Three-Dimensional Modeled Custom-made Noninvasive Positive Pressure Ventilation Masks in an Infant

Allison Carroll, Israel Amirav, Roger Marchand, Deb Olmstead, Heather Logan, Andrew Grosvenor, Carina Majaesic, Joanna MacLean, and Piush J. Mandhan

Division of Pediatric Pulmonology, Department of Mechanical Engineering, and Institute of Reconstructive Sciences in Medicine, University of Alberta, Edmonton, Alberta, Canada

Figure 1. Facial topographic three-dimensional photography (Technion University, Haifa, Israel) was used for rapid facial imaging at the patient bedside. The camera uses a “structured light” method of data acquisition that is converted to stereolithographic files.

Figure 2. Initial mask design was performed by drafting a three-dimensional drawing of a standard infant nasal mask (Fisher and Paykel, Auckland, New Zealand) into computer-assisted design software. Mask–face contours are optimized through this process.

Figure 3. A rapid prototype of the customized noninvasive positive pressure ventilation mask was produced by printing the computer-assisted design file in a pliable photopolymer (Objet Geometries Inc., Rehovot, Israel). The rapid prototype was then tested against the patient’s face, and modifications were identified.

Figure 4. Medical-grade silicone is poured into a negative-image three-dimensional mold and allowed to cure.

Figure 5. The final mask can be adapted to industry standard equipment (Philips-Respironics, Andover, MA).

A 2.5-month-old boy, weighing 3.5 kg, with trisomy 21 and complex congenital heart disease developed severe respiratory compromise because of 50% tracheal narrowing after a central aortopulmonary shunt. The tracheal narrowing was relieved with high-flow nasal cannula. The treatment plan was to complete the cardiac repair after the patient reached 5 kg. Noninvasive positive pressure ventilation was trialed to potentially increase patient mobility and facilitate discharge. Standard available masks were not tolerated because of discomfort and nasal obstruction resulting from their size. The mask limitations initiated development of a multidisciplinary team to determine a process for design and production of customized noninvasive positive pressure ventilation masks for children.

Author disclosures are available with the text of this article at www.atsjournals.org.