

Effect of Tracheal Suctioning on Cuff Pressure in Mechanically Ventilated Patients: a Quasi-Experimental Study

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Background: Endotracheal tube cuff pressure must be kept in an optimal range, but it might change during some nursing procedures. If the cuff pressure gets outside the normal range, it can cause mucosal damage, insufficient ventilation, and microaspiration. This study aimed to determine the effect of endotracheal suctioning on cuff pressure in patients during mechanical ventilation.

Materials and Methods: This is a quasi-experimental study utilizing repeated measures with a within-subject design. Using a simple convenience sampling method, 61 patients were studied during intubation on mechanical ventilation. Baseline cuff pressure was adjusted to 25 cm H₂O. Then, at 15, 30, and 60 minutes' intervals, cuff pressures were measured once without suctioning and again after suctioning.

Results: The results showed a significant change in the mean endotracheal tube cuff pressure during suctioning ($p < 0.001$, $d = 7.47$). During suctioning, cuff pressure exceeded the normal range in 64% of the patients. After suctioning, although endotracheal tube cuff pressure decreased in both conditions, it decreased more significantly ($F(2.17, 260.55) = 238.19$, $p < 0.001$, $\eta = 0.665$, $d = 1.37$) in the suctioning condition.

Conclusion: The results suggest that endotracheal tube cuff pressure increases suddenly and briefly during suctioning, but within 60 minutes after suctioning, it becomes more reduced in suctioning conditions than without suctioning. Therefore, patients are at risk of mucosal damage and microaspiration after and during suctioning, respectively. It is suggested that nurses use continuous cuff pressure regulation methods to prevent potential risks.

Key words: Cuff Pressure; Endotracheal Suction; Intubation; Intensive Care Units

INTRODUCTION

The most commonly used artificial airway for respiratory support is endotracheal intubation (1). However, in the absence of an appropriate endotracheal tube, cuff pressure complications such as aspiration, tracheal ischemia, stenosis, subglottic ulcer, hoarseness, nerve damage, and tracheal wall damage can compromise the care of the patient (2). Therefore, at pressures between

30 and 50 cm H₂O, there is a risk of tracheal damage (3) while a pressure of less than 20 cm H₂O increases the risk of ventilator-associated pneumonia (VAP) (4, 5). To prevent such complications, it is necessary to control the pressure on the tracheal mucous membrane by measuring the pressure in the balloon of the tube cuff (6). This pressure should be in a range that first ensures the delivery of the proper volume regulated in the mechanical

ventilation, second, prevents the aspiration of upper airway secretions and, third, prevents the impairment of perfusion of trachea tissue (2). The optimal cuff pressure, places within the range of 20-30 cmH₂O (2). However, maintaining it in this range is challenging (7-10). Therefore, although a low-pressure cuff is used for airway management, complications associated with cuff pressure are still present in the patient (11).

To prevent cuff complications, it is necessary to monitor cuff pressure in the target range (12). Mousavi et al. reported that despite the pressure adjustment of the cuff in the range of 20-30 cm H₂O and recording it every six hours, in 18% of cases, the pressure of the cuff was outside the normal range (13). Taslimi et al. reported this finding in 21.3% of cases (11). Other studies have reported changes in tube cuff pressure outside the normal range after initial adjustment (2, 14). Some of the reasons that have been reported in studies for these changes include not receiving sedative medications, coughing, and ventilator dyssynchrony (9), changing patient temperature (15), changing head position (16), and changing the size of the tracheal tube (6). However, other factors that may also affect cuff pressure need to be identified and studied. Among these factors, tracheal suctioning is one of the most common interventions in mechanically ventilated patients that may affect the tube cuff pressure (17). In this regard, Sole et al. have argued that suctioning may increase the cuff pressure instantly (10).

To the best of our knowledge, there are no studies that have specifically investigated the effect of suctioning on cuff pressure. Although the continuous and automatic control of cuff pressure is introduced as an ideal method (6, 8), our extensive experience in the intensive care unit shows that the use of a continuous cuff pressure regulator in the Current Intensive Care Units (ICUs) is not common.

With the increasing demand for global intensive care, and the essential role of nurses in ICUs for monitoring, regulating, and maintaining cuff pressure (18), it is necessary to assess cuff pressure changes due to various nursing interventions like suctioning. Therefore, this study

aimed to investigate the effect of endotracheal suctioning on tube cuff pressure in mechanically ventilated patients.

MATERIALS AND METHODS

This is a semi-experimental study with repeated measures utilizing a within-subject design. In a within-subject design, each participant serves as his/her own control. This study was registered at the Iranian Center for Clinical Trials (IRCT20110705006955N5). A convenience sampling method was used at two intensive care units of the Mazandaran University of Medical Sciences. The study comprised 61 patients, over 18 years old, who were admitted to the ICUs and required oral endotracheal intubation and mechanical ventilation. They needed to have an adequate sedation level (giving -4 or -5 scores using Richmond Agitation-Sedation Scale), be non-pregnant, have a central temperature of 35-37.5 °C, and have a BMI <30. Patients with a tracheostomy, high-frequency oscillatory ventilation, and prone position were excluded. According to a previous study (10) and a cuff pressure change of -0.2 cm H₂O (SD±1.0), a confidence level of 95%, and precision of 0.1, a sample size of 61 was calculated using G Power software.

The cuff pressure was measured and recorded by a VBM cuff pressure monitoring alternatively. All endotracheal tubes were made by the same company, with a high-volume, low-pressure cuff at the distal end, and a pilot cuff with a non-return valve. Data were collected by a researcher nurse between 8 a.m. and 8 p.m. in two phases. First, the cuff pressure was measured for each subject and adjusted to 25 cm H₂O. Then, at intervals of 15, 30, and 60 minutes, the pressure was measured again and recorded. This phase was considered the control condition. During this time, intensive interventions or position changes were not performed on patients and the manometer was not removed from the pilot of the cuff. If these interventions were necessary, the patient was excluded. If the subject required endotracheal suctioning but had no change in position, ventilator setting, Richmond Agitation-Sedation Scale (RASS), or body temperature, the cuff pressure was

measured again and recalibrated to 25 cm H₂O. Then, endotracheal suctioning was performed by an open-standard method. The cuff pressure was measured 15, 30, and 60 minutes after suctioning. This phase was considered the intervention condition. If the patients required intensive interventions, position changes, or

repeated and prolonged suctioning, they were excluded from the study. Two patients were excluded due to prolonged suctioning. Endotracheal suctioning was always performed by a trained researcher (ICU nurse). For controlling bias, all measured pressures were approved by the head nurse (Figure 1).

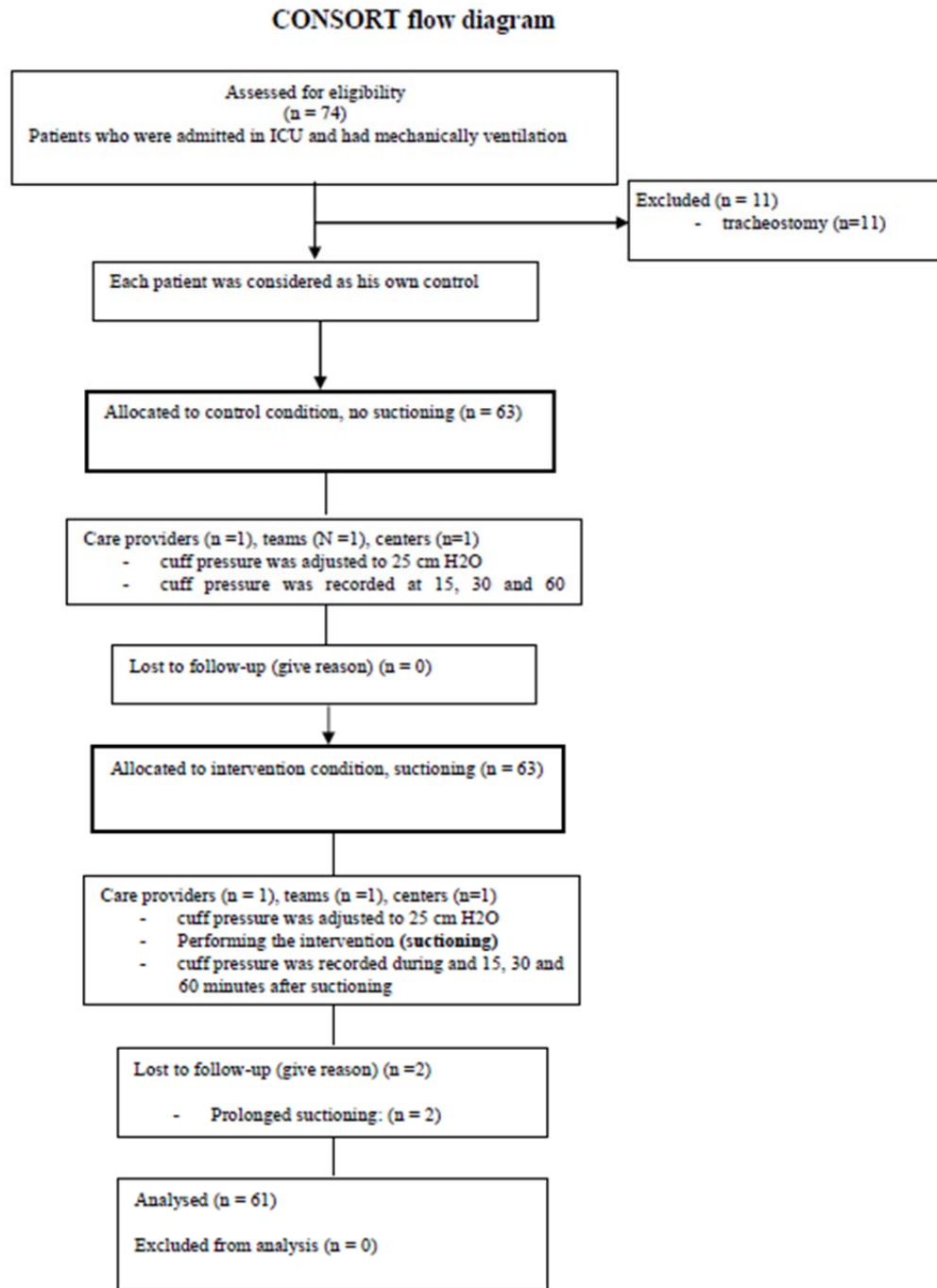


Figure 1. CONSORT flow diagram

The normal distribution of data was assessed using the Kolmogorov-Smirnov test. Data were analyzed by descriptive and analytical statistics. The Independent t-test and repeated measures ANOVA were used. Repeated measures ANOVA were used to test the study hypothesis of within-group differences at three time points. The assumption of sphericity was confirmed by Mauchly's test. If p values were less than 0.05, the Greenhouse-Geisser test was considered. Data analysis was done with MedCalc18 and GPower3.1 software.

Ethical consideration

This study was conducted as per the Helsinki Declaration (Association GAotWM, 2014) and approved by the Ethics Committee of Mazandaran University of Medical Sciences (IR.MAZUMS.REC.1396.2838 code). Informed consent for inclusion in the study was obtained from a family member of the patients. Additional instruments that could lead to an increase in a financial burden to the patient were not used and suctioning was performed only on patients who required the procedure.

RESULTS

The results showed that 86.9% of the subjects were men (n=53), with a mean age of 55.18 (±23.43) (95% CI: 49.17,

61.18) and mean BMI of 25.09 (±4.32) (95% CI: 25.09, 26.20). Besides, 68.9% (n=42) of the endotracheal tubes had an internal diameter (i.d.) of 9.0 mm, and 13 (21.3%) of them had a diameter of 7.5 mm (21.3%).

The results of the independent t-test and Levene's test of equality of variances showed significant changes in the mean cuff pressure during the suctioning condition compared to the non-suctioning condition (1-β =1.0, d=0.747, p<0.001). The repeated measures ANOVA test (Table 1) showed that the cuff pressure changed four times (during suctioning and at 15, 30, and 60 minutes). The findings indicated that cuff pressures decreased at the 60 minutes follow-up in both conditions, but this decrease was greater in the suctioning condition than in the control condition (1-β =1.0, d=1.37, η=0.665, p<0.001, F(2.17,260.55)). The trend of cuff pressure changes in the two conditions is shown in Figure 2.

Table 2 shows that the cuff pressure exceeded the normal range (25-30 cm H₂O) in 63.9% of the patients during suctioning while there was no recorded pressure increase in the control condition.

Table 1. Mean and standard deviation of tube cuff pressure in different measurement in control and intervention condition (n=61)

| Cuff pressure (mean±SD) | During | 15 min later | 30 min later | 1 hour later | Sig |
|----------------------------------|------------|--------------|--------------|--------------|---------|
| Suction (Intervention condition) | 31.29±2.78 | 22.52±1.52 | 22.01±1.54 | 21±1.69 | p<0.001 |
| Non-suction (Control condition) | 25±00 | 24.04±0.84 | 23.32±0.94 | 22.63±1.54 | |

Table 2. Frequency of patients according to tube cuff pressure in control and intervention condition (n=61)

| Group | Cuff pressure | Less than normal | Normal(safe) | More than normal |
|----------------------------------|---------------|------------------|----------------|------------------|
| | | <20 n (%) | 20-30 n (%) | >30 n (%) |
| Suction (intervention condition) | During | 0 | 22 (36.1) | 39(63.9) |
| | 15 | 6 (9.8) | 55 (90.2) | 0 |
| | 30 | 11 (18.0) | 50 (82.0) | 0 |
| | 60 | 25 (36.1) | 36 (36.1) | 0 |
| Non-suction (control condition) | During | 0 | 61 (100) | 0 |
| | 15 | 0 | 61 (100) | 0 |
| | 30 | 0 | 61 (100) | 0 |
| | 60 | 9 (14.8) | 52 (85.2) | 0 |

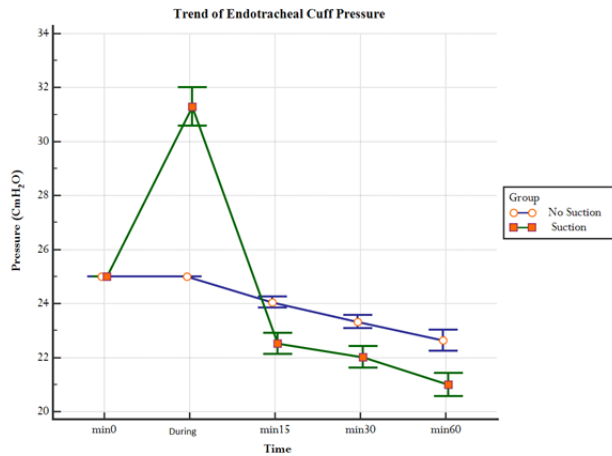


Figure 2. Trend of endotracheal cuff pressure in suctioning and no suctioning condition (n=61)

DISCUSSION

The first question of this study was “Can endotracheal suctioning cause a change in the tube cuff pressure?” The results of this study indicated that cuff pressure increased during suctioning. Additionally, in 64% (n=39) of the subjects, the cuff pressure exceeded 30 cm H₂O. Sole et al. conducted a pilot study to examine the continuous pressure of the tube cuff, its changes over time, and clinical factors affecting the pressure. They reported that endotracheal suctioning, coughing and position changes increased the cuff pressure of 14 to 20 cmH₂O above the initial pressure (10). Li Bassi et al. reported a greater increase in the cuff pressure of more than 50 cmH₂O during suctioning (19).

Our study showed that cuff pressure changes were transient and occurred over 5 minutes. The cause of this pressure increase during suctioning is unknown and requires further study; however, the stimulation caused during suctioning may lead the patient to react and induce airway spasm and thereby increase the cuff pressure. Therefore, we would advocate manual checking and adjustment of the cuff pressure after each episode of suctioning.

The second question of this study was “How the tube cuff pressure changes after suctioning?” The results of our

study suggest that the cuff pressure decreased after suctioning. As Sole et al. observed in their studies, the cuff pressure significantly reduced over time (2, 20). Beccaria et al. also studied seven stages of nursing interventions such as suctioning and showed cuff pressure reduced over time (21). However, the important finding of our study is that although the cuff pressure reduction process was observed over time in both case and control groups, this decreased pressure was more significant in the group that had endotracheal suctioning.

In a similar study, there were more cuff pressure changes over the period when more nursing procedures were performed (21). Rouzé and Nseir also found that reduced pressure was observed over time, especially during nursing procedures such as suctioning (22). This is probably due to air leakage over time, particularly during nursing interventions. Beuret et al. study confirmed that suctioning in intubated patients with a PEEP ≥ 5 and a cuff pressure of 30 cmH₂O causes an aspiration risk since the cuff seal was 76% before suction and 56% after suction (23).

It is recommended that the cuff pressure is measured at least twice in each shift (21, 24) until the cuff pressure is maintained within the target range (20-30 cm H₂O). This is associated with a reduced risk of microaspiration and ventilator-associated pneumonia (VAP) (22, 25). It should be noted that connecting the manometer to the cuff can lead to a temporary decrease in tube cuff pressure (21, 22, 26). In recent years, researchers have suggested that using continuous instead of alternating monitoring better controls cuff pressure changes during nursing procedures (24). We also suggest that continuous adjustment be used to reduce the complications of uncontrolled cuff pressure on the trachea.

Our study has limitations. First, the anatomical differences of patients' trachea were not considered. Second, we did not measure any other pressure although it might have been influenced by cuff pressure, for example, intra-abdominal pressure. The third limitation is that some patients had a reflex cough during suctioning and coughing could alter cuff pressures.

Implications and recommendations for practice

The cuff pressure may require to be changed during suctioning, if so the following is recommended. The first recommendation for ICU nurses is to use a continuous cuff pressure regulator. Continuous cuff pressure control not only reduces air leakage, the risk of microaspiration, and VAP but also can decrease the nurses' workload due to less time spent on adjusting cuff pressure. As the second recommendation, in the absence of access to a cuff pressure regulator, after nursing procedures, the cuff is re-regulated with the manometer and adjusted to the optimal range. The third recommendation is that researchers of future studies include patients with tracheostomy and closed suctioning in their studies. This is because a large number of patients on mechanical ventilation have a tracheostomy.

CONCLUSION

The results of this study indicated that endotracheal suctioning can cause a temporary increase in the endotracheal tube cuff pressure beyond the normal range. But at the 60 minutes follow-up, the group that was suctioned had a greater reduction in cuff pressure than the control group. It is recommended that nurses use continuous cuff pressure regulation methods to prevent potential risks.

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