Research Article

Evaluating the Effects of Post-Intubation Endotracheal Suctioning Before Surgery on Respiratory Parameters in Children with Airway Secretion

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Abstract

Background: Endotracheal suctioning (ETS) is a common procedure in intubated patients for the clearance of secretions and improvement of oxygenation.

Objectives: Owing to the controversies in previous studies, we studied the effects of open ETS before surgery on respiratory parameters in children with pulmonary crackles.

Methods: In this clinical trial, 100 children with pulmonary crackles, candidates for surgery were randomly assigned into two groups. After intubation, in the group A (n = 50), deep and open suction was done until the crackle was cleared and in the group B (n = 50), anesthesia without suctioning was continued. Hemodynamic and respiratory parameters were compared.

Results: The patients in group A had higher oxygen saturation with a statistically significant difference in 15th to 75th minutes of the operation (P < 0.001) and in post-anesthetic care unit (P = 0.004). After suction, before and after extubation, there was a statistically significant reduction of crackles in the group A in comparison to the group B (P < 0.001). There was no statistically significant difference in the end-tidal CO_2, airway pressure and respiratory rate between the two groups (P > 0.05). Relevant complications and the emergence of anesthesia time were statistically lower in the group A (P < 0.001). There was no statistically significant change in terms of blood pressure in the two groups (P > 0.05). The heart rate in the 15th, 30th, and 45th minutes of surgery was statistically lower in the group B (P < 0.05).

Conclusions: This study indicates positive effects of open and deep suction in improving oxygen saturation and reducing complications and emergence time. Pulmonary auscultation of the group A before and after weaning was statistically better than group B. However, this study found no positive effect of ETS on airway pressure, $ETCO_2$, blood pressure, and respiratory rate. Meanwhile, increased heart rate in the group A might introduce the potential risk of dysrhythmia and hemodynamic instability.

Keywords: Anesthesia, Intubation, Children, Respiratory, Suction, Crackles

1. Background

Endotracheal suctioning (ETS) is a component of ventilation therapy that is mechanical suction of pulmonary secretion through the trachea to prevent obstruction in intubated patients. It is regularly provided by physiotherapist and nursing staff in the pediatric intensive care unit (PICU). The primary goal of ETS is to clear airway obstruction to prevent atelectasis, improve oxygenation, ventilation, and respiratory function (1). Several side effects have been reported by ETS such as hypoxia, bradycardia and other arrhythmias, increased intracranial pressure, bacteremia, pneumothorax, mucosal damage, and loss of cil-

iary function. Although there is no clear evidence that ETS improves mechanical ventilation, a number of studies have suggested that pulmonary capacity decreases after suctioning. Studies in animals have shown a decrease in static pulmonary capacity (2).

There are two methods of ETS based on the type of catheter selected: open suction and closed suction. An open suction is a technique, which the patient needs to be separated from the ventilator. In closed suction, a sterile catheter attaches to the ventilator circuit, which allows the passage of a suction catheter from the trachea without isolating the patient from the ventilator (3). In deep suction,

the catheter is inserted to the point where it collides with resistance and then the catheter is withdrawn 1 cm, before negative pressure is applied. A study by Mohammadpour et al. compared the effect of ETS on the oxygenation of post-coronary artery bypass surgery patients using mechanical ventilation and found the better effect of a closed suction on the oxygenation and ventilation in comparison to open suction (4).

Adib et al. studied the effect of ETS with and without normal saline on the hemodynamic and respiratory parameters in patients undergoing mechanical ventilation in intensive care units (ICUs) and indicated that systolic, diastolic, and mean arterial blood pressure were increased in both groups due to procedural pain followed by sympathetic stimulation and muscle contraction. However, there was no statistically significant difference between the two groups (5). The ETS can be a painful and irritating process in intubated patients; therefore, it requires a careful study to evaluate its advantages and side effects on the patient. Most of the previous studies about ETS were related to intubated patients in ICU with wide differences in results.

2. Objectives

As there is not enough study about preoperative ETS and its effects and negative side effects on intraoperative and postoperative period, the aim of this study was to evaluate the effect of preoperative open and deep ETS in children with pulmonary crackles due to secretions who were candidates of surgery and its effects on improving respiratory status, oxygenation, airway pressure changes, and hemodynamic changes before and after suction.

3. Methods

After approving the Ethics Committee of Tabriz University of Medical Sciences, the proposal has been registered in the Iranian center of the clinical trials (IR.TBZMED.REC.1397.204, Clinical Trial registration ID: IRCT20100527004041N14; http://www.irct.ir).

In this single-blind randomized prospective clinical trial, surgical candidates with respiratory crackles who admitted to the operating room were randomly selected by random permuted block using the appropriate online software. The aim of this study was to evaluate the effect of preoperative ETS in children undergoing intubation for surgery and its effect on respiratory complications, oxygenation, airway pressure changes, and hemodynamic changes before and after suction. By using Independent *t*-test and software PS: power and sample size calculation version 3. 1.2. 2014, the number of samples needed for

each group was determined 42 individuals, which was calculated by adding 10% to compensate for the loss to follow-up the required number of each group was estimated at 50 patients.

In this study, 100 children in the age range of 1 month to 6 years, with ASA class I and II, candidates for intubation for elective or emergency surgery with pulmonary crackles due to respiratory secretions auscultated by an expert pediatric anesthesiologist incidentally in preoperative assessment with no clinical signs or symptoms, enrolled in the study. The informed consent form was obtained from all parents of the patients before beginning the study. The exclusion criteria were patients with any respiratory dysfunction, persistent pulmonary hypertension (PPH), acute respiratory tract infection, fever, running nose or cough and airway malformation. They were randomly allocated into two groups of children with preoperative tracheal suctioning (group A) and without suctioning (group B).

All patients received 0.02 mg/kg midazolam, $1\mu g$/kg fentanyl, 0.5 mg/kg atracurium, 1 mg/kg lidocaine and 3 - 4 mg/kg propofol, under standard monitoring and intubation was done with an appropriate tracheal tube size. In the group A, after intubation, open and deep ETS was performed with an appropriate catheter size (half of the size of the patient's tracheal tube) at a pressure of 50 to 95 mmHg, 2 or 3 times (until cleaning the secretions and the destruction of pulmonary crackles). The duration of suction was less than 10 seconds each time. After each suction, the patient was ventilated to prevent pulmonary volume reduction. If the O_2 saturation decreased below 90%, the intervention was done to increase the saturation. In the group B, suction was not performed except for the urgent need for suction and the patient was excluded.

Anesthesia was maintained with sevoflurane 2.5%, 50% O_2, and 50% N_2O. Respiratory parameters (respiratory rate, pulse oximetry (SPO_2), end-tidal CO_2 ($ETCO_2$), and airway pressure), heart rate, and blood pressure (BP) were recorded before surgery, 5 minutes after suction, and every 15 minutes. Respiratory rate was also measured after spontaneous respiratory recovery at the end of the operation and in the post-anesthetic care unit (PACU). The data were recorded by another anesthesiologist who was not aware of the classification of groups. If any medications such as corticosteroids or salbutamol were needed to use, the patients were excluded from the study and other patients were replaced. The lungs were auscultated by an anesthesiologist with a stethoscope before anesthesia, after anesthesia at the start, and at the end of the surgery. If the crackles existed at the end of surgery prior to extubation, it was recorded. The rate of post-extubation complications was also recorded.

All data were reported as means $\pm$ standard deviation

(SD) for quantitative variables and frequency and percentages for qualitative variables. Normality of quantitative variables was investigated by K-S test. For evaluating qualitative and quantitative demographic variables chi-square and independent *t*-test were used. Paired *t*-test was used for comparison of variables in each group. To investigate the effect of the intervention, covariance analysis were used for quantitative variables and logistic regression for qualitative variables. In the case of abnormal distribution of quantitative variables, appropriate transformation or non-parametric equivalent tests were used. Data analysis was performed using SPSS V. 23 software. P < 0.05 was considered statistically significant (6).

4. Results

Overall, 100 patients participated in this study. All of the patients had pulmonary crackles due to respiratory secretions. They were studied randomly in the two groups of A (n = 50) and B (n = 50). There was no statistically significant difference in the patients' gender, mean age, and mean weight between the two groups (P ≥ 0.05) (Table 1).

In evaluating the type of surgical procedures, there was no significant difference between the two groups (P = 0.24) (Table 2). The majority of surgeries were adenotonsillectomy in both groups.

In evaluating the respiratory parameters, there was no significant difference in the mean respiratory rate before the operation and in the PACU between the two groups (P > 0.05). There was no significant difference in the average of $ETCO_2$ and airway pressure changes in 15-minute intervals between the two groups (P > 0.05). The average of SPO_2 in the patients after ETS was statistically higher and had improved in the group A in 15th, 30th, 45th, and 60th minutes after intubation and in the PACU (Table 3).

All of the patients had pulmonary crackles due to respiratory secretions before the surgery. The incidence of crackles in pulmonary auscultation after intubation ± ETS, before extubation, and after extubation were significantly different in the two groups (P < 0.001) (Table 4).

There was no significant difference in the mean systolic and diastolic blood pressure before the operation, after in-

Table 2. Type of Surgical Procedure Performed in the two Groups[a]

Type of Surgical Procedure	Group A (N = 50)	Group B (N = 50)	P Value
Adenotonsillectomy	42	58	
Ureteropelvic junction obstruction	2	2	
Appendectomy	14	14	
Invagination	6	2	
Rigid bronchoscopy	12	2	
Cleft palate repair	6	0	
Stoma repair	2	0	
Adrenal mass	2	0	
Abdomen mass	4	0	
Wilms tumor	2	0	0.24
Cleft lip	0	2	
Thyroglossal duct cyst	2	2	
Laparotomy	2	0	
Diaphragmatic hernia	2	0	
Hirschsprung	2	6	
Cervical mass	0	2	
Periorbital cellulitis	0	2	
Liver hydatid cyst	0	4	
Lower lip cyst	0	2	
Genitalia Repair	0	2	

[a]Values are presented as percent.

tubation, every 15 minutes during the operation and in the PACU between the two groups (P > 0.05). The mean heart rate after intubation, at the minutes of 15, 30, 45, and 60 of the surgery was significantly higher in the group A (P < 0.05) (Table 5).

The postoperative complication incidence was significantly different between the two groups (P < 0.001) (Table 6).

The anesthesia emergence time was 16.22 ± 6.58 minutes in the group A, while it was 21.10 ± 6.70 minutes in the group B. This difference was statistically significant (P < 0.001).

5. Discussion

Most of the previous studies about ETS were related to the intensive care units and there are few studies about its effect during surgery. The ETS can be done in open or closed systems and deep or superficial suction methods. In Gillies and Spence study, there was no statistically significant difference in oxygenation and heart rate between deep and superficial suction methods in children (7).

In Zeitoun et al. study, both closed and open suction methods were effective in reducing infectious complications of intubation. They found that, due to low costs of open suction method, it can be used more widely (8). Peter

Table 1. Demographic Data of All Patients Meeting the Inclusion Criteria[a]

	Group A (N = 50)	Group B (N = 50)	P Value
Gender			0.84
Male	50	54	
Female	50	46	
Age, y	3.90 ± 1.99	4.66 ± 1.70	0.83
Weight, kg	16.46 ± 6.75	18.99 ± 5.95	0.05

[a]Values are expressed as mean ± SD or percent.

Table 3. Comparison of Mean Respiratory Rate Changes, O_2 Saturation (SPO$_2$), End-Tidal CO_2 (ETCO$_2$), and Airway Pressure Changes in the two Groups[a]

Respiratory Rate	Group A (N = 50)	Group B (N = 50)	P Value
Before operation	24.10 ± 5.17	21.96 ± 5.70	0.052
In the PACU	22.62 ± 4.90	21.78 ± 5.69	0.43
SPO$_2$			
Before operation	97.76 ± 1.92	98.24 ± 1.04	0.12
After intubation	98.84 ± 1.89	98.68 ± 1.31	0.62
15 minutes	99.08 ± 0.87	98.08 ± 1.29	< 0.001[b]
30 minutes	99.22 ± 0.97	97.82 ± 1.19	< 0.001[b]
45 minutes	99.23 ± 0.97	97.53 ± 1.38	< 0.001[b]
60 minutes	99.08 ± 0.88	97.27 ± 1.28	< 0.001[b]
75 minutes	99.18 ± 0.87	96.77 ± 2.38	0.004
90 minutes	99.0 ± 1.26	98.0 ± 1.25	0.20
In the PACU	98.02 ± 1.46	96.50 ± 20.23	< 0.001[b]
ETCO$_2$			
15 minutes	28.66 ± 9.76	28.38 ± 8.78	0.88
30 minutes	30.70 ± 9.59	31.36 ± 9.03	0.72
45 minutes	33.92 ± 11.08	36.62 ± 10.72	0.21
60 minutes	36.31 ± 11.47	40.49 ± 11.49	0.07
75 minutes	41.45 ± 14.13	43.38 ± 13.45	0.73
90 minutes	36.83 ± 17.29	41.67 ± 5.98	0.53
Airway pressure			
15 minutes	14.68 ± 4.45	13.30 ± 4.45	0.07
30 minutes	14.52 ± 3.91	13.72 ± 3.05	0.25
45 minutes	14.20 ± 6.9	13.62 ± 3.16	0.56
60 minutes	12.79 ± 3.69	12.71 ± 3.46	0.91
75 minutes	12.10 ± 4.65	11.92 ± 3.79	0.92
90 minutes	14 ± 4.18	12.67 ± 3.50	0.57

[a]Values are expressed as mean ± SD.
[b]P < 0.05 was considered significant.

Table 4. Comparison of Incidence of Crackles After Intubation ± ETS, Before Extubation, and After Extubation in the two Groups[a]

	Group A (N = 50)	Group B (N = 50)	P Value
After intubation ± ETS	0	100	P < 0.001[b]
Before extubation	6	100	P < 0.001[b]
After extubation	4	100	P < 0.001[b]

[a]Values are expressed as percent.
[b]P < 0.05 was considered significant.

et al. also concluded that the open suction was preferred because of low cost (9). In this study, we aimed to investigate the effects or negative side effects of open and deep suction in patients with untreatable pulmonary crackles that were candidates for surgery.

Hamishekar et al. compared open and closed suction in patients undergoing mechanical ventilation in ICU. They reported that closed suction decreases dysrhythmia, hypoxemia, and pulmonary complications. There was no statistically significant difference in ventilator-associated pneumonia (VAP) between the two methods (10). Consis-

tent with the current study, Paula et al. showed a statistically significant improvement in post-procedure oxygen saturation in open and closed suction groups in infants using mechanical ventilators. No statistically significant differences were observed in oxygen saturation before, during, and after suction in both groups (11).

In Choong et al. study, patients suctioned with open catheter suction desaturated to a greater extent than patients suctioned with in-line catheter suction (P = 0.026) (12). In our study, open suction improved oxygenation of patients during surgery in the operating room and PACU and reduced postoperative complications incidence and decreased emergence time. Mohammadpour et al. found that the open suction method increased ETCO$_2$ more than the closed suction method, which can be owing to the separation of patients from the ventilator during open suction (4).

Avena et al. showed that ETS increased the CO_2 arterial pressures (PaCO$_2$) even after 20 minutes; decreased the oxygen saturation (SpO$_2$) immediately after the procedure with regular recuperation after 10 minutes, and decreased

Table 5. Comparison of Mean Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Heart Rate (HR) Changes in the two Groups[a]

	Group A (N = 50)	Group B (N = 50)	P Value
SBP			
Before operation	98.32 ± 11.59	95.42 ± 12.32	0.22
After intubation	92.98 ± 11.95	88.86 ± 12.66	0.09
15 minutes	95.46 ± 11.35	93.68 ± 13.74	0.48
30 minutes	94.12 ± 12.04	93.84 ± 11.96	0.90
45 minutes	94.20 ± 10.70	93.36 ± 12.96	0.72
60 minutes	93.68 ± 11.02	92.39 ± 12.94	0.60
75 minutes	91.80 ± 11.78	97.15 ± 17.19	0.40
90 minutes	86.80 ± 13.02	100.8 ± 13.64	0.11
In the PACU	99.08 ± 9.68	98.34 ± 12.71	0.74
DBP			
Before operation	55.56 ± 11.16	56.36 ± 14.68	0.70
After intubation	49.80 ± 12.41	50.14 ± 14.44	0.90
15 minutes	53.14 ± 13.97	52.72 ± 14.90	0.88
30 minutes	51.96 ± 12.69	51.62 ± 12.84	0.89
45 minutes	50.94 ± 12.09	49.88 ± 14.29	0.69
60 minutes	50.94 ± 12.09	49.82 ± 14.25	0.75
75 minutes	44.70 ± 14.62	53 ± 16.28	0.22
90 minutes	45.60 ± 13.31	51 ± 14.95	0.54
In the PACU	54.12 ± 11.62	54.86 ± 13.59	0.77
HR			
Before operation	122.8 ± 20.31	119.5 ± 19.53	0.70
After intubation	118.9 ± 20.30	109.9 ± 18.35	0.02[b]
15 minutes	124.2 ± 18.04	116.7 ± 19.47	0.04[b]
30 minutes	124.8 ± 18.23	115.2 ± 25.79	0.03[b]
45 minutes	122.2 ± 18.81	114.2 ± 21.21	0.04[b]
60 minutes	120.3 ± 18.79	114.02 ± 20.23	0.11
75 minutes	122.8 ± 20.31	119.5 ± 19.53	0.70
90 minutes	123.4 ± 13.93	116.5 ± 20.29	0.53
In the PACU	119.9 ± 20.81	112.7 ± 20.23	0.08

[a]Values are expressed as mean ± SD.
[b]$P < 0.05$ was considered significant.

Table 6. Comparison of Postoperative Complications in the two Groups[a]

	Group A (N = 50)	Group B (N = 50)	P Value
Nausea and vomiting	0	2	< 0.001[b]
Agitation	0	6	< 0.001[b]

[a]Values are expressed as percent.
[b]$P < 0.05$ was considered significant.

the lung compliance immediately after with lower recuperation after 10 minutes in intubated children with mechanical ventilation in the PICU. They concluded that intratracheal suction was applied as minimal as possible under preventive maneuvers (13).

A study by Caramez et al. in patients with acute respiratory distress syndrome showed that closed ETS preserved PaO_2/FIO_2 ratio better than open method. However, hypoventilation associated with open ETS resulted in hypercapnia which this finding was not evident in our study. The hemodynamic effects of suction was not different in the two groups; however, there is a slight tendency to increase cardiovascular stress during open ETS (14).

Unlike the above study, in the present study, there was no statistically significant increase in $ETCO_2$ in the two groups. In contrast to our findings, Lasocki et al. concluded that open ETS in acute lung injury resulted in a significant decrease in arterial oxygen pressure and increase in arterial CO_2 pressure, with a great impaired gas exchange, up to one minute after suction. Closed suction prevents the observed hypoxemia in open ETS, but appears to be ineffective in the discharge of secretions in comparison to the open method (15).

According to this study, open suction results in a statistically significant reduction in the secretion and incidence of crackles and pulmonary auscultation of the patients whose suction was significantly better than before

and after extubation. In Morrow et al. (2) and Fernandez et al. (16) studies, ETS led to a decrease in pulmonary compliance and volume. Abbasinia et al. studied the effect of superficial and deep ETS in ICU and showed that respiratory rate increased and arterial O_2 saturation decreased; however, these changes were not statistically different between the two groups (17). In this regard, our study showed no statistically significant difference in respiratory rate and airway pressure between the two groups.

Johnson et al. examined the physiologic consequences with two methods of ETS: closed vs. open in trauma ICU. Open ETS resulted in significant increases in mean arterial pressure throughout the suctioning procedure. Both methods resulted in increased mean heart rates. However, 30 seconds after the procedure, the open-suction method was associated with a significantly higher mean heart rate than that of the closed method. Arterial oxygen saturation and systemic venous oxygen saturation decreased with open suctioning (18).

In Clark et al. study, mean heart rate increased from a baseline of 99 beats/min to 104 beats/min immediately after ETS (P = 0.001) in 189 critically ill adults, a 5% change from baseline, and gradually returned to the baseline over the next 4 minutes (19). Ozden et al. determined that heart rate, arterial blood pressure, and arterial blood gases of the patients who underwent open heart surgery and indicated that they were negatively affected by the open suction system (20). Van de Leur et al. demonstrated that routine deep ETS in intubated patients in ICU decreased saturation (P = 0.010), increased systolic blood pressure (P < 0.001), and increased pulse pressure rate (P = 0.007) (21). According to the current study, there was no statistically significant effect on blood pressure changes, preoperative, post-intubation, during operation and in PACU. Nevertheless, there is a statistically significant increase in heart rate in the suction group before and after the intubation and at the 15th, 30th, and 45th minutes during the operation, which shows the potential of open suction in increasing the chance of dysrhythmia.

The findings of this study confirm the positive effect of open and deep suction of pulmonary secretions in patients who are candidates for surgery. Suction improved the patient's oxygen saturation in the operating room and in PACU. On the other hand, it reduced postoperative complications and the incidence of crackles and decreased the emergence time, which indicates a positive effect of suction in the general conditions of the patients. However, the findings of this study revealed no positive effect of ETS on airway pressure, $ETCO_2$, blood pressure, and respiratory rate.

Footnotes

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