

Videolaryngoscope On Demand for Pediatric Patients with Abnormal Airway

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INTRODUCTION

Endotracheal intubation of pediatric patients with complex craniofacial malformations often requires flexible fiberoptic instrumentation but fixed blade videolaryngoscope (VL) may be very useful if angulation of the laryngoscopic blade matches the abnormal anatomy of the airway. VL improves the view of the glottis by reducing the requirement for anterior displacement of the tongue. The optimal angulation may vary from patient to patient. Yet currently available videolaryngoscopes have predetermined fixed angulations (eg. 60⁰ in GlideScope™ blades). The goal of this study was to design a disposable VL with the customized blade angulation based on the airway X-ray anatomy of pediatric patients with abnormal airway.

METHODS

Random lateral airway X-rays of pediatric patients (Fig. 1A) with known difficult airway (e.g. Crouzon syndrome), but the unknown identity were placed on the screen (**Fig. 1 A**) of the pressure-sensitive pen tablet (Huion Kamvas 22). The tablet enabled a drawing of the path between upper incisors and the glottis. The 2-D drawings were transferred to the Autodesk Auto CAD (Fusion 360) program which allowed a 3-D rendering of the airway anatomy and a design of the VL with the customized shape, length and blade angulation. The blade design included an internal duct for the placement of a mini-endoscope. The VLs were 3-D printed using ABS or PLA materials. Mini-endoscopes with six LED lights and a mini-camera at the tip (**Fig. 2 C**) were placed in the internal duct and connected to a laptop computer or the Android cell phone to display images of the upper airway.

RESULTS

These custom made VLs were tested in adult and pediatric intubation manikins. The mini-endoscopes generated very sharp and bright images (**Fig. 2 E, F**) of the glottis and the blades were appropriately shaped and angulated to allow an easy placement of endotracheal tubes.

DISCUSSION

This is a novel study of the customized VL in which the shape, length and angulation of the blade can be preoperatively adjusted based on the airway anatomy of the patient. The availability of inexpensive pressure sensitive tablets, 3-D printing and cheap camera/LED light mini-endoscopes makes the design and preparation of such customizable VLs possible. Since the cost of materials was less than \$ 20 these VLs can be disposable. Although fiberoptic intubation is a method of choice in the management of airway in complex craniofacial malformations, an on demand VL prepared electively before the procedure, may

be a life-saving adjunct when the fiberoptic visualization of the airway is difficult or impossible.

Figure 1

A – an X-ray image of the head of a patient with a history of Crouzon syndrome was imported from the internet to the tablet. The pressure sensitive tablet stored the drawing (green/red) of the path between upper incisors and the glottis.

B - 3-D rendered VL prototype. **C** - computers using Cura software for slicing 3-D models for 3-D printing (**D**, **E**).

Figure 2

A, B, C - a set of pediatric VLs. **D** - testing set-up with mini-endoscopes connected to a laptop computer. The GlideScope™ is used to visualize on demand VLs in the airway of manikins. **E, F** - images of the glottis obtained by the new on demand VL.



