Case Report

Reverse engineering, additive manufacturing (3D printing) as an adjunctive to tackle supply shortage in non-invasive ventilation during the COVID-19 pandemic

Christian Michael Horvath[1], Joël Illi[2], MSc, Jan Hermann[3], Anne-Kathrin Brill[1] MD

[1] Department of Pulmonary Medicine, Inselspital, University Hospital and University of Bern, Bern, Switzerland

[2] Switzerland Innovation Park Biel/Bienne, Biel, Switzerland

[3] ARTORG Center for Biomedical Engineering Research, Bern, University of Bern

Short Title: to be used as running head Additive manufacturing/reverse engineering against NIV supply shortages during pandemic

*Corresponding Author

Christian M. Horvath

Department of Pulmonary Medicine, Inselspital, University Hospital and University of Bern, Switzerland

Freiburgstrasse 4, CH 3010 Bern

PHONE: +41 31 632 80 99

FAX: +41 31 632 14 04

Email: horvathchristianmichael@gmail.com

Keywords: COVID 19, 3D Printing, reverse engineering, 3D scanning, PolyJet

Body

At the beginning of the SARS-CoV-2 pandemic closed boarders and rapidly increasing demands did not only lead to shortages of ventilators but also affected the supply with consumables for ventilation including nonvented masks and adaptors for circuits. In home mechanical ventilation or for sleep apnea treatment usually a broad variety of vented masks is available and local stocks of those masks are larger. Instead of taping or gluing the holes and altering anti-asphyxia valves in the vented elbow of the masks we evaluated options to produce equipment locally.

Using reverse engineering by 3D scanning and 3D printing with biocompatible material (DIN EN ISO 10993-1) we were able to design and manufacture within three days fully functioning customized prototypes of a new mask connector to easily transform vented masks into nonvented masks (Fig. 1). Depending upon the material and printing technology sterilization and multi-use is possible. Pricing depends on the produced numbers. In addition, we developed a prototype of an air tight sleeve connector for a leakage valve to ease the set-up of one of the proposed single limb NIV circuit setups (Fig. 2) of the Swiss Society for Pulmonology (SGP) [2] producing a similar intentional leak as the SGP set-up.

Medical 3-D printing and reverse engineering options are already available in Switzerland and have the potential to be particularly useful if serious shortages in supply recur. Also, a customizable nonvented elbow for the available vented masks can facilitate to find an interface with ideal and comfortable fit for prolonged NIV periods.

References:

1 Ranney ML, Griffeth V, Jha AK. Critical Supply Shortages — The Need for Ventilators and Personal Protective Equipment during the Covid-19 Pandemic. N Engl J Med. 2020 Mar DOI: 10.1056/nejmp2006141

2 Neue Informationen zu SARS CoViD19 - Schweizerische Gesellschaft für Pneumologie [Internet]. [cited 2020 Apr 28]. Available from:

http://www.pneumo.ch/de/newsleser/147.html

Fig 1: a) The new designed nonvented elbow mask connector, b) to be used with the usually vented oropharyngeal mask (AirFit F20, ResMed Ltd, Bella Vista, Australia), and c) the mask with the nonvented mask connector installed.

Figure 2: a) The newly designed sleeve connector for the leakage valve to ease the set-up of a NIV circuit b) Recommended NIV set-up of the Swiss Society of Pneumology during the COVID-19 pandemia c) Adapted NIV set-up using the sleeve connector, where the filter is attached laterally and the exhalation is filtered before exiting.

Statements

Disclosure Statement

The authors have no conflicts of interest to declare."

Funding Sources

There was no external funding for this case report.

Author Contributions

All authors contributed to this paper (design, draft and gave final approval).