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## Newer airway assessment techniques: A view on their utility

The established predictors of difficult airway, both clinical and radiology based, have limitations in routine practice. They do not account for lower airway pathology and the dynamic part of central airway changes related to posture and breathing. Nasendoscopy can provide information up to the vocal cords. This problem is obviated by the use of fibre-optic bronchoscopy (FOB) which can reveal the pathology beyond this level, but its passage may be blocked by pathology along the route, and only the mucosal layer of the structures is visualised.

Multidetector/multislice computed tomography (MDCT) followed by processing for the ideal images and post-processing techniques such as virtual endoscopy (VE)/virtual bronchoscopy (VB) will help assess the different layers and relationships of structures and hence facilitate a complete evaluation of the airways.<sup>[1]</sup> These along with the ultrasound (US) and three-dimensional (3D) printing technology are some of the newer techniques with a lot of potential that have been used in select cases.

MDCT enables rapid acquisition of high-resolution data, almost eliminating the artefacts related to motion and cardiac and respiratory activity. This allows accurate reconstruction of the airway dimensions both externally and internally. The internal rendering can be used to provide a fly-through view of the virtually created intraluminal 3D view which correlates with FOB. VB can 'go across' stenoses where FOB cannot go, allowing for distal airways to be examined. Digital Imaging and Communications in Medicine (DICOM) imaging and related CT-VE application software will aid in generating focussed images, and performing the VB.<sup>[2]</sup>

Ahmed *et al.* initially reported the use of software, the OsiriX Lite<sup>®</sup> Viewer (v5.5 32-Bit, Pixmeo SARL,

Bernex, Switzerland; OsiriX<sup>®</sup> 9.0 is now available) for airway assessment and management of three patients with chronic airway lesions (with glottic, subglottic and multilevel pathology). The CT images of the patient obtained previously were imported into the software. They subsequently underwent awake fibre-optic intubation. The endoscopic flight path was constructed and compared with the fibre-optic views and paths. They found an excellent correlation of the two techniques, related to shapes of structures and of the narrowings.<sup>[3]</sup>

This issue of the Indian Journal of Anaesthesia (IJA) includes a special article on VE.<sup>[4]</sup> The authors lucidly discuss the current status of the VE for head and neck pathologies and the assessment of airway. They cite one of their previous publications wherein the use of VE resulted in significantly improved diagnostic accuracy and significant changes in airway management and suggest the use of VE as an additional airway assessment technique.

There are reports of VE-based assessment and subsequent successful management with airway obstructions at different levels in adults<sup>[5]</sup> and also in paediatric patients.<sup>[6]</sup> The VE can show the narrowing relative to the size of the lumen for a better idea of the difficulty in airway intervention.<sup>[2]</sup> Post-intubation tracheal stenosis can be diagnosed with 100% specificity using MDCT; it is characteristically seen as concentric narrowing producing an hour-glass shaped trachea in the subglottic area and measuring <2 cm in diameter.<sup>[1]</sup>

In this issue of the IJA, pre-operative study of the CT scan of the upper airway pathology in an 8-month old child is reported.<sup>[7]</sup> The CT image reconstruction guided patient's successful airway management.

Another possibility for airway management is the use of dynamic (inspiratory and expiratory) airway CT scan to diagnose or predict the extent of collapse in tracheomalacia, based on changes in the size of tracheal lumen and its configuration with respiration.<sup>[8]</sup> The crescentic, 'frown' shape may be seen in some patients during expiration.<sup>[9]</sup> This could potentially have a role for patients with medical diseases in the intensive care units (ICUs) and help in better management. It allows for a better 'prepared' plan for the airway management, both for laryngoscopy (direct or videolaryngoscope) or use of supraglottic device or endotracheal tube.

Since the images in expiration and inspiration can be assessed and dynamic videos obtained based on the software, VE could have potential for use also in conditions such as obesity, foreign body (including its location and movement); changes in airway with change in patients' position and level of consciousness can be potential areas for investigation.

There are certain technical limitations to the CT and VE views. Presence of secretions and blood will vitiate distal views; poor aeration can exaggerate asymmetry between pathology and the CT-VE for lesions of the valleculae, pyriform sinuses and larynx. Variance in tissue-air threshold values can give false images and measures of narrowing and airway compromise in glottic or other parts of the airway. Another limitation is that the image obtained has same colour irrespective of the type of tissue; this should not lead to misreading of the findings.<sup>[2]</sup>

Printing of the 3D-VE design allows one to practice '*in vitro*' to develop the most reliable strategy for airway management. The 3D printing is a revolutionary technology with a wide range of applications in multiple fields including medicine. It can be used as a visualisation tool before airway intervention wherein the organ of interest as per patient's exact anatomy is bioprinted (based on CT images) and assessed for anatomy, and then suitable management plans are put in place. The information is most useful when it is obtained as close to the day of the scheduled procedure as possible, as the pathology can change with time, especially in younger children where even a few weeks difference can change the airway dimensions considerably.<sup>[10]</sup>

In trauma cases, 3D printing can give a picture of the relations and configurations, again providing a clear

anatomy from the face down to the tracheobronchial tree both for tracheal and bronchial intubation.

US evaluation of the airway is a modality which can be useful in the assessment of the difficult airway. In the past decade, two-dimensional (2D) US-guided (USG) assessment of airway is gaining popularity, and it appears to be promising in predicting the difficult airway with more certainty than the clinical parameters. Main advantages of USG are that it is non-invasive with no risk of radiation and can be used at the bedside, multiple times.<sup>[11]</sup>

The US provides a functional/dynamic assessment of the airway and the data obtained are consistent with CT scan. The 3D-US devices provide the Z-axis i.e., coronal view, in addition to the sagittal and transverse planes obtained with 2D-US, enabling virtual reconstruction of the assessed airway. They help visualise most structures of the upper airway from false vocal cords to mid-trachea. Addition of the fourth dimension, the 'time' to the 3D technology, can enable functional assessment in the times to come.

Localisation of the trachea and the cricothyroid membrane in the presence of obesity, neck swellings and tracheal deviations can be guided by US for elective transtracheal cannulation and emergency cricothyrotomy and percutaneous dilatational tracheostomy. US may have a role in predicting successful extubation but current evidence, again, is limited.<sup>[12]</sup>

#### Unanswered questions

The role that VE can have specifically after extubation is yet to be discussed. Can it predict the influence of the patient position and the level of sedation postoperatively? Can there be a role in ICU management? No report of the use of the CT and VE in obstetrics is available, but according to the consensus statements from the relevant major organisations, the risk of malignancy, miscarriage or major malformations is negligible in foetuses exposed to 50 mGy radiation or less. Typical conceptus dose from single acquisition of head/chest CT would result in 0–0.2 mGy exposure, far below the suggested 50 mGy limit.<sup>[13]</sup> Thus, it is theoretically possible to use the CT and VE for the assessment of airway in specific situations where difficult airway in pregnancy needs to be assessed and managed.

The CT and the VE facility can be availed only in chronic cases of airway pathology for elective

management of the airway. The CT suite is generally located at a distance from the OT. Is it possible to use the CT/VE in semi-elective and emergency situations?

The use of 3D printing is still not widespread as the facility is unavailable in many places and is costly. However, it has great potential as a tool for airway assessment in patients with known airway pathology and polytrauma for adequate preparation of airway management strategies including the choice of the optimal airway devices.

Overall, of the newer modalities, dynamic CT and VE and 3D printing have a role in the assessment of difficult airway in elective procedures but not in emergency situations. US, when available, can be used as a point of care airway assessment device anytime, but unfortunately, its role in a difficult airway scenario is limited. Thus, when the difficulty is unanticipated, there is no immediate role for CT-VE and 3D printing as time is a deciding factor in unanticipated difficult airway management. It is imperative to continue to use the existing guidelines in the management of unanticipated difficult airway; the newer modalities can help in anticipating certain components of difficult airway, especially those below glottis and improve chances of successful airway management. The information gleaned from the use of CT-VE, and 3D printing has the potential to alter the Plan A and the Plan B for management of difficult airway, tilting towards greater success and safety. However, the utility of the newer techniques has to be proven with more studies across all scenarios of difficult airway.

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#### Conflicts of interest

There are no conflicts of interest.

**S Bala Bhaskar**

Department of Anaesthesiology, VIMS, Ballari, Karnataka, India  
E-mail: sbalabhaskar@gmail.com

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