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**Ultrasound: A promising tool for contemporary airway management**

Garg B *et al.* Ultrasound in airway

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**Abstract**

Airway evaluation and its management remains an ever emerging clinical science. Present airway management tools are static and do not provide dynamic airway management option. Visualized procedures like ultrasound (US) provide point of care real time dynamic views of the airway in perioperative, emergency and critical care settings. US can provide dynamic anatomical assessment which is not possible by clinical examination alone. US aids in detecting gastric contents and the nature of gastric contents (clear fluid, thick turbid or solid) as well. US can help in predicting endotracheal tube size by measuring subglottic diameter and diameter of left main stem bronchus. US was found to be a sensitive in detecting rotational malposition of LMA in children. Also, US is the fastest and highly sensitive tool to rule out a suspected intraoperative pneumothorax. In intensive care units, US helps torule out causes of inadequate ventilation, determine the tracheal width and distance from the skin to predict tracheotomy tube size and shape and assist with percutaneous dilatational tracheostomy. US can help in confirming the correct tracheal tube placement by dynamic visualisation of the endotracheal tube insertion, widening of vocal cords (children), and bilateral lung-sliding and diaphragmatic movement. Thus, ultrasonography has brought a paradigm shift in the practise of airway management. With increasing awareness, portability, accessibility and further sophistication in technology, it is likely to find a place in routine airway management. We are not far from the time when all of us will be carrying a pocket US machine like stethoscopes to corroborate our clinical findings at point of care.

**Key words:** Airway; Ultrasound; Evaluation; Management; Difficult

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**Core tip**: Airway evaluation and its’ management is conventionally based on clinical examination and radiological imaging. They remain static and do not provide dynamic airway management option. Visualized procedures like ultrasound (US) provide point of care real time dynamic views of the airway in perioperative, emergency and critical care settings. US also aids in detecting gastric contents and the nature of gastric contents (clear fluid, thick turbid or solid). This detection is important for preventing complication of aspiration during airway management. The ultrasonography has brought a paradigm shift in the practise of airway management. With increasing awareness, portability, accessibility and further sophistication in technology, it is likely to find a place in routine airway management. We are not far from the time when all of us will be carrying a pocket US machine like stethoscopes to corroborate our clinical findings at point of care.

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Contemporary anaesthesia practise is richly blessed with technology based solutions. Technology has served to reduce human error in enumerable ways. Ultrasonography is one such extremely useful tool which is finding increasing applications in anaesthesia. It is already being considered as “gold standard” for central venous cannulations and peripheral nerve blockade. Visualized procedures improve safety and outcomes as compared to conventional techniques. In recent past, accumulated evidence is favouring its utility for various aspects of airway management for preoperative airway assessment, intraoperative management, predicting weaning from ventilation and successful extubation[1-3]. Various closed claim database and national level audits continue to implicate failure in airway management as a major contributor to perioperative morbidity and mortality[4-6]. Hence, constant efforts have been directed towards finding a “fail-safe” device for assisting us with airway management. Ultrasound (US) is turning out to be one such promising tool.

US provides point of care real time dynamic views of the airway inperioperative, emergency and critical care settings. It is free of ionizing radiation, painless, portable, convenient, reproducible, accurate and easily mastered skill and anaesthesiologist need not be dependent on their radiology colleagues. Because of superficial location of larynx, US can provide images of even higher resolution than advanced imaging modalities like computed tomography (CT) or magnetic resonance imaging (MRI)[6].

Conventional airway assessmentfails predict difficult intubation in all patients. US can provide dynamic anatomicalassessment which is not possible by clinical examination alone. Various studies have suggested that US can help in predicting difficult airway by measuring the soft tissue thickness measured on anterior aspect of trachea along with neck circumference[1], hyomental distance ratio[7], width of tongue base and lateral pharyngeal wall thickness[8]. Intraoral sublingual approach to US is being investigated as a useful approach to predict difficult airway[9]. If difficult airway is suspected US can assist in preparing the airway (superior laryngeal and recurrent laryngeal) for awake intubation[10] and identify the cricothyroid membrane so that transtracheal cricothyrotomy cannula can be placed in a “cannot ventilate cannot intubate” (CVCI) scenario[11,12]. Though fasting guidelines are well known, however, gastric emptying is quite variable. US aids in detecting gastric contents and thenature of gastric contents (clear fluid, thick turbid or solid) as well[13].

US can help in predicting endotracheal tube size by measuring subglottic diameter and diameter of left main stem bronchus (for placement of double lumen tube) and help in deciding the appropriate size of the endotracheal tube (ETT)[14,15]. US can also be used to confirm correct laryngeal mask airway (LMA) placement[16]. Its use instead of fiberoptic confirmation averts the hypercapnia associated with the later[17]. US was found to be a sensitive in detecting rotational malposition of LMA in children[18]. Also, US is the fastest and highly sensitive tool to rule out a suspected intraoperative pneumothorax[2].

In intensive care units, US helps to rule out causes of inadequate ventilation, determine the tracheal width and distance from the skin to predict tracheotomy tube size and shape and assist with percutaneous dilatational tracheostomy (PDT)[19,20]. US guided PDT provides real time visualisation of the needle path and guide wire placement using linear array probe. It permits visualisation of pretracheal blood vessels, selection of puncture site, decreases posterior tracheal wall puncture, decreases injury to thyroid isthmus and increases the overall success[21-23]. US has been found to be a better alternative to FOB guided PDT and may replace it in coming years.

US scan help in confirming the correct tracheal ETT placement by dynamic visualisation of the ETT tube insertion, widening of vocal cords (children), and bilateral lung-sliding and diaphragmatic movement[23-25]. Additional advantage of US guided ETT placement is that esophageal intubation can be diagnosed prior to initiation of mechanical ventilation, thus reducing gastric insufflations and its consequences. Recent studies have suggested that bedside US is feasible and fastersubstitute to conventional techniques (auscultation and waveform capnography) and may replace them in future[24].

Expanding literature in recent years is indicating the utility of US in diagnosing various pathologies that can have implication in clinical decision making, *e.g.*, vocal cord malfunction[3], swallowing abnormalities[25], sialolithiasis[26], supraglottic hemangiomas[27], respiratory papillomatosis[28], laryngeal stenosis[29], Zenker’s diverticulum[30-34], *etc*.

Recent advances in airway US include transesophageal US which can provide distal airway images from mid-trachea to bronchi[33]. Additionally, endoscopic high frequency US of larynx has been described where a thin catheter high frequency probe with rotating mirror can produce 360˚ image of larynx[34]. With advent of multiplanar 3D US in airway imaging, spectrum of its application has further widened as spatial information obtained is more detailed and measurements obtained are more precise[35]. A recent report describing the use of 3D US concluded that airway anatomy, anteroposterior diameter of subglottic area and transverse diameter of upper trachea can be accurately measured and correlated with MRI findings[35]. Pocket sized smartphone based system can increase its applicability even in remote areas[36].

US has steep learning curve as depicted by many studies[37]. Inexpensive training models like gel phantom model can help improve US assessment and interventional skills and safety[38]. However, like and any other skill based technique, a degree of manual dexterity and knowledge is required to be proficient in its use. Hence, its accuracy remains operator dependent.

To conclude, ultrasonography has brought a paradigm shift in the practise of airway management. With increasing awareness, portability, accessibility and further sophistication in technology, it is likely to find a place in routine airway management. We are not far from the time when all of us will be carrying a pocket US machine like stethoscopes to corroborate our clinical findings at point of care.

**REFERENCES**

1 **Ezri T**, Gewürtz G, Sessler DI, Medalion B, Szmuk P, Hagberg C, Susmallian S. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. *Anaesthesia* 2003; **58**: 1111-1114 [PMID: 14616599 DOI: 10.1046/j.1365-2044.2003.03412.x]

2 **Alrajhi K**, Woo MY, Vaillancourt C. Test characteristics of ultrasonography for the detection of pneumothorax: a systematic review and meta-analysis. *Chest* 2012; **141**: 703-708 [PMID: 21868468 DOI: 10.1378/chest.11-0131]

3 **Ding LW**, Wang HC, Wu HD, Chang CJ, Yang PC. Laryngeal ultrasound: a useful method in predicting post-extubation stridor. A pilot study. *Eur Respir J* 2006; **27**: 384-389 [PMID: 16452597 DOI: 10.1183/09031936.06.00029605]

4 **Cook TM**, Woodall N, Frerk C. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth* 2011; **106**: 617-631 [PMID: 21447488 DOI: 10.1093/bja/aer058]

5 **Cook TM**, Woodall N, Harper J, Benger J. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. *Br J Anaesth* 2011; **106**: 632-642 [PMID: 21447489 DOI: 10.1093/bja/aer059]

6 **Beale TJ**, Rubin JS. In: Orloff LA (ed) Laryngeal ultrasonography. Plural Publishing, San Diego, 2008: 183-202

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**: 523-528 [PMID: 22441908]

8 **Adhikari S**, Zeger W, Schmier C, Crum T, Craven A, Frrokaj I, Pang H, Shostrom V. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. *Acad Emerg Med* 2011; **18**: 754-758 [PMID: 21707828 DOI: 10.1111/j.1553-2712.2011.01099.x]

9 **Tsui BC**, Hui CM. Sublingual airway ultrasound imaging. *Can J Anaesth* 2008; **55**: 790-791 [PMID: 19138924 DOI: 10.1007/BF03016357]

10 **Kaur B**, Tang R, Sawka A, Krebs C, Vaghadia H. A method for ultrasonographic visualization and injection of the superior laryngeal nerve: volunteer study and cadaver simulation. *Anesth Analg* 2012; **115**: 1242-1245 [PMID: 22822197 DOI: 10.1213/ANE.0b013e318265f75d]

11 **Teoh WH**, Kristensen MS. Ultrasonographic identification of the cricothyroid membrane. *Anaesthesia* 2014; **69**: 649-650 [PMID: 24813143 DOI: 10.1111/anae.12735]

12 **Orr JA**, Stephens RS, Mitchell VM. Ultrasound-guided localisation of the trachea. *Anaesthesia* 2007; **62**: 972-973 [PMID: 17697240 DOI: 10.1111/j.1365-2044.2007.05244.x]

13 **Jacoby J**, Smith G, Eberhardt M, Heller M. Bedside ultrasound to determine prandial status. *Am J Emerg Med* 2003; **21**: 216-219 [PMID: 12811716 DOI: 10.1016/S0735-6757(02)42243-7]

14 **Shibasaki M**, Nakajima Y, Ishii S, Shimizu F, Shime N, Sessler DI. Prediction of pediatric endotracheal tube size by ultrasonography. *Anesthesiology* 2010; **113**: 819-824 [PMID: 20808208 DOI: 10.1097/ALN.0b013e3181ef6757]

15 **Sustić A**, Miletić D, Protić A, Ivancić A, Cicvarić T. 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* 2008; **20**: 247-252 [PMID: 18617120 DOI: 10.1016/j.jclinane.2007.11.002]

16 **Gupta D**, Srirajakalidindi A, Habli N, Haber H. Ultrasound confirmation of laryngeal mask airway placement correlates with fiberoptic laryngoscope findings. *Middle East J Anaesthesiol* 2011; **21**: 283-287 [PMID: 22435281]

17 **Hatfield A**, Bodenham A. Ultrasound: an emerging role in anaesthesia and intensive care. *Br J Anaesth* 1999; **83**: 789-800 [PMID: 10690145 DOI: 10.1093/bja/83.5.789]

18 **Kim J**, Kim JY, Kim WO, Kil HK. An ultrasound evaluation of laryngeal mask airway position in pediatric patients: an observational study. *Anesth Analg* 2015; **120**: 427-432 [PMID: 25545750 DOI: 10.1213/ANE.0000000000000551]

19 **Munir N**, Hughes D, Sadera G, Sherman IW. Ultrasound-guided localisation of trachea for surgical tracheostomy. *Eur Arch Otorhinolaryngol* 2010; **267**: 477-479 [PMID: 20041258 DOI: 10.1007/s00405-009-1187-1]

20 **Hatfield A**, Bodenham A. Portable ultrasonic scanning of the anterior neck before percutaneous dilatational tracheostomy. *Anaesthesia* 1999; **54**: 660-663 [PMID: 10417458 DOI: 10.1046/j.1365-2044.1999.00859.x]

21 **Sustić A**, Zupan Z, Antoncić I. Ultrasound-guided percutaneous dilatational tracheostomy with laryngeal mask airway control in a morbidly obese patient. *J Clin Anesth* 2004; **16**: 121-123 [PMID: 15110374 DOI: 10.1016/j.jclinane.2003.04.005]

22 **McCormick B**, Manara AR. Mortality from percutaneous dilatational tracheostomy. A report of three cases. *Anaesthesia* 2005; **60**: 490-495 [PMID: 15819770 DOI: 10.1111/j.1365-2044.2005.04137.x]

23 **Marciniak B**, Fayoux P, Hébrard A, Krivosic-Horber R, Engelhardt T, Bissonnette B. Airway management in children: ultrasonography assessment of tracheal intubation in real time? *Anesth Analg* 2009; **108**: 461-465 [PMID: 19151273 DOI: 10.1213/ane.0b013e31819240f5]

24 **Adi O**, Chuan TW, Rishya M. A feasibility study on bedside upper airway ultrasonography compared to waveform capnography for verifying endotracheal tube location after intubation. *Crit Ultrasound J* 2013; **5**: 7 [PMID: 23826756 DOI: 10.1186/2036-7902-5-7]

25 **Friedman EM**. Role of ultrasound in the assessment of vocal cord function in infants and children. *Ann Otol Rhinol Laryngol* 1997; **106**: 199-209 [PMID: 9078931 DOI: 10.1177/000348949710600304]

26 **Shawker TH**, Sonies B, Hall TE, Baum BF. Ultrasound analysis of tongue, hyoid, and larynx activity during swallowing. *Invest Radiol* 1984; **19**: 82-86 [PMID: 6398320 DOI: 10.1097/00004424-198403000-00003]

27 **Suhitharan T**, Seevanayagam S, Parker FC, Teoh WH. Acute unilateral submandibular gland swelling associated with the laryngeal mask airway. *Singapore Med J* 2013; **54**: e236-e239 [PMID: 24356762 DOI: 10.11622/smedj.2013248]

28 **Rossler L**, Rothoeft T, Teig N, Koerner-Rettberg C, Deitmer T, Rieger CH, Hamelmann E. Ultrasound and colour Doppler in infantile subglottic haemangioma. *Pediatr Radiol* 2011; **41**: 1421-1428 [PMID: 21904830 DOI: 10.1007/s00247-011-2213-1]

29 **Bryson PC**, Leight WD, Zdanski CJ, Drake AF, Rose AS. High-resolution ultrasound in the evaluation of pediatric recurrent respiratory papillomatosis. *Arch Otolaryngol Head Neck Surg* 2009; **135**: 250-253 [PMID: 19289702 DOI: 10.1001/archoto.2008.544]

30 **Garel C**, Contencin P, Polonovski JM, Hassan M, Narcy P. Laryngeal ultrasonography in infants and children: a new way of investigating. Normal and pathological findings. *Int J Pediatr Otorhinolaryngol* 1992; **23**: 107-115 [PMID: 1563926 DOI: 10.1016/0165-5876(92)90046-R]

31 **Kollig E**, Heydenreich U, Roetman B, Hopf F, Muhr G. Ultrasound and bronchoscopic controlled percutaneous tracheostomy on trauma ICU. *Injury* 2000; **31**: 663-668 [PMID: 11084151 DOI: 10.1016/S0020-1383(00)00094-2]

32 **Lixin J**, Bing H, Zhigang W, Binghui Z. Sonographic diagnosis features of Zenker diverticulum. *Eur J Radiol* 2011; **80**: e13-e19 [PMID: 20576383 DOI: 10.1016/j.ejrad.2010.05.028]

33 **Kristensen MS**, Teoh WH, Graumann O, Laursen CB. Ultrasonography for clinical decision-making and intervention in airway management: from the mouth to the lungs and pleurae. *Insights Imaging* 2014; **5**: 253-279 [PMID: 24519789 DOI: 10.1007/s13244-014-0309-5]

34 **Arens C**, Glanz H. Endoscopic high-frequency ultrasound of the larynx. *Eur Arch Otorhinolaryngol* 1999; **256**: 316-322 [PMID: 10456283 DOI: 10.1007/s004050050254]

35 **Or DY**, Karmakar MK, Lam GC, Hui JW, Li JW, Chen PP. Multiplanar 3D ultrasound imaging to assess the anatomy of the upper airway and measure the subglottic and tracheal diameters in adults. *Br J Radiol* 2013; **86**: 20130253 [PMID: 23966375]

36 **Butcher C**. Ultrasound evaluation of the neck and upper respiratory system. In: Levitov A, Mayo P, Slonim A, editors. Critical Care Ultrasonography, 1st ed. USA: McGraw-Hill, 2010: 235-8

37 **Park SC**, Ryu JH, Yeom SR, Jeong JW, Cho SJ. Confirmation of endotracheal intubation by combined ultrasonographic methods in the Emergency Department. *Emerg Med Australas* 2009; **21**: 293-297 [PMID: 19682014 DOI: 10.1111/j.1742-6723.2009.01199.x]

38 **Schroeder KM**, Ramamoorthy J, Galgon RE. An easily made, low-cost phantom for ultrasound airway exam training and assessment. *Indian J Anaesth* 2013; **57**: 31-34 [PMID: 23716763 DOI: 10.4103/0019-5049.108558]

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