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The Effect of the Duration of Pre-Oxygenation before Endotracheal Suction on Hemodynamic Symptoms

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Abstract

Background: Hypoxia and hypoxemia are among the most common complications of endotracheal suctioning. These complications are often mitigated by the administration of oxygen 100% prior to endotracheal suction. Although several studies have supported the application of this method, none have yet specified the exact duration of pre-oxygenation required to be performed before endotracheal suction. The present study was therefore conducted to determine the effect of the duration of pre-oxygenation before endotracheal suction on heart rate and arterial oxygen saturation in patients in intensive care units.

Objectives: This prospective clinical trial conducted on 63 eligible ICU patients under mechanical ventilator. Subjects randomly divided into three groups. Pre-oxygenation was carried out for 30 seconds in the first group, for one minute in the second group and for two minutes in the third group. All three groups were then hyper-oxygenated for one minute. Arterial oxygen saturation and heart rate were recorded on different occasions in the three groups. The data obtained were analyzed using the ANOVA, the one-way ANOVA, the post-hoc test and the repeated measure ANOVA.

Results: The results obtained showed a greater reduction in the mean O2sat during the suctioning episodes in the 30-second pre-oxygenation group compared to in the one-minute (P=0.046) and two-minute (P=0.001) pre-oxygenation groups. This mean reduction was also observed immediately after suctioning (P=0.001). The mean O2sat was lower in the 30-second pre-oxygenation group than in the one-minute pre-oxygenation group in minutes 5 (P=0.002) and 20 (P=0.001) of the suctioning. Similarly, the mean O2sat was lower in the 30-second pre-oxygenation group than in the two-minute pre-oxygenation group in minutes 5 (P=0.001) and 20 (P=0.001) of the suctioning. The results obtained through the ANOVA showed the lack of significant differences between the three groups in the mean variation in heart rate in the different stages of suctioning.

Conclusions: According to the results obtained, one-minute and two-minute pre-oxygenations cause less disruption in arterial oxygen saturation compared to a 30-second pre-oxygenation. To achieve stability in arterial oxygen saturation and avoid hypoxemia caused by endotracheal suctioning, one-minute or two-minute pre-oxygenation is recommended in ICUs depending on the patient's clinical conditions.

Keywords: pre-oxygenation, endotracheal suctioning, hemodynamic

1. Introduction

The most common critical complaints in Intensive Care Units (ICUs) are concerned with the airways, since respiratory system dysfunction and the inability to breathe spontaneously comprise the main challenges in ICUs (Baun et al., 2002). Mechanical ventilators and endotracheal tubes thus constitute integral parts of ICUs. Endotracheal tube suction is therefore commonly performed in ICUs for clearing the airways (Blattner et al., 2008).

Endotracheal tube suctioning is a standard nursing technique for intubated patients that aims primarily to facilitate the drainage of secretions from the airways, thereby preventing the obstruction of the airways and providing optimal oxygenation (Woodrow, 2002).

Air sac collapse occurs if secretions are not drained in intubated patients unable to cough. Endotracheal tube suctioning facilitates the drainage of secretions and keeps the airways clear, but also causes several complications that threaten the patient in need of suctioning, including the collection of air in the pleural space, pneumonia, bacteremia, tracheal necrosis and blood flow fluctuations (Sole et al., 2003).

According to Lookinland and Appel, "Although endotracheal tube suctioning is a common care technique in ICU patients, it can cause complications such as low blood oxygen pressure, irregular heartbeat and hemodynamic changes" (1991).

According to Glass and Grap, "Endotracheal tube suctioning can cause cardiac irregularities, hemodynamic changes and increased intracranial pressure (1995). Brunner and Suddarth (2010) believe that hypoxia is one of the main complications that could occur during suctioning and that, to prevent this condition, the patient should be oxygenated in different ways such as through an oxygen mask, an oxygen tent or a mechanical ventilator (2010).

Given the complications associated with suctioning, especially hypoxemia and its effects on different body organs, preventing this complication is highly important. Researchers have proposed a technique called pre-oxygenation that can dramatically reduce the hypoxemia caused by endotracheal suctioning (Ahmad et al., 2010; Baun et al., 2002; Berney & Denehy, 2002; Fink et al., 2005; Maggiore & Volpe, 2011).

Jongerden et al. (2012) believe that the incidence of arrhythmia during endotracheal suctioning is caused by hypoxemia, which can be prevented through performing oxygenation before and after suctioning (Jongerden et al., 2012).

Pre-oxygenation involves the administration of a higher-than-usual concentration of oxygen to the patient before performing suctioning (Piacentini et al., 2004).

Considering the limitations in previous studies with regard to the duration of oxygenation before endotracheal suctioning and given the absence of an official guide on the effects of the duration of oxygenation on hemodynamic parameters, the present research was conducted to compare the effects of 30-second, one-minute and two-minute pre-oxygenation before endotracheal suctioning on heart rate and arterial oxygen saturation in ICU patients.

2. The Study

2.1 Aim

The aim of this study was to evaluate the impact of the duration of pre-oxygenation before endotracheal suction on hemodynamic responses to the patients in intensive care unit.

2.2 Design

The present clinical trial was conducted on a statistical population of ICU patients at Peymanieh Hospital of Jahrom, Iran. The research process was explained to the patients' family members and legal guardian. Written informed consent for participating in the study was obtained From July to December 2016.

2.3 Participants

The study inclusion criteria consisted of being aged 18 to 65, having been admitted to the ICU at least 48 hours before beginning the study, being under tracheal intubation and mechanical ventilation, the absence of lung damage according to radiological assessments and a specialist opinion, stable hemodynamic parameters (SBP>100 mmHg, output=30 cc/hr and HR=60-100), the absence of cardiac arrhythmias, having no history of chronic pulmonary diseases or acute respiratory infections, the absence of signs signaling increased ICP and requiring three episodes of airway clearance per each endotracheal suctioning, Do not receive the narcotics before suctioning.

2.4 Data Collection

The data collection tools used in this study consisted of a demographic form with items on hospital admission code, age, gender, date of admission and the study parameters (heart rate and arterial oxygen saturation). These parameters were tabulated five minutes before, 30 seconds before, during, immediately after, five minutes after and 20 minutes after suctioning. The patients' hemodynamic parameters were monitored using S1800-ER monitoring system made by Pooyandegan Rah Saadat Co. Electrodes were placed on the patient's chest for

monitoring his heart rate and a finger probe was attached for monitoring his arterial oxygen saturation. The reliability of this monitoring system was assessed according to the manufacturer's instructions.

2.5 Intervention

The patients experiencing hemodynamic imbalance during the intervention and with a mean arterial blood pressure less than 60 mmHg were excluded from the study. 63 patients were assigned randomly into 3 groups using the Random Allocation Software program: the 30-second, the one-minute or the two-minute pre-oxygenation groups with each group including 21 patients. Endotracheal suctioning was then performed on them by the researcher and as per their needs. Each patient underwent suctioning once. The researcher administered oxygen 100% to the patients using a mechanical ventilation system before performing the suction at a maximum negative pressure of 120 mmHg. Three episodes of tube insertion into the trachea and suctioning were performed in each session of suctioning, which took about 15 seconds. The patient was reconnected to the ventilator for 45 seconds in the intervals between the first, the second and the third episodes so as to receive oxygen 100%. After the third episode was completed, oxygen 100% was administered to all the three groups for one minute. If the patient required fewer or more episodes of catheter insertion and suctioning during any suctioning session, that session was eliminated from the study and measurements were retaken in the following session.

2.6 Data Analysis

The collected were coded and analyzed in SPSS-16 using descriptive statistics such as the mean, percentage and standard deviation as well as the ANOVA and the post-hoc test for the quantitative variables and the Chi-square test for comparing the qualitative variables. The trend of changes was compared across the three groups using the repeated measures ANOVA. The level of statistical significance was set at 0.05. The three groups were first compared to match the underlying and confounding variables and to ensure the normal distribution of the data.

3. Results

Demographic characteristics of patients are shown in Table 1. The results of the ANOVA showed no significant differences between the three groups in terms of the quantitative variables examined (P=0.923). The majority of the patients (76.2%) in all the three groups were male. The three groups were compared in terms of their mean oxygen saturation (Table 2). Chart oxygen saturation changes in the three groups at different times of suction (Figure 1).

Table 1. The mean and standard deviation of arterial oxygen saturation

Groups Feature	**Sex**		**Age**	
	Male	Female	Mean±Sd	Minimum-Maximum
30sec	19(90.5)*	2(9.5)*	42.0000±19.07878	18.00-65.00
1min	12(57.1)*	9(42.9)*	41.0952±16.44963	20.00-64.00
2min	17(81.0)*	4(19.0)*	39.9524±13.73126	20.00-65.00

Table 2. The mean and standard deviation of arterial oxygen saturation

O2sat%/Stage	**Thirty Seconds**	**One Minute**	**Two Minutes**	**Degree of Freedom**	**F**	**P**
Five minutes before	95.85±2.31	95.90±5.39	96.28±1.87	2	0.60	0.55
Pre-oxygenation	96.85±2.20	97.05±5.56	99.33±1.01	2	3.25	0.046
During suctioning	88.90±6.23	92.48±7.40	95.90±3.41	2	7.32	0.001
Immediately after suctioning	88.95±6.21	92.57±7.50	95.61±2.99	2	6.73	0.002
Five minutes after suctioning	93.47±2.80	96.90±4.80	98.04±1.80	2	10.46	0.001
Twenty minutes after suctioning	93.90±2.43	97.3.72	97.57±1.77	2	10.69	0.001

* Statistical significance (P<0.05).

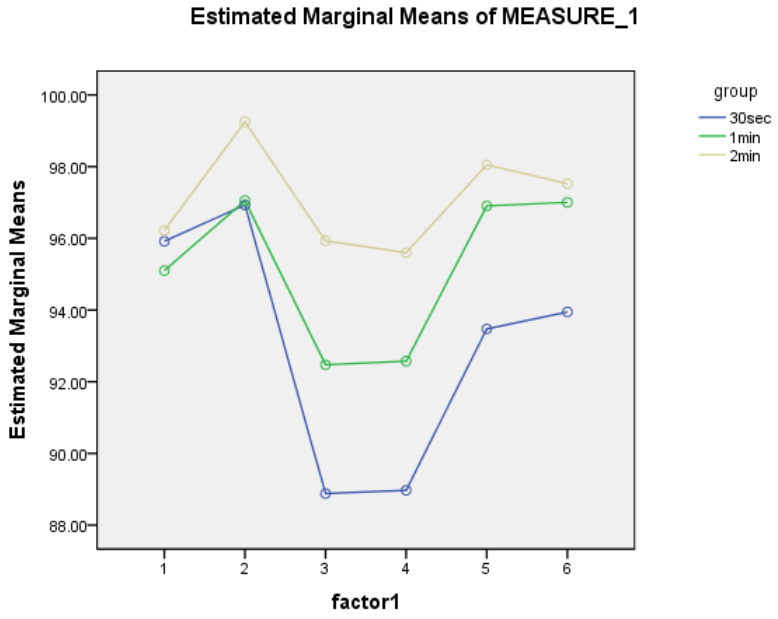

Figure 1. Oxygen saturation changes in the three groups

The results of the ANOVA showed a significant difference between the three groups in the different stages of suctioning. The least significant difference (LSD) post-hoc test showed no significant differences between the three groups in the mean arterial oxygen saturation 5 minutes before suctioning. The two-minute pre-oxygenation caused a greater increase in the mean arterial oxygen saturation compared to the 30 second pre-oxygenation (P=0.026). The 30-second pre-oxygenation caused a greater reduction in the mean arterial oxygen saturation during the suctioning episodes than both the one-minute (P=0.46) and the two-minute (P=0.001) pre-oxygenations, and this mean reduction persisted until immediately after suctioning (P=0.001). The mean arterial oxygen saturation in minutes 5 (P=0.002) and 20 (P=0.001) after suctioning was smaller in the 30-second pre-oxygenation group compared to in the one-minute pre-oxygenation group. Similarly, in minutes 5 (P=0.001) and 20 (P=0.001) after suctioning, the mean arterial oxygen saturation was lower in the 30-second pre-oxygenation group than in the two-minute pre-oxygenation group. No significant differences were observed in the mean arterial saturation between the one-minute and the two-minute pre-oxygenations at any stage of suctioning.

The three groups were also compared in terms of the mean variation in heart rate at different stages of suctioning (Table 3). Chart heart rate changes in the three groups at different times of suction (Figure 2).

Table 3. The mean and standard deviation of heart rate

Heart Rate/Stage	Thirty Seconds	One Minute	Two Minutes	Degree of Freedom	F	P
	Mean and SD of O2sat	Mean and SD of O2sat	Mean and SD of O2sat			
Five minutes before	75.61±10.82	82.19±13.15	83±9.27	2	2.74	0.172
Pre-oxygenation	76.14±10.77	81.33±13.67	83.38±10.07	2	2.169	0.123
During suctioning	87.66±12.41	86.80±19.97	91±12.41	2	0.437	0.648
Immediately after suctioning	88.80±13.70	87.85±19.31	90.61±12.26	2	0.174	0.840
Five minutes after suctioning	84.09±12.24	84.14±19.91	83.47±11.49	2	0.013	0.987
Twenty minutes after suctioning	81.90±11.77	83.42±17.40	85.47±19.02	2	0.252	0.778

* Statistical significance (P<0.05)

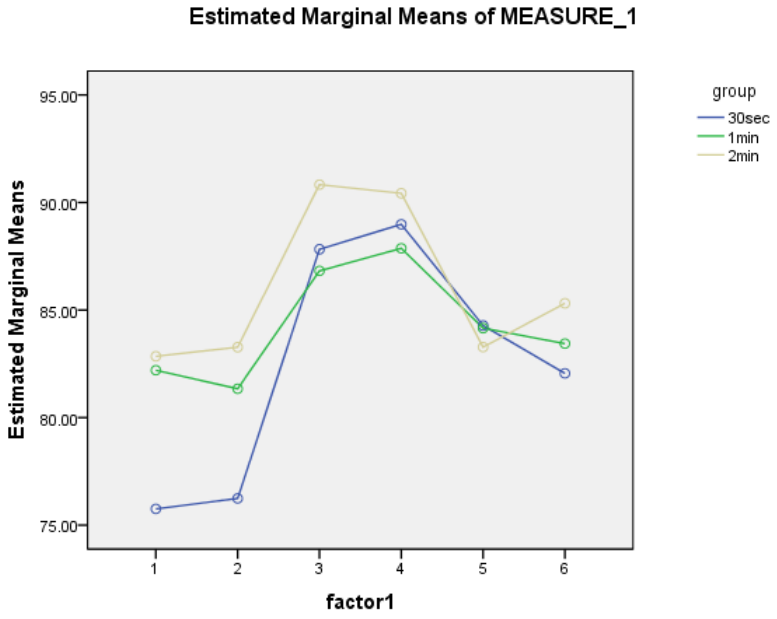

Figure 2. Heart rate changes in the three groups

The results obtained from the ANOVA showed no significant differences between the three groups in the mean variation in heart rate at different stages of suctioning.

4. Discussion

According to the results obtained, the biggest increase in heart rate and the biggest reduction in arterial oxygen saturation occurred during suctioning and in comparison with before the procedure; this finding is consistent with the results obtained by Etemadifar et al. (Etemadifar et al., 2008; Lookinland & Appel, 1991; Oh & Seo, 2003). In a study conducted by Jongerden in Austria entitled "the effect of endotracheal suctioning on oxygenation, blood circulation and lung mechanics in infants", an increase was observed in the infants' heart rate by 20 per minute and a reduction in arterial oxygen saturation during and immediately after suctioning (Jongerden et al., 2012), which is consistent with the results obtained in the present study. A reduction was observed in heart rate and an increase in arterial oxygen saturation in the three groups in minutes 5 and 20 after suctioning compared to during and immediately after the procedure, and these changes were significant in the one-minute and two-minute pre-oxygenation groups, but not in the 30-second group. The mean reduction in the arterial oxygen saturation before suctioning was significantly greater in the one-minute and two-minute pre-oxygenation groups compared to in the 30-second group. The present study found no significant differences between the three groups in the mean increase in heart rate during, immediately after, five minutes after and 20 minutes after suctioning. The results obtained by Jongerden et al. showed a significant increase in the patients' heart rate ten minutes after suctioning (Moore, 2003). Evidence also suggests that changes in heart rate and oxygen saturation by performing endotracheal suctioning can be controlled with a minimum of times during the day (Favretto et al., 2012). The systematic review was conducted by Gholamzadeh and Javadi concluded that the use of normal saline at least (5 ml) can facilitate drainage and arterial oxygen saturation and heart rate changes prevent (Gholamzadeh & Javadi, 2009). It seems suctioning without disconnecting the patient from the mechanical ventilation can increase the heart rate during endotracheal suctioning to prevent (Giakoumidakis et al., 2011).

Perform more than six times a day endotracheal suctioning is one of the risk factors that lead to decreased oxygen saturation in patients undergoing mechanical ventilation (Care, 2010). Although the standard performance of this invasive procedure produces a great physiological response in the body during and immediately after suctioning and thus results in the biggest increase in heart rate and the biggest reduction in arterial blood oxygenation during these stages, it is recommended to reduce the frequency and duration of suctioning in these stages, to further continue oxygenation and to put the patient in a more comfortable breathing position (JAVADI et al., 2016). Given the inability of intubated patients to drain their pulmonary secretions and

to keep their airways clear and open, endotracheal suctioning is crucial for keeping the airways open and for the patients' survival. Despite its great benefits, the complications associated with tracheal tube suctioning such as adverse effects on arterial oxygen saturation and vital signs can threaten the patients' clinical status.

5. Conclusion

The present study as well as similar studies conducted on the subject show that a one-minute or two-minute pre-oxygenation before suctioning and depending on the patient's clinical status can serve as an appropriate tool for preventing the complications associated with endotracheal suctioning. The results of the present study can encourage further studies on oxygenation before, during and after endotracheal tube suctioning in this group of patients.

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Competing Interests Statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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