

COMPARISON OF ENDOTRACHEAL TUBE CUFF INFLATION BY TWO DIFFERENT TECHNIQUES- PRESSURE VOLUME LOOP CLOSURE AND SEALING TECHNIQUE BY AUSCULTATION

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ABSTRACT

Background: Proper endotracheal tube (ETT) cuff inflation is essential to ensure adequate ventilation and prevent airway-related complications. The aim is to compare pressure-volume loop (PVL) closure and auscultation-based sealing techniques for ETT cuff inflation. **Materials and Methods:** Prospective randomized clinical trial including 80 ASA I-II patients undergoing elective surgery under general anaesthesia. **Result:** PVL closure required significantly lower cuff inflation volume and resulted in lower intracuff pressures with fewer postoperative airway complications. **Conclusion:** PVL closure is a simple and reliable method for achieving optimal ETT cuff pressure with reduced postoperative morbidity.

INTRODUCTION

Endotracheal intubation remains the gold standard for airway management during general anaesthesia. The cuff of the endotracheal tube (ETT) plays a crucial role in providing an effective airway seal, preventing aspiration of gastric contents, and facilitating adequate positive pressure ventilation.^[1] Maintaining optimal cuff pressure is essential, as both underinflation and overinflation are associated with significant perioperative complications.

Cuff underinflation may result in air leaks, inadequate ventilation, unplanned extubation, and aspiration of oropharyngeal secretions, thereby increasing the risk of ventilator-associated pneumonia. Conversely, cuff overinflation can impair tracheal mucosal perfusion, leading to airway morbidity ranging from mucosal irritation and necrosis to more severe complications such as tracheal stenosis, rupture, and tracheoesophageal fistula formation. Postoperative sore throat and hoarseness are commonly reported sequelae of excessive cuff pressure.^[2-5]

In routine clinical practice, ETT cuff inflation is often guided by subjective methods such as auscultation or pilot balloon palpation, while objective assessment using cuff manometry is less frequently employed. The pressure-volume loop (PV-L), a real-time ventilatory graphic, has the potential to detect air leaks and guide cuff inflation more precisely.

This study aims to compare ETT cuff inflation using pressure-volume loop closure with the conventional auscultation-based sealing technique and to evaluate their impact on postoperative cuff-related complications.

Aim and Objectives

To compare pressure-volume loop closure and auscultation-based sealing techniques for endotracheal tube cuff inflation in patients undergoing general anaesthesia.

Objectives

Primary objectives:

To compare the volume of air required for cuff inflation.

To compare the cuff pressure achieved using the two techniques.

Secondary objective:

To compare the incidence of postoperative cuff-related complications (cough, sore throat, and hoarseness of voice).

MATERIALS AND METHODS

This prospective randomized clinical trial was conducted over a period of one year at a tertiary care teaching hospital after obtaining institutional ethics committee approval. Adult patients scheduled for elective surgeries under general anaesthesia in the supine position were enrolled after informed consent. A total of 80 patients were included and randomly allocated into two equal groups. Sample size

calculation, based on detecting a minimum difference of 0.25 in endotracheal tube cuff pressure between the two groups with a 95% confidence interval and 90% power, yielded a minimum of 39 patients per group; therefore, 80 patients were recruited.

Inclusion criteria

Adult patients (>18 years), ASA physical status I–II, scheduled for elective surgery under general anaesthesia in the supine position, requiring oral tracheal intubation with a Portex/PVC endotracheal tube, with an expected surgical duration ≤3 hours.

Exclusion criteria

Patients with anticipated difficult airway, chronic lung disease, risk of pulmonary aspiration, non-supine positioning, preoperative cough/hoarseness/sore throat, blood-stained ETT on extubation, use of non-Portex/PVC endotracheal tubes, or use of throat packs.

Methodology: After ethics committee approval, patients meeting the inclusion criteria were enrolled and informed written consent was obtained. Standard intraoperative monitoring included ECG, pulse oximetry, non-invasive blood pressure, and end-tidal CO₂. General anaesthesia was induced with IV fentanyl (2 µg/kg), propofol (2 mg/kg), and rocuronium (1 mg/kg), and patients were ventilated with 100% oxygen and sevoflurane. Male patients received 8.0 mm ID ETT and females 7.0 mm ID, high-volume low-pressure Portex tubes. Patients were randomized into two groups using a computer-generated table:

Group 1 (Pressure–Volume Loop Closure): ETT cuff was inflated in 0.5 mL increments until closure of the PV loop on the ventilator, indicating no expiratory leak.

Group 2 (Auscultation Sealing): Cuff inflated in 0.5 mL increments until audible air leak at the

suprasternal space disappeared during gentle manual ventilation.

Cuff pressure was measured immediately after inflation and prior to extubation by a blinded investigator using an aneroid manometer. Intraoperative ventilation was maintained at 7 mL/kg tidal volume and 16–18 breaths/min with O₂:N₂O (50:50) and sevoflurane. Postoperatively, patients were assessed for cuff-related complications (sore throat, cough, hoarseness) at 2 h and 24 h using a 0–3 severity scale.

RESULTS

A total of 80 patients scheduled for elective surgeries under general anaesthesia were enrolled and randomly allocated into two groups: pressure–volume loop (PVL) closure group (n = 40) and auscultation-based sealing group (n = 40). All patients completed the study, and no exclusions were required after randomization.

Demographic and Baseline Characteristics: The two groups were comparable with respect to demographic variables, including age, sex distribution, height, weight, ASA physical status, and Mallampati classification. There were no statistically significant differences between the groups, indicating adequate randomization and baseline homogeneity

Volume of Air Used for Cuff Inflation: The mean volume of air required to achieve effective cuff inflation was significantly lower in the PVL closure group compared to the auscultation group. Patients in the PVL group required a mean cuff inflation volume of 5.1 mL (range 4–6 mL), whereas the auscultation group required a mean volume of 6.3 mL (range 5.5–8 mL). This difference was statistically significant (P < 0.01) [Table 1, Figure 1].

Table 1: Table showing mean volume of air injected in ETT cuff in different technique [Mann-Whitney U test, n = 80]

Group	n	Mean volume of air (cc)	z-value	p-value
PVL group	40	5.1	-6.7	<0.01
Sealing by Auscultation group	40	6.3		

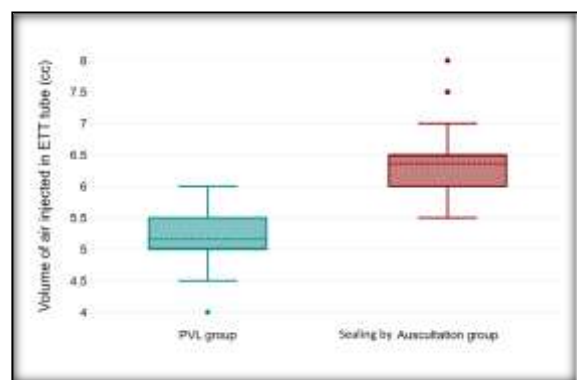


Figure 1: Box plot chart showing volume of air injected in ETT cuff

Endotracheal Tube Cuff Pressure: Intracuff pressure measured immediately after intubation was significantly lower in the PVL group compared to the auscultation group. The mean cuff pressure in the PVL group was 24.8 cmH₂O, whereas it was 36.5 cmH₂O in the auscultation group (P < 0.01). Similarly, cuff pressure measured prior to extubation remained significantly lower in the PVL group (25.9 cmH₂O) compared to the auscultation group (37 cmH₂O), with a statistically significant difference (P < 0.01). These findings demonstrate consistently lower cuff pressures with the PVL closure technique throughout the intraoperative period [Table 2, Figure 2].

Table 2: Table showing mean intracuff pressure post intubation and pre extubation in different technique [Mann-Whitney U test, n = 80]

Phase	Group	n	Mean intracuff pressure (cm H ₂ O)	z-value	p-value
Post-intubation	PVL group	40	24.8	-7.7	<0.01
	Sealing by Auscultation group	40	36.5		

Pre-extubation	PVL group	40	25.9	-7.6	<0.01
	Sealing by Auscultation group	40	37.1		

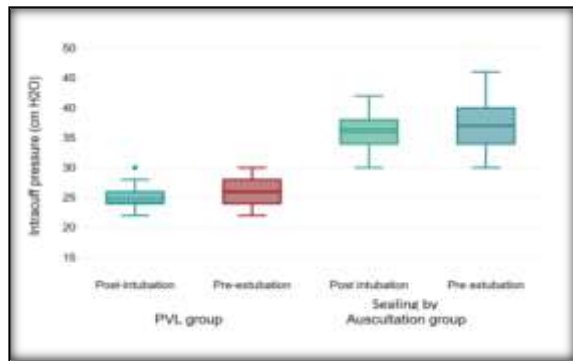


Figure 2: Box plot chart showing intracuff pressure post intubation and pre extubation

Postoperative Cuff-Related Complications:

The incidence of postoperative cuff-related complications—namely sore throat, cough, and hoarseness of voice—was lower in the PVL group compared to the auscultation group at both 2 hours and 24 hours post-extubation. Patients in the PVL group experienced fewer and less severe symptoms on the 0–3 grading scale used for assessment. The difference in the incidence of these complications between the two groups was statistically significant [Table 3].

Table 3: Table showing reported complications postoperatively among patients in both groups at 2 and 24 h (Chi square test, n = 80)

Variable	Time	Grading (0–3 with frequency %)	PVL group (n=40)	Sealing by Auscultation group (n=40)	p-value
Sore throat	2 hrs	0	33 (82.5%)	19 (47.5%)	0.03
		1	5 (12.5%)	6 (15%)	
		2	2 (5%)	12 (30%)	
		3	0	3 (7.5%)	
Sore throat	24 hrs	0	34 (85%)	20 (50%)	0.02
		1	5 (12.5%)	6 (15%)	
		2	1 (2.5%)	12 (30%)	
		3	0	2 (5%)	
Cough	2 hrs	0	38 (95%)	29 (72.5%)	0.002
		1	2 (5%)	8 (20%)	
		2	0	3 (7.5%)	
		3	0	0	
Cough	24 hrs	0	39 (97.5%)	30 (75%)	0.001
		1	1 (2.5%)	8 (20%)	
		2	0	2 (5%)	
		3	0	0	
Hoarseness	2 hrs	0	37 (92.5%)	34 (85%)	0.005
		1	3 (7.5%)	1 (2.5%)	
		2	0	5 (12.5%)	
		3	0	0	
Hoarseness	24 hrs	0	38 (95%)	34 (85%)	0.001
		1	2 (5%)	2 (5%)	
		2	0	4 (10%)	
		3	0	0	

DISCUSSION

Endotracheal intubation is a cornerstone of airway management during general anaesthesia and critical care. The endotracheal tube (ETT) cuff plays a vital role in maintaining an effective airway seal, preventing aspiration of gastric contents, and ensuring adequate ventilation.^[1] Both underinflation and overinflation of the cuff are associated with complications. Underinflation may result in air leaks, unplanned extubation, and increased risk of ventilator-associated pneumonia, while overinflation can compromise tracheal mucosal perfusion, leading to irritation, ulceration, stenosis, or even rupture.^[2-5] Minor postoperative complications such as sore throat, cough, and hoarseness are more frequently observed but can significantly affect patient comfort and recovery.

Various techniques have been described to achieve optimal ETT cuff inflation, including finger

palpation, minimum leak technique, auscultatory sealing, and pressure–volume loop (PVL) closure. Most previous studies have focused on evaluating these techniques in terms of cuff pressure, volume of air used, and adequacy of the airway seal. However, few studies have assessed the relationship between the cuff inflation method and postoperative airway complications. This study aimed to compare the PVL closure technique with auscultation-based sealing in an Indian population, evaluating both cuff inflation parameters and the incidence of post-extubation complications.

A total of 80 ASA I/II patients scheduled for elective surgeries were randomized equally into two groups: PVL closure (n=40) and auscultation sealing (n=40). Both groups were comparable with respect to age, gender distribution, height, weight, ASA physical status, and Mallampati classification, supporting the validity and comparability of the results. The mean age was 42.4 ± 16.1 years in the PVL group and

45.0 ± 14.3 years in the auscultation group, with similar male-to-female ratios (21:19 vs 22:18) and comparable anthropometric parameters. These demographics align with previous studies such as Roshdi et al. (2015),^[6] Almarakbi et al (2014),^[7] Bolzan et al. (2012),^[8] and Jianhui et al (2010),^[9] ensuring external validity.

Cuff Volume and Pressure: In our study, the PVL technique required significantly less air to inflate the ETT cuff (mean 5.1 mL, range 4–6 mL) compared to auscultation-based sealing (mean 6.3 mL, range 5.5–8 mL; $P < 0.01$). Correspondingly, intracuff pressures were lower in the PVL group both immediately after intubation (24.8 cmH₂O) and prior to extubation (25.9 cmH₂O) compared to the auscultation group (36.5 cmH₂O and 37 cmH₂O, respectively; $P < 0.01$). These results are consistent with findings from Roshdi et al,^[6] who reported lower cuff volumes and pressures with sealing techniques compared to finger palpation, and with Almarakbi et al,^[7] and Bolzan et al,^[8] who observed similar trends using PVL or volume-time curve techniques. The reduced cuff volume and pressure with PVL closure indicate more precise inflation, minimizing the risk of overinflation while maintaining an effective airway seal.

Postoperative Cuff-Related Complications: The incidence of postoperative complications such as sore throat, cough, and hoarseness was significantly lower in the PVL group at both 2 h and 24 h post-extubation. This observation aligns with Almarakbi et al,^[7] and Jianhui et al,^[10] who reported fewer airway complications in patients with lower cuff pressures. Excessive cuff pressure can compromise tracheal mucosal perfusion, leading to erosion, ulceration, tracheal stenosis, or tracheomalacia. Maintaining cuff pressures within the recommended range of 25–30 cmH₂O is essential to prevent these adverse effects.

Clinical Implications: Real-time PVL monitoring provides an effective and widely accessible method to guide ETT cuff inflation. It allows the anesthesiologist to detect air leaks and adjust cuff volume precisely, thereby achieving adequate sealing with minimal pressure. In our study, the PVL technique not only optimized cuff function but also reduced postoperative airway morbidity compared to the conventional auscultatory method. These findings suggest that PVL closure can enhance patient safety and comfort, and it may be considered for routine clinical practice where available.

Comparison with Previous Literature: Prior studies corroborate our findings. Roshdi et al,^[6] demonstrated that finger palpation resulted in higher cuff volumes and pressures, whereas sealing techniques provided adequate sealing at lower pressures. Almarakbi et al,^[7] reported a lower incidence of postoperative complications with PVL compared to auscultation, supporting our results. Dullenkopf et al,^[11] and Kumar & Hirsch,^[12] further highlighted that effective airway sealing can be achieved at cuff pressures lower than traditionally applied, emphasizing the importance of monitoring

and limiting intracuff pressure to reduce mucosal injury.

CONCLUSION

In this prospective randomized clinical trial of 80 patients titled “Comparison of Endotracheal Tube Cuff Inflation by Two Different Techniques: Pressure–Volume Loop Closure versus Sealing Technique by Auscultation,” we found that the pressure–volume loop (PVL) closure technique offers significant advantages over auscultation-based sealing. Specifically, PVL closure was associated with:

1. Lower volume of air required to achieve effective ETT cuff inflation
2. Lower intracuff pressures
3. Reduced incidence of post-extubation cuff-related complications, including sore throat, cough, and hoarseness of voice

These findings suggest that real-time PVL monitoring, available on most modern anesthesia machines, provides a reliable and effective method for optimizing ETT cuff inflation, minimizing tracheal mucosal injury, and improving postoperative patient comfort.

REFERENCES

1. 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.
2. Striebel HW, Pinkwart LU, Karavias T. Tracheal rupture caused by overinflation of endotracheal tube cuff. *Anaesthesist.* 1995;44:186–8.
3. Luna CM, Legarreta G, Esteve H, Laffaire E, Jolly EC. Effect of tracheal dilation and rupture on mechanical ventilation using a low-pressure cuff tube. *Chest.* 1993;104:639–40.
4. Reed MF, Mathisen DJ. Tracheoesophageal fistula. *Chest SurgClin N Am.* 2003;13:271–89.
5. Pelc P, Prigogine T, Bisschop P, Jortay A. Tracheoesophageal fistula: Case report and review of literature. *ActaOtorhinolaryngolBelg.* 2001;55:273–8.
6. Al-Metwalli RR, Al-Ghamdi AA, Mowafi HA, Sadek S, Abdulshafi M, Mousa WF. Is sealing cuff pressure, easy, reliable and safe technique for endotracheal tube cuff inflation?: A comparative study. *Saudi J Anaesth.* 2011 Apr;5(2):185–9.
7. Almarakbi WA, Kaki AM. Tracheal tube cuff inflation guided by pressure volume loop closure associated with lower postoperative cuff-related complications: Prospective, randomized clinical trial. *Saudi J Anaesth.* 2014;8(3):328–334.
8. Bolzan DW, Gomes WJ, Faresin SM, de Camargo Carvalho AC, De Paola AA, Guizilini S. Volume-Time Curve: An Alternative for Endotracheal Tube Cuff Management. *Respir Care.* 2012;57:2039–44.
9. Kaki A, Almarakbi W. Use of pressure volume loop closure to check for endotracheal tube cuff function. *Randomized clinical trial. Saudi Med J.* 2012;33:1185–9.
10. Liu J, Zhang X, Gong W, Li S, Wang F, Fu S, Zhang M, Hang Y. Correlations between controlled endotracheal tube cuff pressure and postprocedural complications: a multicenter study. *Anesth Analg.* 2010 Nov;111(5):1133–7.
11. Dullenkopf A, Bernet-Buettiker V, Maino P, Weiss M. Performance of a novel pressure release valve for cuff pressure control in pediatric tracheal tubes. *PaediatrAnaesth.*
12. Kumar RD, Hirsch NP. Clinical evaluation of stethoscope-guided inflation of tracheal tube cuffs. *Anesthesia.* 2011;66:1012–6.