Role of Ultrasonography in Difficult Airway Management

Anju Gupta[1], Nishkarsh Gupta[2]* and Riddhima Sharma[1]

[1]VMMC and Safdarjung Hospital, New Delhi, India

[2]DRBRAIRCH, AIIMS, New Delhi, India

*Corresponding author: Nishkarsh Gupta, Associate Professor, DRBRAIRCH, AIIMS, New Delhi, India, Tel: +91 9868398338; E-mail: drnishkarsh@rediffmail.com

Citation: Gupta A, Gupta N, Sharma R (2018) Role of Ultrasonography in Difficult Airway Management. J Anaesthesiol Crit Care Vol 1 No.2:11

Abstract

Ultrasound is a recent addition to anaesthesiologist armamentarium and is gaining importance in every skill related to the field. Clinical airway assessment is still far from being full proof at present. Use of point of care ultrasound for the real time dynamic imaging of airway structures such as epiglottis, cricoid cartilage, cricothyroid membrane etc. has several advantages. The sono-anatomy of the airway structures may help the anaesthesiologist to assess the size of airway, predict difficulty in intubation, mark the site for needle cricothyroidotomy, and detect any airway related pathologies. In times to come, Ultrasound may become an indispensable tool for management of airway in patients. In this review we discuss the importance of ultrasound as a tool for airway management.

Keywords: Ultrasonography; Airway management

Introduction

Safe airway management is the prime goal of anaesthesiologists. Despite remarkable progress in the technology in this regard with a huge armamentarium to aid of anaesthesiologist difficult airway (DA) remains a significant concern and airway related critical events are the leading cause of anaesthesia related morbidity and mortality [1]. Unanticipated DA continues to be encountered even after airway assessment with clinical tests [2]. Conventionally, airway imaging has been done with X-Ray, MRI and CT-scan. These have the disadvantage of being expensive, pose radiation hazard, provide static images of airway, require bulky equipment, and are not easily available. The application Ultrasonography (US) is increasing exponentially over time in emergency, critical care and perioperative settings. It is increasingly being used as a powerful adjunct in airway assessment and management. In a comparison of visualization of airway structures using CT-scan and ultrasonography and measurement of airway assessment parameters, good correlation was found in the two modalities [3].

Advantage of Ultrasonography for Airway Management

It is a safe, simple, portable, non-invasive, cost effective device that provides real time live views of the airway at the bed side.

Basic Principles

Air in the airway structures may make it difficult for US to spot the anatomy but because of superficial location the sonographic visualization of these structures is possible with high frequency (8-13Hz) probe and may be better than high resolution CT and MRI. Deeper structures are better visualized using the curved low-frequency transducer. Imaging of upper airway is done in transverse, sagittal and parasagittal views at different levels.

Uses of Airway Ultrasound

Its applications include assessment and prediction of difficult airway, prediction of size of the endotracheal and double lumen tube, confirm correct placement of endotracheal intubation, guide percutaneous tracheostomy, time the weaning from ventilator, assess fasting status (measure cross sectional area of stomach antrum) and to rule out airway related emergencies like pneumothorax **(Table 1)** [3,4,5,6,7,8,9,10].

Role of USG in Management of Difficult Airway

Airway assessment

Recognition of difficult airway is purported to be the most important factor in successful management of difficult airway. Regarding difficult airway prediction, recently a lot of sonographic parameters have been suggested as useful like soft tissue thickness anterior to trachea, tongue base width, volume and cross-sectional area of tongue, thickness of lateral pharyngeal wall, hyomental distance ratio and pre epiglottic space [4,5]. A combination of soft tissue thickness on anterior aspect of trachea (at three levels) and the neck circumference

(>50 cm) and hyomental distance ratio<1.1 on US (ratio of hyomental distance in neutral and hyper extended neck) correlates with difficult laryngoscopy in morbidly obese patients [6,7]. Ratio of tongue base width with pharyngeal wall thickness has been associated with obstructive sleep apnoea.8In patients with sleep apnoea, ultrasonic visualization of approximation of tongue base posterior and inferiorly towards the hypopharynx correlated with airway obstruction. Intraoral sublingual approach using visibility of hyoid bone has been suggested as a surrogate to predict difficult airway [9].

Table 1: Clinical applications of airway ultrasonography in DA management [4-10].

Airway US uses	Comment
Predict difficult airway	Shown to be useful in obese patients.
Diagnose airway anomalies	Can diagnose vocal cord malfunction, laryngeal stenosis, papillomatosis, maxillary sinusitis, tumours or a Zenker's diverticulum.
Identify cricothyroid membrane	Can be useful in case emergency cricothyroidotomy is needed, for oxygen insufflations by prophylactic placement of transtracheal catheter, topicalisation or retrograde intubation.
Estimation of gastric volume and nature of contents prior to airway management	Especially useful in emergency cases when history is not available and emptying is variable. Cross section at the level of antrum is reliable and nature of contents (particulate or liquid) can be assessed.
Airway related nerve blocks	Preparation of awake intubation in case of anticipated DA. Superior laryngeal and recurrent laryngeal nerve block increase success and safety.
Predict sleep apnoea	Approximation of tongue base posterior and inferiorly towards the hypopharynx correlated with airway obstruction
Predict the suitable diameter of ETT, or tracheostomy tubes	Prediction of ETT size especially in paediatrics to decrease tube changes.
Detect esophageal intubation	Detects esophageal intubation before ventilation is initiated and may be useful in cardiac arrest situation when capnography may not be reliable.
Detect endobronchial intubation	A bilateral presence of lung sliding and diaphragm descent in noisy environments where it is difficult to listen to stethoscope.
Localise trachea and tracheal ring interspaces for tracheostomy and PDT	Real time US improves the success rate and safety by identifying aberrant vessel in the path and appropriate depth of insertion.

Management of difficult airway

In patients with an anticipated difficult airway, US guided superior laryngeal and recurrent laryngeal blocks for awake intubation using has high success rate and safety [10]. US can also be used to identify and mark the cricothyroid membrane beforehand for rescue cricothyrotomy cannula placement in case of failure to intubate and ventilate [11].

Prediction of endotracheal tube size

US guided measurement of subglottic diameter has been found to accurately predict tracheal tube size in paediatric patients as compared to age-based formulas [12]. US can measure actual subglottic and help in deciding the appropriate size of the endotracheal tube (ETT) [13]. US guided measurement of left main stem bronchus size and reliably predict double lumen tube size and this correlates well with CT and MRI. It also helps to predict size and shape of tracheostomy tube.

Confirm ETT placement

Confirmation of proper endotracheal tube placement is another promising application of US can be done by either direct or indirect method [4,5,14]. Directly visualizing ETT entering either trachea or esophagus by keeping the probe transversely at the level of sternal notch or looking for vocal cords widening keeping probe at thyrohyoid membrane (in children) is one way.

A bright hyperechoic curved line deep to trachea reliably predicts esophageal intubation. This helps to diagnose it before initiating mechanical ventilation and reduces gastric insufflations and its consequences. Also, bilateral lung-sliding and diaphragmatic movement is a surrogate marker for tracheal intubation. Similarly, a unilateral pleural and diaphragmatic movement suggest endobronchial intubation. Bedside US is fast and can be considered a feasible substitute to conventional techniques (auscultation and waveform capnography) especially in emergency room where background noise [14].

Confirmation of laryngeal mask airway placement

US can reliably confirm correct placement of supraglottic devices like laryngeal mask airway (LMA) and rules out causes of inadequate ventilation [15]. A LMA cuff inflated with fluid and seen equally on both sides of larynx suggest a good laryngeal seal and may be better than fiberoptic examination.

Role in intensive care units

US helps to assist during percutaneous dilatational tracheostomy (PDT) by measuring the tracheal width, distance from the skin and provides real time visualisation of the needle and guide wire. It is being increasingly used alone or in conjunction with fiberoptic scope [16]. Thus it may decrease the complications and increase the overall success rate of the procedure (e.g. cranial misplacement, major haemorrhage,

posterior tracheal wall puncture, injury to thyroid isthmus). US use for PDT may decrease the incidence of hypercapnia and inconvenience associated with fibreoptic bronchoscopy (FOB). In addition, it is a fast and sensitive tool to detect suspected pneumothorax or pleural effusion. An air column width of less than 4.5 ± 0.8 mm after extubation may associated with stridor after extubation [17].

Miscellaneous applications

In addition, US has been utilized in diagnosing various conditions with implication for airway management e.g. vocal cord malfunction, swallowing abnormalities, sialolithiasis, supraglottic hemangiomas, respiratory papillomatosis, laryngeal stenosis, Zenker's diverticulum, maxillary sinusitis etc. [5,18,19].

Recent Advances in Airway US

Recently, transesophageal US is used to provide distal airway images from mid-trachea to bronchi. Additionally, endoscopic high frequency US of larynx with a thin catheter high frequency probe with rotating mirror has been shown to produce a 360° image of larynx [20]. With the advancements in technology, small smartphone based systems can increase applicability of US in remote areas.

Limitation of Sonography

Its use is dependent on operator skills and requires training and has a steep learning curve. A high level of physical agility and knowledge of appropriate sonoanatomy is required to become proficient in its use.

Conclusion

Ultrasonography with its numerous applications has brought a paradigm shift in airway management. It has been hailed as visual stethoscope of clinicians. With increased availability, knowledge and further improvement in technology, its use in airway management may become a routine in future. At present, US can be considered as a point of care complement to other imaging techniques to assist in day to day clinical scenarios rather than a replacement.

References

1. Reed MJ, Dunn MJ, McKeown DW (2005) Can an airway assessment score predict difficulty at intubation in the emergency department? Emerg Med J 22: 99-102.

2. Shiga T, Wajima Z, Inoue T, Sakamoto A (2005) Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. Anesthesiology 103: 429-437.

3. Prasad A, Yu E, Wong DT, Karkhanis R, Gullane P, et al. (2011) Comparison of sonography and computed tomography as imaging tools for assessment of airway structures. J Ultrasound Med 30: 965-972.

4. Reddy PB, Punetha P, Chalam KS (2016) Ultrasonography - A viable tool for airway assessment. Indian J Anaesthesia 60: 807-813.

5. Osman A, Sum KM (2016) Role of upper airway ultrasound in airway management. J Intensive Care 4: 52.

6. Ezri T, Gewürtz G, Sessler DI, Medalion B, Szmuk P, et al. (2003) Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. Anaesthesia 58: 1111-1114.

7. Wojtczak JA (2012) Submandibular sonography: assessment of hyomental distances and ratio, tongue size, and floor of the mouth musculature using portable sonography. J Ultrasound Med 31: 523-528.

8. Bilici S, Engin A, Ozgur Y, Onerci CO, Gorkem YA, Hande YA (2017) Submental Ultrasonographic Parameters among Patients with Obstructive Sleep Apnea. Otolaryngol Head Neck Surg 156: 559-566.

9. Tsui BC, Hui CM (2008) Sublingual airway ultrasound imaging. Can J Anaesth 55: 790-791.

10. Kaur B, Tang R, Sawka A, Krebs C, Vaghadia H (2012) A method for ultrasonographic visualization and injection of the superior laryngeal nerve: volunteer study and cadaver simulation. Anesth Analg 115: 1242-1245.

11. Teoh WH, Kristensen MS (2014) Ultrasonographic identification of the cricothyroid membrane. Anaesthesia 69: 649-650.

12. Shibasaki M, Nakajima Y, Ishii S, Shimizu F, Shime N, et al. (2010) Prediction of pediatric endotracheal tube size by ultrasonography. Anesthesiology 113: 819-824.

13. Sustić A, Miletić D, Protić A, Ivancić A, Cicvarić T (2008) Can ultrasound be useful for predicting the size of a left double lumen bronchial tube? Tracheal width as measured by ultrasonography versus computed tomography. J Clin Anesth 20: 247-252.

14. Das SK, Choupoo NS, Halder R, Lahkar A (2015) Transtracheal ultrasound for verification of endotracheal tube placement: a systematic review and metanalysis. Can J Anaesth 62: 413-423.

15. Gupta D, Srirajakalidindi A, Habli N, Haber H (2011) Ultrasound confirmation of laryngeal mask airway placement correlates with fiberoptic laryngoscope findings. Middle East J Anaesthesiol 21: 283-287.

16. Hatfield A, Bodenham A (1999) Portable ultrasonic scanning of the anterior neck before percutaneous dilatational tracheostomy. Anaesthesia 54: 660-663.

17. Ding LW, Wang HC, Wu HD, Chang CJ, Yang PC (2006) Laryngeal ultrasound: a useful method in predicting post-extubation stridor. A pilot study. Eur Respir J 27: 384-389.

18. Kajekar P, Mendonca C, Gaur V (2010) Role of ultrasound in airway assessment and management. Int J Ultrasound Appl Technol Perioper Care 1: 97-100.

19. Kristensen MS (2011) Ultrasonography in management of the airway. Acta Anesthesiol Scand 55: 1155-1173.

20. Arens C, Glanz H (1999) Endoscopic high-frequency ultrasound of the larynx. Eur Arch Otorhinolaryngol 256: 316-322.