

Effect of Endotracheal Suction with and Without Instillation of Normal Saline on Oxygenation, Hemodynamic and Arterial Blood Gases in Adult Mechanically Ventilated Patients

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Abstract: Endotracheal suction is a corner procedure in the management of secretions in mechanically ventilated patients. Normal saline instillation is used by nurses during treatment of intubated patients within the intensive care unit, usually to enhance sputum yield. Its use is controversial; detrimental effects have been documented and evidence of any benefit is limited. Some studies have suggested routine use be discontinued. The aim of this study was to investigate the effect of endotracheal suction with and without instillation of normal saline on oxygen saturation, heart rate, blood pressure and arterial blood gases in mechanically ventilated patients. Material and Methods an experimental cross over design was adopted. The study was carried out at medical and surgical Intensive Care Units of King Fahd Hospital of the University. Sample consisted of 25 adult male and female patients. They were randomly assigned to two techniques of suction (with and without instillation of normal saline) participants are randomly assigned to different orderings of treatment. An Observational checklist was developed by the researchers to collect the needed data that covers patients' demographic data, heart rate, blood pressure, SPO₂, and arterial blood gases before & after suction for 5 minutes. The study reveals that there was statistical significant difference between mean heart rate, PCO₂, PaO₂ and PaO₂/FiO₂ over time after suction with instillation of normal saline while there was no significant difference between mean heart rate, blood pressure and arterial blood gases among the two techniques of suction. Conclusion: There was statistical significant difference between mean heart rate, PCO₂, PaO₂ and PaO₂/FiO₂ over time after suction with instillation of normal saline. Recommendation: Saline instillation should not be used as a routine clinical practice and the nurses should consider other interventions to promote secretion clearance include providing adequate systemic hydration, humidification, chest percussion and vibration.

Keywords: Endotracheal suctioning, Normal saline instillation, Oxygenation.

I. Introduction

The use of isotonic sodium chloride (0.9 %, normal saline) instillation prior to endotracheal suction in intubated patients has been widely practiced for over two decades in ICU, throughout the world. ⁽¹⁾ The purpose of its instillation is to increase sputum yield by diluting & loosening thick secretions, lubricating the suction catheter, enhance cough stimulation & secretion mobilization, thus increase secretion clearance. ^(2,3) Despite these purported effects, best guidelines produced by Joanna Briggs Institution have determined that the instillation of normal saline prior to suction of endotracheal tube is unsubstantiated and has potential adverse effects & routine administration should be discontinued. ⁽⁴⁾

In prospective randomized controlled trial radiolabeled normal saline solution, showed that only 10.7 % to 18.7 % of instilled solution could be retrieved by suctioning, the unretrieved fluid could interfere with alveolocapillary oxygen exchange, the potential adverse effects of instilled normal saline solution during suctioning include interference with alveolocapillary oxygen exchange result in decrease oxygen saturation, decrease mixed venous oxygen saturation, increase frequency of nosocomial pneumonia & increased intracranial pressure. ^(5,6)

Lacking empirical evidence to support saline instillation, nurses may arbitrary decide when instillation of saline is appropriate. Generally, 5 to 10 ml normal saline solution is used prior to suction. Researches on the instillation of normal saline and its relation with oxygenation in intubated and mechanically ventilated patients have been inconclusive. Young et al investigated the effects of a no saline, 2ml and 5 ml saline instillation prior to endotracheal suctioning on O₂ saturation in patients with pneumonia. The finding revealed that recovery time for SaO₂ to return to baseline level following suctioning were 45 seconds after suctioning and in excess of 5 minutes with 0,2,5 ml saline instillations, respectively. ⁽⁷⁾

Ackerman et al studied oxygen saturation in critically ill adult patients with each patient acting as his or her own control. They found a greater decrease in oxygen saturation after suctioning with normal saline solution. ^(8, 9) Akgul S. et al studied the effect of normal saline instillation prior endotracheal suctioning on SaO₂, SPO₂, PCO₂ and PH in 20 patients who were mechanically ventilated. Evaluation of blood gases following suctioning with and without saline solution showed partial decrease in PaO₂, PaCO₂, HCO₃ and O₂ saturation which did not reach a significant level. ⁽¹⁰⁾ It has been also shown that normal saline, instead of softening secretions, actually reduces the amount of oxygen that reaches the lungs, increases both arterial blood pressure and intracranial pressure and increases the risk of nosocomial pneumonia. ⁽¹⁰⁾

An evidence based practice information sheet had been developed by Joanna Briggs Institute entitled "suctioning adults with artificial airway" that covers different concepts related to suctioning in addition to summary of evidence and recommendations. All recommendations in the information sheet fall in the category III and IV levels of evidence. ⁽⁴⁾ Although research has demonstrated the risky nature of such a procedure, it continues to be implemented in Intensive Care Unit in King Fahd Hospital of the University, a factor that emphasizes the need for ongoing research.

1.1 Aim

To determine the effect of endotracheal suction with and without instillation of normal saline on oxygen saturation, heart rate, blood pressure and arterial blood gases in mechanically ventilated patients.

II. Methods

2.1 Research Design

This study was a crossover-experimental design, aimed to compare the effect of endotracheal suction with and without instillation of normal saline on oxygen saturation, blood pressure, heart rate and arterial blood gases in adult mechanically ventilated patient. Randomization: participants were randomly assigned to different orderings of treatment.

2.2 Setting

The present study was conducted at King Fahd University Hospital in Medical & Surgical Intensive Care Unit. The capacity of the units five and seven beds respectively.

2.3 Population and Sampling

The population of this study consisted of 25 adult patients who were admitted to the above-mentioned settings. Patients were intubated with an endotracheal tube and supported by mechanical ventilation. Patients included in the study were selected according to the following criteria: male and female of age group twenty to sixty years, hemodynamically stable (did not require titration of vasoactive medication), cannulated with arterial line. Patients with head injury were excluded.

2.4 Tools

An Observational checklist was developed by the researcher based on review of related literature. The overall purposes of the observational checklist were to obtain baseline data related to patients O₂ saturation, heart rate, blood pressure together with Arterial Blood Gas (ABG) value and record any deviation from the obtained baseline after suctioning.

The observational checklist comprised three sections:

Section one: This section addressed patients' demographic data, medical history, data related to endotracheal tube, suction tube, ventilator setting mode.

Section two: This section investigated patients' oxygen saturation, heart rate, blood pressure which were recorded as baseline (before data collection), then after suctioning at 1,2,3,4, and 5 minutes.

Section three: This section included the measurements of Arterial Blood Gas (ABG) value which were recorded before suctioning then after suctioning at 1, 2, and 5 minutes.

2.5 Ethical consideration and consent

An approval from the Local Committee of Biomedical Ethics at Dammam University to involve human subjects from the King Fahd Hospital of the University in Medical Intensive Care Unit & Surgical Intensive Care Unit was obtained. Permissions from Hospital Administration & Chairman of Intensive care units and Director of Nursing Department of King Fahd University Hospital were obtained. A Written informed consent from patients was obtained.

2.6 Validity

Content validity of the observational checklist was checked by 5 expertise in both medical and nursing field and corrections were carried out accordingly. A pilot study was conducted and necessary modifications were done.

2.7 Procedure

The eligible subjects were randomly assigned by pulling a paper which contains the suction technique (suction with instillation of normal saline or suction without instillation of normal saline) from an envelope.

Each subject was exposed to both methods. The duration between each suctioning method was 2-4 hours according to patient's condition.

First, the researcher recorded baseline parameters of subjects during stable condition, as oxygen saturation, heart rate, blood pressure and arterial blood gas. Second, the suctioning equipment were arranged to set appropriate pressure of vacuum at 150 mmHg. Then, the patient was disconnected from the mechanical ventilator and endotracheal tube was connected to the resuscitating bag for hyper oxygenation with 100% oxygen for a period of 1 minute, through giving three breaths of the manual positive pressure ventilation with the resuscitating bag.

2.7.1 For endotracheal suctioning without normal saline instillation:

After the previously mentioned two steps each subject was suctioned no longer than ten seconds (count from one to ten). Suction was repeated two times. Three breaths of the manual positive pressure ventilation with the resuscitating bag were given. Auscultation of lung sound to evaluate the efficiency of suctioning was done.

2.7.2 For endotracheal suctioning with normal saline instillation:

After the previously mentioned two steps (obtaining baseline data and hyperoxygenation), the researcher instilled five ml normal saline via the endotracheal tube. Each subject was suctioned no longer than ten seconds. Suction was repeated two times. Three breaths of the manual positive pressure ventilation with the resuscitating bag were given. Auscultation of lung sound to evaluate the efficiency of suctioning was done.

After suctioning, the endotracheal tube was connected to the mechanical ventilator, the research assistant checked & recorded the oxygen saturation, heart rate, and blood pressure at 1, 2, 3, 4, 5 minutes after suctioning on observational checklist.

Finally, arterial blood gases were collected by the researcher after suctioning and connecting the mechanical ventilation at minute 1, 2, and 5 then analyzed immediately by ABG machine in the chemistry laboratory.

2.8 Data analysis

Result were calculated using SPSS (version 15) values are expressed as mean ±SD. Analysis of variance with repeated measures (RM ANOVA) was used to determine the effect of suctioning with and without instillation of normal saline on oxygenation, hemodynamic (HR, SBP, DBP), and Arterial Blood Gases (Blood PH, PaCO₂, PaO₂, and PaO₂/FiO₂) and Paired t-test was conducted to compare the mean change of heart rate, PaO₂, PaCO₂, and PaO₂/FiO₂. P value < 0.05 was considered significant.

III. Results

3.1 Part I- characteristics of the sample:

The mean age of the studied sample was 44.64 ± (15.8) years while more than half (52%) were between 50-60 years. As regards sex it appears that more than half (56%) were females. Slightly less than half (48%) were suffering from respiratory disorders where third of cases were diagnosed as aspiration pneumonia, (16%) from road traffic accident while gastrointestinal and neurological disorders were equally distributed (12%). In relation to type of admission 48% of the studied sample was admitted after surgical interference. The largest percentage 68% of the studied sample stayed in the ICU from 1-5 days and emergency intubation represents 60% of cases.

3.2 Part II: Hemodynamic parameter

3.2.1 Heart rates

Table 1: comparison of mean change of heart rate overtime between the endotracheal suctioning with and without instillation of normal saline

Heart rate (beats/ minute)	Suction technique	With instillation of normal saline			Without instillation of normal saline		
	Time	Mean	SD	F value (P value)	Mean	SD	F value (P value)
	Before	92.7	16.4	4.07 (0.024*)	91.8	17.5	1.045 (0.502)
	After 1minute	105.8	65.1		98.8	23.1	
	After 2minute	99.8	23.3		96.9	22.7	
	After 3 minute	94.3	17.6		96.5	20.9	
	After 4 minute	91.5	18.9		97.6	22.2	
	After 5 minute	95	19.1		97	22.1	

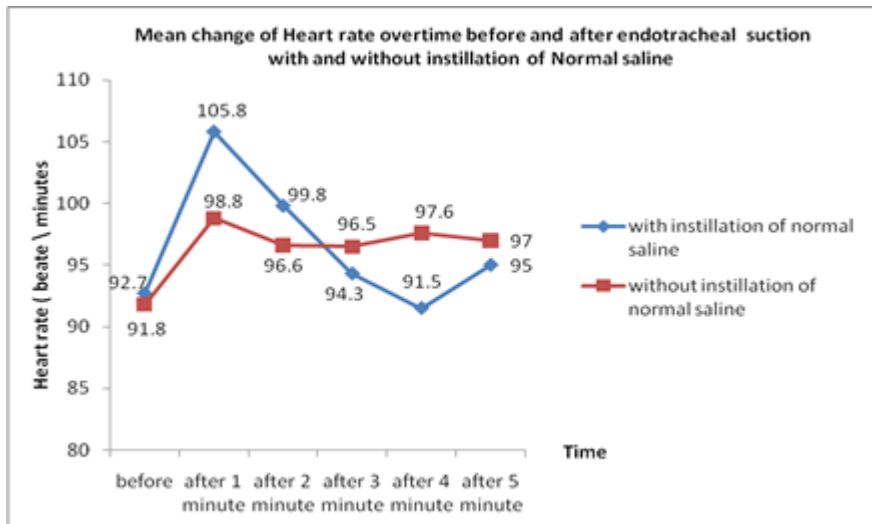
The table illustrates that there was statistically significant difference between mean heart rate at different level of exposure with suction with instillation of normal saline (F = 4.07 p = 0.024).

Upon comparing the mean heart rate before and within 5 minutes after suction, it was observed that there was statistical significant difference at 1, 2 and 5 minute (P = 0.015, 0.026, and 0.038) respectively when suction with instillation of normal saline.

On the other hand, no statistically significant difference was observed among the two techniques of suction.

As shown in "Fig. I" The highest mean heart rate was observed after suction with instillation of normal saline, while heart rate decreased to close to base line values 4 minute after suctioning. One the other hand, in the group

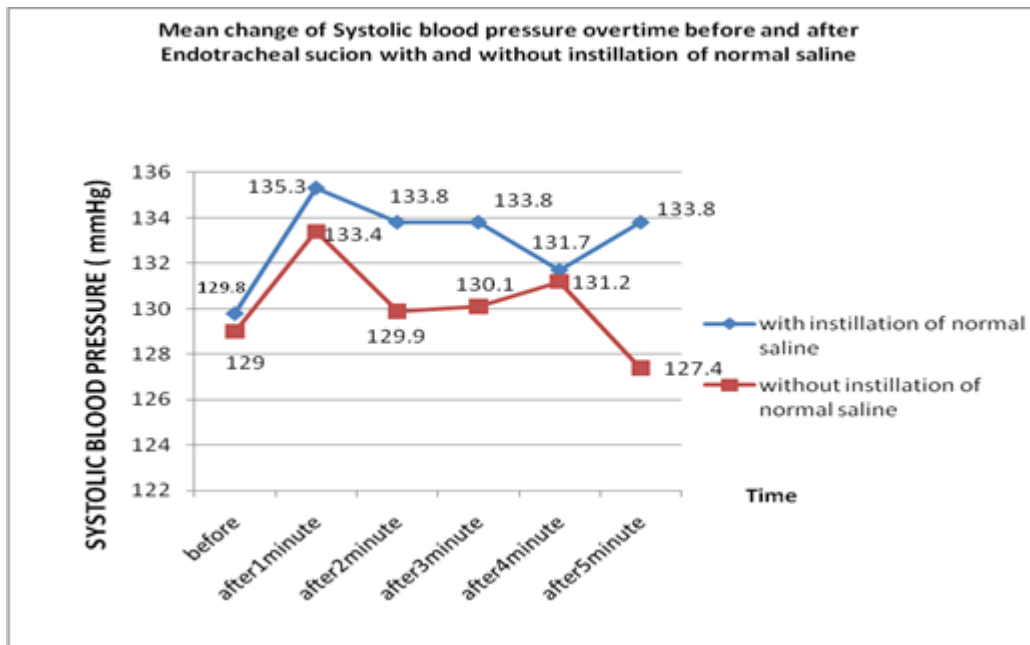
who were exposed to suction without instillation of normal saline, heart rate did not reach the base line value after suctioning



"Fig. 1"

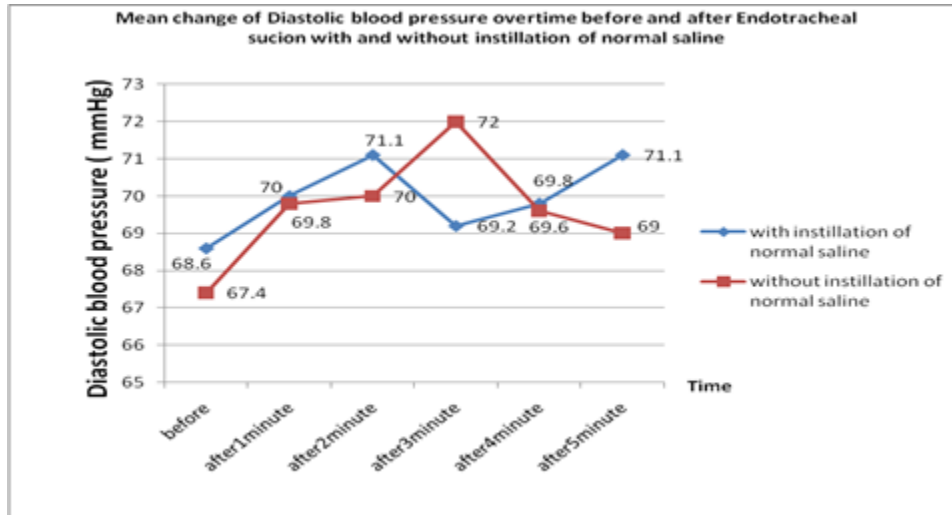
3.2.2 Systolic and diastolic blood pressure

"Fig. 2" Systolic blood pressure increased in both groups; the values in the group who undergo suction with instillation of normal saline increased more than who undergo suction without instillation of normal saline. Moreover, systolic blood pressure decreased to close to base line values at 2 minute after suctioning without instillation of saline and at 4 minutes after suctioning with instillation of normal saline.



"Fig. 2"

"Fig. 3" Shows that diastolic blood pressure increased in both groups. Moreover, diastolic blood pressure reached base line at 3 minutes after suctioning with instillation of normal saline, while in the group who had no instillation of normal saline, diastolic blood pressure returned near to base line at 5 minute after suctioning. There was no statistically significant difference between mean systolic and diastolic blood pressure over time with and without instillation of normal saline. Therefore; no statistically significant difference exists between two techniques of suction.



"Fig. 3"

3.3 Part 3: Oxygen saturation (SPO2)

Table 2: Comparison of mean change of Oxygen saturation (SPO2) overtime between the endotracheal suctioning with and without instillation of normal saline.

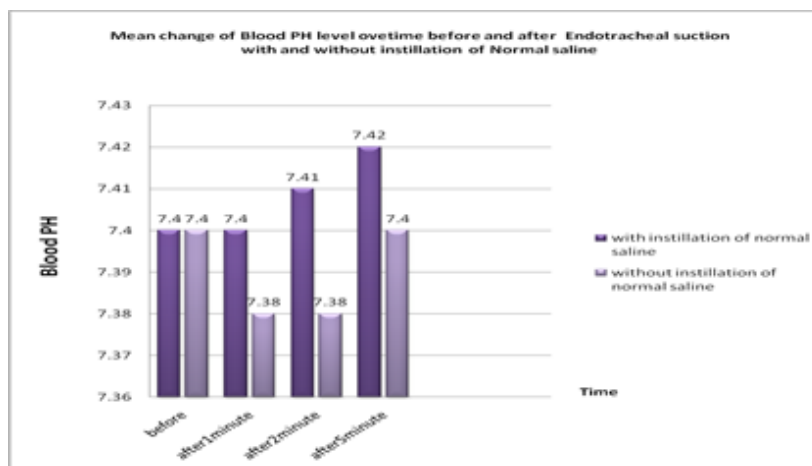
Oxygen saturation %	Suction technique	With instillation of normal saline			Mean	SD	F value (P value)
	Time	Mean	SD	F value (P value)			
	Before	97.6	2.5	0.687 (0.502)	97	3.4	0.393 (0.780)
	After 1minute	97.3	3.9		97.3	3.9	
	After 2minute	97.9	1.9		97.6	2.7	
	After 3 minute	98	1.8		97.5	2.5	
	After 4 minute	97.8	1.9		97.6	2.6	
	After 5 minute	97.6	2.5		97.4	2.3	

This table illustrates that there was no statistically significant difference between mean oxygen saturation within 5 minutes after suction with both techniques. Therefore, no statistically significant difference exists between the two techniques of suction.

3.4 Part 4: Arterial Blood Gas

3.4.1 Blood PH

"Fig. 4" shows that blood PH decreased for both groups after suctioning. This decrease was not clinically important. Moreover, blood PH increase to close to the value before suctioning at 2 minutes after suctioning with instillation of normal saline and at 5 minutes after suctioning without instillation of normal saline. There was no statistically significant difference between mean bloods PH over time with suction with instillation of normal saline. Therefore, no statistically significant difference exists between two techniques of suction, regarding blood PH.



"Fig. 4"

3.4.2 Partial Pressure of Carbon dioxide (PaCO2)

Table 3: Comparison of mean change of Partial Pressure of carbon dioxide (PaCO2) overtime between the endotracheal suctioning with and without instillation of normal saline

PaCO2	Suction technique	With instillation of normal saline			Without instillation of normal saline		
	Time	Mean	SD	F value (P value)	Mean	SD	F value (P value)
	Before	37.8	5.6	3.640 (0.021)*	36.9	8.1	0.551 (0.568)
	After 1min	39.7	5.1				
	After 2min	39.0	5.6				
	After 5 min	37.9	4.3				

The table illustrates that there was statistically significant difference between mean PaCO2 at different levels of exposure with suction with instillation of normal saline (F= 3.640, P= 0.021) Upon comparing the mean pco2 before and at 1, 2,and 5 minutes after suction with normal saline instillation , it was observed that there was statistically significant difference at 1 and 2 minutes when suction with instillation of normal saline. (P = 0.012, 0.004) respectively, while there was no statistically significant difference between the two techniques of suction. Moreover, the mean Pco2 increased with both techniques ; the values rises more with suctioning with instillation of normal saline , while the values return to close to base line after 2 minutes without instillation of normal saline and after 5 minutes with instillation of normal saline.

3.4.3 Partial Pressure of Oxygen (PaO2)

Table 4:Comparison of mean change of arterial Partial Pressure of oxygen (PaO2) overtime between the endotracheal suctioning with and without instillation of normal saline.

PaO2	Suction technique	With instillation of normal saline			Without instillation of normal saline		
	Time	Mean	SD	F value (P value)	Mean	SD	F value (P value)
	Before	129.6	41.3	6.399 (0.015)*	128.7	40.8	1.255 (0.285)
	After 1minute	163.6	70.4				
	After 2minute	159.8	67.5				
	After 5 minute	135.7	41.2				

The table illustrates that there was statistically significant difference between mean PaO2 at different levels of exposure with suction with instillation of normal saline (F= 6.399, P= 0.015). Upon comparing the mean PaO2 before and at 1, 2,and 5 minutes after suction with normal saline instillation , it was observed that there was statistically significant difference at 1 and 2 minutes when suction with instillation of normal saline (P = 0.012, 0.020) respectively. Moreover, there was no statistically significant difference exists between the two techniques of suction regarding PaO2. It was observed that PaO2 increased in both groups; the values in the group who had instillation of normal saline before suction increased more than who had no instillation of normal saline; PaO2 in both groups did not returned to base line.

3.4.4 Partial Pressure of Oxygen (PaO2) \ Fraction of inspired oxygen (FiO2) ratio.

Table 5: Comparison of mean change of Partial Pressure of oxygen (PaO2) \ Fraction of inspired oxygen (FiO2) ratio overtime between the endotracheal suctioning with and without instillation of normal saline.

PaO2/FiO2 ratio	Suction technique	With instillation of normal saline			Without instillation of normal saline		
	Time	Mean	SD	F value (P value)	Mean	SD	F value (P value)
	Before	332.2	161.5	5.728 (0.021)*	335.3	163.9	1.302 (0.275)
	After 1minute	417.2	209				
	After 2minute	409.8	210.5				
	After 5 minute	307.6	166.7				

The table illustrates that there was statistically significant difference between mean PO2\FiO2 ratio at different levels of exposure with suction with instillation of normal saline (F =5.728, P= 0.021). Upon comparing the mean PO2\FiO2 ratio before and at 1, 2,and 5 minutes after suction with, instillation of normal saline, it was observed that there was statistically significant difference at 1 ,2 and 5 minutes when suction with instillation of normal saline (p = 0.029 , 0.015 ,0.002) respectively. It also shows that shows that the mean PO2\FiO2 ratio increased in both techniques of suction, the values rises more with suctioning without instillation of normal saline, while the values did not reach the baseline value in both techniques, putting into consideration that PO2\FiO2 ratio decrease below the base line with suction with instillation of normal saline. After 5 minutes to reach 307.6 which is considered a critical sign. Moreover, there was no statistically significant difference exists between the two techniques of suction.

IV. Discussion

The results of the present study showed that more than half of the studied subject was between 50-60 years of age. This was in line with OH. H et al.⁽¹¹⁾ who stated that the most prevalent mean age of subjects was between 50 and 60 years.⁽¹¹⁾ In addition to Paratz J and Stockton who stated that the mean age of participants in the adult studies was 61.7 years⁽¹²⁾.

Furthermore, the present study illustrated that females represented higher percentage than male this was in contrast with Akgul S. et al and Morrow B. et al who mentioned that more than half of the patients included in the study were men^(10, 13)

In relation to diagnosis the present study revealed that respiratory disorders, especially pneumonia (68%) are the prevailing diagnosis, this was in agreement with Morrow B et al who mentioned that the majority (78 %) of the studied sample were diagnosed as pneumonia⁽¹³⁾. The result of the present study showed that there was no statistical significant change in oxygen saturation (SPO2 %) in both techniques of suction. This was in line with Akgul S. and Akyolcu N. findings which revealed no meaningful difference was found regarding oxygen saturation and PaO2 levels of patients suctioned did with and without instillation of saline solution⁽¹⁰⁾. Moreover, Jiraporn P. findings were in contrast with the finding of the present study where their findings revealed that oxygen saturation decreased at 1, 2 minutes after endotracheal suctioning with normal saline instillation while return to the baseline at 5 minutes after suctioning.⁽¹⁴⁾

The results also revealed that there was statistical significant difference at 1, 2, and 5 minutes post suctioning regarding heart rate upon comparing the mean heart rate before and within 5 minute after suctioning with instillation of normal saline. This finding was in line with Ackerman and Mick who showed that normal saline was a source of stress for the patients and resulted in statistical significant increase in heart rate after the procedure.⁽¹⁵⁾ While a study by Ji et al examined the instillation of saline before suctioning in patients with pneumonia showed that the difference in heart rate was not significant⁽¹⁶⁾.

It was also observed that both systolic and diastolic blood pressure had increased in both techniques of suction, where the values increased more in those undergo suction with instillation of normal saline, but this increase was not significant. This finding was supported by Leur J et al who stated that increased systolic blood pressure is one of the suction related adverse effect.⁽¹⁷⁾ Moreover, Jiraporn P. explained that the comparison of mean change of mean blood pressure overtime between endotracheal suctioning with and without normal saline instillation revealed a higher increase in the subjects after endotracheal suctioning with normal saline instillation than after endotracheal suctioning without normal saline instillation.⁽¹⁴⁾

The findings of the present study showed that there was no significant change in PH in both techniques of suction. This was in line with Akgul S. et al who explained that in cases where normal saline was not given there was a slight rise in PH, but not to a significant degree.⁽¹⁰⁾ Regarding PaCO₂, the mean PaCO₂ increased with both suction techniques, where the values increased more with suctioning with instillation of normal saline and there was statistical significant difference at 1 and 2 minutes after suctioning. This finding was in line with Jiraporn P who mentioned that increase in PaCO₂ after the endotracheal suctioning with normal saline instillation was higher than after the endotracheal suctioning without normal saline instillation.⁽¹⁴⁾

A regards PaCo₂, that mean PaO₂ showed an increase over time in both suction techniques, this can be explained by the fact that hyper-oxygenation before suction can interfere with PaO₂. Moreover, there was no significant change in PaO₂ in both techniques of suction. This was in line with Akgul S et al who showed that there was statistically significant difference between PaO₂ levels in both techniques of suction.⁽¹⁰⁾ It was also observed that the mean ratio sharply decreased after 5 minutes with instillation of normal saline which represented a significant adverse effect as stated by Bostick and Wendelgass, who found a downward trend of PaO₂ in patients suctioned after instillation of normal saline.⁽¹⁸⁾

V. Conclusions And Recommendations

Based on the present study findings, it can be concluded that there was statistical significant difference between mean heart rate, PCO₂, PaO₂ and PaO₂/FiO₂ over time after suction with instillation of normal saline. The researcher strongly recommended that saline instillation should not be used as a routine clinical practice and the nurses should consider other interventions to promote secretion clearance include providing adequate systemic hydration, humidification, chest percussion and vibration.

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