Original Article

The effect of expiratory rib cage compression before endotracheal suctioning on the vital signs in patients under mechanical ventilation

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Abstract

Background: In patients undergoing mechanical ventilation, mucus production and secretion is high as a result of the endotracheal tube. Because endotracheal suction in these patients is essential, chest physiotherapy techniques such as expiratory rib cage compression before endotracheal suctioning can be used as a means to facilitate mobilizing and removing airway secretion and improving alveolar ventilation. As one of the complications of mechanical ventilation and endotracheal suctioning is decrease of cardiac output, this study was carried out to determine the effect of expiratory rib cage compression before endotracheal suctioning on the vital signs in patients under mechanical ventilation.

Materials and Methods: This study was a randomized clinical trial with a crossover design. The study subjects included 50 mechanically ventilated patients, hospitalized in intensive care wards of Valiasr and Mousavi hospitals in Zanjan, Iran. Subjects were selected by consecutive sampling and randomly allocated to groups 1 and 2. The patients received endotracheal suctioning with or without rib cage compression, with a minimum of 3 h interval between the two interventions. Expiratory rib cage compression was performed for 5 min before endotracheal suctioning. Vital signs were measured 5 min before and 15 and 25 min after endotracheal suctioning. Data were recorded on a data recording sheet. Data were analyzed using paired *t*-tests.

Results: There were statistically significant differences in the means of vital signs measured 5 min before with 15 and 25 min after endotracheal suctioning with rib cage compression ($P < 0.01$). There was no significant difference in the means of diastolic pressure measured 25 min after with baseline in this stage). But on the reverse mode, there was a significant difference between the means of pulse and respiratory rate 15 min after endotracheal suctioning and the baseline values ($P < 0.002$). This effect continued up to 25 min after endotracheal suctioning just for respiratory rate ($P = 0.016$). Moreover, there were statistically significant differences in the means of vital signs measured 5 min before and 15 min after endotracheal suctioning between the two methods ($P \leq 0001$).

Conclusions: Findings showed that expiratory rib cage compression before endotracheal suctioning improves the vital signs to normal range in patients under mechanical ventilation. More studies are suggested on performing expiratory rib cage compression before endotracheal suctioning in patients undergoing mechanical ventilation.

Key words: Endotracheal suctioning, expiratory rib cage compression, mechanical ventilation, vital signs

Introduction

In patients under mechanical ventilation, airway secretions are notably increased due to constant positive pressure ventilation. As the function of existing cilia in the airway and cough reflex are weakened in these patients, airway obstruction occurs which may lead to atelectasis and pulmonary collapse.[1,2]

In addition, inadequate and non-efficient cough in these patients results in the secretions remaining in the airway, which may lead to pneumonia.[3] Obstruction of airway in patient under mechanical ventilation can ultimately result in hazardous complications such as acidosis, cyanosis, and cardiac dysrhythmia, and threaten the patient's life.[4,5] These complications are among the common complications of patients under mechanical ventilation, which prolong their hospitalization time.[6]

Therefore, prevention of such complications is among the care goals of these patients. To achieve this goal, endotracheal suctioning, chest physiotherapy, frequent position change, increase of physical activity, provision of adequate humidity, and fluid therapy are some of the needed nursing interventions.[7] With regard to the above-

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mentioned issues, endotracheal suction in patients under mechanical ventilation is essential.[3] This intervention is invasive and may have dangerous complications such as hypoxia, dysrhythmia, atelectasia, vagus nerve stimulation, and consequently, a decrease in BP. There has been controversy in the method of endotracheal suctioning and the factors that make it more efficient.[8] One of the factors that helps in efficient endotracheal suctioning and removal of secretions from the airways is administration of chest physiotherapy before endotracheal suctioning.[7] Expiratory rib cage compression or squeezing is one of the chest physiotherapy methods and includes chest compression by hands during expiration and releasing that at its end to assist movement of pulmonary secretions, facilitate active inspiration, and improve alveolar ventilation.[9,10] This technique increases forced expiratory volume by 30% and leads to resting of expiratory muscles. Most of all, the technique is quite safe, as it has been employed in some patients for more than 3 years with no complications.[11] Therefore, this technique can be used before patients' endotracheal suctioning. The effect of this technique on atrial blood gases and the amount of pulmonary secretions has been already studied,[12,13] but no study has focused on its effect on vital signs, as the major indexes of hemodynamic stability. As the patients under mechanical ventilation face low cardiac venous return due to ventilation with positive pressure, and consequently, reduction of BP,[14] the present study aimed at investigating the effect of expiratory rib cage compression before endotracheal suctioning on the vital signs in patients under mechanical ventilation.

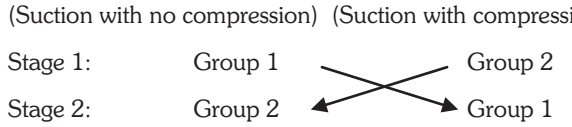
Materials and Methods

This was a clinical trial with crossover design conducted on male patients (due to Islamic issues) under mechanical ventilation hospitalized in educational and treatment centers of Ayatollah Mousavi and Valiasr hospitals affiliated to Zanjan University of Medical Sciences. In the present study, the patients under mechanical ventilation and hospitalized in the intensive care unit (ICU) were selected by consecutive sampling after getting permission from the faculty authorities and ethics committee of Zanjan University of Medical Sciences and obtaining a written consent from the patients' immediate relatives and related physicians. Inclusion criteria were male patients with stable hemodynamic status, age 18-70 years,hematocrit HCT >25%, no history of hyperthermia and chest injuries, no chest tube and chest surgeries, and lack of mechanical ventilation with end-expiratory positive airway pressure. Exclusion criteria were intake of muscle paralyzing drugs such as Pavulom during the study, beginning and stopping of bronchodilators during the study, any change in mechanical devices' settings due to any reason during the study, receiving endotracheal suctioning within 1 h before each procedure, putting the patient on continuous mandatory ventilation CMV mode, and any history of active asthma and emphysema. The patients who satisfied the criteria were selected and randomly assigned to groups 1 and 2. Based on the results of earlier studies, sample size in the present study was calculated and estimated to be 50 subjects, through sample size formula and consideration of $Z_{\alpha} = 1.96$ and power = 80% ($Z_{\beta} = 0.84$). It should be noted that a total of 15 subjects were excluded. Five were excluded due to a change in the setting of mechanical ventilation during the intervention time positive end-expiratory pressure (PEEP) and five subjects were excluded due to being on CMV mode.

Primary sampling was non-random, and then, for subjects' allocation, random numbers chart was adopted to assign the subjects to groups 1 and 2. Data were collected by a data record note containing two sections of demographic characteristics and a subjects' vital signs data record chart. In group 1, the patients underwent endotracheal tube suctioning without rib cage compression in the first stage. Firstly, patients' vital signs data were recorded in the related note. Five minutes after recording the vital signs, endotracheal suctioning procedure was performed for each patient by the researcher according to the existing standard techniques. To prevent hypoxia and suctioning complications before beginning suctioning, within specific time points and at its end, the device was fixed on hyperoxygenated mode (100% oxygen) and hyperinflation (tidal volume 1.5-folds more than before). Finally, 15 and 25 min after endotracheal suctioning, patients' vital signs were checked and recorded in the related data record note. After at least 3 h, endotracheal suctioning was performed for these patients through expiratory rib cage compression during which the researcher gradually compressed the end and lateral parts of patients' rib cage during expiration by his hands. This technique was bilaterally performed, and in the end of expiration, the compression was released from the patients' rib cage to let them have a free inspiration. Researcher paid close attention to have identical pressure on every patient's rib cage.

In group 2, the patients firstly underwent endotracheal suctioning with rib cage compression procedure, and then, endotracheal suctioning was performed without rib cage compression through a similar technique. It should be noted that Pooyandegan Rah Saadat vital signs monitoring device, made in Iran, was used to check the vital signs. To confirm validity of the data collection tool (data record note), content validity was used, and for the reliability of the vital signs checking device, the manufacturer's instructions were followed before the study began.

Data were analyzed by paired *t*-test to compare before and after intervention values in each group and by independent *t*-test to compare changes in both groups through SPSS.



Results

In the present study, the subjects' age ranged 18-70 years. Their mean age was 45.46 (18.14) years. Independent *t*-test showed that age distribution was similar in both groups.

Out of 50 studied subjects, 30 (60%) had been hospitalized in the ICU due to surgical problems and accidents. Chi-square test showed that the distribution of the cause of disease was similar in both groups. Mean lengths of mechanical ventilation time until administration of intervention in groups 1 and 2 were 3.7 (4) and 2.7 (1) days, respectively. Independent *t*-test showed no significant difference in the length of hospitalization time between the two groups. In endotracheal suctioning with rib cage compression method, comparison of vital signs' variables at expiration time 2 min before and 15 and 25 min after showed that the mean systolic pressure increased by 5 and 3 mm Hg, respectively ($P = 0.0001$). The mean diastolic pressure increased by 3 mm Hg compared to 15 min after suctioning ($P = 0.001$). Results showed that diastolic BP returned to its baseline value after 25 min.

Mean pulse per minute increased by 3 and 2 pulses in 15 and 25 min after endotracheal suctioning with rib cage compression, compared to baseline time ($P < 0.01$). Mean of respiration rate increased by 2 and 1 respirations per minute during this time, compared to baseline time ($P < 0.006$) [Table 1].

In endotracheal suctioning method without rib cage compression, comparison of mean vital signs' variables during expiration 5 min before suctioning with 15 and 25 min after that showed a slight reduction in systolic and diastolic BP. Reduction of pulse was 3 and 1 pulse in a minute, and the respiration rate was 1 respiration in a minute at time points of 15 and 25 min after suctioning, respectively, compared to the baseline time. This difference was significant just for pulse 15 min after suctioning and for respiration rate at time points of 15 and 25 min after suctioning, compared to the baseline time ($P < 0.016$) [Table 1].

On comparing the two above-mentioned methods, there were significant differences between means of vital signsvalues measured 5 min before with 15 and 25 min after suctioningexcept for mean systolic BP 25 min after suctioning and baseline time ($P < 0.01$) [Table 2].

Discussion

Based on the research goal and the obtained results, investigation of vital signs during endotracheal suctioning without expiratory rib cage compression in patients under mechanical ventilation and comparison of the changes before and after it showed that endotracheal suctioning without rib cage compression causes a slight reduction in vital signs. These findings are consistent with physiological principles, so that vague nerve stimulation, and consequently, a decrease in pulse and respiration rate, a decrease in BP, a decrease in the level of consciousness, hypoxia, and cardiac dysrhythmia can be mentioned as the complications of endotracheal suctioning.[14] The obtained results are in line with those of Nazmiyeh *et al.* (2010) concerning a slight reduction in variables of systolic and diastolic BP and pulse 15 min after suctioning.[15] Meanwhile, in the study of Zolfaghari *et al.* (2006), the obtained results showed that mean systolic and diastolic BP and pulse had a higher increase in measurements at two time points of 2 and 5 min after suctioning in the open suction method compared to closed suction method, but no significant difference was reported for respiration rate.[16]

As in the present study, suctioning was performed by open method; the observed difference may be due to the

Table 1: Mean of vital signs in endotracheal suction stages with and without rib cage compression at time points of 5 min before and 15 and 25 min after suctioning in patients under mechanical ventilation

Vital signs	With compression				Without compression			
Time	Systole Mean (SD)	Diastole Mean (SD)	PR Mean (SD)	RR Mean (SD)	Systole Mean (SD)	Diastole Mean (SD)	PR Mean (SD)	RR Mean (SD)
5 min before	120.7 (17)	76.6 (12)	83 (15)	15 (5)	122.5 (18)	75.7 (12)	86 (15)	16 (5)
15 min (*P* value)	125.5 (18) (0.0001)	79.0 (12) (0.001)	86 (14) (0.0001)	17 (4) (0.0001)	120.3 (18) (0.107)	75.2 (12) (0.558)	83 (15) (0.002)	15 (4) (0.0001)
25 min (*P* value)	123.7 (16) (0.0001)	76.7 (10) (0.822)	85 (14) (0.016)	16 (5) (0.006)	120.3 (18) (0.129)	74 (12) (0.095)	85 (14) (0.178)	15 (5) (0.016)

Systole, systolic pressure; diastole, diastolic pressure; PR, pulse rate; RR, respiratory rate

difference in measurement time of the studied variables. In Zolfaghari *et al*.'s study, the vital signs were checked before and 2 and 5 min after suctioning,[16] while in the present study, they were checked 15 and 25 min after suctioning, which is consistent with the results of Nazmiyeh *et al*., for 15 min after open suction. Based on the research goal, which was investigation of vital signs in the stage of endotracheal suctioning with expiratory rib cage compression and the comparison of their changes before and after that, the obtained results showed that endotracheal suctioning with expiratory rib cage compression leads to an increase in mean changes of vital signs' variables within a normal range. Although mean diastolic BP decreased 2 mm Hg at 15 minas compared with 25 min after suctioning, this difference is not clinically significant as the least significant clinical difference is 3 mm Hg.[17] It should be noted that the changes in vital signs have not been clinically significant in other studies.[15,16]

Based on the research goal which was comparison of changes in vital signs' values in endotracheal suctioning with and without expiratory rib cage compression in patients under mechanical ventilation, the findings showed that suctioning with expiratory rib cage compression led to a significant increase in systolic BP value, pulse and respiration rate within normal range, at 15 and 25 min after suctioning, compared to 5 min before that. Meanwhile, the above-mentioned values at 15 min after suctioning did not show a significant difference, compared to 25 min after that.

These results are consistent with the results of the study conducted by Van der Touw *et al*. in Australia, titled "Cardio respiratory effects of manually compressing the rib cage during tidal expiration in mechanically ventilated patients recovering from acute severe asthma."[18] The only difference is that they checked the vital signs once immediately after performing the technique, while in the present study, the vital signs were checked twice at 15 and 25 min after suctioning with expiratory rib cage compression.

The obtained results are consistent with the physiological principles, so that during a natural expiration, venous return to the left ventricle is temporarily increased which leads to preload and, consequently, temporary increase of the left ventricle stroke volume.[19]

Conclousion

As the technique of rib cage compression increases forced expiratory volume by 30% and facilitates active inspiration,[10,11] this technique can be expected to increase the cardiac output and improve the vital signs. Based on our obtained results, performing suctioning with expiratory rib cage compression can significantly improve the vital signs of the patients undergoing mechanical ventilation, compared to without expiratory rib cage compression. As the results concerning the effect of rib cage compression 15 min after suctioning compared to 25 min after that showed no significant difference, it reveals the continuous effect of rib cage compression up to 25 min after suctioning and can be a good sign for improvement of vital signs. It is recommended to perform this technique for more than one time in each patient to determine its effect more precisely in further studies. More studies are suggested to be carried out in this context. In case of the approval of their results, this method can be performed in all patients with endotracheal tube, especially those undergoing mechanical ventilation.

This can prevent endotracheal suctioning complications (hypoxia, bradycardia, and hypotension) and facilitate these patients' recovery and, consequently, reduce their costs of care. As the present study investigated just the effect of expiratory rib cage compression before endotracheal suctioning on the vital signs of the patients under mechanical ventilation and since in these patients variables like length of connection to mechanical ventilation device and their stay in the ICU are of great importance, it is suggested to investigate the effect of this technique on the above-mentioned variables in future studies.

Acknowledgments

This article is the extract of an MS dissertation research project which was financially sponsored by the Vice Chancellery for research in Zanjan University of Medical Sciences, and the study was conducted after obtaining approval No. 8912215 from the ethics committee. The authors appreciate Vice chancellor of Zanjan University of medical sciences and health services for financial support and also all patients and their family and physicians, staff of ICU wards of Mossavi and Valiasr hospitals. This project was recorded in a clinical trial center with registration number of IRCT201205079664N1.

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How to site: Bousarri MP, Shirvani Y, Agha-Hassan-Kashani S, Nasab NM. The effect of expiratory rib cage compression before endotracheal suctioning on the vital signs in patients under mechanical ventilation. Iranian Journal of Nursing and Midwifery Research 2014;19:285-9.

Source of Support: Nil, **Conflict of Interest:** None declared.