

COMPARISON OF MINIMAL LEAK TEST AND MANUAL CUFF PRESSURE MEASUREMENT TECHNIQUE METHOD FOR INFLATING THE ENDOTRACHEAL TUBE CUFF

Sambhunath Das^{1,*}, Pankaj Kumar²

¹Additional Professor, ²Senior Resident, Department of Cardiac Anaesthesia, AIIMS, New Delhi

***Corresponding Author:**

E-mail: dr_sambhu@yahoo.com

ABSTRACT:

Background: Appropriate management of endotracheal tube (ETT) cuff pressure is essential during mechanical ventilation of an intubated patient. The ETT cuff should be inflated in order to seal the airway without volume loss or pharyngeal content aspiration. It is desirable that the cuff seal the airway without exerting high pressure on the trachea to compromise mucosal circulation. The aim of this study is to assess importance of monitoring of ETT cuff pressure in intubated patients and effect of intervention in preventing complications related to over and under inflation of ETT cuff.

Method: An observational prospective study performed between January and April 2015. All patients having cardiac surgery with cuffed ETT insertion were included. In Group1 cuff pressure manometer was used to monitor the cuff pressure and adjusted in the range of 20-30 cm H₂O within 15 min before going on cardiopulmonary bypass. In Group2 only minimal leak test (MLT) done to guide inflation and cuff pressure measured by cuff pressure manometer but no intervention was made. Patients were followed in postsurgical care till extubation and observed till discharge for complication like sore throat, voice changes and tracheomalacia.

Results: In group 1 9(25.7%) patient had cuff pressure within normal limit whereas 25 (71.4%) patient had cuff pressure higher than normal and 1 (2.9%) patient had cuff pressure measurement less than 20 cm H₂O. Volume of air added or removed from cuff was -0.89 ± 1.14 to optimize cuff pressure. Cuff pressure ranged from 15 to 120(47 ± 23) cm H₂O. In group 2 11(32.4%) patient had cuff pressure within normal limit whereas 22 (64.7%) patients had cuff pressure higher than normal and 1 (2.9%) patient had cuff pressure measurement less than 20 cm H₂O. Cuff pressure ranged from 18 to 100(47.4 ± 20.3) cm H₂O. In group 1, 11 patients developed hoarse voice compared to 32 patients in group 2. $P=0.000$ In group 1, 15 patient developed sore throat versus 21 patients in group 2, $P = 0.187$.

Conclusion: Measurements of endotracheal tube intra cuff pressure are essential to avoid over or under inflation of ETT cuff. Adjusting the cuff pressure to 20-30cmH₂O will prevent volume loss during ventilation and complications like sore throat, hoarseness of voice and tracheomalacia. Measurement of cuff pressure with timely intervention should be made standard of care in operation theatre and ICU.

Keywords: Endotracheal tube cuff pressure, Minimal leak test, Minimum occlusive volume, Manual cuff pressure measurement, Cardiac surgery

INTRODUCTION

Endotracheal tube (ETT) cuff pressure management is an important step in airway management after tracheal intubation. Studies have shown that postoperative respiratory complications can be related to endotracheal cuff pressures.¹ High cuff pressure prevents aspiration, ventilator leaks, and eccentric positioning of tube in the trachea but can cause damage to the tracheal mucosa. A low cuff pressure minimizes tracheal damage. It can act to relieve excessive airway pressure but may result in aspiration pneumonia, leaks and displaced tube positioning.

The ETT cuff inflated in order to seal the airway without volume loss or pharyngeal content aspiration. It is desirable that the cuff seal the airway without exerting so much pressure on the trachea that its circulation is compromised. Recommend that the pressure on the lateral tracheal wall measured at end expiration should be between 20 and 30 cm H₂O (18 to 25 mm Hg) in normotensive adults.^{2,3}

Patients having high peak inflation pressures need a higher cuff pressure to prevent leaks (minimum occlusive pressure) thereby increasing the risk of ischemic tracheal injury⁴.

The techniques described to maintain cuff pressure include minimal leak technique (MLT) after injecting air from a syringe, minimal occlusive volume (MOV) after injecting a fixed volume of air from syringe and cuff pressure measurement (CPM).⁵ The common practice to inflate the ETT cuff is MLT or MOV. Best practice recommendations include initial cuff inflation using MLT followed by direct CPM using an aneroid manometer.⁶ Hence we studied to assess practices related to cuff pressure management in the mechanically ventilated patient in cardiac surgery operation room in our center. The aim of the study was to assess importance of monitoring of endotracheal tube (ETT) cuff pressure in intubated patients and effect of intervention in preventing complications related to over and under inflation of ETT cuff.

MATERIALS AND METHODS

A prospective observational and mono-centric study was conducted between January and April 2015 in tertiary apex teaching hospital. All patients having cardiac surgery with cuffed ETT insertion were included. Patients having tracheostomy, lateral and prone positioning, emergency surgery were excluded. Sixty nine patients were selected in two groups and the ETT cuff pressures (Portex Profile^R) estimated by clinical MLT method. In group 1 cuff pressure manometer (Hand cuff pressure gauge, MallinckrodtTM Coviden Inc., MA, U.S.A. Figure 1) was used to monitor the cuff pressure and adjusted in the range of 20-30 cm H₂O by withdrawing or adding air by the help of a syringe. In group 2 only MLT done to guide inflation and cuff pressure measured by cuff pressure manometer (figure 1) but no intervention was made. All patients were followed in postsurgical care till extubation and observed till discharge for complication like sore throat, voice changes, aspiration pneumonitis and tracheomalacia.



Figure 1: Hand cuff pressure gauge

The variables collected prospectively for all patients were age, gender, weight, diagnosis and extubation time. Cuff pressure (CP) measured in both the groups were recorded. In group1 intervention done to maintain optimal cuff pressure and the amount of air needed to correct the CP were recorded. Incidences of complications after tracheal extubation were recorded in both groups.

RESULT

Statistical analysis consisted mainly of descriptive parameters. STATA 11.2, Texas, USA was used for data analysis. Continuous variables were presented as means \pm SD and nominal variables as percentages. Chi-square used for qualitative variables. Two groups of patients were created depending on intervention to optimize cuff pressure. A p value $<$ 0.05 was considered statistically significant.

Sixty nine patients were enrolled in the study out of 120 who underwent cardiac surgery

during the study period. Out of this 34 patient (group1) underwent direct cuff pressure measurement after MLT, in rest 35 patients (group2) only MLT technique was used.

There was no significant difference in age, weight, cuff pressure measurement, extubation time variables between two groups (Table 1). In total subject 44(64%) were male and 25(36%) were female (Table 1).

In group 19(25.7%) patient had cuff pressure within normal limit whereas 25 (71.4%) patient had cuff pressure higher than normal and 1 (2.9%) patient had cuff pressure measurement less than 20 cm H₂O. Maximum air added was 2mL with maximum air removed from cuff was 3mL with mean value of (-0.89 ± 1.14) to optimize cuff pressure between 20-30 cm H₂O (Table 3). Cuff pressure ranged from 15 to 120(47 ± 23) cm H₂O (Table 1).

In group 2 11(32.4%) patient had cuff pressure within normal limit whereas 22 (64.7%) patients had cuff pressure higher than normal and 1 (2.9%) patient had cuff pressure measurement less than 20 cm H₂O. Cuff pressure ranged from 18 to 100(47.4 ± 20.3) cm H₂O (Table 1).

In group 1, 11 patients developed hoarse voice compared to 32 patients in group 2 had hoarseness. This was significant ($P=0.000$)(Table 2). In group 1, 15 patient developed sore throat versus 21 patients in group 2, $P = 0.187$ (Table 2). There was no incidence of aspiration pneumonia and tracheomalacia in either of the groups up to discharge.

Table 1: Demographic and other variables

Parameter	Group 1(N=34)	Group 2(n=35)	P value
Age (year, mean \pm SD)	31.5 \pm 19.8	33 \pm 21.8	NS
Sex (M:F)	20:14	24:11	NS
Weight (kg, mean \pm SD)	47.8 \pm 18.3	47.9 \pm 19.1	NS
CPM (cm H ₂ O, mean \pm SD)	47 \pm 23	47.4 \pm 20.3	NS
Extubation Time (hour, mean \pm SD)	9.7 \pm 2.7	8.2 \pm 2.8	NS

NS= not significant

Table 2: complications after extubation

Side effect	Group 1	Group 2	P value
Sore Throat	15	21	0.187
Hoarse voice	11	32	0.00
Aspiration pneumonia	0	0	-
Tracheomalacia	0	0	-

Table 3: Air removed or added to optimize cuff Pressure in Group 1(N=34)

Mean (ml of air removed)	SD	Minimum (maximum withdrawn)	Maximum added/ filled
.89	1.14	-3	2

DISCUSSION

Over-inflation can lead to tracheal mucosa edema causing stridor and sore throat after extubation.⁷ Under-inflation can lead to aspiration of secretions, particularly during inspiration. Aspiration of pharyngeal secretions has been associated with ventilator-associated pneumonia.⁸ Potential injuries from cuff over-inflation include tracheal rupture, necrosis and stenosis, tracheo-esophageal fistula, and recurrent laryngeal nerve palsy. Tracheal stenosis may produce no symptoms until the lumen has been reduced by 50 - 75% and develops as long term side effect if the patient has undergone mechanical ventilation.⁹ The condition has been confirmed in mechanically ventilated patients as a complication related to over-inflated cuffs.^{10,11}

In our study around 70% of patients had cuff pressure measurements higher than normal limit. In previous studies that used continuous monitoring of ETT cuff pressure, only 54% to 75% of measurements were between 15 and 30 cm H₂O.^{1,12} In study done by Nseir and colleagues cuff pressure was adjusted to 25 cm H₂O and continuous monitoring was started, yielding 808 hours of data in 101 patients.¹⁴ Cuff pressure < 20 cm H₂O was noted in 54% of patients, and more than 30 cm H₂O occurred in 73% of patients. Under inflation was associated with absence of sedation and longer duration of intubation.¹³ Above findings suggest the importance of cuff pressure monitoring. Hence anesthesiologists can't rely only on clinical estimation technique like MLT and MOV. Maintaining the ETT cuff pressure within normal range is challenging. There are evidence of high intracuff pressure even for brief periods might resulting in tracheal injury.^{7,14} Many factors such as the patient's position, temperature and certain anesthetic agents have influence on cuff pressure.^{12,13}

In our study incidence of tracheomalacia, aspiration pneumonia and other tracheal injuries were not present. It can be due to less duration between intubation and extubation. The total number of patients in the study might be insufficient to detect the less common complications. In our institute mechanical ventilation duration ranges between 6 to 12 hours. But this range of duration was enough to cause sore throat in 36(52%) and hoarseness of voice 43 (62%) after extubation with higher incidence in group2.

Standard of care for cuff pressure in postanesthesia care unit and critical care areas

includes intermittent measurement of endotracheal tube cuff pressure monitoring and adjustment. This should also be practised from the beginning in operation room after intubation especially in cardiac surgery, long duration surgery and high risk patients as duration of surgery is prolong and fluctuation in hemodynamic occurs due to temperature changes and CPB.

Limitations: ETT cuff pressures were measured only for a single time in the operation room. Single intervention was done to optimize the cuff pressure in study group. The total number of patients for the study was less. A comprehensive assessment of cuff pressure throughout the duration of tracheal intubation may provide greater evidence of the relationship of cuff pressure to outcomes of mechanical ventilation.

CONCLUSION

Measurements of endotracheal tube intra cuff pressure are essential to avoid over or under inflation of ETT cuff. Adjusting the cuff pressure to 20-30cmH₂O will prevent volume loss during ventilation and complications like sore throat, hoarseness of voice and tracheomalacia. Measurement of cuff pressure with timely intervention should be made standard of care in operation theatre and ICU.

REFERENCES:

1. Nseir S, Duguet A, Copin MC, et al. Continuous control of endotracheal cuff pressure and tracheal wall damage: a randomized controlled animal study. *Crit Care*. 2007;11(5):R109. doi: 10.1186/cc6142.
2. 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* 1984;288:965-968.
3. Guyton DC. Endotracheal and tracheotomy tube cuff design: influences on tracheal damage. *Critical Care Updates* 1990;1:10.
4. Guyton DC, Barlow MR, Besseliebre TR. Influence of airway pressure on minimum occlusive endotracheal tube cuff pressure. *Crit Care Med* 1997;25:91-94.
5. Sengupta P, Sessler DI, Maglinger P, et al. Endotracheal tube cuff pressures in three hospitals, and the volume required to produce an appropriate cuff pressures. *BMC Anesthesiology* 2004;4(8):6- 10.
6. Jordan P, Rooyen D., Venter D. Endotracheal tube cuff pressure management in adult critical care units. *S Afr J Crit Care* 2012;28(1):13-16.
7. Stewart SL, Secrest JA, Norwood BR, Zachary R. A comparison of endotracheal tube cuff pressures using estimation techniques and direct intracuff measurement. *AANA J* 2004;71 (6):443-447.
8. Rose L, Redl L. Survey of cuff management practices in intensive care units in Australia and New Zealand. *Am J Crit Care* 2008;17(5):428-435.
9. Epstein SK. Late complications of tracheostomy. *Respir Care* 2005;50(4):542-549.
10. De S. Post intubation tracheal stenosis. *Indian Journal of Critical Care Medicine* 2008; 12(4):194-197.

11. Spittle CSN, McCluskey A. Tracheal stenosis after intubation. *BMJ* 2000; 321(7267):1000-1002.
12. Duguet A, D'Amico L, Biondi G, Prodanovic H, Gonzalez- Bermejo J, Similowski T. Control of tracheal cuff pressure: a pilot study using a pneumatic device. *Intensive Care Med.* 2007;33:128-132
13. Nseir S, Brisson H, Marquette CH, et al. Variations in endotracheal cuff pressure in intubated critically ill patients: prevalence and risk factors. *Eur J Anaesthesiol.* 2009;26:229-234.
14. Lim H, Kim JH, Kim D, Lee J, Son JS, Kim DC, Ko S Tracheal rupture after endotracheal intubation - A report of three cases. *Korean Journal of Anesthesiology* 2012: 62:277-80.