Critical Care Nursing
Iran J Crit Care Nurs. 2014;6(3):102-109
Journal home page: www.inhc.ir

Is there a relationship between core body temperature and changes of endotracheal tube cuff pressure?

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ARTICLE INFO

Article type:
Original article

Article history:
Received: 6 May 2013
Revised: 5 May 2014
Accepted: 9 Jun 2014

Key word:
Endotracheal tube cuff pressure
Core body temperature
ICU
Nurse

ABSTRACT

Aims: Many factors such as positive pressure ventilation, lack of coordination between patients and ventilator, suction, patient's position and physiologic factors can influence endotracheal tube cuff pressure. The purpose of this study was to determine relationship between core body temperature and changes of endotracheal tube cuff pressure.
Methods: This correlational descriptive analytical study was done in 2012 in Intensive Care Unit (ICU) of Imam Reza hospital in Kermanshah. In this study, 259 intubated patients recruited with convenient sampling method. Endotracheal tube cuff pressure and core body temperature were measured twice in 6-hour intervals. Data analysis was performed by using SPSS-16 software, descriptive and analytic statistic including Wilcoxon test and Spearman correlation coefficients.
Results: In 65% of patients, cuff pressure was out of the standard range in its first measurement. At the second time, after correction of cuff pressure, it decreased to 20% of patients. There was significant difference between mean of core body temperature before and after correction ($p \leq 0.001$), but there was not statistically significant relationship between core body temperature and changes of endotracheal tube cuff pressure before and after the correction of cuff pressure.
Conclusions: Results showed that there is no relationship between core body temperature and changes of endotracheal tube cuff pressure. However, regular monitoring of cuff pressure and core body temperature of patients hospitalized in Intensive Care Unit (ICU) is recommended and further investigations are suggested.

Please cite this paper as:
Sharyfy A, Khatony AR, Rezaey M. Is there a relationship between core body temperature and changes of endotracheal tube cuff pressure? Iran J Crit Care Nurs. 2014;6(3):102-109.

1. Introduction

Using endotracheal tubes for opening and maintaining airway, different surgeries and using ventilator have been increased in recent years [1, 2]. It is estimated that only in The United States of America, thirteen to twenty

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times of this method is using annually. By using this method, airway is separated from the digestive way and respiratory support and positive pressure are possible in the airway [3].

Along with daily increase of using endotracheal tube, complications of this method is more clear and there is the possibility of irreversible complications, most of these complications are due to excessive pressure of endotracheal tube cuff [4,5]. Results achieved from the study of Sole et al. indicate that only in 54% of the patients cuff pressure is in normal range; Mousavi has also reported the same [6, 7].exerted pressure on the tracheal wall depends on the size of the endotracheal tube, tracheal diameter and cuff pressure and in this regard cuff pressure has the most important role in these complications [8].

Tracheal capillary blood flow has reverse relationship with the endotracheal tube cuff pressure and the normal pressure is about 32 mmHg. When the cuff pressure is over 40 cmH2o, tracheal mucosa is pale and in 50 cmH2o, tracheal mucosa is white and in 60 cmH2o, tracheal blood flow is stopped [9]. High endotracheal tube cuff pressure emerges some complications such asattrition, tracheal stenosis, dilatation of trachea, destruction of bronchial trachea, tracheal-esophagus fistula, Softening of trachea cartilaginous rings and laryngeal nerve paralysis [6].

In the study of Touat, it was clear that 83% of intubated patients suffer from tracheal ischemia because of high pressure of endotracheal tube cuff which can lead to tracheal rupture in the end [10]. From the other side, pressure less than 18 cmH2o leads to pulmonary aspiration, upper airway secretions and increased risk of suffering from pneumonia related to ventilator. For dealing with these complications, using cuffed endotracheal tubes with low pressure and high volume and maintaining cuff pressure in the range of twenty to thirty cmH2o are recommended [6,11]. Also endotracheal tube cuff pressure should be measured and recorded in appropriate time intervals and the least pressure with appropriate volume should be prepared [9].

Clinical evidences indicate that several factors such as patient's position in bed, suction, cuff, lack of patient-ventilator coordination, intubation time, mechanical ventilation with positive pressure and endotracheal genus can influence level of endotracheal tube cuff pressure [6,11,1213,14,15].

Also in some studies, the effect of physiologic factors such as body temperature and blood pressure on the level of endotracheal tube cuff pressure are mentioned as an interferer, but there is little information about the effect of these factors on the level of endotracheal tube cuff pressure [7, 16, 17, 18]. From the other side, body temperature is one of the most important parameters of vital signs in patients hospitalized in ICU [19]. Results of some studies in this regard indicate that lots of changes in body temperature along with anatomic changes which happen in cardiopulmonary bypass surgery can make change in endotracheal tube cuff pressure [20, 21]. In a math model which was provided by Atlas in laboratory conditions, the effect of gas emissions and temperature on the level of endotracheal tube cuff pressure was studied. Results indicated that remarkable increase in temperature of the injected gas into the endotracheal tube cuff leads to a slight increase of cuff pressure [18].

Considering complications due to inappropriate pressure of endotracheal tube cuff, maintaining cuff pressure in the safe zone during patient's hospitalization in ICU is very important. Considering this important issue, researchers decided to assess the probable relationship between core body temperature and cuff pressure, in addition to measuring and controlling endotracheal tube cuff pressure in appropriate time intervals. The aim of this study was to determine relationship between changes of core body temperature and changes of endotracheal tube cuff pressure.

2. Methods

In this correlational descriptive analytical study which was done in March 2013 in ICU of Imam Reza hospital of Kermanshah, 259 hospitalized patients in ICU were assessed through convenient sampling. The size of the samples was achieved based on the study of Sole et al. [6] with 95% confidence and 0.5 accuracy. Inclusion criteria included: having oral endotracheal tube, attachment to ventilator, patient-ventilator coordination, and intubation time less than one week, lack of infection and history of recent trauma in external ear and healthy tympanic membrane. Otoscope was used for assessing health of tympanic membrane. The researcher entered the patients with these inclusion criteria into the study after achieving permission from the deputy of university technology and taking necessary permissions from the hospital authorities, with daily reference to ICU. The main confounding variable in this study was suction which could influence level of endotracheal tube cuff pressure, for controlling this confounding factor, suction was forbidden in all the patients half an hour before measuring endotracheal tube cuff pressure. If during the said time, the patient needed suction, he/she was excluded from the study.

Data collection tools included the following factors:

1. Data registration paper including demographic information (age, gender, the reason of hospitalization) and information related to endotracheal intubation (the reason of intubation, endotracheal tube cuff pressure, endotracheal tube size)
2. Mallinckyodt-Germany standard manometer made in Germany for measuring endotracheal tube cuff pressure
3. Gnius Tympanic thermometer device made in America for measuring core body temperature

Considering that measuring tools of endotracheal tube cuff pressure and core body temperature are able to be calibrated, they are calibrated before every measuring and for being certain about reliability of the measurement tools; endotracheal tube cuff pressure and core body temperature were measured for three times in 5-minutes time interval in five patients with the same conditions and Chronabch's alpha coefficient was achieved 0.88. For measuring reliability between the measurement tools, core body temperature of thirty patients was measured by two people during a preliminary study. The mean of core body temperature for the first person and for the second person was respectively 37.6±3 and 37.6±0.2. Considering normal distribution of temperature, Pearson correlation coefficient was used for determining correlation of the two measurements that 0.895 was achieved. Also intraclass correlation coefficient was calculated 0.877.

The using manometer in this study was also standard and its accuracy was 0.5 cmH2o . Also genius tympanic thermometer has the 0.1^{o}C accuracy. For doing the study, patients were in the supine position while the head of the bed was in the angle of 30 to 45 degrees. Half an hour after changing patient's position, endotracheal tube cuff pressure was measured by using manometer. While in the first time of measurement, cuff pressure was not in an appropriate zone (between twenty to thirty cmH2o) in compare with its correction in the said range, some actions were done to not hear leakage sound from around of the tube. Then temperature of the right and the left ear were measured one time (for reducing measurement error) by using tympanic thermometer and their mean was recorded as core body temperature. After six hours of the firs measurement, again endotracheal tube cuff pressure and core body temperature were measured and recorded like the above method.

In the main study for increasing study accuracy, all the measurements were done by the researcher. Data after collection were entered into SPSS-16 software and were analyzed by using analytic-descriptive statistic. Spearman correlation coefficient was used to determine relationship between the level of core body temperature changes and endotracheal tube cuff pressure changes and Wilcoxon test was used for comparing the mean of the level of endotracheal tube cuff pressure and core body temperature before and after cuff pressure correction. Significant level of this study was less than 0.05.

3. Results

In this study 60% of the patients were male. The mean and standard deviation of the patients' age was 60.35±9.25. 42% of the patients were in the age range of 57 to 66 years old and they had the most frequency. Brain problems were the cause of intubation of 58% of the patients (table 1).

In the first time of measuring endotracheal tube cuff pressure, cuff pressure in 65% of the patients was out of the standard range which was corrected by the researcher. In the second time of measuring, this level was decreased to 20% (table 2). Mean and standard deviation of endotracheal tube cuff pressure and core body temperature in the first time of measuring was respectively 35.33±6.58 cmH_2O and 37.6±0.4^{o}C.

After correcting cuff pressure, in the second

Table 1: Distribution of the patients hospitalized in ICU based on the cause of intubation.

Cause of intubation	frequency	
	number	percent
Lung problems (pneumonia, pulmonary embolism, COPD, asthma, etc.)	57	22
Brain problems (CVA, tumor, trauma, seizures, etc.)	150	58
Other (malignancies, heart problems, kidney problems, etc.)	52	20
total	259	100

Table 2: The level of endotracheal tube pressure before and after correcting cuff pressure in patients hospitalized in ICU.

The level of endotracheal cuff pressure (based on water centimeter)	First time of measurement		Second time of measurement	
	number	percent	number	percent
Less than the standard level (less than 19)	3	1	0	0
In the standard range (20 to 30)	90	35	208	80
More than standard level (more than 31)	166	64	51	20

Table 3: Comparing the mean of endotracheal tube cuff pressure and core body temperature before and after correcting cuff pressure in patients hospitalized in ICU.

Variable	Before correcting cuff pressure	After correcting cuff pressure	Results of Wilcoxon test
	Mean (standard deviation)	Mean (standard deviation)	
Endotracheal tube cuff pressure	35.33(6.58)	28.88(2.83)	p≤0.001
Core body temperature	37.6(0.4)	37.5(0.5)	p≤0.001

time of measurement, the mean of endotracheal tube cuff pressure and core body temperature were respectively 28.88±2.83 cmH_2O and 37.5±0.5°C. Wilcoxon statistical test showed significant difference between the mean of endotracheal tube cuff pressure and before and after correcting cuff pressure (p≤001). Also by using this test, there was a significant statistical difference between mean of the level of core body temperature and before and after cuff pressure correction (p≤001) which was not significant clinically (table 3). Spearman correlation test showed negative and very weak correlation between changes of core body temperature and endotracheal tube cuff pressure changes after cuff pressure correction, which was not significant statistically (r=-0.038).

4. Discussion

The aim of this study was determining relationship between core body temperature and changes of endotracheal tube cuff pressure. Endotracheal tube cuff pressure in the first time of measurement was higher than the standard range in most of the patients. Also in the study of Mousavi et al., endotracheal tube cuff pressure in 49% of the patients was out of the normal range [7]. In this regard, results of the studies of Vas and Braz indicate that in 55% to 62% of the patients hospitalized in ICU, endotracheal tube cuff pressure is higher than the standard level [4, 22] which is in consistent with findings of our study. Sole et al. by permanent monitoring of the pressure of the endotracheal tube cuff found out that several factors such as patient's positioning on bed, endotracheal tube suction, lack of patient-ventilator coordination and cough can cause change in the level of cuff pressure [6].

Inada et al. also in assessing changes of endotracheal tube cuff pressure during cardiopulmonary bypass surgery found out that extreme changes in temperature along with anatomic changes which happen during cardiopulmonary bypass surgery make change in endotracheal tube cuff pressure [20]. It seems that in the current study, the cause of high endotracheal tube cuff pressure in the first time of measurement was lack of sufficient accuracy in filling endotracheal tube cuff at the time of intubation and lack of measuring that in appropriate time intervals.

In the present study, there was significant difference between the mean of the level of endotracheal tube cuff pressure in the stage before and after correction of cuff pressure (p≤0.001). in the first time of measuring cuff pressure , 65% of the patients had abnormal pressure that some actions were done to correct it; in the second time of measurement, 20% of the patients had pressure higher than the standard level; in a study by Mousavi et al., endotracheal tube cuff pressure was measured in two different times with six-hour time interval. Results showed that endotracheal tube cuff pressure in 49% of the patients was out of the standard range in the first stage that after correcting it, this level in the second time of measurement was reached to 18.5%. In justifying the cause of change in endotracheal tube cuff pressure in the second stage of measurement, they stated that some factors such as underlying diseases, choosing incorrect size of the tube and patient's core body temperature may play important roles [7]. Hanania & Zimmerman also state that one of the factors influencing volume and pressure in the endotracheal cuff tube is core body temperature [17].

There was negative and very weak correlation between the level of change in endotracheal tube cuff pressure, before and after correcting cuff pressure and changes of core body temperature which was not statistically significant. Results of some studies indicate that extreme change in core body temperature along with anatomic changes which happen during cardiopulmonary bypass surgery can cause change in endotracheal tube cuff pressure [20, 21]; Atlas suggested a math model for assessing the effect of temperature and gases emissions on endotracheal tube cuff pressure.

He used air temperature the same as the room temperature (20°C) for filling endotracheal tube cuff and after injecting into the cuff increased temperature of that gas to the body temperature (37 °C).

He reported that there is a direct relationship between gas temperature and cuff pressure, remarkable increase of gas temperature (more than 10 °C) leads to little increase of endotracheal tube cuff pressure; it should be mentioned that the said results are related to laboratory conditions and are not achieved at the patient's bedside [18]. In addition to that, results of the study of Souza et al. which are done on two groups with 22 patients under cardiac bypass surgery with normal temperature (normotermic) and less than the normal extent (hypothermic) showed that endotracheal tube pressure in the patients with normal temperature is more than hypothermic patients ($p \leq 0.05$) [21].

In a study which was done by Saleh Moghadam et al. in 2013, a positive correlation was found between the level of temperature and changes of endotracheal tube cuff pressure. They state that the level of endotracheal tube cuff pressure in 10 different times of measurement had downward trend and the reason is that in the first time of measuring temperature, the patient had high fever and consequently high cuff pressure, but considering the done actions for decreasing fever, temperature was decreased in the next times of measurement and also endotracheal tube cuff pressure was decreased too [23].

Nonetheless, there was no relationship between changes of endotracheal tube cuff pressure and changes of core body temperature in our study. In explaining the cause of contradiction between our study and the mentioned studies, it can be pointed out to extreme changes of core body temperature and also anatomic changes which happen during cardiopulmonary bypass. During cardiopulmonary bypass surgery, Media Sternotomy is done and all around tracheal wall pressure will be decreased by that which can cause decrease of endotracheal tube cuff pressure. From the other side, extreme changes of temperature (more than 10 °C) which happen during coronary artery bypass surgery cause low blood pressure of mean arterial and endotracheal capillaries will be decreased which decrease contact pressure of tracheal mucosa and also decrease of endotracheal tube pressure and the studies themselves confirm it too [20-25].

Also in our study, there was significant statistical difference between the means of core body temperature in two different times of measurement which is not very important clinically because only 0.1 °C difference has been seen between the means of two different times of measuring core body temperature. In the study of Saleh Moghadam [23] the difference of temperature in ten times of measurement is not mentioned and may be temperature changes range in his study is more than the present study which can cause contradiction between findings of these two studies.

In addition to core body temperature, there are some other factors which can influence endotracheal tube cuff pressure , among them, it can be pointed out to compliance of endotracheal tube different cuffs pressure which are made by factories and different substances; this factors is a limitation of our study which can influence the achieved results. It is recommended to do more studies in this regard for accurate evaluation of the relationship between endotracheal tube cuff pressure and core body temperature and also other effective factors.

5. Conclusions

In most of the patients, endotracheal tube cuff pressure in the first time of measurement was more than the standard level and after correction of endotracheal cuff pressure in the second time of measurement, one-fifth of the patients had abnormal cuff pressure. There was no significant statistical difference between changes of core body temperature and changes of endotracheal tube cuff pressure. It is recommended to monitor endotracheal tube cuff pressure and also core body temperature of the patients hospitalized in ICU at regular intervals.

6. Acknowledgments

This article is the result of a research project approved by the Student Research Committee of Kermanshah University of Medical Sciences. Researchers thank and appreciate all the honorable staff of ICU of Imam Reza hospital in Kermanshah.

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