
DM	4	9	0.059
HTN	12	17	0.723
CKD	6	9	0.500
RTA	4	3	0.500
APACHE II score during admission	13.1 ± 4.2	17.0 ± 5.7	0.012
GCS score	12.2 ± 1.6	11.5 ± 2.5	0.142

In the Group-A, 10 (25%) out of 40 patients (Hi-Lo Evac) and in Group-B, 22 (55%)out of 40 patients (conventional ETT without SSD) developed VAP (Figure 1).

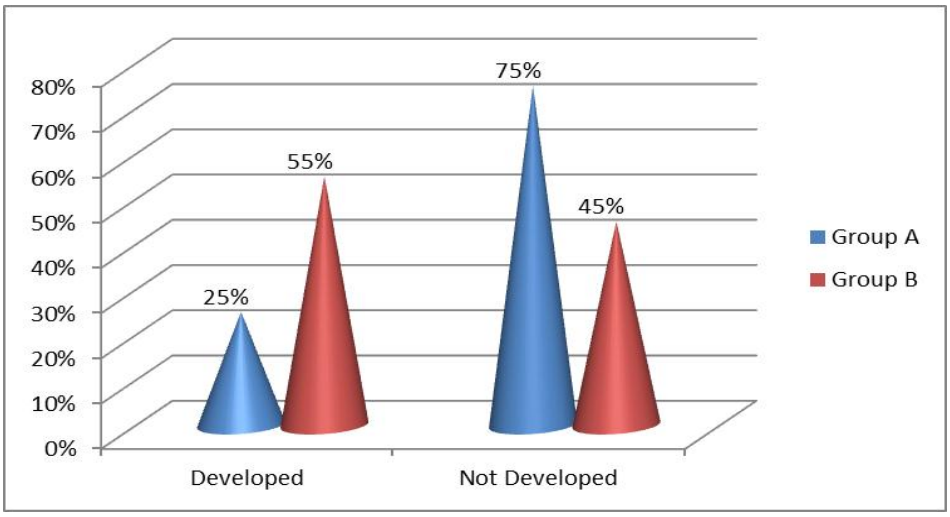

Figure 1: Rate of VAP in Groups.

The risk of developing VAP in the Group-A was calculated to be 0.52 or 52% (95% CI = 0.25 – 1.09) less compared to that in the Group-B ($p = 0.056$) (Table 3).

Table 3. Comparison rate of developing VAP between groups.

VAP*	Group		RR (95%CI of RR)	P-value
	Group-A (n = 40	Group-B (n = 40)		
Developed	10 (25)	22 (55)	0.52(0.25-1.09)	0.056
Not developed	30 (75)	18 (45)		

Figures in the parentheses indicate corresponding **%;**
*** Chi-squared Test (χ^2)** was done to analyze the data**.**

Of the 10 patients who developed VAP in the Group-A 7 (70%) had late onset VAP and 3 (30%) early-onset VAP, but in the Group-B out of 22 patients 20 (90.90%) patients had late VAP (Fig. 2).

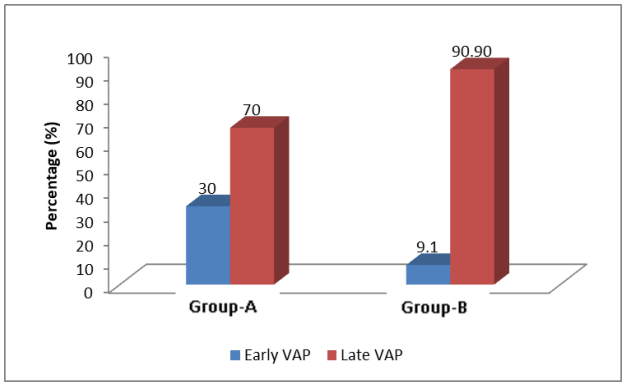

Fig. 2: Distribution of early and late ventilator-associated pneumonia(VAP).

Growth of organisms found on culture of tracheal aspirate is shown in table 4. A significant proportion of patients of Group-B demonstrated growth of microorganisms compared to Group-A (p = 0.056).

Table 4. Association between type of ETT used andgrowth of microorganism.

Growth of organisms*	Group		P-value
	Group-A (n = 40)	Group-B (n = 40)	
No growth	30 (70)	18 (45)	0.056
Growth	10 (30)	22 (55)	

Figures in the parentheses indicate corresponding **%;**
***Chi-squared (χ^2) Test** was employed to analyze the data

The growth of organisms found in tracheal aspirate cultivation is shown in Table 5. Compared to Group-A, a large proportion of Group-B patients exhibited microorganism development (p = 0.058).

Table 5: Rate of growth of microorganisms between groups.

Growth of organisms	Groups		P Value
	Group-A (n = 40)	Group-B (n = 40)	
No growth	30	18	
Growth	10	22	0.058

Figure 3 shows the pattern of microorganisms grown between groups. Acinatobacter was the predominant bacteria observed in both groups at the same frequency. In group A (SSD group) total growth was 10, among them 87.28% was acinatorbacter, 12.72% was Group B streptococcus. In Group B (conventional ETT group) total growth was 22, among them 87.28% was acinatorbacter, 9.12% klebsiella, 3.6% pseudomonas.

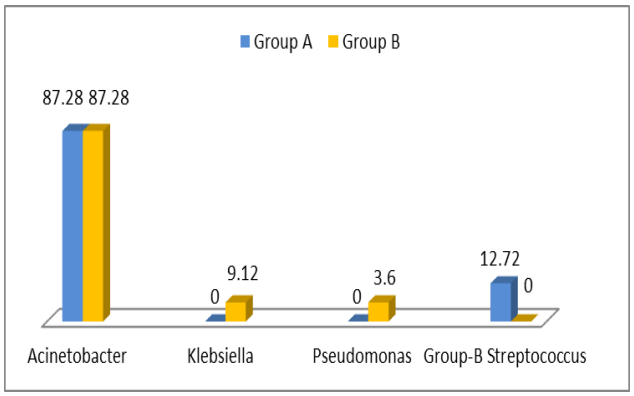

Figure 3: Pattern of microorganisms grown on culture change.

DISCUSSION

Globally, the astoundingly high incidence of ventilator-associated pneumonia (VAP) (between 8 and 68%)[12] in ICU patients with a correspondingly high case fatality rate (20-50%)[13] shows that prevention of VAP in critically ill patients is a priority. One of the issues that leads to the production of VAP is the existence of the ETT tube itself. It hinders natural defense mechanisms of the respiratory system and provides a gateway for bacterial colonization in the lungs. The ETT balloon or cuff offers a platform for the processing of polluted secretions and a tub. These pooled pollutants are known as subglottic secretions and can be sucked in the lower respiratory tract[14] The microaspiration of these secretions is a preventable etiological cause for the production of VAP.[15] Aspiration of subglottic secretions is therefore an effective first step in preventing early and late-onset VAP in ICU-supported patients.[16]

In the present analysis, the incidence of VAP in Group-A (ETT with SSD) was 25% compared to 55% in Group-B (Conventional ETT without SSD). The risk of developing VAP was lower than in the control group. Since all the basic characteristics (age, sex, smoking habit, reasons for admission to ICU, period MV, related comorbidities, GCS score) except for the APACHE-II

score during admission were almost identically divided between classes, the result could be attributed to the use of intermittent subglottic suction devices.In line with our results, Safdar et al., (2005)[15] in a study in Iran demonstrated that sporadic SSD with inspiring pause maneuvers resulted in a substantial reduction in the incidence of early-onset VAP in an unselected ICU patient population.

Likewise, Lacherade et al. (2010)[16] and Smulders et al. (2002)[9] reported VAP reductions in their sporadic SSD analysis with Hi Lo Evac ETT, while Liu et al. (2006)[17] found more VAP reductions in the research group than in the control group in their continuous SSD studies with Hi Lo evac ETT. In their systematic review and meta-analysis of 13 randomized clinical trials, Muscedere and colleagues recorded a 50 % reduction in VAP incidence using Hi Lo Evac ETT.[4]

The predominant microorganisms grown in this study were acinatobacter (in both groups). Pseudomonas aeruginosa was the most common VAP-causing organism in the observational analysis (Di Pasquale et al., 2014).[18] The explanation for such predominance in this study may be that acinatobacter is prevalent in our hospital setting. The predominant bacteria were present in a retrospective analysis of different ICUs of different patient groups in Bangladesh (Banik et al., 2014).[19]

In their pilot randomized trial on the impact of continuous oral suction on the production of VAP, Chow et al. (2012)[20] documented a substantial reduction in the incidence of VAP. Thus, it is concluded from the results of the present study and those of the other studies (already discussed) that the reduction of VAP in ICU patients undergoing mechanical ventilation is very much dependent on the removal of accumulated secretions from subglottic space as achieved by Hi Lo Evac ETT with SSD and oral suction.

CONCLUSION

It is concluded that a substantial reduction in the incidence of VAP in ICU patients under mechanical ventilation could be accomplished by the use of Hi Lo Evacendotracheal tube withthe SSD.Future clinical trials with a greater sample size are recommended to confirm the results of this report. Until such data are available, clinicians must learn how to make the best use of advanced approaches such as those used in this research.

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