Assessment of a procedural curriculum using 3D printed airways to teach pediatric flexible bronchoscopy

Natalia Painter MD[1,2] and Thomas G. Saba MD[1]

[1]Department of Pediatrics, University of Michigan, Ann Arbor, Michigan

[2]Corresponding author

Corresponding author information:
Natalia Painter MD
jovanovi@med.umich.edu
L2221 UH South, 1500 E. Medical Center Drive, Department of Pediatrics, University of Michigan, Ann Arbor, Michigan 40108

Abstract

Background: Pediatric flexible bronchoscopy is a relatively high-risk procedure usually performed under general anesthesia. The indications are to assess for congenital airway malformations and collect bronchoalveolar lavage fluid for diagnostic purposes. Given the high risk of this procedure, simulation models are required to gain competency. No studies to date have adequately explored the use of 3D printed airways in pediatric flexible bronchoscopy training. The use of 3D printing has provided an opportunity to design realistic and durable surgical models for medical education. Compared to traditional virtual reality (VR) simulators, 3D printed airways have been shown to be more affordable, more realistic, and provide better haptic feedback [1-4]. Our aim is to create a sustainable and transferable pediatric flexible bronchoscopy training curriculum using 3D printed pediatric airways to teach pediatric pulmonology, pediatric critical care and pediatric surgery fellows pediatric flexible bronchoscopy skills under simulation. Our hypothesis is that this will be a well-liked curriculum and that 3D printed airways are a satisfactory teaching model. The primary outcome is the overall feasibility and satisfaction of learners. Secondary outcomes include: a) competency of learners at the end of the course and b) comparison of the learner assessment of the traditional VR model and the novel 3D printed airway.

Methods: This curriculum employs three different teaching tools: a didactic instructional video, VR modules on the CAE Endoscopic Simulator (CAE, Sarasota, FL), and a custom 3D printed airways. The 3D printed airway model was produced from a CT scan of a de-identified patient and built by computer aided design. An airway reconstruction from the larynx to the 4th generation airways was isolated, printed in polylactic acid, and silicone dyed using methods previously described [4, 5]. The model was encased in an external box designed to produce airway compression at different locations at the instructor's discretion in order to simulate congenital tracheobronchomalacia (Figure 1). Participants used the two simulation models under expert supervision and guidance. Participants learned technical skills, normal anatomy, how to identify tracheobronchomalacia and how to perform a bronchoalveolar lavage. After course completion, each participant assessed the two simulation models using a modified version of a validated tool using a 5-point Likert scale across 5 domains: physical attributes, realism of experience, ability to perform tasks, value, relevance, and global assessment. Faculty experts used the same assessment tool in the model validation process. The expert instructors also observed each learner perform a bronchoscopy on a 3D printed model and assessed the learner's competency using a modified version of the validated Bronchoscopy Skills and Tasks Assessment Tool [6].

Results: Four faculty experts participated in validation and four learners participated in the curriculum. Faculty assessments were very favorable but small improvements were suggested. All participants agreed or strongly agreed that it was valuable use of their time. All learners successfully identified right and left sided bronchial anatomy on the 3D printed pediatric airway model under expert observation. Learners provided very favorable assessments of both the VR simulator and 3D printed airway models, although a more comprehensive comparison will be pursued once more learners complete the course (Figure 2).

Conclusion: This course, employing didactic training, a traditional VR simulator and a novel 3D printed pediatric airway was well liked by participants. Participants provided similar assessments of the two simulation models. We present early promising data on a new simulation model with significant potential for growth and development. If this basic model is

proven to be an effective training tool with a larger study, this approach can be further developed to simulate various airway pathologies and offer a new and inexpensive model for training programs without virtual reality systems.

Tables and figures

Figure 1: (A) 3D printed pediatric airway model, (B) Representation of fellow using model to learn airway anatomy, (C) Casing housing airway model with external pegs to simulate airway compression.

Figure 2: Faculty and fellow assessment of simulation models.

References

[1] Pedersen TH, Gysin J, Wegmann A, Osswald M, Ott SR, Theiler L, et al. A randomised, controlled trial evaluating a low cost, 3D-printed bronchoscopy simulator. Anaesthesia. 2017;72:1005-9.
[2] Ha JF, Morrison RJ, Green GE, Zopf DA. Computer-Aided Design and 3-Dimensional Printing for Costal Cartilage Simulation of Airway Graft Carving. Otolaryngol Head Neck Surg. 2017;156:1044-7.
[3] Ho BHK, Chen CJ, Tan GJS, Yeong WY, Tan HKJ, Lim AYH, et al. Multi-material three dimensional printed models for simulation of bronchoscopy. BMC Med Educ. 2019;19:236.
[4] Reighard CL, Green K, Powell AR, Rooney DM, Zopf DA. Development of a high fidelity subglottic stenosis simulator for laryngotracheal reconstruction rehearsal using 3D printing. Int J Pediatr Otorhinolaryngol. 2019;124:134-8.
[5] Berens AM, Newman S, Bhrany AD, Murakami C, Sie KC, Zopf DA. Computer-Aided Design and 3D Printing to Produce a Costal Cartilage Model for Simulation of Auricular Reconstruction. Otolaryngol Head Neck Surg. 2016;155:356-9.
[6] Gopal M, Skobodzinski AA, Sterbling HM, Rao SR, LaChapelle C, Suzuki K, et al. Bronchoscopy Simulation Training as a Tool in Medical School Education. Ann Thorac Surg. 2018;106:280-6.