ORIGINAL ARTICLE

Relationship of Endotracheal Tube Cuff Pressures with Changes in Body Positions of Critically Ill Patients on Mechanical Ventilation: An Observational Study

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Abstract

Aims and background: Endotracheal tube cuff pressure (ETCP) is an important factor to determine the development of complications associated with invasive mechanical ventilation. To avoid preventable complications arising out of immobilization, frequent changes in body positioning are necessary. Such variations in body position can affect ETCP in critically ill patients who are on mechanical ventilation. So, our study aimed to assess the effect of changes in body position on ETCP in patients who are on mechanical ventilation.

Materials and methods: This prospective observational study included 31 critically ill intubated patients. Each study subject was first placed in a neutral starting position with a 30º head elevation. Then, they were subjected to a sequential change in body position based on the 16 most used positions as part of the critical care unit's (CCUs) daily routine. Endotracheal tube cuff pressure was measured after each position change. Data were analyzed using standard statistical tests.

Results: Statistically significant difference in ETCP was observed during anteflexion of neck, hyperextension of neck, left lateral flexion of neck, right lateral flexion of neck, left lateral rotation of neck, right lateral rotation of neck, 10° recumbent position, supine position, Trendelenburg position, and right lateral 30° and 45° positions. Maximum increase in ETCP was seen during anteflexion of neck (31 ± 4.5; 22–42 cm H_2O).

Conclusion: Our study demonstrates significant deviations in ETCP from the recommended range following changes in the body position of mechanically ventilated patients, highlighting the need for the measurement of ETCP after each position change and maintenance of the same within the target range.

Keywords: Body position change, Critically ill patient, Endotracheal tube cuff pressure, Mechanical ventilation, Tracheal perfusion.

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Highlights

- Variations in body position can affect endotracheal tube cuff pressure (ETCP) in critically ill patients who are on invasive mechanical ventilation.
- We observed significant deviations in ETCP from the recommended range.
- Endotracheal tube cuff pressure should be measured after each position change and should be maintained within the target range.

Introduction

Although mechanical ventilation provides supportive care in patients suffering from respiratory failure, it has the potential to cause serious complications.[1,2] Endotracheal tube cuff pressure is an important factor determining the development of complications associated with invasive mechanical ventilation. So, routine ETCP measurement is recommended to maintain the perfusion of trachea, while ensuring adequate ventilation. Several guidelines recommend the maintenance of ETCP within the range of 20–30 cm H_2O.[3] This is ideal as the value is high enough to prevent aspiration, while being sufficiently low, thus, ensuring tracheal capillary perfusion.[4,5] Hence, accurate and regular cuff pressure monitoring remains crucial in endotracheal tube (ETT) management, though frequently overlooked.

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Factors leading to increased ETCP include positive pressure ventilation, N_2O, high altitudes such as during helicopter transport, laryngospasm, bronchoconstriction, and edema.[6] The excess ETCP is transmitted to the tracheal wall, resulting in tracheal hypoperfusion which causes tracheal ischemia, ulceration, stenosis, and may even lead to fistula formation.[6,7] Increased ETCP may also cause other complications, such as sore throat, hoarseness, dry cough etc.[6,8] It is estimated that exposures to ETCP higher than 30 cm H_2O for even short periods of time can cause significant tracheal lesions.[6] ETCP below optimal levels may also result in adverse course, due to increased risk of accidental extubation and inadequate ventilation as well as microaspiration of secretions, leading to ventilator-associated pneumonia.[3,7] Low ETCP may occur secondary to sedation, administration of neuromuscular blockers, low core temperature, and body positioning.[9] Despite these commonly understood, aforementioned risks, cuff pressure monitoring remains the most neglected component of critical care. The frequency of ETCP measurement and adjustment varies from zero to every 8 hours.[10,11]

To avoid preventable complications arising out of immobilization, such as deep vein thrombosis, pulmonary embolism, and bed sores, frequent changes in the body positions of the patients are necessary in critical care practice. Positioning critically ill patients allows better visibility and accessibility during treatment and diagnostic procedures, in addition to promoting comfort, preventing injuries and bed sores, stimulating circulation, and improving gastrointestinal and respiratory functions.[6] Such variations in body position can affect ETCP in critically ill patients who are on mechanical ventilation, which must be maintained at optimal levels to ensure adequate tracheal perfusion and prevent ventilator-associated pneumonia. However, it is challenging to maintain ETCP within the specific recommended range due to various patient-related causes, treatment-related factors and sometimes equipment malfunctions.[7–9]

Since changes in body position is a regular nursing practice in any critical care setup, the potential effect of such movements on ETCP should be addressed. However, adequate knowledge regarding the extent of ETCP deviations from the target range produced by different body positions remains lacking. Therefore, our research work seeks to study and measure the effect of body position changes on ETCP in patients who are on invasive mechanical ventilation.

Materials and Methods

This cross-sectional observational analytical study was done in the critical care unit (CCU) of our institution from April 2017 to September 2018 after getting institutional ethical committee clearance. The study included a total of 31 critically ill intubated patients, aged more than 18 years, who were on invasive mechanical ventilation with optimum sedation (Richmond Agitation-Sedation Scale score of –5)[12] and analgesia (behavior pain scale score of 3–4).[13] Written informed consent was taken from the surrogate decision makers (e.g., near relatives) of all the study participants. The sample size was calculated based on the difference in ETCP between the neutral position and any deviation from the same. It was estimated that at least 31 measurements were necessary for a particular position to detect a difference of 5 cm H_2O cuff pressure between two positions with 80% power and a 5% probability of type I error.[14]

Factors which influence ETCP or compromise the safety of patients, such as pregnant patients, patients requiring palliative care, patients in whom endotracheal intubation was difficult, with decreased neck mobility, patients with history of neck surgery, core temperature <35ºC or >37.5ºC, morbid obesity (BMI >35 kg/m^2), unstable spinal cord injury and presence of other contraindications to changing body position and hemodynamic and respiratory instability were identified. Patients with the aforementioned factors were excluded.

Each participant in our study was subjected to detailed history taking, clinical evaluation, and all investigations were reviewed. To study the effect of different body positions on ETCP, every patient was first placed in a neutral position along with a 30º head of the bed elevation.

Using a protractor, the elevation of the bed was measured. The suctioning system of the ETT was disconnected after establishing a neutral starting position to avoid any effect of suctioning on the ETCP. Neuromuscular blockade was achieved with intravenous Atracurium (0.5 mg/kg) so that patients do not breath against the ventilator, which can cause an increase in ETCP during the study intervention.

A calibrated universal ETCP monitor was used to measure the ETCP by attaching it to the pilot balloon of the ETT. In our study, we have used a pressure monitor of PORTEX, Smiths Medical International Ltd., which could measure the pressures ranging from 0 to 120 cm H_2O with an accuracy of ± 2 cm H_2O. Before each observation, zero error was corrected. The ETCP was set at 25 cm H_2O, at the neutral starting position with end-expiratory hold.[8] The pressure monitor was continuously attached to the pilot balloon of the ETT during the entire procedure to avoid air loss due to reconnections.

Every patient under study was subjected to a sequential change in body positioning based on positions most commonly used as part of the daily CCU routine. Sixteen different body positions from the neutral starting position in order were: anteflexion of the head → hyperextension of the head → left lateral flexion of the head → right lateral flexion of the head → rotation of the head to the left → rotation of the head to the right → semi-recumbent position with 45° elevation of the head of the bed → recumbent position with 10° elevation of the head of the bed → horizontal backrest (i.e., supine position) → trendelenburg position 10° → left lateral position 30° → left lateral position 45° → left lateral position 90° → right lateral position 30° → right lateral position 45° → right lateral position 90°.

For lateral positioning at different angles, foam blocks with slopes of 30°, 45°, and 90° were used. Achieving a specific position often required a series of previous positionings, and so, patients were not returned to the initial position after each measurement. This also considerably decreased the duration of the entire procedure. For example, a patient had to sequentially be subjected to the following changes: recumbent position with head of bed elevation of 10°→ supine position → lateral position 30° → lateral position 45°, for achieving a 90° lateral position starting from a semi-recumbent position.

Measures were taken to avoid traction on the ETT in every position and during position changes. After achieving a target position of the study subject, ETCP was recorded during an end-expiratory hold of 4–5 seconds.

The procedure required at least four healthcare workers, that is, an intensivist for providing sedation, neuromuscular blockade, and end-expiratory ventilator holds, two nurses to place the patient in predetermined target positions, and one researcher (C.L.) to monitor the ETCP and the factors which can affect the measurements (e.g., traction on the ETT).

Statistical Analysis

Data were analyzed with the help of SPSS for Windows version 23.0. The sampling strategy for the study was to randomly select three patients per week based on CCU bed number using a random number table. Each patient served as their own control, countering the issue of non-equivalence between experimental and control groups. Numerical variables with normal distribution were expressed as mean and standard deviation, whereas categorical variables were summarized as count and percentage. ETCP at a neutral position and at any defined position were assessed for statistically significant differences by one sample *t*-test. Variability in cuff pressures among patients across 16 positions was evaluated using Friedman's test. A statistically significant result was regarded to have a p-value < 0.05.

Results

Endotracheal tube cuff pressure of 31 patients was measured in 16 different positions, resulting in a total of 496 observations (31 × 16 = 496). Out of 496 measurements of ETCP, 4 (0.8%) were lower than 20 cm H_2O, 54 (10.88%) were higher than 30 cm H_2O, and 438 (88.30%) were between 20–30 cm H_2O.

Table 1 depicts the measured ETCP values in total 496 observations (31 × 16). There was statistically significant difference in ETCP during anteflexion of neck, hyperextension of neck, left lateral flexion of neck, right lateral flexion of neck, left lateral rotation of neck, right lateral rotation of neck, 10° recumbent position, supine position, Trendelenburg position, and right lateral 30° and 45° positions. The remaining positions showed statistically insignificant changes in ETCP from baseline. Maximum increase in ETCP was seen during anteflexion of neck (31 ± 4.5; 22–42 cm H_2O).

Figure 1 depicts the cuff pressure for each body position. The lower borders of the blue boxes depict the lower quartile, and the upper borders upper quartile.

Discussion

Though frequent changes in the body positions are necessary in critical care practice, studies regarding the effect of frequent changes in position as well as each position individually on ETCP are severely lacking.[15] Our study thus attempts to bridge this need gap.

Results of our study indicate that any change in body position has a significant effect on the ETCP of a patient on mechanical ventilation, with 11.69% of ETCP measurements failing to fall within the recommended range (0.8% falling below range and 10.88% overshooting the range). Our study also reported no relationship between ETCP and patient characteristics, that is, comorbidities, age, gender, and body mass index. Size of the ETT and are of fixation also did not have any effect on ETCP. It is noteworthy that due to high patient variability, we were unable to predict and identify patients with the potential to develop high cuff pressure in particular positions.

Athiraman et al. observed a considerable reduction in ETCP in patients who were in the supine and prone positions.[16] Minonishi et al. also found a relationship between ETCP and a change in position from supine to prone in patients who were undergoing spine surgery.[16,17] Kim et al. further observed that ETCP increases when patient is turned from supine to prone positions and with flexion of the head.[15] Kako et al., in a study conducted on pediatric subjects, also noted variation in ETCP with changes in body positions.[18] These observations were further reinforced by Inoue et al.[19] We observed statistically significant deviations in ETCP

Table 1: ETCP values after position change from the baseline (25 cm H_2O)

Patient position ETCP range	*ETCP range number (%)*	*Mean value of ETCP*	*p-value*
Ante flexion of the head			
<20	0 (0)	31.10 ± 4.52	0.000
20–30	11 (35.48)	Min: 22	
>30	20 (64.51)	Max: 42	
Hyper-extension of head			
<20	2 (6.45)	28.29 ± 4.69	0.000
20–30	21 (67.74)	Min: 18	
>30	8 (25.80)	Max: 39	
Left lateral flexion of head			
<20	0 (0)	26.74 ± 2.46	0.000
20–30	29 (93.54)	Min: 22	
>30	2 (6.45)	Max: 33	
Right lateral flexion of head			
<20	0 (0)	27.61 ± 3.61	0.000
20–30	24 (77.41)	Min: 21	
>30	7 (22.58)	Max: 39	
Left lateral rotation			
<20	0 (0)	26.87 ± 2.33	0.000
20–30	30 (96.77)	Min: 23	
>30	1 (3.22)	Max : 35	
Right lateral rotation			
<20	0 (0)	27.58 ± 2.98	0.000
20–30	26 (83.87)	Min: 21	
>30	5 (16.12)	Max: 34	
Semi-recumbent 45°			
<20	0 (0)	25.16 ± 2.08	0.669
20–30	30 (96.77)	Min: 21	
>30	1 (3.22)	Max: 32	
Recumbent with 10°			
<20	0 (0)	24.32 ± 1.64	0.029
20–30	31 (100)	Min: 20	
>30	0 (0)	Max: 28	
Supine			
<20	0 (0)	23.19 ± 1.77	0.000
20–30	31 (100)	Min: 20	
>30	0 (0)	Max: 27	
Trendelenburg position 10°			
<20	2 (6.45)	22.42 ± 2.09	0.000
20–30	29 (93.54)	Min: 18	
>30	0 (0)	Max: 26	
Left lateral 30°			
<20	0 (0)	1.83	0.250
20–30	31 (100)	Min: 22	
>30	0 (0)	Max: 29	

(Contd...)

Table 1: *(Contd...)*

Patient position ETCP range	*ETCP range number (%)*	*Mean value of ETCP*	*p-value*
Left lateral 45°			
<20	0 (0)	24.81 ± 1.55	0.495
20–30	31 (100)	Min: 22	
>30	0 (0)	Max: 28	
Left lateral 90°			
<20	0 (0)	24.52 ± 2.29	0.249
20–30	31 (100)	Min: 21	
>30	0 (0)	Max: 30	
Right lateral 30°			
<20	0 (0)	26.90 ± 2.41	0.000
20–30	29 (93.54)	Min: 22	
>30	2 (6.45)	Max: 33	
Right lateral 45°			
<20	0 (0)	28.03 ± 3.01	0.000
20–30	25 (80.64)	Min: 23	
>30	6 (19.35)	Max: 35	
Right lateral 90°			
<20	0 (0)	25.81 ± 2.82	0.122
20–30	29 (93.54)	Min: 20	
>30	2 (6.45)	Max: 32	

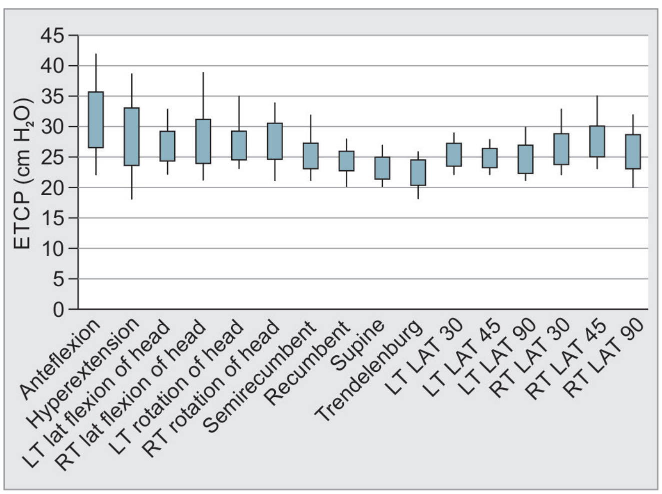

Fig. 1: Cuff pressure for each body position

from baseline in positions of anteflexion, hyperextension, left and right lateral flexion, and left and right lateral rotation of the neck. We also observed that movements of head and neck contributed to ETCP deviations probably due to displacement of the ETT in the trachea. This alteration can be explained by the knowledge of the anatomy of neck and an increase in intra-thoracic pressure due to the gravitational effect of position change.[15,17,20] Significant cuff pressure changes were also noted from neutral to 10° recumbent position, supination, Trendelenburg, and right lateral 30° and 45° positions. A study by Wu et al. observed an increase in ETCP following positioning the patients to a head-down position during laparoscopic surgeries.[20] Yildirim et al. demonstrated that pneumoperitoneum affected intra-thoracic pressure by moving the diaphragm upward, which in turn increased the inspiratory pressure and ETCP during laparoscopic surgeries.[21] Moreover, changes in head and neck positions moved the ETT, which affected ETCP.

Several risks are associated with deviation of cuff pressure from the target range, which is further exacerbated in critically ill patients with compromised circulation, obtunded laryngeal reflexes, and high secretion load. A study by Sole and colleagues claimed that it is difficult to maintain ETCP within a target range, thus, resulting in some deviations between intermittent measurements.[22] Fortunately, devices which can automatically adjust and maintain the ETCP within a target range, have been developed in recent times.[10] Such devices are more effective in maintaining ETCP compared with manually correcting ETCP intermittently.[23–25] Our data indicate that ETCP should be measured after every position change and continuous monitoring of ETCP with automatic adjustment to a pre-set pressure should be done.

There are some limitations in our study. It is important to note that there is loss of ETCP with time.[6] Sole et al. studied the changes in ETCP over 4, 8, and 12 hours and found that there is loss of ETCP over time.[22] Hence, the primary limitation of our study lies in the absence of monitoring of ETCP over a period to assess potential pressure variations. Additionally, due to the usage of ETTs with tapered cuff in our CCU setup, the influence of cuff shape on ETCP following changes in body position remains unclear. Clinical outcomes of individual subjects were not separately studied. Lastly, intra-abdominal pressure monitoring, although known to influence ETCP, was not done in our study.

Even though having limitations, the strength of our study is as follows: first, every patient serving as their own control counters the problem of non-equivalence between the experimental and control group. Secondly, factors that could influence the ETCP were eliminated. Finally, we assessed the effect of changes in body position over a broad range of positions that are frequently used in the daily nursing care of critically ill patients and we used the same brand of ETT and pressure manometer to avoid erroneous measurements and results.

Conclusion

Our study demonstrates significant deviations in ETCP from the recommended range following changes in body position of mechanically ventilated patients in the CCU, thereby, highlighting the need for the measurement of ETCP after each position change and maintenance of the same with target range.

Clinical Significance

Our study recommends the measurement of ETCP following every position change a patient undergoes and supports the usage of devices which continuously monitor the ETCP with automatic adaptation to pre-set pressure values.

We encourage further studies to evaluate the effects of different techniques to achieve a uniform ETCP, such as usage of continuous ETCP monitoring systems, and measure their long term outcomes.

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References

1. Yentür E. Mechanical ventilation. In: M. Bahar (Ed.) Anesthesiology, Intensive Care and Pain: Basic Concepts. 1st ed. Cerrahpaşa Medical Faculty Publications, Istanbul. 2007, 271–283.
2. Hess DR, MacIntyre, N.R. Mechanical ventilation. In: Hess DR, MacIntyre NR, Mishoe SC, Galvin WF, Adams AB (Eds.) Respiratory Care Principles and Practice. Canada: Jones & Bartlett Learning, 2012. pp. 462–500.
3. Sole ML, Su X, Talbert S, Penoyer DA, Kalita S, Jimenez E, et al. Evaluation of an intervention to maintain endotracheal tube cuff pressure within therapeutic range. Am J Crit Care 2011;20(2):109–117; quiz 118. DOI: 10.4037/ajcc2011661.
4. Lorente L, Blot S, Rello J. Evidence on measures for the prevention of ventilator-associated pneumonia. Eur Respir J 2007;30(6):1193–1207. DOI: 10.1183/09031936.00048507.
5. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med 2005;171(4):388–416. DOI: 10.1164/rccm.200405-644ST.
6. Sultan P, Carvalho B, Rose BO, Cregg R. Endotracheal tube cuff pressure monitoring: A review of the evidence. J Perioper Pract 2011;21(11):379–386. DOI: 10.1177/175045891102101103.
7. Rello J, Soñora R, Jubert P, Artigas A, Rué M, Vallés J. Pneumonia in intubated patients: role of respiratory airway care. Am J Respir Crit Care Med 1996;154(1):111–115. DOI: 10.1164/ajrccm.154.1.8680665.
8. Lizy C, Swinnen W, Labeau S, Poelaert J, Vogelaers D, Vandewoude K, et al. Cuff pressure of endotracheal tubes after changes in body position in critically ill patients treated with mechanical ventilation. Am J Crit Care 2014;23(1):e1–e8. DOI: 10.4037/ajcc2014489.
9. Jordan P, Van Rooyen D, Venter D. Endotracheal tube cuff pressure management in adult critical care units. S Afr J Crit Care 2012;28: 13–16. DOI: 10.7196/SAJCC.129.
10. Labeau S, Bleiman M, Rello J, Vandijck D, Claes B, Blot S. Intensive care nurses' knowledge and management of tracheal tube cuffs [abstract 0786]. Intensive Care Med 2009;35(suppl 1):S203. DOI: https://doi.org/10.1007/s00134-009-1601-6.
11. Hoffman RJ, Parwani V, Hahn IH. Experienced emergency medicine physicians cannot safely inflate or estimate endotracheal tube cuff pressure using standard techniques. Am J Emerg Med 2006;24(2): 139–143. DOI: 10.1016/j.ajem.2005.07.016
12. Ely EW, Truman B, Shintani A, Thomason JW, Wheeler AP, Gordon S, et al. Monitoring sedation status over time in ICU patients: reliability and validity of the Richmond agitation-sedation scale (RASS). JAMA 2003;289(22):2983–2991. DOI: 10.1001/jama.289.22.2983.
13. Alderson S, McKechnie SR. Unrecognised, undertreated, pain in ICU—Causes, effects, and how to do better. Open Journal of Nursing 2013;03:108–113. DOI: 10.4236/ojn.2013.31014.
14. Kim HJ, Jang J, Kim SY, Park WK, Kim HJ. Effects of head and neck position on nasotracheal tube intracuff pressure: a prospective observational study. J Clin Med 2021;10(17):3910. DOI: 10.3390/jcm10173910.
15. Kim D, Jeon B, Son JS, Lee JR, Ko S, Lim H. The changes of endotracheal tube cuff pressure by the position changes from supine to prone and the flexion and extension of head. Korean J Anesthesiol 2015;68(1): 27–31. DOI: 10.4097/kjae.2015.68.1.27.
16. Athiraman U, Gupta R, Singh G. Endotracheal cuff pressure changes with change in position in neurosurgical patients. Int J Crit Illn Inj Sci 2015;5(4):237–241. DOI: 10.4103/2229-5151.170841.
17. Minonishi T, Kinoshita H, Hirayama M, Kawahito S, Azma T, Hatakeyama N, et al. The supine-to-prone position change induces modification of endotracheal tube cuff pressure accompanied by tube displacement. J Clin Anesth 2013;25:28–31. DOI: 10.1016/j.jclinane.2012.05.007.
18. Kako H, Krishna SG, Ramesh AS, Merz MN, Elmaraghy C, Grischkan J, et al. The relationship between head and neck position and endotracheal tube intracuff pressure in the pediatric population. Paediatr Anaesth 2014;24(3):316–321. DOI: 10.1111/pan.12308.
19. Inoue S, Takauchi Y, Kuro M, Ninaga H. Effects of changes in head and neck position on a tracheal tube cuff. Masui 1998;47:1069–1072. PMID: 9785780.
20. Wu CY, Yeh YC, Wang MC, Lai CH, Fan SZ. Changes in endotracheal tube cuff pressure during laparoscopic surgery in head up or head down position. BMC Anesthesiol 2014;14:75. DOI: 10.1186/1471-2253-14-75.
21. Yildirim ZB, Uzunkoy A, Cigdem A, Ganidagli S, Ozgonul A. Changes in cuff pressure of endotracheal tube during laparoscopic and open abdominal surgery. Surg Endosc 2012;26(2):398–401. DOI: 10.1007/s00464-011-1886-8.
22. Sole ML. Changes in endotracheal cuff pressures over time. Critical Care Med 2002;30(12):A144.
23. Bhowmick R. Endotracheal tube cuff pressure monitor: a fancy gadget or necessary tool in intensivist's armamentarium. Indian J Crit Care Med 2021;25(2):121–122. DOI: 10.5005/jp-journals-10071-23742.
24. Mohammad H, Jain G, Agarwal A, Kausar S, Sama S. Application of endotracheal tube cuff pressure monitoring during percutaneous dilatational tracheostomy: A novel technique. Indian J Crit Care Med 2021;25(9):1040–1041. DOI: 10.5005/jp-journals-10071-23961.
25. Valencia M, Ferrer M, Farre R, Navajas D, Badia JR, Nicolas JM, et al. Automatic control of tracheal tube cuff pressure in ventilated patients in semirecumbent position: A randomized trial. Crit Care Med 2007;35(6):1543–1549. DOI: 10.1097/01.CCM.0000266686.95843.7D.