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Effect of Combinational Changes of Catheter Size and its Negative Suction Pressure on Hemodynamic Parameters of Mechanical Ventilation Patients

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ABSTRACT

Aims Endotracheal suctioning is the most effective way to clear discharge and maintain open airway. This is usually done by nurses. This study aimed to determine the effect of combinational changes of catheter size and its related suction negative pressure on hemodynamic parameters of patients undergoing mechanical ventilation.

Materials & Methods In this clinical trial study, thirty-five patients undergoing ventilators were eligible for inclusion were selected by available sampling method. Endotracheal suctioning was performed for each patient 4 times with at least 2 hours interval by catheter 10 and 12 and negative pressures of 100 and 150 were used. Hemodynamic parameters of all patients were recorded immediately before, immediately after, 10 and 20 minutes after each intervention. The data were then analyzed using SPSS 21 and ANOVA with repeated measures.

Findings Suctioning with catheters 10 and 12 at pressures of 100 and 150 increased the hemodynamic parameters immediately after endotracheal suction. These increases was significant in systolic blood pressure (p=0.004) and mean arterial blood pressure (p=0.01). This test showed a statistically significant difference between intervention and intra-intervention in mean arterial oxygen saturation at post-suction time (p=0.001).

Conclusion Although the catheter 12 and pressure 100 and 150 indicated a greater increase in hemodynamic parameters at the time immediately after endotracheal suctioning, the changes are minor and within the normal range and decreased 10 and 20 minutes after the procedure and approached pre-suction time.

Keywords Mechanical Ventilation; Endotracheal Suctioning; Intensive Care

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Introduction

Gas exchange is a critical function of the respiratory system for opening the airway [1]. The use of an artificial airway is mandatory when a person is naturally unable to maintain an open airway [2]. Tracheal tube placement is one of the specialized interventions in intensive care departments [3], which maintains and keeps the airway open through discharge secretions from the airway and improves ventilation and oxygenation [4]. The number of people who need respiratory support with mechanical ventilation is increasing [3], so that 33-56% of all patients in intensive care departments and 2.8% of all hospitalized patients need mechanical ventilation. Many problems arise after using artificial airways [5], which cause secretions in the airway [6]. Obstruction of the airway due to the rapid secretions causes disturbances in gas exchange and different side effects such as increased intracranial pressure, cardiac dysrhythmias (premature ventricular contraction (PVC), tachycardia as a result of stimulation of the sympathetic system, and bradycardia due to stimulation of the vagus nerve [7, 8], hypoxia and hypoxemia [9], decreased arterial blood oxygen saturation [10], scratches and wounds in the tracheal mucosa [11], infection and atelectasis [12], increase in resistance and airway pressure, pain and discomfort and feeling of suffocation during suction [13], tachycardia, hypertension, heart failure and death [14, 15]. Also, lactate accumulation and insufficient tissue perfusion reduce myocardial function and cause hemodynamic instability [14].

Therefore, one of the significant objectives for caring is the prevention of the above complications [16]. In the patients, secretions moved from the lower airway to the center of the airway by repeatedly changing the patient's position, humidifying the incoming air, and chest physiotherapy [17]. Tracheal tube suction is one of the most effective methods to prevent secretion, which is usually performed by nurses [23]. There are two recognized standard methods for endotracheal tube suction, including the open method and the closed method [19]. The most common endotracheal suction of patients in Iran is open suction. In open suction, the connection between the patient and the ventilator is cut off during suction, and suction is performed under negative pressure by inserting the catheter size. In this method, separating the ventilator can cause a decrease in airway pressure, and increases the risk of pulmonary collapse. This process is the cause of hypoxia in patients [6] and a significant disturbance in gas exchange [20].

Although the closed method is a safe method of endotracheal suction, it is less effective in clearing secretions than the open method [10]. Currently, the open method is used in most special care departments due to the lack of familiarity of nurses with the instrument used in the closed method and the high price of the suction set in this method [20]. Despite the complications, suction is still the only acceptable way to drainage of pulmonary secretions and clear airways in patients under mechanical ventilation [21]. The suction technique should be safe and effective to improve the values of arterial blood gases and keep the normal range of hemodynamic parameters [22, 23]. The American Respiratory Care Association recommends that variables such as oxygen saturation level of arterial blood, skin color, heart rate, blood pressure, and cardiac rhythm should be monitored before, during, and after suctioning [22].

The use of negative pressure and appropriate catheter size during tracheal tube suction is a suitable way to reduce complications and perform tracheal tube suction effectively [24]. The suction catheter size depends on the tracheal tube size [25]. The recommended catheter size for adults is 10-16 French [26]. It is recommended that the diameter of the suction catheter in adults is less than half of the inner diameter of the tracheal tube [22]. Findings suggest using the smallest catheter that can adequately remove secretions. This suggestion is based on the fact that a larger catheter size narrows the endotracheal tube and creates more negative pressure and causes a further reduction of lost volume and extensive atelectasis during tracheal tube suction. Accordingly, the suction catheter should be large enough to clear secretions but not reduce tracheal pressure below clinically acceptable levels [26]. When the catheter is small, the air from around drowns down the lung during open suction and prevents the sudden drop of the remaining functional capacity, and reduces the risk of atelectasis [27]. The results of a study showed that if the ratio of the external surface of the catheter to the internal diameter of the tracheal tube is 5. or less, the intratracheal pressure does not fall below atmospheric pressure by 2 mmHg; so, it doesn't seem to have a risk during short-term open suctioning [24]. Studies on the suction pressure state that the suction pressure should be as low as possible to remove secretions without damaging the tracheal tissue. It is believed that the level of pressure possessed through the airway during tracheal tube suction is determined by a combination of suction catheter size and the applied pressure [28]. It is crucial to use proper suction pressure during suctioning of the tracheal tube. The appropriate pressure is to use the minimum level of pressure to achieve clearance of secretions to avoid atelectasis, hypoxia, and mucosal damage [29]. Different sources have recommended different levels of negative pressure during tracheal tube suction. The American Respiratory Care Association has recommended performing tracheal tube suction with a pressure of less than 150mmHg [30]. In a study, it has been stated that negative pressure 200mmHg can be used for suctioning patients if a suitable-size catheter is used [27]. Some studies recommended the pressure level equal to or less than 150mmHg during suction [31].

Few researchers have studied the efficiency of open-method suction by changing the pressure and catheter size. There was no study comparing the combined effects of catheter size and negative suction pressure on the desired parameters in the adult intensive care departments. The limited studies and different results have arisen uncertainty in the medical staff, especially the nurses of the special departments. This study aimed to compare the combined changes in catheter size and negative suction pressure on the hemodynamic parameters of patients under mechanical ventilation.

Instrument & Methods

This is a clinical intervention study with a pre- and post-design through repeated measurements. The plan has been registered on Iran's clinical trial website (IRCT ID: 20190120042436N1). This study was carried out on all patients under mechanical ventilation, who were specialized in the special care units of the teaching hospitals affiliated with the University of Medical Sciences and Health Services of Kohgiluyeh and Boyer Ahmad provinces and the Shiraz University of Medical Sciences in 2019-2020.

Sampling method & sample size

The sample size was determined to be 32, considering Coutinho *et al.* [32], and the parameters of d=0.6, $Z_{1-\frac{\alpha}{2}} = 1.96$, $z_{1-\beta}$=0.85, 1-β=0.8, β=0.2, 1-α=0.95, α=0.95, α=0.05, σ=2.04, The ultimate sample size was determined by 35 concerning the %10 statistical declines.

Inclusion & exclusion criteria

Inclusion criteria were a minimum age of 18 and a maximum of 65 years, use of a tracheal tube and connecting to a ventilator with constant volume mode (SIMV-A/C), being hospitalized in the intensive care unit under mechanical ventilation at least 24 hours before the intervention, use of tracheal tube size 5/7 with Supa brand, stable hemodynamic status (Mean arterial pressure between 60-110mmHg, systolic blood pressure more than 90 and less than 140, diastolic pressure less than 100mmHg, heartbeat rate less than 100mmHg and more than 60 beats per minute, and arterial blood oxygen saturation more than 90%) and acquiring a score of 2 to 5 based on the Richmond Agitation Sedation Scale. The reason for choosing subjects in this range was not restless to enter the study. Respiratory diseases such as asthma, emphysema, COPD (Chronic Obstructive Pulmonary Disease), ARDS (Acute Respiratory Distress Syndrome), the use of positive inotrope medicine such as dopamine and dobutamine, severe heart failure and pulmonary insufficiency, high intracranial pressure, acquiring a score of -1 to +4 based on the Richmond scale, blood coagulation disorders and thrombocytopenia were the exclusion criteria.

Data Collection Instrument

The data collection tools were a questionnaire consisting of a demographic and clinical profile form (gender, age, medical diagnosis, duration of hospitalization, score based on the Richmond criteria, catheter size, negative suction pressure, and suction time) and information registration form for vital signs monitoring devices and ventilators. Hemodynamic status (systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, heartbeat rate, and arterial blood oxygen saturation) was measured and recorded using the central monitoring device and pulse oximetry monitor connected to the patient. The vital signs monitor had a color LED screen. With continuous working mode, this system monitors vital signs, ECG, respiratory rate, ST segment deviation, analysis of 13 types of arrhythmias, NIBP, SPO_2, and 2 channels of temperature and brain function assessment (BFA).

A research checklist was prepared according to similar studies and available articles and books, and its face and content validity was confirmed by the exploring opinion of experts. Preparing the instrument from reputable companies, also the self-adjustment feature for measuring the accuracy and reliability of the instruments were the options for guaranteeing the accuracy of the vital signs monitoring devices and ventilators. A standard monitor produced by the Medical equipment manufacturer of Pooyandegane Rahe Salamat Company was used to record heartbeat, blood pressure, and arterial blood oxygen saturation percentage. Supa brand suction catheter and endotracheal tube were used for all subjects.

Intervention

The inclusion criteria of all patients with a tracheal tube under mechanical ventilation admitted to the intensive care unit were checked by the researcher. The aims and methods, the freedom to withdraw from the research, and the confidentiality of the patient's personal information were fully explained to the legal guardians of the patients under mechanical ventilation. And informed consent was obtained from the patient's guardian to allow their patient to participate in the study. First, questionnaires were completed only based on the identification code. This research was carried out on 35 patients with a tracheal tube under mechanical ventilation in a single group method. Each patient underwent endotracheal suction 4 times at least 2 hours apart: at first time, with catheter 10Fr and negative pressure of 100mmHg; a second time with a catheter 10Fr and negative pressure of 150mmHg; a third time with a catheter 12Fr and negative pressure of 100mmHg; and at the fourth time, with a catheter Fr and 150mmHg negative pressure. Tracheal tube suction was performed as follows:

The patient's requirements for suction were determined based on ventilator findings, including high airway pressure alarm, decreased expiratory current volume, observing the clinical condition of the patient including rattling sounds in the lungs, deterioration of oxygen saturation or arterial blood gas levels, secretions in the airway, and respiratory distress. Basic information, including hemodynamic parameters, was measured and recorded immediately before tracheal tube suction. Then, open tracheal suction was performed by the researcher based on the protocol of the American Respiratory Care Association. In this study, the suction pressures were selected based on the protocol of the American Respiratory Care Association [26] and the same tracheal tube size of 5.7 was considered for all research units. The catheters 10Fr and 12Fr were used, which according to the protocol are less than half the inner radius of the tracheal tube.

The patient was placed in a supine position and in a 45 degrees semi-sitting position with the head and neck in a straight line to prevent aspiration. The patient was hyper-oxygenated by turning on 100% oxygen mode by the ventilator for 1 minute before suction. Then, the suction device was turned on, and the suction catheter was slowly and circularly inserted into the endotracheal tube in a clamped position with the free hand, concerning the correct and sterile technique. The catheter was withdrawn 1 cm to avoid mucosal damage when applying suction. The clamp was then opened and suction was performed for 10 seconds while the catheter was withdrawn slowly and rotationally. The patient was connected to a ventilator and received 100% oxygen for 30 seconds. The catheter head was cleaned using a sterile normal saline solution. Then, the patient was separated from the device, and suction was performed for the second time for 10 seconds according to the previous steps. Oropharyngeal suction was performed after tracheal suction to ensure the removal of secretions and to prevent contamination of the trachea with oral secretions. The patient was connected to a ventilator and placed under 100% oxygen for 1 minute [30], and the desired hemodynamic parameters were recorded 10 and 20 minutes after suction.

Data Analysis

The data was analyzed using SPSS 21 software through descriptive and inferential statistics with a confidence level of 95%. The normal distribution of the variables was checked with the Kolmogorov-Smirnov test. ANOVA repeated measure test was used for data analysis considering the data normal distribution.

Findings

The average age of the subjects was 50.4±12.7 years. 60% of the subjects were female. 71.4% of patients have been treated with mechanical ventilation due to internal diseases such as diabetes, kidney disease, autoimmune disease, etc. The average duration of hospitalization of the patients was 5.4±5.1 days. According to the Richmond criteria, most patients under mechanical ventilation had a score of -4 (deep anesthesia). The mechanical ventilation mode of majority of patients (82.9%) was treated with mechanical ventilation of the synchronized intermittent mandatory ventilation (SIMV) mode. The distribution of scores of outcome variables, including systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, and normal heartbeat rate, was investigated using the Kolmogorov-Smirnov test. Therefore, the ANOVA test was used to compare the measurements.

The findings showed that suction with catheter 10Fr and 12Fr and pressures of 100mmHg and 150mmHg increases systolic blood pressure in patients immediately after suction. Although, in time intervals of 10 and 20 minutes after suction, the systolic blood pressure decreases and returns to the time before suction. These changes were more in catheter 12Fr and pressure 150mmHg compared to catheter 10Fr and pressure 100mmHg. Although some changes in mean systolic blood pressure were reported to be statistically significant (repeated measure ANOVA), it seems that these changes are not clinically significant (140>SBP>90; Table 1).

Table 1) Inter-intervention and intra-intervention comparison of average systolic blood pressure according to catheter size, negative suction pressure, and measurement times

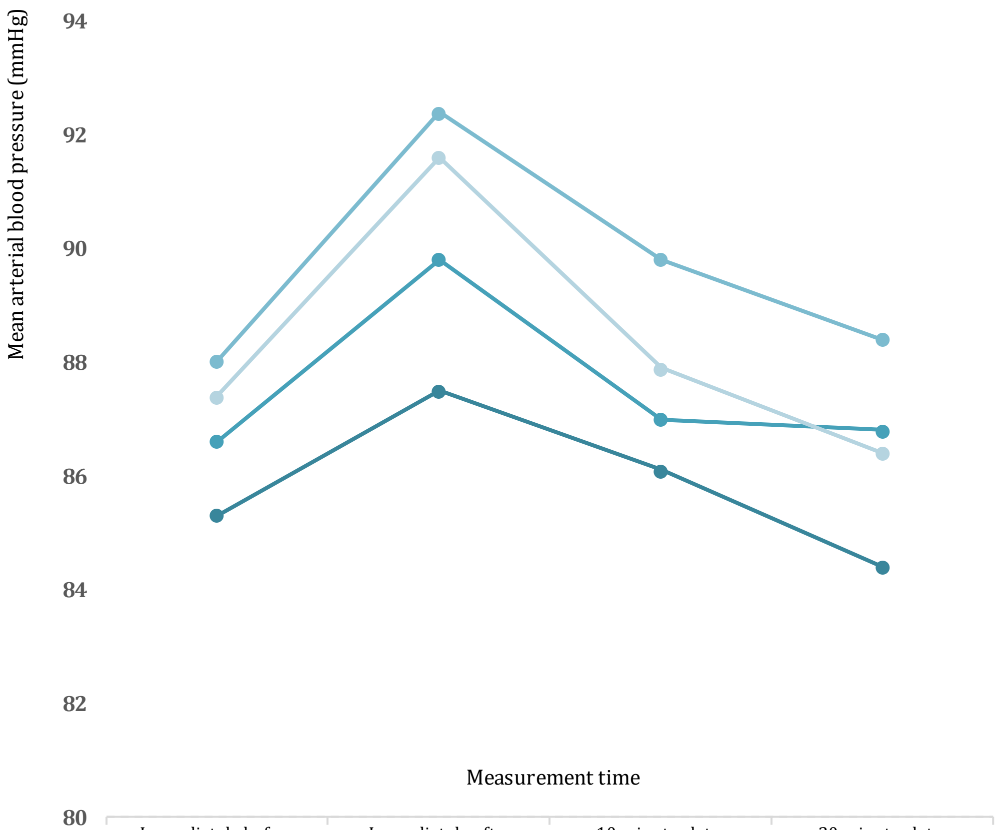
Repeated measures ANOVA test (inter-intervention)				Repeated measures ANOVA test (intra-intervention)			
Parameter	**Statistics**	**df**	**Sig.**	**Time**	**Statistics**	**df**	**Sig.**
Catheter 10 pressure 100	7.8	3	0.001	**Immediately before**	0.3	3	0.8
Catheter 10 pressure 150	2.08	2.1	0.1	**Immediately after**	4.8	3	0.004
Catheter 12 pressure 100	14.08	1.95	0.001	**10 minutes later**	0.2	3	0.8
Catheter 10 pressure 150	34.9	2.3	0.001	**20 minutes later**	1.4	3	0.2

There was an increase in diastolic blood pressure immediately after suction compared to before suctioning with catheter sizes 10Fr and 12Fr and pressures 100mmHg and 150mmHg. Although, diastolic blood pressure decreased between 10 and 20 minutes after suction. the increase in the average diastolic blood pressure in catheter 12Fr and pressure 150mmHg was more than in catheter 10Fr and pressure 100mmHg. However, there was no significant difference in terms of the catheter size and the negative suction pressure. Although, in the comparison of intra-interventional changes, a significant difference has been observed in the average diastolic blood pressure immediately after suction compared to other measurement times in catheter 12Fr with pressures of 100mmHg and 150mmHg. Although in the comparison of intra-interventional changes, a significant difference was observed in the average diastolic blood pressure immediately after suction compared to other measurement times in catheter 12Fr with pressures of 100mmHg and 150mmHg; whereas, it seems to be clinically insignificant (DBP<100; Table 2).

Table 2) Inter-intervention and intra-intervention comparison of average diastolic blood pressure according to catheter size, negative suction pressure, and measurement times

Repeated measures ANOVA test (inter-intervention)				**Repeated measures ANOVA test (intra-intervention)**			
Parameter	**Statistics**	**df**	**Sig.**	**Time**	**Statistics**	**df**	**Sig.**
Catheter 10 pressure 100	4.6	2.3	0.09	**Immediately before**	2.7	3	0.05
Catheter 10 pressure 150	2.2	1.9	0.1	**Immediately after**	1.8	3	0.1
Catheter 12 pressure 100	3	3.5	0.01	**10 minutes later**	3.1	3	0.05
Catheter 10 pressure 150	2.2	7.3	0.001	**20 minutes later**	1.9	3	0.1

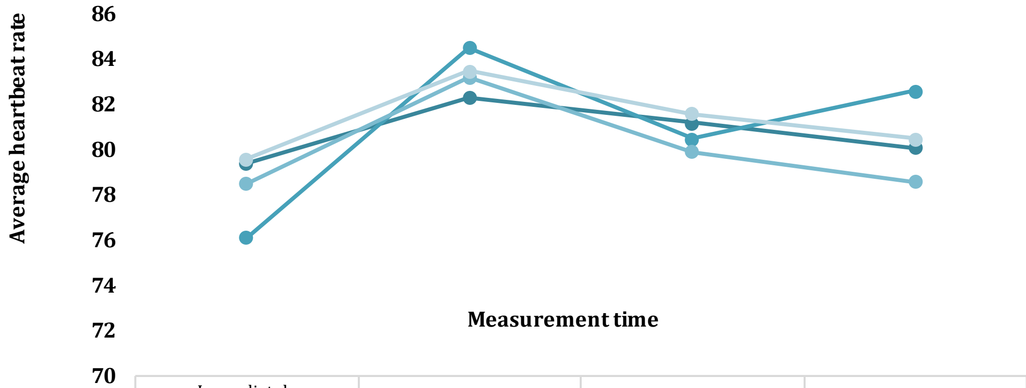
The findings showed an increase in mean arterial blood pressure immediately after suction compared to before suction with catheters size 10Fr and 12Fr and pressures of 100mmHg and 150mmHg, which decreased in 10 and 20 minutes after suction and approached the average blood pressure before suction. The increase in the mean arterial blood pressure in catheter 12Fr with pressures of 100mmHg and 150mmHg was more than in catheter 10Fr with pressures of 100mmHg and 150mmHg. There was a significant difference in the comparison of inter and intra-intervention changes based on the ANOVA repeated measure test; however, it was insignificant clinically (110>MAP>60; Figure 1).



	Immediately before	Immediately after	10 minutes later	20 minutes later
Catheter 10 pressure 100	85.3	87.5	86.1	84.4
Catheter 10 pressure 150	86.6	89.8	87	86.8
Catheter 12 pressure 100	88.02	92.4	89.8	88.4
Catheter 12 pressure 150	87.4	91.6	87.9	86.4

Figure 1) Inter-intervention and intra-intervention comparison of mean arterial blood pressure according to catheter size, negative pressure, and measurement times

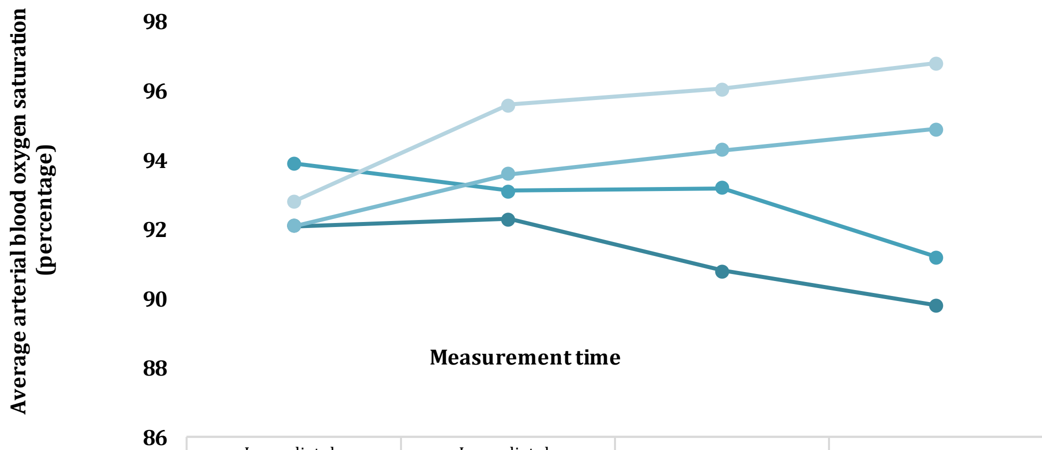
The heartbeat rate increased immediately after suction with catheters of 10Fr and 12Fr and pressures of 100mmHg and 150mmHg compared to before suction; whereas, at 10 and 20 minutes after suction, it decreased and approached the average heartbeat rate before suction. The ANOVA repeated measure test showed a significant difference between inter-intervention and intra-intervention changes, whereas it is clinically insignificant (100>HR>60; Figure 2).



	Immediately before	Immediately after	10 minutes later	20 minutes later
Catheter 10 pressure 100	79.4	82.3	81.2	80.1
Catheter 10 pressure 150	76.1	84.5	80.5	82.6
Catheter 12 pressure 100	78.5	83.2	79.9	78.6
Catheter 12 pressure 150	79.6	83.5	81.6	80.5

Figure 2) Inter-intervention and intra-intervention comparison of average heart rate according to catheter size, suction negative pressure, and measurement duration

Also, the findings showed an increase in the average oxygen saturation of arterial blood immediately after suction with catheters 10Fr and 12Fr and pressures 100mmHg and 150mmHg, with the exception of catheter 10Fr and pressure 150. This increase in catheter 12Fr and 150 pressure was more compared to catheter 10Fr and pressure 100mmHg. Also, the increase was observed at 10 and 20 minutes after suction, with a catheter 12Fr and pressures of 100mmHg and 150mmHg, whereas, there was an increase with a catheter 10Fr and a pressure of 100mmHg and 150mmHg. The ANOVA repeated measure test showed a significant difference between the inter-intervention and intra-intervention recorded changes (o2sat>96>100; Figure 3).



	Immediately before	Immediately after	10 minutes after	20 minutes after
Catheter 10 Pressure 100	92.1	92.3	90.8	89.8
Catheter 10 Pressure 150	93.9	93.1	93.2	91.2
Catheter 12 Pressure 100	92.08	93.6	94.3	94.9
Catheter 12 Pressure 150	92.8	95.6	96.05	96.8

Figure 3) Inter-interventional and intra-interventional comparison of average arterial blood oxygen saturation according to catheter size, negative suction pressure, and measurement times

Discussion

This study aimed to compare the combined changes in catheter size and negative suction pressure on the hemodynamic parameters of patients under mechanical ventilation. There was no significant difference between the scores of the outcome variables before the intervention.

Catheter size changes and negative suction pressure caused a significant difference in the average hemodynamic parameters including systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, and heartbeat rate at the time points immediately, 10, and 20 minutes after the intervention. However, the changes in the average of the mentioned variables were in the normal range.

The hemodynamic parameter changes can be justified with a scientific basis; because based on theoretical knowledge, suctioning the tracheal tube causes pain in the patient. On the other hand, the patient under mechanical ventilation is not able to express this pain and this increases muscle contraction and stimulates the sympathetic system, which is the cause of increased heartbeat rate and blood pressure during suction and shortly after suctioning the tracheal tube returns to the initial state. Paying attention to the changes in hemodynamic parameters due to pain during tracheal suction can be a part of health care to investigate pain and discomfort in unconscious patients; otherwise, the patients are unable to express their pain [33]. Comparison of the results of this study with other studies in the field of systolic blood pressure showed a significant increase in the mean systolic blood pressure immediately after suction in the inter-interventional comparison; however, it does not show a significant difference at the time points of 10 and 20 minutes after suction. In this regard, Paymard *et al*. investigated the effect of open-method suction with catheters 12Fr and 14Fr on the systolic blood pressure of patients in the intensive care unit at the time points of 5 minutes before, during, 5, and 20 minutes after suction, which showed a significant difference in systolic blood pressure before and after suction. In such a way, this difference increased with larger catheters. There was a significant difference in the systolic blood pressure with the large and small catheters. The increase in systolic blood pressure in the next 5 minutes was greater in the larger size catheter and decreased in the next 20 minutes in both catheters. The findings of Paymard *et al*. are consistent with this study [34]. However, the sizes of the catheters and the number of suctions are different in the two studies. Also, the research findings of Mohammadi *et al*. and Etemadifar are consistent with the findings of this study, emphasizing a significant increase in systolic blood pressure in one minute after suctioning, however, the suction method was not mentioned in the two studies [18, 35].

Based on the findings of the inter-interventional comparison, there was no significant difference in the mean diastolic blood pressure after suction. Also, an intra-interventional comparison showed a significant difference in a catheter 12Fr with pressures of 100mmHg and 150mmHg after suction. Our findings are consistent with the findings of Etemadifar regarding the increase in diastolic blood pressure after suction; however, the intervention method was not stated in this study [35]. The results of Mohammadi *et al*. showed a significant increase in diastolic blood pressure 1 minute after suction, and their findings are consistent with the results of the present study. One of the possible reasons for the significant increase in the study by Mohammadi *et al*. is the use of invasive methods for measuring blood pressure [18].

The results of the present study showed that, in an inter-interventional comparison, the mean arterial blood pressure increased significantly immediately after suctioning. Also, there was a significant difference in different catheters and pressures in intra-interventional comparison. Consistent with this study, Yousefi *et al*. showed a significant difference in the average arterial blood pressure at the time points after suctioning in the intra-group comparison. Also, Yousefi *et al*. showed an increase in average arterial blood pressure and then a gradual decrease and approaching the initial state 20 minutes after suction, which is consistent with the present study. On the other hand, there was no significant difference between the two groups after suctioning [36]. Due to not mentioning the size of the catheter and endotracheal tube used, it is not possible to make a proper judgment about comparing the results of the study by Yousefi *et al*. with the present study. Also, the duration of suctioning and the number of interventions are different in the two studies. The findings of this study are also consistent with the results of Mohammadpour *et al*. regarding the significant increase in average arterial blood pressure after suction. However, the measurement instrument in the study by Mohammadpour *et al*. was invasive and the intervention method was not stated in detail [37]. However, inconsistent with our findings, Elsaman showed a reduction in mean arterial blood pressure after endotracheal tube suction [38]. To justify this contradiction, we can mention the difference in the formula for calculating the catheter size, the intervention duration, and the mode of mechanical pressure ventilation.

The results of this study in the field of average heartbeat rate indicate a statistically significant difference in the inter-intervention comparison at 20 minutes after suction and the intra-intervention comparison in different catheters and pressures. In this regard, Paymard *et al*. are following the results of the present study indicating an increase in heartbeat rate after suction compared to before suction, and a decrease in the heartbeat rate at 20 minutes after suction. On the other hand, it showed that the average heartbeat rate during and after suction is higher in people under suction with a larger catheter, which is different from the present study [39].

The reason for this can be found in the different sizes of the catheters and the pressures, despite the same size of the tracheal tube and the number of suctions. Consistent with our findings, Dadkhah *et al*. showed an increase in the heartbeat rate immediately after suction and a significant difference in time intervals before, immediately after, 5, 10, and 15 minutes after suction [40]; although there are differences in the size of the suction catheter, the duration of hyperoxygenation, and the number of subjects between our study. The findings by Rafiei *et al.*, Mohammadpour *et al.*, and Zulfiqar *et al.* are consistent with the present study regarding the increased heartbeat rate after suction; however, the size of the catheter and endotracheal tube used in these studies are not mentioned [2, 41, 42]. The findings of Elsaman are consistent with the present study regarding the increase in heartbeat rate after suctioning [38]. Yousefi *et al.* investigated the effect of open suction with 2 negative pressures of 100mmHg and 200mmHg on heartbeat rate at the time points immediately before, during, 5, and 20 minutes after tracheal tube suction. They showed significant changes in the average heartbeat rate in different stages after suction in both suction groups with negative pressure of 100mmHg and 200mmHg ($p>0.05$), and an increase in the heartbeat rate after suction and then a gradual decrease and approached the initial state 20 minutes after suction, which is consistent with the present study [36]. Although the results of the study are consistent with the present study, the duration of the intervention, hyperoxygenation, and the number of interventions are different from our study. Singh *et al.* found that all suction catheters at different pressures resulted in similar changes in heartbeat rate after tracheal tube suction [43]. However, due to the different age groups of the patients in the two studies, it is not possible to make a proper comparison in this field.

Comparison of the results of the present study with other studies in the field of arterial blood oxygen saturation showed an increase in the times after suction with catheter 12Fr and pressures 100mmHg and 150mmHg, and a decrease in catheter 10Fr and pressures 100mmHg and 150mmHg, except the time immediately. It seems that the arterial blood oxygen saturation has increased in most of the catheters and different pressures immediately after the suction due to the hyperoxygenation of the patient. Also, 10 and 20 minutes after suction, increasing the catheter size and the negative suction pressure have been more effective in cleaning the secretions. Muhaji *et al.* showed a significant difference in the arterial blood oxygen level before and after suction at two pressures of 130mmHg and 140mmHg ($p<0.05$) and a significant difference in arterial blood oxygen level ($p<0.05$). A pressure of 140mmHg had a more effect on increasing the arterial blood oxygen level than a pressure of 130mmHg after endotracheal suction, which is consistent with the present study [25]. The reason for the consistent findings by Muhaji *et al.* with our study is the compatibility of the calculation formula for selecting the catheter size and the standard pressure used in both studies. Also, Lasocki *et al.* showed that increasing the pressure from 200mmHg to 400mmHg during suction in a closed method increases the property and efficiency of suction in the aspiration of lung secretions, which is consistent with the findings of our study [44]; however, the method of recording arterial blood gases ad suction method is different from the present study. In addition, Yousefi *et al.* showed a significant difference in the average arterial blood oxygen saturation in different stages before, during, 5, and 20 minutes after suction in both suction groups with negative pressure of 100mmHg and 200mmHg ($p>05$); also in the 20th minute after suction, the pressure increase of 200mmHg was more compared to the pressure 100mmHg, which is consistent with our findings [45]; however, the duration and of suctioning and the hyperoxygenation and pressure used in the two studies are different. Inconsistent with our findings. Shomali *et al.* showed a decrease in arterial blood oxygen levels immediately after suction [46]. Due to not mentioning the size of the tracheal tube, the suction catheter, and the pressure used, it is not possible to compare the study by Somali *et al.* with the present study. Also, Etamadifer showed a decrease in arterial blood oxygen saturation, 1 minute after suction [35]. Although this decrease is not statistically significant, however, due to not mentioning the intervention method, it is not possible to make a proper explanation in this field.

The present study has limitations that should be taken into account specially to generalize the results. Some of the limitations are the application of the inclusion criteria and the possibility of changes in the patient's condition at least 2 hours between each intervention, which may affect the hemodynamic parameters and remain unobvious. The results of the present study are applicable in the clinic. The catheters 10Fr and 12Fr have a diameter less than half of the inner diameter of the size 5/7 tracheal tube and the pressures of 100mmHg and 150mmHg are within the normal range of recommended suction pressure for adults in the special care department. Based on these findings, although catheter 12Fr and pressure 100mmHg and 150mmHg increased the hemodynamic parameters immediately after tracheal tube suction, the changes are in the normal range, which does not seem to be clinically significant, and at 10 and 20 minutes after this procedure, it decreases and approached the time before suction. On the other hand, changing the suction catheter size from 10Fr to 12Fr and changing the suction negative pressure from 100mmHg to 150mmHg did not cause clinically significant changes in the hemodynamic parameters of patients undergoing mechanical ventilation during tracheal tube suction. In other words, there was the same clinical effect of these processes on the hemodynamic parameters of patients under mechanical ventilation. Catheter 12Fr and pressure 100mmHg and 150mmHg have more power in cleaning secretions, so it's recommended to use catheter 12Fr and pressure 100mmHg and 150mmHg. Therefore, the results of this research and similar studies in the field of endotracheal tube suction must be made available to nurses working in special care departments, so that they can benefit from these findings to provide the best clinical services to patients.

Considering that one of the influencing factors on the hemodynamic parameters is the sedation level of the patient, therefore, in future studies, it is suggested to perform an intervention on patients at the same level in terms of consciousness level. In addition, in the current study, the effect of these catheters and pressure was measured before and after suction, so it is suggested to check their effect during suction on the mentioned parameters. In addition, the effect of these catheters and pressure was measured before and after suction, so it is suggested to check their effect on the mentioned parameters during suction.

Conclusion

Although the catheter 12 and pressure 100 and 150 indicated a greater increase in hemodynamic parameters at the time immediately after endotracheal suctioning, the changes are minor and within the normal range and decreased 10 and 20 minutes after the procedure and approached pre-suction time. Since both size 10 and 12 catheters have a diameter less than half the inner diameter of the endotracheal tube 7.5 and pressures 100 and 150 are within the normal range of recommended adult suction pressure in the ICU.

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