

Comparison of Endotracheal Tube Cuff Pressure with Passive Release Technique for Cuff Inflation between Disposable and Loss of Resistance Syringe in Patients Undergoing General Anesthesia

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Abstract

Background: The standard technique to maintain optimal endotracheal tube cuff pressure is the manometer, but it is not always available. Passive release technique has been shown in previous studies to be one of the most accurate alternative methods to provide cuff pressure within an optimal range (20-30 cmH₂O). The objective of the study is to compare endotracheal tube cuff pressure in patients undergoing general anesthesia by inflating the endotracheal cuff with passive release technique between two types of syringes; disposable and loss of resistance syringes.

Methods: A prospective double-blinded randomized control study was conducted in Rajavithi Hospital, enrolling patients undergoing elective surgery under general anesthesia with endotracheal tube. Cuff pressure after passive release technique was measured. If cuff pressure was less than 20 cmH₂O, air inflation was done

until it reached 20 cmH₂O. If cuff pressure exceeded 30 cmH₂O, air deflation was done until it reached 25 cmH₂O.

Results: One hundred patients were randomized to the disposable syringe and loss of resistance syringe group, with fifty patients in each group. Mean cuff pressure after passive release technique was 29.24±6.02 cmH₂O in the disposable syringe group which was statistically significantly different from the loss of resistance syringe group (19.24±6.27 cmH₂O). There were 23 patients (46%) in the disposable syringe group and 15 patients (30%) in the loss of resistance group with cuff pressure within an optimal range.

Conclusion: The disposable syringe group was superior to the loss of resistance syringe group in providing cuff pressure within an optimal range.

Keywords: endotracheal cuff pressure, loss of resistance syringe, passive release technique

Introduction

Endotracheal tube is commonly used in general anesthesia. Following endotracheal intubation, cuff inflation by a syringe via pilot balloon is done. Overinflation and underinflation of cuff pressure can cause several complications.^{1,2} Overinflation can cause laryngeal or airway injuries, sore throat, and hoarseness.³ Underinflation can cause air leakage and gastric content aspiration.⁴ The cuff pressure should be maintained in an optimal range, which is between 20-30 cmH₂O from previous studies.^{5,6} A cuff pressure manometer is considered a gold standard for estimating cuff pressure. However, in current practice, manometer is not always available in every operating room therefore several alternative techniques have been used. Manual palpation of pilot balloon, minimal occlusive volume technique, and passive release technique are commonly performed.⁷⁻⁹ According to previous studies, the passive release technique provided the most precise cuff pressure.

Different types of syringes can be used to inflate the endotracheal tube cuff with passive release technique. These include disposable and loss of resistance syringes, which provide different ranges of cuff pressure. While both syringe types provide high incidence of the appropriate endotracheal cuff pressure, conflicting findings exist in the literature. Some studies suggest that loss of resistance syringes result in more adequate cuff pressure⁷, while others suggested that their use may lead to cuff pressure below the optimal range¹⁰, which could cause air leakage. Currently, there is no study comparing

endotracheal tube cuff pressure between disposable and loss of resistance syringes using passive release technique for endotracheal cuff inflation.

Our study was conducted to compare the accuracy of optimal cuff pressure by inflation endotracheal cuff using passive release technique between disposable and loss of resistance syringes in patients undergoing general anesthesia. The primary outcome was to compare endotracheal tube cuff pressure using passive release technique between disposable and loss of resistance syringes. Secondary outcomes were to determine the incidence of endotracheal tube cuff pressure less than 20 cmH₂O, the volume of air needed to be inflated to provide adequate seal in case of cuff pressure less than 20 cmH₂O, and the incidence of endotracheal tube cuff leak from passive release technique.

Materials and methods

This prospective double-blinded randomized control study was performed at Rajavithi hospital from October 2021 to June 2022. This study was approved by Rajavithi Hospital Ethics Committee on March 8th, 2021 (MURA2021/165) and registered for Thai Clinical Trial on September 2nd, 2021 (TRTC20210902012). Written informed consent was obtained from patients who met the eligibility criteria. We included patients aged 18-80 years old with ASA class I to III undergoing elective surgery under general anesthesia with endotracheal intubation at Rajavithi Hospital between October 2021 to June 2022. Pregnancy patients, patients with a high risk of aspiration, expected

difficult airway patients, patients with limited communication skills, patients undergoing procedures involving head and neck, and patients undergoing laparoscopic surgery were excluded from this study.

After screening, participants were allocated to either 10 ml TERUMO® disposable syringe group (group C) or 10 ml PORTEX® loss of resistance syringe group (group L) using computer generated randomization. The allocation was concealed in opaque envelopes until the time of the intervention. All patients and outcome assessors were blinded to group allocation.

Study Protocol

After patient arrived at the operating theater, the standard ASA monitoring was applied. To induce anesthesia, all patients were preoxygenated with 100% oxygen for 3-5 min before induction. Propofol at the dose of 1.5-2.5 mg/kg and fentanyl at the dose of 1-2 mcg/kg were administered. After mask ventilation could be done, cisatracurium 0.15 mg/kg was administered to the patients. The patient was intubated using a PORTEX® cuffed endotracheal tube with a female size of 7.0-7.5 ID or a male size of 7.5-8.0 ID by either an anesthesiologist, a 2nd or 3rd-year anesthesiology resident, or a nurse anesthetist with more than 3 years of experience. After endotracheal tube was placed in the trachea, 6 ml of air was inflated via pilot balloon using a syringe according to the allocation.

Cuff pressure was measured by a manometer which was connected to a 3-way stopcock and adjusted to 30 cmH₂O by

incremental inflation or decremental deflating of 0.5 ml of air using the same syringe. The ventilator was set to volume cycling mode with a tidal volume of 6-8 ml/kg and no PEEP was set. The respiration rate was set to 12 times/min and could be adjusted to achieve normocarbida. General anesthesia was maintained with 1-2% sevoflurane and 60% oxygen in air with total flow of 2 L/min. After that, tidal volume at expiration (V_E) and tidal volume at inspiration (V_I) as shown on ventilator spirometry were recorded, calculating the V_E/V_I ratio for baseline measurement. Inflate 4 ml of air via pilot balloon using the same syringe and let it passively release until stopped. Then, the syringe was removed from the operating room.

After that, the researcher who was blinded to the allocation entered the room and recorded the endotracheal tube cuff pressure, tidal volume at expiration (V_E), and tidal volume at inspiration (V_I). Then the calculation of the V_E/V_I ratio after the passive release was done. If cuff pressure is less than 20 cmH₂O or the ratio difference is more than 2% from baseline, inflate 0.2 ml of air incremental using a 3 ml TERUMO® disposable syringe until cuff pressure reaches 20 cmH₂O. If cuff pressure exceeds 30 cmH₂O, deflate 0.2 ml of air decremental using a 3 ml TERUMO® disposable syringe until cuff pressure reaches 25 cmH₂O. Then the surgery would start, and continue until completed. All patients were assessed for postoperative complications, including hoarseness and sore throat in the ward.

The sample size was calculated based on previous studies conducted to estimate cuff pressure provided by disposable and loss of

resistance syringes. Mean cuff pressure was 30.4 ± 5.5 cmH₂O⁸ in the disposable syringe group and 27.0 ± 5.8 cmH₂O⁷ in the loss of resistance group. To achieve a power of 0.8 and an alpha error less than 0.05, 44 participants were required in each group. We estimated that at least 50 patients would be needed in each group, allowing for a dropout rate of 10%.

Statistical Analysis

Data were analyzed with IBM SPSS statistics version 26.0. Continuous data were tested for normality by using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. For descriptive statistics, continuous data showing normal distribution were presented as the mean $\pm$ SD, and data showing nonnormal distribution were presented as the median and interquartile range. Categorical data were presented as numbers and percentages. For inferential statistics, continuous data showing a normal distribution were analyzed using independent Student's t-test, and data showing a nonnormal distribution were analyzed using Mann-Whitney U-test. Categorical data were analyzed using Pearson Chi-square test. A *P*-value less than 0.05 was considered statistically significant.

Results

One hundred patients were assessed for eligibility, all of them were included in this study and were randomly allocated to either the disposable syringe group (group C) or the loss of resistance syringe group (group L) as shown in Figure 1. Baseline characteristics of the participants were summarized in Table 1. Most

of the participants were female in both groups. Age, body weight, height, BMI, ASA physical status, and Mallampati classification were similar in both groups. Endotracheal tubes used in both groups were mostly 7.5 in size.

The mean endotracheal tube cuff pressure after passive release technique in the disposable syringe group was 29.24 cmH₂O (SD=6.02, min=14, max=42), which showed a statistically significant difference from the loss of resistance syringe group where it was 19.24 cmH₂O (SD=6.27, min=10, max=42) (*P*<0.001). There were 23 patients (46.0%) from the disposable syringe group and 15 patients (30.0%) from the loss of resistance syringe group with endotracheal tube cuff pressure between 20-30 cmH₂O. In the loss of resistance group, there were 33 patients (66.0%) with cuff pressure less than 20 cmH₂O while there were only 4 patients (8.0%) in the disposable syringe group. For cuff pressure of more than 30 cmH₂O, there were 23 patients (46.0%) in the disposable syringe group and 2 patients (4.0%) in the loss of resistance syringe group. (Table 2)

We recorded tidal volume at the expiration and inspiration phase to compare the ratio between baseline and after the passive release technique. As demonstrated in Table 3, in participants with cuff pressure less than 20 cmH₂O after the passive release technique, V_E/V_I ratio at baseline was 0.993 (SD=0.051) and V_E/V_I ratio after the passive release technique was 0.998 (SD=0.044) which were not statistically significant different.

Table 4 shows volume of air inflated or deflated in case of cuff pressure is out of an optimal range. In the group of cuff pressure was

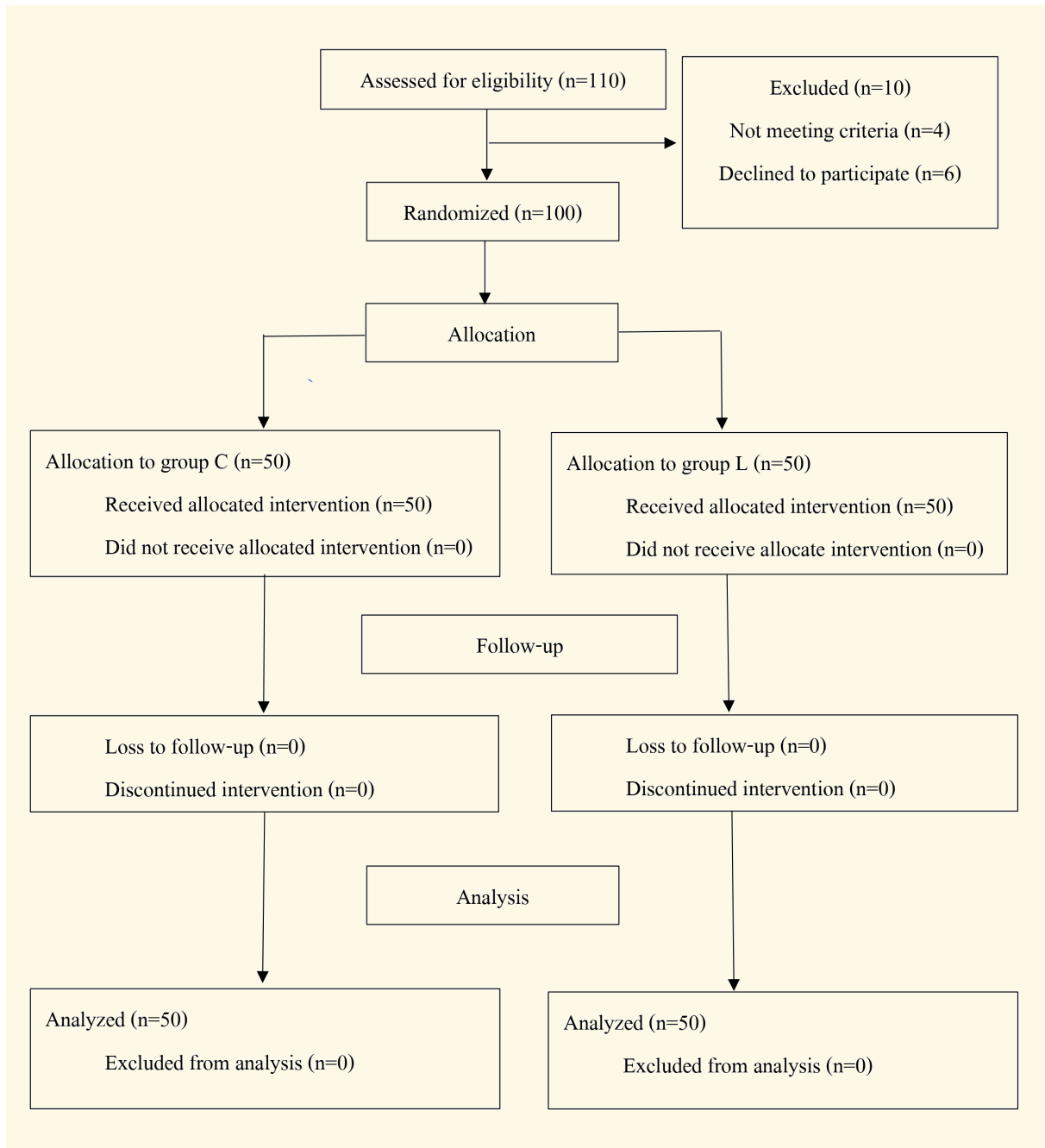


Figure 1 CONSORT flow diagram of patient recruitment

less than 20 cmH₂O, the median volume of air inflated was 0.4 ml (min=0.2, max=1.2). In the group of cuff pressure was more than 30 cmH₂O, the median volume of air deflated was 0.4 ml (min=0.2, max=1.2). There were 8 patients (16.0%) who experienced hoarseness in the disposable

syringe group, which was higher than the loss of resistance syringe group (5 patients, 10.0%). Additionally, there was a higher incidence of sore throat in the disposable syringe group (22.0%) compared to the loss of resistance syringe group (16.0%). There was not statistically significantly

Table 1 Baseline characteristics of patients

	Group C (n=50)	Group L (n=50)	P-value
Gender, n (%)			0.590
Male	13 (26.0)	13 (26.0)	
Female	37 (74.0)	37 (74.0)	
Age (yr), mean (SD)	50.3 (12.5)	52.4 (13.9)	0.505
Height (cm), mean (SD)	159.2 (7.9)	159.5 (8.8)	0.123
Weight (kg), mean (SD)	60.1 (10.1)	57.2 (11.4)	0.380
BMI (kg/m ²), mean (SD)	23.7 (3.7)	22.3 (4.1)	0.292
ASA physical status, n (%)			0.734
I	18 (36.0)	16 (32.0)	
II	29 (58.0)	29 (58.0)	
III	3 (6.0)	5 (10.0)	
Mallampati classification, n (%)			0.279
1	10 (20.0)	11 (22.0)	
2	32 (64.0)	36 (72.0)	
3	8 (16.0)	3 (6.0)	
Endotracheal tube size (ID), n (%)			0.828
7.0	11 (22.0)	13 (26.0)	
7.5	29 (58.0)	26 (52.0)	
8.0	10 (20.0)	11 (22.0)	
Intubators, n (%)			0.524
Anesthesiologist	23 (46.0)	28 (56.0)	
2 nd and 3 rd year anesthesiology residents	19 (38.0)	17 (34.0)	
Nurse anesthetists (>3 yr-experience)	8 (16.0)	5 (10.0)	

Table 2 Endotracheal cuff pressure after passive release technique

	Group C	Group L	P-value
Cuff pressure (cmH ₂ O), mean (SD)	29.24 (6.02)	19.24 (6.27)	<0.001*
Cuff pressure range (cmH ₂ O), n (%)			<0.001*
< 20	4 (8.0)	33 (66.0)	
20-30	23 (46.0)	15 (30.0)	
> 30	23 (46.0)	2 (4.0)	

* Statistically significant

Table 3 V_E/V_I ratio in case of cuff pressure less than 20 cmH₂O

	Mean (SD)	P-value
V_E/V_I ratio at baseline	0.993 (0.051)	0.422
V_E/V_I ratio after passive release technique	0.998 (0.044)	

Table 4 Volume of air inflated or deflated in case of cuff pressure is out of an optimal range

	Median	Min-max	S.E.
Volume of air inflated in a group of cuff pressure < 20 cmH ₂ O (ml)	0.4	0.2-1.2	0.039
Volume of air deflated in a group of cuff pressure > 30 cmH ₂ O (ml)	0.4	0.2-1.2	0.047

different between the disposable syringe group and the loss of resistance syringe group in terms of hoarseness or sore throat.

Discussion

Our study found that the mean endotracheal tube cuff pressure was 29.24±6.02 cmH₂O in the disposable syringe group and 19.24±6.27 cmH₂O in the loss of resistance syringe group. Comparing our findings to previous studies, the mean cuff pressure from the disposable syringe group aligned closely with those reported by Laksono and colleagues which was 30.4±5.5 cmH₂O⁸ and Huh and coworkers which was 26.4±5.9 cmH₂O¹¹. However, in the loss of resistance syringe group, our results indicated lower mean cuff pressure compared to the study conducted by Bulamba and colleagues⁷, which reported the mean cuff pressure of 27.0±5.8 cmH₂O.

Cuff pressure should be maintained

within 20-30 cmH₂O which is considered to be an optimal range to prevent air leaks and complications. Both the disposable and the loss of resistance syringes were effective in achieving endotracheal tube cuff within this range when compared with other techniques. However, no study has compared the cuff pressure between these two syringe types. Our study revealed higher proportions of participants with cuff pressure within an optimal range in the disposable group (46%) compared to the loss of resistance group (30%). A previous study reported a higher incidence of endotracheal cuff within the optimal range (70%) in the study using the disposable syringe.¹² It employed a slightly broader recommended range of 20-35 cmH₂O for cuff pressure, potentially contributing to a higher proportion of optimal endotracheal tube cuff pressure compared to our study.

The disposable syringe group in our study demonstrated a higher incidence of cuff pressure

exceeding 30 cmH₂O (46%), compared to previous findings reported by Laksono and coworkers (23%)⁸. Given the potential complications arising from overinflation with cuff pressures exceeding 30 cmH₂O, we took measures to address this concern. We determined the volume of air required to deflate the cuff to achieve a pressure of 25 cmH₂O. The median volume of air deflated for this purpose was found to be 0.4 ml.

Since friction forces between the syringe plunger and barrel within the loss of resistance syringes were lower than the plastic syringes¹³, this might explain the lower mean cuff pressure observed in the loss of resistance syringe group. As we expected, the loss of resistance syringe group in this study resulted in cuff pressure falling below the optimal range, accounting for 66%. This finding aligned with the previous study by Kim and coworkers (62.5%).¹⁰ However, our study showed a higher proportion of underinflation compared to the study by Bulamba and colleagues which reported 12.3%.⁷ Their study used a smaller-sized loss of resistance syringe (7 ml) compared to the 10 ml syringe used in our study and the study by Kim and coworkers. A recent study reported that the incidence of cuff pressure within the optimal range (20-30 cmH₂O) after inflation endotracheal cuff with 10 ml loss of resistance syringe was 59.3%.¹⁴ Additionally, their study showed that the incidence of underinflation was 18.5%. Due to cuff pressure falling below the optimal range, we raised concerns about airway leakage and aspiration risk in these patients. To address this, we aimed to ensure that the cuff pressure would exceed 20 cmH₂O. Our study revealed that the median volume of air needed to be inflated to

achieve a cuff pressure of 20 cmH₂O was 0.4 ml.

As we were concerned about complications from underinflation of the cuff pressure, we measured the ratio of tidal volume at expiration (V_E) to tidal volume at inspiration (V_I) to detect air leakage. Our findings indicated that the V_E/V_I ratio after the passive release technique was not statistically different from the baseline. This suggests that there might not be a cuff leak present. Furthermore, the study by Park and colleagues demonstrated that the adequate endotracheal cuff pressure capable of preventing air leak, as determined by the spirometer was 18.7 ± 5.2 cmH₂O.¹⁵ This suggests that loss of resistance syringes might achieve an adequate cuff pressure seal without generating excessive pressure that could lead to complications. Besides that, our study did not observe any event of a low tidal volume alarm occurring in any participant, nor did we detect any air leakage audibly. This could imply that there was no incidence of air leaks in this study. However, further studies are needed to confirm this implication.

Concerning the airway complication, we corrected the incidence of hoarseness and sore throat. The incidence of hoarseness and sore throat did not exhibit a statistically significant difference between these two syringe types. These rates are comparable to those reported in the study by Mamuda and coworkers.¹⁶

Our study had several limitations. Firstly, we utilized loss of resistance syringes of different sizes compared to previous studies, which could have resulted in variations in cuff pressure. We aimed to compare the same syringe size between the disposable and loss of resistance syringes.

Secondly, we employed three different brands of anesthetic machines (Drager, GE Datex Ohmeda, and Mindray), which may have contributed to variations in measured tidal volume.

This study represents the initial study to compare cuff pressure following inflation using the passive release technique between the disposable and the loss of resistance syringes. Our findings reveal that the mean cuff pressure obtained through the loss of resistance syringe group in our study is lower compared to some previous studies. Additionally, fewer endotracheal tube cuff pressures were in the optimal range. Further studies involving larger populations are necessary to validate these implications.

Conclusion

The disposable syringe group was superior to the loss of resistance syringe group in providing cuff pressure within an optimal range.

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