

Original Research Article

COMPARISON OF PREOPERATIVE BEDSIDE AIRWAY ULTRASOUND MEASUREMENTS BETWEEN PATIENTS WITH EASY AND DIFFICULT LARYNGOSCOPY DURING CARDIAC SURGERY: A COMPARATIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Difficult laryngoscopy in cardiac surgery carries heightened haemodynamic risk. Bedside airway ultrasound provides objective, quantifiable measurements of neck anatomy that may supplement conventional clinical predictors and improve preoperative identification of at-risk patients.

Objectives: To compare preoperative bedside airway ultrasound measurements between patients with easy (Cormack–Lehane grade I/II) and difficult (Cormack–Lehane grade III/IV) laryngoscopy during cardiac surgery.

Materials and Methods: A total of 80 adult patients scheduled for elective cardiac surgery under general anaesthesia were enrolled: 57 with easy laryngoscopy (Group A, Cormack–Lehane grade I/II) and 23 with difficult laryngoscopy (Group B, grade III/IV). Preoperative assessments included modified Mallampati score, thyromental distance, sternomental distance, mouth opening, and neck circumference. Bedside ultrasound measured anterior neck soft tissue (ANS) thickness at the hyoid, thyrohyoid membrane, and vocal cord levels; pre-epiglottic space depth; skin-to-epiglottis distance; hyomental distances at rest and full extension; and tongue and sublingual dimensions.

Results: Both groups were comparable in age and sex. All measured ultrasound parameters differed significantly between groups ($p < 0.001$). Patients with difficult laryngoscopy had greater anterior neck soft tissue thickness, greater pre-epiglottic and skin-to-epiglottis distances, larger tongue and sublingual measurements, and shorter hyomental distances at rest and full extension.

Conclusion: Preoperative bedside airway ultrasound demonstrates measurable anatomical differences between cardiac surgery patients with easy and difficult laryngoscopy, particularly in anterior neck soft tissue, epiglottic-region, hyomental, tongue, and sublingual measurements.

Keywords: airway ultrasound; difficult laryngoscopy; cardiac surgery; anterior neck soft tissue; pre-epiglottic space; hyomental distance.

INTRODUCTION

Securing a patent airway is the most critical step at the start of any general anaesthetic. Failure to intubate the trachea — or failure to anticipate the difficulty before anaesthesia is induced — leads to hypoxia, haemodynamic instability, and death. Difficult laryngoscopy, defined as a Cormack–

Lehane grade III or IV at direct laryngoscopy, is reported in 1–18% of patients across general surgical populations, and failed intubation occurs in approximately 0.1–0.3% of cases. The wide variation in reported incidence reflects differences in case mix, patient population, and the criteria used to define difficulty, but even at the lower end of this range the absolute number of patients affected across millions of anaesthetics each year is substantial.

For decades, clinicians have relied on bedside clinical tests to predict difficult laryngoscopy. The modified Mallampati scoring system, introduced to assess the relationship between tongue size and pharyngeal space, remains one of the most widely used tools in preoperative airway evaluation.^[1] The Cormack–Lehane grading system provides a direct intraoperative classification of the laryngeal view obtained at direct laryngoscopy and is the standard reference for defining difficulty.^[2] Other clinical predictors — thyromental distance, sternomental distance, inter-incisor distance, neck circumference, and head-and-neck mobility — have been studied individually and in composite scoring systems. Each has well-documented limitations: sensitivity and specificity for any single test are modest, performance deteriorates in obese patients or in those with distorted neck anatomy, and no combination of clinical tests reliably identifies all patients at risk.

Airway ultrasound has emerged over the past two decades as a reproducible, non-invasive complement to clinical examination. Because ultrasound directly images soft tissue, it quantifies structures that clinical inspection cannot: the thickness of tissue overlying the vocal cords and hyoid bone, the depth of the pre-epiglottic space, the distance from the skin to the epiglottis, and the dimensions of the tongue and sublingual musculature. Systematic documentation of the role of ultrasonography in airway management — including identification of the hyoid bone, thyroid cartilage, cricothyroid membrane, and epiglottis as reliable sonographic landmarks — established a framework within which clinicians with basic point-of-care ultrasound training can obtain reproducible airway measurements at the bedside.^[3]

Specific measurement techniques for the anterior neck and submandibular region were characterised in detail and linked to the practicalities of clinical airway assessment. These descriptions standardised how ANS thickness is measured at multiple anatomical levels — the hyoid bone, the thyrohyoid membrane, and the vocal cords — and how each level corresponds to identifiable sonographic landmarks, making the measurements reproducible across operators and settings.^[4] The anterior neck soft tissue thickness at the vocal cord level, in particular, has been shown to correlate with the degree of laryngeal visualisation, as excess soft tissue in this region narrows the hypopharyngeal space and impedes the line of sight to the glottis during direct laryngoscopy. The hyomental distance and its ratio between the neutral and fully extended head position can also be measured ultrasonographically, providing a bedside assessment of effective neck extension that is independent of body habitus and therefore applicable even when clinical palpation is unreliable.

The practical value of point-of-care ultrasound in predicting difficult laryngoscopy was demonstrated in a pilot study showing that anterior neck soft tissue measurements in awake patients before induction of anaesthesia were feasible, reproducible, and correlated with the laryngoscopy grade subsequently

obtained.⁵ That early work catalysed a series of prospective studies evaluating the hyomental distance ratio, the depth of the pre-epiglottic space, and soft tissue thickness at multiple cervical levels as individual and combined predictors of difficult laryngoscopy across general surgical, obstetric, and emergency medicine settings.

Cardiac surgery patients represent a distinct and high-risk subset within this literature. Many are older, carry a higher prevalence of obesity and obstructive sleep apnoea, may have undergone prior sternotomy or neck surgery, and present with significant cardiovascular comorbidities that reduce tolerance of prolonged or repeated laryngoscopy attempts. In this population, even a brief hypoxic episode from a failed first attempt at laryngoscopy can precipitate ventricular arrhythmia or haemodynamic collapse. Despite the elevated clinical stakes, data evaluating airway ultrasound specifically in cardiac surgical patients remain limited. Most published data derive from general surgical, obstetric, or emergency medicine populations, and whether the same ultrasound parameters and their optimal thresholds apply to patients presenting for cardiac procedures is unknown.

This comparative observational study was designed to address that gap. We compared preoperative bedside airway ultrasound measurements between patients who had easy laryngoscopy (Cormack–Lehane grade I/II) and those who had difficult laryngoscopy (Cormack–Lehane grade III/IV) during elective cardiac surgery.

MATERIALS AND METHODS

This was a comparative observational study conducted in the department of anesthesiology of a tertiary care medical institute. Adult patients (aged 18 years and older) scheduled for elective cardiac surgery under general anaesthesia with endotracheal intubation were enrolled after obtaining written informed consent. Patients with emergency surgery, known airway pathology (tumours, burns, or fibrosis involving the neck or oropharynx), tracheostomy in situ, refusal of consent, or inability to cooperate with preoperative ultrasound were excluded.

Preoperative clinical airway assessment was performed by the attending anaesthesiologist and included: modified Mallampati score (Class I–IV) in the sitting position with the tongue maximally protruded; thyromental distance (mentum to thyroid notch with head fully extended); sternomental distance (mentum to sternal notch with head fully extended); inter-incisor distance in maximum mouth opening; neck circumference at the level of the thyroid cartilage; and head-and-neck mobility (classified as normal or reduced).

Bedside airway ultrasound was performed by a trained anaesthesiologist using a portable ultrasound machine with a high-frequency linear probe (7.5–10 MHz) for anterior neck measurements and a

curvilinear probe for hyomental distance assessment. The patient was supine with head in neutral position. Parameters measured were: ANS thickness at the hyoid level, thyrohyoid membrane level, and vocal cord level, using the corresponding sonographic landmark at each level; depth of the pre-epiglottic space; distance from skin to epiglottis; hyomental distance at rest (HMD-R) and at full neck extension (HMD-FE); tongue width and thickness by submental scan; and sublingual soft tissue thickness. All measurements were made before induction of anaesthesia. The sonographer was blinded to the subsequent laryngoscopy grade.

Laryngoscopy was performed by a senior anaesthesiologist using a Macintosh direct laryngoscope following standard induction. The

laryngeal view was graded according to the Cormack–Lehane classification: Grade I (full glottis view), Grade II (partial view), Grade III (only epiglottis visible), Grade IV (no laryngeal structures visible). Grades I and II were classified as easy laryngoscopy (Group A) and Grades III and IV as difficult laryngoscopy (Group B). The laryngoscopist was blinded to ultrasound findings.

Data were analysed using SPSS version 25.0. Continuous variables are expressed as mean $\pm$ standard deviation and compared between groups by the independent-samples t-test. Categorical variables are expressed as frequencies and percentages and compared by chi-square test or Fisher's exact test as appropriate. A p-value < 0.05 was considered statistically significant.

RESULTS

Table 1: Age and gender distribution of the study population (n = 80). p-values by independent-samples t-test (age) and chi-square test (sex). NS = not significant

Variable	Group A — Easy (n = 57)	Group B — Difficult (n = 23)	p-value
Mean age (years $\pm$ SD)	54.3 $\pm$ 9.8	57.1 $\pm$ 10.2	0.26
Age ≤ 40 years, n (%)	7 (12.3%)	2 (8.7%)	
Age 41–50 years, n (%)	16 (28.1%)	5 (21.7%)	
Age 51–60 years, n (%)	23 (40.4%)	9 (39.1%)	
Age > 60 years, n (%)	11 (19.3%)	7 (30.4%)	
Male sex, n (%)	38 (66.7%)	14 (60.9%)	0.62
Female sex, n (%)	19 (33.3%)	9 (39.1%)	

A total of 80 patients were enrolled: 57 in Group A (easy laryngoscopy) and 23 in Group B (difficult laryngoscopy). The two groups were comparable in age and sex. [Table 1]

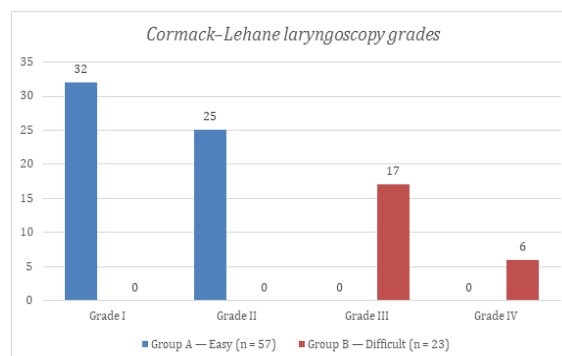
Patients with difficult laryngoscopy had significantly higher BMI and neck circumference, shorter

thyromental and sternomental distances, smaller mouth opening, higher modified Mallampati class, and more frequent reduced head-and-neck mobility compared with the easy laryngoscopy group. [Table 2]

Table 2: Anthropometric and clinical airway assessment parameters by group. Continuous variables by independent-samples t-test; categorical variables by chi-square test. IID = inter-incisor distance; BMI = body mass index

Parameter	Group A — Easy (n = 57)	Group B — Difficult (n = 23)	p-value
BMI (kg/m ²), mean $\pm$ SD	24.8 $\pm$ 3.2	28.6 $\pm$ 3.9	< 0.001
Neck circumference (cm), mean $\pm$ SD	35.4 $\pm$ 2.8	39.2 $\pm$ 3.1	< 0.001
Mouth opening / IID (cm), mean $\pm$ SD	4.4 $\pm$ 0.5	3.6 $\pm$ 0.6	< 0.001
Thyromental distance (cm), mean $\pm$ SD	7.8 $\pm$ 0.9	6.2 $\pm$ 0.8	< 0.001
Sternomental distance (cm), mean $\pm$ SD	14.2 $\pm$ 1.4	12.1 $\pm$ 1.3	< 0.001
Mallampati class I/II, n (%)	51 (89.5%)	7 (30.4%)	< 0.001
Mallampati class III/IV, n (%)	6 (10.5%)	16 (69.6%)	< 0.001
Normal head/neck mobility, n (%)	54 (94.7%)	16 (69.6%)	0.002

By design, all patients in Group A had a Cormack–Lehane grade of I or II and all in Group B had a grade of III or IV. The distribution of grades within each group is shown in Graph 1.



Graph 1: Distribution of Cormack–Lehane laryngoscopy grades within each group (n = 80)

Hyoid and epiglottic region measurements all differed significantly between groups. The difficult laryngoscopy group had shorter hyomental distances

at rest and full extension, greater pre-epiglottic space depth, and a greater skin-to-epiglottis distance. [Table 3]

Table 3: Comparison of hyoid and epiglottic region ultrasound measurements between groups. All comparisons by independent-samples t-test. HMD-R = hyomental distance at rest; HMD-FE = hyomental distance at full neck extension

Ultrasound Parameter	Group A — Easy (n = 57)	Group B — Difficult (n = 23)	p-value
HMD at rest [HMD-R] (cm), mean ± SD	6.8 ± 0.7	5.6 ± 0.8	<0.001
HMD at full extension [HMD-FE] (cm), mean ± SD	8.1 ± 0.8	6.4 ± 0.7	<0.001
Pre-epiglottic space depth (cm), mean ± SD	1.4 ± 0.3	2.1 ± 0.4	<0.001
Distance skin to epiglottis (cm), mean ± SD	2.3 ± 0.4	3.1 ± 0.5	<0.001

ANS thickness was significantly greater in Group B at all three measurement levels. The distance from the skin surface to the vocal cords was also significantly

increased in the difficult laryngoscopy group. [Table 4]

Table 4: Comparison of anterior neck soft tissue (ANS) measurements between groups. All comparisons by independent-samples t-test

Ultrasound Parameter	Group A — Easy (n = 57)	Group B — Difficult (n = 23)	p-value
ANS thickness at hyoid level (cm), mean ± SD	0.7 ± 0.1	1.2 ± 0.2	<0.001
ANS thickness at thyrohyoid membrane (cm), mean ± SD	0.9 ± 0.2	1.5 ± 0.3	<0.001
ANS thickness at vocal cord level (cm), mean ± SD	1.8 ± 0.3	2.8 ± 0.4	<0.001
Distance skin to vocal cords (cm), mean ± SD	2.6 ± 0.4	3.6 ± 0.5	<0.001

Tongue dimensions and sublingual tissue thickness were significantly larger in the difficult laryngoscopy group. [Table 5]

Table 5: Comparison of tongue and sublingual region ultrasound measurements between groups. All comparisons by independent-samples t-test

Ultrasound Parameter	Group A — Easy (n = 57)	Group B — Difficult (n = 23)	p-value
Tongue width (cm), mean ± SD	5.1 ± 0.5	5.8 ± 0.6	<0.001
Tongue thickness (cm), mean ± SD	4.8 ± 0.6	5.7 ± 0.7	<0.001
Sublingual soft tissue thickness (cm), mean ± SD	1.4 ± 0.3	2.0 ± 0.4	<0.001

DISCUSSION

This comparative observational study enrolled 80 cardiac surgery patients, including 57 with easy and 23 with difficult laryngoscopy and compared preoperative bedside airway ultrasound measurements between them. Every measured ultrasound parameter differed significantly between groups. ANS thickness at the vocal cord level was substantially greater in the difficult group (2.8 ± 0.4 cm) than in the easy group (1.8 ± 0.3 cm; $p < 0.001$), and pre-epiglottic space depth was likewise greater in the difficult group (2.1 ± 0.4 cm versus 1.4 ± 0.3 cm; $p < 0.001$).

The finding that increased ANS thickness at the vocal cord level was associated with difficult laryngoscopy echoes the landmark work of Ezri et al., who first demonstrated in obese patients that the skin-to-anterior-tracheal-wall distance at the vocal cord level was significantly greater in those with difficult versus easy intubation (2.7 cm versus 1.8 cm).^[6] Our mean values — 2.8 ± 0.4 cm in the difficult group versus

1.8 ± 0.3 cm in the easy group — are similar in magnitude to those measurements, supporting an association between greater anterior neck soft tissue thickness and poorer laryngeal visualisation.

Submandibular sonography has been used to assess hyomental distance and changes in hyomental distance with neck extension when clinical measurement is limited by obesity or soft tissue excess.^[7] In the present study, both HMD at rest and HMD at full extension were shorter in the difficult laryngoscopy group than in the easy group (5.6 ± 0.8 cm versus 6.8 ± 0.7 cm, and 6.4 ± 0.7 cm versus 8.1 ± 0.8 cm, respectively; both $p < 0.001$).

A systematic review and meta-analysis by Benavides-Zora et al. pooled data from multiple prospective studies and identified ultrasound measurements around the epiglottic region as useful components of difficult-laryngoscopy assessment.^[8] In the present study, pre-epiglottic space depth was greater in the difficult group than in the easy group (2.1 ± 0.4 cm versus 1.4 ± 0.3 cm; $p < 0.001$),

supporting the presence of a measurable anatomical difference in this region.

Srinivasarangan et al. evaluated ANS measurements specifically at the hyoid and vocal cord levels and reported differing diagnostic performance across measurement sites.^[9] In the present study, ANS measurements at the hyoid, thyrohyoid membrane, and vocal cord levels were all greater in the difficult laryngoscopy group (all $p < 0.001$). Petreşor et al. compared clinical and ultrasound-derived hyomental measurements in patients with and without morbid obesity and found that ultrasound measurements were useful when clinical landmarks were obscured by excess soft tissue.^[10] The shorter hyomental distances observed in the difficult group in our study are consistent with the relevance of this sonographic region to airway assessment.

Yadav et al. reported that ultrasound-assisted airway parameters provided useful information alongside conventional clinical predictors.^[11] Waindeskar et al. similarly evaluated skin-to-epiglottis distance and anterior neck measurements in a prospective cohort.^[12] In the present study, both skin-to-epiglottis distance and ANS thickness at the vocal cord level were significantly greater in patients with difficult laryngoscopy (both $p < 0.001$).

Harjai et al. evaluated preoperative ultrasonographic airway assessment and reported useful discrimination from anterior neck measurements at the thyrohyoid membrane level.^[13] Udayakumar et al. likewise evaluated ultrasound and clinical airway parameters for difficult laryngoscopy.^[14] The present study does not compare diagnostic accuracy across parameters, but it demonstrates significant between-group differences at all three ANS measurement levels.

Andrews et al. compared routine preoperative ultrasound-guided airway examination with clinical examination alone in elective surgical patients and found broadly comparable predictive performance between the two approaches.^[15] Their findings support a complementary rather than a replacement role for ultrasound in preoperative assessment. In the cardiac surgical context specifically, where the consequences of an unanticipated failed airway are disproportionately severe, a brief preoperative ultrasound assessment could enable earlier preparation of alternative strategies — awake fiberoptic intubation or video laryngoscopy — when the scan identifies high-risk anatomy.

This study adds comparative data from a cardiac surgery setting that is largely absent from the existing literature. The consistent direction of between-group differences across the ultrasound parameters suggests that a brief bedside assessment of anterior neck, epiglottic-region, hyomental, tongue, and sublingual measurements may provide objective supplementary information during preoperative cardiac anaesthesia evaluation.

Several limitations apply. The relatively small single-centre sample limits precise estimation of the prevalence of difficult laryngoscopy. The study is single-centre and used only Macintosh direct

laryngoscopy; performance relative to video laryngoscopy grading was not assessed. External prospective validation in larger cardiac surgical cohorts is needed.

CONCLUSION

Preoperative bedside airway ultrasound identifies anatomical differences between cardiac surgery patients with easy and difficult laryngoscopy. Differences were demonstrated in anterior neck soft tissue, epiglottic-region, hyomental, tongue, and sublingual measurements. These findings support the use of airway ultrasound as an objective adjunct to conventional preoperative airway assessment.

Declarations

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Consent: Obtained

REFERENCES

1. Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict difficult tracheal intubation: a prospective study. *Can Anaesth Soc J*. 1985;32(4):429–434. doi:10.1007/BF03011357
2. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia*. 1984;39(11):1105–1111. PMID: 6507827
3. Kristensen MS. Ultrasonography in the management of the airway. *Acta Anaesthesiol Scand*. 2011;55(10):1155–1173. doi:10.1111/j.1399-6576.2011.02518.x
4. Kundra P, Mishra SK, Ramesh A. Ultrasound of the airway. *Indian J Anaesth*. 2011;55(5):456–462. doi:10.4103/0019-5049.89868
5. Adhikari S, Zeger W, Schmier C, et al. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. *Acad Emerg Med*. 2011;18(7):754–758. doi:10.1111/j.1553-2712.2011.01099.x
6. Ezri T, Gewürtz G, Sessler DI, et al. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. *Anaesthesia*. 2003;58(11):1111–1114. doi:10.1046/j.1365-2044.2003.03412.x
7. Wojtczak JA. Submandibular sonography: assessment of hyomental distances and ratio, tongue size, and floor of the mouth musculature using portable sonography. *J Ultrasound Med*. 2012;31(4):523–528. doi:10.7863/jum.2012.31.4.523
8. Benavides-Zora D, Jaramillo MC, Townsley MM, et al. Diagnostic performance of airway ultrasound for the assessment of difficult laryngoscopy: a systematic review and meta-analysis. *J Cardiothorac Vasc Anesth*. 2023;37(7):1101–1109. doi:10.1053/j.jvca.2023.02.036
9. Srinivasarangan M, Akkamahadevi P, Balkal VC, Javali RH. Diagnostic accuracy of ultrasound measurements of anterior neck soft tissue in determining a difficult airway. *J Emerg Trauma Shock*. 2021;14(1):33–37. doi:10.4103/JETS.JETS_12_20
10. Petreşor C, Trancă S, Szabo R, Simon R, Prie A, Bodeola C. Clinical versus ultrasound measurements of hyomental distance ratio for the prediction of difficult airway in patients with and without morbid obesity. *Diagnostics*. 2020;10(3):140. doi:10.3390/diagnostics10030140
11. Yadav U, Singh RB, Chaudhari S, Srivastava S. Comparative study of preoperative airway assessment by conventional clinical predictors and ultrasound-assisted predictors. *Anesth Essays Res*. 2020;14(2):213–218. doi:10.4103/aer.AER_52_20
12. Waindeskar V, Padala SRAN, Jain S, Kiran M, Mandal P, Pakhare AP. Prediction of the difficult airway by pre-operative ultrasound-based measurement of airway

- parameters: a prospective observational study. *Indian J Anaesth.* 2023;67(9):785–790. doi:10.4103/ija.ija_464_23
13. Harjai M, Alam S, Rastogi S, Kumar S. Effectiveness and validity of preoperative ultrasonographic airway assessment and clinical screening tests to predict difficult laryngoscopy: a prospective, observational study. *Cureus.* 2023;15(7):e41933. doi:10.7759/cureus.41933
 14. Udayakumar GS, Priya L, Narayanan V. Comparison of ultrasound parameters and clinical parameters in airway assessment for prediction of difficult laryngoscopy and intubation: an observational study. *Cureus.* 2023;15(7):e41392. doi:10.7759/cureus.41392
 15. Andrews G, Kalingarayar S, Nandhakumar A, Pr B, Kesavan B, Kola Sridharan N. Comparison of routine preoperative ultrasound-guided airway examination versus clinical airway examination in predicting difficult laryngoscopy in patients coming for elective surgery: an observational study. *Cureus.* 2024;16(11):e73225. doi:10.7759/cureus.73225.