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CORRESPONDENCE

Anticipated difficult airway management using a model of the upper airway

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To the Editor,

Airway assessment is a cornerstone of anesthesia care, and attention needs to be paid to potential difficulties with ventilation, intubation, and front of neck surgical access (FONA) should a "rescue" surgical airway rescue be required.[1–3] We describe the airway management preparation for a patient (who consented to this report) with an anticipated difficult airway using a model of his upper airway anatomy.

A 45-yr-old man with juvenile rheumatoid arthritis was scheduled for revision hip arthroplasty under general anesthesia (neuraxial anesthesia was precluded because of lumber spine deformity). He had limited head and neck mobility due to fusion of the C1–5 vertebrae (Figure A). Airway examination revealed a 2-cm mouth opening, modified Mallampati class 4, limited mandibular protrusion, small sternomental distance, narrow dental arch, and decreased submandibular compliance. Ventilation, intubation, and FONA were anticipated to be challenging.

A method to secure the airway and an "extubation" strategy were required. We fashioned a model of the patient's upper airway from the computed tomography (CT) scan of his upper airway (Figure A) to evaluate the feasibility of inserting various airway devices into the airway. The CT scan was taken with maximum head extension and mouth opening. The CT image was enlarged to full scale and pasted on a wooden slab. Aluminum plates (Alfence, Alcare, Tokyo, Japan) were bent to align with the jaw-cervix-sternum and the palate-pharynx-anterior surface of the cervical spine vertebral bodies. The tongue was made of sponge, which could be compressed to about half of its original thickness. These materials were anchored with screws onto the wooden slab with CT image (Figure B).

The model oropharynx could not accommodate the direct laryngoscope blades, McGrath^{TM} MAC laryngoscope blade #2 (Covidien, Tokyo, Japan), videolaryngoscope blades (AirwayScope S-200 Pediatric Pblade, Nihon Kohden, Tokyo, Japan), supraglottic devices (LMA Classic^{TM} #2.5, Teleflex, Westmeath, Ireland; i-gel® #2.5, Intersurgical, Wokingham, Berkshire, UK), or oral airways (8-cm oropharyngeal airway, Smiths Medical, Ashford, Kent, UK). Nevertheless, we found that a 6.0-mm internal diameter (ID) Parker Flex-Tip^{TM} endotracheal tube (Parker Medical, Highlands Ranch, CO, USA) "railroaded" over a 4.9-mm flexible bronchoscope (BF-P60, Olympus, Tokyo, Japan) fitted the oropharynx model. To facilitate oral bronchoscopic intubation, we modified an 8-cm oropharyngeal airway by removing the back (Figure C). For extubation, we verified that the endotracheal tube inserted into the model could accommodate an airway exchange catheter (Cook Medical, Bloomington, IN, USA, Figure D). We also determined that the model could accommodate a 6.0-mm ID nasopharyngeal airway (Mercury Medical, Clearwater,

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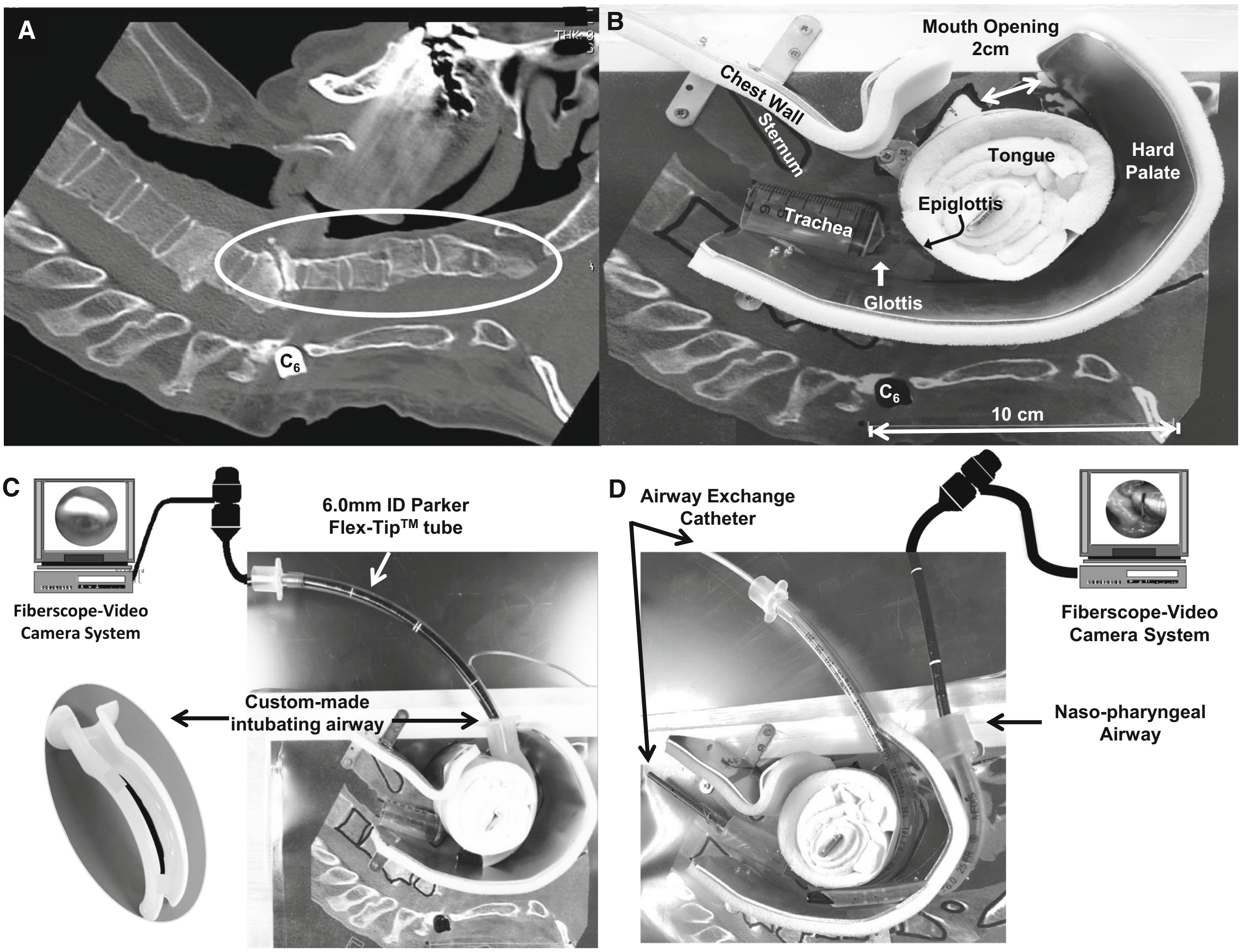

Figure A) Computed tomography (CT) of the cervical spine and upper airway. The first through fifth cervical vertebrae are fused (circle). The head and neck cannot be extended because of a fixed cervical flexion deformity. B) An upper airway model fashioned from CT data of the patient's airway anatomy. C) Tracheal intubation using a fibrescope-video camera system. A fibrescope attached to a video camera monitor system, passed into a 6.0-mm internal diameter endotracheal tube, is inserted through the custom-made intubating airway (circle). D) Tracheal extubation using an exchange catheter during fibrescope visualization. The exchange catheter is inserted into the endotracheal tube immediately before extubation, and then the tube is removed over the catheter, which remains *in situ*. A nasopharyngeal airway, inserted into the nasopharynx, permits passage of the fibrescope to observe the upper airway after extubation. After confirming a patent upper airway the catheter can be removed.

FL, USA) through which the bronchoscope could be inserted to provide a view of the larynx during extubation.

The patient was pre-medicated with 0.5 mg atropine and 50 mg ranitidine, standard monitors were applied, and oxygenation was achieved with high-flow oxygen via nasal cannula (Optiflow™, Fisher and Paykel, Auckland, New Zealand). After administration of midazolam (2 mg) and fentanyl (0.1 mg), 5 mL of 2% lidocaine was sprayed into the oral cavity and pharynx with a Fineatomizer (Fuji Medical, Tokyo, Japan). The modified oropharyngeal airway was placed into the mouth, through which we inserted the bronchoscope (attached to an Olympus video system OTVF7, Tokyo, Japan) "railroaded" through the endotracheal tube. The bronchoscope was advanced, providing an excellent view of the larynx; 2 mL of 2% lidocaine was sprayed into the larynx and trachea through the bronchoscope's working channel. Afterwards, the bonchoscope was inserted into the trachea and the endotracheal tube was advanced. After confirmation of successful intubation (positive end-tidal carbon dioxide), general anesthesia was induced with 50 mg propofol and maintained with 1.5–2% sevoflurane and remifentanil 0.1–0.15 $\mu g \cdot kg^{-1} \cdot min^{-1}$. The 220 min operation was uneventful. Following reversal of anesthesia, the airway exchange catheter was inserted into the trachea through the endotracheal tube. A lubricated nasopharyngeal airway was inserted into the right nares through which the bronchoscope was inserted for visual inspection of the oropharynx during extubation. The endotracheal tube was then withdrawn, and after confirming a patent upper airway the exchange catheter was removed, followed by withdrawal of the nasopharyngeal airway and bronchoscope.

The advantages of the airway model included the simulated insertion of various airway devices including those requiring modification. It also provided the perioperative team an opportunity to practice a simulated challenging airway management scenario. Finally, it is inexpensive and relatively easy to make.

Shortcomings of our model include the capture of a single, stationary position that may not be the most suitable for the patient. It cannot provide information about the degree of tissue displacement and elasticity that may affect insertion of airway devices. Two-dimensional CT data to construct a three-dimensional model may result in inaccuracies; this may be addressed by evolving three-dimensional printing and modeling technologies.[4] There should be a "failed" airway scenario strategy especially when FONA is very difficult or impossible. Back-up plans should consider extracorporeal membrane oxygenation or heart lung bypass rescue.[5]

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