

Enhancing airway assessment of patients with head and neck pathology using virtual endoscopy

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ABSTRACT

Studies have demonstrated that poor assessment and planning contribute to airway complications and that current airway assessment strategies have a poor diagnostic accuracy in predicting difficult intubation in the general population. Patients with head and neck pathology are at higher risk for difficulties during airway management and are more likely to need emergency surgical access. Therefore, thorough assessment of this group of patients is mandatory. The addition of virtual endoscopy (VE) to clinical history and computerised tomography imaging has been shown to improve diagnostic accuracy for supraglottic, glottic and infraglottic lesions and has a positive influence in formulating a more cautious and thorough airway management strategy in this high-risk group of patients. This article reviews whether VE can enhance airway assessment in patients with head and neck pathology and help reduce airway complications.

Key words: Airway assessment, awake fiberoptic intubation, head and neck pathology, virtual endoscopy

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INTRODUCTION

One of the pivotal findings of the Royal College of Anaesthesiologists 4th National Audit Project (NAP4) report was that poor assessment and planning led to significant airway morbidity. Nearly, a third of all the cases reported were considered poorly managed, with inadequate airway assessment and planning identified as a common contributing factor.^[1] Accurate prediction of a difficult airway should reduce the risk of potential complications, however many studies, including meta-analyses, have demonstrated that there is no single predictor of difficult intubations which is sufficiently reliable^[2-7] and there is only sparse evidence for a pre-operative assessment based on a single risk factor. In addition to this, previous studies seem to suggest that the diagnostic accuracy of prediction of difficult intubation, made by an individual anaesthesiologist, is poor and 75%–93% of all difficult intubations are unanticipated.^[8] This does not seem to improve with any targeted, additional training or standardisation of assessment. A simplified airway risk index approach to airway assessment failed to produce statistically significant reduction in rates of unanticipated difficult intubation when compared

with a pre-operative assessment performed in a traditional, *ad hoc* manner.^[9]

Consensus is that pre-operative airway assessment of all patients must be performed to help identify those who are at risk of difficulty with intubation. Current diagnostic accuracy is deficient. We require additional tools universally available to us which can enhance airway assessment in a non-invasive, easy to interpret and easily communicable manner.

To establish if we could find an appropriate additional assessment tool, we reviewed the published data relating to airway assessment, incidence of complications in patients with head and neck pathology and the use of virtual endoscopy (VE) in anaesthesia practice.

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ASSESSING PATIENTS WITH AIRWAY PATHOLOGY

Unsurprisingly, a subgroup of patients that were found by NAP4 to be at higher risk of difficulties during airway management were those with upper airway pathology. Approximately 40% of all cases reported were associated with a disease process in the head, neck, or trachea, and 70% of these reports were associated with airway obstruction.^[10] This implies that it is imperative that this group of patients have a thorough pre-operative airway assessment. Worryingly, however, not only has clinical examination been shown to be both inaccurate and insufficient, there is evidence to suggest that it is particularly inadequate in patients with head, neck and tracheal disease.^[8] Despite numerous advances in airway management in anaesthesia over recent decades, including drugs, equipment and techniques, there has been disappointingly little headway in airway assessment. Could one solution be VE of the airway?

CURRENT AIRWAY IMAGING TOOLS AND PRACTICES

Multi-plane computerised tomography (CT) scanning is often performed for patients with head and neck disease. This can provide information regarding anatomical abnormality, location of lesion and any tumour involvement of the airway.^[11] These images are presented in a two-dimensional (2D) format and partly due to unfamiliarity, can be difficult for the anaesthesiologist to interpret. However, most anaesthesiologists are familiar with the anatomy of the upper airway as viewed by laryngoscopy, either direct or endoscopically.

Flexible nasendoscopy can be a useful tool, providing a dynamic assessment of supraglottic disease and a more complete understanding of intraluminal anatomy. Rosenblatt *et al.* studied 138 patients, presenting for upper airway surgery with pathology in a variety of locations.^[12] A pre-operative endoscopic airway evaluation (PEAE) was undertaken, involving visualisation of the epiglottis, vallecula, vocal cords and both pyriform sinuses. One-hundred and fourteen (83%) of the 138 patients had their airway management after induction of anaesthesia (all without incident). Notably, of the 94 patients for whom the initial plan was to manage the airway under general anaesthesia, 8 (9%) patients were unexpectedly found to have severe airway pathology on PEAE, so their airway plan was changed to awake intubation;

this was deemed a direct result of the PEAE findings. However, there are some limitations to performing these pre-operative nasendoscopies, such as having the availability of a skilled anaesthesiologist to perform the examination, the need to arrange a suitable time and location preoperatively, the requirement of specialised equipment and patient compliance. In addition, and crucially, it fails to provide any information on any infraglottic pathology which may exist.

IMPORTANCE OF THOROUGH ASSESSMENT OF AIRWAY PATHOLOGY

The location of any airway pathology can be broadly classified as being supraglottic, glottic or infraglottic. The location will have a bearing on the choice of anaesthetic and airway management technique and equipment used. It is also prudent to determine the nature of the pathology, and whether and to what degree it is causing distortion or narrowing. The assessment of narrowing at supraglottic but particularly glottic and infraglottic levels will have an influence on the selection of size and type of endotracheal tube. Conventional airway assessment can fail to determine the exact location of the lesion so additional investigations should be undertaken.

NAP4 revealed that there were 58 cases where emergency surgical airway was attempted. Forty-three (74%) were patients with head and neck pathology. In eight cases (14%), emergency surgical access failed, and four patients (7%) died as a result of airway complications.^[13] These alarming figures illustrate the importance of thorough assessment and planning in patients who present with airway pathology. If complications do occur during airway management in this group, there is an increased risk of the need for emergency surgical access and death.

THE PROBLEM WITH 'ASLEEP' INTUBATION

'Asleep' intubation of the trachea can be performed in the apnoeic, as well as spontaneously ventilating patient (using gaseous technique), using direct laryngoscopy, videolaryngoscopy or with the use of fibrescopes. Gaseous induction can affect airway tone and result in the loss of patency of the airway.^[14,15] Conventionally, the use of intravenous techniques has relied on either the intubation being completed within the desaturation time or the patient having a patent upper airway under anaesthesia and being amenable to intermittent positive pressure ventilation

using a bag-valve mask or supraglottic airway. With the recent introduction of Transnasal Humidified Rapid Insufflation Ventilatory Exchange^[16] which can prolong safe apnoea time, a patent upper airway is a prerequisite and there are subgroups, such as the obese or in upper airway obstruction, where that effectiveness may be reduced.

In a study by Kheterpal *et al.*,^[17] the risk of a number of components of difficult airway management were demonstrated. Difficult laryngoscopy occurred in 5.8%; difficult mask ventilation occurred in 5% and difficulty with both in 0.4%. Of note, fiberoptic intubation (awake or asleep), awake tracheostomy or primary use of a supraglottic airway were in the exclusion criteria for this study, and so we can postulate that the incidence of difficulty may be even higher.

Without being able to predict with a 100% certainty that these factors required for safe intubation under general anaesthesia will be present, there is always an inherent risk with the 'asleep' techniques of intubation.

ADVANTAGES OF AWAKE FIBROPTIC INTUBATION

Awake intubation allows the airway of high-risk patients to be secured with the patient spontaneously ventilating and maintaining a patent airway.^[18,19] This is widely regarded as the safest technique for managing the airway of a patient with anticipated difficulty but without complete obstruction. A flexible fibrescope enables the operator to navigate around lesions within the upper airway and allow placement of a pre-loaded endotracheal tube once the trachea has been successfully identified.^[20] NAP4 reported 18 cases where the expert reviewers believed that an awake fiberoptic intubation (AFOI) may have offered advantages over the airway management the patient received under general anaesthesia.^[21]

THE PROBLEM WITH AWAKE FIBROPTIC INTUBATION

This technique is thought to have a failure rate of 1%, ascertained in a large prospective cohort study of AFOIs.^[20] It is worth noting, and remarkably reassuring, that there were no episodes of death, cannot intubate/cannot oxygenate, emergency tracheostomy or long-term sequelae in any of the failed AFOI patients.^[20] Similar failure rates have been attested in retrospective case series,^[22,23] demonstrating the

safety of this technique in a cohort of patients with anticipated difficult airways.

NAP4 reported 15 cases where AFOI was unsuccessful. Reasons for failure included: Inability to recognise appropriate airway anatomy, anatomical distortion and inability to pass the endotracheal tube. All of these contributing factors may have been negated with a pre-operative VE fly through video demonstrating the endoscopic anatomy before performing the AFOI.

In addition, there are a number of human factors surrounding the procedure. Their existence can be deduced from the results of reports, suggesting that anaesthetists may avoid performing AFOI in patients who would be suitable, for reasons including worry of procedural failure^[24] and due to a lack of gaining or maintaining competence in the procedure.^[25]

VIRTUAL ENDOSCOPY

For many years, radiologists have been using multidimensional image navigation and display software to create VE images of the tracheobronchial tree. These have been used to aid in pathological diagnoses and CT-guided biopsies.^[26-28] Having been introduced to this existing, free technology, we wanted to establish whether VE could help us as airway anaesthesiologists, and we became the first group of anaesthesiologists to describe the use of VE to assess and plan airway management of patients with difficult airways.^[29] We imported the Digital Imaging and Communications in Medicine (DICOM) data files to the free OsiriX Lite Viewer v5.5 32-Bit (Pixmeo Sari, Bernex, Switzerland), and the 3D endoscopy software function was utilised to construct a 3D flight path by advancing and rotating a virtual camera to simulate endoscopic views.

VE potentially bridges the gap in airway assessment by providing a non-invasive, anatomically accurate representation of the patient's whole airway, from naso- or oro-pharynx to the carina, in a format familiar to all anaesthesiologists. The patient's pre-existing diagnostic CT images can be reconstructed into a 3D 'fly-through' video of endoscopic anatomy, using the OsiriX Viewer software. This can contribute to planning airway management strategies well in advance of any direct patient intervention and therefore risk of harm.^[29] The VE videos created can be viewed simultaneously with the CT images, thus also improving the interpretation of the anatomy viewed in the conventional 2D format [Figures 1-3].

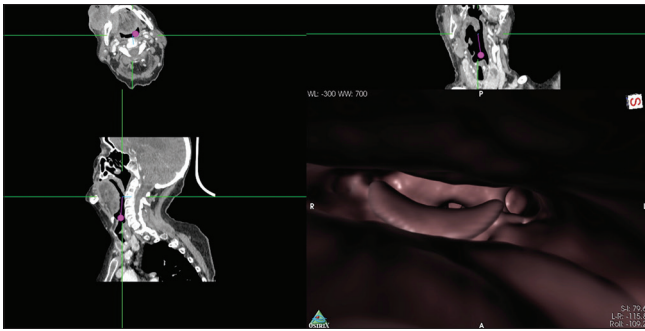


Figure 1: Supraglottic virtual endoscopy reconstruction showing the epiglottis

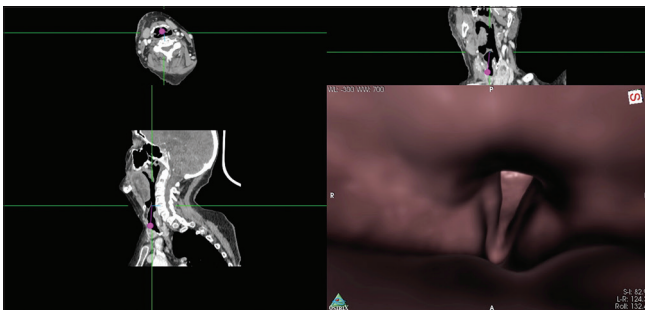


Figure 2: Virtual endoscopy reconstruction showing the glottic opening

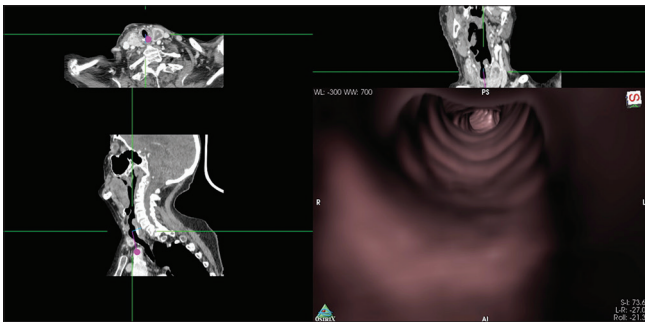


Figure 3: Subglottic virtual endoscopy reconstruction showing the trachea

ENHANCING AIRWAY ASSESSMENT AND PLANNING

Having a pre-operative VE video of a high-risk patient with head and neck pathology will enable us to have a better understanding of the airway imaging in a familiar format and offers the added advantage of allowing us to plan the path the fibroscope should ideally take to perform a successful AFOI.^[30] Inevitably, the question arose: ‘does VE actually influence anaesthesiologist’s planning of airway strategies when faced with patients who have head and neck pathology?’ We performed a further study^[30] to assess the utility of VE by performing a convenience survey series of twenty anaesthesiologists, asking them to describe their preferred airway management plan for ten airway scenarios (three with supraglottic

pathology, three with glottic pathology, three with infraglottic pathology and one case with normal airway anatomy). Each of these scenarios included a brief clinical history and a standard helical CT scan of the head and neck. 3D VE follow through videos were subsequently provided, and airway management choices were re-requested. Diagnostic accuracy of airway pathology by anaesthesiologists was improved by 13% when VE videos were reviewed in addition to the initial CT images. The addition of VE to airway assessment led to changes in airway management in 48% of cases ($P = 0.005$), with 90% ($P = 0.005$) of these changes toward a more cautious plan (i.e., AFOI instead of an ‘asleep’ intubation).

This study demonstrates that by adding VE to the airway assessment armamentarium, there is a significant increase in diagnostic accuracy for supraglottic, glottic and infraglottic lesions and suggests that this can lead to safer airway management strategies in patients with head and neck pathology. This could be attributed to the format of the VE videos, which replicates the views of the airway more familiar to anaesthesiologists.

Despite all the benefits of VE, it is worth noting that there are limitations associated with this technique. The quality of the fly through videos are dependent on the quality of the uploaded DICOM data files; small lesions may not be reconstructed, natural colour is absent, excessive smoothening of the airway walls may occur, and it is a static (not dynamic) examination technique.

SUMMARY

Patients who present with head and neck pathology are more likely to have difficult airways, are at increased risk of difficulties during airway management, and they are also more likely to require an emergency surgical airway when difficulties arise. We are convinced of the merits of the addition of VE in assessment and planning of airway management in these high-risk patients. We believe that VE can assist in making a more accurate airway assessment, formulate a more cautious airway plan and provide a virtual run through video of best path for the fibroscope, should an AFOI technique be selected, potentially further reducing the failure rate of this technique. VE has the potential to reduce the number of airway complications in patients with head and neck pathology, although further studies will be required to demonstrate this.

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Conflicts of interest

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REFERENCES

- Pearce A, Shaw J. Fourth National Audit Project of the Royal College of Anaesthetists and The Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings. Ch. 17. London: Airway Assessment and Planning; 2011.
- Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. *Anesthesiology* 2005;103:429-37.
- Lee A, Fan LT, Gin T, Karmakar MK, Ngan Kee WD. A systematic review (meta-analysis) of the accuracy of the mallampati tests to predict the difficult airway. *Anesth Analg* 2006;102:1867-78.
- Lundstrøm LH, Møller AM, Rosenstock C, Astrup G, Wetterslev J. High body mass index is a weak predictor for difficult and failed tracheal intubation: A cohort study of 91,332 consecutive patients scheduled for direct laryngoscopy registered in the Danish Anesthesia Database. *Anesthesiology* 2009;110:266-74.
- Lundstrøm LH, Møller AM, Rosenstock C, Astrup G, Gätke MR, Wetterslev J, et al. Avoidance of neuromuscular blocking agents may increase the risk of difficult tracheal intubation: A cohort study of 103,812 consecutive adult patients recorded in the Danish Anaesthesia Database. *Br J Anaesth* 2009;103:283-90.
- Lundstrøm LH, Møller AM, Rosenstock C, Astrup G, Gätke MR, Wetterslev J, et al. A documented previous difficult tracheal intubation as a prognostic test for a subsequent difficult tracheal intubation in adults. *Anaesthesia* 2009;64:1081-8.
- Lundstrøm LH, Vester-Andersen M, Møller AM, Charuluxananan S, L'hermite J, Wetterslev J, et al. Poor prognostic value of the modified mallampati score: A meta-analysis involving 177 088 patients. *Br J Anaesth* 2011;107:659-67.
- Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH, et al. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: A cohort study of 188 064 patients registered in the Danish Anaesthesia Database. *Anaesthesia* 2015;70:272-81.
- Nørskov AK, Wetterslev J, Rosenstock CV, Afshari A, Astrup G, Jakobsen JC, et al. Effects of using the simplified airway risk index vs. usual airway assessment on unanticipated difficult tracheal intubation - A cluster randomized trial with 64,273 participants. *Br J Anaesth* 2016;116:680-9.
- Patel A, Pearce A, Pracy P. Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings. Ch 18. London: Head and Neck Pathology; 2011.
- Forastiere A, Koch W, Trotti A, Sidransky D. Head and neck cancer. *N Engl J Med* 2001;345:1890-900.
- Rosenblatt W, Ianus AI, Sukhupragarn W, Fickenscher A, Sasaki C. Preoperative Endoscopic Airway Examination (PEAE) provides superior airway information and may reduce the use of unnecessary awake intubation. *Anesth Analg* 2011;112:602-7.
- Frerck C, Cook T. Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings. Ch. 13. London: Management of the 'Can't Intubate Can't Ventilate' and the Emergency; 2011.
- Hillman DR, Platt PR, Eastwood PR. The upper airway during anaesthesia. *Br J Anaesth* 2003;91:31-9.
- Nouraei SA, Giussani DA, Howard DJ, Sandhu GS, Ferguson C, Patel A, et al. Physiological comparison of spontaneous and positive-pressure ventilation in laryngotracheal stenosis. *Br J Anaesth* 2008;101:419-23.
- Patel A, Nouraei SA. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE): A physiological method of increasing apnoea time in patients with difficult airways. *Anaesthesia* 2015;70:323-9.
- Kheterpal S, Healy D, Aziz MF, Shanks AM, Freundlich RE, Linton F, et al. Incidence, predictors, and outcome of difficult mask ventilation combined with difficult laryngoscopy: A Report from the Multicenter Perioperative Outcomes Group. *Anesthesiology* 2013;119:1360-9.
- Kristensen MS, Teoh WH, Baker PA. Percutaneous emergency airway access; prevention, preparation, technique and training. *Br J Anaesth* 2015;114:357-61.
- Kristensen M. Predicting difficult intubation 2. *Anaesthesia* 2002;57:612.
- El-Boghdadly K, Onwochei DN, Cuddihy J, Ahmad I. Current practice for awake fiberoptic intubation - Asking the right questions. *Anaesthesia* 2017;72:1149-50.
- Popat M, Woodall N. Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major complications of airway management in the United Kingdom Report and findings. Ch. 14. London: Fiberoptic intubation; Uses and Omissions; 2011.
- Law JA, Morris IR, Brousseau PA, de la Ronde S, Milne AD. The incidence, success rate, and complications of awake tracheal intubation in 1,554 patients over 12 years: An historical cohort study. *Can J Anaesth* 2015;62:736-44.
- Joseph TT, Gal JS, DeMaria S Jr., Lin HM, Levine AI, Hyman JB, et al. A retrospective study of success, failure, and time needed to perform awake intubation. *Anesthesiology* 2016;125:105-14.
- Fitzgerald E, Hodzovic I, Smith AF. 'From darkness into light': Time to make awake intubation with videolaryngoscopy the primary technique for an anticipated difficult airway? *Anaesthesia* 2015;70:387-92.
- Ahmad I, Bailey CR. Time to abandon awake fiberoptic intubation? *Anaesthesia* 2016;71:12-6.
- Higgins WE, Ramaswamy K, Swift RD, McLennan G, Hoffman EA. Virtual bronchoscopy for three - Dimensional pulmonary image assessment: State of the art and future needs. *Radiographics* 1998;18:761-78.
- Neumann K, Winterer J, Kimmig M, Burger D, Einert A, Allmann KH, et al. Real-time interactive virtual endoscopy of the tracheo-bronchial system: Influence of CT imaging protocols and observer ability. *Eur J Radiol* 2000;33:50-4.
- Finkelstein SE, Summers RM, Nguyen DM, Stewart JH 4th, Tretler JA, Schrupp DS, et al. Virtual bronchoscopy forevaluation of malignant tumors of the thorax. *J Thorac Cardiovasc Surg* 2002;123:967-72.
- Ahmad I, Millhoff B, John M, Andi K, Oakley R. Virtual endoscopy - A new assessment tool in difficult airway management. *J Clin Anesth* 2015;27:508-13.
- El-Boghdadly K, Onwochei DN, Millhoff B, Ahmad I. The effect of virtual endoscopy on diagnostic accuracy and airway management strategies in patients with head and neck pathology: A prospective cohort study. *Can J Anaesth* 2017;64.