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Original Contribution

Virtual endoscopy—a new assessment tool in difficult airway management☆

I. Ahmad FRCA[a,*], B. Millhoff FRCA[a], M. John FRCA[a], K. Andi FRCS (OMFS)[b], R. Oakley FRCS (ORL-HNS)[c]

[a]*Department of Anaesthesia, Guy's Hospital, Great Maze Pond, SE1 9RT, London, United Kingdom.*
[b]*Department of Maxillofacial Surgery, St George's Hospital, Blackshaw Rd, SW17 0QT, London, United Kingdom.*
[c]*Department of Ear, Nose and Throat, Guy's Hospital, Great Maze Pond, SE1 9RT, London, United Kingdom.*

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Abstract Preemptive mapping of the airway is a useful adjunct to conventional clinical assessments when airway management planning for patients with complex head and neck pathology. Nasendoscopy is frequently used for this purpose but is also invasive and poorly tolerated in a subset of patients and, even in expert hands, may not allow complete visualization of the glottis and subglottic structures. We present a novel tool for difficult airway management planning in the form of virtual endoscopy by applying free online OsiriX software to head and neck computed tomographic scans to generate a "fly-through" airway reconstruction. To highlight how well virtual endoscopy correlates to conventional fibreoscopy, we compare both of these assessment tools in 3 patients with glottic, subglottic, and multilevel airway pathologies. Virtual endoscopy represents a unique, noninvasive, safe, and accurate airway assessment and educational resource, which warrants further exploration.

1. Introduction

The 4th National Audit Project [1] assessing major complications of airway management in the United Kingdom revealed that, in 40% of all cases reported, the airway problem was associated with a disease process in the head, neck, or trachea. Case studies of patients within the audit requiring emergency airway management revealed that many could have been better managed if a full airway assessment had been performed. The audit report contained recommendations to guide improvements in care adoption of which should lead to a systematic reduction in the incidence of airway complications. Comprehensive multidisciplinary assessment by an anesthetist and surgeon, using both direct visualization of the airway with a flexible nasendoscope and thorough review of any imaging available, was suggested as part of the ideal airway assessment.

In chronic obstruction and nonurgent cases, there is time to perform computed tomographic (CT) scans to delineate the extent of disease pathology and perform nasendoscopy to inspect the upper airway. This allows potential areas of airway obstruction to be clearly defined along with a bespoke airway strategy for all phases of the patients' anesthetic and recovery. Nasendoscopy is a valuable tool in assessing the airway but has limitations. A small proportion of patients will not tolerate the procedure; and even in the most skilled

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* Corresponding author. Tel.: +44-207-188-7188.
E-mail address: drimranahmad1@gmail.com (I. Ahmad).

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hands, it can be difficult to examine the subglottis and upper trachea. Expert interpretation of axial and sagittal airway imaging generally falls to sup-specialist radiology consultants, although more user-friendly formatting of CT scans is available.

To overcome these obstacles to a comprehensive airway assessment, we have been using the free online multidimensional image navigation and display software OsiriX to reconstruct 3-dimensional (3D) virtual endoscopy (VE) images of the airway from the patient's diagnostic CT images [2]. This technology facilitates an anatomically accurate reproduction of the endoscopic findings within the airway in a format easily interpreted by the anesthetist without having to perform nasendoscopy. Such virtual visualization of the airway facilitates a bespoke airway strategy based on the patient's preexisting diagnostic CT images. Subsequent recording of the real-time intubation allows retrospective comparison with the VE to assess fidelity. This process facilitates the provision of a safe airway for surgery and enhanced opportunities for training safely through virtual rehearsal, intubation, and review on complex airway cases.

We would like to report 3 patients with chronic airway lesions where OsiriX software was used to create virtual airway endoscopic images. These images were retrospectively compared to the conventional endoscopic findings perioperatively to assess for accuracy and usefulness in planning of the airway strategy.

2. Methods

To demonstrate the accuracy and use of VE for the assessment of various airway pathologies, we chose 3 patients with glottic, subglottic, and multilevel pathology. All 3 patients underwent awake fiberoptic intubation or assessment in theater. The images taken during the procedures were filmed with a high-definition (HD) camera. Written consent was obtained from all patients for recording and use of video footage in presentations and publications with the patient's identity protected. All patients had recent helical CT scans of the head and neck (slice thickness between 1 and 2 mm, space between slices −1.0) as part of their diagnostic process.

DICOM data were imported into the Osirix Viewer v5.5 32-Bit (Pixmeo Sari), and the images were opened in the 3D Endoscopy viewer.

The endoscopic flight path was then constructed by rotating the focal point to simulate endoscopic views while advancing the camera using the zoom function with key steps recorded as a series for fly-through reconstruction. We have found this method to be far more accurate particularly in the head and neck where soft tissues project intimately into the airway than the default pathway assistance tools provided.

For video reconstruction of the key frame images, a frame count of 200 was used during interpolation using the spline method to provide smooth transitions from one frame to another. Video files at a resolution of 1228 × 657 were then saved using the .mov format.

We were then able to compare these VE movie clips to the videos taken with a (HD) camera for accuracy.

3. Results

3.1. Glottic pathology

The first patient was a 66-year-old gentleman who presented for a radical neck dissection as treatment for a residual base of tongue carcinoma. Because he had previously received radiotherapy to his neck and was suffering from dysphagia with a limited mouth opening and reduced tongue protrusion, a difficult airway was anticipated.

To manage his airway perioperatively, we performed an awake fiberoptic intubation, which was filmed using an HD camera. Fiberoptic intubation was uneventful but revealed an abnormally shaped epiglottis, which potentially could have caused an impediment to intubation (Fig. 1).

A comprehensive 3D appreciation of periglottic post-radiotherapy changes affecting airway management can be difficult to achieve with conventional CT slice evaluation. However, when we compared our real-life fiberoptic findings with the VE fly through reconstruction (Movie 1), the images correlated accurately (Figs. 1 and 2). We found the VE images much easier to interpret than the CT slices, as they were in a form more familiar to us.

Visualizing the run through videos beforehand in this way can also prepare us for potential hazards during the actual awake fiberoptic intubation.

3.2. Subglottic pathology

A 58-year-old gentleman presented to the ENT clinic with worsening stridor. He was known to suffer from Wegener granulomatosis causing subglottic stenosis, for which he had

Fig. 1 View during awake fiberoptic intubation showing an abnormally shaped epiglottis.