Echogenic 3-D Printed Laryngeal Mask Airways for Ultrasonic and Mini-endoscopic Guidance

Jacek A. Wojtczak MD, PhD

Department of Anesthesiology, University of Rochester School of Medicine and Dentistry, Rochester, New York

INTRODUCTION

Supraglottic airway devices (SADs) are inserted blindly which results in malposition or suboptimal position within oro/hypopharynx in nearly 50% of all insertions [1]. The purpose of this study was to develop a non-cuffed SAD that could be used both for vision and ultrasound guided insertions.

METHODS

The SAD was designed (**Fig. 1A)** using a pressure-sensitive pen tablet (Huion Kamvas 22).The 2D drawings were transferred to the Autodesk CAD (Fusion 360) program which allowed a 3-D rendering (**Fig. 1B**) and a design of the SAD with the customized shape, length and angulation. The SAD design included a large internal channel for ventilation and placement of a mini-endoscope. The prototypes were manufactured using 3-D printers (**Fig. 1E)** and elastic, echogenic printing materials**.** A disposable mini-endoscope with six LED lights and a mini-camera at the tip (**Fig. 1G**) was placed in the channel and was connected to a laptop computer or an Android cell phone to display the airway images. All SAD prototypes were immersed in a water bath or embedded in gelatin and their echogenicity was tested (**Fig. 2A,B,C)** using BK Medical Flex Focus 400 US system with 5 MHz curved and 15 MHz linear probes. The final tests were performed in the Laerdal intubation manikin and non-embalmed cadavers (**Fig. 2D-I**).

RESULTS

The custom made SAD placed in the water bath was strongly echogenic (**Fig. 2 A-C**) but its echogenicity was attenuated when it was placed in the oropharynx of cadavers. Some information about its midline alignment and the relation of the epiglottis to the non-inflatable cuff could be obtained, but in general the ultrasonic guidance was difficult. The attenuation of the ultrasound signal may be due to the cadaveric tissue characteristics and the experiments will be repeated in animals. The vision guidance of this SAD with the mini-endoscope was more promising. The disposable mini-endoscope placed in the large ventilatory channel of the SAD generated very clear images of the oropharynx and allowed an easy midline alignment of the channel that opposed the entrance to the trachea (**Fig. 2 H,I**).

DISCUSSION

This study describes a method to develop a custom made, 3-D printed echogenic LMA. The availability of inexpensive pressure sensitive tablets, 3-D printing and the variety of elastic, echogenic materials made the design and preparation of such customizable non-cuffed SAD possible. Commercially available SADs are produced only in the limited number of sizes. This 3-D printed SAD can be prepared in the infinite increments of size. Its shape, softness and contours can be customized to accurately mirror the paralaryngeal anatomy.

1. Van Zundert A. et al. Br J Anaesth 2016, 116, 579.

Figure 1

A - pressure sensitive tablet. **B** - 3-D rendered SAD prototype. **C** - Cura software workstation for slicing 3-D models for 3-D printing (**D, E**). **F, H** - SAD prototype with the mini-endoscope (**G)** attached to an Android phone.

Figure 2

A,BC - SAD placed in the water bath. Sagittal submandibular (**F**) and transverse (**G**) [at thyro-hyoid membrane] ultrasound of the cadaver neck (**epi** - epiglottis, **a** - arytenoids) with the SAD. **H,I** - mini-endoscopic view of the manikin uvula and glottis from the SAD cuff channel.