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Original Article

Comparison Between the Effect of Open and Closed Tracheal Suction Systems on Physiological Parameters of Critically Ill Patients

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1.ABSTRACT

Background: Endotracheal suctioning is one of the fundamental procedures practiced in intensive care units. There are two methods used for suctioning: open and closed suction systems. There is a debate in the literature regarding which suctioning method has a positive impact on the hemodynamic state of critically ill patients (CIPs). **Aim**: This study aimed to compare the effect of open and closed tracheal suction systems on physiological parameters of CIPs. **Method**: A quasi-experimental design was used to conduct the present study in two intensive care units allocated in the Specialized Medical Hospital, at Mansoura University. A sample of 94 patients was enrolled in this study and was randomly assigned to the closed suction group (n = 47) and the open suction group (n = 47). Data were collected using the patients′ physiological parameters assessment tool. **Results**: The findings showed no statistically significant differences between the two suctioning methods except for the diastolic blood pressure (*P*=0.049). A slight improvement in patients' physiological parameters was noticed after closed suctioning. **Conclusion and Recommendations:** The open and closed suction systems are considered efficient methods for suctioning the secretion of CIPs. This study highlights the need for further research with a large sample in different clinical settings to contribute to the body of knowledge and evidence related to endotracheal suction.

Key terms: Open suction, Closed suction, Physiological parameters, Critically ill patients.

2.Introduction:

Mechanically ventilated patients (MVPs) are usually present with impaired airway clearance that promote the retention of airway secretions. This consequently increases the airflow resistance and work of breathing, thereby inducing breathing discomfort and slowing the ventilator weaning. It also impaired gas exchange, collapsed the airway, and increased the risk for lung infections **(Martí & Martinez-Alejos, 2020)**. Thus, it is essential to regularly clean and suction the artificial airway to maintain ventilation **(Mwakanyanga, Masika, & Tarimo, 2018)**.

Endotracheal suctioning is one of the most necessary procedures performed by critical care nurses in intensive care units (ICUs) to remove lung secretions. This procedure leads to increase oxygenation and reduced breathing difficulties. It also prevents the accumulation of secretions, atelectasis, and pulmonary infection **(Bozan & Güven, 2020)**. According to the recommendation of the American Association for Respiratory Care guidelines **(AARC, 2010)**, suctioning is a sterile procedure that is performed according to the patient's needs and not a routine schedule. There are two different methods of suctioning based on the type of catheter: the open suction system and the closed suction system **(Raimundo et al., 2021)**.

The open suction system requires disconnecting the patient from the ventilator and inserting a single-use disposable suction catheter into the artificial airway **(Raimundo et al., 2021; Urden, Stacy, & Lough, 2020)**. Evidence suggested that the open suction system must be performed under an aseptic technique to prevent pulmonary infection **(Imbriaco & Monesi, 2021)**. Despite the importance of open suctioning, it can cause hypoxemia which is considered a common complication with this type of suctioning **(Tavangar, Javadi, Sobhanian, & Jahromi, 2017)**. Hypoxemia can result from disconnecting the oxygen source from the patient airway when the suction is applied **(Greenwood & Winter, 2019)**.

Another method of suctioning is the closed suction system which consists of a multiple-use sterile suction catheter that is enclosed in a transparent plastic sheath and allows the patient to remain on the ventilator during suctioning **(Imbriaco & Monesi, 2021; Urden et al., 2020).** Evidence suggested the use of the closed suction system, especially for patients requiring high friction inspired oxygen (FiO_2) and high levels of positive end-expiratory pressure as in patients who have acute lung injury **(AARC, 2010; Mohammadpour, Amini, Shakeri, & Mirzaei, 2015).** The closed suction system is protecting the health care team from exposure to the patient's secretions **(Imbriaco & Monesi, 2021).** Also, it was cost effective when used for patients who stay more than 48 hours in the ICU, and causes fewer disturbances in the hemodynamic state **(Afshari, Safari, Oshvandi, & Soltanian, 2014).**

Significance of the Study

Endotracheal suctioning is a powerful stimulus that can lead to several complications. These complications include hypoxemia, cardiovascular disturbances, bronchospasm, and atelectasis **(AARC, 2010; Bozan & Güven, 2020).** Many studies compared the effect of open and closed suction systems on physiological parameters. Some of these studies showed that the differences between the two suctioning systems were clinically not significant regarding some parameters such as the blood pressure **(Afshari et al., 2014; Dastdadeh, Ebadi, & Vahedian-Azimi, 2016; Ebrahimian, Tourdeh, Paknazar & Davari, 2020; Elmelegy & Ahmed, 2016; Siyasari, Rahnama, Shahrakimoghadam, Shahdadi, & Abdollahimohammad, 2018),** and oxygen saturation **(Elmelegy & Ahmed, 2016; Mohammadpour et al., 2015).** However, other investigations reported that the implementation of the closed system leads to fewer disturbances in the patient's physiological parameters than the open system **(Alavi et al., 2018; Faraji, Khatony, Moradi, Abdi, & Rezaei, 2015; Özden & Görgülü, 2015).**

From the previously mentioned studies, there is a debate about the best suctioning method that causes better improvement and maintains the stability of CIPs' hemodynamic state. This inspired us to conduct this study.

Research Aim

The current study aimed to compare the effect of open and closed tracheal suction systems on physiological parameters of CIPs.

Research Hypothesis

Critically ill patients who receive the closed tracheal suctioning method will have better physiological parameters compared to patients who receive the open suctioning method.

Method

Research Design

A quasi-experimental research design was adopted in the current study. This design aims to assess the effect of an intervention on its target population with lack of randomization. Moreover, quasi-experimental designs are more frequently used in nursing research for their suitability in real-world settings than true experimental research designs **(Polit & Beck, 2018).**

Setting

This study was conducted in two medical ICUs including the hepatic and gastrointestinal ICU, and the diabetic and endocrinal ICU at Specialized Medical Hospital, Mansoura University. These units receive patients with hepatic, gastrointestinal tract, diabetic, and endocrinal disorders. Each unit has a capacity of 7 beds and these units are well equipped with advanced technology, machines, and manpower required for the CIPs' care and management. The nurse-to-patient ratio is nearly 1:2 in these ICUs.

Sample

The study included a convenience sample of 94 patients who were assigned randomly into two groups: the closed suction group and the open suction group (47 patients in each group). The MVPs aged > 18 years of both genders were involved in this study. While patients who have any respiratory disease were excluded.

Sample size calculation

The sample size for this study was calculated by G*Power software (version 3.1.9.7). The primary outcome of interest is systolic blood pressure. A previous study revealed that mean systolic blood pressures were 125.4 ±8.1 and 119.8 ± 10.1 in open and closed suction: respectively **(Afshari et al., 2014)**, with an ∞ error of 5%, study power of 90%. Accordingly, the sample size was determined to be 94 patients.

Data Collection Tools

Data in the present study were collected using one tool:

Patients' Physiological Parameters Assessment Tool

This tool was developed by the primary investigator (PI) after reviewing the relevant literature **(Afshari et al., 2014; Mengar & Dani, 2018; Siyasari et al., 2018)**. This tool was used to assess the effect of closed and open suction on physiological parameters of mechanically ventilated patients. It is compromised of 3 parts:

Part I: Patients' Socio-Demographic Characteristics and Health-Relevant Data

This part was used to collect data about patients' socio-demographic characteristics, including gender, age, marital status, and occupation. It also covered patients' health-relevant data, including date of admission, current diagnosis, past medical history, and the type of suction system. Additionally, the Modified Glasgow Coma Scale (MGCS) was used to assess the patients' level of consciousness **(Tatman, Warren, Williams, Powell, & Whitehouse, 1997)**. It consists of four graded items: eye-opening score (from 1 to 4), motor response score (from 1 to 6), and verbal response score (from 1 to 5) or grimace response score (from 1 to 5). **Tatman et al. (1997)** proved that the grimace score of the MGCS is more reliable than the verbal score for intubated patients. The total score ranged between 3 and 15 and was ranked as follows:

(1) MGCS from 3 to 8 points→ Unconscious

(2) MGCS from 9 to 12 points → Semi-conscious

(3) MGCS from 13 to 15 points → Conscious

Part II: Ventilator Modalities Data

This part involved 4 items related to the type of artificial airway, ventilation data, mode of mechanical ventilation, and the duration of ventilation.

Part III: Physiological Parameters Assessment Sheet

This part contained 6 items concerning the patients' physiological parameters including respiratory rate (RR), oxygen saturation (SpO2), heart rate (HR), systolic and diastolic blood pressures (SBP and DBP), and mean arterial pressure (MAP).

Validity and Reliability

Seven experts in the field of critical care from the Faculties of Nursing and Medicine examined the tool's content validity. Their modifications and suggestions were considered. The Internal consistency and reliability of the tool were tested using Cronbach's alpha test and its value was 0.865 which indicates that the tool is reliable.

Pilot Study

A pilot study was carried out on 10% of the total sample (9 patients) before commencing the data collection process to test the clarity, objectivity, feasibility, and applicability of the tool. This group was excluded from the study sample.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing - Mansoura University (No. P.0241). Written informed consent was acquired from the relatives of participants (Next of Kin) after explaining the study's aim, procedure, benefits, and risks. Additionally, those relatives were notified that participation in the study was voluntary and they had the opportunity to approve or reject their patient's participation. Additionally, they were assured that the participants' personal data would be protected and they had the right to withdraw their patients from the study at any time without any responsibility.

Data Collection

Data were collected by the PI between August and December 2020. Official permission to perform this study was approved by the hospital administrative authorities after an explanation of the purpose and nature of the stud. An initial assessment was carried out by the PI to confirm that the patients met the inclusion criteria and were free from the exclusion criteria. Then, the informed consent was retrieved from the patient's family (First Kin). Patients were assigned randomly into two equal groups: the closed suction group and the open suction group using the coin toss method.

Intervention

Patients' socio-demographic characteristics and health-relevant data were obtained by the PI from their medical records and documented in **part I** of the tool. Then the patient's level of consciousness was assessed by using the MGCS using **part I** of the tool. The PI collected the ventilator's data by using **part II** of the tool. The patient's physiological parameters were assessed using a bedside monitor and recorded in **part III** of the tool immediately before suctioning to obtain the baseline data.

The endotracheal suctioning methods were demonstrated based on the **AARC (2010)** guidelines and after reviewing the literature and clinical practices concerned with endotracheal suctioning **(Elmansoury & Said, 2017; Seckel, 2016; Urden et al., 2020)**. Hence, the suctioning procedure was performed as follows:

For both groups:

Endotracheal suctioning was performed according to the patient's clinical needs and under the aseptic technique for 10-15 seconds. The vacuum pressure was adjusted to the desired level of 80-120 mmHg. All studied patients received 100% oxygen for at least 30-60 seconds via the hyperoxygenation button on the mechanical ventilator before and after the suctioning.

For the closed suction group:

A closed suction catheter sized 14-Fr was used, which was available in the study setting. This catheter was connected continuously with the endotracheal tube (ETT). The thumb control valve was unlocked then, the ETT was stabilized with the non-dominant hand and the suction catheter was inserted into the ETT with the dominant hand. The suctioning was applied using intermittent suctioning. The control valve was depressed continually while gently withdrawing the catheter out of the airway until the black marking ring appeared inside the sleeve. The suction catheter was irrigated by attaching a sterile 0.9% saline ampoule or syringe with sterile normal saline to the irrigation port and intermittently depressing the thumb control valve until the catheter was cleared. After that, the thumb control valve was locked and the irrigation port was closed/ caped.

For the open suction group:

A disposable suction catheter sized 16-Fr was used, which was available in the study setting. The patient was disconnected from the ventilator circuit then, the catheter was inserted gently into the ETT and intermittent suctioning was applied. After suctioning, the suction catheter and the connection tube were rinsed until clear with a sterile saline solution that was decanted into a basin. Then, the patient was immediately reconnected to the mechanical ventilator circuit and hyperoxygenated with 100% oxygen.

Outcome measures

The patient's physiological parameters including RR, SpO_2, HR, SBP, DBP, and MAP were monitored immediately before and after suctioning, and 5 minutes, 10 minutes, and 15 minutes after suctioning by using a bedside monitor. The changes in the physiological parameters were compared between both groups.

Statistical Analysis

The data were coded and analyzed by the Statistical Package for Social Sciences program version 25.0. Qualitative data were expressed as numbers and frequency. The mean ± standard deviation (SD) was used to express the quantitative data. Shapiro-Wilk's test was used to check the normality of quantitative data at first. The Chi-Square test and Fisher's exact test were used to assess the qualitative data of both groups. Additionally, the two-way repeated-measures ANOVA is used to illustrate differences between more than two related groups (successful observations of physiological parameters). The results were considered statistically significant if the *P*-value ≤ 0.050, for any used tests.

Results

Table 1 presents the socio-demographic characteristics of the study groups. The finding showed that male patients were dominant in the closed suction and open suction groups (53.2% & 61.7% respectively), and more than half were > 60 years old (61.7% & 53.2% respectively). The majority of the patients in both groups were married with a statistically significant difference (*P*= 0.043), and the large proportion of patients in both groups was unemployed (53.2% & 44.7% respectively). No statistically significant differences were noted between both groups regarding gender, age, and occupation that indicated the similarity of the study groups.

Table 2 illustrates the health-relevant data of the study groups. The results revealed that the common medical diagnosis in both groups was liver cirrhosis (46.8% & 48.9% respectively) followed by acute kidney injury in the closed suction group (29.8%) and septic shock in open suction group (23.4%). Additionally, the most evident past medical history in both groups were cardiac disease (51.1%, 46.8% respectively), and diabetes mellitus (44.7% & 57.4% respectively). Statistically significant differences were detected between both groups regarding the medical diagnosis of acute kidney injury and the past medical history of chronic kidney disease (P = 0.021 & P = 0.006 respectively).

Concerning the MGCS, the level of consciousness was assessed for only 77 patients while 17 patients were sedated. The results showed that the majority of the patients in both groups were unconscious (71.1% & 89.7% respectively).

Table 3 differentiates between the mean scores of patients' physiological parameters for both groups across the five measurements time points of the study. The results highlighted that the mean ± SD of RR was slightly higher immediately after open suctioning compared with before suctioning (22.5±3.5 & 20.4±3.3 respectively). However, the difference was not statistically significant.

This table also showed that the reduction in SpO2 immediately after suctioning compared to before suctioning was higher in the open suction group (94.2±3.3 & 95.5±3.3 respectively) than the closed suction group (95±3.5 & 95.8±3.3 respectively). The HR value improved and reached the baseline after 15 minutes following closed suctioning, however it was still high after open suctioning. No statistically significant changes were noted in the patients' physiological parameters for both groups throughout the five consecutive measurements of the study.

Table 4 compares the effect of closed and open suction systems on patients' physiological parameters. The results revealed that there was a statistically significant difference between the two groups regarding DBP (P = 0.049). However, there were no statistically significant changes in other physiological parameters (RR, SpO_2, HR, SBP, MAP) between the two groups.

Table 1 *Patients' Socio-Demographic Characteristics*

Variables	Closed Suction Group n=47	Open Suction Group n=47	Significance Test	
			χ^2	*P* value
	No. (%)	No. (%)		
Gender				
• Male • Female	25 (53.2%) 22 (46.8%)	29 (61.7%) 18 (38.2%)	0.696	0.404
Age category				
• 18-30 years	1 (2.1%)	1 (2.1%)		

• 31-40 years	3 (6.4%)	2 (4.3%)	FET	0.852
• 41-50 years	4 (8.5%)	4 (8.5%)		
• 51-60 years	10 (21.3%)	15 (31.9%)		
• > 60 years	29 (61.7%)	25 (53.2%)		
Marital Status				
• Single	2 (4.3%)	0 (0.0%)	FET	**0.043**
• Married	37 (78.7%)	45 (95.7%)		
• Widow	7 (14.9%)	2 (4.3%)		
• Divorced	1 (2.1%)	0 (0.0%)		
Occupation				
• Employed	15 (31.9%)	18 (38.3%)	0.687	0.709
• Unemployed	25 (53.2%)	21 (44.7%)		
• Retired	7 (14.9%)	8 (17%)		

Data are expressed as numbers (No.) and frequency (%), *P*-value by FET= Fisher's Exact Test, Chi-Square test (χ^2), statistically significant at p ≤0.05.

Table 2 *Patients' Health-Relevant Data*

Variables	**Closed Suction Group n=47**	**Open Suction Group n=47**	**Significance Test**	
	No. (%)	**No. (%)**	χ^2	***P* value**
Medical Diagnosis				
• iver cirrhosis	22 (46.8%)	23 (48.9%)	0.043	0.836
• ndocrine emergency	6 (12.8%)	8 (17%)	0.336	0.562
• cute kidney injury	14 (29.8%)	5 (10.6%)	5.343	**0.021**
• thers (septic shock)	11 (23.4%)	11 (23.4%)	0.000	1.00
Past Medical History				
• troke	4 (8.5%)	5 (10.6%)	FET	1.000
• ardiac disease	24 (51.1%)	22 (46.8%)	0.170	0.680
• hronic kidney disease	8 (17%)	0 (0%)	FET	**0.006**
• hronic liver disease	17 (36.2%)	21 (44.7%)	0.708	0.400
• iabetes mellitus	21 (44.7%)	27 (57.4%)	1.537	0.215
• ancer	6 (12.8%)	4 (8.5%)	0.450	0.502
MGCS	**n = 38**	**n= 39**		
• onscious (13-15)	3 (7.9%)	1 (2.6%)	FET	0.127
• emiconscious (9-12)	8 (21.1%)	3 (7.7%)		
• nconscious (3-8)	27 (71.1%)	35 (89.7%)		
• **edated n= 17**	9 (19%)	8 (17%)		

Data are expressed as numbers (No.) and frequency (%), *P*-value by Chi-Square test, FET= Fisher's Exact Test, statistically significant at *p* ≤0.05, MGCS: Modified Glasgow Coma Scale

Table 3 *Comparing the Physiological Parameters Between the Studied Groups Across the Five Measurement Time Points*

Parameters	Group	Immediately Before Suction	Immediately After Suction	5 Min. After Suction	10 Min. After Suction	15 Min. After Suction	Significance Test		
		$\bar{x} \pm$ SD	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD	$\bar{x} \pm$ SD	*F*	*P*	Partial η^2
RR	CSS	21.2±3.2	22.7±3.8	21.3±3.1	21±3	20.9±2.9	1.175	0.313	0.025
	OSS	20.4±3.3	22.5±3.5	20.9±3.2	20.6±3	20.3±3			
SpO2	CSS	95.8±3.3	95±3.5	96.4±2.9	96.8±2.6	96.9±2.8	1.351	0.263	0.029
	OSS	95.5±3.3	94.2±3.3	96±2.6	96.3±2.5	96.7±2.4			
HR	CSS	92.4±12.1	99±15.2	96.8±14.5	94±12.8	92.7±11.5	2.828	0.054	0.058
	OSS	88.6±11.8	97.9±14.2	90.5±17.9	91.6±12	90±10.9			
SBP	CSS	111.6±16.7	120.6±10	117.3±10.1	116.6±10.6	114.6±18	0.603	0.539	0.013
	OSS	116.5±10.3	123±8.2	118.8±8.8	118.3±8.1	116.3±17			
DBP	CSS	71.9±9	77.7±7.5	74.6±7.3	73.9±8.1	74±8.4	1.090	0.343	0.023
	OSS	75.9±9	80.9±7.5	77.4±7.1	75±12.3	77.4±7.5			
MAP	CSS	83.8±8.7	90±7.4	87±7.5	86.5±8	86.4±8.2	1.394	0.253	0.029
	OSS	87.7±9	93±7	89.8±6.7	87.1±13.7	89.1±8			

Data are expressed as $\bar{X}$: mean, SD: Standard Deviation, *F*: Annova test. *P*-value: Two-Way repeated measures ANOVA, statistically significant at $p \leq 0.05$. CSS: Closed Suction System, OSS: Open Suction System, RR: Respiratory Rate, SpO_2: Oxygen Saturation, HR: Heart Rate, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, *MAP*: Mean Arterial Pressure, Min: Minute

Table 4 *Comparing the Effect of Suctioning System on Patients' Physiological Parameters*

Parameters	Closed Suction Group n=47	Open Suction Group n=47	Significance Test		
	Mean (SE)		*F*	*P*	Partial η^2
RR	21.4 (0.443)	20.9 (0.439)	0.806	0.374	0.017
SPO2	96.2 (0.425)	95.7 (0.395)	0.737	0.395	0.016
HR	95 (1.85)	91.7 (1.75)	2.183	0.146	0.045
SBP	116.1 (1.526)	118.6 (1.225)	1.698	0.199	0.036
DBP	74.4 (1.1)	77.3 (1.0)	4.105	**0.049**	0.082
MAP	86.7 (1.06)	89.4 (1.05)	3.255	0.078	0.066

Data expressed as mean, SE: Standard Error, *P*-value by *F*: Two-Way repeated measures ANOVA, Partial η2 = Partial eta square, statistically significant at $p \leq 0.05$.

Discussion

The present study showed that elderly males were predominant in the study sample. These findings are in agreement with similar studies **(Ebrahimian et al., 2020; Faraji et al., 2015; Özden & Görgülü, 2015).** This may be due to aging being characterized by progressive loss in the immune system function, impaired adaptive mechanism, and activation of the entire inflammatory cascade which leads to increased morbidity and mortality **(Aiello et al., 2019; Franceschi & Campisi, 2014).** No statistically significant differences were noted between studied groups regarding their socio-demographic characteristics, except for marital status. This confirms that the two groups were homogenous during the study.

Regarding the medical diagnosis, the current study found that nearly half of the participants in both groups were diagnosed with liver cirrhosis. This can be attributed to the nature of the study setting as data were collected from medical ICUs where most of the patients were admitted with gastrointestinal disorders. These findings incorresponded with **Elmelegy and Ahmed**

(2016) who noted that neurological disorders were the mutual admission reason in their studied patients. This could be attributed to the nature of the study setting.

Cardiac disease and diabetes mellitus were the dominant past medical history among the studied patients. This is in harmony with **Abbasinia, Irajpour, Babaii, Shamali, and Vahdatnezhad (2014)** who illustrated that the majority of their participants had a history of heart disease. Additionally, **Ebrahimian et al. (2020)** declared that hypertension (43.7%) and diabetes (28.57%) were the dominant co-morbidities among their studied patients. This could be because the dominant sample was elderly and suffering from chronic disease.

The current study illustrated that the mean score of RR slightly increased after open suctioning compared to closed suctioning, and this value was returned to the initial reading after 5 minutes in both groups with no statistically significant difference. This may be attributed to occlusion of the tracheal tube by the suction catheter and interruption of oxygen supply which results in hypoxia and consequently increased respiratory rate **(Sinha, Semien, & Fitzgerald, 2021)**. This is supported by the findings of the study done by **Cardoso, Kusahara, Guinsburg, and Pedreira (2017)**. They observed that the RR value increased after the open suctioning while the value did not change after the closed suctioning.

On the contrary, other investigations reported a statistically significant difference in the mean RR between the two suctioning methods after 2 and 5 minutes following the suctioning **(Ebrahimian et al., 2020; Elmelegy & Ahmed, 2016)**. This contradiction may be because the MV is responsible for controlling the breathing of the patients in ICU which makes respiration faster or slower.

The current study found that the SpO_2 value slightly decreased after open suctioning and increased than the initial value after 5 minutes following both suctioning methods. The changes in SpO_2 value were not statistically significant. This could be attributed to the good preparation for the studied patients before suctioning including pre oxygenation, using appropriate pressure, and limiting the suction time to less than 15 seconds. This is aligned with the recommendations of updated AARC guidelines for airway suctioning **(Blakeman, Scott, Yoder, Capellari, & Strickland, 2022)**. Also, **Maggiore et al. (2013)** concluded that the implementation of practice guidelines reduced the incidence of all adverse effects associated with tracheal suctioning.

Our findings are supported by other studies **(Elmelegy & Ahmed, 2016; Mohammadpour et al., 2015)**. By contrast, the current findings are inconsistent with other studies that evaluated the effect of open and closed suctioning on physiological indicators in MVPs and noted significant changes in SpO_2 value between both suction groups **(Alavi et al., 2018; Ebrahimian et al., 2020; Özden & Görgülü, 2015)**.

In the present study, no statistically significant differences were noted in the patients' HR between the two studied groups. The HR values increased immediately after suctioning in both groups. However, these values decreased after 15 minutes from the closed suctioning toward the baseline values and are still slightly high after open suctioning. Supporting these findings, some studies reported no statistically significant changes in patients' HR after both suctioning methods **(Ebrahimian et al., 2020; Sayed, 2019; Siyasari et al., 2018)**.

However, **Alavi et al. (2018)** assessed which suctioning method is preferable for patients after cardiac surgery and reported a highly significant difference in the HR between closed and open suction groups. This discrepancy may be due to the nature of the study population, where this cited study included post cardiac surgical patients. According to the literature, each surgical intervention is usually associated with postoperative pain **(Zubrzycki et al., 2018)**. In addition, tracheal suctioning is one of the most common causes of pain for CIPs **(Ruan, Khasanah, & Kongkeaw, 2017)**. Generally, acute pain increases the HR and blood pressure secondary to the stress response **(Dayoub & Jena, 2015)**. This supports the results of **Alavi et al. (2018)** who illustrated that there were statistically significant changes in SBP and MAP following both suctioning methods.

These results contradict our findings because they noted no significant changes in the patients' SBP and MAP values between open and closed suctioning, and the statistically significant differences were detected only in DBP between both groups. However, the improvement of SBP and MAP toward the normal values was observed after using the closed suction system. This may be because most cirrhotic patients receive systemic drugs such as non-selective beta-blockers to decrease their high blood pressure and reduce portal hypertension and associated complications **(Sauerbruch, Schierwagen, & Trebicka, 2018)**. Similarly, **Siyasari et al. (2018)** reported that the differences in the patients' SBP and MAP were not statistically significant between the two groups.

Conclusion and Recommendations

Based on the findings of the present study, it can be concluded that closed and open tracheal suction systems improve the physiological parameters of MVPs with no statistically difference between the two methods. However, the closed suction system leads to fewer disturbances in the physiological parameters. This highlights the need for further research with a large sample in different clinical settings to contribute to the evidence related to endotracheal suctioning.

Limitations

A small sample size that was drawn from one hospital in one geographical area in Egypt may limit the generalizability of the study findings.

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Declaration of Conflicting Interests

There are no potential conflicts of interest.

References

Abbasinia, M., Irajpour, A., Babaii, A., Shamali, M., & Vahdatnezhad, J. (2014). Comparison the effects of shallow and deep endotracheal tube suctioning on respiratory rate, arterial blood oxygen saturation and number of suctioning in patients hospitalized in the intensive care unit: A randomized controlled trial. *Journal of Caring Sciences*, *3*(3), 157. DOI:10.5681/jcs.2014.017

Afshari, A., Safari, M., Oshvandi, K., & Soltanian, A. R. (2014). The effect of the open and closed system suctions on cardiopulmonary parameters: Time and costs in patients under mechanical ventilation. *Nursing and Midwifery Studies*, *3*(2). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4228526/

Aiello, A., Farzaneh, F., Candore, G., Caruso, C., Davinelli, S., Gambino, C. M., ... & Accardi, G. (2019). Immunosenescence and its hallmarks: How to oppose aging strategically? A review of potential options for therapeutic intervention. *Frontiers in Immunology*, *10*, 2247. Retrieved from https://doi.org/10.3389/fimmu.2019.02247

Alavi, S. M., Babaei, T., Shaverdian, S., Norouzi, Z., Ghadrdoost, B., Ziyaeifard, M., & Bakhshandeh, H. (2018). Which suction method is preferable for patients after cardiac surgery: Open or closed endotracheal suction system?. *Iranian Heart Journal*, *19*(3), 51-59. Retrieved from https://idml.research.ac.ir/files/site1/rds_journals/162/article-162-608615.pdf

American Association for Respiratory Care. (2010). AARC clinical practice guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. *Respiratory Care*, *55*(6), 758. Retrieved from https://pubmed.ncbi.nlm.nih.gov/20507660/

Blakeman, T. C., Scott, J. B., Yoder, M. A., Capellari, E., & Strickland, S. L. (2022). AARC clinical practice guidelines: Artificial airway suctioning. *Respiratory Care*, *67*(2), 258-271. Retrieved from https://doi.org/10.4187/respcare.09548

Bozan, S., & Güven, Ş. D. (2020). Evaluation of knowledge and behavior of nurses working in intensive care units for endotracheal aspiration application. *Journal of Surgery and Medicine*, *4*(4), 296-300. DOI: 10.28982/josam.693310

Cardoso, J. M., Kusahara, D. M., Guinsburg, R., & Pedreira, M. L. (2017). Randomized crossover trial of endotracheal tube suctioning systems use in newborns. *Nursing in Critical Care*, *22*(5), 276-283. DOI: 10.1111/nicc.12170

Dastdadeh, R., Ebadi, A., & Vahedian-Azimi, A. (2016). Comparison of the effect of open and closed endotracheal suctioning methods on pain and agitation in medical ICU patients: A clinical trial. *Anesthesiology and Pain Medicine*, *6*(5). DOI: 10.5812/aapm.38337.

Dayoub, E. J., & Jena, A. B. (2015). *Does* pain lead to tachycardia? Revisiting the association between self-reported pain and heart rate in a national sample of urgent emergency department visits. *Mayo Clinic Proceedings, 90*(8), 1165–1166. DOI:10.1016/j.mayocp.2015.06.007

Ebrahimian, A., Tourdeh, M., Paknazar, F., & Davari, H. (2020). The Effect of the open and closed system suctions on pain severity and physiological indicators in mechanically ventilated patients with traumatic brain injury: A randomised controlled trial. *Turkish Journal of Anaesthesiology and Reanimation*, *48*(3), 202. DOI: 10.5152/TJAR.2019.03342

Elmansoury, A., & Said, H. (2017). Closed suction system versus open suction. *Egyptian Journal of Chest Diseases and Tuberculosis*, *66*(3), 509-515. Retrieved from https://doi.org/10.1016/j.ejcdt.2016.08.001

Elmelegy, O. E. A., & Ahmed, R. (2016). Effect of open versus closed endotracheal suctioning system on vital signs among mechanically ventilated patients in ICU. *Journal of Nursing and Health Science*, *5*(6), 91-100.

Faraji, A., Khatony, A., Moradi, G., Abdi, A., & Rezaei, M. (2015). Open and closed endotracheal suctioning and arterial blood gas values: A single-blind crossover randomized clinical trial. *Critical Care Research and Practice, 2015,* 1–7. DOI:10.1155/2015/470842

Franceschi, C., & Campisi, J. (2014). Chronic inflammation (inflammaging) and its potential contribution to age-associated diseases. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, *69*(Suppl_1), 4-9. Retrieved from https://doi.org/10.1093/gerona/glu057

Greenwood, J. C., & Winters, M. E. (2019). Tracheostomy care. In J. R. Roberts & J. R (7th ed.). *Roberts and hedges' clinical procedures in emergency medicine E-book*. Elsevier Health Sciences. Retrieved from https://www.sciencedirect.com/topics/medicine-and-dentistry/suction-drainage

Imbriaco, G., & Monesi, A. (2021). Closed tracheal suctioning systems in the era of COVID-19: Is it time to consider them as a gold standard?. *Journal of Infection Prevention*. Retrieved from https://doi.org/10.1177/1757177420963775

Maggiore, S. M., Lellouche, F., Pignataro, C., Girou, E., Maitre, B., Richard, J. C. M., ... & Brochard, L. (2013). Decreasing the adverse effects of endotracheal suctioning during mechanical ventilation by changing practice. *Respiratory Care*, *58*(10), 1588-

1597. Retrieved from https://doi.org/10.4187/respcare.02265

Martí, J. D., & Martinez-Alejos, R. (2020). Respiratory and mechanical ventilation management: Avoidance of complications. In C. Boulanger & D. McWilliams. *Passport to successful ICU discharge* (pp. 15-27). Springer: Cham, Switzerland. Retrieved from https://doi.org/10.1007/978-3-030-38916-1

Mengar, R. S., & Dani, P. (2018). A comparative study to assess the effectiveness of open tracheal suction system and closed tracheal suction system on physiological parameters. *International Journal of Nursing Education*, *10*(4), 109. DOI: 10.5958/0974-9357.2018.00114.9

Mohammadpour, A., Amini, S., Shakeri, M. T., & Mirzaei, S. (2015). Comparing the effect of open and closed endotracheal suctioning on pain and oxygenation in post CABG patients under mechanical ventilation. *Iranian Journal of Nursing and Midwifery Research*, *20*(2), 195. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4387642/

Mwakanyanga, E. T., Masika, G. M., & Tarimo, E. A. (2018). Intensive care nurses' knowledge and practice on endotracheal suctioning of the intubated patient: A quantitative cross-sectional observational study. *PloS One*, *13*(8). Retrieved from https://doi.org/10.1371/journal.pone.0201743

Özden, D., & Görgülü, R. S. (2015). Effects of open and closed suction systems on the haemodynamic parameters in cardiac surgery patients. *Nursing in Critical Care*, *20*(3), 118–125. DOI:10.1111/nicc.12094

Polit, D. F., & Beck, C. T. (2018). *Essentials of nursing research: Appraising evidence for nursing practice* (9th ed.). Philadelphia: Wolters Kluwer Health /Lippincott Williams & Wilkins.

Raimundo, R. D., Sato, M. A., da Silva, T. D., de Abreu, L. C., Valenti, V. E., Riggs, D. W., & Carll, A. P. (2021). Open and closed endotracheal suction systems divergently affect pulmonary function in mechanically ventilated subjects. *Respiratory Care*, *66*(5), 785-792. Retrieved from https://doi.org/10.4187/respcare.08511

Ruan, Q., Khasanah, I. H., & Kongkeaw, O. (2017). Pain management during endotracheal tube suctioning: An evidence-based approach for nurses. *International Journal of Nursing and Care*, *1*(4), 1-3. Retrieved from https://www.scivisionpub.com/pdfs/pain-management-during-endotracheal-tube-suctioning-an-evidencebased-approach-for-nurses-168.pdf

Sauerbruch, T., Schierwagen, R., & Trebicka, J. (2018). Managing portal hypertension in patients with liver cirrhosis. *F1000Research, 7*, 533. DOI:10.12688/f1000research.13943

Sayed, Z, A. (2019). Effect of open versus closed suction system on cardiorespiratory parameters and suction duration among critically ill mechanically ventilated patients. *Egyptian Journal of Health Care*, *10*(2), 409-418. Retrieved from file:///E:/protochol/%D8%A7%D9%84%D8%B1%D8%B3%D8%A7%D9%84%D9%87/discucion/paper/Zahra%20Ahmed%20Sayed.pdf

Seckel, M. A. (2016). Suctioning: Endotracheal or tracheostomy tube. In: D. L.Wiegand (7th ed.). *AACN procedure manual for high acuity, progressive, and critical care-e-book*, (pp. 71-77). Elsevier Health Sciences. Retrieved from https://www.aacn.org/docs/Photos/Procedure-10-kmptp0mn.pdf

Sinha, V., Semien, G., & Fitzgerald, B. M. (2021). Surgical airway suctioning. In *StatPearls [Internet].* StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK448077/

Siyasari, A., Rahnama, M., Shahrakimoghadam, E., Shahdadi, H., & Abdollahimohammad, A. (2018). Comparing the effect of tracheal tube suction using open and closed methods on hemodynamic indexes of COPD patients under mechanical ventilation. *Medical Science*, *22*(94), 539-543. Retrieved from http://www.discoveryjournals.org/medicalscience/current_issue/v22/n94/A7.pdf

Tatman, A., Warren, A., Williams, A., Powell, J. E., & Whitehouse, W. (1997). Development of a modified paediatric coma scale in intensive care clinical practice. *Archives of Disease in Childhood*, *77*(6), 519-521. Retrieved from http://dx.doi.org/10.1136/adc.77.6.519

Tavangar, H., Javadi, M., Sobhanian, S., & Jahromi, F. F. (2017). The effect of the duration of pre-oxygenation before endotracheal suction on hemodynamic symptoms. *Global Journal of Health Science*, *9*(2), 127-33. DOI:10.5539/gjhs.v9n2p127

Urden, L. D., Stacy, K. M., & Lough, M. E. (2020). *Priorities in critical care nursing* (8th ed.). Canada: Elsevier Health Sciences.

Zubrzycki, M., Liebold, A., Skrabal, C., Reinelt, H., Ziegler, M., Perdas, E., & Zubrzycka, M. (2018). Assessment and pathophysiology of pain in cardiac surgery. *Journal of Pain Research*, *11*, 1599-1611. DOI: 10.2147/JPR.S162067