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Endotracheal tube cuff pressure monitoring in intensive care units

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Abstract

Background: Improper inflation of endotracheal tube cuff is associated with various complications. Recently, there has been high referral of patients with post-intubation complications to the clinics affiliated to Shiraz University of Medical Sciences. Herein, we examined the practice of cuff pressure monitoring at 9 adult intensive care units in 3 university-affiliated hospitals.

Methods: The present study was performed on 57 tracheally intubated patients, whose cuff pressures were measured using either a cuff pressure gauge on 12 patients (Group 1) or manual palpation of the pilot balloon on 45 cases (Group 2) during summer 2004. The intracuff pressure (P_1), intracuff volume (V_1), and pressure exerted by the cuff against the tracheal mucosa (ΔP) were determined., analyzed and compared with the recommended values.

Results: The P_1 in Group 1 was 35.3 ±32.8 SD cmH_2O, with 33.3% of the patients having values below 20 cmH_2O. In group two, P_1 was 88.8±27.1 cmH_2O, all of which being above 40 cmH_2O. The ΔP for the Groups 1 and 2 were 16.3 ±11.1SD cm H_2O and 35.5 ±15.6 cm H_2O, respectively.

Conclusion: Our findings indicated that manual palpation of balloon cuff to monitor cuff pressure was not an accurate procedure. They also suggested that measures to increase the knowledge and skills of ICU staff and posting of cuff pressure monitoring protocols might help improve the practice.

Keywords: Intensive care unit; Endotracheal intubation; Monitor; Pressure

Introduction

Proper inflation of endotreacheal tube cuff during anesthesia or critical care setting is of vital importance in ensuring adequate ventilation, preventing the complications of intubation, and protecting against pulmonary aspiration of gastric content.[1] Over or under inflation of the cuff is associated with a number of grave complications. Overinflation have been reported to cause tracheal rupture,[2] tracheal stenosis,[3] tracheal mucosal erosion,[4] tracheal pain,[5] tracheomalacia,[6] tracheoesophageal fistula,[7] cartilage lesion,[3] sore throat,[8] recurrent laryngeal nerve palsy,[9] vocal cord granulomas and ulceration,[10] vocal cord paralysis,[11] vocal cord dysfunction,[12] laryngeal injury,[10] and hoarseness.[13] On the other hand, complications relating to under-inflation include leaks of the tidal volume,[14] post–extubation stridor,[15] laryngotracheal edema,[16] as well as microaspiration of oropharyngeal secretions.[14] A variety of methods have been advocated to avoid over- or under inflation of endotracheal tube cuff, namely frequent cuff pressure measurement by a cuff pressure gauge (CPG),[17,18] no leak test and manual palpation of the pilot balloon. However, frequent cuff pressure measurement by a CPG remains the most accurate procedure.[19,20] In recent years, we have encountered unacceptably high number of patients with post-intubation complications referring to university-affiliated thoracic surgery and Ear, Nose and Throat clinics. Considering the role of cuff inflation in the post-intubation complications, the objec-

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tive of the present study was to compare the methods of tracheal tube care in 3 teaching hospitals affiliated to Shiraz University of Medical Sciences.

Materials and Methods

The study was performed according to the guidelines of local ethics committee on clinical research..The study subjects were patients (n=57) requiring tracheal intubation hospitalized in 9 intensive care units (ICUs) during summer 2004 in Namazi, Faghihi and Chamran teaching hospitals affiliated to Shiraz University of Medical Sciences. Patients with unstable cardiopulmonary status, airway tumors, respiratory anatomical anomalies, and upper respiratory problems were excluded from the study. The patients were divided into two groups based on the method of monitoring of the intracuff pressure in the intensive care units. The first group (n=12) including 10 males and 2 female, were patients in whom the intracuff pressure was monitored by a CPG. The second group of patients (n=45), comprised 35 males and 10 females in whom the pressure was monitored by "no leak test" and manual palpation of the pilot balloon. The endotracheal tubes used were either SUPA (high volume-low pressure, SUPA Medical Devices) or Kendall (high resting cuff diameter, Tyco/healthcare, Sampran). The type and size of endotracheal tubes and duration of intubation were recorded for each patient. Complete suctioning of oropharyngeal secretions was then performed, and afterwards the patients' intracuff pressure (P_1) and intracuff volume (V_1) were measured by a CPG (VBM, Medizinteknik, Germany) and a 20 ml syringe, respectively. Having measured the intracuff volume, the aspirated air was immediately returned to the cuff. Subsequently, the *in vitro* compliance curves for the tracheal tube used were determined employing another tube with the same brand and size. To determine the curves, intra cuff volume was increased stepwise by one ml increments and the intra cuff pressure was measured by the same CPG (Figure 1). The pressure exerted by the cuffs on the tracheal mucosa (ΔP) was calculated using the following formula:[21]

$\Delta P = P1 - P2$

Where, P_2 is the intracuff pressure following *in vitro* inflation of the tube cuff by V1.

The data, presented as mean ± SD, were compared by unpaired student t or Mann-Whitney test using Statistical Package for Social Sciences (SPSS) version 11.5. A P value of ≤0.05 was considered statistically significant.

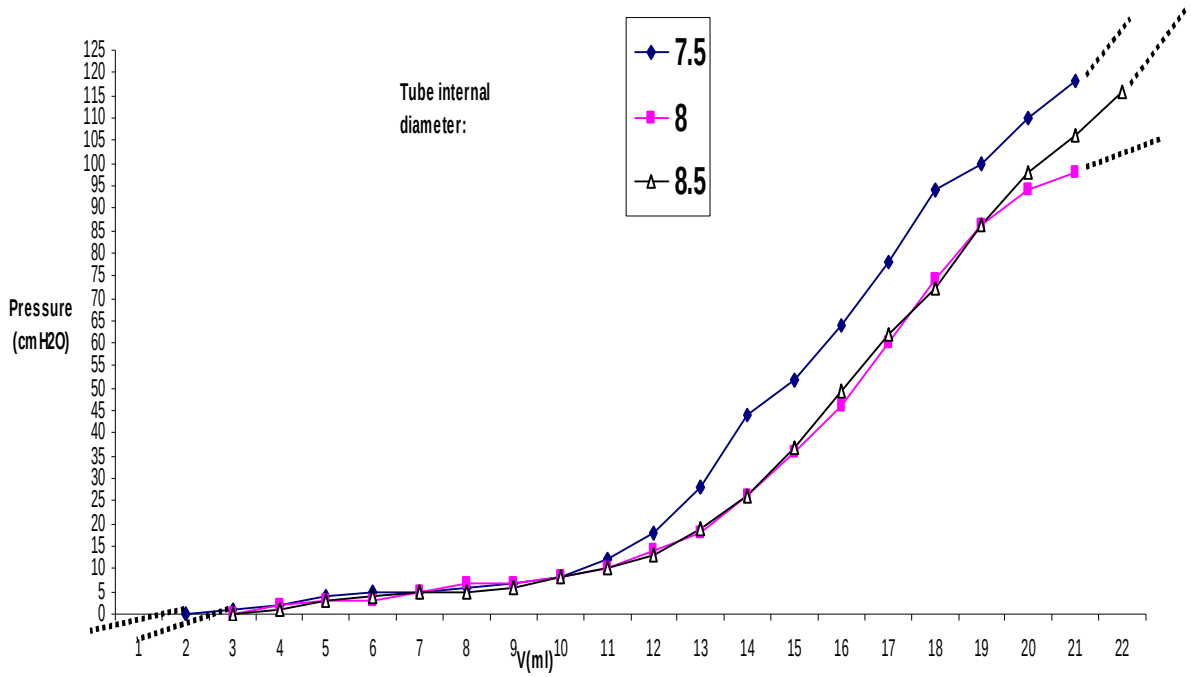

Fig 1: Cuff compliance curves in different sizes of Kendall endotracheal tubes.

Results

There was no significant difference in the duration of intubation between Group 1 in which the intracuff pressure was monitored by a CPG (4.0±2.8 days) and Group 2 whose cuff pressure were monitored by "no leak test" and manual palpation of the pilot balloon (4.1±5.1 days). However, the age of patients in Group 1 (36.5±17 years) was significantly lower than that of group 2 (53.5 ± 18.8 years). The intracuff pressures in Groups 1 and 2 were 35.3±32.8 cmH_2O and 88.8±27.1 cmH_2O, respectively with corresponding intracuff volumes of 9.1±3.7 ml and 15.5±4.1 ml. The calculated pressures exerted on tracheal mucosa (ΔP) for Group 1 (16.3±11.1 cmH_2O) was significantly lower than that of Group 2 (35.5±15.6 cmH_2O) (Tables 1 and 2).

Discussion

A number of procedures have been proposed for monitoring the appropriate tracheal cuff pressure, among which CPG is the highly recommended and most reliable method.[19,20] The pressure exerted by the cuff on the tracheal wall, seems to be the major factor responsible for the complications of cuff's overinflation.[22,23] Such a pressure, which is largely determined by the compliance of the tracheal tube cuff, is recommended to be less than that established by mucosal perfusion (30 cmH_2O).[24] Various methods have been employed for the measurement of pressure exerted by the cuff on the tracheal wall; however, no single method is entirely satisfactory.[25] The most accurate methods in cluded microchip transducers implanted between the cuff and tracheal mucosa[26,27] and estimation of the pressure using calculated cuff compliance. This study employed the latter method, which was reported to provide measurements comparable to those made by the former.[28] In the present study, the pressure exerted on the tracheal mucosa in patients in whom the intracuff pressure was monitored by palpation, was relatively higher than the recommended values. However, such a pressure was relatively lower in patients in whom the intracuff pressure was monitored by CPG. The values of intacuff pressure measured by CPG were not normally distributed, which led to a large standard deviation. This might equally be attributed to the small sample size or the inherent variability of the data. The involvement of either of these factors in bringing about large standard deviations needs further investigation. Our results are compatible with those of previous studies that demonstrated the inadequacy of manual palpation technique to estimate appropriate cuff pressures.[29,30] In the ICUs, where the present study was conducted, the cuff pressure was underestimated, because it was mainly monitored by palpation. This condition as well as higher pressure exerted on tracheal mucosa might account for the high incidence of patients referring to our clinics with overinfaltion and resultant tracheal stenosis, The acceptable minimum intracuff pressure is believed to be 20 cmH_2O.[31,32] However, there is no universal consensus about acceptable maximum values of intracuff pressure which according to previous studies it might range from 25 to 40 cmH_2O.[33-36] Patients whose

Table 1: The values of age, intubation time, intracuff volume (V_1), intra cuff pressure (P_1) and the pressure exerted on tracheal mucosa (ΔP) from group one and two. The comparisons were made using student t test.

Parameter	Group 1	Group 2	P value
Age(year)	36.5 ± 17	53.5 ± 18.8	0.007
Intubation time(day)	4 ± 2.8	4.1 ± 5.1	0.343
V_1 (ml)	9.1 ± 3.7	15.5 ± 4.1	.000
P_1(cmH_2O)	35.3 ± 32.8	88.8 ± 27.1	.000
ΔP(cmH_2O)	16.3 ± 11.1	35.5 ±15.6	.000

Table 2: The percent and number sex and brand of endotracheal tube in group 1 (G_1) and group 2 (G_2).

	Group 1	Group 2
Male	10 (83.3%)	35 (77.8%)
Female	2 (16.7%)	10 (22.2%)
Supa tube	11 (91.7%)	32 (71.1%)
Kendall tube	1 (8.3%)	13 (28.9%)

intracuff pressures were monitored by palpation technique had an intracuff pressure of more than 40 cmH_2O, whereas the corresponding value measured by CPG were lower than 20 cmH_2O.

Regardless of the problems associated with the palpation method to monitor intracuff pressure, the findings of present study might indicate the inadequate training and/or skill of nursing staff for ICUs at the hospitals studied. Moreover, lack of written posted protocols, which the staff could refer to refresh their awareness of the procedure, might have been important in the poor practices observed. The mean age of the patients in Group 1 was significantly lower than that in Group 2. This difference in age, although undesirable in a comparative study, can rarely influence the results, since no relationship existed between the patients' age and the size of proper endotracheal tube, cuff pressure seal or needed intracuff pressure in adults.

In conclusion, the results of present study showed that monitoring of cuff pressure by palpation was less efficient and should be superseded by more accurate methods such as CPG. The other issues that help reduce complications of tracheal intubation, include adequate training of nursing staff and their continuous professional practice through modification of nursing curriculum and posting the foregoing written protocols. The study; however, suffered from a drawback of unequal sample sizes assigned to the groups under study. Therefore, the findings of the must be interpreted in the light of such a limitation.

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References

1 Collins VJ. In Principles of Anesthesiology. 3rd ed. 1993, Lea and Febiger Philadelphia, PA.

2 Yam LY, Tai YP, Wong KS, Li MK. Tracheal rupture from incorrect positioning of endotracheal tube. *Ann Acad Med Singapore* 1992;**21:**823-6. [1295426]

3 Vukanovic S, Sidani AH, Ducommun JC, Suter P, Wettstein P. Tracheal and subglottic lesions following long–standing intubation. A radiological and clinical study. *Diagn Imaging* 1982;**51:**224-33. [7128397]

4 Loeser EA, Hobges M, Gliedman J, Stanley TH, Johansen RK, Yonetani D. Tracheal pathology following short–term intubations with low- and high-pressure endotracheal tube cuffs. *Anesth Analg* 1978;**57:**577-9. [568428]

5 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. [11381810]

6 Ravin CE, Handel DB, Kariman K. Persistent endotracheal tube cuff overdistension; a sign of tracheomalacia. *Am J Roentgenol* 1981; **137**:408-9. [6789655]

7 Stauffer J, Olsen D, Petty HT. Complications and consequences of endotracheal intubation and tracheostomy. *Am J Med* 1981;**70:**65-76. [7457492]

8 Lipp M, Brandt L, Daublander M, Peter R, Barz L. Frequency and severity of throat complaints following general anesthesia with the insertion of various endotracheal tubes. *Anaesthesist* 1988;**37:**758-66. [3064648]

9 Otani S, Fujii H, Kurasako N, Ishizu T, Tanaka T, KousogabeY, Tokioka H. Namba M. Recurrent nerve palsy after endotracheal intubation. *Masui* 1998;**47:**350-5. [9560550]

10 Kastanos N, Estopa Miro R, Marin Prez A, Xaubet Mir A, Agusti-Vidal A. Laryngotracheal injury due to endotracheal intubation: incidence, evolution, and predisposing factors. A prospective long-term study. *Critical Care Med* 1983;**11:**362-7. [6839788]

11 Cros AM, Esteben D, Verhulst J, Cazaugade J. Unilateral recurrent laryngeal nerve palsy following brief periods of intubation. Two cases. *Anesth Analg (Paris)* 1981;**38(5-6):**265-8. [7270943]

12 Shafei H, el-Kholy A, Azmy S, Ebrahim M, al-Ebrahim K. Vocal cord dysfunction after cardiac surgery: an overlooked complication. *Eur J Cardiothorac Surg* 1997;**11:**564-6. [9105825]

13 Inada T, Fujise K, Shingu K. Hoarseness after cardiac surgery. *J Cardiovasc Surg* 1998;**39:**466-9. [9788791]

Tobin MJ, Grenvik A. Nosocomial lung infection and its diagnosis. *Crit Care Med* 1984;**12:**191-9. [6697743]

14 Miller RL, Cole RP. Association between reduced cuff leak volume and postextubation stridor. *Chest* 1996;**110:**1035-40. [8874265]

15 De Bast Y, De Baker D, Moraine JJ, Lemaire M, Vandenborght C, Vincent JL. The cuff leak test to predict failure of tracheal extubation for laryngeal edema. *Intensive Care Med* 2002;**28:**1267-72. [12209275]

16 Braz JRC, Navarro LHC, Takata IH, Nascimento P Jr. Endotracheal tube cuff pressure: need for precise measurement. *Sao Paulo Med J* 1999;**117:**243-7. [10625887]

17 Ganner C. The accurate measurement of endotracheal tube cuff pressures. *Br J Nurs* 2001;**10:**1127-34. [11904572]

18 Spittle CSN, Beavis SE. Do you measure tracheal cuff pressure? A survey of clinical practice. *Br J Anaesth* 2001;**87:**344P-345P.

19 Vyas D, Inweregbu K, Pittard A. Measurement of tracheal tube cuff pressure in critical care. *Anaesthesia* 2002;**57(3):**275-7. [11892637]

20 Latto P. The cuff. In: Latto IP, Vaughan RS, eds. Difficulties in tracheal intubation. 2nd Edition, Philadelphia: WB Saunders, 1997; pp. 51-78.

21 Lewis F, Schlobohm R. Thomas A.

Prevention of complications from prolonged tracheal intubation. *Am J Surg* 1978;**135**:452-7. [626327]

22 Joh S, Matsura H, Kotani Y, Sugiyama K, Hirota Y, Kiyomitsu Y, Kubota Y. Change in tracheal blood flow during endotracheal intubation. *Acta Anaesth Scand* 1987;**31:**300-6. [3109197]

23 Bryant L, Trinkle J, Dubilier L. Reappraisal of tracheal injury from cuffed tracheostomy tubes. *JAMA* 1971;**215:**625-8. [5107440]

24 Wu WH, Lim IT, Simpson FA Jr. Tundrof H. Pressure dynamics of endotracheal and tracheostomy cuffs. Use of tracheal model to evaluate performance. *Crit Care Med* 1973;**1:**197-202. [4519961]

25 Carrol R, Hedden M, Safar P. Intratracheal cuffs performance characteristics. *Anesthesiology* 1969;**31:**275-81. [5801269]

26 Dobrin P, Canfield T. Cuffed endotracheal tubes: mucosal pressures and tracheal wall blood flow. *Am J Surg* 1977;**133:**562-8. [860779]

27 Black AMS, Seegobin RD. Pressure on endotracheal tube cuffs. *Anaesthesia* 1981;**36:**498-511. [7258585]

28 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 Car Med* 1990;**18:**1423-1426. [2245619]

29 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. [15098531]

30 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. [8680665]

31 Dallenkopf A, Gerber A, Weiss M. Fluid Leakage past tracheal tube uffs: evaluation of the new microcuff endotracheal tube. *Intensive Care Med* 2003;**29:**1849-53. [12923620]

32 Rader JC, Borchgrevink PC, Sellevold OM. Tracheal tube cuff pressures: the effects of different gas mixtures. *Anaesthesia* 1985;**40:**444-447. [4014621]

33 Lu YH, Hsieh MWW, Tong YH. Unilateral vocal cord paralysis following endotracheal intubation. A case report. *Acta Anaesthesiol Sin* 1999;**37:**221-4. [10670122]

34 Pelc P, Prigogine T, Bisschop P, Jortay A. Tracheoesophageal fistula; case report and review of literature. *Acta Otorhinolaryngol Belg* 2001;**55:**273-8. [11859645]

35 Terashima H, Sakurai T, Takahashi S. Postintubation tracheal stenosis; problems associated with choice of management. *Kyobu Geka* 2002;**55:**837-42. [12233101]