Open versus Closed Suctioning in Mechanically Ventilated Patients: A Comparative Study on Suctioning Time, Gas Exchange, and Cardiorespiratory Effects

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Abstract

Background: One technique to keep the airway open and eliminate secretions from ventilated patients is to suction the endotracheal tube. There are a number of dangers involved in this process. Variations in blood pressure, heart rate, respiratory rate, and oxygen saturation are among the initial issues with suctioning. It is recommended to utilize closed-circuit endotracheal suctioning (CES) to avoid hypoxemia, which is brought on by the loss of lung volume via open endotracheal suctioning (OES)**. This study** was aimed to compare the effects of open versus closed suctioning in mechanically ventilated patients on suctioning time, gas exchange, and cardiorespiratory parameters. **Design**: **A quasi- experimental research design (two groups)** was carried out to achieve the aim of this study. **Setting**: The study was conducted at general intensive care at Sohag University Hospital. **Subjects:** A convenient sample included 100 critically ill patients undergoing mechanical ventilation were recruited from the previously selected setting within six months and was randomly assigned to the closed suction group (n = 50) and the open suction group (n = 50). **Tools: One tool was used for data collection: I: Patient assessment sheet** which included three parts: Part (I): bio-demographic data Part (II): Cardiorespiratory parameters assessment sheet, and Part (III): Gas exchange assessment sheet. **Results:** The mean duration of suction for patients in open and closed suctioning was 15.41 ± 2.37 and 7.50 ± 2.50 seconds, respectively. An improvement in patients' suctioning time, gas exchange, and cardiorespiratory parameters was noticed after closed suctioning .The closed suction system group have a higher mean Oxygen saturation than those in the open group during suction and after suction measurements. Closed suction has a considerable positive impact on suctioning time, gas exchange, and cardiopulmonary parameters. **Conclusion:** The implementation of the closed suction system leads to decrease instabilities in the cardiorespiratory parameters compared to open suction system in mechanically ventilated patients. **Recommendation:** This study emphasizes on 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.

Keywords: Cardiorespiratory effects, Gas exchange, Mechanically ventilated patients, Open versus closed suctioning, Suctioning time.

Introduction:

One essential part of the human body is the heart and lungs. The respiratory and cardiac systems cannot operate as separate organs since they are always integrated as one system. For people to live regular, healthy lives, both are necessary. A patient is taken to the intensive care unit (ICU) following cardiopulmonary surgery for hemodynamic monitoring, adequate volume therapy, and treatment with positive inotropic and vasopressor medications because their cardiopulmonary functions are impaired by the post-anesthesia effect and any other negative effects of the procedure (**Harada, 2020**).

Mechanical breathing and intubation significantly reduce the clearance of airway secretions; intubated patients need intermittent suctioning of secretions since they are unable to clear their airways on their own. To extract secretions from intubated patients receiving mechanical ventilation, tracheal suctioning is performed in the intensive care unit. Therefore, suctioning is recommended for patients on mechanical ventilation in order to reduce airway obstruction and the effort required to breathe because of retrained secretions (**Jongerden et al., 2022**). However, this maneuver carries the risk of being hazardous and could have major, life-threatening repercussions **(Fernandez, 2021).**

The majority of patients on mechanical ventilation (MVP) have poor airway clearance, which encourages the retention of secretions in the airways. This causes respiratory pain and slows the ventilator weaning process by increasing the airflow resistance and work of breathing. Additionally, the airway contracted, gas exchange was compromised, and the risk of lung infections was elevated (**Martí & Martinez-Alejos, 2020).** To sustain ventilation, it is therefore crucial to clean and suction the artificial airway on a frequent basis (**Mwakanyanga et al., 2018**).

Endotracheal suction risks include bleeding, infection, atelectasis, hypoxemia, cardiovascular instability, abnormalities of the tracheal mucosa, and high intracranial pressure. Because the suctioning process increases the heart's workload and oxygen consumption, patients have reported it to be painful and unpleasant. This has also been connected to serious postoperative outcomes; especially for patients who have had coronary artery bypass grafts (CABGs) (**Pedersen et al., 2019).**

By eliminating secretions, endotracheal suction keeps the airway clean and open, facilitating easy and successful breathing. The two methods of endotracheal suction are the closed suction system and the open suction system. A disposable sterile catheter connected to the vacuum system is used to suction the airway, and the patient is then connected to the ventilator once the patient has been withdrawn from any mechanical ventilator (**Cereda et al., 2021; Jongerden et al., 2022).**

The open suction system and the closed suction system are the two suctioning techniques that vary according to the type of catheter (**Raimundo et al., 2021**). With the open suction system, a single-use disposable suction catheter must be inserted into the artificial airway after the patient is disconnected from the ventilator. In order to prevent lung infections, there is evidence that the open suction system needs to be used aseptically (**Imbriaco & Monesi, 2021**). Despite the significance of open suctioning, hypoxemia is a typical adverse effect that can result from this technique. Disconnecting the oxygen supply from the patient's airway while the suction is being done may cause hypoxemia (**Greenwood & Winter, 2019**).

The closed suction system is an additional suctioning technique that enables the patient to stay on the ventilator while suctioning. It is comprised of a sterile, multiple-use suction catheter that is protected by a transparent plastic sheath (**Imbriaco & Monesi, 2021; Urden et al., 2020**). There is evidence to support the use of the closed suction system, particularly for patients who need high levels of positive end-expiratory pressure and friction inspired oxygen (FiO2), such as those with acute lung injury. The medical staff is shielded from the patient's secretions by the closed suction system (**Imbriaco & Monesi, 2021**). Additionally, it caused fewer disruptions in the hemodynamic state and was cost-effective when utilized for patients who were in the intensive care unit for more than 48 hours **(Afshari et al., 2024)**.

More than 30 years ago, hypoxemia brought on by suctioning was documented in patients on mechanical ventilation. 1–4 In the event of acute lung injury (ALI), the main cause of hypoxemia is the significant loss of lung capacity brought on by the patient's removal from the ventilator (**Lu et al., 2020).** Moreover, the loss of lung volume is exacerbated by the strong negative suctioning pressure needed to extract bronchial secretions. In the beginning, closed-circuit endotracheal suctioning (CES) was created to avoid arterial desaturation that could complicate ventilator disconnection. Despite being significantly less than open endotracheal suctioning (OES), the amount of lung volume lost during CES is still reliant on the negative pressure used during the procedure (**Lindgren et al., 2024**).

Recent experimental research and clinical experience, however, indicate that OES is more effective than CES at eliminating tracheobronchial secretions. Therefore, it appears necessary to generate sufficient negative pressure during CES in order to promote effective secretion clearance. A recruitment technique right at the end of the operation has been shown to be helpful in limiting the amount of time that the loss of lung capacity from the negative pressure created during CES causes arterial oxygenation impairment (**Lu et al., 2020).**

Weaning the patient off of mechanical ventilation during open endotracheal suction decreased lung volume as well as arterial and venous oxygen saturation, according to research on the effects of open and closed endotracheal suction on patient oxygenation, lung volume, and hemodynamic status. Hypoxemia could happen because the procedure takes air out of the lungs. The patient's heart rate (HR) and arterial blood pressure may increase during this transition, which could cause the cardiac rhythm to be disturbed (**Johnson et al., 2019**). Closed endotracheal suction prevents problems like decreased lung volume, hypoxemia, high blood pressure, and cardiac arrhythmia while the patient is still on mechanical breathing.

Significance of the Study

Endotracheal suctioning is a strong stimulation that can cause a number of issues. According to **Bozan and Güven (2020),** these side effects include atelectasis, bronchospasm, hypoxemia, and cardiovascular abnormalities. Numerous research evaluated how physiological parameters were affected by open and closed suction systems. According to several of these investigations, the two suctioning systems' differences were not clinically significant for some measures, like blood pressure and oxygen saturation (**Ebrahimian et al., 2020**). Other studies, however, found that the closed system causes fewer disruptions to the patient's gas exchange, cardiorespiratory parameters, and suctioning duration than the open system. It is possible to identify an appropriate suction technique to avoid a number of issues (**Afshari et al., 2024).** According to the aforementioned research, there is disagreement about the optimal suctioning technique that improves and preserves the hemodynamic stability of CIPs. This inspired us to conduct this study to compare the effects of open versus closed suctioning in mechanically ventilated patients on suctioning time, gas exchange, and cardiorespiratory parameters.

Aim of the study

The current study aimed to compare the effects of open versus closed suctioning in mechanically ventilated patients on suctioning time, gas exchange, and cardiorespiratory parameters.

Research Hypothesis

Mechanically ventilated patients who receive the closed suctioning method will have less suctioning time, less deterioration in gas exchange, and better cardiorespiratory parameters compared to mechanically ventilated patients who receive the open suctioning method.

Subjects and 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

The study was conducted at general intensive care at Sohag University Hospital.

Sample

A convenient sample included 100 critically ill patients undergoing mechanical ventilation were recruited from the previously selected setting within six months and was randomly assigned to the closed suction group (n = 50) and the open suction group (n = 50)

Data Collection Tools:

One tool divided into three parts was used for data collection:

Tool I: Patient assessment sheet:

The tool was developed by the researchers after reviewing the relevant literature **(Jansson et al., 2019; Mengar & Dani, 2018; Siyasari et al., 2018)**. This tool was used to compare the effects of open versus closed suctioning in mechanically ventilated patients on suctioning time, gas exchange, and cardiorespiratory parameters. It divided into the following parts:

Part (I): Bio-demographic data

This part was used to collect data about patients' socio-demographic characteristics, including gender, age, and occupation, date of admission, current diagnosis, and suction duration.

Part (II): Cardiorespiratory 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).

Part (II): Gas exchange assessment sheet:

This part contained 2 items concerning the patients' gases such as **PaO_2 and $PaCO_2$**

Validity and Reliability

Five experts in the field of critical care, three experts from the Faculty of Nursing and two experts from Faculty of Medicine examined the tool's content validity. No modifications and suggestions were considered. The Internal consistency and reliability of the tool were tested using Cronbach's alpha test and its value was 0.934 which indicates that the tool is reliable.

Pilot Study

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

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Nursing - Sohag University (No. 129-10-2023). Oral consent was acquired from the relatives of participants 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 researchers between November 2023 and April 2024. Official permission to perform this study was approved by the hospital administrative authorities after an explanation of the purpose and nature of the study. Patients were assigned randomly into two equal groups: the closed suction group and the open suction group using the coin toss method.

Intervention

The researchers collected the biodemographic information and suctioning time of the patients from their medical records and recorded it in part I of the instrument. Before suctioning to collect the baseline data, the patient's cardiorespiratory parameters were measured using a bedside monitor and entered in part II of the instrument. Part III of the instrument was used to record the patient's gasses, which were measured with a bedside monitor before starting suctioning. Following a review of the literature and clinical procedures pertaining to endotracheal suctioning, the suctioning techniques were shown in accordance with the **AARC (2020**) standards (**Seckel, 2016; Urden et al., 2020).** As a result, the following suctioning technique was used:

For both groups:

According to the patient's clinical requirements, endotracheal suctioning was carried out for ten to fifteen seconds using aseptic technique. The vacuum pressure was adjusted to 80 - 120 mmHg to get the desired effect. Prior to and during the suctioning, all patients in the study were given 100% oxygen for a minimum of 30 to 60 seconds using the hyperoxygenation button on the mechanical ventilator.

For the closed suction group:
The study used a 14-Fr closed suction catheter that was readily available. The endotracheal tube (ETT) was continuously attached to this catheter. After unlocking the thumb control valve, the dominant hand was used to put the suction catheter into the ETT while the non-dominant hand stabilized it. Intermittent suctioning was used to apply the suction. While carefully removing the catheter from the airway, the control valve was continuously depressed until the black marking ring showed up inside the sleeve. A sterile 0.9% saline ampoule or syringe filled with sterile normal saline was attached to the irrigation port of the suction catheter, and the thumb control valve was periodically depressed 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:
The study setting provided a disposable 16-Fr suction catheter, which was employed. After the patient's connection to the ventilator circuit was cut off, the catheter was carefully placed into the ETT and intermittent suctioning was used. Using a sterile saline solution that was decanted into a basin, the suction catheter and the connecting tubing were cleaned until clear after suctioning. Immediately after, the patient was hyperoxygenated with 100% oxygen and linked to the mechanical ventilator circuit.

Measurements:
The patient's gas exchange, suctioning time, and cardiorespiratory parameters, such as RR, SpO2, HR, SBP, DBP, and MAP, were tracked using a bedside monitor 15 minutes prior to, during, and 15 minutes following endotracheal suctioning. PaO2 and PaCO2 baselines were determined by taking the mean of the 4-minute measurements before endotracheal suctioning. Two timings were selected following the recording of baseline values in order to compare gas exchange during each procedure in the two study sections. Blood pressure, heart rate, and oxygen saturation were measured with a monitor, and the mechanical ventilator was used to measure the respiration rate. The two groups' variations in gas exchange, suctioning time, and cardiorespiratory parameters were contrasted.

Statistical analysis:
The Statistical Package for Social Science (SPSS) version 19 was utilized for data entry and analysis. A standard deviation and a mean were used to display the data. The Chi-square and Fisher Exact tests were employed to compare qualitative variables. Quantitative variables were compared using the Mann-Whitney test when dealing with non-parametric data. P-values below the significance level of 0.05 were deemed statistically significant.

Results:

Table 1 shows that the majority (40%) of the patients in the open suction group were 40-50 years old, (60%) were males, (36%) of them had higher secondary education, (64%) were not working, and **(44%) had respiratory disease**. Comparatively, 36% of the patients in the closed suction group were >50 years old, 22 (74 %) were men, (56%) were university education, and (56%) were in not working. In general, the patients in both the groups had similar characteristics. The mean suction duration in open and closed suction methods was 16.33 ± 2.11 and 8.11 ± 2.23seconds, respectively with a statistically significant difference at p=0.002*.

Table 2 shows that the mean heart rate was higher during suction and after suction in closed suction than in open suction (105.88 ± 11.79 vs. 97.78 ± 16.22 and 96.77 ± 14.22 vs. 91.55 ± 13.67, respectively). However, Also, the same table reveals that not all repeated measurements showed any significant differences between the open and closed suction methods.

The mean ±SD of respiratory rates for the mechanically ventilated patients in open and closed suction groups under study are shown in **Table 3**. Prior to suction, there were no statistically significant differences between the two suction groups, but there were differences in respiratory rates between the open and closed suction groups. Also, the same table portrays that both P-values during and after suction showed statistically significant improvements (0.025 and 0.024, respectively).

Table 4 reveals that during suction, there is a considerable change in SpO2 between open and closed suction methods. The results demonstrate that during and after suction, there is a significant difference between open and closed suction which was significant.

Table 5 demonstrates that there is no significant difference between open and closed methods of suction before suctioning, but there is significant differences in MAP during and after the suctioning procedure at p=0.001.

Table 6 shows that changes in PaO_2 and $PaCO_2$ were statistically different between the studied mechanically ventilated patients in both open and closed suction groups regarding changes in PaO2 and PaCO2.

Table 1: Distribution of bio-demographic data of the studied mechanically ventilated patients in both open and closed suction groups

Demographic data		Group				P-value
		Open suction group (n=50)		Closed suction group (n=50)		
		n	%	n	%	0.678
Age	Below 30 years	5	10%	3	6%	
	30 - 40 years	10	20%	12	24%	
	40 – 50 years	20	40%	17	34%	
	>50 years	15	30%	18	36%	
Gender	Male	30	60%	37	74 %	0.643
	Female	20	40%	13	26 %	
Education	Primary	8	16%	12	24%	0.621
	Secondary	18	36%	11	22%	
	University	16	32%	28	56%	
	Post graduate	8	16%	4	8%	
Occupation	Working	18	36%	22	44%	0.178
	Not working	32	64%	28	56%	
Diagnosis:	Respiratory disease	22	44%	15	30%	0.167
	Respiratory disease with other	12	24%	23	46%	
	Other	16	32%	12	24%	
Duration of suction		16.33 ± 2.11		8.11 ± 2.23		0.002*

Data are expressed as numbers (No.) and frequency (%), *P*-value by Chi-Square test (^{2}), statistically significant at p ≤0.05.

Table 2: Mean difference of the studied mechanically ventilated patients in both open and closed suction groups regarding heart rate

Heart rate	Group				P-value
	Open suction group (n=50)		Closed suction group (n=50)		
	Mean	SD	Mean	SD	
Before	95.33 ± 14.42		97.44 ± 16.32		0.085
During	105.88 ± 11.79		97.78 ± 16.22		0.554
After	96.77 ± 14.22		91.55 ± 13.67		0.516

Table 3: Mean difference of the studied mechanically ventilated patients in both open and closed suction groups regarding respiratory rate

Respiratory rate	Group				P-value
	Open suction group (n=50)		Closed suction group (n=50)		
	Mean	SD	Mean	SD	
Before	18.22 ± 4.63		19.31 ± 8.66		0.654
During	22.44 ± 9.66		18.59 ± 3.88		0.025*
After	21.77 ± 7.64		16.58 ± 4.60		0.024*

Table 4: Mean difference of the studied mechanically ventilated patients in both open and closed suction groups regarding oxygen saturation

Oxygen saturation		Group				Independent t-test
		Open suction group (n=50)		Closed suction group (n=50)		
		Mean	SD	Mean	SD	
Before	$SpO_2 1$	98.44	1.21	97.55	8.43	t=0.36, p=0.71
	$SpO_2 2$	98.77	1.01	93.30	4.79	t=5.18, p=0.001
	$SpO_2 3$	98.66	1.44	94.40	7.31	t=2.67, p=0.01
During	SpO21	96.50	0.70	98.10	1.20	t=6.10, p=0.001***
	SpO22	95.50	1.70	98.50	1.10	t=6.13, p=0.001***
	SpO23	95.80	1.00	98.00	1.20	t=7.89, p=0.001***
After	$SpO_2 1$	96.44	0.66	98.12	1.20	t=6.10, p=0.001***
	$SpO_2 2$	95.46	1.22	98.48	1.39	t=7.27, p=0.001***
	$SpO_2 3$	95.65	1.33	98.49	0.89	t=8.19, p=0.001***

Table 5: Mean difference of the studied mechanically ventilated patients in both open and closed suction groups regarding MAP

MAP		Group				Independent t-test
		Open suction group (n=50)		Closed suction group (n=50)		
		Mean	SD	Mean	SD	
Before	MAP1	101.07	7.67	101.05	7.71	t=0.00, p=1.00
	MAP2	99.6	7.0	99.61	7.00	t=0.00, p=1.00
	MAP3	104.1	6.9	104.10	6.91	t=0.00, p=1.00
During	MAP3	116.12	9.80	104.40	6.9	t=4.97, p=0.001***
	MAP4	112.90	7.90	107.10	11.18	t=3.01, p=0.04*
	MAP5	116.9	8.80	104.10	7.20	t=6.13, p=0.001***
After	MAP1	115.70	10.05	101.0	7.8	t=6.01, p=0.001***
	MAP2	116.12	9.80	104.40	6.9	t=4.97, p=0.001***
	MAP3	116.9	8.80	104.10	7.20	t=6.13, p=0.001***

Table 6: Mean difference of the studied mechanically ventilated patients in both open and closed suction groups regarding changes in PaO2 and PaCO2

Items	Group	Before	During	After	P-value
PaO2, mmHg	Open suction group (n=50)	221 ± 87	185 ± 65*	178 ± 64*	0.02
	Closed suction group (n=50)	225 ± 103	239 ± 106	218 ± 113	0.02
PaCO2, mmHg	Open suction group (n=50)	41 ± 7	44 ± 9‡	43 ± 7	0.006
	Closed suction group (n=50)	41 ± 7	42 ± 6	42 ± 8	0.07

Discussion

In ventilated patients, one method of keeping the airway open is to suction the endotracheal tube. There are a number of dangers involved in this process. Acute issues can be avoided by using suctioning techniques that are suitable for the circumstance. Although neither technique worked better than the other in the intensive care unit, there are two methods for endotracheal suctioning: open suction and closed suction. Side effects of suctioning include bradycardia, irregular breathing, arterial blood oxygen desaturation, and brief increases in arterial blood pressure. A lower heart rate and oxygen saturation are associated with frequent use of the endotracheal suctioning process (**Evans et al., 2024**).

The greatest impairment in gas exchange occurs within one minute of the procedure's conclusion. In patients with ALI, OES causes a considerable and prolonged fall in PaO2 and an increase in PaCO2. In comparison to OES, CES appears to be less effective at removing secretions, although it does prevent the hypoxemia that is seen during OES. In order to assess the effects of open versus closed suctioning on suctioning time, gas exchange, and cardiorespiratory parameters in patients on mechanical ventilation, the current study was conducted, (**Keykha et al., 2024)**.

According to the current study, the study sample was primarily composed of men. Similar research by **(Ebrahimian et al., 2020)** supports these findings. This could be because aging is marked by a reduction in adaptive mechanisms, a progressive loss of immune system function, and the activation of the entire inflammatory cascade, all of which increase morbidity and mortality (**Aiello et al., 2019**). Marital status was the only sociodemographic factor that showed statistically significant differences between the groups under study. This attests to the two groups' uniformity throughout the research.

The present study showed that the mean suction duration in open and closed suction methods was 16.33 ± 2.11 and 8.11 ± 2.23seconds, respectively with a statistically significant difference. According to **the American Association of Respiratory Care (AARC) (2020),** as little time as possible should be spent suctioning. Less than 10 seconds or 15 seconds are mentioned by some writers. In a closed suction (CS) system, the nurse connects the catheter to the ventilator circuit, integrates it into the mechanical ventilator device, and maintains contact with the patient for a longer period of time than in an open suction system. In contrast, in an open suction system, patients are disconnected from the ventilator and the suction catheter is connected to the endotracheal tube, the researchers speculate. The business claims that because the nurse does not have to set up the equipment or implant or unhook the catheter during each suction session, CS procedures save time.

There were no statistically significant variations in the patients' heart rates between the two groups under investigation in this study. Following suctioning, the HR values rose in both groups. These values are remained a little high following open suctioning, but they dropped approaching the baseline levels following closed suctioning. These conclusions are supported by a research that found no statistically significant changes in patients' heart rates following any of the suctioning techniques used (**Ebrahimian et al., 2020). Alavi et al. (2018**), however, evaluated which suctioning technique is best for patients following heart surgery and found that the HRs of the closed and open suction groups differed significantly. This disparity might result from the study population's makeup, as the mentioned study included individuals who had undergone heart surgery.. Every surgical procedure is typically accompanied with postoperative pain, according to the literature (**Zubrzycki et al., 2018)**. This was consistent with a research by **Futter et al. (2024)** that showed a substantial increase in RR during ES due to suction causing pain and restlessness.

The results of **Yazdannik et al. (2023**), who discovered no discernible difference in heart rate between closed and open suction systems, are consistent with this investigation. The closed suction exhibited a substantially lower pulse rate than the open suction, (**Keykha et al., 2024).**

The current study illustrated that the mean ±SD of respiratory rate among studied mechanically ventilated patients in open and closed suction, as revealed in this table before suction, there was no statistical significant differences between the two suction groups, but respiratory rate differences between the open and close suction groups, during suction, and after suction there was statistically significant improved. 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)**.

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)**. 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 during suction, there is a considerable change in SpO2 between open and closed suction methods. The results demonstrate that during suction, there is a significant difference between open and closed suction which was 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. This is aligned with the recommendations of updated AARC guidelines for airway suctioning **(Blakeman et al., 2022)**. Our findings are supported by another study **(Elmelegy & Ahmed, 2019)**. By contrast, the current findings are inconsistent with another study 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 **(Ebrahimian et al., 2020).**

According to a study by **Taheri et al. (2022**), hypoxia triggers the adrenergic nerve system, which regulates cardiovascular and hemodynamic reactions like tachycardia. The study also found that the arterial blood oxygen saturation ratio dramatically decreased during and immediately after suctioning. A study that found that open system suctioning is the cause of bacterial contamination, lung collapse, and desaturation showed similar results. By permitting respiration to continue during suctioning, a closed suction system lessens desaturation and lung collapse. Closed suctioning was initially employed for hygienic reasons, as well as to prevent desaturation and lessen lung volume loss while suctioning, according to a few further investigations. A study by Ali **Mohammadpour et al., (2019**) also concluded that oxygenation and ventilation are better preserved with closed suctioning system.

These findings showed that while there was a significant variation in MAP during the suctioning process, there was no significant difference between the open and closed ways of suction prior to suctioning. Similar to this, **Evans et al., (2024)** investigated the effects of cardiac respiratory parameters in both open and closed suction using a quasi-experimental design. A total of sixty mechanically ventilated patients were selected. The study's conclusions indicate that closed suction significantly affects cardiovascular parameters. In order to maintain oxygen saturation and provide patients with safe, high-quality care, it makes sense to use the closed suction approach when they are on ventilation.

In the current study, mean arterial blood pressure increased significantly during suction in the groups using open suction systems. This result is in line with earlier studies that discovered a statistically significant variation in mean arterial blood pressure when suctioning. **Favretto et al. (2022)** and **Adib et al. (2024**) found that oxygenation before to endotracheal suction increased variability in mean arterial blood pressure readings in a study of patients undergoing coronary artery bypass grafting. According to the researchers, the catheter is a component of a ventilator circuit in a close endotracheal suction system, which improves oxygenation by removing the need to disconnect the ventilator and thereby lowering hemodynamic parameters like heart rate and mean arterial blood pressure. Also, **Chegondi al., (2024)** also agreed that the mean minimum SpO2 was significantly greater during closed suction compared to open suction.

These results contradict our findings because they noted no significant changes in the patients' 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 et al., 2018)**. Similarly, **Siyasari et al. (2018)** reported that the differences in the patients' SBP and MAP were not statistically significant between the two groups.

These results of the current study showed that changes in PaO_2 and $PaCO_2$ were statistically different between the studied mechanically ventilated patients in both open and closed suction groups regarding changes in PaO2 and PaCO2. This result was in the same line with two studies demonstrated that CES could partially prevent lung volume loss and arterial oxygenation impairment in patients with ALI receiving mechanical ventilation with positive end-expiratory pressure. Based on continuous blood gas monitoring, the results demonstrate that CES did not induce significant deleterious change in gas exchange during the procedure itself (**Lee & Kim, 2024).**

Conclusion:

Based on the findings of the present study, it can be concluded that the implementation of the closed suction system leads to decrease instabilities in the cardiorespiratory parameters, less suctioning time, less deterioration in gas exchange compared to patients on mechanical ventilation using an open suction system. Thus, in general intensive care units, the close suction system are the most effective suctioning technique for patients on mechanical ventilation.

Recommendation:

Based on the results of the present study, the current study recommended that:

1. The closed suction technique must be used by all healthcare organizations as a high nursing care standard.
2. All critical care units should encourage and train their critical care nurses to use the closed suction system.
3. 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.

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