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The Effect of Closed Versus Open Suction on Cardiorespiratory Parameters in Mechanically Ventilated Children

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Abstract
Background Endotracheal suctioning is a significant aspect of the care of intubated child, however this procedure are associated with many risks. **Aim:** to evaluate the effect of closed versus open suction on cardiorespiratory parameters in mechanically ventilated children. **Design:** A quasi-experimental research design was used. **Sample:** A purposive sample of 60 children aged (2 to 7years' old) who met the inclusion criteria at PICU of Assiut University Children Hospital. They were selected randomly and divided into two groups: **Group I:** Included 30 children for whom open suction method was used. **Group II:** Included 30 children for whom closed suction method was used. **Tools:** One structured tool was utilized to collect the relevant data which include: Structure questionnaire sheet which divided into three parts, Personal characteristics, Medical data, and cardiorespiratory parameters of children record. **Results:** Highly statistical significance difference between open and closed suction method regarding cardiorespiratory parameters during and immediately after suction **(**P. <0.001**).However, there were no statistically significant differences in ABG parameters before and after suction in both open and closed suction groups. **(**P. 0.33, 0.29, 0.688**) Conclusion:** Closed suction method is more effective than open suction method in daily practice**.** So, the researcher **Recommendation:** Closed suction method should be incorporated as one of the best method of suction on reducing hemodynamic instability in daily practice.

Keywords: Cardiorespiratory parameters, Closed suction, Open suction & Mechanically ventilated children.

Introduction
Mechanical ventilation is a standard treatment in neonates and pediatric intensive care and is used for several physiological and clinical reasons and is increasingly used as a lifesaving tool in treating acute and chronic respiratory failure, especially in reversible cases. **(Sayin & ErdaL., 2018**).

The clinical goals of mechanical ventilation can be very varied, including maintaining gas exchange, reducing or replacing respiratory effort, reducing systemic and/or myocardial oxygen consumption, improving lung expansion, enabling sedation and anaesthesia, relaxing the muscles, and stabilising the thoracic wall. This supportive treatment is associated with many complications that may cause it to last longer, such as ventilator-associated lung injury, sepsis and pneumonia **(Sauthier , et al.,2017)**.

Endotracheal intubation inhibits the cough reflex and interferes with normal muco-ciliary function, increasing the production of airway secretions and decreasing the ability to clear them so that endotracheal tube suction is required to clear secretions and to maintain airway patency in a ventilated patient **(Seitz,et al., 2016).**

Endotracheal suction (ETS) is one of the most frequent airway interventions performed on children who need invasive mechanical ventilation. It is a crucial airway clearing technique to avoid residual secretions obstructing the endotracheal tube (ETT) or leading to pulmonary problems like diffusion impairment and its defined as‘ :the mechanical aspiration of respiratory secretions from the endotracheal tube (ETT) to maintain airway patency **(Schults., 2020).**

The clinical indications for suctioning include bradycardia ,tachycardia, absent or decreased chest movement, coarse or decreased breath sounds , visible secretions in endotracheal tube and respiratory distress due to increased copious, retained secretions, Increased resistance, decreased oxygen saturation , increased Positive end-expiratory pressure (PEEP) and an increasing Fraction of Inspired Oxygen (FiO2). **(Sole et al., 2015 & Oh, et al., 2015)**.

Suction system includes two methods known as open and closed suction, which are standard methods for suctioning airway secretions. An open suction technique is traditionally performed with the disconnection of the patient from the ventilator and

inserting suction catheter into the endotracheal tube. Alternatively, it can be done with a closed suctioning system included in the ventilatory circuit, allowing introducing the suction catheter into the airways without**,** disconnecting the patient from the ventilator **(Thabet, & Sayed, 2019)**.

Open suctioning has been reported to be associated with arterial desaturation, inability to maintain Positive end-expiratory pressure (PEEP), elevated heart rate, blood pressure and cardiac arrhythmias , especially in patients with cardiorespiratory instability. Closed suction has been shown in some studies to demonstrate fewer physiological disturbances compared to open suction. In neonates and children, evidences are limited, with closed suction showing less lung volume loss and some physiological benefit. **(Schults et al., 2021 & Dastdadeh et al., 2016)**

The main risk and complications of endotracheal suctioning include hypoxemia, tissue hypoxia, significant changes in heart rate or blood pressure, presence of cardiac dysrhythmias and cardiac or respiratory arrest. Additional complications include tissue trauma to the tracheal or bronchial mucosa, broncho constriction or bronchospasm, infection, pulmonary bleeding, increased intracranial pressure and interruption of mechanical ventilation. Therefore, it's critical to monitor physiological parameters during and after the suction procedure is important to reduce the associated complication **(Elmansoury & Said., 2017)**.

Nurses play a vital role in the suction process and their experience in using the conventional or new methods is essential for development of evidence-based practices Their role including: monitoring respiratory status, assessing need for suctioning secretions, and evaluate outcome, prepare the children by explaining the procedure in terms they can understand, choose the right equipment(right catheter size), don't use suction too long because prolonged suctioning increases the risk of hypoxia and other complications **(Valizadeh et al., 2014)**.

Significance of the study:

The Suctioning system is a very important procedure used to prevent accumulation of secretions and keeping airway patent especially in mechanically ventilated children. However beside this benefit it also has adverse effect on cardiorespiratory parameters, so that it is very important to select the best method of suctioning system to prevent complications that may occur.

During the routine care of children at intensive care unit it was observed that the children undergoing closed and open suction were exposed to some complications so the researchers decided to conduct a study to evaluate the effect of the two types of suction to prevent complications

Aim of the Study:

The aim of this study was to:

Evaluate effect of closed versus open suction on cardiorespiratory parameters in mechanically ventilated children

Operational definitions

Closed suction: Is the incorporation of a suction device into a mechanical ventilator that permits airway suctioning without removing patients from the ventilator.

Open suction: Is clearing the airways of a patient on mechanical ventilation using a suction catheter inserted into the endotracheal tube after the patient has been disconnected from the ventilator circuit.

Research hypothesis:

1. There were relation between suction methods and cardiorespiratory parameters in mechanically ventilated children
2. The closed suction method was more effective on cardiorespiratory parameters than open suction method in mechanically ventilated children

Null hypothesis:

There is no difference between open and closed suction in cardiorespiratory parameters in mechanically ventilated children.

Subjects and Method

Research design: A Quasi experimental research design was used in this study.

Setting: This study was carried out at pediatric intensive care unite in Assuit university

Children hospital which serves upper Egypt from El-fayoum to Aswan. The Hospital consisted of 6 floors and pediatric intensive care unit was located on the second floor and the bed capacity of this unit is 34 beds, however only 13 beds were occupied by the patients due to administrative problems. The numbers of medical and nursing staff in this unite are 4 medical representative, 16 head nurses and 19 nurses

Subjects: The study subject included a purposive sample of 60 children undergoing mechanical ventilation from (2 to 7years' old) of both sexes. They were selected randomly and divided into two groups:

Group I: Included 30 children for whom open suction method was used.

Group II: Included 30 children for whom closed suction method was used.

Inclusion criteria included:

Children were chosen based on inclusion criteria:

- Mechanically ventilated children aged from 2 to 7years.
- The children were stable hemodynamic (as regard: pulse, blood pressure, respiration, capillary refill time and skin perfusion).

- The children didn't have refractory hypoxemia (low oxygen saturation {SpO2<90%} in spite of providing high oxygen concentration {FiO2 ≥ 60%}.

Exclusion criteria included:

- The children who had hemodynamic problems (as regard: pulse, blood pressure, respiration, capillary refill time and skin perfusion).
- The children with refractory hypoxemia (low oxygen saturation {SpO2<90%} in spite of providing high oxygen concentration {FiO2≥ 60%}.

Tools of data collection: One structured tool was used to collect the required data for this study

Tool (1): Structure questionnaire sheet it was developed by the researcher which include three parts

Part 1: Personal characteristics of children as gender, age, and weight.

Part 2: Medical data of children as duration of hospital stay, diagnosis, duration on mechanical ventilation, sedation, size of endotracheal tube**,** size of suction catheter, date of admission and Pediatric Risk of Mortality score (PRISM)score on admission

Part 3: Cardiorespiratory parameters record including **cardiac parameters** (heart rate, mean arterial pressure, systolic and diastolic blood pressure)

and respiratory parameters (oxygen saturation, respiratory rates and tidal volume) **and ventilator mode:** PEEP and ABG before and after suction

Methods of data collection

1. An official permission was obtained from the director of pediatric intensive care unit at Assuit university children hospital to collect the necessary data for this study.
2. At the pediatric intensive care unit, the researcher introduced herself and informed the nurses about the nature of the study
3. Apilot study was carried out on 10 %(6) of children to test the clarity, applicability of the sheet and to estimate the time need to fulfill sheet and the necessary modification was done and the final form developed and these were excluded from the total sample of the study.
4. Written approvals were taken from the parents of the hospitalized children after presenting herself to them and explaining the purpose of the study and confidentiality of obtained data.
5. Validity of tool was tested using contents validity index by 5 experts in both pediatric nursing and pediatrics fields and it equaled 91%
6. Reliability of the tool was calculated statistically by using alpha crombach test (r=0.82).

Field of the work:

This research was carried out through five months period from the beginning of December (2021) to the end of April (2022). The researcher collected data in three days per week. This was done during the routine work of the hospital at evening shift. The assessment sheet requires about 15-20 minutes filling; about 1-4 children under mechanical ventilator were collected per week.

Intervention

- 60 Mechanically ventilated children who fulfill the inclusion criteria, they were divided into 30 children for open suctioning methods (group 1) and 30 children for closed suctioning methods (group 2).
- Children' personal data were collected from the children record.
- All children received oxygen by 100% for 2 minutes before suction then apply suction method. In the open suction group, the endotracheal tube was disconnected from the ventilator. Disposable suction catheter were passed down to the endotracheal tube and extended until resistance was met and 0.5 cm was withdrawn. Children in the close endotracheal suction system (CTSS) group were connected to an appropriate size close suction catheter which selected according to the manufacturer's recommendations for every size of endotracheal tube. It was placed between the endotracheal tube and the Y piece. The suction catheter was in the locked position and the water irrigation port was kept closed all the time. Then for suctioning, it was unlocked and inserted into the endotracheal tube via controlled by thumb valve, and then received oxygen by 100% for 2 minutes after the suction immediately.
- The researcher monitored cardiorespiratory parameters before suction, during suction, immediately after suction and 15minutes after suction.

Ethical consideration

1. Research proposal was approved from Ethical Committee in the Faculty of Nursing.
2. There was no risk for study subject during application of the research.
3. The study followed common ethical principles in clinical research.
4. Written consent was obtained from parents that were willing to participate in the study, after explaining the nature and purpose of the study.
5. Parents were assured that the data of this research was used only for the purpose of research.
6. Confidentiality and anonymity was assured.
7. The parents had the right to withdraw from the study at any time during the study without any effect on the care provided that for their children

Statistical analysis

Data entry and data analysis were done by using SPSS program (Statistical Package for Social Science) version 16. Data were presented as number, percentage, mean and standard deviation. Chi- square test and fisher exact test were used to compare qualitative data. For non-parametric quantitative data between the two groups, the Kruskal-Wallis was used, for parametric quantitative data between two groups the T- test was used .P value was considered statistically significant when $p < 0.05$.

Results

Table (1): Percentage distribution of studied children regarding to their personal data (n=60)

	Open suction group I (n=30)		Closed suction group II (n=30)		P. value
	No	%	No	%	
Gender					
Male	11	36.7	14	46.7	0.432
Female	19	63.3	16	53.3	
Age					
2-4years	12	40.0	11	36.7	0.950
4-6years	10	33.3	10	33.3	
>6years	8	26.7	9	30.0	
Mean±SD (range)	4.96±1.69(2-7)		5.11±1.65(2-7)		0.735
Wight					
Mean±SD (range)	22.1±10.76(10-45)		25.37±12.02(7-45)		0.272

- Chi square test for qualitative data between the two groups
Independent T-test quantitative data between the two groups -

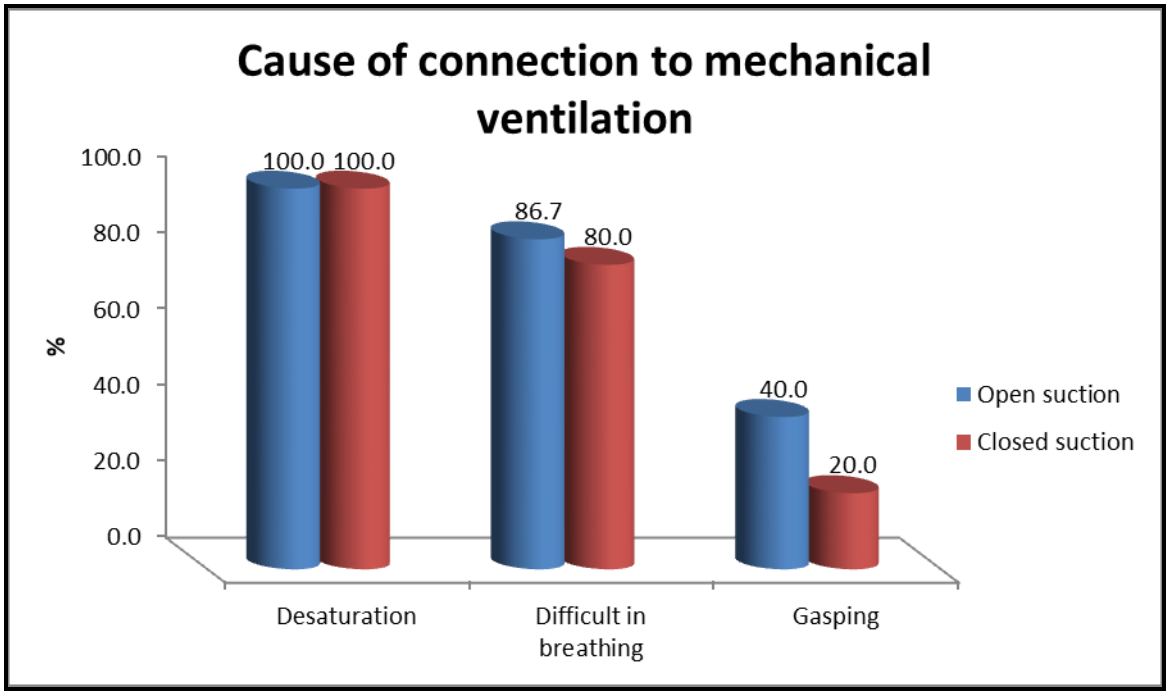

Figure (1): Comparison between studied groups (open and closed suction) regarding causes of connection to mechanical ventilation.

Table (2): Percentage distribution of studied children regarding to their medical data. (n=60)

	Open suction group I (n=30)		Closed suction group II (n=30)		P. value
	No	%	No	%	
Duration of hospital stay					
<3days	1	3.3	16	53.3	<0.001**
3-6 days	1	3.3	14	46.7	
> 6 days	28	93.3	0	0.0	
Duration on mechanical ventilation					
<3days	0	0.0	13	43.3	<0.001**
3-6 days	2	6.7	17	56.7	
> 6 days	28	93.3	0	0.0	
Sedation	30	100.0	30	100 .0	-
Size of endotracheal tube					
4-4.5	10	33.3	6	20.0	0.499
5-5.5	12	40.0	15	50.0	
6-6.5	8	26.7	9	30.0	
Size of suction catheter					
8.00	7	23.3	4	13.3	0.574
10.00	21	70.0	23	76.7	
12.00	2	6.7	3	10.0	
PRISM score on admission:					
Mean±SD(range)	7.23±3.35(0-15)		5±2.35(0-9)		0.004**

***Significant level at P value < 0.01*

Table (3): Comparison between studied children in open and closed suction related to cardiac parameters (n=60)

	Open suction group I (n=30)	Closed suction group II (n=30)	P. value
	Mean ±SD	Mean ±SD	
Heart rate			
Before suction	111.13±19.24	110.17±15.99	0.833
During suction	130.9±18.45	114.37±15.99	<0.001**
Immediately after suction	128.57±17.31	109.13±21.64	<0.001**
15 minutes after suction	111.7±19.18	110.2±16.03	0.744
Mean arterial pressure			
Before suction	85.14±5.77	85.85±5.7	0.649
During suction	98.93±6.02	91.37±4.26	<0.001**
Immediately after suction	91.68±6.06	87.96±4.76	<0.001**
15 minutes after suction	85.89±6.26	85.85±5.7	0.982
Systolic blood pressure			
Before suction	109±9.95	111.33±10.08	0.371
During suction	129.5±9.32	118.83±9.62	<0.001**
Immediately after suction	120.33±9.99	115±9.83	<0.001**
15 minutes after suction	109±9.95	111.33±10.08	0.371
Diastolic blood pressure			
Before suction	72.67±5.83	74±6.21	0.395
During suction	83.33±6.06	78±5.51	<0.001**
Immediately after suction	77.87±4.84	75±6.30	<0.001**
15 minutes after suction	73.07±6.19	74±6.21	0.562

Independent T-test quantitative data between the two groups -
Significant level at P value < 0.05,Significant level at P value < 0.01*

Table (4): Comparison between studied children in open and closed suction related to respiratory parameters (n=60)

	Open suction group I (n=30)	Closed suction group II (n=30)	P. value
	Mean ±SD	Mean ±SD	
Oxygen saturation			
Before suction	98.17±1.62	98±1.49	0.680
During suction	83.2±4.49	94.53±1.5	<0.001**
Immediately after suction	85.07±2.83	96±1.08	<0.001**
15 minutes after suction	98.97±1.22	98.83±0.99	0.643
Respiratory rates			
Before suction	24.47±5.56	24.47±5.69	1.000
During suction	35.23±5.79	27.73±5.99	<0.001**
Immediately after suction	32.67±5.68	26.17±5.83	<0.001**
15 minutes after suction	24.5±5.48	24.6±5.74	0.945
Tidal volume			
Before suction	138.67±69.03	147.77±49.97	0.561
During suction	0±0	133.77±42.61	<0.001**
Immediately after suction	119.53±61.33	141.97±47.35	<0.001**
15 minutes after suction	144.4±66.67	155.2±51.35	0.485
PEEP			
Before suction	4.37±0.61	4.53±0.68	0.324
During suction	0±0	4.53±0.68	<0.001**
Immediately after suction	4.37±0.61	4.53±0.68	<0.001**
15 minutes after suction	4.37±0.61	4.53±0.68	0.324

Independent T-test quantitative data between the two groups -
***Significant level at P value < 0.01*

Table (5): Comparison between studied children in open and closed suction regarding arterial blood gases (ABG) parameters (n=60)

	Open suction group I (n=30)	Closed suction group II (n=30)	P. value
	Mean ±SD	Mean ±SD	
PH			
Before suction	7.43±0.1	7.33±0.55	0.336
After suction	7.36±0.1	7.39±0.09	0.265
PCO2			
Before suction	39.8±12.67	42.94±10.12	0.293
After suction	50.6±10.22	47.85±8.69	0.266
HCO3			
Before suction	26.29±7.01	26.97±5.99	0.688
After suction	31.84±6.67	30.36±5.47	0.351

Independent T-test quantitative data between the two groups -

Table (1): Showed percentage distribution of studied children regarding to their demographic data. Finding revealed that there more than one third (36.7%) of children were male in open suction group I compared to (46.7%) in closed suction group II and also more than half of children (63.3%) were female in group I compared to 53.3% in group II. The finding also revealed that two fifth (40.0 %) of children in group I his age ranged from 2-4years compared to more than one third (36.7%) in in group II. Also finding revealed that age and sex weren't significantly different between 2 groups. Finally the mean weight ±SD in group I and group II were 22.1±10.76and 25.37±12.02respectively.

Figure (1): Showed comparison between studied groups (open and closed suction) regarding causes of connection to mechanical ventilation. It was revealed that all children (100%) in both groups

connected to mechanical ventilation due to desaturation

Table (2): Represented percentage distribution of studied children regarding to their medical data. Results revealed that there were highly statistically significant differences between open and closed suctions groups regarding duration of hospital stay, duration on mechanical ventilation and PRISM score on admission. (P 0.001**& <0.001**&0.004**) respectively**.** It was also found that the majority of children duration of hospital stay and duration on mechanical ventilation more than 6 day in open suction group compared to no one of children (0%) in closed suction group.

Table (3): Demonstrated comparison between studied children in open and closed suction related to cardiac parameters. It was revealed that there were highly statistically significant differences in (Heart rate, Mean arterial pressure, Systolic blood pressure and Diastolic blood pressure) during suction and immediately after suction between children in open and closed groups.(P<0.001**).While no statistically significant differences was found before suction and 15 minutes after suction in both groups.

Table (4):- Demonstrated comparison between studied children in open and closed suction related to cardiac parameters. Finding revealed there were highly statistically significant differences in (oxygen saturation , respiratory rate ,Tidal volume and PEEP) during suction and immediately after suction between open and closed groups (P 0.001**). While no statistically significant differences were found before suction and 15 minutes after suction in both groups.

Table (5): Showed comparison between studied children in open and closed suction regarding arterial blood gases parameters. Finding revealed there were no statistically significant differences in ABG parameters before and after suction in both groups. (P.Value =0.33, 0.29, 0.688).respectively.

Discussion

Endotracheal suction (ETS) is required for any child who has an endotracheal tube (ETT), with the primary goal of removing secretions and preventing obstruction of the child's airway. Failure to clear secretions can lead to an obstructed or occluded ETT, which, if untreated will impair oxygenation and ventilation and gas exchange, potentially leading to cardiopulmonary arrest**.** Although necessary, ETS has established adverse effects including bradycardia, atelectasis, hypertension, hypoxemia, and cardiac arrest, and the risk of these complications may be increased in high-risk children **(Rad et al., 2021).**So the current study was conducted to evaluate effect of closed versus open suction on cardiorespiratory parameters in mechanically ventilated children.

The present study revealed that there were no statistically significant differences between open and closed suction group regarding to personal characteristics of children. This confirms that these two groups were matchable during the study (Table 1) Results of the current study demonstrated that there were highly statistically significant differences between open and closed suctions groups regarding duration of hospital stay, duration on mechanical ventilation and PRISM score on admission. (Table 2) .This was supported with the study by (**Elmansoury & Said.,2017)** who illustrated that children who used a closed suction system had a shorter length of stay than patients who used an open suction system.. Also supported by (Ahmed**, 2019)** who found that patients with a closed suction system spent a shorter time in the ICU than patients with an open suction system and there was a statistically significant difference between the two suction method regarding duration of hospital stay. This result opposed with **(Ardehali, et al., 2020)** who showed that no significant difference between open and closed suction group regarding length of ICU stay, duration of MV and mortality rate.

The present study revealed that there were highly statistically significant differences in (Heart rate, Mean arterial pressure, Systolic blood pressure and Diastolic blood pressure) during suction and immediately after suction between open and closed suctions groups. While no statistically significant differences was found before suction and 15 minutes after suction in both groups. (Table 3). This result supported by **(Alavi,et al.,2018)** who found that the mean heart rate, the mean systolic blood pressure, and the mean arterial blood pressure initially rose after airway suctioning and then declined in the open suction groups and closed suction groups, but the changes were less pronounced in the closed suction groups and were significant just after the suctioning of the airway. This results also supported with **(Dastdadeh et al ., 2016)** who demonstrated that The measurement of the heart rate, systolic blood pressure, and diastolic blood pressure variables at different temporal stages revealed a significant difference over time between the two groups of open suctioning and closed suctioning. However, at all stages, these variables did not show a significant difference between the two groups. Also supported with**(Mengar, & Dani., 2018)** who similarly reported that heart rate increased during both open and closed endotracheal suction, but the increase during open tracheal suction group higher than in the closed tracheal suction group.

The results of the present study indicated that, there was a decrease in the mean of heart rate in closed suction groups compared to open suction

groups. (Table 3). This agreed with (**Asgari et al., 2013)** who found that pulse rate was significantly lower in the closed suction groups than in the open suction groups one. From the researchers' point of view, these results may be related to, in the open suction method the suction tube disconnect from the ventilator and this lead to desaturation and hypoxia induced, Then, hypoxia stimulates the adrenergic nervous system, which controls the cardiovascular and hemodynamic responses as tachycardia, hypertension a compensatory response to the lack of blood oxygen saturation .

Increase in HR in open suction groups more than in closed suction groups and returned to the baseline after 15 minutes in both group compared with before ES. The researcher explains that this finding could be attributed to irritation by suction tube movements as well as fear, pain and stress which are caused by the ES technique itself.

The present study revealed that there were highly statistically significant differences in (Systolic blood pressure, Diastolic blood pressure and mean arterial pressure) during suction and immediately after suction between open and closed suctions groups. This finding contradicts with that of **(Afshari et al., 2014)** who found that no significant differences were observed between the two suctioning methods in terms of mean systolic blood pressure, diastolic blood pressure and mean arterial pressure.

The result of this study showed that there were highly statistically significant differences in (oxygen saturation, respiratory rate, Tidal volume and PEEP) during suction and immediately after suction between open and closed suction groups. While no statistically significant differences were found before suction and 15 minutes after suction in both groups. (Table 4).

The results of the current study indicated that, the mean of oxygen saturation was higher in the closed method compared with the open method with a highly statistically significant difference between the open and closed suction groups during and immediately after suction. This result was coordinated with **(Thabet & Sayed., 2019)** who found that there were highly statistical significant differences between the two methods of suctioning as regards the mean of, oxygen saturation, among children during and immediately after the closed and open suctioning **.** The researcher explains that this could be due to that in a close endotracheal suction system, the catheter is a part of a ventilator circuit without the need to disconnect the ventilator and thus improve oxygenation; significantly reduce signs of hypoxemia; subsequently the hemodynamic parameters .The result also in the line with **(Ahmed., 2019)** who found that closed suction system group have a higher mean oxygen saturation than those in the open group during suction and immediately after suction measurements. This also supported with a study conducted by **(Ebrahimian et al., 2020)** who reported significant differences with respect to the mean values of oxygen saturation during and immediately after suction. Also this study agreed with (**Pirr et al., 2013)** who illustrated that, the mean minimum SpO2 was significantly higher during closed suction compared to open suction and agreed with **(Evans et al., 2014)** who said that open suction demonstrated a greater reduction in oxygen saturation than closed suction.

The result of this study demonstrated that there were highly statistically significant differences in respiratory rate during and immediately after suction **(**table 4).This finding supported by **(Ebrahimian, et al., 2020),** who reported significant differences with respect to the mean values of respiratory rate during and immediately after suction. This was also in line with the study by (**Asgari, etal., 2013)** who found that there was statistically significant differences in respiratory rate during and immediately after the closed and open suctioning . This finding was opposed to another study by (**Cardoso et al., 2017)** who reported that, there was an increase in respiratory rate only with the use of open suction without significant differences.

The result of this study revealed that there were highly statistically significant differences in Tidal volume and PEEP during suction and immediately after suction between open and closed suctions groups. **(**table4).these result could be due to from the researcher point of view that during suctioning with a closed suctioning system, mechanical ventilation support is continuous, allowing PEEP to be maintained with minimal changes in FiO2. This prevents lung volume loss and causes fewer changes in oxygenation and ventilation during suctioning. In open suction, disconnecting the patient from the ventilator results in a loss of positive end-expiratory pressure (PEEP) and tidal volume. **(Schults et al.,2021).** This also supported by **(Alshahrani., 2021)** who found that Loss in lung volume during OS was significantly higher than during CS.

The result of the present study revealed that there were no statistically significant differences in arterial blood gases parameters before and after suction in both open and closed suction groups. (table5).

The result of study illustrated that no significance difference between open and closed suction regarding PaCO2. This supported by **(Özden & Görgülü., 2015)** who found that there was no significant difference between open suction and closed suction groups in terms of PaCO2. In patients who underwent open ES, mean PaCO2 increased after aspiration was stopped and decreased after ES. The researcher

explains that this could be due to a partial restriction in oxygen and carbon dioxide exchange during mechanical ventilation disconnection and aspiration catheter forward manipulation. Also may be due to the interruption of mechanical ventilation and drainage of oxygenated air and secretion through the respiratory tract during endotracheal suctioning resulted in decrease in PaO2 and hypoxemia. PaCO2 levels rise as PaO2 levels fall.

The result of the present study showed that no significance difference between open and closed suction groups regarding PH and PaCO2 in open and closed suctions groups and this supported by **(Alavi,et al., 2018)** who found that there is no significant changes in both open and closed suctioning groups regarding PH and PaCO2 and also supported with **(Cocca & Mincolelli., 2022) w**ho found that no statistically significant differences between pre and post endotracheal aspiration values of pH, pO2 and pCO2 in open and closed suction groups.

The results of the present study revealed that there were increase in HCO3 in both open and closed suction groups .This may be related to elevation in PaCO2 as soon as aspiration was terminated during both open and closed ES, which lead to reduced pH and elevated HCO3.

Conclusion

Based on the results of the present study, it can be concluded that;

Closed suction method method is more effective than open suction method on cardiorespiratory parameters in mechanically ventilated children

Recommendations

Based on the results of the present study the following recommendations can be suggested:

1. Closed suction should be integrated as a routine care for children in PICU
2. Closed suction method should be incorporated as one of the best method of suction on reducing hemodynamic instability in daily practice.
3. PICU nurses should be aware of using the nursing guidelines of closed suction system in daily practice and these nursing guidelines should be available in all pediatric intensive care units.
4. Future studies should be replicated and extended to include a large sample focusing on comparing suction method with acquired infection in PICU.

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