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Ultrasound comparison of external and internal neck anatomy with the LMA Unique

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Keywords

airway anatomy, ultrasound, extraglottic device

Abstract

Introduction: Internal neck anatomy landmarks and their relation after placement of an extraglottic airway devices have not been studied extensively by the use of ultrasound. Based on our group experience with external landmarks as well as internal landmarks evaluation with other techniques, we aimed use ultrasound to analyze the internal neck anatomy landmarks and the related changes due to the placement of the Laryngeal Mask Airway Unique. **Methods:** Observational pilot investigation. Non-obese adult patients with no evidence of airway anomalies, were recruited. External neck landmarks were measured based on a validated and standardized method by tape. Eight internal anatomical landmarks, reciprocal by the investigational hypothesis to the external landmarks, were also measured by ultrasound guidance. The internal landmarks were re-measured after optimal placement and inflation of the extraglottic airway devices cuff Laryngeal Mask Airway Unique. **Results:** Six subjects were recruited. Ultrasound measurements of hyoid-mental distance, thyroid-cricoid distance, thyroid height, and thyroid width were found to be significantly ($p < 0.05$) overestimated using a tape measure. Sagittal neck landmark distances such as thyroid height, sternal-mental distance, and thyroid-cricoid distance significantly decreased after placement of the Laryngeal Mask Airway Unique. **Conclusion:** The laryngeal mask airway Unique resulted in significant changes in internal neck anatomy. The induced changes and respective specific internal neck anatomy landmarks could help to design devices that would modify their shape accordingly to areas of greatest displacement. Also, while external neck landmark measurements overestimate their respective internal neck landmarks, as we previously reported, the concordance of each measurement and their respective conversion factor could continue to be of help in sizing extraglottic airway devices. Due to the pilot nature of the study, more investigations are warranted.

Introduction

Ultrasound is a versatile way of visualizing internal anatomy noninvasively. In anesthesia, ultrasound has been growing in use for procedures such as peripheral nerve blocks and for anatomical landmark recognition in airway assessment[(1)]. In this regard, placement of an extraglottic device might modify airway anatomy and such change could be evaluated using ultrasound.

Use of extraglottic airway devices (EADs) is an alternative way to maintain the airway during surgical procedures compared to endotracheal tubes. Even though success rates are high for EADs and they are widely used, there are many risks that may lead to complications[(2)]. Both methods require accurate sizes and placement in order to function well and avoid complications such as sore throat and vocal cord paralysis[(3–5)].

	Mdn	IQR
Age (yr)	26.5	24.5–41.3
Height (cm)	176.5	173.6–179.5
Weight (kg)	81.5	79.5–87.3
BMI (kg/m^2)	27.0	24.3–29.4
	n	%
Male	5	80

Tab. 1. *Demographics of the study population*

Recent studies have tried to resolve this issue by directly examining airway size using radiologic measurements[6–8]. Ultrasound (US) imaging technique has recently emerged as a simple, portable, and noninvasive tool to assess airway management[1,8,9]. Limitations of ultrasound include the decrease in resolution when observing dense tissue and internal anatomy of obese patients.

There are a wide variety of EADs[3,10–12] with many different indications: they are categorized by mechanism of seal (cuffed or uncuffed), site of sealing (peri-laryngeal or base-of-tongue), and type of material. Insertions of EADs may fail due to anatomical differences in the peri-laryngeal area. Furthermore, some clinicians have been using a height-based model instead of the manufacturer (weight) model. New sizing criteria in adults that include an assessment of neck anatomy might be preferred over a height- or weight-based model[13–15].

In the present observational pilot investigation, we aimed to utilize ultrasound to assess internal landmarks before and after extraglottic device insertion: specifically, the primary aim of this study was to compare changes in internal neck anatomy after the EAD is inserted and inflated. The secondary aim of this study was to compare measurements of internal neck landmark (INL) diameters with the laryngeal mask airway (LMA) Unique dimensions in order to assess the efficacy of the manufacturer's sizing criteria. The third aim of this study was to create a new model to estimate internal neck landmark diameters using tape measurements of external landmarks based on previous simulations utilizing ENL and EAD dimensions[14,15].

Material and methods

After obtaining institutional approval from the Committee for the Protection of Human Subjects (HSC-MS-10-0204), written informed consent was acquired from 6 non-obese (BMI 30 kg/m^2) subjects that were 18–80 years old, ASA I-II and Mallampati I-II, with no evidence of airway anomalies, presenting for anesthesia preoperative assessment (Tab. 1). Each subject was measured for external landmarks outlined in Tab. 2 using a measuring tape to the nearest tenth of a centimeter, mirroring the methods in a previous study[13]. The same neck landmarks were assessed by using a 12 MHz linear transducer (Sonosite M-Turbo) before and after extraglottic airway device LMA Unique placement. All tape measurements were performed by a research team member after a training period, assessing concordance between an anesthesiologist expert in airway management and the team. The ultrasound measurements were performed by the anesthesiologist. Inner and outer dimensions (inner cuff length and width; outer cuff length and width) of these devices were measured to the nearest tenth of a centimeter while inflated. Each patient was sized based on a manufacturer (weight-based) model (Tab. 3).

Imaging data was assessed utilizing ImageJ software and the ultrasound machine program's caliper as a standard. Medians and interquartile range (IQR) were summarized for patient demographics. Differences in measurements were compared using a Wilcoxon signed-ranked test. Concordance was defined as ≤ 0.5 cm difference in neck landmark measurement and device dimensions. Transverse neck landmarks were only compared with LMA cuff width, and sagittal neck landmarks were only compared with LMA cuff length. Statistical analyses were performed using SAS 9.3 (SAS Institute. Inc., Cary, NC) and an $\alpha = 0.05$ was considered significant.

Results

The sagittal INLs such as thyroid height (TH), sternal-mental distance (SMD), and thyroid-cricoid distance (TCD) significantly decreased after placement of an LMA

Landmark	Description
Hyoid mental distance (HMD)	Lower midline border of mandible in jaw occlusion extended to upper border of hyoid bone
Thyroid mental distance (TMD)	Mentum as per HMD extended to thyroid notch
Sternal mental distance (SMD)	Mentum as per HMD extended to sternal notch
Hyoid thyroid distance (HTD)	Upper border of hyoid bone extended to thyroid noth
Hyoid cricoid cartilage distance (HCD)	Hyroid bone to upper border of cricoid cartilage
Thyroid height (TH)	Thyroid notch to lower border of cricoid cartilage
Thyroid cricoid distance (TCD)	Thyroid notch to upper border of cricoid cartilage
Thyroid width (TW)	Lateral border of upper thyroid cartilage
External neck landmarks were measured with a tape measure; internal neck landmarks with a digital caliper. Images were combined and distances summated if too large to fit in one picture.	

Tab. 2. *Guidelines for measuring external and internal landmarks*

Sizing criteria		LMA Unique – dimensions (cm)			
Size	Masa ciała (kg)	Outer cuff width (OW)	Outer cuff width (OW)	Inner cuff width (IW)	Inner cuff length (IL)
3	30–50	5	7.5	4.5	5
4	50–70	6	8.5	5	6
5	70–100	6.5	9.5	6	6.5

Criteria for sizing of the LMA Unique used for each participant. Sagittal neck landmarks were compared with cuff length and transverse measurements were compared with cuff width

Tab. 3. *Extraglottic airway device sizing criteria*

(Fig. 1 and Tab. 4). Thyroid width (TW) was the only transverse landmark to significantly show an increase in size after placement of an LMA (Fig. 2). Concordance (maximum of 0.5 cm difference) was only found between inner dimensions of the LMA and INL measurements. Hyoid-cricoid distance (HCD) and inner cuff length had the least difference in diameter (Tab. 5). All INL measurements except for SMD were smaller than both outer and inner LMA cuff dimensions. Based on ultrasound evaluation, hyoid-mental distance (HMD), TCD, thyroid height (TH), and TW were found to be significantly ($p < 0.05$) overestimated using a tape measure with TW being the most overestimated. Using a linear regression a patient's predicted internal neck measurement can be calculated using the following equation: (0.9 × external neck tape measurement) – 0.4 cm (Fig. 3). The predicted internal neck measurement increased by 0.9 cm for each cm of external neck measurement.

INL	No LMA		With LMA		*p* – value
	Mdn	*IQR*	*Mdn*	*IQR*	
HMD	3.48	3.27–3.86	3.04	2.92–3.48	0.046
TMD	5.27	5.17–6.44	5.02	3.86–5.34	0.046
SMD*	13.50	13.19–13.99	11.75	11.53–11.90	0.028
HTD	1.88	1.76–2.04	2.09	1.67–2.25	0.917
HCD	6.33	5.95–6.88	5.73	5.18–6.05	0.075
TH*	3.18	2.83–3.71	2.79	2.58–2.96	0.028
TCD*	4.38	4.29–4.66	3.69	3.57–3.85	0.028
TW*	3.72	3.06–3.94	4.14	3.92–4.72	0.028

Significant decreases in sagittal neck landmark measurements as a result of the LMA.

* Calculated W < critical W for 5% level. *P*-values are not accurate due to a sample size <10

Tab. 4. *Comparison of LMA and no LMA US measurements (cm)*

Discussion

This study, while pilot and preliminary, showed that internal neck measurements are overestimated by using external neck tape measurements (Fig. 3). Placement of an inflatable EAD has shown to alter the anatomy of the neck. In adults, EAD caused compression and ventral displacement of the laryngeal inlet (Fig. 2): such alteration could be seen by the LMA shortening the linear distance between sagittal neck landmarks such as HMD (Fig. 1). Russo and colleagues found similar distortions to the neck anatomy, using MRI, assessing the position of i-gel and LMA Supreme[7], yet a radiological evaluation in a pediatric cohort did not show changes in respiration

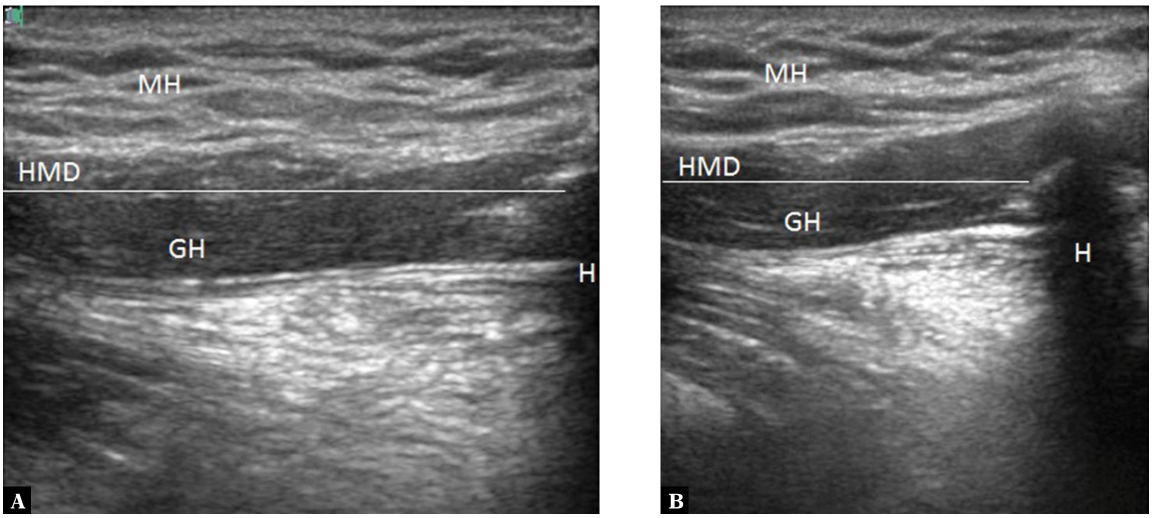

Fig. 1. A. *Submandibular sagittal view no LMA.* ***B.*** *Submandibular sagittal view with LMA. H – hyoid bone, MH – mylohyoid, GH – geniohyoid, HMD – hyoid-mental distance*

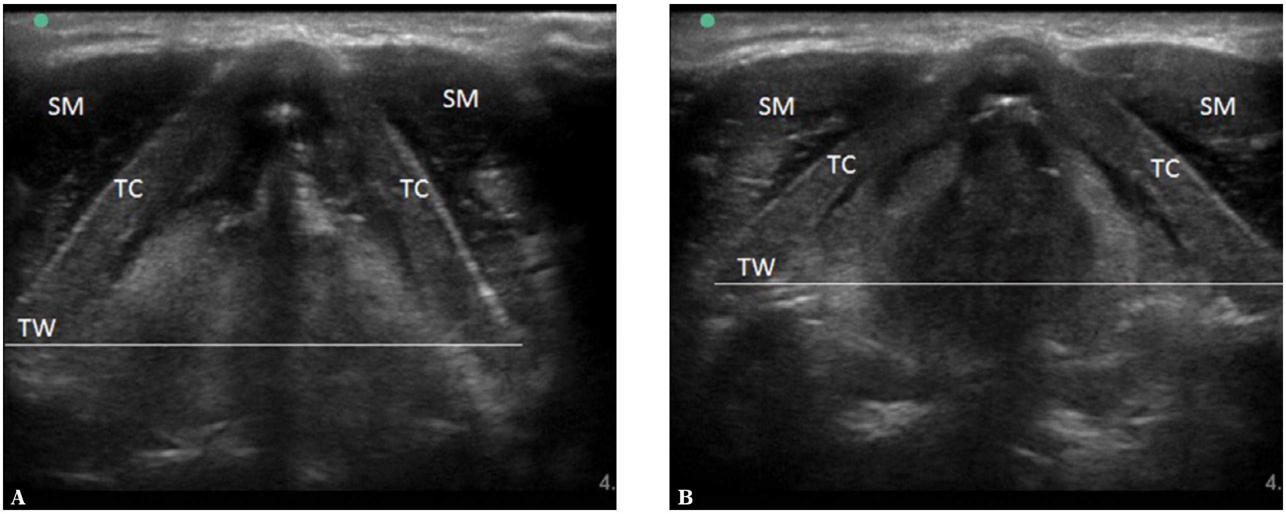

Fig. 2. A. *Midline transverse view of upper thyroid no LMA.* **B.** *Midline transverse view of upper thyroid with LMA. SM – strap muscles, TC – thyroid cartilage, TW – hyroid width*

or effectiveness due to sizing(16). Interestingly, almost all internal neck diameters were overestimated by measuring the LMA inner cuff diameter, a result that was significantly different from what was previously studied(15). Based on this preliminary study (Fig 3.), a linear regression could help to correct the overestimation of internal anatomy and be used in EAD sizing, as previously noted for ENL correlation(14).

A possible explanation for our results could lay in the fact that EADs are designed to be larger to compensate for diversity in airway anatomy and to maintain sufficient seal pressure. However, having a larger deviation in size could lead to more complications: for example, wearing shoes that are too large or too small for your foot can lead to injuries caused by friction between your foot and the shoe. Using an insole for your shoe, much like an inflatable cuff on an EAD, will help reduce injury, but it is not comparable to simply wearing a shoe with an appropriate shoe size.

There are limitations to the use of external neck landmarks as measuring tools or predictive tools of the airway. The first study that we have done used tape measurements of ENLs(13) and correlated the measurements with EAD diameters(14,15). Even though ENLs such as thyromental distance has been associated in predictions of difficult laryngoscopy, results have been unreliable and inconsistent(17,18). In addition, previous studies have looked at ratios of different external landmarks to improve predictions(19–21). These results have been more promising but there is no clear indicator as to why these ratios are important.

Limitations of this study include generalization between different extraglottic airway devices with differing mecha-

Anatomy dimmension	LMA Unique					
	Outer dimension			Inner dimension		
	Concordance (%)	Difference (LMA-INL)		Concordance (%)	Difference (LMA-INL)	
		Mdn (cm)	IQR (cm)		Mdn (cm)	IQR (cm)
HMD	0.0	5.8	5.4–6.0	0.0	2.9	2.6–3.0
TMD	0.0	3.7	2.8–4.3	16.7	1.0	–0.1–1.3
SMD	0.0	–4.4	–4.6–3.9	0.0	–7.2	–7.5–6.9
HTD	0.0	7.6	6.9–7.7	0.0	4.6	4.1–4.7
HCD*	0.0	2.9	2.2–3.6	33.3	–0.1	–0.5–0.6
TH	0.0	5.9	5.7–6.4	0.0	3.1	2.8–3.5
TCD	0.0	4.9	4.5–5.2	0.0	1.9	1.7–2.2
TW	0.0	2.8	2.6–3.1	0.0	2.1	2.1–2.4

Concordance (maximum 0.5 cm difference) was only found between inner dimensions of the LMA and INL measurements. Objaśnienia skrótów – patrz tab. 2.

* HCD and inner cuff length had the least median difference of -0.1 cm

Tab. 5. *LMA compared with INL*

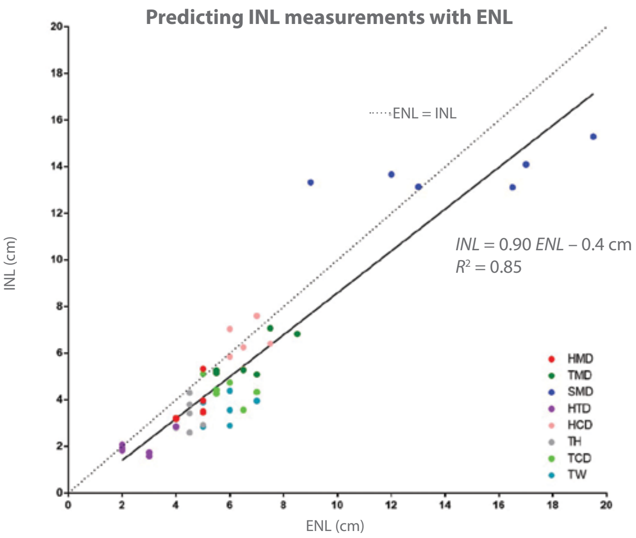

Fig. 3. *Comparison of INL (ultrasound) and ENL (tape measure) measurements. The dotted line represents a 1:1 conversion of ENL and INL measurements. Most ENL measurements are greater than INL measurements*

nisms (inflated versus uninflated cuff) and low sample size. Differences in the positioning of EADs complicates things further[2,3]. Even though placement of these EADs could be different, outcomes from using different devices do not differ though.

External landmarks are imprecise and can alter outcomes dramatically because they are not good estimators of internal anatomy[22]. However, ENL, INL and US could be useful when combined to assess noninvasively, conveniently, and reliably the position of an EAD. The current manufacturer sizing system considers weight in its criteria, but there could be other parameters that may set better criteria and improve successful device placement. In addition, these tools can be used to help to design more effective EADs. Future studies should compare and confirm the concordance of EAD dimensions[15,16] and INL measurements with difficulty in EAD placement.

Conclusions

The insertion of the laryngeal mask airway Unique resulted in significant changes in internal neck anatomy. The induced changes and respective specific INL could help design devices that would modify their shape accordingly to areas of greatest displacement. Also, while external neck landmark measurements overestimate their respective internal neck landmarks, as we previously reported, the concordance of each measurement and their respective conversion factor could continue to be of help in sizing EAD. Due to the pilot nature of the study, more investigations are warranted.

Conflict of interest

Authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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