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Frequency of Ventilator Associated Pneumonia with Closed Tracheal Suction versus Open Tracheal Suction

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ABSTRACT

Objective: To determine frequency of ventilator associated pneumonia (VAP) with closed tracheal suction versus open tracheal suction.
Study Design: Quasi Experimental Study.
Place and Duration of Study: Medical ICU, Pak Emirates Military Hospital, Rawalpindi Pakistan, Jul to Dec 2023.
Methodology: Patients aged >15 years of either gender who underwent mechanical ventilation for above 48 hours were incorporated in this research. Patients not willing to take part, already diagnosed with pneumonia or pre-existing respiratory illness at the time of admission in intensive care unit and patients were intubated for more than 48 hours before admission to ICU were omitted. Selected 86 patients were allotted one of the two groups: Group C and Group O. Tracheal suction of Group C and Group O was performed using closed tracheal suction system (CTSS) and open tracheal suction system (OTSS) respectively. VAP occurrence as well as ventilator days of the two groups were compared. Duration of mechanical ventilation and developing VAP after 48 hours of intubation were recorded.
Results*:* In O group, there were 25(58.13%) male patients and 18(41.86%) females. Thirteen out of 43 patients in C group (30.23%) developed VAP compared with 16 out of 43 patients (37.21%) in O group (p=0.494). In addition, mean number of ventilator days was 8.16±2.32 and 8.21±3.09 in C and O group respectively (p=0.937).
Conclusion: Closed tracheal suction failed to decrease the frequency of VAP and ventilator days.

Keywords: Clinical Pulmonary Infection Score, Closed Tracheal Suction System, Open Tracheal Suction System, Ventilator Associated Pneumonia, Ventilator Days.

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INTRODUCTION

Patients admitted in critical care units at supports remain at greater risk of getting infections.[1] VAP is the most common infection in patients of critical care unit.[2] Rough mortality rate among intensive care patients without nosocomial infection reported by International Nosocomial Infection Control Consortium (INICC) was 17.12% compared with 42.32% in patients with Ventilator-associated pneumonia (VAP).[3] Ventilator-associated pneumonia remains known adverse problem of intubated critical subjects. The presence of artificial airway like endotracheal tube (ETT) is one of the key reasons for developing VAP. Air flow transports pathogenic organisms to the distal airways. Moreover, tracheal toilet is impaired due to decreased tracheal ciliary motion and diminished cough reflex. VAP is defined as pneumonia which develops post-48 hours of invasive ventilation.[4] Its incidence ranges from 5-50% in ventilated patients.[5] Since VAP worsens the morbidity including prolonged ICU stay, duration of mechanical ventilation, and hospital stay and mortality, its prevention is vital in the management of patients on mechanical ventilator.[6] Preventive strategies remain crucial and main concern to prevent Ventilator-associated pneumonia. A fundamental group of strategies should be practiced which are acknowledged in past research as a care bundle. VAP bundle includes the elevation of head of bed to 30-45 degrees, regularly holding sedation, daily spontaneous breathing test trials, oral care with disinfectant: chlorhexidine, subglottic secretions suction, maintaining cuff pressure, deep venous thrombosis prophylaxis, and stress ulcer prophylaxis.[7,8,9] Awareness regarding VAP prevention is on the rise, and described frequency of Ventilator-associated pneumonia is falling; In contrast, some researchers opine that such a decrease is because of under reporting.[4]

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Suction of tracheal tube is in routine use in patients on ventilator with tracheal tube to ensure the airways patent. Moreover, suction of tracheal tube with accuracy is important to prevent VAP. Two strategies are adopted for tracheal tube clearance: open tracheal suction system (OTSS) and closed tracheal suction system (CTSS). Open tracheal suction system technique utilizes two nurses and results in brief disruption of ventilation and oxygenation because of disconnection from ventilator during suction and main hazard in this method is lack of oxygenation. In contrast, in closed tracheal suction system technique, tracheal tube suction is performed via joints in closed suction system and thus ventilation remains uninterrupted during suction.[10]

The rationale of our study was to research into possible potential benefits of closed tracheal suction in local population in decreasing frequency of VAP and therefore reducing cost of treatment, morbidity and mortality.

METHODOLOGY

This experimental study was conducted prospectively on patients admitted in Medical intensive care unit of a Tertiary Care Hospital, Rawalpindi, from 1st July 2023 to 30th December 2023. Keeping confidence interval 90%, power of study 80%, anticipated VAP 16.27% in Closed tracheal suction group "Group C" and 39.53% in open tracheal suction group "O group", sample size came out to be 86(43 in each group).[11]

Inclusion Criteria: Patients with age more than 15 years of either gender who underwent mechanical ventilation for more than 48 hours were included in this research.

Exclusion Criteria: Subjects not willing to be part in the study or those with lung infection or any other pre-existing respiratory illnesses which enhances the chance of developing pneumonia at admission in intensive care unit and those who were having an endotracheal tube/tracheostomy tube for more than 48 hours prior to admission to ICU were not included in the research.

Selected patients were allotted one of the two groups (43 in each group) as per our convenience: Group C and Group O. Tracheal suction of Group C and Group O was performed using closed tracheal suction system (CTSS) and open tracheal suction system (OTSS) respectively. Primary outcome (VAP occurrence) and secondary outcome (ventilator days) of both groups were recorded and contrasted. This research work was carried out after receiving sanction from the ethical body of the hospital (Reference No. A/28/EC/517/23 dated 27 Jun 2023) and obtaining a written informed consent from next of kin of patients.

Tracheal suction was carried out by skilled nursing staff in ICU. In the O group, suctioning was done using single use catheters with full barrier precautions including hand sanitization and using sterile disposable gloves. Subjects were pre-oxygenated for 2 minutes prior to suction. In the C group, the system used for airway suctioning was (Smiths medical portex® manufactured by Smiths Medical ASD, Inc USA) and which was replaced after 2 days. Not unlike the O group, patients were given 100% oxygen, however suctioning was carried out and patients were not disconnected from mechanical ventilator.

The succeeding recommended VAP prevention methods were adopted in all subjects: elevation of head of bed from 30 to 45°, heat and moisture exchanger (HME) for passive humidification, protocoled sedation and nutrition via enteral route. The patients' airways were suctioned only if needed. Routine replacement of the breathing circuit was also circumvented unless seemed essential.Oral hygiene using chlorhexidine was ensuredin every 8 hour shift. Omeprazole 40 mg was given daily for prevention of stress ulcer. Nasogastric aspirate volume was confirmed in each shift. Other measures included preventing needless extubation or intubation, keeping artificial airway cuff pressure between 25-30 mmHg and uninterrupted aspiration of subglottic secretions. Suction methods were used as per the guidelines of American Association for Respiratory Care (AARC).[12]

In both groups, throat samples from endotracheal tubes and ventilation circuit were collected for identification of the speed of colonization. Traditional bacteriological techniques were used to identify isolated microbes. Antimicrobial susceptibility test was carried out with Kirby Beur Disk Diffusion method as per CLSI (Clinical and Laboratory Standards Institute) recommendations.[13]

Demographic characteristics of patients, duration of mechanical ventilation and developing VAP after 48 hours of intubation were examined and recorded by a critical care physician for all cases.

Ventilator associated pneumonia diagnosis was made using clinical pulmonary infection score (CPIS) which includes 6 parameters.[14] Bacterial pneumonia

index was sorted out depending on presence of persistent infiltrates in the chest radiography, temperature of body, Total lecucocyte count, secretions in airway, PaO2/FiO2 and culture and smear of lung secretions were noted. Subjects were labelled having pneumonia if they had a CPIS score greater than 6 (Table-I).[15]

Table-I: Clinical Pulmonary Infection Score (CPIS)

Criterion	Score
Temperature (°F)	
≥97.7 and ≤101	0
101 to 102	1
≥102 or ≤96.8	2
White blood cells count (/mm 3)	
More than 4,000 but less than 11,000	0
Less than 4,000 or more than11,000	1
+band forms more than 500	2
P:F	0
>240 or ARDS	2
≤240 and no evidence of ARDS	0
Chest X-ray	
Absent infiltrates	0
Diffused (or patchy) infiltrate present	1
Confined infiltrate	2
Airway secretions	
Less than 14+	0
More than 14+	1
+ purulent secretion	2
Culture of airway secretions	
Pathogenic bacteria cultured ≤1+ or no growth	0
Pathogenic bacteria cultured >1+	1
+ same pathogenic bacteria seen on the Gram stain >1+	2

For analyzing data, SPSS version 25 (SPSS Inc., IMB Corporation, Chicago, Illinois, USA) was used. Mean and SD of age and gender were recorded. Chi-square was also used to compare variables (ventilator associated pneumonia and ventilator days) between the two groups.

RESULTS

In total, 91 patients were enrolled, however 5 participants were excluded due to death within 3 days of ICU admission. The mean age of patients in closed suction group 50.51±13.59 years, while it was 53.30±13.71 years and in open suction group. In closed suction group, 28 patients were male (65.11%) and 15 female (34.89%). In open suction group, there were 25 male patients (58.13%) and 18 female (41.86%). The frequency of VAP was compared between the two groups of open and closed suction groups. Thirteen out of 43 patients in C group (30.23%) developed VAP compared with 16 out of 43 patient (37.21%) in O group (p=0.494). Mean number of ventilator days was 8.16±2.32 and 8.21±3.09 in C and O group respectively (p=0.937) shown in Table-II.

Table-II: (Characteristics Comparison of Patients in O and C group)

Variable	C group(43)	O group(43)	*p*-value
Age(years)	50.51±13.59	53.30±13.71	
Males	28(65.11%)	25(58.13%)	
Females	15(34.89%)	18(41.86%)	
Ventilator associated pneumonia (present)	13(30.23%)	16(37.21%)	0.494
Ventilator associated pneumonia (absent)	30(69.77%)	27(62.79%)	
Ventilator days	8.16±2.32	8.21±3.09	0.937

DISCUSSION

In a prospective RCT by Alipour *et al.,* 7 out of 43 patients with CTSS developed VAP compared with 17 out of 43 (p=0.016) cases with OTSS. The result was statistically significant. In their opinion, considering benefits of closed tracheal suction in contrast with open suction which include preserving ventilation with positive pressure during suction, less decrease in arterial oxygen saturation, reduced adverse effects such as hypoxia or atelectasis, lesser risk of spreading contaminated bronchial secretions and microbes entry to airways, using closed suction is recommended to reduce the development of ventilator associated pneumonia.[11] Rabitsch *et al.,* had also proved superiority of CTSS over OTSS (p=0.037) in 2004, however their research included a very small sample of 24 patients in total only. Oxygen saturation was reduced significantly in the Open tracheal suction group when compared with presuctioning values of the closed tracheal suction group. Whereas presuctioning values were comparable between the two groups, post-suctioning SpO2 was much higher in the closed suction group. Closed suction significantly minimized cross-contamination between bronchial system and stomach fluids and also reduced the frequency of Ventilator associated pneumonia when contrasted with Open suction. They concluded that hypoxia events can be minimized by using closed suction.[16]

Two clinical trials on larger scale were conducted in 2005 and 2006, however both of those trials failed to prove benefit of using CTSS.[17,18] The first trial included 443 patients which were divided into 210 and 233 in CTSS and OTSS groups respectively. Forty-three out of 210 and 42 out of 233 patients developed VAP in CTSS and OTSS groups respectively (p=0.62).[17] Similarly, the second large trial included 457 patients which were

distributed into 236 and 221 in CTSS and OTSS groups respectively. Thirty-three out of 236 and 31 out of 221 patients developed VAP in CTSS and OTSS groups respectively (p=0.99).[18]

An open-labelled randomized controlled trial involving 200 patients by David *et al.*, comparing finances and clinical outcomes of OTSS with CTSS in patients admitted in medical intensive care unit also failed to justify clinical benefit of closed suction over open suction as the result was statistically insignificant (p=0.07). In this randomized control trial of closed tracheal suction versus Open tracheal suction, an advantage of decrease in frequency of ventilator-associated pneumonia was obvious for late-onset ventilator-associated pneumonia. As the cost price of closed suction was greater, reduction in VAP was likely to explain to cost savings as a whole, given the high price of managing VAP with antibiotics. In their opinion, closed tracheal suctioning tubes must be considered in subjects who are expected to remain on ventilatior for more than 4 days. Their results mandated further research in this area before devising guidelines to use closed suction system in routine.[19]

Four more clinical trials during last 25 years also remained unsuccessful in proving supremacy of closed tracheal suction system.[20-23]

A latest comparative study by Ardehali et al researched from 2018 to 2019 on 120 subjects also could not find any significant difference in frequency of VAP using closed suction or open suction (p=0.637). The most common bacteriological causes of Ventilator associated pneumonia found in their research were Acinetobacter_Baumannii (72.7%), Klebsiella pneumoniae (18.2%), and Methicillin-Resistant Staphylococcus aureus (9.1%), respectively.[10]

Our study also failed to prove supremacy closed tracheal suction over open tracheal suction with respect to development of ventilator associated pneumonia.

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CONCLUSION

It is vital to search into development of new techniques that may help in reducing incidence of Ventilator associated pneumonia as it increases the cost of treatment due to pro-longed stay in ICU and antibiotics. Closed tracheal suction system increased the cost of treatment, however it failed to decrease the frequency of VAP as well as ventilator days.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

KHQ & AR: Data acquisition, data analysis, critical review, approval of the final version to be published.

MZS & JZ: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SARAS & BA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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