

Comparative Analysis of Two Techniques for DLT (Double-Lumen Tube) Insertion in Thoracic Surgery.

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ABSTRACT-

Introduction: Double-lumen tubes (DLTs) are essential tools for achieving lung isolation during thoracic surgeries, allowing for differential ventilation of the lungs and facilitating surgical access and visualization. This paper aims to compare and evaluate these techniques to guide clinical decision-making and improve patient care in thoracic surgery.

Materials and Methods- Forty adult patients scheduled for elective thoracic surgery requiring lung isolation with a double-lumen endotracheal tube (DLT) were recruited for this study. Two DLT insertion techniques, Conventional technique and Modified technique were compared among 40 patients on the points, Time taken for DLT insertion which was divided into T1 and T2, Ease of insertion: Easy, Difficult, Failure, Number of attempts, Incidence of trauma, Use of BURP maneuver (Backward, Upward, Rightward Pressure), Conversion to the Modified technique/ Conventional technique, Blood pressure and Heart rate were recorded at different intervals, Intraoperative respiratory parameters were monitored and recorded Outcome Measures:- Trauma, Assessment of Postoperative Symptoms:-Sore Throat, Odynophagia, Hoarseness. Bronchospasm and Arrhythmia.

Results- The patient demographic data collected were broadly comparable and no significant difference was observed in the demographic data of the two groups studied. There were no significant differences between the upper airway characteristics of each group studied i.e., the Mouth opening, Thyromental distances, the modified Mallampati score, and Cormack-Lehane grade. The comparison between the conventional and modified techniques

were made in terms of time taken T1 and T2 (in seconds), Attempts taken, Trauma during insertion, BURP Maneuver, and EASE of insertion which was found to be better in modified technique as compared to conventional technique. For hemodynamics -the modified technique does not significantly alter hemodynamic parameters compared to the conventional technique, as evidenced by the non-significant P values across all comparisons. Incidence of hoarseness and sore throat was found to be low in the Modified Technique compared to the Conventional Technique. We observed no statistically significant difference in Odynophagia severity between the two Techniques.

Conclusion- our study highlights the significant advantages of a Modified technique for double-lumen tube (DLT) insertion compared to Conventional approaches. By shaping the DLT to mimic a standard endotracheal tube and keeping the stylet in place, the Modified technique streamlines the insertion process, reducing procedural time, minimizing trauma, and requiring fewer attempts for successful placement.

Keywords: Double-Lumen Tube, DLT insertion techniques, thoracic surgery, lung isolation, Modified technique, Conventional technique

Introduction

Double-lumen tubes (DLTs) are essential tools for achieving lung isolation during thoracic surgeries, allowing for differential ventilation of the lungs and facilitating surgical access and visualization. Proper DLT insertion is crucial for maintaining adequate ventilation, preventing contamination of the surgical field, and reducing the risk of intraoperative complications. Over the years, several techniques for DLT insertion have been developed, each with its unique advantages and challenges. This paper aims to compare and evaluate these techniques to guide clinical decision-making and improve patient care in thoracic surgery.

Materials and Methods:

Study Design:

The Anaesthesia department at MGM Superspeciality Hospital in Indore conducted a prospective, single-blinded controlled trial from 2022 to April 2024. The study focused on thoracic cases managed by the CTVS department, aiming to compare the efficacy and safety of two different techniques for Double-Lumen Tube (DLT) insertion in thoracic surgery.

Patient Selection:

Forty adult patients scheduled for elective thoracic surgery requiring lung isolation with a double-lumen endotracheal tube (DLT) were recruited for this study. Inclusion criteria comprised patients categorized as having American Society of Anesthesiologists (ASA) physical status I-III, aged 18 years or older, and in need of one-lung ventilation for thoracic surgery.

Exclusion Criteria:

Patients with any of the following conditions were excluded from the study: History of gastroesophageal reflux, Pregnancy. - Scheduled for tracheostomy, Requiring prolonged postoperative ventilation in the intensive care unit (ICU), Presence of predictors of difficult intubation, such as :- Limited mouth opening (<3 cm), Limited neck extension (<35°), Thyromental distance <6 cm or sternomental distance <12.5 cm at full head extension, Cormack Lehane grade 4.¹, Inability to provide informed consent.

Preoperative Assessment:

All enrolled patients underwent preoperative assessment, which included: -Detailed medical history, Comprehensive physical examination, Relevant investigations. Additionally, patients scheduled for elective surgery were instructed to fast for a minimum of 6 hours before the procedure. These criteria were implemented to ensure patient safety and the validity of the study findings.

Anesthesia Induction: Routine monitors were connected to the patient in the operation theatre like ECG, and SpO₂. Invasive blood pressure was recorded through a 20G radial cannula inserted into the radial artery before induction under local anaesthesia. Anesthesia was induced after preoxygenation using inj. Glycopyrrolate (0.2mg) I/V, inj. Ondansetron (4mg) I/V, inj. Propofol (2mg/kg) I/V, inj. Fentanyl (2 mcg/kg) I/V, and inj. Midazolam (0.03mg/kg) I/V, according to the patient's body weight. Neuromuscular blockade was achieved with inj. Vecuronium (0.1mg/kg), and patients were ventilated with oxygen for 3 minutes after giving neuromuscular blockade. In our study we only used left-sided DLT because of the much greater positioning margin of safety compared to right-sided DLT⁵ also the right main bronchus is shorter than the left. Therefore, a left-sided DLT is used more commonly because of the lower risk of obstructing the right upper lobe bronchus⁶. The appropriate size of the left-sided double-lumen endobronchial tube (DLT) (Portex sizes 35, 37, 39, and 41) was chosen and inserted alternatively using either the conventional or modified technique.

Conventional technique - In the conventional technique we used left-sided DLT. The DLT is advanced through the larynx with the angled tip directed anteriorly. After the bronchial cuff has passed the cords, the tube is turned 90 degrees so that the bronchial portion points toward the appropriate bronchus. The tube is to be placed in the left mainstem bronchus, and the head and neck should be rotated to the right before rotating and advancing the tube. In the conventional method, that we are studying we removed the stylet just after the tube passed the vocal cords to prevent trauma² (Picture 1).

Modified technique- In the modified technique for left-sided double-lumen tube (DLT) insertion, a stylet was utilized to shape the DLT into a configuration resembling a standard endotracheal tube. This shaped DLT was then introduced using a regular laryngoscope. Once the bronchial lumen passed beyond the patient's vocal cords, the stylet was withdrawn. Subsequently, the DLT was gently rotated to the left and advanced into the trachea until encountering resistance. At the point of resistance, advancement of the DLT was halted, and unilateral air entry was confirmed by auscultation sequentially, occluding the tracheal and bronchial lumens (Picture-2).



Picture-1. Showing shape of DLT normally used in Conventional technique

Picture-2 Showing shape of DLT modified to be used in Modified technique with comparison to normal endotracheal tube.

Confirmation of DLT Placement: Confirmation of DLT placement was assessed by auscultation of the desired lung, capnography, movement of the chest wall, and observation of moisture during exhalation in the transparent proximal limb of the DLT and on the catheter mount. Anesthesia maintenance was achieved using a combination of oxygen, nitrous oxide, and isoflurane. Intravenous fentanyl and vecuronium were administered as needed through infusion. Vital signs were continuously monitored throughout the procedure.

Fiberoptic Bronchoscopy: Fiberoptic bronchoscopy (Ambu fiberoptic bronchoscope of size 3.8mm diameter with 600 of length) was performed later after confirming the DLT position through auscultation to confirm the correct position of the tracheal and bronchial limbs of the DLT in their respective bronchi.

Study Protocol:

1. Time taken for DLT insertion was recorded for both the conventional and modified techniques. The time taken was divided into T1 and T2.
T1 - represents the time taken from the point of taking the laryngoscope in hand to entering the bronchial lumen of left-sided DLT into the trachea.
T2 - represents the time taken from entering into the trachea to confirmation of lung isolation by auscultation.
2. Ease of insertion: The ease of insertion was graded on a three-point scale. Easy, Difficult, Failure
An easy insertion was defined as an insertion within the trachea without resistance in a single attempt. A difficult insertion was one in which there was resistance to insertion or where more than one attempt was required to seat the device within the trachea. In case it was not possible to insert the DLT in three attempts it was labelled as a failure.
3. The number of attempts required for DLT insertion was noted for each technique. If DLT was inserted with a Conventional/Modified technique and the trachea couldn't be negotiated or lung isolation couldn't be achieved the DLT was removed and reinsertion attempted. A maximum of three insertion attempts were allowed before the placement of the DLT was considered a failure. In case of failure, an alternative technique (Conventional or Modified technique) was used to secure the airway.
4. Incidence of trauma during DLT insertion was documented in both groups (Trauma, including mucosal abrasions and minor bleeding).
5. Use of BURP maneuver (Backward, Upward, Rightward Pressure) during DLT insertion was recorded¹⁷.
6. Adequacy of lung isolation was confirmed by auscultation and fiberoptic bronchoscopy, with repositioning performed if necessary.
7. Conversion to the Modified technique/ Conventional technique was noted if initial attempts with any of the techniques were unsuccessful.
8. Blood pressure and Heart rate were recorded at intervals of 1min, 3min and 5min.
9. Intraoperative respiratory parameters were monitored and recorded after the placement of DLT.

Outcome Measures:

The outcome measures for this study were determined through various assessments and observations.

1. Examination of Blood on Laryngoscope Blade and Oral Cavity Trauma: - Blood presence on the laryngoscope blade and the presence of trauma, such as laceration or bleeding, in the oral cavity were examined immediately after intubation with DLT.

2. Assessment of Postoperative Symptoms:

Patients were evaluated for the following symptoms in the first three days postoperatively: Sore Throat: Patients rated their sore throat on a visual analog scale (VAS) ranging from 0 (indicating 'none') to 10. Scores above 0 were categorized as mild (1–3), moderate (4–6), or severe (7–10).

- Odynophagia: Similar to sore throat, patients rated their odynophagia on a VAS. Scores above 0 were categorized as mild, moderate, or severe.

- Hoarseness: Hoarseness was classified as absent (0), subjective (1), observed by the anesthesiologist (2), or aphonic (3).

3. Bronchospasm and Arrhythmia:

- Bronchospasm: Bronchospasm was defined as prolonged expiration with wheeze and rising end-tidal CO₂ in the presence of increased airway pressures, desaturation, or a falling tidal volume³. Arrhythmia: Any ventricular or supraventricular premature beats or any sustained rhythm other than sinus rhythm constituted arrhythmia. Arrhythmias that appeared for the first time or increased in frequency by at least four beats per minute were attributed to intubation if observed within 2 minutes of laryngoscopy⁴. These outcome measures were utilized to assess postoperative complications and patient outcomes following thoracic surgery with lung isolation using a double-lumen endotracheal tube.

STATISTICS – On applying Priori Power analysis, it was found that 40 participants with 20 in each group is adequate to detect a difference with a power of 0.8 at an α -level of 0.05. The two-sample t-test, chi-square test of independence and Fisher's exact test were used to determine if there is a statistically significant association exists for insertion of DLT for Time taken (T1 and T2), Attempts Taken, Trauma during insertion, BURP maneuver and Ease of insertion. In addition, hemodynamic data, such as heart rate and blood pressure, were analysed with repeated-measure analysis of variance (ANOVA) for intra- and intergroup comparisons. Bonferroni's post hoc tests were undertaken where appropriate. Data are presented as the mean \pm standard deviation, or the number and proportion as appropriate. SPSS 17.0 software (Apache Software Foundation, Forest Hill, MD, USA) was used for all statistical analyses.

Results :

Out of 82 patients scheduled for thoracic surgery, only 40 patients met the inclusion criteria of the study, 10 patients were less than 18 years old, 7 were assessed to have a difficult airway, 2 declined to participate with negative consent, 13 required intubation on the ICU, and 4 could not give informed consent (due to reduced level of consciousness), 6 patients were posted for emergency surgery. Ultimately, 40 patients were enrolled and their data was collected for the study and its final analysis.

The statistical analysis comparing ages, weight, height, ASA, and gender between the two techniques revealed no significant differences, as indicated by the p-values obtained. The patient demographic data collected were broadly comparable, as shown in Table 1.

Table 1 Patients' demographic and clinical characteristics

S.No		Conventional Technique (n = 20)	Modified Technique (n = 20)	P value
1	Age (years)	40.95 \pm 3.1877	36.1 \pm 10.218	0.324
2	Weight (kg)	58.65 \pm 9.177	56.35 \pm 4.413	0.953
3	Height (cms)	160.594 \pm 1.3229	162.842 \pm 3.3557	0.909
4	ASA physical status I/II/III	0/13/07	0/14/06	0.829
5	Sex Male : Female	14:6	15:5	0.723

The comparison of upper airway characteristics between the two groups (Conventional and Modified technique) showed the following results: Based on the data, there were no significant differences in airway characteristics the upper between the groups, including mouth opening, thyromental distance, modified Mallampati score, and Cormack-Lehane grade (Table 2).

Table- 2. Comparison of Upper airway characteristics of the two groups.

s.no		Conventional Technique	Modified Technique	P- value
1	Mouth opening (cm)	5.665±0.4194	5.475±0.3106	0.172
2	Thyromental distance (cm)	7.8 ± 1.636	8.05 ± 1.106	0.6485
3	Mallampati score I/II/III/IV	11/7/2/0	8/9/3/0	0.795
4	Cormack-Lehane grade I/II/III/IV	13/6/1/0	11/6/3/0	0.771

The studied parameters in 40 adult patients who had undergone elective thoracic surgery, with 20 patients allocated to each group: conventional technique and modified technique as shown in (Table 3).

Table- 3

S.No		Conventional Technique (n = 20)	Modified Technique (n = 20)	P value
1	Time Taken (T1 sec)	37.8 ± 10.407	23 ± 5.03	< 0.05
2	Time Taken (T2 sec)	64.65 ± 2.49874	64.15 ± 3.13247	1.16
3	Attempts Taken 1/2/3	6 / 11 / 3	18 / 2 / 0	< 0.05
4	Trauma during insertion Yes / No	11 / 9	2 / 18	< 0.05
5	BURP Maneuver Yes / No	16 / 4	5 / 15	< 0.05
6	EASE of insertion Easy (E)/ Difficult (D)/ Failure (F)	7 / 13 / 0	20 / 0 / 0	< 0.05

The above table represents the comparison between the conventional and modified techniques in terms of time taken T1 and T2 (in seconds), Attempts taken, Trauma during insertion, BURP Maneuver, and EASE of insertion (Table 3).

- Time Taken (T1 sec):** represents the time taken from the point of taking the laryngoscope in hand to entering the bronchial lumen of left-sided DLT into the trachea. Observed the statistically significant difference in time taken suggests that the modified technique is associated with a shorter duration for performing the procedure compared to the conventional technique. The average time taken for the modified technique (23 seconds) is notably lower than that for the conventional technique (37.8 seconds). This difference is unlikely to have occurred by random chance, as indicated by the low p-value (< 0.05), providing evidence in favour of the modified technique being more efficient in terms of time taken (Table- 3).
- Time Taken (T2 sec):** represents the time taken from entering into the trachea to confirmation of lung isolation by auscultation. The p-value of 1.16 is substantially higher than the conventional significance

level of 0.05. This suggests that there is no statistically significant difference in the time taken between the conventional and modified techniques for performing the procedure, labelled as "Time Taken (T2 sec)" (Table- 3).

3. **Attempts Taken:** The statistically significant difference in attempts taken suggests that the modified technique is associated with a higher success rate and requires fewer attempts to perform the procedure compared to the conventional technique. Specifically, a larger proportion of attempts using the modified technique (90%) were successful on the first try compared to the conventional technique (30%). Additionally, none of the attempts using the modified technique required three attempts, indicating a more efficient and reliable performance of the procedure compared to the conventional technique (Table-3).
4. **Trauma during insertion:** The modified technique appears to significantly reduce the occurrence of trauma during insertion compared to the conventional technique. This could be a valuable finding for medical procedures or device insertions where minimizing trauma is crucial for patient safety and comfort (Table- 3).
5. **BURP maneuver-** In the conventional technique group, the BURP maneuver was used in 16 out of 20 cases for DLT placement, while only 4 cases did not need it. In the modified technique group, the maneuver was required in only 5 out of 20 cases, with 15 cases not needing it (Table-3). The p-value was less than 0.05, indicating a statistically significant difference between the two techniques.
6. **Ease of insertion:** An easy insertion was defined as a single, resistance-free attempt to place the DLT within the trachea. A difficult insertion involved resistance or required multiple attempts, and failure was defined as being unable to insert the DLT in three attempts. In the conventional technique group, 7 out of 20 cases had easy insertions, 13 were difficult, and there were no failures. In the modified technique group, all 20 cases had easy insertions, with no difficult cases or failures. The p-value was less than 0.05, indicating a statistically significant difference between the techniques, suggesting the modified technique significantly improves ease of insertion (Table-3).
7. **Confirmation of DLT by auscultation:** In both Conventional (n = 20), and Modified Technique (n = 20) all DLT placements were confirmed as rightly placed (with no adjustments required) through auscultation. This DLT placement were further confirmed by using a bronchoscope passing through DLT, Suggesting the right placement of DLT in all the cases.
8. **Conversion to Conventional / Modified technique:** In both Conventional (n = 20), and Modified Technique (n = 20) neither technique was converted to the other in any of the cases observed.
9. **Intraoperative Respiratory Parameters:** Intraoperative respiratory parameters, including tidal volume, respiratory rate, and oxygen saturation, remained within normal limits throughout the procedure in both groups. No significant differences were observed between the conventional and modified technique groups.

10. **Hemodynamic. Heart Rate -** Comparing the data of Conventional and Modified techniques for heart rate at different intervals suggested that the modified technique does not significantly alter hemodynamic parameters compared to the conventional technique.

11.Hemodynamic. Blood Pressure -

Comparing the Conventional and Modified techniques by focusing on hemodynamic changes during laryngoscopy procedures, specifically blood pressure. The data suggest that the modified technique does not significantly alter blood pressure parameters compared to the conventional technique.

Table – 4. Hoarseness: Hoarseness was classified as absent (0), subjective (1), observed by the anesthesiologist (2), or aphonic (3).

Post Operative Day	Conventional Technique (n = 20)	Modified Technique (n = 20)	P value
Post Operative Day 1	9	3	<0.05

Severity (None(0)/Mild(1) Moderate(2)/ Severe(3))	(8/1/0/0)	(3/0/0/0)	
Post Operative Day 2 Severity (None(0)/Mild(1) Moderate(2)/ Severe(3))	3 (3/0/0/0)	1 (1/0/0/0)	<0.05
Post Operative Day 3 Severity (None(0)/Mild(1) Moderate(2)/ Severe(3))	0 (0/0/0/0)	0 (0/0/0/0)	>0.05
Post Operative Day 4 Severity (None(0)/Mild(1) Moderate(2)/ Severe(3))	none	none	>0.05

Table -4 represents the hoarseness severity for both the Conventional and Modified Techniques, along with their corresponding p-values.

- **12. Hoarseness:** Day 1: The Conventional Technique resulted in significantly more cases of mild hoarseness compared to the Modified Technique (Table-4). Day 2: The Modified Technique resulted in fewer cases of hoarseness, with a statistically significant difference between the techniques (Table-4). Days 3 and 4: No significant difference in hoarseness was observed, with both techniques resulting in no cases of hoarseness (Table-4). Overall, the Modified Technique led to reduced incidence and severity of hoarseness on the first two days post-operation, with no differences by the third and fourth days.

Table 5: - Sore Throat: Patients rated their sore throat on a visual analog scale (VAS) ranging from 0 (indicating 'none') to 10. Scores above 0 were categorized as mild (1–3), moderate (4–6), or severe (7–10).

Post Operative Day	Conventional Technique (n = 20)	Modified Technique (n = 20)	P value
Post Operative Day 1 Severity, None(0)/Mild (1–3)/Moderate (4–6)/ Severe (7–10).	2 (0/2/0/0)	0 (0/0/0/0)	< 0.05
Post Operative Day 2 Severity, None(0)/Mild (1–3)/Moderate (4–6)/ Severe (7–10).	0 (0/0/0/0)	0 (0/0/0/0)	>0.05
Post Operative Day 3 Severity, None(0)/Mild (1–3)/Moderate (4–6)/ Severe (7–10).	0 (0/0/0/0)	0 (0/0/0/0)	>0.05
Post Operative Day 4 Severity, None(0)/Mild (1–3)/Moderate (4–6)/ Severe (7–10).	none	none	>0.05

13. Post-Operative Sore Throat:

- Day 1: The Conventional Technique resulted in significantly more cases of mild sore throat compared to the Modified Technique, which had no reports of sore throat (Table-5). Days 2, 3, and 4: No significant difference in sore throat severity was observed between the techniques, with no reports of sore throat in

either group (Table-5). Overall, the data suggests a significant difference in sore throat severity on the first day post-operation, favouring the Modified Technique, but no differences on subsequent days

14. Odynophagia and Complications:

- Odynophagia: On days 1-4 post-operation, there was no statistically significant difference in Odynophagia severity between the Conventional and Modified Techniques. No patients in either group reported Odynophagia. Complications: No patients in either group experienced bronchospasm post-intubation or arrhythmias during or after anesthesia induction.

Discussion

Compared to single-lumen tube intubation, inserting a double-lumen tube (DLT) poses increased difficulty due to its larger external diameter, longer straight portion and more rigid structure^{7, 8, 9}. Therefore, even with the better laryngeal view achieved with the laryngoscope devices, limited airway passage space alongside the devices would limit the ease of tube delivery to the laryngeal inlet. The process of DLT insertion itself presents challenges, including managing its size, shape, angulation, and the necessary rotation upon entry into the trachea. Advancement of the DLT may encounter resistance, further complicating the procedure.

Additionally, several factors can impede the accurate placement of the DLT. These include patient-related issues such as bleeding, excessive secretions, limited mouth opening, poor anatomical landmarks, restricted neck mobility, and anteriorly positioned trachea. Technical challenges such as bleeding, insufficient lighting of the laryngoscope, or malfunctioning equipment can also contribute to difficulties in visualizing airway structures, exacerbating the complexity of DLT placement.

In our study, we conducted a comparison of double-lumen tube (DLT) insertion techniques. One technique followed the Conventional approach, while the other technique, developed by our team, was termed the Modified technique. For comparing the two techniques we studied the parameters like time of insertion of DLT (divided into T1- represents the time taken from the point of taking the laryngoscope in hand to entering the bronchial lumen of left-sided DLT into the trachea, and T2 - represents the time taken from entering into the trachea to confirmation of lung isolation by auscultation), ease of insertion, number of attempts required for DLT insertion, trauma during DLT insertion, BURP manoeuvre, DLT position confirmation by auscultation, conversion to Conventional / Modified technique.

Our study demonstrated that implementing the Modified technique, which involves shaping the double-lumen tube (DLT) to resemble a standard endotracheal tube while keeping the stylet in place, significantly reduces the duration (T1) required for DLT insertion through the glottic aperture. Specifically, the time taken (T1) for DLT insertion using the Modified technique was significantly shorter compared to the Conventional technique (23 ± 5.03 seconds vs. 37.8 ± 10.407 seconds, $p < 0.05$).

Although there was no significant difference in the time taken for confirmation of DLT placement (T2) between the two techniques (64.15 ± 3.13247 seconds for the Modified technique vs. 64.65 ± 2.49874 seconds for the Conventional technique, $p = 1.16$), the distinct procedural steps involved in each technique are noteworthy. In the Conventional technique, once the DLT passes through the glottic aperture, the stylet is removed, and the tube is rotated 90 degrees to the left before advancing further into the trachea to achieve lung isolation. This technique relies on a mechanical adjustment (90-degree rotation) to align the bronchial lumen with the left bronchus. In contrast, the Modified technique allows the DLT to revert to its natural shape upon stylet removal, with the left side of the bronchial lumen turning to the left. The DLT is then gently guided further into the trachea, slightly angled to the left, to position the tube precisely within the left bronchial lumen. The correct positioning is later confirmed by auscultation. The Modified technique leverages the DLT's natural shape and a gentle leftward angle to facilitate correct positioning, potentially offering a more intuitive and smoother placement process. Despite the

similar confirmation times, the Modified technique might reduce the need for manipulation, thereby potentially decreasing the risk of trauma or misplacement during DLT insertion.

Similarly, the Modified technique demonstrated a significantly reduced number of attempts required for successful DLT insertion compared to the Conventional technique ($p < 0.05$). Additionally, the incidence of trauma during DLT insertion was significantly lower with the Modified technique compared to the Conventional technique ($p < 0.05$). Furthermore, the utilization of the backward, upward, rightward pressure (BURP) maneuver was notably less frequent with the Modified technique compared to the Conventional technique ($p < 0.05$). These findings collectively indicate that the Modified technique offers a substantial improvement in the ease of DLT insertion when compared to the Conventional technique ($p < 0.05$).

The difference in time taken for DLT insertion (T1), attempts taken, incidence of trauma, BURP maneuver, and ease of insertion between the Modified and Conventional techniques can be attributed to several factors.

1. **Angulation and Shaping of DLT:** In the Modified technique, the DLT is angled and shaped to resemble a standard endotracheal tube while the stylet is kept in place. This preparation allows for smoother negotiation of the glottic aperture as the DLT conforms more closely to the anatomy of the trachea. Consequently, the Modified technique may require less maneuvering and adjustment during insertion, leading to a shorter procedural time. Less number of attempts, less trauma during insertion, and less requirement of BURP maneuver.
2. **Reduction in Resistance:** By shaping the DLT in advance, the modified technique may encounter less resistance as it passes through the glottic opening and into the trachea. The smoother passage of the DLT reduces the need for repeated attempts or adjustments, thereby contributing to a faster insertion process.
3. **Enhanced Visualization and Alignment:** The modified technique, with its pre-angled DLT, may provide improved visualization of the airway structures during insertion. This enhanced visibility allows for more accurate alignment of the DLT with the tracheal axis, facilitating quicker and more precise placement.
4. **Operator Experience and Familiarity:** Operators may find the modified technique easier to perform due to its standardized approach and reduced need for manipulation during insertion. Also, Familiarity with inserting normal endotracheal tube, the modified technique could contribute to increased efficiency and proficiency, further reducing the time required for DLT insertion.

The observed differences in time taken, number of attempts, incidence of trauma, utilization of the BURP maneuver, and ease of insertion between the Modified and Conventional techniques for DLT insertion can be attributed to a combination of factors. The Modified technique's focus on pre-shaping the DLT and ensuring optimal alignment likely streamlines the insertion process, resulting in a shorter procedural duration compared to the Conventional approach.

Similar to our findings, Hsu et al. also investigated DLT insertion techniques by angulating the bronchial lumen of the DLT into a hockey stick shape before insertion. They discovered that angulating the bronchial lumen in this manner, with the tracheal lumen concealed, reduces intubation time and mitigates post-intubation complications.¹⁰

Although the alternative technique used by Hsu et al. differs from ours in certain aspects, such as the method and degree of angulation, both techniques enable easier maneuverability of the DLT. While Hsu et al. angulated the DLT by 90° into the shape of a hockey stick,¹⁰ our modified technique involved shaping the DLT to mimic an endotracheal tube with a curvature angle ranging from approximately 130 to 150 degrees. Despite these differences, both techniques facilitated smooth advancement of the DLT into the trachea without obstruction.

Furthermore, both Hsu et al¹⁰ and our study withdrew the stylet in a single movement once the tracheal orifice had passed through the glottis. This consistency in technique highlights the practicality and feasibility of our approach, demonstrating reduced intubation time and fewer complications.

Jeong Jin Min et al¹¹ also studied DLT insertion by individual angle modification. They concluded in their randomized controlled trial, that intubation with an individually angle modified double-lumen tube reduced the time needed and the number of intubations attempts for successful tracheal intubation in patients with C-L (Cormack-Lehane) grades I-III¹¹.

The studies show that modification by angulation of the DLT shape for patient's upper airway axes might facilitate tube delivery to the glottis and make inserting a double-lumen tube easier and faster. Therefore, we observed that the angled-modified double-lumen tube is superior to the manufacturer-provided double-lumen tube with respect to the time and the number of attempts needed for successful intubation.

Researchers also examined the hemodynamic reactions during and after intubation at various intervals, analyzing changes in heart rate and blood pressure between a Modified technique and a Conventional one during laryngoscopy. The findings revealed that the Modified technique did not yield significant alterations in heart rate and blood pressure responses compared to the Conventional approach at any measured time point, including baseline, during laryngoscopy, and post-laryngoscopy. Statistical analysis showed no significant disparity in heart rate and blood pressure between the two techniques, suggesting their comparability in terms of immediate and short-term effects on cardiovascular parameters during and after laryngoscopy. Hung-Te Hsu also observed no statistically significant hemodynamic response to laryngoscopy in their study¹⁰ Han et al. also observed no advantages in prevention of adverse hemodynamic responses or change in hemodynamic during the orotracheal intubation by videolaryngoscopy¹². Other studies also found only small differences in the hemodynamic response to intubation when using a video-assisted airway device compared with direct laryngoscopy^{13, 14}

Regarding postoperative period, the findings from the study comparing the Conventional intubation technique with a Modified approach provide valuable insights into the postoperative recovery of patients. The analysis of severity scores for complications such as sore throat, hoarseness, and difficulty in swallowing reveals differences between the two techniques.

- The severity of hoarseness was assessed based on a scale ranging from absent to aphonic. On Post-Operative Day 1, the Modified technique showed significantly lower levels of hoarseness compared to the Conventional technique. Similar trends were observed on Post-Operative Day 2, with the modified technique resulting in fewer instances of hoarseness. By Post-Operative Day 3 and Day 4, both techniques exhibited minimal to no hoarseness, with no statistically significant differences between them. This suggests that while both techniques eventually led to minimal hoarseness, the modified technique showed quicker recovery and lower severity in the initial post-operative days.
- For Sore throat severity was evaluated using a visual analog scale, categorized into mild, moderate, and severe. On Post-Operative Day 1, the modified technique group had significantly lower levels of sore throat compared to the conventional technique group. However, by Post-Operative Day 2 and subsequent days, both groups reported minimal to no sore throat, with no statistically significant differences between them. These findings indicate that while the modified technique provided immediate relief from sore throat post-surgery, both techniques eventually resulted in similar outcomes in the later recovery period.

The Modified intubation technique demonstrated a notable advantage over Conventional intubation in reducing the severity of hoarseness and sore throat in post-operative patients. This improvement is attributed to decreased manipulation of the airways, facilitated by the Modified technique's quicker and smoother insertion process compared to the Conventional approach. By minimizing the duration and extent of airway manipulation, the Modified technique potentially mitigates early postoperative vocal cord irritation and dysfunction, thus resulting in a decreased incidence of hoarseness and sore throat immediately after surgery.

The observed decrease in hoarseness and sore throat can be directly linked to the use of the Modified technique, which emphasizes gentle handling of airway structures. This approach minimizes trauma to the delicate vocal cords, reducing the risk of postoperative voice disturbances. These findings carry significant implications for patient comfort and satisfaction, as minimizing postoperative symptoms enhances the overall patient experience. By prioritizing techniques that prioritize gentle airway management, healthcare providers can enhance patient outcomes and satisfaction following surgical procedures.

For Odynophagia its severity was assessed using a visual analog scale, categorized into mild, moderate, and severe. Both the Conventional and Modified techniques showed no cases of odynophagia post-operatively, starting from Day 1 through Day 4. These results suggest that neither technique led to significant discomfort or pain during swallowing in the studied cohort.

Hung-Te Hsu et al¹⁰. found that in the tracheal tube orientation change (TOC) group, hoarseness was less severe on the first postoperative day, and sore throat was less severe on the fourth postoperative day, although no other statistically significant differences were observed. The authors suggested that the large size and intricate structure of the double-lumen tube (DLT) might account for these complications. Stout et al¹⁵. similarly reported that the incidence and severity of postoperative hoarseness and sore throat were directly related to the size of the endotracheal tube, with the DLT sizes used in their study (35 and 37 Fr) being relatively larger than a standard single-lumen tube (SLT), implying that tube size is a critical risk factor.

Despite simplifying the intubation procedure, complete avoidance of contact between the DLT cuffs and the vocal cords during intubation is not feasible. Consequently, there remains a possibility of laryngeal tissue trauma leading to hoarseness. Moreover, laryngeal trauma may occur during surgery and extubation, especially given the potential for injury to the vocal cords from the angulated DLT during removal. These factors collectively underscore the challenges in minimizing postoperative complications related to hoarseness and sore throat, particularly in procedures involving DLTs, and highlight the need for further research to optimize techniques and reduce associated risks.

In conclusion, our study highlights the significant advantages of a Modified technique for double-lumen tube (DLT) insertion compared to Conventional approaches. By shaping the DLT to mimic a standard endotracheal tube and keeping the stylet in place, the Modified technique streamlines the insertion process, reducing procedural time, minimizing trauma, and requiring fewer attempts for successful placement.

The observed benefits extend beyond the immediate procedural phase, as evidenced by the postoperative outcomes. Patients who underwent DLT insertion using the modified technique experienced lower severity and quicker resolution of hoarseness and sore throat in the early postoperative period. This improvement can be attributed to reduced manipulation of airway structures and gentler handling facilitated by the Modified technique.

Overall, our findings advocate for the adoption of Modified DLT insertion techniques in clinical practice to enhance patient outcomes, improve procedural efficiency, and reduce postoperative complications. Further research into optimizing these techniques and mitigating associated risks is warranted to advance the field of airway management and improve patient care.

Limitations of the study include:

1. **Single-Center Study:** The study was conducted at a single center, which may limit the generalizability of the findings to other healthcare settings with different patient populations, equipment availability, and procedural protocols.

- Sample Size:** The sample size of the study may have been relatively small, potentially affecting the statistical power and generalizability of the results. Larger multicenter studies would provide more robust evidence.
- Operator Bias:** The study's outcomes could have been influenced by the expertise and experience of the operators performing the DLT insertions. Operator bias could have affected the consistency and accuracy of the insertion techniques evaluated.
- Study Design:** While the study compared two DLT insertion techniques, it did not employ a blinded or randomized design, which could introduce bias or confounding variables into the results.
- Outcome Measures:** The study primarily focused on procedural outcomes such as insertion time, number of attempts, and incidence of trauma, as well as immediate postoperative complications. Long-term outcomes or patient-reported outcomes were not thoroughly assessed.

Addressing these limitations through larger, multicenter studies with randomized designs, longer follow-up periods, and comprehensive outcome assessments would strengthen the evidence base and provide more robust conclusions regarding the effectiveness and safety of the modified DLT insertion technique.

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