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Role of Ultrasound in Airway Assessment

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Abstract:

Airway management remains a cornerstone of safe anesthesia practice. Unanticipated difficult intubation continues to be a major cause of perioperative morbidity and mortality. Traditional bedside airway assessment methods such as the Mallampati classification and thyromental distance have limited predictive value. Recently, ultrasonography (USG) has emerged as a promising, non-invasive, and reproducible tool for real-time visualization of airway anatomy and prediction of difficult laryngoscopy and intubation.

Keywords: Ultrasonography; Airway assessment; Difficult intubation; Hyomental distance ratio; Skin-to-epiglottis distance; Cormack–Lehane grade.

Introduction:

Difficult airway management remains a persistent challenge in anesthetic practice and a leading cause of perioperative complications worldwide. Accurate preoperative identification of potentially difficult intubation is critical for planning and preventing adverse outcomes such as hypoxia or failed airway **(1).** Traditional bedside predictors like the Mallampati classification, thyromental distance, and inter-incisor gap are commonly used; however, their sensitivity and specificity remain suboptimal, and unanticipated difficulties still occur **(2).**

Recently, ultrasonography (USG) has gained increasing attention as a reliable imaging modality for dynamic visualization of the airway. It allows for real-time assessment of soft tissue structures including the tongue, epiglottis, vocal cords, and trachea, without exposure to radiation or discomfort **(3).** USG has been successfully used to estimate the degree of airway difficulty, guide endotracheal intubation, confirm endotracheal tube placement, and evaluate airway pathology **(4).**

Ultrasound-based airway measurements, such as skin-to-epiglottis distance**,** tongue thickness**,** and hyomental distance ratio**,** have demonstrated significant correlation with Cormack–Lehane grades, improving prediction accuracy compared to traditional methods **(5).** As ultrasonography becomes increasingly accessible in perioperative settings, integrating it into routine preoperative assessment protocols may enhance airway safety and reduce the incidence of unanticipated difficult intubations.

With conventional transcutaneous ultrasonography, the airway can be visualized from the tip of the chin to the midtrachea, along with the pleural aspect of the most peripheral alveoli and the diaphragm (**6**).

A. Mouth and Tongue

The floor of the mouth and the tongue are easily visualized by placing the transducer submentally. If the transducer is placed in the coronal plane just posterior to the mentum and from there moved posteriorly until the hyoid bone is reached, one can perform a thorough evaluation of all the layers of the floor of the mouth, the muscles of the tongue, and any possible pathologic processes (**7).**

A longitudinal scan of the floor of the mouth and the tongue (Figure 1) is obtained if the transducer is placed submentally in the sagittal plane. The acoustic shadows from the symphysis of the mandible and from the hyoid bone form the anterior and posterior limits of this image (**8).**

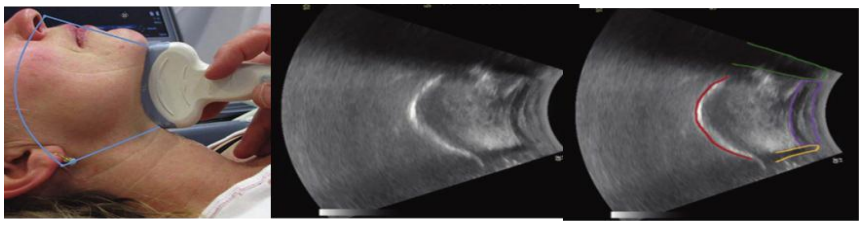

Figure (1): Longitudinal scan of the floor of the mouth and the tongue. **Left**, Placement of the curved low-frequency transducer. The area covered by the scan is outlined in light blue. **Middle**, The resulting ultrasound image. **Right**, The shadow from the mentum of the mandible is outlined in green, the muscles in the floor of the mouth in purple, the shadow from the hyoid bone in light orange, and the dorsal surface of the tongue in red (**9).**

Transverse scans obtained in the midsection of the tongue (at the glossal end of the genioglossus muscle) provided a measure of the tongue width, which was measured between the most distant points on its upper surface. The midsagittal scans were also used to measure the cross-sectional area of the tongue. The tongue volume was derived from multiplication of the midsagittal cross-sectional area by the tongue width (Figure 2). **(10).**

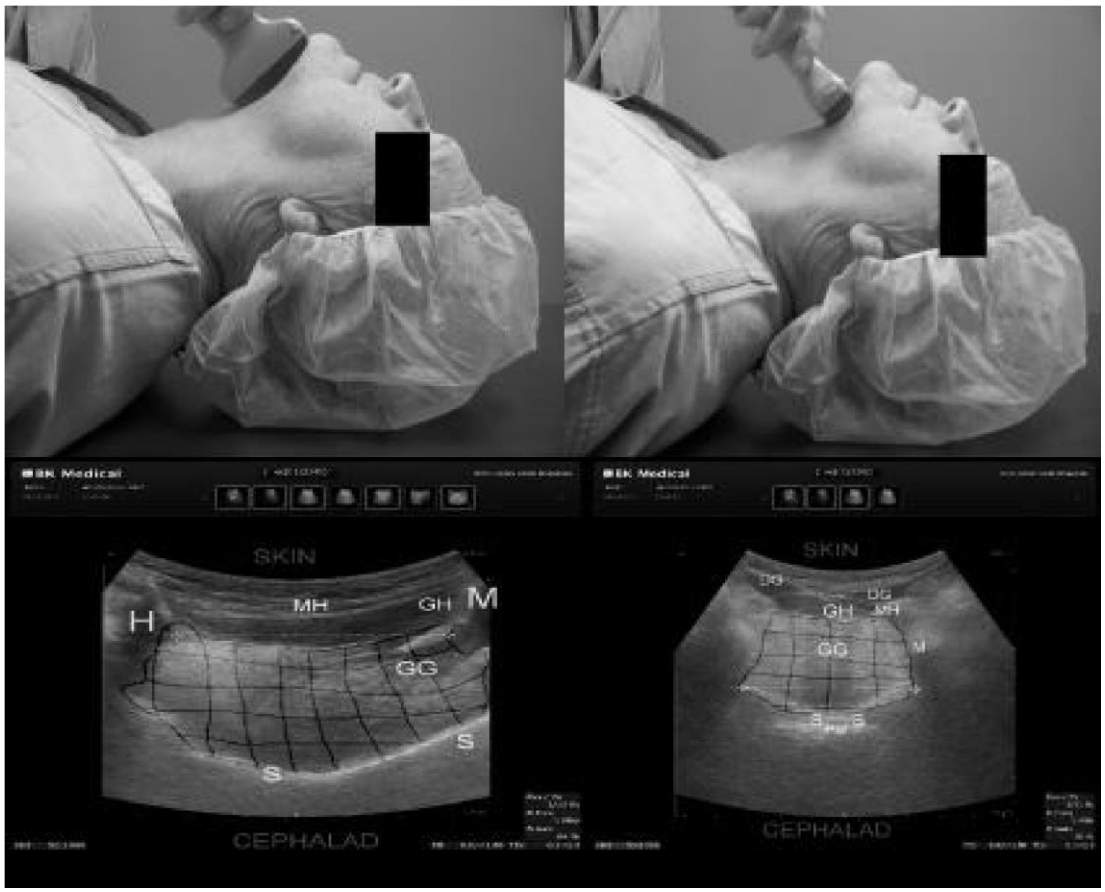

Figure (2): Positioning of the ultrasound probe and sonographic anatomy of the suprahyoid airway in midsagittal (left) and transverse (right) scans.DG indicates diglossus muscle; GG, genioglossus muscle; GH, geniohyoid muscle; H, hyoid bone; M, mandible; MH, mylohyoid muscle; Pal, palate; and S, tongue surface (**11).**

B. Hyoid Bone

The hyoid bone is visible on the transverse view as a superficial, hyperechoic, inverted U shaped, linear structure with posterior acoustic shadowing. On the sagittal and parasagittal views, the hyoid bone is visible in cross section as a narrow, hyperechoic, curved structure that casts an acoustic shadow (**12).**

The anterior neck soft tissue thickness at the level of the hyoid bone (ANS-Hyoid) (Figure 3) is one of the methods of airway assessment by ultrasonography. If it is 1.69 cm [1.19 cm to 2.19 cm], this suspects difficult laryngoscopy. If it is 1.37cm [1.27 cm to 1.46 cm], this suspects easy laryngoscopy **(13).**

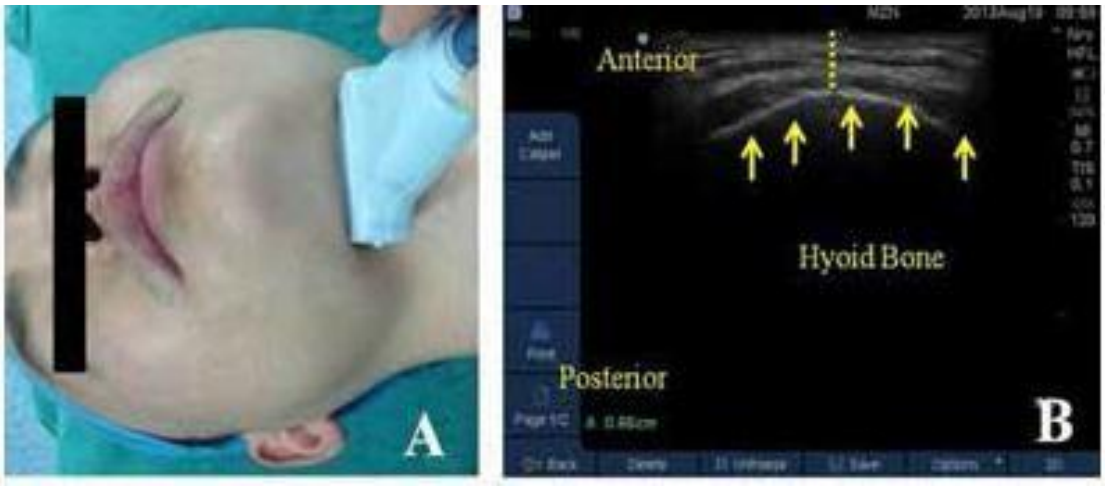

Figure (3): shows the anterior neck soft tissue thickness at the level of the hyoid bone , (A)hyoid bone level,(B)yellow arrows denote hyoid bone, yellow dotted line denotes the distance from skin to hyoid bone (**7).**

The hyomental distance of the patient in neutral position of the neck and in fully extended neck calculating the ratio between both of them is one of methods of airway assessment by ultrasonography. If the mean hyomental distance ratio is (1.02 ± 0.01), this suspects difficult intubation. If it is (1.14 ± 0.02), this suspects easy intubation **(9).**

C. Larynx

The different parts of the laryngeal skeleton have different sonographic characteristics. The hyoid bone is calcified early in life, and its bony shadow is an important landmark. The thyroid and cricoid cartilages show variable but progressive calcification throughout life, whereas the epiglottis stays hypoechoic. The true vocal cords overlie muscle that is hypoechoic, whereas the false cords contain echoic fat. The thyrohyoid membrane runs between the caudal border of the hyoid bone and the cephalad border of the thyroid cartilage and provides a sonographic window through which the epiglottis can be visualized in all subjects when the linear transducer is oriented in the transverse plane (with varying degrees of cephalad or caudad angulation) (**11).**

The midline sagittal scan through the upper larynx (Figure 4) from the hyoid bone cranially to the thyroid cartilage distally reveals the thyrohyoid ligament, the pre-epiglottic space containing echogenic fat, and, posterior to that, a white line representing the laryngeal surface of the epiglottis.**(6).**

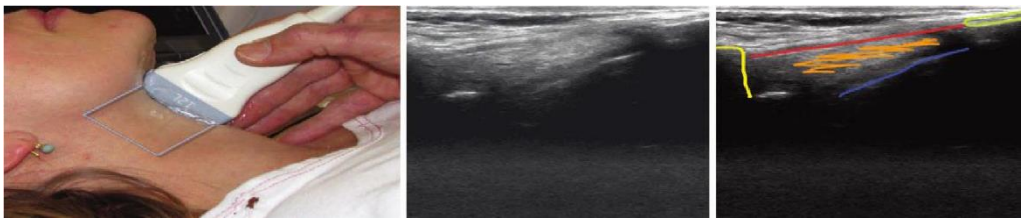

Figure (4): shows midline sagittal scan from the hyoid bone to the proximal part of the thyroid cartilage. Left, the light blue outline shows the area covered by the scan. Middle, The scanning image. Right, The shadow from the hyoid bone is marked in yellow, the thyrohyoid membrane in red, the posterior surface of part of the epiglottis in blue, the pre-epiglottic fat in orange, and the thyroid cartilage in green (**6).**

The ratio of the depth of the pre-epiglottic space (Pre-E) to the distance from the epiglottis to the mid-point of the distance between the vocal cords (E-VC) is one of the methods of airway assessment by Ultrasonography (Figure 5) **(9).**

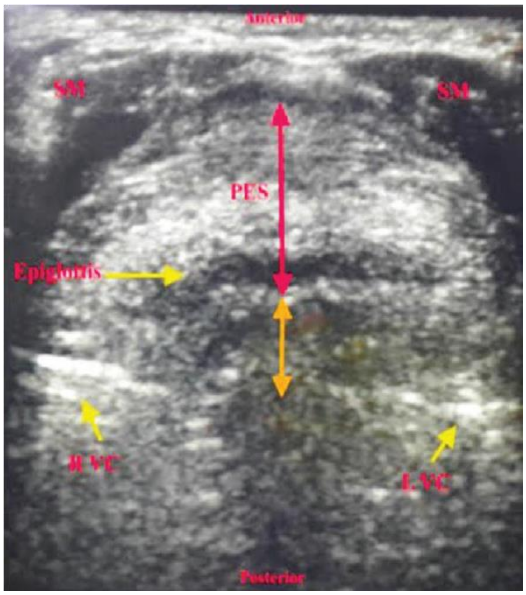

Figure (5): shows the preepiglottic space .SM – Strap Muscles; R VC – Right Vocal Cord; L VC – Left Vocal Cord; Red arrow – Depth of the pre-epiglottic space; Orange arrow – Distance from the epiglottis to the mid-point of the distance between the vocal cords (**6).**

If it is [0–1], this suspects Cormack-Lehane Grade 1. If it is [1–2], this suspects Cormack-Lehane Grade 2. If it is [2–3], this suspects CormackLehane Grade 3.

D. Vocal Cords

In individuals with noncalcified thyroid cartilages, the false and the true vocal cords can be visualized through the thyroid cartilage (Figure 6). In individuals with calcified thyroid cartilage, the vocal cords and the arytenoid cartilages can still be seen by combining the scan obtained by placing the transducer just cranially to the superior extension (**11).**

The true vocal cords appear as two triangular, hypoechoic structures (the vocalis muscles) outlined medially by the hyperechoic vocal ligaments. They are observed to oscillate and move toward the midline during phonation. The false vocal cords lie parallel and cephalad to the true cords, are more hyperechoic in appearance, and remain relatively immobile during phonation. **(6).**

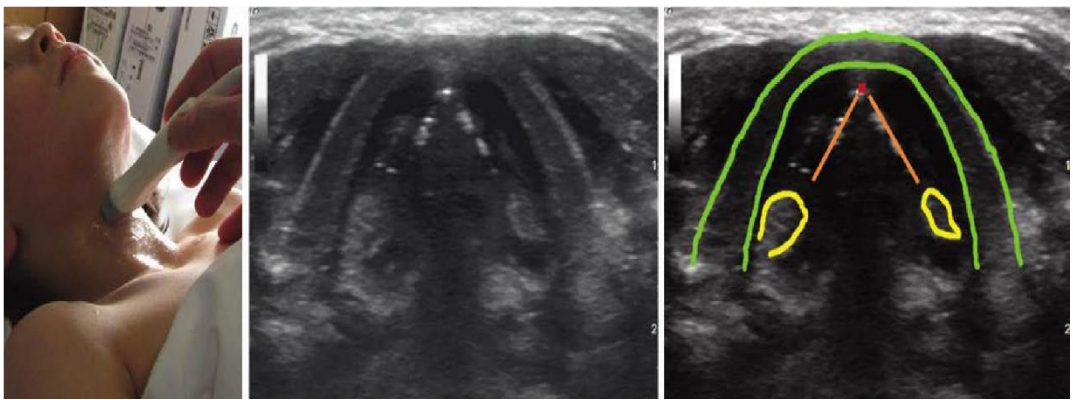

Figure (6): shows transverse midline scan over the thyroid cartilage in an 8-year-old boy. Left, Placement of the transducer. Middle, The scanning image. Right, The thyroid cartilage is marked in green, the vocal cords in orange, the anterior commissure in red, and the arytenoid cartilages in yellow (**6)**

The anterior neck soft tissue thickness at the level of the vocal cords

(ANS-VC) is one of the methods of airway assessment by ultrasonography. ANS-VC >0.23 cm had a sensitivity of 85.7% in predicting a Cormack-Lehane Grade 3 or 4 **(11).**

E. Cricothyroid Membrane and Cricoid Cartilage

The cricothyroid membrane runs between the caudal border of the thyroid cartilage and the cephalad border of the cricoid cartilage. It is clearly seen on sagittal and parasagittal views as a hyperechoic band linking the hypoechoic thyroid and cricoid cartilages (Figure 7). The cricoid cartilage has a round, hypoechoic appearance on the parasagittal view and an arch-like appearance on the transverse view **(9).**

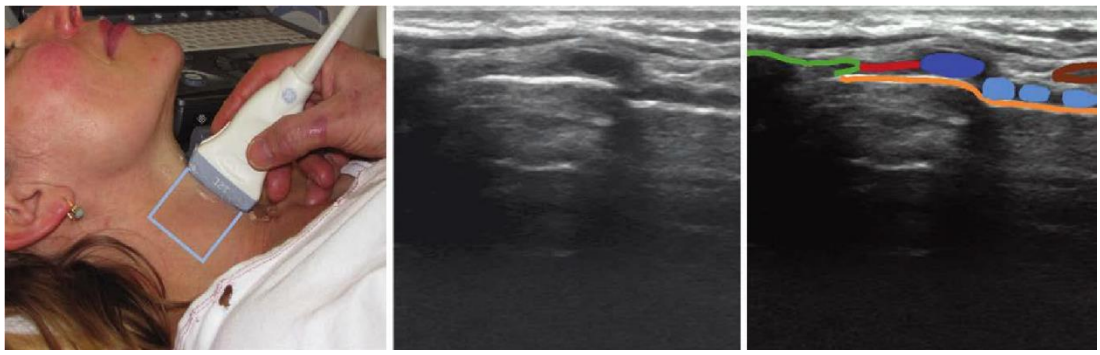

Figure (7): shows cricothyroid membrane. Left, the linear high-frequency transducer is placed in the midsagittal plane. The scanning area is marked with light blue. Middle, the scanning image. Right, the thyroid cartilage is marked in green, the cricoid cartilage in dark blue, the tracheal rings in light blue, the CTM in red, the tissue-air border in orange, and the isthmus of the thyroid **(6).**

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