Original Article

Intensive Care Nurses' Performance of Open versus Closed Endotracheal Suction on Critically Ill Patients in Ismailia City

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Abstract

Background: Endotracheal Tube Suctioning (ETS), which involves either an open or closed suctioning system, is a crucial practice for mechanically ventilated patients. The nursing practice of airway suctioning is inevitable. This study was designed to compare the intensive care nurses' performance of open versus closed endotracheal suction on critically ill patients in Ismailia City. **Materials and Methods:** A non-participant structured observational study design was conducted on a convenient sample (N = 63) at intensive care units at a teaching hospital through March and August 2022 to evaluate how nurses practice different procedures in open suctioning compared with the closed suctioning system of Endotracheal Suction (ES) through a 32-item structured checklist. Additionally, authors compared their levels of knowledge in both suctioning systems. **Results:** Approximately 75% and 65% of the study participants had a satisfactory level of knowledge about the open system compared with the closed system, respectively. The total percentage of patients who achieved a satisfactory level of practice was 72% for the open-system group, compared with 56% for the closed-system group. Overall, there were significant differences between total nurses' performances in the open-system and closed-system systems. Independent sample t-tests revealed a statistically significant correlation between overall nurses' performance in both systems ($t = 6.04$, $p < 0.001$). **Conclusions:** The findings revealed significant differences in nurses' performance between open and closed-system suctioning. The researchers recommend in-service-led training programs to improve nurses' performance, and other studies with larger sample sizes should be supported.

Keywords: *Critical care nursing, critical illness, endotracheal, suction*

Introduction

Mechanical ventilation is necessary for most critically ill patients in Intensive Care Units (ICUs).[1] Patients with life-threatening conditions require Endotracheal tube suctioning (ETS) to improve the natural airway by partially or completely inhibiting endotracheal tube obstruction.[2] These patients are unable to naturally clean their airways, and ES removes secretions from the endotracheal tree, ensures an appropriate supply of oxygen demand, prevents clogging of the tube lumen, reduces the patient's breathing load, and inhibits pulmonary infection and atelectasis.[3,4] Two suctioning systems are accessible: Open System Suctioning (OSS) is the traditional suctioning procedure, which involves separating the ventilator from the patient through ETS utilizing a single-use catheter and then rejoining the ventilator to the patient.[5] In contrast, a Closed Suctioning System (CSS) can be applied for multiple suction steps due to the remaining route for the shift.[6] The nurse is not in contact with airway secretions because the usage catheter is covered by a plastic sheath.[7]

Nursing practices in ES procedures for critically ill patients vary among both organizations and practitioners, possibly because of barriers to change, a lack of managerial support, a loss of adult ICU training, a lack of easy access to the guidelines, time constraints, workload pressures, inadequate knowledge about this procedure, and nurses' practices based on their personal experiences.[8–10] Intensive care nurses are among the most vital members of multidisciplinary teams and are the primary caregivers for critically ill patients.[11,12] Cleaning the airways of mechanically ventilated patients with ES is an inevitable practice and an issue in

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nursing practice.[13] Potentially, when completed incorrectly or inappropriately, this is a harmful practice that may cause further complications.[14,15]

Worldwide, numerous studies have been performed on both suctioning systems in nursing practice, and it has been shown that CSS is the most effective at promoting airway clearance and has fewer harmful effects.[16,17] ETS can lead to a life-threatening condition and should be applied within standard guidelines, protocols, and evidence-based care to promote quality outcomes by reducing morbidity, mortality, budget, and the extent of hospitalization and enhancing patient recovery.[18–20] As CSS has recently been adopted in the study hospital in Ismailia city and mostly remains in critical care wards, an observational research study was essential to evaluate the actual nursing practice of open versus closed suctioning. The aim of this study was to compare intensive care nurses' performance of open versus closed ES on critically ill patients in Ismailia City.

Materials and Methods

A non-participant structured observational study was conducted at a teaching hospital from March to August 2022 in Ismailia City, Egypt. The study population consisted of a nonprobability convenient sample (N = 63) that are performing care for intubated critically ill patients in an adult ICU, and the participants were selected based on the inclusion criteria of having a nursing certificate, both genders, direct clinical work with patients, a minimum of six months of experience working in the ICU, and willingness to participate in the study. Refusing to participate, having a plan for a vacation, having debilitating conditions, receiving a recent educational program about suctioning, a lack of response to five or more questions in the knowledge questionnaire, and a lack of willingness to continue participating in the study were the exclusion criteria. The sample size was determined based on the type of study, similar articles,[10,12] and consultation with statistics experts. z_1 has a 95% Confidence Interval (CI) of 1.96, z_2 is 80% of the test power factor of 0.84, $(Z\beta)$ = 0.91, $Z\alpha$ = 2.01, and in addition, d must be less than s. Based on the above formula, the sample size at 95% CI and a power factor of 80% was determined to be 57 participants. Considering the probable 10% sample loss, 63 nurses were selected and participated as study participants during the study implementation.

Observational studies are wide-ranging studies utilized to evaluate practice, as in this technique, in which data are gathered based on participants' observations in a real situation and traditional setting.[11] The researcher started the study after ethical approval and authorization were obtained from the study setting. After sampling, the study participant was informed about the study details and their right to withdraw from the study at any time they liked. The study data collection was conducted for five consecutive months in three adult ICUs for patients on mechanical ventilation and high-dependency care. Therefore, every nurse was assigned two patients on average per shift. The critical care nurses in the two ICUs composed the study target group. The nurses performed ETS on a regular basis. Before beginning the research, the wards had been using the CSS with OSS for all intubated patients for five years. Sampling was conducted on several shifts, and two suctioning events were observed per nurse on one shift. The study included all 63 full-time ICU nurses with at least six months of ICU experience. More than six months is an acceptable period for all nurses to have the same practice and knowledge groundwork.[22,23]

The data collection tools involved a demographic profile of nurses to assess nurses' age, gender, experience, educational level, type of ICUs, and training courses about ETS. The nurses' performance was evaluated in two categories. The first was a self-administered knowledge questionnaire adapted by researchers after reviewing the standard guidelines, textbooks,[5,7,12] and content from relevant studies.[6,24] Knowledge of nurses was collected by consuming 30 items within 10–15 minutes with true/false and multiple-choice answers. It is sectioned into six items: definition (three questions), indication (six questions), contraindication (five questions), type (four questions), possible complications (five questions), and infection control (seven questions).[8,10,11] Each right answer is given one grade, while the wrong answer is given zero. A score of 1 was given to the correct answer, and a score of 0 was given to the wrong answer. The maximum score was 21, and the minimum was zero, which is interpreted as a satisfactory level of knowledge if more than or equal to 75%.[9,23]

Nurses' practices were evaluated with a 32-item structured observational checklist (pre-procedure, procedure of closed versus open ETS, post-procedure). This checklist was adapted from related clinical textbooks and relevant previous studies.[3,6,20] Every study nurse observed their actual practice in ES for 5–10 minutes. Responses in the 32-item checklist were scored with zero for the incorrect step (even incomplete) and one for the correct step (done completely). The raw scores obtained from the checklist were converted to standard scores from zero to 32 based on a formula. Mean scores were calculated for each domain as well as for the whole checklist. Higher scores and scores greater than or equal to 75% indicated better performance.[9,23]

The face validity of the knowledge questionnaire and performance checklist was evaluated by an expertise committee, including faculty members of critical care, medical-surgical nursing, and three certified nurses with the experience working among critically ill patients. In the review of the Content Validity Ratio (CVR), the expert committee was asked to categorize each question based on

a three-point Likert scale including the items "necessary," "useful but not necessary," and "not necessary." Then, based on Lawshe's CVR formula, items with a CVR <0.63 were deleted.[8] In the next step, the Waltz and Bausell method was used to examine the index validity content (CVI),[13] and the expert committee was asked to rate the relevance, clarity, and simplicity of each item based on a four-point Likert scale. Finally, items with a CVI <0.71 were excluded.

To determine the reliability of the performance checklist, the interrater reliability method of simultaneous observation of two researchers was used. The interrater reliability of the knowledge and observational checklist was evaluated using the Spearman correlation coefficient, and the Spearman correlation coefficient and split-half method were 0.82 and 0.799, respectively. For this purpose, the performance of seven nurses who met the inclusion criteria was examined by two evaluators simultaneously and in parallel while applying the OSS and CSS blindly, and the checklist was used three times: pre-procedure, closed versus open ETS, and post-procedure. After completing the checklist and recording the performance score, the correlation coefficient of the two evaluators was calculated (r = 0.91).

The nature and goal of the study were explained to the study population at the conclusion of the sampling. The three shifts were collected three days per week, and the data were tabulated and analyzed statistically using the statistical program Statistical Package for Social Sciences (SPSS) (version 24). The Kolmogorov-Smirnov test was used to determine if the acquired data were normal, which indicated that the data were normally distributed. The collected data were reviewed for frequency and distribution to describe their characteristics. Independent sample t-tests (t) for related groups, the Pearson correlation coefficient (r), and the Spearman correlation coefficient were utilized to determine the correlation between standard variables and the scores of suctioning practices. At $p \leq 0.05$, the significance level was established. The researcher was always on hand to clear up any doubts and queries. The fieldwork lasted for six months, from March to August 2022. In total, seventy-one sessions of data collection were conducted, with an average of 12 hours for knowledge assessment and nine hours for observing nurses' practices.

Ethical considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing at Suez Canal University, Ismailia, Egypt. The acceptance was February 2022 and its No. (49), code (149/12022). The directors of the participating hospitals approved the study after being fully informed of its goals, benefits, and methods. Additionally, oral consent was acquired from each nurse participant prior to data collection, following an explanation of the purpose and methods of the study.

Results

Throughout the two months of the current study, 63 checklists were checked for study subjects working in adult ICUs. The research did not exclude any subjects [Table 1]. Approximately 60.30% of the study nurses had scores ≥25 and a mean (Standard Deviation [SD]) of 28.87 (6.79). Most (57.10%) of the nurses were women. Approximately 71.40% of nurses had a technical degree, and 6.4% had a technical bachelor's degree in nursing. More than two-quarters had 4–6 years of ICU experience. Approximately 62.70% of the study nurses did not receive an ES training program, while 30.7% received it [Figure 1]. Approximately 53% of them worked in the general ICU.

A comparison of the total nurses' performance scores in the open and closed ES systems is shown in Table 2. The frequency distribution was used to evaluate the suctioning performance scores of the OSS and CSS. For the OSS, the minimum score was 21, while the maximum score was 30; for the CSS, the minimum score was 17, while the maximum score was 23. The mean actual score for the

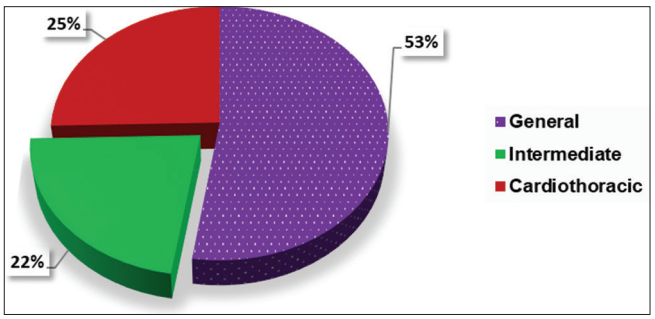

Figure 1: Frequency and distribution regarding type of intensive care unit in the study subjects (*No* = 63)

Table 1: Demographic attributes of study subjects (*n*=63)

Variables among nurses	*N0 (%)	**Mean (SD)
Age years		
<25	25 (39.70)	28.87 (6.79)
≥25	38 (60.30)	
Gender		
Females	36 (57.10)	
Males	27 (42.90)	
Education level		
Bachelor	14 (22.20)	
Technical nursing	45 (71.40)	
Technical bachelor	4 (6.40)	
Experience years		
1–3 years	15 (23.80)	
4–6 years	38 (60.30)	9.60 (6.80)
7 plus years	10 (15.90)	
Receiving ES training program		
Yes	19 (37.30)	
No	44 (62.70)	

*No: number, **Mean (SD): standard deviation

OSS was 24.23 (68%) with a mean (SD) = 24.23 (3.01), while that for the CSS was 20.15 (47%) with a mean (SD) =20.15 (2.90). The potential score was equal to 31 for both systems.

Nurses' overall satisfactory level of performance in terms of suctioning is presented in Figure 2. To assess the level of study nurses' knowledge of and practices related to OSS compared with their knowledge of and practices related to CSS. Approximately 75% of the study participants had a satisfactory level of knowledge about OSS, while 65% had a satisfactory level of knowledge about CSS. The percentage of patients with a satisfactory level of practice was less than two-thirds (72%) of those with a satisfactory level of practice, compared with more than half (56%) of those with a satisfactory level of practice, such as CSS. Overall, there was a significant difference in total nurses' performance in the OSS group compared with the CSS group. Independent sample t-tests revealed a statistically significant correlation between overall nurses' performance and OSS and CSS ($t = 19.47$; $p < 0.001$).

Furthermore, the results of the Pearson correlation coefficient test are shown in Table 3. There was a statistically significant correlation between the level of nurses' knowledge of the OSS and education level, as did the correlation between the level of nurses' knowledge of the CSS and education level ($p = 0.05$ and 0.02, respectively). The study subjects' years of experience had a statistically significant correlation with the OSSs' level of knowledge and practice compared with the CSSs' level of practice only ($p \leq 0.05$). Similarly, there was a statistically significant correlation between OSS nurses' knowledge level and the type of ICU ($p = 0.05$).

Table 2: A comparison of total nurses' performance score in open versus closed suctioning system (*No*=63)

Variables	Open Suctioning System (OSS)	Closed Suctioning System (CSS)
Minimum score	21	17
Maximum score	30	23
Mean actual scores (%)	24.23 (68%)	20.15 (47%)
Standard deviation	3.01	2.90
Presenting potential score	31	31

Discussion

The current research compared the current ES practice, conducted by the open system (OSS) versus the CSS, in the study setting. According to the actual nursing practice in ESs,[25] ES is necessary for any seriously ill patient who requires invasive mechanical breathing, with the main objective of clearing secretions and avoiding airway blockage of the endotracheal tube. Failure to remove secretions could result in clogged or blocked secretions.[4,12] The suction system consists of two suction techniques: first, the patient is customarily disconnected from the ventilator, and second, an endotracheal tube is fitted with a suction catheter.[26] Regardless of the method used for suctioning, intensive care nurses are vital in peri-suctioning, involving baseline screening for signs of respiratory distress and monitoring for frequent problems such as bradycardia and hypoxia. Following the procedure, it is important to pay attention to any complaints the patient may have, such as symptoms such as light-headedness, breathing problems, a racing heart, and harsh breathing; others may indicate suction-related issues and documentation of the procedure.[5,27]

Approximately sixty of the study participants were aged ≥25 years. More than half (57.10%) were female, and approximately seventy had a technical degree in nursing. Approximately sixty of the nurses had 4–6 years of experience, and most of them worked in the general ICU. Most of the study nurses did not receive ES training. It is

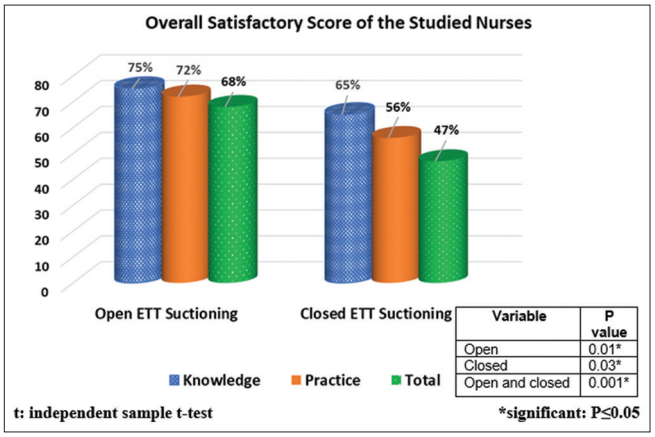

Figure 2: Overall satisfactory performance score for open versus closed endotracheal suctioning in critically ill patients (*No* = 63)

Table 3: Correlation matrix between open versus closed system suction performance score with demographic attributes in the study subjects (*No*=63)

Variables	***OSS Knowledge		****OSS Practice		****CSS Knowledge		****CSS Practice	
	*r	**p	*r	**p	*r	**p	*r	**p
Age years	0.21	0.06	0.36	0.65	0.23	0.05	0.41	0.66
Education Level	0.81	0.05*	0.41	0.51	0.11	0.02*	0.51	0.78
Experience years	0.22	0.003*	0.32	0.002*	0.91	0.4	0.10	0.02*
Type of intensive care unit	0.08	0.05*	0.95	0.41	0.68	0.06	0.77	0.70

***OSS: open suctioning system, ****CSS: closed suctioning system. (*r*) Pearson Correlation coefficient, **significant *p* value at the 0.05 level

presented in [Table 1 and Figure 1]. From the researchers' point of view, the majority of the nurses in Egypt are female and recruited nurses who graduated from university nursing institutes. Most of the nurses who were at the head of work had a technical degree in nursing. These concerns are in line with the findings of Dastdadeh and Vahedian, who reported that these findings are compatible with their research findings.[9] These findings were incompatible with those of Aboalizm and Elhy, who reported that in nurses aged 22–31 years, most of the participants had more than eight years with a high educational level.[2]

A comparison of total nurses' performance scores between the OSS and CSS was performed. This is clarified in Table 2. The study subjects in the OSS group had minimum and maximum scores of 21 and 30, respectively, compared to those in the CSS group (17 and 23, respectively). Moreover, their mean actual scores with standard deviations were 24.23 (68%) and 3.01, respectively, whereas the corresponding CSSs were 20.15 (47%) and 2.90, respectively. Similarly, the presenting potential score was 31 for both suctioning systems. The results of the independent sample *t*-test (t) showed that the overall satisfaction level of nurses' performance scores differed significantly between the OSS and CSS groups based on the overall percentages of all the scores. Furthermore, in the same way, nurses' knowledge and level of practical satisfaction with OSS differed greatly from those of CSS. Based on the statistical analysis, there was a significant correlation between overall nurses' OSS performance and their CSS performance ($t = 19.47$; $p < 0.001$). This is described in Figure 2.

In this interest, the researchers' point of view may be due to the greater experience of the study nurses in the open suction procedure than in the closed, individual bias, traditional practice of open path suction, and the greater availability of resources to use the open path compared to the closed suctioning path. Similarly, these results agreed with those of Pinto, D'Silva, and Sanil, who demonstrated that the results of their study were more similar to those of nurses who performed better on open suction paths than on closed suction paths. The mean score for the OSS was highly different from that for the CSS, with the same presenting score.[18,21] Similarly, Mwakanyanga *et al*.[28] disagreed with these findings and reported a nonsignificant correlation between nurses' performance in open and closed ES. The study participants had an adequate level of CSS.[28] This current finding is reinforced by other studies that clarified that the primary knowledge and practices of the study nurses in relation to ES were poor.[13,18]

Moreover, the Pearson correlation coefficient test measures the relationships between the study variables statistically. The results are described in Table 3. There was a statistically significant correlation between the OSS scores of nurses and education level, years of experience, and type of ICU. The CSS scores of nurses were significantly correlated with their education level. On the other hand, another significant finding in our current study was that the nurses' practice scores on the OSS compared with the same items on the CSS were significantly correlated with years of experience. This finding was related to the highly satisfactory performance of nurses in the OSS compared to that in the CSS, as well as the most significant number of years of experience among the subjects in the study. This finding was supported by another study by Elmansoury and Said,[6] which reported that there was a statistical correlation between the studied nurses' performance on the OSS and years of experience and age. Compared with the findings of other studies by Aboalizm and Elhy, these findings disagreed with our findings and clarified that workplace and age were significantly correlated with CSS performance.[2]

Commonly, the use of the direct observation approach in two practices is incapable of interpreting the study's subjective decisions; some aspects of ES practices such as assessment for OSS or CCS, lung auscultation, pain assessment, or other related findings, may impact nurses' behavior. Additionally, when the nurse performs quickly, issues such as issues affecting the correct interpretation of subjects' practice by the observer may be problematic. The study's limitations involved repetition of the observation, and the researcher's presence throughout various work shifts attempted to significantly control this effect. Additionally, this could have had an uncontrollable impact on the findings. Therefore, to overcome this limitation, the existing research was conducted in three general ICUs in a single university teaching hospital and on different shifts.

Conclusion

Overall, based on the findings of the present study, it can be concluded that the intensive care nurses in the study setting had a highly satisfactory performance on the OSS compared with their performance on the CSS. Based on the statistical analysis, there was a significant correlation between overall nurses' performance on the OSS and that on the CSS. This result is compatible with previous findings on nurses' performance in both suctioning systems in other settings. Previous studies have revealed higher practical scores for the OSS than for the same items related to the CSS. The researchers recommend that in-service intervention programs and standard protocols for intensive care nurses in ES practice be included in the present education. The OSS maximum score was greater than that of the CSS, which is strongly related to patients' years of experience and educational level. Experienced nurses had higher scores than those with less experience. This emphasizes the need for extra training in hospital studies based on clinical standard protocols and guidelines. Additionally, continuing in-service education, especially for ICU staff who work with complicated and new devices

and equipment, is essential. In general, it is crucial to continuously assess nurses' performance regarding the use of safe and accurate procedures.

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Conflicts of interest

Nothing to declare.

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