Development of Appropriate Procedures for Inflation of Endotracheal Tube Cuff in Intubated Patients

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Background: *Hyperinflation of endotracheal tube cuff causes tracheal mucosal damage and underinflation increases the risk of pneumonia. The current practice on inflation of endotracheal tube cuff in the intubated patients hospitalized at Siriraj Hospital uses the estimation method. The authors determined appropriateness of such current practice and developed an appropriate procedure for inflation of endotracheal tube cuff in intubated patients.*

Material and Method: *The endotracheal tube cuff pressures of 34 intubated patients in Siriraj Hospital were measured by manometer once daily. Inflation of the endotracheal tube cuffs of 20 patients was done and the volume of air required to optimize the intracuff pressure of 25 cmH_2O was recorded. The intracuff pressure was measured every one hour for eight consecutive hours in the patients who had initial intracuff pressure of 25 cmH_2O and 30 cmH_2O. The nurses in the experimental wards used a manometer as a guide to inflate endotracheal tube cuff until the intracuff pressure was 30 cmH_2O every eight hours, whereas the control wards used conventional procedures to inflate the endotracheal tube cuff. The endotracheal tube cuff pressures of the patients in both groups were measured twice daily.*

Results: *Only 34% of intracuff pressure measurements were 20-30 cmH_2O. The mean volume of inflated air required to achieve an intracuff pressure of 25 cmH_2O was 7.1 ml. An initial intracuff pressure of 30 cmH_2O decreased to 20 cmH_2O at 7 to 9 hours after inflation. The rate of optimum endotracheal tube cuff pressure was 90.5% in the group guided by manometer and 31.8% in the conventional procedure group ($p < 0.001$, RR 2.85, 95% CI 2.44-3.32).*

Conclusion: *Inflation of endotracheal tube cuff should be guided by manometer to achieve a pressure of 30 cmH_2O every eight hours.*

Keywords: *Endotracheal tube cuff pressure, Intubated patients*

J Med Assoc Thai 2007; 90 (Suppl 2): 74-8
Full text. e-Journal: *http://www.medassocthai.org/journal*

Many hospitalized patients need endotracheal intubation. An inflation of the endotracheal tube cuff is important to secure the tube in position in the trachea to prevent self-extubation. The effects of endotracheal tube cuff pressure are well documented. Hyperinflation of endotracheal tube cuff causes tracheal mucosal damage subsequent to restricted capillary blood flow[1-3] and underinflation of the cuff increases pulmonary aspiration risk leading to pneumonia[4]. Therefore, it is recommended that endotracheal tube cuff pressure should be within 20 to 30 cm H_2O[1, 5, 6]. Estimation of endotracheal tube cuff pressure by finger palpation of the external balloon is one of the methods currently used in the clinical setting. It was shown that an inflation of endotracheal tube cuff to achieve optimum pressure by experienced healthcare personnel or using finger palpation of the external balloon or inflating a particular air volume was not accurate, and the use of direct measurement of cuff pressure by manometer is recommended[1,7-11]. A survey of 64 acute care hospitals in the northeastern United States revealed that intracuff pressures were measured every

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8 to 12 hours or daily with a recommended maximum range of 20 to 30 cm H_2O[12]. The current practice on inflation of endotracheal tube cuff in the intubated patients hospitalized in general wards of Department of Medicine, Siriraj Hospital is estimating endotracheal tube cuff pressure by finger palpation of the external balloon or inflating 5 ml of air. The frequency of inflating endotracheal tube cuff varies from once daily to every other day or when the external balloon of the endotracheal tube cuff is soft. The objectives of the present study were to determine an appropriateness of such current practice and to develop appropriate procedure for inflation of endotracheal tube cuff in the intubated patients.

Material and Method

Determination of frequency of optimum endotracheal tube cuff pressure

Thirty-four hospitalized patients with indwelling endotracheal tubes in 10 general medical wards in Siriraj Hospital between August and October 2006 were included. The endotracheal tube cuff pressure of each patient was measured by manometer (VBM Medizintecnik GmbH) once daily until the endotracheal tube was removed. The data were analyzed by descriptive statistics.

Determination of the volume of air required to optimize the endotracheal tube cuff pressure

Inflation of the endotracheal cuff of 20 patients was done and the volume of air required to optimize the endotracheal tube cuff pressure to 25 cmH_2O was recorded and analyzed by descriptive statistics.

Determination of the kinetics of endotracheal tube cuff pressure

The cuffs of endotracheal tubes of three patients were inflated until the cuff pressure achieved 25 cmH_2O and the cuff pressure was measured every one hour for eight consecutive hours. The cuffs of the endotracheal tubes of another three patients were inflated until the cuff pressure achieved 30 cmH_2O and the cuff pressure was measured every one hour for eight consecutive hours.

Assessment of frequency of optimum endotracheal tube cuff pressure between the two procedures

This experiment was conducted in December 2006. The nurses in three general wards were instructed to use the manometer as a guide to inflate the endotracheal tube cuff until the intracuff pressure was 30 cmH_2O every eight hours (experimental wards). Another seven general wards used the conventional procedures to inflate the endotracheal tube cuff (control wards). The investigators measured the endotracheal tube cuff pressure of the intubated patients in all general medical wards twice daily until the endotracheal tubes were removed. The rates of optimum intracuff pressure between both groups of the general medical wards were compared by chi-square statistics.

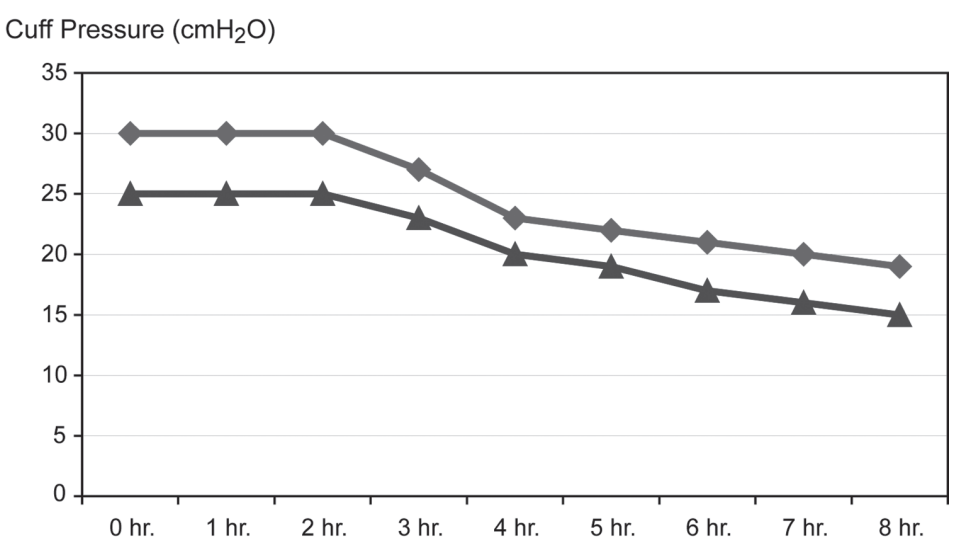

Fig. 1 Kinetics of endotracheal tube cuff pressure (cmH_2O) for 8 consecutive hours

Table 1. Comparison of frequency of optimum endotracheal tube cuff pressure between the two procedures

	3 Experimental Wards	7 Control Wards	
Number of Patients	20	39	
Number of Intracuff Pressure Measurements	200	387	
Number of Measurements with Intracuff Pressure 20-30 cmH_2O	181 (90.5%)	123 (31.8%)	$p < 0.001$ RR 2.85 (95%CI 2.44-3.32)
Number of Measurements with Intracuff Pressure > 30 cmH_2O	7 (3.5%)	83 (21.4%)	
Number of Measurements with Intracuff Pressure < 20 cmH_2O	12 (6%)	181 (46.8%)	
Range of Intracuff Pressure	10-34 cmH_2O	4-120 cmH_2O	

Results

Frequency of optimum endotracheal tube cuff pressure

The endotracheal tube cuff pressures of 34 patients (188 measurements) revealed that 33% of the measurements were between 20 and 30 cmH2O, 51.6% of the measurements were lower than 20 cmH_2O and 15.4% of the measurements were higher than 30 cmH_2O. The lowest intracuff pressure was 5 cmH_2O and the highest intracuff pressure was 55 cmH_2O.

The volume of air required to optimize the endotracheal tube cuff pressure

The mean volume of inflated air required to achieve an intracuff pressure of 25 cmH_2O was 7.1 ml, a standard deviation was 1.8 ml, the smallest air volume of 4.5 ml and the largest air volume was 12 ml. No association between the air volume required to achieve an intracuff pressure of 25 cmH_2O and the type of endotracheal tube, gender & age & body weight of the patients was observed.

Kinetics of endotracheal tube cuff pressure

The decrements of endotracheal tube cuff pressure over eight hours are shown in Fig. 1. An initial endotracheal tube cuff pressure of 25 cmH_2O decreased to 20 cmH_2O at 4 to 5 hours after inflation whereas an initial endotracheal tube cuff pressure of 30 cmH_2O decreased to 20 cmH_2O at 7 to 9 hours after inflation.

Frequency of optimum endotracheal tube cuff pressure between the two procedures

The endotracheal tube cuff pressures of the patients in the experimental wards and those in the control wards are shown in Table 1. The rate of optimum endotracheal tube cuff pressure was 90.5% in the group guided by the manometer and 31.8% in the conventional procedure group ($p < 0.001$, RR 2.85, 95% CI 2.44-3.32). The rates of low endotracheal tube cuff pressure and high endotracheal tube cuff pressure were also significantly higher in the conventional procedure group. The lowest endotracheal tube cuff pressure was 4 cmH_2O and the highest endotracheal tube cuff pressure was 120 cmH_2O in the conventional procedure group. Healthcare personnel who used the manometer as a guide for inflating the endotracheal tube cuff indicated that the procedure was quite simple and convenient, and it took only one minute to do so.

Discussion

The authors' observations confirmed the findings of the previous reports that an inflation of endotracheal tube cuff by experienced healthcare personnel or using finger palpation of the external balloon or inflating a particular air volume was insufficient to achieve optimum cuff pressure[1,7-11]. Most of the intubated patients whose endotracheal cuffs were inflated by the current procedures were at risk of tracheal mucosal ischemia due to hyperinflation and pneumonia due to underinflation of the endotracheal tube cuff. The authors also observed that it was not possible to recommend an inflation of endotracheal tube cuff with a particular air volume since there was no association between the air volume required to achieve an intracuff pressure of 25 cmH_2O and the type of endotracheal tube, gender & age & body weight of the patients. The mean volume of air required to optimize the endotracheal tube cuff pressure of 25 cmH_2O in the present study was 7.1 ml. The observed value was more than 4 ml in the previous report[5]. This might be due to a

difference in the type of endotracheal tube. The present study on kinetics of endotracheal tube cuff pressure revealed that endotracheal tube cuff pressure needed to be measured and refilled every eight hours and the recommendation on checking the endotracheal cuff pressure once daily[13] was not valid in the present settings. The authors also showed that using the manometer as a guide to inflate the endotracheal tube cuff until the intracuff pressure was 30 cmH_2O every eight hours led to a significantly higher rate of endotracheal tube cuff pressure within the recommended range of 20-30 cmH_2O. Healthcare personnel who used the manometer as a guide for injecting air into the cuff were satisfied with the procedure and it took only one minute to do this. Many patients who received conventional procedures for inflating endotracheal tube cuff were at an increased risk of tracheal mucosal ischemia and pneumonia due to hyperinflation or underinflation of the endotracheal cuff similar to the observations made earlier. Therefore, the current procedures for inflating the endotracheal tube cuff should be abandoned since some patients had very low intracuff pressure and some patients had extremely high intracuff pressure up to 120 cmH_2O. A limitation of the present study was the authors did not compare the ultimate outcomes of the patients who had optimum endotracheal tube cuff pressure with those who had intracuff pressures outside the recommended range.

Based on the aforementioned observations, the authors recommend that inflation of endotracheal tube cuff should be guided by the manometer to achieve an intracuff pressure of 30 cmH_2O every eight hours.

The aforementioned observations and recommendation were presented to Siriraj Hospital administrators in January 2007. The recommendation was adopted as a clinical practice policy for all medical wards and the hospital has provided a manometer for each medical ward since February 2007.

Acknowledgements

The authors wish to thank the Faculty of Medicine Siriraj Hospital and The Thailand Research Fund for supporting the present study.

References

1. Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. Br Med J (Clin Res Ed) 1984; 288: 965-8.
2. Curiel Garcia JA, Guerrero-Romero F, Rodriguez-Moran M. Cuff pressure in endotracheal intubation: should it be routinely measured?. Gac Med Mex 2001; 137: 179-82.
3. Nordin U. The trachea and cuff-induced tracheal injury. An experimental study on causative factors and prevention. Acta Otolaryngol Suppl 1977; 345: 1-71.
4. Rello J, Sonora R, Jubert P, Artigas A, Rue M, Valles J. Pneumonia in intubated patients: role of respiratory airway care. Am J Respir Crit Care Med 1996; 154: 111-5.
5. Sengupta P, Sessler DI, Maglinger P, Wells S, Vogt A, Durrani J, et al. Endotracheal tube cuff pressure in three hospitals, and the volume required to produce an appropriate cuff pressure. BMC Anesthesiol 2004; 4: 8.
6. Diaz E, Rodriguez AH, Rello J. Ventilator-associated pneumonia: issues related to the artificial airway. Respir Care 2005; 50: 900-6.
7. Fernandez R, Blanch L, Mancebo J, Bonsoms N, Artigas A. Endotracheal tube cuff pressure assessment: pitfalls of finger estimation and need for objective measurement. Crit Care Med 1990; 18: 1423-6.
8. Svenson JE, Lindsay MB, O'Connor JE. Endotracheal intracuff pressures in the ED and prehospital setting: is there a problem? Am J Emerg Med 2007; 25: 53-6.
9. Stewart SL, Secrest JA, Norwood BR, Zachary R. A comparison of endotracheal tube cuff pressures using estimation techniques and direct intracuff measurement. AANA J 2003; 71: 443-7.
10. Ganner C. The accurate measurement of endotracheal tube cuff pressures. Br J Nurs 2001; 10: 1127-34.
11. Braz JR, Navarro LH, Takata IH, Nascimento JP. Endotracheal tube cuff pressure: need for precise measurement. Sao Paulo Med J 1999; 117: 243-7.
12. Crimlisk JT, Horn MH, Wilson DJ, Marino B. Artificial airways: a survey of cuff management practices. Heart Lung 1996; 25: 225-35.
13. Sierra R, Benitez E, Leon C, Rello J. Prevention and diagnosis of ventilator-associated pneumonia: a survey on current practices in Southern Spanish ICUs. Chest 2005; 128: 1667-73.

การพัฒนาแนวทางการเติมลมใน cuff ของท่อช่วยหายใจในผู้ป่วยที่มีท่อช่วยหายใจ

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การเติมลมใน cuff ของท่อช่วยหายใจในผู้ป่วยที่มีท่อช่วยหายใจที่มากเกินไปจะกดเยื่อบุท่อลมจนขาดเลือด ส่วนการเติมลมที่น้อยเกินไปจะเกิดปอดอักเสบ วิธีปฏิบัติการเติมลมใน cuff ของท่อช่วยหายใจที่บุคลากรของโรงพยาบาลศิริราชปฏิบัติใช้วิธีคาดประมาณ วัตถุประสงค์ของการศึกษานี้เพื่อสร้างแนวทางการเติมลมใน cuff ของท่อช่วยหายใจในผู้ป่วยที่มีท่อช่วยหายใจ

วัสดุและวิธีการ : *สำรวจความดันใน cuff ของท่อช่วยหายใจในผู้ป่วย 34 คนที่รับไว้รักษาที่หอผู้ป่วยสามัญโดยวัดความดันใน cuff ของผู้ป่วยวันละครั้งด้วยเครื่องวัดความดัน, เติมลมใน cuff ของท่อช่วยหายใจในผู้ป่วย 20 คน จนได้ความดันใน cuff เป็น 25 ซม.น้ำแล้วบันทึกปริมาณลมที่ใช้, สังเกตการลดลงของความดันใน cuff ภายหลังเติมลมจนได้ความดัน 25 ซม.น้ำ และ 30 ซม.น้ำ, ฝึกพยาบาลใน 3 หอผู้ป่วยให้ใช้เครื่องวัดความดันเป็นแนวทางในการเติมลมใน cuff ให้เป็น 30 ซม.น้ำ ทุก 8 ชั่วโมง ส่วนอีก 7 หอผู้ป่วยใช้วิธีการเติมลมตามแนวทางที่เคยปฏิบัติอยู่เดิม แล้ววัดความดันใน cuff ด้วยเครื่องวัดความดันวันละ 2 ครั้ง*

ผลการศึกษา : *ร้อยละ 34 ของการวัดความดันใน cuff อยู่ในช่วง 20 ถึง 30 ซม.น้ำ, ค่าเฉลี่ยของปริมาณลมที่ทำให้ความดันใน cuff เป็น 25 ซม.น้ำ คือ 7.1 มล., การเติมลมให้ได้ความดันตั้งต้น 30 ซม.น้ำ สามารถคงความดัน $\geq$ 20 ซม.น้ำ ได้นาน 7-8 ชั่วโมง, ร้อยละ 90.5 ของการวัดความดันใน cuff ของผู้ป่วยในหอผู้ป่วยที่ใช้เครื่องวัดความดันมีความดันอยู่ในช่วง 20 ถึง 30 ซม.น้ำ ซึ่งมากกว่ากลุ่มที่เติมลมโดยการคาดประมาณ (ร้อยละ 31.8) อย่างมีนัยสำคัญ ($p<0.001$, RR 2.85, 95%CI 2.44-3.32)*

สรุป : *การเติมลมใน cuff ของท่อช่วยหายใจในผู้ป่วยที่มีท่อช่วยหายใจควรใช้เครื่องวัดความดันเป็นแนวทางโดยเติมลมจนได้ความดัน 30 ซม.น้ำ ทุก 8 ชั่วโมง*