Effect of Shallow versus Deep Suctioning Techniques on Endotracheal Tube Cuff Pressure Measurements and Physiological Indices among Patients Undergoing Mechanical Ventilation

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Background: Endotracheal suctioning has a significant impact on the physiological indices, and it is one of the most common interventions in mechanically ventilated patients that can impact the endotracheal tube cuff pressure. **Aim:** The current study aimed to investigate the effect of shallow versus deep suctioning techniques on endotracheal cuff pressure measurements and physiological indices among patients undergoing mechanical ventilation. **Design**: Quasi-experimental study design. **Setting:** This study was conducted at both Anesthesia Intensive Care Unit and Traumatology and Emergency Medicine Intensive Care Unit in Tanta Emergency Hospital affiliated to Tanta University Hospitals. **Subjects:** A purposive sampling of 100 adult patients from previously mentioned setting. **Tools:** Three tools were used to obtain necessary data for this study: **Tool I:** Mechanically ventilated patient assessment tool, **tool II:** Endotracheal cuff pressure measurements schedule. **Tool III:** Physiological indices assessment. **Results:** there was a decrease in ETT cuff pressure after suctioning compared to pre suctioning in both groups. Also, SBP increased immediately after suctioning among both groups, then returned to the previous range after 10 minutes of suctioning. On the other hand, significant differences were noticed regarding MAP, HR, and SpO_2 only in the deep suctioning group with $P<0.05$. **Conclusion:** It can be concluded that deep endotracheal suctioning is more effective in removing secretions and improving SpO_2. Meanwhile, it may induce higher variations in hemodynamic parameters and tube cuff pressure than shallow endotracheal suctioning. **Recommendations:** CCNs are recommended to perform ETT suctioning using the shallow method while deep suctioning should be used only if indicated.

Key Words: Deep suctioning, Endotracheal tube cuff pressure, Mechanically ventilated patients, Physiological indices & Shallow suctioning.

Introduction

Critically ill and intubated patients are at risk of excessive secretions because they are sedated, immobile, and have mechanical adjuncts that prevent secretions from clearing spontaneously. Suctioning can maintain gas exchange, adequate oxygenation, and alveolar ventilation. Furthermore, there are two types of endotracheal tube suctioning: Shallow and deep suctioning. **Deep endotracheal suctioning** means inserting the catheter until resistance or cough detected, then slowly withdrawing it 1-2 cm before applying suction then slowly withdrawing it from the airway. On the other hand, **shallow endotracheal suctioning** involves inserting the catheter till it emerges from the lumen of the tracheal tube during which stimulation of the carina should be avoided. (**Shamali, et al., 2019; Shamali, et al., 2017; Sinha, et al., 2022)**

Endotracheal suctioning technique has a significant impact on the physiological indices of critically ill ventilated patients. Tracheal suctioning causes mental stress, pain and panic, which stimulates the sympathetic nervous system, that increases peripheral vascular resistance, potentially blood pressure, and heart rate. Moreover, the most common complication of endotracheal suctioning is hypoxemia. Additionally, hemorrhage, infection, atelectasis, cardiovascular instability, high intracranial pressure, and tracheal mucosa lesions are complications of endotracheal suctioning. (**Alavi, et al., 2018; Alshahrani, 2021; Kostekli, et al., 2022)**

Therefore, because airway suctioning has many adverse effects, it should be performed only when indicated rather than on a predetermined schedule. The indications for suctioning include visible secretions in the tube, frequent coughing, presence of rhonchi, oxygen desaturation, a change in vital signs such as increased or decreased heart rate or respiratory rate, dyspnea, restlessness, increased peak inspiratory pressure (PIP), or high-pressure ventilator alarms. (**Heidari, et al., 2017)**

Additionally, Tracheal cuff pressure management is a critical component of artificial airway management. Cuffed endotracheal tubes are used to maintain ventilator compliance and prevent pulmonary aspiration in mechanically ventilated patients. Capillary perfusion requires a safe perfusion pressure of 20–30 cmH_2O. However, keeping it in this range is challenging. Thus, a cuff pressure greater than this value may cause ischemic changes in the tracheal mucosa resulting in ulceration, necrosis, and fistula formation. while a pressure of less than 20 cm H_2O raises the risk of ventilator-associated pneumonia. **(Letvin, et al., 2018; Nazari, et al., 2021; Özcan, et al., 2018)**

Many studies have found changes in tube cuff pressure outside the normal range following initial adjustment. These variations have been attributed to a variety of factors, including insertion of the suction catheter, coughing, ventilator desynchrony, changing patient temperature, and changing head position. Among these factors, tracheal suctioning, which is one of the most common interventions in mechanically ventilated patients that can impact the tube cuff pressure. **(Krisciunas, et al., 2020; Nazari, et al., 2020; Nazari, et al., 2021; Nazari, et al., 2020; Orandi, et al., 2021; Parsian, et al., 2019)**

In this regard, with the increasing demand for global intensive care, the role of the critical care nurse is to achieve the optimal breathing pattern in an intubated patient and prevent side effects of intubation and suctioning procedure, this could be achieved by assessing patient's hemodynamic and respiratory parameters to identify whether the suction is indicated, preoxygenating the patient with 100% oxygen for at least 30 seconds prior to and after the suctioning procedure to prevent desaturation, position the patient in a semi fowler's position and the size of the suction catheter should be less than half the diameter of the tracheal tube. **(Afenigus, et al., 2021; Chen, et al., 2021; Mokadem, et al., 2020)**

Moreover, a negative pressure of (80 - 120 mmHg) is applied only while withdrawing the suction catheter in a rotational movement, suction time should not exceed 10-15 seconds, the use of aseptic technique throughout the procedure to prevent infection, reassessing patient's hemodynamics and respiratory parameters during and after suctioning, assessing the endotracheal tube cuff pressure changes before and post suctioning, and maintain proper cuff inflation and monitoring techniques. **(Ghorbanpoor, et al., 2018; Ismail, et al., 2022; Miller, et al., 2019) .**

Significance of the study:

Although mechanical ventilation and endotracheal intubation remains a lifesaving supportive therapy. It also poses a significant risk for complications such as aspiration, hypoxemia, and airway ischemia as a result of hyper inflated cuff. Moreover, extubation should be attempted as soon as clinically indicated in order to prevent respiratory complications and minimize the risks of morbidity and mortality associated with prolonged mechanical ventilation. So, the current research aims to evaluate the effectiveness of shallow versus deep artificial airway suctioning techniques on endotracheal cuff pressure measurement and physiological indices.

Aim of the study:

The current study aimed to evaluate the effect of shallow versus deep suctioning techniques on endotracheal cuff pressure measurements and physiological indices among patients undergoing mechanical ventilation.

Research hypothesis:

The mechanically ventilated patients who will undergo shallow suctioning technique are expected to exhibit less alterations of endotracheal cuff pressure measurements and physiological indices than those who will undergo deep suctioning technique.

Subjects and Method

Subjects

Design:

A quasi-experimental study design was utilized in the current study.

Study setting:

This study was conducted at:

- The Anesthesia Intensive Care Unit in Tanta Emergency Hospital is affiliated to the Ministry of Higher Education and Scientific Research. It was prepared and equipped with 5 wards; each ward equipped with 4 beds; the total number of beds is 20.
- Traumatology and Emergency Medicine Intensive Care Unit in Tanta Emergency Hospital is affiliated to the Ministry of Higher Education and Scientific Research. It was prepared and equipped with 3 wards; each ward equipped with 4 beds; the total number of beds is 12.

Subjects:

A purposive sampling of 100 adult patients from the previously mentioned setting who fulfilled the inclusion criteria. The sample size was calculated using Epi-Info software statistical program according to the total population admitted per year to the Emergency Intensive Care Unit and undergo endotracheal intubation (200 patients). Allocating the subjects to the shallow and deep suctioning groups. The sample size was calculated as the following:

Z= confidence level 95%, d= Error proportion (0.05), P= population (60%).

The patients were divided into two equal groups; 50 patients in each as follows: -

Group I: Shallow ETT suctioning technique: The ETT cuff pressure was set at 30 cmH_2O using a cuff inflator. The suction catheter was inserted until it emerged from the lumen of the ETT.

Group II Deep ETT suctioning technique: The ETT cuff pressure was set at 30 cmH2O using a cuff inflator. The suction catheter was inserted and advanced to the end of the ETT until resistance or coughing was detected.

The patients enrolled in the study according to the following inclusion criteria: Adult patients aged from 21-60 years, undergoing oral or nasal endotracheal tube, mechanically ventilated with a positive end expiratory pressure (PEEP) of 5 cmH2O, hemodynamically stable, and had the indications for suction.

Tools of data collection: Three tools were used in order to collect the necessary data for this study as follows: -

Tool I: Mechanically Ventilated Patient Assessment Tool: This tool was developed by the researcher after reviewing of related literature (**Ahmed, et al., 2017; Allam, et al., 2022; Jansson, et al., 2017; Mohammed, et al., 2021)** to assess mechanically ventilated patients. It consisted of three parts as the following:

Part (1): Bio-sociodemographic Data of the Intubated Patients; this part concerned data related to patients' age, gender, diagnosis, and past and present medical history.

Part (2): Mechanically Ventilated Patient Assessment Sheet; This part was used to assess parameters of mechanical ventilation such as fraction of inspired oxygen (FIO_2), Tidal volume (V_T), mandatory and spontaneous respiratory rate, pressure support (Ps), duration of mechanical ventilation, and mode of mechanical ventilator. Also, this part was used to assess the depth of breathing, amount, consistency and color of secretions, chest movement and chest sound.

Part (3): Suction Assessment Profile; This part was used to assess data related to size of endotracheal tube and site of endotracheal tube insertion.

Tool II: Endotracheal Cuff Pressure Measurements Schedule; This tool was developed by the researcher after reviewing a relevant literature (**Nazari, et al., 2020)** to measure the endotracheal cuff pressure pre and post suction of both shallow and deep suctioning techniques and the pressure was monitored using an aneroid manometer.

Tool III: Physiological Indices Assessment; This tool was developed by the researchers after reviewing a relevant literature (**Shamali, et al., 2019)** to assess measurements of the physiological indices before, immediately after, and 10 min after endotracheal suctioning. It included systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and peripheral oxygen saturation.

Method

1. **Administrative process:** An official permission was obtained from the Dean of Faculty of Nursing to the director of Anesthesia Intensive Care Unit in Tanta Emergency Hospital and the Surgical Intensive Care Unit in International Educational Hospital, Tanta University Hospitals, to obtain their permissions to collect data from selected setting**.**

- **Ethical and legal considerations:** Approvals of The Scientific Research Ethics Committee of the Faculty of Nursing with code number (28/11/22) and the Scientific Research Ethics Committee of the Faculty of Medicine with code number (36104/11/22) were obtained.
- The study didn't cause any harm to the intubated patients as the researcher had performed the shallow and deep suctioning techniques under medical supervision.
- Confidentiality of data collected, and privacy of patients was put into consideration.

2. All tools of the study were developed by the researcher based on a review of the relevant literature.
3. All tools of the study were tested for content validity, clarity and applicability by five experts in the field of specialty such as Critical Care and Emergency Nursing, Anesthesia and Biostatistics.
4. The reliability of the developed tools was tested by using Cronbach's alpha factor and found to be **0.885** for the tool I, **0.826** for tool II and **0.951** for tool III which represented reliable tools.
5. **A pilot study** was conducted before the actual study on 10 patients of the subjects for testing the tools for its clarity, applicability and to identify obstacles that may be encountered with the researcher during data collection. Accordingly, the necessary modification was done by the researcher before study. The subjects in pilot study were excluded from the current study.
6. **Field work:** Data were collected within 6 months started from the first of February 2023 to the end of July 2023.
7. **The present study was conducted through four main phases:** assessment, planning, implementation, and evaluation.

I. Assessment phase: During this phase the researcher assessed the mechanically ventilated patients who fulfilled inclusion criteria.

The patients' sociodemographic and clinical data, parameters of mechanical ventilation, chest assessment, characteristics of secretions, suction catheter size were assessed by using **tool I**.

Also, ETT cuff pressure was monitored by using **tool II**. Moreover, physiological indices such as systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and peripheral oxygen saturation were assessed by using **tool III.**

II. Planning phase: This phase was formulated based on the subjects' assessment and extensive review of the related literature.

Expected clinical outcomes of the study included:

1. The patients who undergo shallow suctioning technique exhibit normal or minimal alterations of physiological indices post suction than those who undergo deep suctioning technique.
2. The endotracheal tube cuff pressure measurements exhibit less or no changes post suction in the shallow suctioning group than those in the deep suctioning group.

III. Implementation phase: at the beginning of this phase, the researcher prepared the patients and equipment, then started the techniques of suctioning as the following:

- The patients were assessed in both groups for signs of airway compromise or inadequate oxygenation to determine the need for suction.
- The appropriate depth to advance the suction catheter was predetermined for each group.
- Physiological indices were measured immediately pre-suctioning in addition to respiratory rate, depth of breathing and breath sounds.
- The ETT cuff was inflated before applying suction to maintain the cuff pressure at 30 cmH_2O using a cuff manometer.
- The researcher put the patients in a semi-Fowler position with the head on one side.
- The work area was prepared in a clean, easily accessible and all necessary supplies were assembled.
- The unit's negative pressure was checked by occluding the end of the suction tube before attaching it to the suction catheter and it was adjusted to less than 150 mm Hg.
- The researcher ensured that patients were connected with pulse oximeter throughout the procedure to be monitored for hypoxia.
- The diameter of the suction catheter was limited to less than 50% of ETT internal diameter, resulting in lower negative pressure. **(Ahmed, et al., 2017)**
- The researcher used aseptic technique during the procedure, the flexible catheter package was opened on a clean surface, the inside of the wrapping was used as a sterile field; the package was just opened enough to expose the connecting end.
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For study group I (Shallow ETT suctioning);

- The intubated patients were disconnected from the ventilator without negative pressure, the suction catheter was inserted only to the end of the endotracheal tube end.
- The size of endotracheal tube was measured using a ruler. Then, using this ruler and according to the size of patient's endotracheal tube, the size of inserted suction catheter was calculated.
- With the dominant hand, the catheter was prevented from entering further into the patient's endotracheal tube.
- To perform a sterile procedure, it was ensured that the catheter did not touch the ruler and the measurement on the ruler was done from a close distance.
- **For study group II (Deep ETT suctioning);**
- The researcher disconnected the patient from ventilator and stopped any negative pressure, the suction catheter was introduced to the end of the endotracheal tube until resistance or cough was detected, then it was pulled back 1-2cm and suctioning was performed while the catheter was removed.
- Suctioning time didn't exceed more than 10-15 seconds from insertion to removal of the catheter for a maximum of three suction passes. **(Afenigus, et al., 2021)**
- All of patients in both shallow and deep suctioning groups were hyper-oxygenated with 100% oxygen for at least 30 s before and after the endotracheal tube suctioning procedure. **(Afenigus, et al., 2021)**
- The suction catheter was advanced through the artificial airway into the trachea and the negative pressure was applied as the catheter was being withdrawn.
- Patients' breath sounds, respiratory rate, chest movement, and characteristics of secretions were monitored and documented after endotracheal tube suctioning to ensure effective cleaning.
- The endotracheal tube cuff pressure was measured and recorded immediately after and after 10 minutes of ETT suctioning in both groups.
- Physiological parameters were measured and recorded immediately after and after 10 minutes of ETT suctioning in both groups.

IV. Evaluation phase: All mechanically ventilated patients in both groups were evaluated by using tool I part (2) after implementation of shallow and deep suctioning. Also, endotracheal cuff pressure measurements (using tool II) and physiological indices (using tool III) were measured immediately after, and after 10 minutes from suctioning.

Statistical analysis: The collected data was processed, tabulated, and statistically analyzed with SPSS Version 25.0. Qualitative data were described using numbers and percentages. Quantitative data were presented as mean ± standard deviation. Finally, data were analyzed and interpreted. P-values of 0.05 or less were considered statistically significant.

Results

Table (1) shows percent distribution of the studied patients according to their sociodemographic characteristics. It was observed that about half (50%, 48%) of the studied patients in both shallow and deep suctioning groups were in age group between (50-60) years with mean ± SD (47.22±10.426 and 46.78±10.461) respectively. Also, more than half (54%, 56%) of them were male, respectively.

Table (2) illustrates percent distribution of the studied patients according to their clinical data. it was noticed that more than one third (32%, 40%) of the studied patients in both shallow and deep suctioning groups were diagnosed as head/spinal cord injury, respectively. Also, nearly one third (30%, 32%) of them had metabolic disorders as a comorbid disease. On the other hand, the majority (90%, 88%) of patients in both shallow and deep suctioning groups had no surgical history.

Figure (1) illustrates the percent distribution of the studied patients regarding modes of mechanical ventilation. It was noticed that higher percentages (72%, 90%) of critically ill patients in both shallow and deep suctioning groups were on SIMV-VC mode, respectively. On the other hand, the lower percentages (12%, 0%) of them were on CPAP/Ps mode, respectively.

Table (3) demonstrates the mean scores of ventilator parameters of the studied patients. The table presents that the mean scores of FiO_2 in both shallow and deep suctioning groups were 44.00±9.689 and 48.40±13.607 respectively. While the mean ± SD of tidal volume was 422.44±29.429 in the shallow suctioning group and 424.00±32.598 in the deep suctioning group. Additionally, the mean ± SD of mandatory respiratory rate that was set in the shallow suction group was 12.52±5.296 while in the deep suction group was 14.16±2.280. On the other hand, the mean ± SD of spontaneous respiratory rate of both shallow and deep suctioning groups were 19.30±4.423 and 18.70±4.590 respectively.

Table (4) demonstrates the percentage distribution of the studied patients regarding their chest assessment. Concerning the depth of breathing, it was noticed that more than half (54%) and nearly half (48%) of the studied patients of both shallow and deep suctioning groups had shallow breathing, respectively. Additionally, nearly two thirds (60%, 58%) of patients in both studied groups had symmetrical chest movement. Moreover, no significant difference was observed regarding depth of breathing, chest sounds and chest movement among shallow and deep endotracheal suctioning groups.

Table (5) illustrates distribution of the studied patients regarding their characteristics of secretions. It was observed that 82%, 52% and 60% of patients in shallow suctioning group had amount of secretions less than 100 ml that were thick/tenacious in consistency with clear color, respectively. On the other hand, only 44% of the studied patients in deep suctioning group had amount of secretions less than 100 ml and (58%, 40%) of them had thick/tenacious with clear color, respectively.

Table (6) illustrates mean scores of endotracheal tube cuff pressure in the studied patients throughout periods of intervention. The mean cuff pressure of all patients in both shallow and deep suctioning groups was (30.00±0.00) pre suction. On the other hand, there was a decrease in the mean values of ETT cuff pressure after suctioning compared to pre suctioning mean values. In shallow suctioning group, the cuff pressure mean values decreased to (26.08±1.46, 26.16±1.45) immediately after suctioning during morning and afternoon shifts, respectively. Then it continued to decrease (22.12±1.78, 22.20±1.77) after 10 minutes of suctioning during morning and afternoon shifts. In the deep suctioning group, the cuff pressure mean decreased to (22.84±1.41, 22.96±1.47) immediately after suctioning during morning and afternoon shifts compared to shallow suctioning group. Moreover, these values continued to decrease (18.12±1.64, 18.18±1.56) after 10 minutes of suctioning during morning and afternoon shifts. There were statistically significant differences among both groups and throughout periods of intervention where p = 0.000.

Table (7) represents comparison between shallow and deep endotracheal tube suctioning groups according to physiological indices throughout periods of intervention. Regarding systolic and diastolic blood pressure, it was noticed that the mean of systolic blood pressure on the morning shift was increased (126.88±19.35, 130.74±17.30) immediately after suctioning among both groups respectively, then it returned to the previous range after 10 minutes of suctioning (114.52±18.64, 118.42±15.77) respectively. Also, the mean score was increased on the afternoon shift immediately after suctioning among both groups where it was (127.28±17.89, 130.16±16.04) respectively. Statistically significant differences were observed among shallow and deep suctioning groups and throughout the periods of intervention where p = 0.000.

Regarding arterial pressure and heart rate, statistically significant differences were noticed only in the deep suctioning group on the morning and afternoon shifts with p = (0.019, 0.023) and (0.001, 0.001) respectively.

Concerning oxygen saturation, the mean score was increased among shallow suctioning group after 10 minutes of suction (98.00±1.59) compared to (97.68±1.74) in the deep suctioning group. Statistically significant differences were noticed among the deep suctioning group throughout period of study on the morning and afternoon shifts with p=0.000 and 0.017.

Table (1): Percent distribution of the studied patients according to their bio-demographic characteristics.

Characteristics	The studied ventilated patients (n=100)				
	Shallow suction (n=50)		Deep suction (n=50)		χ^2 P
	N	%	N	%	
Age (in years)					
▪ (21-<30)	4	8.0	5	10.0	
▪ (30-<40)	7	14.0	8	16.0	0.235
▪ (40-<50)	14	28.0	13	26.0	0.972
▪ (50-60)	25	50.0	24	48.0	
Range **Mean ± SD**	**(21-60)** **47.22±10.426**		**(22-60)** **46.78±10.461**		t=0.211 P=0.834
Gender					
▪ Male	27	54.0	28	56.0	FE
▪ Female	23	46.0	22	44.0	1.00

FE: Fisher’ Exact test

Table (2): Percent distribution of the studied patients according to their clinical data.

Clinical data	The studied ventilated patients (n=100)				
	Shallow suction (n=50)		Deep suction (n=50)		χ^2 P
	N	%	N	%	
Medical diagnosis					
▪ Respiratory disorders	11	22.0	10	20.0	
▪ Acute kidney injury	2	4.0	2	4.0	
▪ Shock	5	10.0	6	12.0	5.975
▪ Poisoning	0	0.0	2	4.0	0.650
▪ Head/spinal cord injury	16	32.0	20	40.0	
▪ Metabolic disorder	9	18.0	7	14.0	
▪ Hepatic encephalopathy	7	14.0	3	6.0	
Past medical history					
▪ Respiratory disorders	10	20.0	13	26.0	
▪ Cardiovascular disease.	5	10.0	3	6.0	
▪ Neurological disorder.	4	8.0	3	6.0	2.053
▪ Gastrointestinal disorder	7	14.0	9	18.0	0.726
▪ Metabolic disorder	15	30.0	16	32.0	
▪ None	9	18.0	6	12.0	
Surgical history					9.011
▪ No	45	90.0	44	88.0	0.531
▪ Yes	5	10.0	6	12.0	

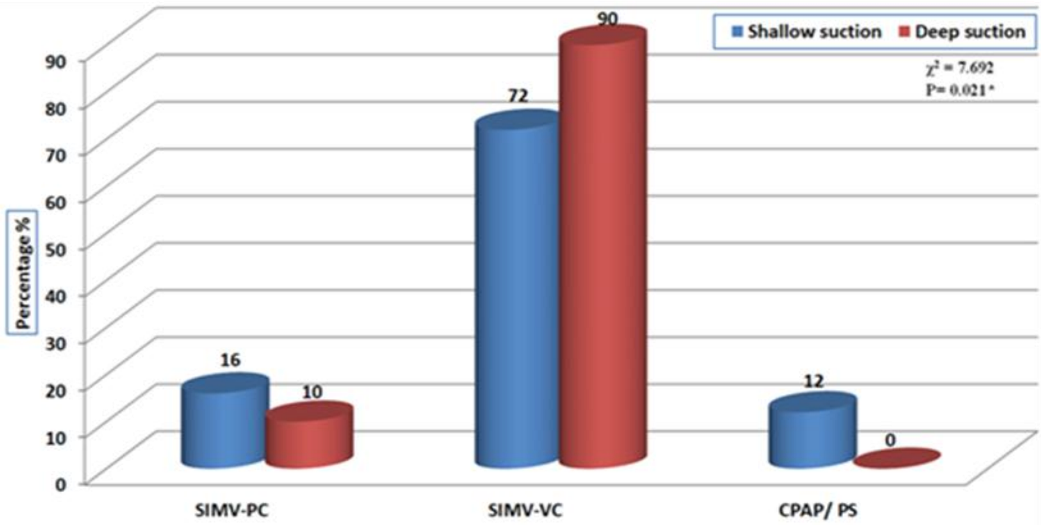

Figure (1): Percent distribution of the studied patients regarding modes of mechanical ventilation.
SIMV: synchronized intermittent mandatory ventilation. PC: pressure control
VC: volume control CPAP: continuous positive airway pressure PS: pressure support

Table (3): Mean scores of ventilator parameters of the patients of both the studied groups.

Ventilator Parameters	The studied ventilated patient (n=100) Range Mean ± SD		t P
	Shallow suction (n=50)	Deep suction (n=50)	
1. Friction of inspired oxygen (FiO2)	(40-80) 44.00±9.689	(40-80) 48.40±13.607	1.863 0.066
2. Tidal volume (VT)	(375-450) 422.44±29.429	(375-450) 424.00±32.598	0.251 0.802
3. Mandatory respiratory rate	(0-18) 12.52±5.296	(12-18) 14.16±2.280	**2.011 0.047***
4. Spontaneous respiratory rate	(13-30) 19.30±4.423	(13-30) 18.70±4.590	0.666 0.507
5. Pressure support	(8-14) 10.52±2.013	(8-14) 10.68±1.963	0.402 0.688

* Significant at level P<0.05

Table (4): percent distribution of the studied patients regarding their chest assessment.

Chest Assessment	The studied ventilated patients (n=100)				
	Shallow suction (n=50)		Deep suction (n=50)		χ^2 P
	N	%	N	%	
Depth of breathing					
▪ Normal	9	18.0	7	14.0	1.184 0.553
▪ Deep	14	28.0	19	38.0	
▪ Shallow	27	54.0	24	48.0	
Chest sounds					
▪ Normal	6	12.0	2	4.0	4.451 0.217
▪ Crackles	20	40.0	23	46.0	
▪ Wheezing	15	30.0	15	30.0	
▪ Others	9	18.0	10	20.0	
Chest movement					
▪ Symmetrical	30	60.0	29	58.0	1.993 0.369
▪ Asymmetrical	9	18.0	14	28.0	
▪ Paradoxical chest movement	11	22.0	7	14.0	

Table (5): Distribution of the studied patients regarding their characteristics of secretions.

Characteristics of secretions	The studied ventilated patients (n=100)				
	Shallow suction (n=50)		Deep suction (n=50)		χ^2 P
	N	%	N	%	
Amount					
▪ No secretions	6	12.0	1	2.0	**28.867 0.000***
▪ <100 ml	41	82.0	22	44.0	
▪ (100-150) ml	3	6.0	20	40.0	
▪ >150 ml	0	0.0	7	14.0	
Consistency of secretions					
▪ Thick/tenacious secretions	26	52.0	29	58.0	FE 0.688
▪ Watery secretions	24	48.0	21	42.0	
Color of secretions					
▪ Clear	30	60.0	20	40.0	5.919 0.314
▪ Blood streaked	2	4.0	5	10.0	
▪ Pink	3	6.0	2	4.0	
▪ Green	0	0.0	1	2.0	
▪ Purulent	11	22.0	15	30.0	
▪ White and milky	4	8.0	7	14.0	

* Significant at level P<0.05.

Table (6): Mean scores of endotracheal tube cuff pressure in the studied patients throughout periods of intervention.

Cuff pressure Monitoring	The studied mechanically ventilated patient (n=100)							
	Shallow suction			F P	Deep suction			F P
	Pre Suction	Immediately after Suctioning	After 10 min of suctioning		Pre Suction	Immediately after Suctioning	After 10 min of suctioning	
Morning shift	(30-30) 30.00±0.00	(24-28) 26.08±1.46	(20-26) 22.12±1.78	**440.61** **0.000***	(30-30) 30.00±0.00	(20-26) 22.84±1.41	(16-22) 18.12±1.64	**1153.43** **0.000***
Afternoon shift	(30-30) 30.00±0.00	(24-28) 26.16±1.45	(20-26) 22.20±1.77	**435.53** **0.000***	(30-30) 30.00±0.00	(20-26) 22.96±1.47	(16-22) 18.18±1.56	**1153.35** **0.000***
t, P	-	0.389, 0.699	0.340, 0.735		-	0.425, 0.673	0.191, 0.849	
Shallow Vs Deep **t** **P**	**Morning**	**11.329** **0.000***	**11.696** **0.000***					
	Afternoon	**10.966** **0.000***	**12.034** **0.000***					

* Statistically significant at level P<0.05

Table (7): Comparison between shallow and deep endotracheal tube suctioning groups according to physiological indices throughout periods of intervention.

Physiological Indices	The studied mechanically ventilated patient (n=100) Range Mean ± SD							
	Shallow suction (n=50)			F P	Deep suction (n=50)			F P
	Pre Suction	Immediately after Suctioning	After 10 min of suctioning		Pre suction	Immediately after suctioning	After 10 min of suctioning	
Blood pressure **1. Systolic (SBP)**								
▪ Morning shift	(87-159) 112.48±19.09	(96-176) 126.88±19.35	(91-161) 114.52±18.64	**8.38** **0.000***	(87-162) 116.44±16.97	(96-175) 130.74±17.30	(91-159) 118.42±15.77	**10.78** **0.000***
▪ Afternoon shift	(90-158) 112.48±18.03	(105-177) 127.28±17.89	(89-156) 113.56±17.37	**10.78** **0.000***	(90-158) 115.92±16.02	(97-169) 130.16±16.04	(89-156) 117.70±15.70	**11.87** **0.000***
t , P	-	0.678, 0.501	**2.221, 0.031***			1.029, 0.308	1.522, 0.134	
Shallow Vs Deep **t , P**	**Morning** **Afternoon**	1.052, 0.296 0.848, 0.399	1.130, 0.261 1.250, 0.214					
2. Diastolic (DBP)								
▪ Morning shift	(52-95) 70.16±13.89	(54-97) 71.12±13.89	(53-95) 70.32±13.91	0.07 0.934	(52-95) 72.94±12.91	(55-102) 77.48±13.44	(53-97) 73.86±12.81	1.69 0.188
▪ Afternoon shift	(53-92) 70.52±13.43	(54-94) 71.48±13.58	(52-92) 70.60±13.08	0.08 0.924	(53-99) 73.76±12.53	(56-103) 77.80±12.41	(52-97) 74.18±12.26	1.61 0.204
t , P	-	0.967, 0.338	0.741, 0.462			0.525, 0.602	0.711, 0.481	
Shallow Vs Deep **t , P**	**Morning** **Afternoon**	**2.327, 0.022*** **2.430, 0.017***	1.324, 0.189 1.412, 0.161					
3. **Mean Arterial pressure (MAP)**								
▪ Morning shift	(64-113) 83.92±15.43	(68-120) 89.48±15.39	(66-114) 84.68±15.22	1.93 0.149	(64-114) 87.10±14.01	(72-126) 94.58±14.51	(66-114) 88.38±13.42	**4.09** **0.019***
▪ Afternoon shift	(65-114) 84.16±14.82	(71-121) 89.76±14.77	(65-112) 84.52±14.35	2.29 0.105	(65-114) 87.52±13.37	(73-121) 94.46±13.46	(65-115) 88.74±13.18	**3.86** **0.023***
t , P	-	0.772, 0.444	0.474, 0.637			0.216, 0.830	0.629, 0.532	
Shallow Vs Deep **t , P**	**Morning** **Afternoon**	1.705, 0.091 1.663, 0.099	1.289, 0.200 1.531, 0.129					

Heart rate (HR)									
▪ Morning shift	(58-114) 83.56±16.21	(71-129) 97.84±16.75	(60-117) 85.76±16.04	1.08 0.295	(57-126) 83.70±16.44	(63-131) 95.40±17.06	(59-117) 85.06±15.87	**7.55 0.001***
▪ Afternoon shift	(59-112) 82.84±16.01	(73-128) 97.32±16.81	(62-114) 85.20±15.93	1.42 0.215	(59-118) 83.48±15.30	(63-127) 94.22±16.23	(59-114) 84.54±14.94	**7.29 0.001***
t , P	-	1.061, 0.294	1.281, 0.206			1.632, 0.109	0.871, 0.388	
Shallow Vs Deep t , P	**Morning**	0.722, 0.472	0.219, 0.827					
	Afternoon	0.938, 0.351	0.214, 0.831					
Oxygen saturation (SpO2)								
▪ Morning shift	(89-97) 94.12±2.13	(92-100) 96.92±1.98	(94-100) 98.00±1.59	**54.89 0.000***	(86-96) 92.06±2.77	(92-100) 96.96±2.02	(94-100) 97.68±1.74	**94.73 0.000***
▪ Afternoon shift	(90-97) 94.48±1.88	(94-99) 97.20±1.37	(95-100) 98.16±1.39	**74.56 0.000***	(88-97) 92.86±2.37	(94-100) 97.58±1.58	(94-100) 98.14±1.53	**120.70 0.000***
t , P	-	1.819, 0.075	1.112, 0.272			**4.185, 0.000***	**2.478, 0.017***	
Shallow Vs Deep t , P	**Morning**	0.100, 0.921	0.959, 0.340					
	Afternoon	1.285, 0.202	0.069, 0.946					

* Statistically significant at level P<0.05.

Discussion

Endotracheal tube suctioning is one of the most common ICU interventions. Despite the risks, suction remains the only appropriate method for removal of secretions and airway clearance in patients receiving mechanical ventilation. Effectiveness and adverse effects of suction vary according to the depth of catheter, which may impact endotracheal tube cuff pressure and physiological parameters in critically ill patients. **(Liao, et al., 2019; Nazari, et al., 2021)**

Part I: Socio-demographic characteristics and clinical data of the studied intubated patients.

Regarding the age of the studied patients, the current study reported that about half of patients in both groups were in the age group between (50-60) years. It can be interpreted that aging as a medical concept represents a complex transition that includes numerous physiological changes which affect the immune system and change the functions of cells and organs. Therefore, old patients are at greater risk of falls, disability, cognitive decline, hospitalization, and the need for care.(**Guo, et al., 2022)**

This finding matched with, **Chung, et al., (2023)**, who conducted a study about "impact of age on mortality and transfer to long-term care in patients in an intensive care unit" and found that nearly half of the studied patients' ages ranged between 47-61 years old.

Concerning sex, the present study reported that more than half of the studied patients in both groups were male. This can be explained by the fact that men have a higher prevalence of high-risk behaviors and were more likely to work in high-risk jobs which increases their risk of exposure to infections or accidents. This finding agreed with, **Çardaközü, et al., (2023),** who conducted a study about "objective and subjective evaluation of endotracheal tube cuff pressure between different levels of anesthesia experiences" and found that more than half of the studied patients were male.

Regarding medical diagnosis, the current results indicated that more than one third of the patients in both studied groups were admitted with head/spinal cord injury. This because the percentage of men is greater than that of women in this study and may be attributed to the fact that severe injuries constitute a public health problem that increases due to accidents, violence, and criminal activities. So, head/spinal cord injuries remain a major cause of hospitalization and intensive care admission. **(Berheto, et al., 2023)**

This finding matched with, **Allam, et al., (2022)**, who reported in a study about "Effect of suctioning on endotracheal cuff pressure monitoring during fixed volume versus minimal leak techniques among mechanically ventilated patients" that found that more than one third of the studied patients in both groups were admitted with trauma. Additionally, about one third of the studied patients in both groups have a history of metabolic disorder. This may be due to physiological and pathological changes related to the age of the studied patients. These findings agreed with, **Thomas-Rüddel, et al., (2023),** who illustrated in a study about "Sepsis and underlying comorbidities in intensive care unit patients" that more than one third of the studied patients have a history of diabetes mellitus and about one quarter of them had renal disease.

Moreover, the present study revealed that higher percentages of the studied patients of both groups had no past surgical history. This finding supported by **Lema-Zuluaga, et al., (2018),** who conducted a study entitled

"As-needed endotracheal suctioning protocol vs a routine endotracheal suctioning in Intensive Care Unit: A randomized controlled trial" and found that most of the studied patients of both studied groups had no past medical history.

Part II: Assessment of ventilator data and parameters of both studied groups.

According to the mode of ventilator, the present study revealed that the majority of the studied patients in both groups were on SIMV-VC mode. This may be due to the effect of good treatment regimen for the patients in ICU and also about half of the patients stayed more than 6 days while the researcher was starting the current study after the physicians transferred the patients from assist control mode to modes of weaning.

These findings agreed with, **Ismail, et al., (2022),** who conducted a study about "comparison between endotracheal tube cuff pressure measurements before and after nursing interventions among mechanically ventilated patients" that found that most of patients were on SIMV mode.

Part III: Assessment of patient's chest and characteristics of secretions of the studied groups.

As regards to depth of breathing, the current study reported that around half of the studied patients of both shallow and deep suctioning groups had shallow breathing. This is because this breathing pattern is associated with a reduced work of breathing. Also, in critically ill patients, sensory and emotional stimuli such as pain and anxiety can significantly affect the respiratory drive. Moreover, critical illness can affect patients' respiratory drive as the changes in arterial blood gases and pH directly affect the response of the respiratory center's output. **(Vaporidi, et al., 2020)**

This finding was supported by **Gattinoni, et al., (2020)**, who reported that rapid shallow breathing pattern was in half of the studied population due to changing lung mechanics, ventilation needs, and neural sensitivity interact.

Regarding chest movement, symmetrical chest movement was reported in nearly two thirds of patients in both the groups in the present study. From the researcher point of view this may be related to the accurate depth of the endotracheal tube above the carina and the absence of rib deformities or fractures. This finding was supported by **Lubin, et al., (2021)**, who concluded in a study about "Evaluation of endotracheal tube depth in the out-of-hospital setting" that the majority of the participants had symmetrical chest movement.

According to amount of secretions, the present study reported that most of the studied patients in shallow suctioning group had less than 100 ml of secretions compared to only 44% of the deep suctioning group. It may be related to stimulation of carina and cough reflex in the deep suction that results in removal of larger amount of secretions. This finding was supported by **Li, et al., (2021),** who illustrated in a study about "Effect of different depth of aspiration on patients without effective cough response" that the amount of sputum in the deep suctioning group was significantly higher than that in the shallow suctioning group.

Part IV: Effect of shallow versus deep suctioning techniques on endotracheal tube cuff pressure measurements and physiological indices of both the studied patients of both groups.

Regarding cuff pressure measurement, the current study shows that ETT cuff pressure significantly decreased below the baseline measurements immediately after and after 10 minutes of both shallow and deep endotracheal tube suctioning. This decrease may be related to the difference between the pressure of the subglottic fluid above the cuff and the tracheal pressure under the cuff. Therefore, tracheal suctioning with prolonged mechanical ventilation decreases tracheal pressure and increases fluid leakage. **(Khalil, et al., 2018)**

This finding was congruent with **Khalil, et al., (2018)**, who conducted a study about "Factors affecting endotracheal tube cuff pressure measurement" and found that the average cuff pressure decreased immediately after closed endotracheal suctioning. Additionally, **Beccaria, et al., (2017)** reported that the mean ETT cuff pressure decreased post aspiration of the endotracheal tube.

On the other hand, this result was inconsistent with **Ismail, et al., (2022),** who reported that cuff pressure changes were increased above the baseline measurement only immediately after suction. While the ETT cuff pressure significantly decreased below the baseline measurements after 15 minutes and 30 minutes.

As regards physiological indices, the present study showed that there were statistically significant differences among both studied groups immediately after and after 10 minutes of suctioning regarding SBP, MAP, HR, and SpO_2, but not in diastolic blood pressure (DBP). Also, the study revealed that the most statistically significant differences were in the deep suctioning group. The changes in

SBP, MAP and HR were due to the effect of stress response of patients' bodies during endotracheal suctioning. This is because adrenaline and noradrenaline hormones released in response to stress increase the heart's contraction strength and speed by stimulating beta 1 receptors. As a result, systolic blood pressure and mean arterial pressure also increase. The changes were greater in the deep suctioning group suggested that the deep suctioning technique has more manipulative effect on the trachea. **(Chu, et al., 2021)**

This was supported by **Kostekli, et al., (2022),** who conducted a study about "Effect of deep and superficial endotracheal suctioning on hemodynamic parameters and pain in neurosurgical intensive care patients" and indicated that the mean systolic blood pressure and heart rates of the patients increased at 1 and 5 min after suctioning and decreased in the 30 min after both suctioning methods. Also, they reported that SpO_2 levels measured at 1, 5, and 30 min after both suctioning types were continuously higher when compared with values just before suctioning.

Also, this was in line with **Liao, et al., (2019),** who reported that both shallow and deep suctioning improve oxygen saturation, but deep suctioning is more effective in airway cleaning and improve patient's SpO_2 better. On the other hand, it may cause bigger fluctuation in heart rate and systolic blood pressure than shallow suctioning. Moreover, **Thabet, et al., (2019)** reported that the mean of Oxygen saturation was higher with a highly statistically significant differences immediately after, and 5-min after suctioning.

Conversely, a study conducted by **Shamali, et al., (2019),** revealed that there were no significant differences in mean HR between both groups immediately before, immediately after, and after 10 minutes of suctioning. However, there was a significant drop in SpO_2 across the three time points in the routine endotracheal suctioning (RETS) group compared to the minimally invasive endotracheal suctioning (MIETS) group. Furthermore, there was a significant increase in systolic blood pressure, diastolic blood pressure, and mean arterial pressure across the three time points in the RETS group compared to the MIETS group.

Conclusion

The present study revealed that deep endotracheal suctioning is more effective in removing secretions and improving SpO_2. Meanwhile, it may induce higher variations in hemodynamic parameters and endotracheal tube cuff pressure than shallow endotracheal suctioning.

Recommendations

In the light of the current study findings the following recommendations are suggested:

1. **Recommendations for nurses:**

- Critical care nurses (CCNs) are recommended to perform the endotracheal tube suctioning by the shallow method while deep suctioning should be used only if indicated.

- Monitoring of endotracheal tube cuff pressure and physiological indices should be integrated into routine care for critically ill patients to improve patients' clinical outcomes and prevent adverse events.
- A training program for CCNs about deep and shallow endotracheal suction for updating their knowledge and performances in ICU.

2. **Recommendations for research:**

- Further studies will be needed to evaluate the effect of different body positions and body temperature on endotracheal tube cuff pressure.
- Further studies will be needed to compare the effect of shallow versus deep suctioning techniques on pain and arterial blood gases.

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