Effects of endotracheal aspiration on respiratory parameters in the pediatric setting

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Abstract: Introduction: The endotracheal suctioning is an invasive practice performed in critical care units that allows removal of the pulmonary secretions in intubated patients. During this procedure, patients are exposed to potential risks that health professionals, should prevent or minimize. At date is a shortage of published studies on the frequency of endotracheal suction in pediatric critically ill patients. It is supposed that the endotracheal suction does not affect significantly the assessment of short-term respiratory parameters and therefore may be deferred by the clinical condition of the patient. Methods The study carried out from 1 January to 30 September 2016 in mechanically ventilated pediatric patients at pediatric intensive care unit of Salesi children's Hospital of Ancona. The study involved the collection of two venous blood samples taken from a central venous catheter: the first blood gas analysis was performed on each patient 1 minute before endotracheal aspiration and a second sample from the same vascular access device. Mean and percentages were calculated for qualitative variables, mean and standard deviation were calculated for quantitative parameters. For inferential purposes, to evaluate the effects of endotracheal aspiration on respiratory parameters detected by blood gas analysis, the student T test was performed for paired data with a 95% confidence interval. Results A total of 40 patients were recruited, of which 14 were females (35%) and 26 were males (65%). The results were as follows: For pH, the mean of the difference in values is .0065 [95% CI -0.0067 - 0.0197]. According to T test for paired data, a p=.3256 was obtained. From the inferential point of view, this difference is not considered statistically significant. For the pO2 the mean of the difference in values is .03 [95% CI -1.62 -1.67]. According to T tests for paired data, a p =.9756 was obtained. For the pCO2, the mean of the difference in values is -1.88 [95% CI -3.81 - 0.06] with a p value = .0577.

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Introduction

Endotracheal suctioning is an invasive practice carried out in critical area wards that allows the removal of pulmonary secretions in intubated patients undergoing artificial ventilation using a flexible probe inserted inside the endotracheal tube. Patients are exposed to potential risks when this maneuver is performed and doctors and nurses should work to prevent or minimize the risk of complications.

Respiratory complications related to aspiration are: hypoxia, pneumothorax caused by pulmonary perforation due to the aspiration tube, mucosal trauma, atelectasis. Cardiovascular complications include bradycardia, arrhythmias and increased blood pressure.

Neurologically, there is an increase in intracranial pressure. In addition, aspiration decreases the percentage of oxygenated blood with a consequent decrease in the availability of oxygen in the brain. In addition, hypoxia caused by aspiration in newborns contributes to the development of hypoxic-ischemic encephalopathy.

Intubated patients are unable to effectively clear secretions due to impaired glottal closure and deterioration of normal mucociliary function. Inadequately humidified inspired gases and the presence of the endotracheal tube could cause irritation of the airways and increase secretion production.

In addition, many children with respiratory tract infections have an increase in sputum volume and impaired flow which further hinders the clearance of secretions.

Therefore, all artificially ventilated infants and children require endotracheal aspiration to remove secretions and prevent airway obstruction.

It is recognized that aspiration is a technique with many complications. Despite this, the practice of endotracheal aspiration continues without adequate evidence due to the different techniques used. Although there are proposals for recommendations and clinical guidelines regarding suction pressures, insertion depth and suction catheter size, only some of these have been objectively demonstrated to be adequate for treatment or safe.

The aim of this study is to compare the blood gas values of pediatric patients before and after endotracheal suctioning to evaluate the impact of this invasive procedure on respiratory values.

Methods

An observational study was conducted from 1 January to 30 September 2016 at the Pediatric Intensive Care Unit (PICU) of a middle Italy pediatric hospital.

A convenience sampling was performed during the study period: all pediatric patients admitted to PICU, undergoing endotracheal intubation, were consecutively enrolled.

All patients admitted to the pediatric resuscitation ward in spontaneous breathing and tracheostomized patients with chronic diseases are excluded from the study.

The study involved the collection of venous blood samples taken from a central venous catheter in 2 moments: the first blood gas analysis was performed on each patient 1 minute before endotracheal aspiration (T0). Subsequently to the same patient, after having received a pre-oxygenation with FiO2 100% for 30 seconds, an endotracheal suctioning was performed and after a time interval of about 30 minutes from the procedure a second venous blood sample from the same vascular access device (T1) was collected to carry out the comparison between the 2 samples.

To avoid random misclassification, health care professionals follow always the same procedure: disconnection from the ventilator, an aspiration catheter is inserted inside the endotracheal tube.
by applying an output suction by rotating it in order to remove most of the secretions present in the endotracheal tube. The patient is then reconnected to the ventilation circuit. This is followed by a 30 second post oxygenation and the FiO2 is set back to the original values unless there is desaturation (10). To avoid bias related to the execution of the procedure, all phases were carried out by the same nurse; in addition, the same blood gas analyzer (GEM Premier 4000®) was used for both samples to avoid variations related to the calibration of the equipment.

Glass capillaries were used to collect the blood sample as they allow the examination to be carried out by collecting a lower amount of blood than a standard blood gas analysis heparinized syringe (1ml). Furthermore, the storage of the sample in glass compared to plastic has the advantage of avoiding overestimations of the pO2 (11). The samples taken were analyzed within 1 minute of collection as there are studies showing that the temperature and the delay in performing the blood gas analysis generate a decrease in pH, a decrease in pO2 and an increase in PCO2 (12). This study recommends the analysis of the blood sample within 15 minutes stored at room temperature or on ice if it is impossible to analyze the sample within this time interval (12).

For each patient, data were collected on: age, sex, etiology of hospitalization divided into macro areas (internist, surgical, neurological and traumatic), artificial ventilation methods. The respiratory function data evaluated in the 2 different time (T0-T1) were: pH, pO2, pCO2. Mean and percentages were calculated for qualitative variables, mean and standard deviation were calculated for quantitative parameters. For inferential purposes, to evaluate the effects of endotracheal aspiration on respiratory parameters detected by blood gas analysis, the student T test was performed for paired data with a 95% confidence interval. The calculations were performed through the GraphPad® data processing software.

Ethical Concerns

The research was conducted by the principles of the original Declaration of Helsinki and its subsequent amendments. Data were stored and managed in accordance with current Italian legislation on data protection. Data were collected and analyzed in anonymous and aggregated form.

Results

A total of 40 patients were recruited, of which 14 were females (35%) and 26 were males (65%). All patients aged 1 month to 14 years, 14 females and 26 males admitted to the Pediatric Resuscitation Department and undergoing endotracheal intubation and mechanical ventilation in the period from January 2013 to September 2013 are included in the study (40 surveys for a total of 80 blood gas samples).

All underwent endotracheal aspiration with blood gas sampling pre-post procedure for a total of 80 measurements. For statistical purposes for the calculation of the mean age and Standard Deviation, the patients were divided into 2 subgroups: the first (A) ranges from 1 to 11 months (3.8 ± 2.8 months), the second (B) from 1 year to 13 years (7 ± 5.3 years). The subdivision of patients based on the etiology of hospitalization is as follows: 3 traumatic cases (8%); 17 internist cases (42%); 16 surgical cases (40%); 4 neurological cases (10%). According to the artificial ventilation mode, there is the following subdivision: Guaranteed Volume Adjusted to Pressure (VGRP) 18 patients (45%); Ventilatory Support Pressure (PSV) 14 patients (35%); High Frequency oscillation or High Frequency Ventilation (HFO) 3 patients (8%); Synchronized Intermittent Mandatory Ventilation (SIMV) 5 patients (12%). (Tab.1)

In evaluating the pH, pO2 and pCO2, the difference in values was calculated by subtracting the data of the second sample (T1) from the first (T0) in order to evaluate increases or decreases caused by the endotracheal aspiration procedure (Table 2). The results were as follows: For pH, the mean of the difference in values is .0065 [95% CI -0.0067 - 0.0197]. According to T test for paired data, a p=.3256 was obtained. From the inferential point of view, this difference is not considered statistically significant. For the pO2 the mean of the difference in values is .03 [95% CI-1.62 -1.67]. According to T tests for paired data, a p =.9756 was obtained. For the pCO2, the mean of the difference in values is -1.88 [95% CI -3.81 - 0.06] with a p value = .0577.
Table 1: Socio-demographic features of the sample

<table>
<thead>
<tr>
<th>Gender</th>
<th>n (%)</th>
<th>Type of disease</th>
<th>n (%)</th>
<th>Ventilation mode</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26 (65)</td>
<td>Internist</td>
<td>17 (42)</td>
<td>VGRP</td>
<td>18 (45)</td>
</tr>
<tr>
<td>Female</td>
<td>14 (35)</td>
<td>Surgical</td>
<td>16 (40)</td>
<td>PSV</td>
<td>14 (35)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neurologic</td>
<td>4 (10)</td>
<td>SIMV</td>
<td>5 (12)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traumatic</td>
<td>3 (8)</td>
<td>HFO</td>
<td>3 (8)</td>
</tr>
</tbody>
</table>

Age: Average (SD)
(A) 3.8 ± 2.8 month
(B) 7 ± 5.3 years

Table 2: Summary analysis of changes in respiratory parameters with application of the two-tailed Student’s T test.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(T0) Average, SD</th>
<th>(T1) Average, SD</th>
<th>T0-T1 Average, SD</th>
<th>IC 95%</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.3782 ± 0.0728</td>
<td>7.3848 ± .0770</td>
<td>.0065 ± .0412</td>
<td>-.0067; 0.0197</td>
<td>.3256</td>
</tr>
<tr>
<td>pO₂</td>
<td>36.95 ± 6.94</td>
<td>36.98 ± 7.87</td>
<td>.03 ± 5.13</td>
<td>-1.62; 1.67</td>
<td>.9756</td>
</tr>
<tr>
<td>pCO₂</td>
<td>52.55 ± 13.93</td>
<td>50.68 ± 12.65</td>
<td>-1.88 ± 6.06</td>
<td>-3.81; .06</td>
<td>.0577</td>
</tr>
</tbody>
</table>

Discussion

Endotracheal suctioning is a procedure used routinely in PICU. Despite this, there is limited evidence to support the various elements from a practical point of view. In addition, controlled clinical trials are needed to develop evidence-based protocols for endotracheal aspiration of infants and children to examine the impact of different aspiration techniques on the duration of ventilatory support, the incidence of nosocomial infections, and the duration of hospital stay in the pediatric intensive care unit.

There is no absolute contraindication to performing endotracheal aspiration as this procedure is required in all intubated and ventilated patients to keep the airways open. Particular attention should be paid to patients suffering from neurological disease who have an increase in intracranial pressure as endotracheal aspiration and cough can worsen the clinical picture. All patients must undergo continuous monitoring to evaluate clinical or physiological changes as a response to endotracheal aspiration.

Disconnection from the mechanical ventilator leads to a decrease in airway pressure with loss of lung volume and a further loss of lung volume with the application of negative suction pressure. (13). Unfortunately in clinical practice, the use of the open circuit technique is still widely used compared to the closed circuit.

There are studies that demonstrate the effectiveness of pre and post oxygenation with respect to insufflation by manual ventilation through the pulmonary recruitment maneuver (14), to reduce hypoxia induced by the endotracheal aspiration procedure. The suction procedure must last less than 15 seconds with a suction pressure between 80 and 120 mmHg (15).

The administration of sedative drugs before the endotracheal aspiration procedure minimizes the probability of the onset of bradycardia during the procedure due to the stimulation of the afferent fibers of the vagal system (16). During endotracheal aspiration, heart rate decreases and blood pressure increases (2). In the literature there is a similar study that evaluates the response of pediatric patients to different endotracheal aspiration techniques to avoid a worsening of the pO₂ detected by arterial blood gas analysis (17). However, this study only refers to pO₂ assessments of hemodynamically stable intubated patients. Furthermore, the collected samples were stored on ice and analyzed only after the necessary samples were collected. This study was conducted to delineate the changes in respiratory parameters caused by endotracheal aspiration. The analysis of the data collected by venous blood gas analysis shows
that for the parameters of pH, pO2, pCO2 there is no statistically significant variation in the pre-post aspiration values for the sample under examination. For this reason, for the purpose of the frequency of aspirations, it is desirable to carry out this procedure only when the clinical conditions of the patient make this invasive maneuver necessary. Endotracheal aspiration is useful and effective only when applied in the presence of a careful evaluation of the patient. It is expensive, inefficient and wastes valuable resources if applied regularly and without clear directions. The results of this study also suggest that a 30-second pre-oxygenation is sufficient to avoid a significant decrease in pO2, an increase in pCO2 and avoid hypoxia related to the execution technique.

Limits of the study
The limitations of this study are given by the size of the sample and the lack of randomization in the choice of participating subjects. In addition, the heterogeneity of the sample from the point of view of age and the co-morbidities present at the time of admission make the result less generalizable but lays the foundations for targeted and in-depth research. Another limitation of the study is the inability to follow the same group of patients in the 24 hours and during the clinical course to carry out the same investigation in the various ventilatory modes up to weaning and the resumption of normal spontaneous respiratory activity.

Conclusions
The effects of aspiration on respiratory mechanics are poorly understood. However, a decrease in lung dynamic compliance and end-expiratory volume in artificially ventilated children caused by the aspiration procedure has been demonstrated. The increase in dynamic compliance observed after the procedure suggests that aspiration has beneficial effects on lung mechanics only when performed in the presence of obstructive secretions. For this reason, endotracheal aspiration can be deferred and carried out within 24 hours based on the patient’s clinical condition and underlying pathology. It is therefore assumed that reducing the frequency of endotracheal aspiration in the pediatric setting leads to a decrease in the risks associated with the procedure, a reduction in costs associated with the aids used and respiratory nosocomial infections with a consequent reduction in the length of hospital stay. Further investigations should be conducted to evaluate the validity of the results on larger samples by carrying out a multicenter study. It is also desirable to conduct a study on the variability of respiratory parameters and on the compensation after endotracheal aspiration according to the patient’s ventilatory mode.

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References