



THE EVALUATION OF CEREBRAL OXYGENATION CHANGES DURING OPEN ENDOTRACHEAL SUCTIONING IN CONVENTIONALLY MECHANICALLY VENTILATED PATIENTS

Paediatrics

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ABSTRACT

Background: To determine changes in pulse rate, arterial blood pressures, splanchnic and cerebral oxygen saturation and arterial oxygen saturation during endotracheal suctioning in patients requiring ventilation support in the Pediatric Intensive Care Unit.

Methods: This prospective study was performed between June 2014 and December 2014 with patients requiring mechanical ventilation support in the Pediatric Intensive Care Unit. All patients underwent superficial endotracheal suctioning. Patients' cerebral oxygen saturation (rSO₂), splanchnic oxygen saturation (rBO₂), arterial oxygen saturation (SaO₂), and heart rate were recorded at the beginning of preoxygenation, at the beginning of and at 5 and 10 sec during suctioning, and over 1 min following suctioning. rSO₂ and rBO₂ levels were measured using a near infrared spectroscopy (NIRS) device.

Systolic, diastolic and mean arterial blood pressures were measured before and 60 sec after suctioning. Fraction of inspired oxygen (FiO₂) values were made up to 100% before suctioning, and preoxygenation was performed for 10 sec. FiO₂ values returned to basal levels at 80 sec.

Results: No statistically significant difference was observed in rSO₂, rBO₂, heart rate or arterial oxygen saturation during and after suctioning. Statistically significant increases were determined in systolic, diastolic and mean arterial blood pressures after suctioning. The most significant decrease in rSO₂ and rBO₂ was observed at 30 sec, while the most significant decrease in arterial oxygen saturation and the most significant increase in heart rate were observed at 40 sec. rSO₂ and rBO₂ decreased 10 sec before SO₂.

Conclusions: Standard endotracheal suctioning does not cause any deterioration in rSO₂, rBO₂, SO₂ or heart rate.

KEYWORDS

Endotracheal suctioning, Near Infrared Spectroscopy, Pediatric Intensive Care Unit

INTRODUCTION

Patients who are intubated and receiving mechanical ventilation support cannot effectively eliminate their secretions. If appropriate moisturizing and warming are not provided, the presence of the endotracheal tube will lead to irritation of the airways and increased secretion production. All babies and children with artificial airways therefore require secretion removal and endotracheal suctioning in order to prevent airway obstruction (1,2). Increased respiratory workload, atelectasis and pulmonary can be prevented with the removal of secretions, making it possible for oxygen requirements to be met. Cardiac side-effects such as bradycardia, cardiac arrhythmias and increased systemic blood pressure, respiratory side-effects such as hypoxia, pneumothorax, mucosal trauma, atelectasis and ciliary function loss, and neurological side-effects such as increased intracranial pressure (ICP), intraventricular hemorrhage and hypoxic ischemia have been reported in association with endotracheal suctioning (3-6).

The purpose of this study was to evaluate the effects of endotracheal suctioning procedures on cerebral oxygen saturation (rSO₂), splanchnic oxygen saturation (rBO₂), arterial oxygen saturation (SO₂), heart rate and arterial blood pressure in patients in the Pediatric Intensive Care Unit.

Material and Methods

This study was performed with Gaziantep University Medical Faculty Ethical Committee approval between June and December, 2014, with 38 children receiving mechanical ventilation in the Pediatric Intensive Care Unit. Patients' demographic characteristics (age, gender), primary diagnoses and mechanical ventilation characteristics (type of ventilation, Fraction of inspired oxygen (FiO₂), positive inspiration pressure (PIP), positive end-expiration pressure (PEEP), frequency values, sedation, analgesia and muscle relaxant support) were recorded. Patients with increased ICP, and pre-procedural arterial desaturation or bradycardia were excluded from the study.

The endotracheal suctioning procedure was performed in the event of presence of secretions inside the endotracheal tube, increased respiratory workload, a decrease in tidal volume at pressure controlled ventilation, or a requirement for tracheal aspiration culture. Patients'

heart rates and SO₂ values were measured non-invasively using a Nihon Kohden BSM-4114K intensive care monitor. rSO₂ and rBO₂ values were measured using a somatic-cerebral oximetry device (INVOS 5100C, Somanetics). Blood pressures were measured noninvasively from the upper part of the right arm using an automatic sleeve of appropriate size with an intensive care monitor. Patients' heart rate, SO₂, rSO₂ and rBO₂ values at the beginning of preoxygenation were recorded as 0 sec values. These values were then recorded twice at 5 sec intervals during suctioning and six times at 10 sec intervals beginning from 20 sec after the end of suctioning. Systolic, diastolic and mean arterial pressure (MAP) were recorded before suctioning and at 60 sec after the end of the suctioning procedure.

Patients' FiO₂ were increased to 100%, and preoxygenation was applied for 10 sec. At 10 sec the patient was removed from the ventilator, and the endotracheal suctioning procedure was started. Open endotracheal suctioning was performed. The catheter was inserted 1 cm beyond the neck of the endotracheal tube without pressure, after which negative pressure began being applied. Endotracheal suctioning was applied for 10 sec.

The aspiration catheter was bent in the middle of the catheter and removed. The patient was then attached to the mechanical ventilator. At 80 sec the ventilator FiO₂ levels were returned to pre-suctioning values.

Statistical Analysis

Data analysis was performed on SPSS Windows 11.5 software. Descriptive data were expressed as mean ± standard deviation for constant variables and as number and (%) for nominal variables. The Wilk Lambda test was employed with analysis of variance to test for statistical significance in heart rate, saturation, rSO₂ and rBO₂ levels between the monitoring intervals. The presence of significant differences in terms of blood pressure levels between monitoring intervals was evaluated using the independent t test. Spearman's correlation analysis was used to test for significant relations between constant variables.

Statistical significance was set at p<0.05. However, Bonferroni

Correction was performed to test for type 1 errors in multiple comparisons.

Results

Mean patient age was 56.7±62.1 months, ranging between 2 and 192 months. Fourteen (36.8%) patients were male and 24 (63.2%) female.

Analysis of primary diagnoses revealed that central nervous system and respiratory system diseases constituted 39.5% of cases (Table 1).

Five patients (13.2%) were ventilated with a tracheostomy cannula and 33 (86.8%) with endotracheal intubation.

SIMV-PS mode was applied in all cases. The mechanical ventilation techniques employed are shown in Table 2.

No statistically significant difference was observed in terms of mean heart rate between the monitoring intervals on the basis of analysis of variance results at repeated measurements ($F=1.729$ and $p=0.127$).

Despite not attaining statistical significance, the most marked changes in heart rate were observed between 10 and 40 sec and between 15 and 40 sec.

Analysis of variance revealed no statistically significant difference in terms of mean $r\text{BO}_2$ between the monitoring intervals at repeat measurements ($F=1.437$ and $p=0.219$). Despite not attaining statistical significance, the most pronounced change in $r\text{BO}_2$ was observed between 0 and 30 sec. Statistically significant increases were observed in systolic and diastolic pressure and MAP at 60 sec compared to values at 0 sec ($p<0.05$). Blood pressure levels are shown in Table 3.

Bonferroni Correction revealed no significant changes in heart rate and saturation and $r\text{SO}_2$ and $r\text{BO}_2$ levels ($p>0.001$). Bonferroni Correction also revealed no significant correlation between change in $r\text{SO}_2$ and changes in $r\text{BO}_2$ levels ($p>0.001$). No significant correlations were observed at Bonferroni Correction between changes in heart rate, saturation, $r\text{SO}_2$ and $r\text{BO}_2$ during endotracheal suctioning and FiO_2 ($p>0.001$) (Table 4).

Discussion

Endotracheal suctioning in intubated patients is important for reducing atelectasis and consolidations leading to insufficient ventilation. Endotracheal suctioning is frequently performed in pediatric intensive care units. However, it must not be forgotten that the procedure is also painful and invasive. Although it is regarded as essential in order to prevent secretion-related airway obstruction, adverse events deriving from endotracheal suctioning have also been reported (7).

Endotracheal suctioning should not therefore be regarded as a routine procedure in pediatric and neonatal intensive care units. In our study, we used a near infrared spectroscopy (NIRS) device to investigate how the oxygen saturation index, particularly of the central nervous system, is affected after attachment to the ventilator during endotracheal aspiration. We also analyzed the effects on SO_2 , heart rate, systolic and diastolic pressure and MAP and $r\text{BO}_2$ in the same period.

NIRS, which has started being used in clinical practice in recent years, is capable of showing momentary effects in cerebral oxygenation in a non-invasive manner. NIRS is an optical technique that monitors regional oxygenation, particularly in the brain. This technique, developed on the basis of the Beer-Lambert law, measures oxyhemoglobin (810 nm) and deoxyhemoglobin (730 nm) concentrations using light waves of different lengths (650-850 nm) passing through a sectional tissue in the frontal cortex with an oximeter probe attached to the forehead for cerebral monitoring. Studies of healthy young adults and children have reported a mean cerebral $r\text{SO}_2$ value of 70%, and have shown that values below 40-50% or 20% below basal levels can be used as a marker of hypoxic ischemic neuronal injury (8-10).

In our study we determined no statistically significant difference between patients' SO_2 values during and for 1 min after endotracheal suctioning and saturation values before endotracheal suctioning.

Mosca et al. (11) studied the effects of open and closed endotracheal suctioning in cerebral blood flow and oxygenation in 11 preterm infants, and assessed changes in CPF and oxidized cytochrome

oxidase using a NIRS device. They simultaneously recorded SO_2 , heart rate, transcutaneous PaCO_2 and MAP, and reported significant decreases in heart rate, saturation and CBF in the open endotracheal suctioning system. In our study, however, no significant changes were observed in patients' SO_2 , $r\text{SO}_2$ or $r\text{BO}_2$ values. This may be due to the larger patient number, to the majority of patients receiving sedation and analgesia and to the vagal nerve not being stimulated in association with preoxygenation and suctioning being performed in such a brief period as 10 sec.

In a study of 8 preterm infants with respiratory distress syndrome, Cabal et al. (12) assessed the effects of open and closed endotracheal suctioning systems on SO_2 and heart rate. They reported a decrease in SO_2 and heart rate values with both suctioning techniques, but that bradycardia and arterial desaturation were shorter in the closed suctioning system. In our study there was no significant decrease in patients' SO_2 and heart rates. We think that our patient group being older and that our patients having received sedation, analgesia and muscle relaxant support may have affected this change.

Rieger et al. (13) investigated the effects of open and closed endotracheal suctioning systems on cerebral blood flow and the cardiovascular system in low birth weight infants on mechanical ventilation support. They reported that cerebral artery blood flow and maximum heart rate first decreased, independently of suctioning technique and ventilation mode, but then returned to pre- aspiration values. No bradycardia occurred in our study, and cerebral oxygenation was not affected.

No statistically significant change occurred in our patients' cerebral oxygenations during and after endotracheal suctioning.

Kohlhauser et al. (14) investigated the effects of endotracheal suctioning on cerebral hemodynamics in 26 newborns receiving high frequency oscillatory ventilation (HFOV) and conventional ventilation. They measured oxygenated cerebral hemoglobin, deoxygenated cerebral hemoglobin and oxidized cytochrome a3 levels using a non-invasive NIRS device. They reported significant decreases in heart rate, SO_2 and cerebral oxyhemoglobin values and an increase in deoxygenated hemoglobin throughout endotracheal suctioning in both groups, and that mode of mechanical ventilation had no significant effect on cerebral hemodynamics. This may have been due to saline being administered before aspiration into the endotracheal tube and to duration of suctioning being kept between 10 and 20 sec.

Skov et al. (15) observed that cerebral oxygenation decreased in parallel to arterial saturation throughout endotracheal suctioning in 29 newborns with gestational ages of 31 weeks. They reported observing no decrease after administration of preoxygenation. We attributed the absence of a significant decrease in saturation and cerebral oxygenation in our study, too, to the application of preoxygenation. In addition, no correlation was observed in our study between saturation and cerebral oxygenation. At comparison of our patients' arterial saturation and $r\text{SO}_2$ values, no decrease in arterial oxygenation was observed in 18 patients during the 80 sec period, while a decrease in $r\text{SO}_2$ was seen at the same time, although this was not statistically significant. The $r\text{SO}_2$ parameter was found to detect hypoxia 10 sec before SO_2 .

In a study of premature infants with RDS, Shah et al. (16) demonstrated a decrease in SO_2 and an increase in CPF with endotracheal suctioning. The study was repeated by increasing FiO_2 in 6 infants and allowing SO_2 to reach 100%, and CBF and SO_2 levels remained stable in these patients. Durand et al. (17) applied a closed suctioning system in patients with birth weights less than 1500 grams. They reports that PaCO_2 increased 1 min after suctioning, while PaO_2 decreased. Increases were observed in arterial blood pressure and ICP.

ICP returned to basal values immediately, while intra-arterial pressure exhibited moderate elevation 1 min after suctioning. They concluded that endotracheal suctioning caused a significant increase in ICP and CBF in ventilated preterm infants in the first month of life. We also determined a significant increase in blood pressures after suctioning compared to pre-suctioning values.

In conclusion, endotracheal suction using a standard technique in pediatric patients receiving mechanical ventilation support causes no deterioration in $r\text{SO}_2$, $r\text{BO}_2$, SO_2 or heart rate values.

Table 1: Patients' primary diagnoses

Patients' primary diagnoses	n (%)
Central nervous system diseases	8 (21.05%)
Respiratory system diseases	7 (18.4%)
Hematological diseases	5 (13.1%)
Kidney diseases	5 (13.1%)
Metabolic diseases	5 (13.1%)
Other (scorpion sting, non-vehicular traffic accident)	4 (10.5%)
Skin diseases	2 (5.2%)
Soft tissue tumors	1 (2.6%)
Gastrointestinal system diseases	1 (2.6%)
Total	38 (100%)

Table 2: Mechanical ventilation techniques

	n=38 (%)
Tracheostomy	5 (13.2%)
Endotracheal intubation	33 (86.8%)
FiO ₂ (mean ± SD)%	71.3±26.3
PIP (mean ± SD)cm H ₂ O	18.1±6.0
f (mean ± SD)/m	28.2±11.1

PEEP (mean ± SD)cm H ₂ O	5.8±2.7
Sedation use	31 (81.6%)
Analgesia use	26 (68.4%)
Muscle relaxant use	9 (23.7%)

FiO₂: Fraction of inspired oxygen, PIP: positive inspiratio pressure, PEEP: positive end-expiratio pressure, f: frequency

Table 3: Blood pressure levels at observation times

	Pre-suctioning*	Post-suctioning *	p a
Systolic blood pressure (mmHg)	102.6±23.0	106.2±23.0	0.032
Diastolic blood pressure (mmHg)	53.7±17.6	58.3±19.2	<0.001
Mean blood pressure (mmHg)	70.0±18.5	74.3±19.7	<0.001

a: Dependent t-test.

*: A significant increase was observed in systolic, diastolic and mean arterial blood pressures before and after suctioning.

Table 4: Heart rate, SatO₂, rSO₂, and rBO₂ values before and during suctioning

Procedure rSO ₂ (SD)	Sec.	rBO ₂ (mean ± SD)	Heart rate (mean ± SD)	SatO ₂ (mean ± SD)	(mean ± SD)
Preoxygenation 64.2 ± 14.9	0	130.5 ± 27.4	97.34 ± 3.24	72.0 ± 14.3	
ET suctioning start 64.1 ± 15.1	10	130.4 ± 27.6	97.37 ± 3.12	72.3 ± 14.4	
ET suctioning 5 sec 63.7 ± 16.1	15	130.4 ± 26.9	97.34 ± 3.02	72.2 ± 13.9	
ET suctioning end 63.0 ± 16.0	20	131.0 ± 28.0	96.87 ± 3.50	71.1 ± 14.6	
30 62.0 ± 16.2		134.7 ± 26.5	96.10 ± 4.26	70.6 ± 14.9	
40 60.5 ± 15.6		136.0 ± 26.3	95.55 ± 5.45	70.9 ± 15.5	
62.4 ± 15.7		135.9 ± 26.3	95.63 ± 5.71	71.8 ± 15.9	
60 63.1 ± 15.4		134.7 ± 25.6	95.63 ± 5.34	71.8 ± 15.8	
70 63.2 ± 14.9		135.0 ± 26.3	95.89 ± 5.24	71.8 ± 15.8	
Return to basal FiO ₂ 63.2 ± 15.2	80	134.6 ± 26.4	96.18 ± 4.71	72.2 ± 15.7	

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