Effect of open and closed endotracheal suction systems on heart rhythm and arterial blood oxygen level in intensive care unit patients

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Abstract

Aims: Many patients need special care, and endotracheal tube and the use of mechanical ventilation is essential. This type of airway leads to mucosa stimulation and production of mucus. Suctioning is associated with complications such as severe hypoxia and significant cardiovascular disorders. Therefore, selecting the least dangerous way of endotracheal tube suction can reduce severe complications. This study compared the effect of two open and closed methods of suctioning on heart rate pattern and arterial blood oxygen saturation.

Methods: This crossover clinical trial study performed during 2008-2008 in critical care units of army selected hospitals, 60 patients who were connected to ventilator were selected. Open and closed suction techniques were carried on samples and heart rate patterns and arterial blood oxygen saturation was measured in patients before and several times after each type of suction and was compared. For analysis of data the paired t-test and ANOVA and SPSS 17 software were used.

Results: There was a significant difference in heart rate and oxygen saturation in different times after closed suction system and open suction system (p<0.0001). The difference was more obvious in different periods after open suction method, but there was no change in cardiac rhythm in both open and closed suction methods (p>0.05).

Conclusion: Open and closed suction methods are effective on heart rate and arterial blood oxygen saturation and it is suspected that closed suction method causes less changes in patient’s hemodynamic status.

Keywords: Closed Suction, Open Suction, Oxygen Saturation Level, Heart Rate, Heart Rhythm

Introduction

Progress of sciences and technology has led to extensive changes in treatment and care methods. So that many of patients who are in acute or chronic critical stages are completely or relatively improved using new methods of treatment, skilled nursing staff and the advanced technology [1]. Today, about 7.8% of patients require post-surgery care in CCU and ICU [2, 3]. Since the main problem of these patients is the respiratory system, thus endotracheal intubation and mechanical ventilation are increasing in these units [2, 4]. Establishing these artificial air ways leads to mucus stimulation and increase in mucus production. These patients are not able to effectively cough and excrete the secretions due to larynx closure and lack of increase in intra thoracic pressure; therefore, the airway suctioning is highly important [1, 5]. Authorities believe that if the suction is not performed by a correct and standard method, it will lead to complications such as cardiac arrhythmias, infection, blood oxygen decrease, damage to the mucus layer, carbon dioxide pressure increase, ICP rising, atelectasis or even death. In addition, suction itself causes the stimulation of mucus and the evacuation of oxygen from airways [5, 6]. Hypoxia resulted from suction puts pressure on cardiovascular system and lead to tachycardia, dysrhythmias, blood pressure increase, breathing pressure increase and eventually cyanosis and dizziness [7]. Observing principles seems necessary to minimize the complications of endotracheal tube (ETT) suctioning and in spite of these principles' observation, selecting an appropriate method of ETT suction for reducing of complications is helpful [8].

At the present time, the most common method used for ETT tube suctioning in patients, is the open technique that requires patients’ disconnection from ventilator and results in pressure drop of airways and lung volume loss [9]. However, there is another method known as closed suction, in which the patient is not separated from the ventilator during the suction [8, 10]. In this method, the patient’s suctioning can be done by connecting an interface to the ventilator simultaneous with supplying Oxygen. Therefore, due to positive pressure during the suction, hemodynamic disturbances could be prevented.

Researchers believe that in closed suction the pressure of arterial oxygen is less reduced compared to open suction. Meanwhile, cardiac complications (such as tachycardia and dysrhythmias) are more seen in open suction [9]. However, despite these comments, some articles have hesitated about the use of these methods. Statistics show that over the past decade use of closed
suction has had more fans; so that 85% of intensive care units of the hospitals in the United States of America use closed suction that is due to the decreasing hemodynamic and physiologic disorders [11]. For this aim, with regard to the importance of the issue and proving the superiority of each of these two types of suction on reduction of complications, the present study was performed to investigate and compare the effect of these two methods of suctioning on heart rhythm and rate and the amount of arterial blood oxygen saturation.

Methods

In this crossover clinical trial which was conducted on patients who were hospitalized in intensive care units of the army selected hospitals in 2007-8, 60 patients were studied. Subjects were connected to a ventilator and were ventilated in volume; however, they were controlled before the suction in terms of cardiac rhythm, and their arterial blood oxygen saturation was higher than 90% and their heart rate was between 60 to 100. All ventilator machines and monitors were of the same type and were calibrated. After selection of participants and before endotracheal tube suctioning, patients were at first hyper oxygenated for 2 minutes (4-6 breaths) by 100% oxygen with ventilator and their heart rate pattern (heart rate and rhythm) and the percentage of their arterial blood oxygen saturation were measured and recorded by a monitor beside the patient’s bed and immediately the endotracheal tube suctioning was carried out. Endotracheal tube suctioning was done once using a closed technique and another time by open technique and their interval was at least 90 minutes in order to let the heart rate pattern and the percentage of arterial blood oxygen saturation fully be back to its initial condition after the first suction [12]. Immediately after suction and recording of the number and percentage of heart rate and rhythm, and the percentage of arterial blood oxygen saturation, all subjects were hyper oxygenated using ventilator for 2 minutes (3 to 5 breaths) with 100% oxygen [13]. Two to 5 minutes after suction these criteria were also recorded by monitor. At every turn of endotracheal tube suction, suction was done 1-3 times and endotracheal tube suction time was 5 to 10 seconds for both methods [14]. The patient was excluded from the study if he needed repetitive suctioning or if he needed suctioning with less than 90 min intervals or any change in his medication state or his device position within the intervals of two suction. Endotracheal tube suctioning was done by a suitable suction catheter (half of tracheal tube diameter) [13] with the pressure of 120 mm Hg. The obtained data was analyzed using SPSS 17 software.

To compare the heart rate in open and closed methods the repeated measures ANOVA was used. The mean heart rate and arterial blood oxygen saturation amount were studied and compared at different stages in two open and closed methods by paired t-test. According to suction type, the effect of different times on heart rate and arterial blood oxygen saturation amount were studied and compared using repeated measures ANOVA. To determine the changes in heart rhythm in both open and closed methods in different times Cochran’s Q test was used. To evaluate the heart rate at different stages in the two methods, closed and open tests, McNemar statistical test was used. For comparing the arterial blood oxygen saturation in various stages of study with two open and closed methods, repeated measures two-way ANOVA was used.

Results

The mean age of subjects was 63±17.48 years with the range of 21 to 86 years, and 25 patients (41.7%) were male. The mean of intubation duration was 7.5 days and patients had at least one and the maximum of 28 tracheal tubes. 17 patients were admitted with CVA diagnosis. 38 patients’ ventilators were of synchronized intermittent mandatory ventilation (SIMV) type and the average of support pressures (Ps) was 9.09±2.979. Mean fraction of inspired oxygen (FIO2) was 47.88% and the average of the tidal volume (VT) was 501.93cc with the average of continuous positive airway pressure on whole voluntary breathing period (CPAP) equal to 2.938cm of water and mean of positive end-expiratory pressure (PEEP) equal to 3.660 cm of water. The mean number of exerted breaths by device was 9.80 and the mean number of patient respiration was 9.92. In 53 patients, Nelaton catheter number 14 was used during suction. 36 patients had tracheal tube of size 7.5. The mean of 24-hour serum intake was 2361.67±631.407 and 21 patients received at least 2000 cc.

Considering the significance of Mauchly test results (p<0.0001), the variance uniformity assumption was rejected. Therefore the more conservative test of Greenhouse-Geisser was used. Heart rate change in different stages using different suctioning methods was significant (F (1 and 59) = 18.55; p<0.0001). On the other hand, the interaction of two closed and open suction methods with the time factor also confirmed a significant difference (F (2 and 127) = 61.33; p<0.0001).
Consequently, changes in heart rate during different times with closed and open methods showed a significant difference ($F_{(2, and 127)} = 40.59; \ p<0.0001$).

Table 1- Comparison of heart rate mean in open and closed suction method in terms of time and type of suction

<table>
<thead>
<tr>
<th>Stages→ Method</th>
<th>Open</th>
<th>Closed</th>
<th>Paired t-test df=59</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before suction</td>
<td>±14.13</td>
<td>±14.65</td>
<td>T=-0.421</td>
</tr>
<tr>
<td>Immediately after suction</td>
<td>±13.97</td>
<td>±13.61</td>
<td>T=5.39</td>
</tr>
<tr>
<td>2 minutes after suction</td>
<td>±13.38</td>
<td>±14.93</td>
<td>T=7.413</td>
</tr>
<tr>
<td>5 minutes after suction</td>
<td>±13.76</td>
<td>±15.07</td>
<td>T=3.037</td>
</tr>
<tr>
<td>Single factor ANOVA</td>
<td>F=76.093</td>
<td>F=27.502</td>
<td>p=0.0001</td>
</tr>
</tbody>
</table>

In each interval after suctioning, a significant difference was observed in terms of change in heart rate ($p<0.0001$), but this statistical difference was not significant in open and closed suctioning method before the suction ($p>0.05$). In analyzing the results five minutes after the open and closed suction by paired t-test, despite the significant difference ($p=0.0004$), comparison of means indicated the less difference between open and closed method at this time (Table 1). Greenhouse-Geisser modifying test (with regard to the Mauchly sphericity test being significant; $p<0.01$), confirmed the statistically significant difference ($p<0.0001$) between heart rate and different suctioning times. So that these changes in different time intervals after closed suction were less than changes in heart rate in different times with open suction (Table 1).

In open and closed suction, no statistically significant difference was observed in terms of heart rhythm change in different stages of suction ($p>0.05$). Meanwhile, the frequency of sinus cardiac rhythm in closed method was higher than the open method. In terms of cardiac rhythm, there was no statistically significant difference in each stage of open and closed suctioning method ($p>0.05$; Table 2).

According to the results of Greenhouse-Geisser statistical test ($p<0.0001$), arterial blood oxygen saturation rate change at different stages was significant, by different suction methods. ($F_{(1,7 \ and \ 127)} =17.361; \ p<0.0001$). On the other hand, the interaction of two closed and open suction methods along with the time factor also confirmed the significant difference ($F_{(1.7 \ and \ 127)} =58.780 \ p<0.0001$). Consequently, changes in heart rate during different times with closed and open methods revealed a significant difference ($F_{(2.5 \ and \ 127)} =1.355; \ p<0.0001$).

Table 2- Frequency distribution and comparison of cardiac rhythm by time (McNemar; $p>0.05$) and type of suction (Cochran’s Q; $p<0.05$)

<table>
<thead>
<tr>
<th>Steps→ Method</th>
<th>Open</th>
<th>Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before suction</td>
<td>Sinus</td>
<td>Number 57</td>
</tr>
</tbody>
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| &nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;&amp;
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oxygen saturation at different minutes after suction with open and close methods are different compared to before the suction, although the difference of these two factors immediately after the suction is too obvious compared to two or five minutes after suction. In addition, these changes have also significant difference in various times after suction in comparison of two suction methods, so that the rate of the change of these two factors is lower when using the closed suction method. In this regard, Lee et al. found that the open suction method further enhance the heart rate immediately after tracheal tube suctioning compared to closed method and arterial blood oxygen saturation immediately after the open suction method has a significant decrease [15]. On the other hand, open suction method averagely increases the heart rate to six beats compared to the close suction method [9], while arterial oxygen pressure after suction in both methods, has a significant decrease but this decrease is more in the open suction [16], which is in accordance with the findings of this study.

According to the results of the present study, suction type (open or close) does not change the heart rhythm. Nevertheless, some researchers believe that the prevalence of arrhythmia is considerably higher in open suction method [15, 17] that apparently is incompatible with results of present study. However, with a more precise view on this study’s statistics, it becomes clear that the result of this part of research is very close to significant level. Therefore there is the possibility that with more samples, the significance of changes in heart rhythm be assured in closed suction method compared to the open suction.

Conclusion

Suction with close method has less effect on the pattern of heart rate and arterial blood oxygen saturation compared to suction with open method and induce less disorder in patients’ hemodynamic symptoms.

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