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DEVELOPMENT OF Y CONNECTOR FOR MECHANICAL FAN FROM ADDITIVE MANUFACTURING DURING THE COVID 19 PANDEMIC

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INTRODUCTION

The severe acute respiratory syndrome (SARS-CoV-2) pandemic has increased the global burden of patients requiring mechanical ventilation. According to studies, 5% to 20% of patients hospitalized for coronavirus (COVID-19) require ICU-level care, and many of these need mechanical ventilation (GRASSELLI; PESENTI; CECCONI, 2020; WU; MCGOOGAN, 2020; WUNSCH, 2020).

In addition to the lack of understanding of the mechanisms of lung injury caused by the virus, and the divergences in the forms of treatment due to numerous complications associated with the disease (ACKERMANN et al., 2020; GATTINONI et al., 2020), there was concern about the lack of personal protective equipment (PPE) and procedures, including mechanical ventilation devices, their parts and circuits (WHO, 2021).

Mechanical ventilators allow patients to breathe in different ways, patterns and breathing modes, requiring indispensable parts, for individual use and/or disposable, to connect the equipment to the user/patient interface (BIYOVENT, 2016).

This set of parts constitutes the mechanical ventilation circuit, a pipe that is connected to the ventilatory support device, although there is a division between non-invasive and invasive mechanical ventilation circuits, every basic circuit is composed of: silicone trachea, drain for circuit, straight connector and Y connector (CPAPS, 2021).

A strategy used during the COVID-19 pandemic in an attempt to address the great demand for lung ventilators was to adapt the valve system through Y-connectors in order to function as 'ventilator splitters', to allow a single ventilator to support the two or more patients during the crisis (NEYMAN, IRVIN, 2006). Even so, the availability of these connectors in the market proved to be insufficient and, converging with the growing influence of the use of three-dimensional technologies (3D) in health, Additive Manufacturing (AM) rose as an important ally in the manufacturing process.

The AM processes allow, in most cases, the realization of objects of any complexity, with greater speed and lower cost (GARCIA, 2010), through the successive addition of material in flat and overlapping layers (VOLPATO, 2017). The viability of AM as an expressive technology applied to this global scenario was further strengthened due

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to the emergency measures adopted during the pandemic by the National Health Surveillance Agency (ANVISA), through Resolution nº 356, where the standards for the manufacture and acquisition of medical devices such as valves, circuits and connectors, necessary for the operation of artificial respirators, were made more flexible (COSTA et al, 2021).

Therefore, the aim of the present study is to present AM as a viable manufacturing process for a Y-connector for mechanical ventilators due to the demand of covid-19 for hospital in the city of Campina Grande.

METHODOLOGY

The present study is a scientific research of an applied nature and a qualitative approach submitted and approved by the Ethics and Research Committee under CAAE 10308819.5.0000.5187, with opinion number 3,240,444.

The part of the mechanical ventilator, known as Connector Y, used as an intermediary in double branch breathing circuits, was developed in the first half of 2020 in unit I of the Laboratory of Three-Dimensional Technologies - LT3D, located at the Center for Strategic Technologies in Health - NUTES, located at the State University of Paraíba (UEPB).

The Y Connector development process involves five methodological steps: Step 1: Original part dimensioning; Step 2: Virtual development of the part; Step 3: Print Parameters and Adjustment; Step 4: Additive Manufacturing; Step 5: Post Processing.

The Step 1 refers to sizing the original part. This was done using a measuring instrument, a caliper.

Step 2 comprises the virtual development of the part using the CAD (Computer-Aid Design) software, where a three-dimensional modeling of the Y connector is performed. In this phase, the digital file is obtained in .IPT format and later exported to .STL (Standard Triangle Language) , which refers to a standard language of triangles for forming a surface mesh.

The Step 3 corresponds to the parameters and settings for 3D printing the connector. At this stage, the digital file is exported again, this time to the CAM (Computer Aided Manufacturing) software

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Objet Studio®, already embedded in the printer used, responsible for generating the G-code (Geometric Code), where the printing parameters are stored for manufacturing .

Step 4 concerns the creation of the Y connector. To perform this step, the 3D printer Connex 350 with PolyJet technology was used, using Vero White resin as material. The choice of material was based on the mechanical properties that were desired to be achieved in the connector.

In step 5, the post-processing of additive manufacturing takes place, where all the support material is removed using a high-pressure water washer, giving the final finish to the part.

RESULTS AND DISCUSSIONS

The original piece used as a basis for measurements was provided by the Hospital de Emergencia e Trauma Dom Luiz Gonzaga Fernandes of Campina Grande/PB, which requested the demand. An operator with preparation and mastery of the digital caliper performed the collection of measurements from all sides of the original object and, thus, it was possible to precisely determine the dimension of the conector.

After the study and recognition of the original part, a virtual three-dimensional model was developed through Autodesk Inventor CAD software, generating an STL file. With the file imported into the CAM software Objet Studio, the third stage began. The determination of printing parameters and adjustments was influenced by the need for specification, detailing and smoothing required for part applicability.

The AM technology adopted was PolyJet, which uses the blasting process of different materials for manufacturing, with one of the resins directed to printing the part and another directed to generating the supports (VOLPATO, 2017). For this type of technology, a photosensitive material in the form of a gel is used which, after sandblasting on the platform, immediately polymerizes by means of a UV light source (STRATASYS, 2021). Furthermore, this material allows the devices to later face dataless sterilization processes.

PolyJet technology is capable of obtaining objects with complex shapes, intricate details, smooth characteristics, in addition to having

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a high degree of surface finish and greater dimensional accuracy, when compared to other processes such as FDM (Fused Deposition Modeling) (MA et al., 2018).

The printing step was performed using the Connex 350 printer. At the end, the support material is removed manually with the aid of a water jet, thus completing the last step of the process. For the complete manufacture and cleaning of the Y connector, the process took about three hours.

The final piece obtained comprises an original Y-connector replica. It has a massive structure, does not allow leaks, in addition to providing sterilization in several ways.

FINAL CONSIDERATIONS

The use of AM as a manufacturing process brought several advantages during the COVID-19 pandemic, such as speed in production and replacement of important supplies for the treatment of complications from the coronavirus. Furthermore, with the advent of parts shortages in the market, AM made it possible to manufacture custom medical devices.

This work, in particular, demonstrated the applicability of AM in the manufacture of a Y-connector for a mechanical respirator. The piece developed presents similarity with the original piece made available as a mold by the hospital. Thanks to the production process, as a final result, a Y connector was obtained with resistance, precision, good surface finish and, also, passive to face the sterilization processes.

In addition, from the important aspects achieved, it is worth mentioning that the study provides an alternative for the development of medical devices with time and cost savings, providing a relevant advance of AM in the health area.

Keywords: Pandemic, Ventilators Mechanical , Three-dimensional printing.

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