Effect of Minimally Invasive Endotracheal Suctioning on Physiological Parameters Among Mechanically Ventilated Preterm.

Seham Hamdy Darwish Abdelkader, Clinical instructor
Pediatric Nursing department, Faculty of Nursing, Alexandria University, Egypt.
Yousr Abd- Elsalam Gaafar, *Professor Emeritus*
Pediatric Nursing department, Faculty of Nursing, Alexandria University, Egypt.
Marwa Mohamed Farag, Assistant Professor
Pediatrics Department, Faculty of Medicine, Alexandria University, Egypt.
Eman Arafa Badr, Lecturer in Pediatric Nursing
Pediatric Nursing department, Faculty of Nursing, Alexandria University, Egypt.

Corresponding Author: *Seham Hamdy Darwish Abdelkader*, Faculty of Nursing, Pediatric Nursing Department. Email: seham-hamdy@alexu.edu.eg

Article History:
Received: 7/2/2025
Revised:10\2\2025
Accepted: 25\2\2025
Published:1\9\2025

Abstract:

Background: A mechanical ventilator is a significant life-saving intervention for preterm neonates. Thus, those neonates need recurrent endotracheal suctioning to remove pulmonary secretions. However, it is necessary, as it is a noxious stimulus, and physiological changes can be observed during this procedure. Therefore, critical neonatal nurses have a crucial role during endotracheal suctioning with minimal negative side effects. **Aim of the study:** to evaluate the impact of minimally invasive endotracheal suctioning on physiological parameters among mechanically ventilated preterm. Design: A quasi-experimental research design was used. **Settings:** This study was conducted at the Neonatal Intensive Care Unit at Alexandria University Children's Hospital at El-Shatby. **Subjects and Method:** A convenient sample of 60 mechanically ventilated preterm neonates who were admitted to the previously mentioned settings (25 neonates from were fulfilled the following criteria; mechanically ventilated preterm neonates on invasive endotracheal tube, gestational age less than 37 weeks at birth and not receiving any sedatives. Those neonates were distributed equally into control and study groups (30 neonates in each one). Preterm neonates in the control group experienced routine endotracheal suctioning in the unit (deep suctioning) by the assigned neonatal nurse. In contrast, those in the study group experienced minimally invasive endotracheal suctioning by the researcher. Physiological parameters of neonates were assessed before, during, immediately, after three and ten minutes of the procedure. **Results:** it was found that more than three-quarters of preterm neonates (76.7%) in the study group had normal heart rate immediately after suctioning, compared to most of the neonates in the control group (96.7%) who still recorded tachycardia ($p<0.001$). A statistically significant difference between both groups of the study was found immediately after and after three minutes of suctioning concerning respiratory rate ($p<0.001$), whereas around two-thirds of neonates in the study had normal respiratory rate, but almost all of the neonates in the control group recorded tachypnea ($p<0.001$). Regarding oxygen saturation during suctioning, the means of oxygen saturation were 88.4±7.0% and 90.0±3.6% in the control and study groups, respectively. A statistically significant difference was found between both groups of study ($p=0.001$). **Conclusion**: This study demonstrates that minimally invasive endotracheal suctioning in intubated preterm neonates had less effect on physiological parameter alterations than routine deep endotracheal suctioning. **Recommendations:** The following recommendations are suggested: The critical neonatal nurse must assess the need of neonates for suctioning and monitor the preterm infant during and after the procedure. Additionally, those nurses need to practice minimal invasive endotracheal suctioning for preterm neonates to aviod potential outcomes. **Keywords:**Mechanical ventilator, physiological parameters, minimally invasive endotracheal suctioning, preterm neonates.

Mechanical Ventilator, Physiological Parameters, Minimally Invasive Endotracheal Suctioning.

Introduction

Preterm neonates are defined as any neonate who has a gestational age below 37 weeks at birth (World health organization [who], 2024).Globally, according to WHO, (2020) it was reported that 13.4 million preterm neonates were born **in 2020**. Nearly all of them (96%) are found in developing countries. Unfortunately, prematurity is the leading first cause of death in children under the age of 5 years all over the world (Algameel et al., 2020).

Preterm birth is the major cause of neonatal mortality and complications related to prematurity. Preterm neonates suffer from many complications as impaired respiration, apnea of prematurity, cardiovascular disorders, bradycardia, neurological disorders, gastrointestinal disorder, hematological disorder, neonatal jaundice, and retinopathy of prematurity (Zivaljevic et al., 2024).

Prematurity-related complications require special care in the Neonatal Intensive Care Unit (NICU), as preterm neonates suffer from delayed pulmonary maturation and are in increased need of Mechanical Ventilation (MV) support (Rocha et al., 2018). It is estimated that between 10%-20% of all neonates admitted to the NICU receive MV (Javadi, 2017).

Mechanical ventilation is a recurrent intervention applied for preterm neonates (Bose et al., 2023; Green, 2020). The main purpose is to ensure the provision of adequate gas exchange, including delivery of adequate oxygenation and enough ventilation for excretion of carbon dioxide, stable airway, adequate lung recruitment, avoidance of hypoxemia and hypercarbia with the use of the lowest necessary tidal volume and peak inspiratory pressures (Chkkarapani et al.,2020).

Preterm neonates undergoing mechanical ventilator require special care particularly Endotracheal tube Suction (ETTS). Intubation prevents the cough reflex and interferes with normal mucociliary function, therefore increasing airway secretion production and decreasing the ability to clear secretions (Eid et al., 2022).

Endotracheal suction is a common procedure carried out on intubated preterm neonates. Endotracheal Tube Suction is necessary to clear secretions, maintain airway patency, and optimize oxygenation and ventilation in mechanically ventilated preterm neonates. The goal of ETTS is to remove the maximum amount of secretions with minimal adverse effects associated with the procedure (Bruscettini et al., 2016).

Preterm neonates are vulnerable and at risk for several suction-related complications, including hypoxemia, bradycardia, tachycardia, atelectasis, pneumonia, fluctuations in blood pressure and intracranial pressure, localized trauma to the airway and suction-related pain. However, ETS is one of the invasive painful procedures that is frequently needed among preterm neonates. Therefore, suction-related pain is felt and associated with ETTS (Shamali et al., 2017)

Routine endotracheal suctioning technique has a consequence on the hemodynamic parameters of mechanically ventilated preterm neonates. Stress is increased during these techniques which leads to increases in intra-thoracic pressure, cardiac output, and venous return. Additionally, tracheal suctioning causes increases in peripheral vascular resistance, potential blood pressure, heart rate, and arterial blood gasses (Ahmed et al., 2017).

Minimally Invasive Endotracheal Suctioning (MIETS) is suggested as a suction method that is as non-invasive as conceivable. It's a beneficial method used by the neonatal nurse to overcome these complications. This method has fewer episodes with de-saturation, a rise in systolic blood pressure, and a rise in pulse pressure rate. A significantly was found less blood in aspirated secretions (Shamali, et al., 2019)

Neonatal critical care nurses have a crucial role in caring for mechanically ventilated preterm neonates (Mustafa et al., 2019). The neonatal nurse must assess the need for ETS, perform the procedure, and monitor the preterm neonate during and after the procedure. Additionally, the neonatal nurse should assess pain level, airway clearance, and physiological parameters before ETS. Therefore, it is essential that these nurses are aware of ETS risks and can practice minimal invasive endotracheal suctioning (Mohamed et al., 2011). It is imperative that this study is the first study occurring in the preterm neonate's field to decrease the disturbance of physiological parameters occurring during endotracheal suctioning.

Aim of the Study: Evaluate the effect of minimally invasive endotracheal suctioning on physiological parameters for mechanically ventilated preterm neonates.

Research hypothesis: Mechanically ventilated preterm neonates who receive minimally invasive endotracheal suctioning exhibit more stable physiological parameters than those who don't receive it.

Materials and Method.

Design: A quasi-experimental research design was used to accomplish this study.

Settings: This study was conducted at Neonatal Intensive Care Units (NICUs) of Smouha Children's University Hospital and El Shatby Maternity and Children University Hospital of Alexandira.

Subjects A convenient sample of 60 mechanically ventilated preterm neonates who were admitted to the previously mentioned settings and fulfilling **inclusion criteria were included:**

- Mechanically ventilated preterm neonates on invasive ETT.
- Gestational age less than 37 weeks at birth.

The exclusion criteria were:

- Receiveing any sedatives.

The Exclusion criteria are:

- Any neonatal neurological problems e.g. Intra intra-ventricular hemorrhage, Hypoxic Ischemic Encephalopathy as evidenced by neonate's record.
- Major congenital anomalies such as congenital heart disease.

The study subjects were randomly assigned into two equal groups: control group and MIETS group (30 neonates in each). The first mechanically ventilated preterm neonates were assigned to the control group, and the second preterm neonates was assigned to the MIETS group (study group)

Control Group: mechanically ventilated preterm neonates who received routine hospital care for ETTsuctioning and did not receive MIETS intervention.

Minimally Invasive ETT Suctioning Group (MIETS) (Study group): mechanically ventilated preterm neonates who received the minimally invasive ETT suctioning intervention.

Tools: two tools were used to collect the needed data.

Tool One: Preterm Neonates' Characteristics and Biomedical Data Assessment Record.

This tool was developed by the researcher to assess the characteristics, biomedical data, and mechanically ventilated data of preterm neonates. It included two parts:

- **Part I: Preterm Neonate's Characteristics; as** Gestational Age (GA), postnatal age, gender, birth weight and method of delivery.
- **Part II: Biomedical Data of Preterm Neonates;** as diagnosis, medications, applied negative pressure during suction and mechanical ventilator mode.

Tool two: Physiological Parameters of Preterm Neonates; it included heart rate, respiratory rate, and oxygen saturation of preterm neonates, as well as the standard normal value as illustrated in Table (1) (Wilson & Hockenberry, 2019;).

Table (1): Normal value of physiological parameters of preterm neonates:

Physiological parameters	Normal value
Heart Rate (b/m)	120-140 b/m.
Respiratory rate (c/m)	30-60 c/m.
O2 saturation (%)	85-95%

Method

1- Approval from the Research Ethics Committee, Faculty of Nursing, Alexandria University was obtained before carrying out this study on 15/12/2022.

2- An official letter was sent from the Faculty of Nursing to the directors of the study settings to facilitate research implementation after explanting the aim of the study.

3- Study tools were developed by the researcher after reviewing the related literature**.**

4- Study tools were tested for their content validity by five experts in the field of pediatric nursing and necessary modifications were accepted by (96%).

5- The reliability of the study tools were ascertained by using the appropriate statistical tests (Cronbach's Alpha test, r = 0.929%).

6- A pilot study was conducted on 10% of mechanically ventilated critically ill children (six preterm neonates) to test the feasibility, applicability, and clarity of the tools. The necessary modifications were done. Those preterm neonates were excluded from the total study subjects.

7- Initially, preterm neonates' characteristics were obtained by using study tool one for all preterm neonates in both study groups.

8- The preterm neonates were assessed for their physiological parameters before ETT suctioning in both study groups by using tool two.

9- Preterm neonates were divided equally into two groups, (control and MIETS group).

Interventions for both groups:

- **For Control Group:** mechanically ventilated preterm neonates received the routine hospital care for ETS as needed. Endotracheal tube suctioning was done without sterile glove and a negative pressure ranging from 60-80 mmHg was commonly used during ETS. The suction catheter was inserted into the carina ETS was done with manual hyperinflation, installation of normal saline and deep ETS.
- **For the study group:** mechanically ventilated preterm neonates in the study group received the Minimally Invasive Endotracheal Suctioning intervention as follows:
- The researcher performed hand hygiene and wore a sterile gown, sterile gloves, and mask.
- The researcher demonstrate hyperoxygenation to preterm neonates by increasing FiO_2 10-20% above the baseline setting for approximately two minutes before ETT suctioning (Wilson & Hockenberry, 2014).
- Hyperoxygenation was continued after suctioning until the preterm neonate returned to normal oxygen saturation

level (85 to 95 %) (Amaliya et al., 2024).

- Negative pressure was limited to the minimum that was able to remove the secretions and did not be exceed 60 mm Hg.
- The size of the suction catheter was selected and did not exceed 50% of the internal diameter of the ETT size. Endotracheal tube suction size was determined according to ETT suction formula calculation; (Size of endotracheal – 2) x 2 = Correct French) Bellini & Massirio, 2022).
- Safe suction depth was determined by using a graduated suction catheter; the inserted length of the suction catheter was measured by only introducing the suction catheter into an ETT sample, which was the same size as the preterm neonate's ETT. until the suction catheter reached 0.5–1 cm beyond the end of ETT, the landmark was identified. The predetermined length for a suction catheter insertion was verified on the catheter suction and was introduced into the ETT until it reached that length.
- During MIETS suction the catheter passes were limited to maximum three passes. Each pass was performed from five to ten seconds maximum.
- Between the suction catheter passes, preterm neonates were allowed recovery time (until restoring baseline ventilation and oxygen saturation) with the connection again to the mechanical ventilator.
- The researcher was check the preterm neonates' response to ETT suctioning continuously throughout the procedure by monitoring cardio-respiratory monitor and if preterm neonates had serious physiological parameters deterioration during ETT, the researcher stop the procedure.
- Preterm neonates' physiological parameters were monitored during, immediately after, and after three and ten minutes of ETT suctioning for both study groups by using (tool II).
- A comparison of physiological parameters was done between both groups of study to determine effect of MIETS on suction -related physiological parameters among mechanically ventilated preterm neonates.

Ethical Considerations: Written informed consent was obtained from every preterm neonate's caregiver after explaining the aim of the study. The voluntary participation of their preterm neonates, and the right to withdraw their preterm neonates from the study was assured at anytime. Confidentiality of preterm neonates' data was ascertained. The privacy of preterm neonates was maintained.

Statistical Analysis of the Data: Data were fed to the computer and analyzed using IBM SPSS software package version 23.0**.** Qualitative data were described using number and percentages. Quantitative data were described using mean, standard deviation. Significance of the obtained results was judged at the 5% level.

Results

Table (2) presents the characteristics of the mechanically ventilated preterm neonates in the study groups. The mean gestational age for neonates was 30.7 ± 2.8 and 31.5±2.5 weeks in the control and the MIETS group, respectively. The postnatal age of the mechanically ventilated preterm neonates in the study groups (control and MIETS) were 5.8±5.0 and 4.4±4.0 days, respectively. Additionally, it was noticed that half of the preterm neonates (50%) in the control were male compared to 60 % in the MIETS group. Regarding weight, it was noticed that the mean birth weight for preterm neonates was 1502.3± 576.1 grams and 1164.2±121.9 gm in the control and the MIETS groups, respectively. It is striking that most preterm neonates (90% in each group) were delivered by cesarean section in both groups of study.

Table (3) shows the biomedical data of mechanically ventilated preterm neonates in the study groups. The majority of mechanically ventilated preterm neonates (86.7% & 80%) were admitted to NICU with respiratory distress in the control and the MIETS groups, respectively. Additionally, it was recorded that most of the preterm neonates (86.7% and 96.7%) were prescribed antibiotics in the control and the MIETS groups, respectively. Also, it was found that 73.3% and 60% of preterm neonates were receiving caffeine citrate in the control and the study groups, respectively. It was seen that the applied negative pressure during endotracheal tube suctioning ranged between 40-60 MMHG. in 76.7% of preterm neonates in the control group compared to 100% in the MIETS group, with a statistically significant difference (p=0.011).

Figure (1) reflects the mechanically ventilated mode of preterm neonates in the study groups. It was found that most used mechanical ventilator mode among preterm neonates was pressure target ventilation (86.7% and 80%) in the control and MIETS study groups respectively.

Table (4) exemplifies the effect of minimally invasive endotracheal suction on the respiratory rate of mechanically ventilated preterm undergoing endotracheal suctioning. It was observed that during ETT suctioning most of the neonates (96.7% & 90.0%) in the control and MIETS groups, respectively. A statistically significant difference was found between both groups immediately after suctioning (p<0.001), whereas nearly two-thirds of neonates (63.3%) in the MIETS had normal respiratory rates but all neonates (100%) in the control group recorded tachypnea. Moreover, 70.0% of preterm neonates in the MIETS group documented normal respiratory rate after three minutes of suctioning compared to 96.7% of neonates in the control group who had tachypnea, with a statistically significant difference (p<0.001). Furthermore, a percentage of neonates in the MIETS group documented improvement in their respiratory rate to 90% after ten minutes of suctioning, while the same percentage of neonates (96.7%) in the control group still had tachypnea with a statistically significant difference (p<0.001)

Table (5) Shows the effect of minimally invasive endotracheal suction on the oxygen saturation of mechanically ventilated preterm undergoing endotracheal. It was observed that during suctioning, these means of oxygen saturation decreased to 88.4±7.0% and 90.0±3.6% in the control and MIETS groups, respectively. A statistically significant difference was found between both groups of study (p=0.001). It was found that 43.3% and 56.7% of neonates in the control and the MIETS had oxygen saturation ranging from 95 to 100% immediately after suctioning with a mean saturation of 84.5±22.8% and 98.5±1.3%, respectively. A statistically significant difference was found between both groups of the study immediately after suctioning (p=0.002). It is noted that 100% of preterm neonates had oxygen saturation ranging from 95 to 100% in the MIETS compared to 50% in the control group after three minutes of suctioning with a mean 98.5±1.3% and 91.9±7.7%, respectively (p=0.001). Moreover, the mean oxygen saturation of preterm neonates after ten minutes of suctioning was 94.4±5.3% and 98.8±1% in the control and the MIETS groups, respectively (p=0.001)

Table (6) summarizes the effect of Minimally Invasive Endotracheal Suctioning on the heart rate of mechanically ventilated preterm neonates during endotracheal suctioning .The table clarifies that more than half of preterm neonates (56.7%) in the control group and two-thirds (66.7%) in the MIETS group recorded tachycardia before ETT suctioning with mean heart rates 162.0±17.7 and 165.1±9.3 b/min respectively. Additionally, these percentages increased during suctioning to 100% and 93.3% of preterm neonates in the control and MIETS groups with mean heart rates of 180.4±14.2 and 164.3±15.8 beats/min., respectively. A statistically significant difference ($p<0.001$). Fortunately, more than three-quarters of preterm neonates (76.7%) in the MIETS group had normal heart rate immediately after suctioning, while most of the neonates in the control group (96.7%) still recorded tachycardia with statistically significant differences ($p<0.001$). Moreover, it was recorded that 83.3% of preterm neonates in the MIETS group had normal heart rate after 3 minutes of suctioning however the same percentage in the control group had tachycardia, with statistically significant differences ($p<0.001$). Furthermore, after ten minutes of suctioning the majority of preterm neonates (86.7%) in the MIETS group recorded a normal heart rate compared to 50.0% in the control group, with statistically significant differences ($p<0.001$).

Discussion:

Many premature neonates require prolonged ventilator support to improve their ventilation and perfusion and support pulmonary gas exchange. To provide ventilator support, an artificial airway must be inserted mostly with an endotracheal tube. to enhance airway secretion production and falling the neonates' ability to clear secretions. So, ETTS is a common procedure carried out on intubated neonates to maximize the amount of secretion removed with minimal adverse effects associated with the procedure (Volsko & Barnhart, 2020).

Endotracheal suctioning is a powerful stimulus that can lead to several complications. These complications include hypoxemia, cardiovascular disturbances, bronchospasm, and atelectasis that lead to change in physiological parameters. Heart rate is the first one to be disturbed among physiological parameters during suction (Mohamed et al., 2023).

Compared to standard normal values, both groups showed an increase in mean heart rate during ETS, with the heighest increase in the control group. Moreover, around three quarters of neonates in the MIETS group returned to normal heart rate immediately after suctioning compared to half of neonates in control group after 10 minutes of suctioning with statistically significant differences across the times of recordings.

Suctioning preterm neonates is a painful and stressful procedure due to mechanical stimulation from the catheter that causes deterioration in their physiological parameters (Sinha et al., 2025). These results may be due to less pain occurring during MIETS which leads to less disturbance in physiological parameters. Also, the traditional deep technique of ETS entails a blind advancement of the suction catheter through the ETT until it meets resistance, with high negative pressure applied that may cause more tachycardia.

These findings are matched with Ahmed et al. (2017) findings that reflected significant differences among deep and shallow endotracheal suction groups regarding pulse rate with $p< 0.05$. On the other hand, these findings are inconsistent with the findings of Al-Mayetiazidy et al. (2024) which non-statistically reported significant differences in heart rate of preterm neonates receiving shallow versus deep suctioning techniques.

The study findings revealed a positive effect of MIETS on the neonates' physiological changes induced by suctioning. A statistically significant difference was found regarding respiratory rate among preterm neonates of MIETS compared to control groups. Whereas the majority of preterm neonates recorded tachypnea during suctioning in both groups of study. Additionally, nearly two-thirds of neonates in the MIETS group returned to normal respiratory rate immediately after suctioning, while nearly all neonates in the control group still recorded tachypnea after ten minutes of suctioning (table 4). This may be related to irritability and desaturation associated with endotracheal suctioning. Additionally, Ahmed et al. (2017) reported significant differences among deep and shallow endotracheal suction groups about respiration at three periods of the study with $p < 0.05$.

A significant drop in oxygen saturation may be considered clinically important in critically ill neonates. A decrease in SpO2 is assumed to be a common frequent adverse complication of ETS, so preoxygenation is recommended before ETS in all neonates. Factually, based on the oxyhemoglobin dissociation curve, a 1% decrease in SpO2 results in a reduction of PaO2 by 4 mmHg (Shamali et al., 2019).

The result of the current study revealed a significant decline in mean Spo2 during suctioning in both groups of study. However, all neonates in MIETs group recorded normal Spo2 immediately after suctioning compared to neonates in the control group who still complained of desaturation **Table (5)**.

The statistically significant drop in SpO2 in association with routine suctioning compared to the MIETS may be attributed to the instillation of normal saline before ETS in the control group. Some studies showed that patients receiving a bolus of normal saline before ETS suffered a much greater fall in SpO2. Another contributive factor may be the application of manual hyperoxygenation which is used in routine suctioning or neglected preoxygenation before suctioning. Hyperoxygenation through a mechanical ventilator has been conveyed to be more effective than the manual resuscitator bag in restricting hypoxemia before suctioning. Other factors may be related to long periods of disconnecting from MV during suctioning and more applied negative pressure.

These findings are consistent with the findings of Al-Mayetiazidy et al. (2024) that the mean score of O2 was increased among the shallow suctioning group after 10 minutes of suction (98.00±1.59) compared to (97.68±1.74) in the deep suctioning group. Similar findings were reported by Ahmed et al., (2017) who found an improvement in the mean of O2 saturation immediately after the procedure among the shallow endotracheal suction group with $p<0.05$. Another study entitled The Effect of Minimally Invasive endotracheal tube Suctioning on Physiological Indices in Adult Intubated Patients reported the same results (Shamali et al., 2019).

Conclusion: This study demonstrated that minimally invasive endotracheal suctioning in intubated preterm neonates had less effect on physiological parameters alterations than routine deep endotracheal suctioning

Recommendations: Based on the previous findings and conclusion, the following recommendations are suggested:
The neonatal nurse must assess the need for ETTS, perform the procedure, and monitor the preterm infant during and after ETTS. Additionally, the neonatal nurse should assess pain level, airway clearance, and physiological parameters throughout the ETTS. Therefore, it is essential that these nurses are aware of ETTS risks and should practice Minimal Invasive Endotracheal Suctioning.

Table (2): Characteristics of Mechanically Ventilated Preterm Neonates in the Study Groups.

Preterm Neonate's Characteristics	Control group (n = 30)		MIETS Group (n = 30)		Test of sig.	p
	No.	%	No.	%		
Gestational Age (GA)/ weeks						
Min. – Max.	27.0–36.0		28.0–36.0			
Mean ± SD	30.7±2.8		31.5±2.5		t = 1.213	0.230
Median	30.0		32.0			
Postnatal age (days)						
Min. – Max.	1.0-17.0		2.0-17.0			
Mean ± SD	5.8±5.0		4.4±4.0		U =395.0	0.403
Median	4.0		3.0			
Gender						
Male	15	50.0%	18	60.0%	χ^2=0.606	0.436
Female	15	50.0%	12	40.0%		
Birth weight (gm)						
Min. – Max.	830.0-2500.0		860.0-1370.0			
Mean ± SD	1502.3±576.1		1164.2±121.9		U =376.0	0.272
Median	1185.0		1185.0			
Method of delivery						
Normal vaginal delivery	3	10.0%	3	10.0%	χ^2=0.0	1.000
Cesarean section delivery	27	90.0%	27	90.0%		

χ^2: Chi-square test t: Student t-test U: Mann Whitney test

Table (3): The Biomedical Data of Mechanically Ventilated Preterm Neonates in the Study Groups.

The Biomedical Data	Control group (n = 30)		MIETS Group (n = 30)		Test of sig.	p
	No.	%	No.	%		
Diagnosis						
Respiratory Distress Syndrome	26	86.7%	24	80.0%		
Congenital pneumonia	2	6.7%	4	13.3%	χ^2=0.862	0.872
Transient Tachypnoea of neonates	2	6.7%	2	6.7%		
Medication prescribed #					χ^2	P
Caffeine Citrate	22	73.3%	18	60.0%	1.200	0.273
Antibiotics	26	86.7%	29	96.7%	1.964	0.353
Corticosteroids	4	13.3%	9	30.0%	2.455	0.177
Vitamins Supplementation	7	23.3%	8	26.7%	0.089	0.766
Ibuprofen	1	3.3%	0	0.0%	1.017	1.000
Dopamine	4	13.3%	2	6.7%	0.741	0.671
Iron Supplementation	8	26.7%	7	23.3%	0.089	0.766
Others	5	16.7%	5	16.7%	0.0	1.000
Applied negative pressure (mmHg)						
40 – 60	23	76.7%	30	100%	χ^2=7.925*	0.011*
60 – 80	7	23.3%	0	0.0%		

χ^2: Chi-square test # = multiple response

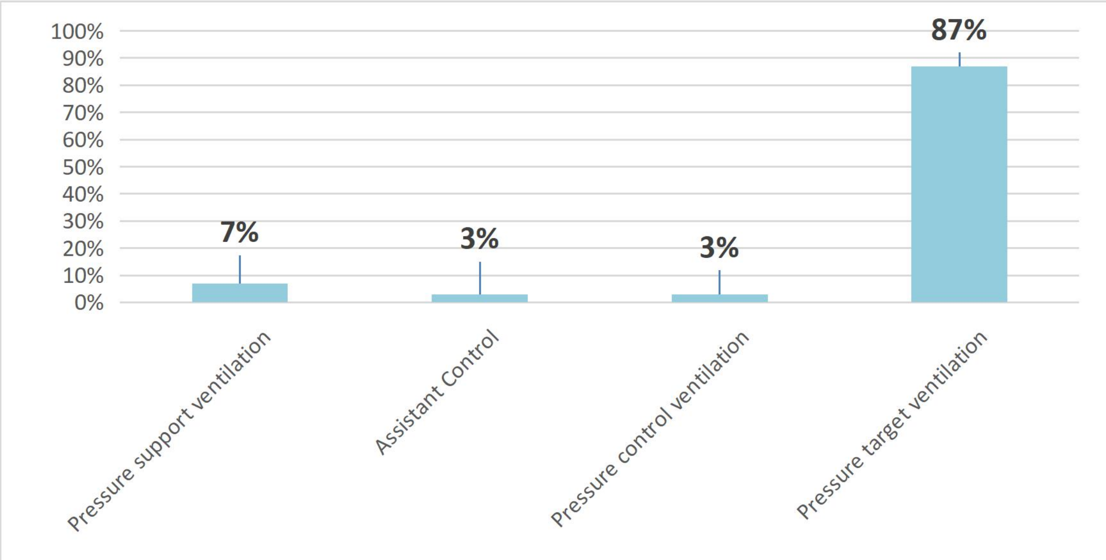

Figure (1): Modes of Mechanically Ventilated Preterm Neonates

Table (4): The Effect of Minimally Invasive Endotracheal Suction on Respiratory Rate of Mechanically Ventilated Preterm Undergoing Endotracheal Suctioning.

Respiratory Rate	Control (n=30)		MIETS (n=30)		Test of sig.	p
	No.	%	No.	%		
Before Suction						
– Bradypnea	0	0.0%	0	0.0%	χ^2 =0.659	0.417
– Normal	12	40.0%	9	30.0%		
– Tachypnea	18	60.0%	21	70.0%		
Mean ± SD	69.2±13.6		66.6±9.5		t =0.849	0.399
During Suction						
– Bradypnea	0	0.0%	0	0.0%	χ^2 =1.071	0.612
– Normal	1	3.3%	3	10.0%		
– Tachypnea	29	96.7%	27	90.0%		
Mean ± SD	73.5±11.9		59.4±7.6		t =5.474*	0.001*
Immediately After Suction						
– Bradypnea	0	0.0%	0	0.0%	χ^2 =27.80*	<0.001*
– Normal	0	0.0%	19	63.3%		
– Tachypnea	30	100.0%	11	36.7%		
Mean ± SD	73.9±11.4		52.2±9.7		t =7.771*	<0.001*
3Min. After Suction						
– Bradypnea	0	0.0%	0	0.0%	χ^2 =37.31*	<0.001*
– Normal	1	3.3%	21	70.0%		
– Tachypnea	29	96.7%	9	30.0%		
Mean ± SD	72.4±11.3		47.6±12.7		t =8.008*	<0.001*
10 Min. After Suction						
– Bradypnea	0	0.0%	0	0.0%	χ^2 =58.03*	<0.001*
– Normal	1	3.3%	27	90.0%		
– Tachypnea	29	96.7%	3	10.0%		
Mean ± SD	72.7±11.9		46.1±11.6		t =8.787*	<0.001*

t: Student t-test χ^2: Chi square test MC: Monte Carlo
FE: Fisher Exact *: Statistically significant at $p \le 0.05$

Table (5): The Effect of Minimally Invasive Endotracheal Suction on Oxygen Saturation of Mechanically Ventilated Preterm Undergoing Endotracheal Suctioning.

Oxygen Saturation (Spo2)	Control (n=30)		MIETS (n=30)		Test of sig.	p
	No.	%	No.	%		
Before Suction						
<85%	4	13.3%	3	10.0%		
85 - <90%	7	23.3%	8	26.7%		
90 - <95%	4	13.3%	6	20.0%	$\chi^2 = 0.854$	$^{MC}p = 0.891$
95 – 100%	15	50.0%	13	43.3%		
Mean ± SD	91.1±9.1		91.5±6.2		**t** =0.216	0.830
During Suction						
<85%	4	13.3%	0	0.0 %		
85 - <90%	10	33.3%	3	10.0 %		
90 - <95%	13	43.3%	23	76.7 %	$\chi^2 = 15.308^*$	$^{MC}p = 0.001^*$
95 – 100%	3	10.0%	4	13.3%		
Mean ± SD	88.4±7.0		90.0±3.6		**t** =1.108	0.272
Immediately After Suction						
<85%	10	33.3%	0	0.0%		
85 - <90%	1	3.3%	4	13.3%		
90 - <95%	6	20.0%	9	30.0%	$\chi^2 = 13.884^*$	$^{MC}p = 0.002^*$
95 – 100%	13	43.3%	17	56.7%		
Mean ± SD	84.5±22.8		94.2±3.3		**t** =2.323*	0.027*
3Min. After Suction						
<85%	2	6.7%	0	0.0%		
85 - <90%	10	33.3%	0	0.0%		
90 - <95%	3	10.0%	0	0.0%	$\chi^2 = 20.329^*$	$^{MC}p < 0.001^*$
95 – 100%	15	50.0%	30	100.%		
Mean ± SD	91.9±7.7		98.5±1.3		**t** =4.636*	<0.001*
10 Min. After Suction						
<85%	2	6.7%	0	0.0%		
85 - <90%	0	0.0%	0	0.0%		
90 - <95%	10	33.3%	0	0.0%	$\chi^2 = 15.707^*$	$^{MC}p < 0.001^*$
95 – 100%	18	60.0%	30	100.%		
Mean ± SD	94.4±5.3		98.8±1.1		**t** =4.449*	<0.001*

t: Student t-test χ^2: Chi square test MC: Monte Carlo
FE: Fisher Exact *: Statistically significant at $p \leq 0.05$

Table (6): The Effect of Minimally Invasive Endotracheal Suction on Heart Rate of Mechanically Ventilated Preterm Undergoing Endotracheal Suctioning.

Heart Rate	Control (n=30)		MIETS (n=30)		Test of sig.	p
	No.	%	No.	%		
Before Suction						
– Bradycardia	1	3.3%	1	3.3%		
– Normal	12	40.0%	9	30.0%	χ^2 =0.918	0.783
– Tachycardia	17	56.7%	20	66.7%		
Mean ± SD	162.0±17.7		165.1±9.3		**t** =0.847	0.402
During Suction						
– Bradycardia	0	0.0%	1	3.3%		
– Normal	0	0.0%	0	0.0%	χ^2 =1.017	1.000
– Tachycardia	30	100%	29	96.7%		
Mean ± SD	180.4±14.2		164.3±15.8		**t** =4.161*	<0.001*
Immediately After Suction						
– Bradycardia	0	0.0%	0	0.0%		
– Normal	1	3.3%	23	76.7%	χ^2 = 37.28*	^{MC}p<0.001*
– Tachycardia	29	96.7%	7	23.3%		
Mean ± SD	169.7±22.0		159.8±15.7		**t** =2.003*	0.049*
3Min. After Suction						
– Bradycardia	0	0.0%	0	0.0%		
– Normal	5	16.7%	25	83.3%	χ^2 = 42.85*	^{MC}p<0.001*
– Tachycardia	25	83.3%	5	16.7%		
Mean ± SD	177.3±15.8		154.7±17.4		**t** =5.274*	<0.001*
10 Min. After Suction						
– Bradycardia	0	0.0%	0	0.0%		
– Normal	15	50.0%	26	86.7%	χ^2 = 45.88*	^{MC}p<0.001*
– Tachycardia	15	50.0.%	4	13.3%		
Mean ± SD	169.8±13.1		153.0±18.7		**t** =4.029*	<0.001*

t: Student t-test χ^2: Chi square test   MC: Monte Carlo
*: Statistically significant at $p \le 0.05$

References:

Ahmed, S. E. S., Younis, G. A., & Al-Metyazidy, H. A. (2017). Effect of shallow versus deep endotracheal tube suctioning on hemodynamic parameters in mechanically ventilated patients in the intensive care unit. *International Organization of Scientific Research-Journal of Nursing and Health Science,* *6*(4), 28-38. https://doi.org/10.9790/1959-0604072838.

Al-Mayetiazidy, R. A., Younis, G. A., Ahmed, S. A., & Allam, Z. A. (2024). Effect of shallow versus deep suctioning techniques on endotracheal tube cuff pressure measurements and physiological indices among patients undergoing mechanical ventilation. *Tanta Scientific Nursing Journal, 32*(1), 218-241. https://doi.org/10.21608/tsnj.2024.349143.

Algameel, A., Elhawary, M., Amin, S., & Abd Elmenem, M. (2020). Outcome of late preterm newborns in Upper Egypt. *Egyptian Pediatric Association Gazette, 68*(1), 11. https://doi.org/10.1186/s43054-020-00023-1.

Amaliya, S., Rustina, Y., & Efendi, D. (2024). The effectiveness of hyperoxygenation in preventing oxygen desaturation in intubated infants treated with endotracheal suctioning. *Healthcare in Low-resource Settings*, *12*(s1). https://doi.org/10.4081/hls.2024.13045

Bellini, C., & Massirio, P. (2022). Optimal insertion length of endotracheal tube in neonates. *European Journal of Pediatrics*, *181*(7), 2885-2885. Vol.:(0123456789)13 https://doi.org/10.1007/s00431-022-04465-0

Bruschettini, M., Zappettini, S., Moja, L., & Calevo, M. G. (2016). Frequency of endotracheal suctioning for the prevention of respiratory morbidity in ventilated newborns. *The Cochrane database of systematic reviews*, *3*(3), CD011493. https://doi.org/ 10.1002/14651858.CD011493.pub2

Bose, S. N., Defante, A., Greenstein, J. L., Haddad, G. G., Ryu, J., & Winslow, R. L. (2023). A data-driven model for early prediction of need for invasive mechanical ventilation in pediatric intensive care unit patients. *Plos One, 18*(8), e0289763. https://doi.org/10.1371/journal.pone.0289763.

Chakkarapani, A. A., Adappa, R., Ali, S. K. M., Gupta, S., Soni, N. B., Chicoine, L., & Hummler, H. D. (2020). "Current concepts of mechanical ventilation in neonates"–Part 1: Basics. *International Journal of Pediatrics and Adolescent Medicine*, *7*(1), 15-20. https://pubmed.ncbi.nlm.nih.gov/32373697/

Eid, M., ȚÂNȚU, M. M., Sultan, M., & Kandeel, N. (2022). Suction System Flushing with Chlorhexidine and Prevention of Ventilator-Associated Pneumonia: Current Evidence. Mansoura Nursing Journal, 9(2), 69-86. https://doi.org/10.21608/mnj.2022.293710

Green, A. D. (2020). *Mechanical ventilation: Pediatric pressure mode (respiratory therapy)*. Elsevier.

Javadi, M., Hejr, H., Zolad, M., Khalili, A., & Paymard, A. (2017). Comparing the effect of endotracheal tube suction using open method with two different size catheters 12 and 14 on discharge secretion, pain, heart rate, blood pressure, and arterial oxygen saturation of patients in the intensive care unit: A randomized clinical trial. *Ann Trop Med Public Health*, *10*(5), 1312-1317

Mohamed, H., Mahmoud, M., Gouda, T., & Kandeel, N. (2023). Comparison between the effect of open and closed tracheal suction systems on physiological parameters of critically ill patients. *Mansoura Nursing Journal,* *10*(1), 271-282. https://doi.org/10.21608/mnj.2023.320391.

Mohamed, B. M., El Dakhakhny, A. M., Bassam, S. E. A., & El Sayed, L. M. (2011). Assessment of nursing care provided to premature neonates at the neonatal intensive care unit at Zagazig University Children's Hospital. Zagazig Nursing Journal, 7(2), 1-14.

Mustafa, S. A. A., Refaat, N. H., Mohammed, F. Z., & Zaki, N. A. E. H. (2019). Quality of Nursing Care Provided for Neonates on Mechanical Ventilation. Assiut Scientific Nursing Journal, 7(18), 41-50. 10.21608/asnj.2019.58125

Rocha, G., Soares, P., Gonçalves, A., Silva, A. I., Almeida, D., Figueiredo, S., Pissarra, S., Costa, S., Soares, H., Flôr-de-Lima, F., & Guimarães, H. (2018). Respiratory Care for the Ventilated Neonate. Canadian respiratory journal, 2018, 7472964. https://doi.org/10.1155/2018/7472964

Shamali, M., Abbasinia, M., Østergaard, B., & Konradsen, H. (2019). Effect of minimally invasive endotracheal tube suctioning on physiological indices in adult intubated patients: An open-labeled randomized controlled trial. *Australian Critical Care, 32*(3), 199-204. https://doi.org/10.1016/j.aucc.2018.03.007.

Shamali, M. , Abbasinia, M. , Babaii, A. , Abbasinia, M. , Shahriari, M. , Akbari Kaji, M. and Oren Gradel, K. (2017). Effect of Minimally Invasive Endotracheal Tube Suctioning on Suction-Related Pain, Airway Clearance and Airway Trauma in intubated Patients: A Randomized Controlled Trial. *Nursing and Midwifery Studies*, *6*(2), -. doi: 10.5812/nmsjournal.35909

Sinha V, Semien G, Fitzgerald BM. Surgical Airway Suctioning. [Updated 2023 Feb 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448077/

Volsko, T. A., & Barnhart, S. (2020). Neonatal disorders resulting from respiratory care. In T. A. Volsko & S. Barnhart (Eds.), *Foundations in neonatal and pediatric respiratory care* (p.p. 131-150). Jones & Bartlett Learning.

World Health Organization (2024). Preterm birth. available at: https://www.who.int/news-room/fact-sheets/detail/preterm-birth retrieved on Dec 2024.

Wilson, D., & Hockenberry, M. J. (2014). *Wong's clinical manual of pediatric nursing*. Elsevier Health Sciences.

Zivaljevic, J., Jovandaric, M. Z., Babic, S., & Raus, M. (2024). Complications of preterm birth—the importance of care for the outcome: A narrative review. *Medicina, 60*(6), 1014. https://doi.org/10.3390/medicina60061014