Cost-Effective Resuscitation Device with Real-Time Health Monitoring Capabilities

Kosaraju Swathi[1], Bandela Rajani[2], Gudela Viswa Teja[3], Rachabathula Prabhas Ragava[4],
Gadiparthi Sudheer Babu[5], Pallepogu Suresh Babu[6]

[1],[2]*Assistant Professor,* [3],[4],[5],[6]*Undergraduate. Department Of ECE, PSCMR College Of Engineering And Technology, Vijayawada, Andhra Pradesh, India swathi7201@gmail.com[1], rajani.bandela@gmail.com[2], tejaviswa583@gmail.com[3], Prabhas2824@gmail.com[4], Sudheer.gadiparthi1401@gmail.com[5], Pallepogusureshbabu1@gmail.com [6]*

Abstract—"**Cost-Effective Resuscitation Device with Real-Time Health Monitoring Capabilities**" offers the first solution to provide a critical, accessible and safe respiratory support system during emergencies such as the COVID-19 pandemic. Using NodeMCU technology, our model offers an innovative mechanism based on a pneumatic motor, providing precise control over ventilation parameters. With toggle switches and variable poten-tiometers, adjustments can be made to individual patient needs, increasing ventilation efficiency. The resuscitator bag integrates sensors to monitor blood oxygen levels and breathing pulmonary pressure, with real-time data displayed on a small screen. The emergency buzzer warns health care workers immediately of any disturbance. In particular, our system allows doctors and relatives to monitor the patient's condition in real time, reducing the need for constant physical presence. Using the NodeMCU as the central controller, our low-cost automated resuscitator case provides a cost-effective solution for resource-constrained settings without compromising performance or reliability. This article represents an important step in democratizing life-saving respiratory support, improving patient outcomes, and improving healthcare resilience in a crisis.

Index Terms—**Resuscitator Bag, NodeMCU, Ventilation efficacy, Oxygen levels, healthcare resilience**

the ventilation you need, addressing the critical need for a cost-effective and efficient solution. Central to the design of this automated resuscitator case is the use of NodeMCU technology, a versatile platform known for its robustness and cost-effectiveness. By integrating the NodeMCU as a central controller, this system achieves precise control over ventilation parameters, providing optimal support

I. INTRODUCTION

The global healthcare landscape is facing unprecedented challenges, especially in emergencies such as the COVID-19 pandemic, where the demand for respiratory systems is increasing. Access to reliable and affordable medical equip-ment remains a critical issue, especially in resource-limited settings. In response to this urgent need, there is a need to develop innovative technologies to ensure effective patient care and the sustainability of the healthcare system. "Cost-Effective Resuscitation Device with Real-Time Health Monitoring Ca-pabilities" means a solution designed to replace the respiratory support system, especially in emergency situations. Leveraging technological advances, this advanced model takes a new approach to providing
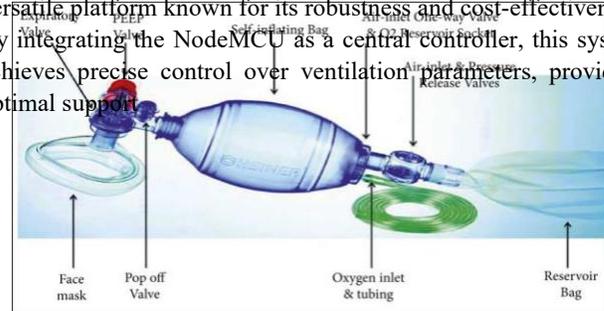
Fig. 1. Resuscitator Bag

tailored to individual patient needs. This not only improves ventilation efficiency, but also offers critical flexibility and adaptability in a dynamic healthcare environment. At the heart of this innovative solution is a core mechanism powered by a pneumatic motor that provides a reliable and efficient means of ventilation support. Combined with built-in controls such as variable switches and variable potentiometers, healthcare professionals can adjust ventilation settings with ease, facilitat-ing seamless adaptation to evolving patient needs. In addition, the integration of sensors to continuously monitor important parameters such as blood oxygen levels and pulmonary pres-sure adds a layer of safety and security. Real-time feedback displayed on the mini-screen allows healthcare professionals to monitor the patient's condition, while the emergency buzzer immediately warns of deviations from normal parameters and provides timely intervention when needed. One of the most im-portant advantages of the "Cost-Effective Resuscitation Device with Real-Time Health Monitoring Capabilities" is the ability to monitor remotely, which allows doctors and caregivers to monitor the patient's progress without the need for constant physical presence. This not only improves resource allocation, but also improves patient care by responding quickly to changing conditions.

Access to safe and affordable medical equipment is a priority for effective patient care during a crisis. The demand for respiratory support systems, especially in emergencies such as the COVID-19 pandemic, highlights the urgent need for innovative solutions that can be easily deployed in resource-

constrained settings. By addressing this challenge, the development of the Automatic Resuscitator Bag (Fig.1) is an important step towards democratizing access to life-saving technology. Leveraging the power of NodeMCU technology, this breakout model offers a cost-effective and versatile approach to provid-ing ventilation support. Through a unique alarm mechanism powered by pneumatic actuators, ventilation parameters are precisely controlled, thus tailoring support to the specific needs of the patient. The integration of sensors and sensors for continuous monitoring increases the efficiency and safety of the system, allowing immediate intervention in the event of an emergency. What sets this automatic resuscitator bag apart is its ability to monitor remotely, giving healthcare providers real-time insight into the patient's condition without having to be physically present at all times. This not only optimizes resource allocation, but also facilitates timely decision-making and ultimately improves patient outcomes.

II. DESIGN OBJECTIVES

Affordability: The main goal is to create a low-cost automatic resuscitator bag that is affordable for healthcare facilities in resource-constrained settings, without compromising quality or performance.

Precision Control: This system aims to achieve precise control of air supply parameters, allowing healthcare professionals to support the specific needs of patients. It includes adjustable settings for ventilation rate, tidal volume, and pressure to maximize efficiency and patient comfort.

Remote Monitoring: Facilitating remote monitoring capabilities is essential to allow healthcare providers to monitor a patient's condition in real-time without the need for physical monitoring. This goal increases efficiency, enables rapid response to emergencies, and optimizes resource allocation.

III. LITERATURE SURVEY

A literature review examines research and development related to automatic resuscitator bags, their effectiveness, limitations, and technological advances. This critical anal-ysis provides valuable insights to inform the design and implementation of innovative solutions in respiratory support systems. Teddy Ort et.al [1] This innovative system uses a unique sero-based robotic handle to automate ventilation by uniformly compressing the resuscitator bag. In particular, the prototype was conceptualized, built and subjected to pig testing in just one month, laying the foundation for large-scale production. Embracing an open source approach, the project provides mechanical drawings, design spreadsheets, circuit diagrams, and control code, facilitating global adoption and manufacturing efforts. This initiative directly addresses ventilator shortages during the COVID-19 pandemic, dramatically improving patient care and strengthening the resilience of healthcare systems globally. Mohit Kumar et.al, [2], Low-cost alternatives to mechanical ventilation, especially the automatic manual ventilator bag (AMBU), have attracted the attention of healthcare providers, researchers and policy makers. This appeal is based on its ability to be rapidly produced, econom-ically distributed and accessible to a wider population. This

automated device is designed to help patients breathe by compressing and deflating the AMBU bag at a precise frequency, while providing oxygen that includes respiratory rate, pressure, and tidal volume. In addition, the automated AMBU bag offers distinct advantages over its manual counterpart, freeing healthcare providers to focus on important aspects of patient care. Its simple design, low cost, portability, and easy operation make it ideal for use while transporting patients, whether powered by batteries or batteries. With an intuitive control system that requires minimal training to operate, these devices provide efficient and safe respiratory support in a variety of clinical settings, facilitating seamless integration into health-care protocols. Significant advances in the understanding and analysis of ventilation procedures during neonatal resuscita-tion. It successfully identifies and parameterizes events related to ventilatory interventions by using basic signal processing techniques on multiple signal channels, including pressure, flow, CO_2, and ECG. This allows for the characterization of the ventilation procedure and the extraction of meaningful information from the recordings obtained through the Laerdal Neonatal Resuscitation Monitor. Insights such as ventilatory events and parameters have great potential to improve resus-citation practice. It not only facilitates retrospective analysis to identify associations between ventilation parameters and positive responses in neonates, but also provides immediate feedback to health care providers in resuscitation situations. Ultimately, this study contributes to improving the effective-ness and efficiency of neonatal resuscitation protocols, thereby reducing the severity of complications related to asphyxia and improving neonatal outcomes. The AARMED (Ambu Bag for Rapid Mass Emergency Deployment) system provides an inexpensive and straightforward solution for mechanical ventilation in emergencies. It has been rigorously tested to meet ISO certified standards, ensuring adherence to regimens and recommended parameters for the effective management of COVID-19 patients. Capable of continuous operation in vol-ume control, pressure control and auxiliary control, AARMED offers a cost-effective alternative to traditional ventilators. With a battery backup that lasts 2.5 hours, it is ideal for transportation purposes. AARMED directly addresses venti-lator shortages during the COVID-19 pandemic, providing a reliable solution for healthcare systems with limited re-sources. By improving patient care and strengthening health system resilience, AARMED plays a critical role in mitigating the challenges posed by the pandemic. Rohan Lal Kshetri, et al. This device provides accurate ventilation to patients in need with a real-time feedback mechanism that allows tidal volume adjustments based on the patient's condition, thereby increasing efficiency. The simple yet powerful design facilitates easy performance and portability for emergency availability. This low-cost ventilator is a solution to ventilator shortages, especially during the COVID-19 pandemic, and provides healthcare facilities around the world with a cost-effective way to save lives and manage patients with acute respiratory distress syndrome (ARDS).

IV. Equipment

The materials used in the proposed system are listed in the below table with their parameters and the minimum ranges of a healthy people.

Name	Parameter	Range
MG995	Gear Servo Motor	0-180deg
MAX30100	BPM, Oxygen Levels	60-100beats, 95
DHT11	Temperature, Humidity	98.6F(37∘C), 30-50%

NodeMCU is an open source software with an open source prototype board design. The name "NodeMCU" is a combination of "node" and "MCU" (microcontroller unit). Strictly speaking, the term "NodeMCU" refers to the software, not the associated development tools. NodeMCU has a more powerful processor, larger memory and can handle larger sketches and more complex devices.

Fig. 2. NodeMCU (ESP8266)

The ESP32 is a chip that provides Wi-Fi and (in some models) Bluetooth connectivity for embedded devices—in other words, IoT devices. Although ESP32 is technically just a chip, modules and development boards that contain this chip are often called "ESP32" by the manufacturer.

Fig. 3. ESP 32

The MAX30100 sensor is used as a heart rate monitor and pulse oximeter. A pulse oximeter consists of a light emitting diode and an IR sensor. A signal processing unit to improve the quality of the output signal. It operates at an input voltage of 1.8V to 3.3V.

Fig. 4. MAX30100 Sensor

These sensors are used in various applications such as measuring humidity and temperature values in heating, ventilation and air conditioning systems. Weather stations also use these sensors to forecast weather conditions. Moisture sensors are used as a preventive measure in the homes of people affected by moisture.
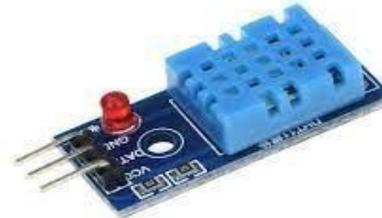

Fig. 5. DHT11 Sensor

V. Methodology

proposed emergency ventilator is a compact version of a commercial ventilator intended to help patients experiencing respiratory distress. The mechanism shows natural breathing, ensuring that the parameters of air exchange necessary for the safety of the patient are maintained. In practice, the microcontroller controls the motor responsible for compressing the resuscitator bag, facilitating oxygen infusion. The system includes a mechanical compressor designed to regulate the flow of air into and out of the lungs. In addition, it integrates an LCD screen with sensors for pressure, temperature and pulse oximetry, showing important medical parameters in real time for patient monitoring. Key design considerations include mobility, cost-effectiveness, accuracy, reliability, and user-friendliness. Air carriers aim to provide suitable solutions

for emergencies by prioritizing these factors. Its compact size improves portability allowing efficient deployment in various healthcare settings. Cost-effectiveness ensures access while maintaining high standards of accuracy and reliability in ventilation support, especially in resource-limited environments. The addition of real-time monitoring capabilities via sensors and LCD displays improves patient care by allowing healthcare providers to monitor vital signs and adjust treatment as needed. Overall, the proposed emergency ventilator represents a holistic approach to address the need for effective respiratory support in emergency situations. By balancing technical functionality with practical considerations, it promises to be a valuable tool for saving lives and improving patient outcomes in critical medical emergencies.

This design features a silicone air exchange bag driven by a DC motor that uses a double push mechanism to facilitate ventilation. Control switches, including toggle switches and variable potentiometers, allow you to adjust breath length and breaths per minute (BPM) to meet patient needs. Our system includes blood oxygen sensors and sensory pressure sensors to monitor critical patient vitals such as blood oxygen levels and airway pressure. These vital signs are displayed in real-time on mobile screens for the convenience of healthcare providers. In addition, an emergency alarm has been integrated to immediately alert caregivers of detected anomalies. The entire system is powered by an Arduino controller that ensures accurate and efficient operation to help patients during the COVID pandemic and other emergencies.

The power supply is the backbone, providing power to the entire system. At the core is a Microcontroller (ESP8266) and ESP32 that controls the operation of other components. It reads sensor data, makes decisions based on current parameters, and communicates with other parts of the system. The Pressure button allows the user to adjust the pressure for delivered breaths, the Start button initiates automatic ventilation, and the Off button stops ventilation when needed. Information about the system, such as pressure settings and ventilation speed, is displayed on the LCD screen. LED indicators (LED 1 LED 2) provide a visual indication of system status and a Buzzer emits an audible alert or alarm. A Servo Motor adjusts the inflation and deflation of the bag by compressing it as needed. The MAX30100 sensor measures blood oxygen levels and heart rate to monitor the patient's condition. The DHT11 sensor measures temperature and humidity to help monitor the environment. The Age Group button allows you to select appropriate settings for the patient's age or size. Finally, WiFi Devices make it easy to connect to log data, monitor remotely, or receive updates. Overall, this system is designed to provide automatic chest compressions and mask valve bag by controlling the microcontroller pressure and ventilation rate based on user input and sensor feedback, while visual and audible indicators provide status updates.

"Low-Cost Automated Resuscitator Bag" Models offer an affordable and reliable solution for respiratory support, especially in emergency situations. Moving away from the complicated and expensive nature of conventional ventilators, our model uses a simple but effective design. Using NodeMCU technology, orchestrating the system built around container-
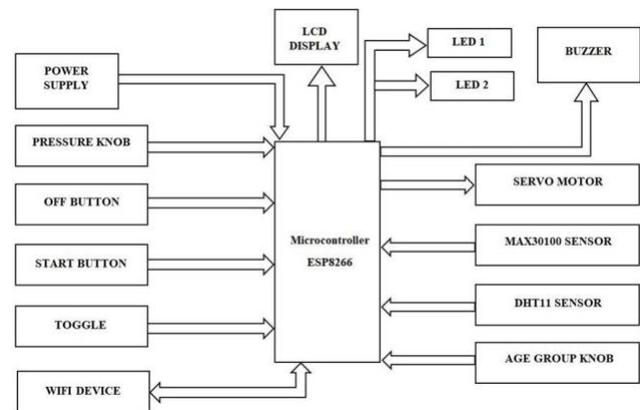

Fig. 6. Block Diagram

based mechanisms driven by pneumatic actuators is central to its functionality. These settings allow precise adjustment of ventilation parameters, including respiratory rate, volume, and inspiratory-expiratory ratio. What sets our models apart is their adaptability and user-friendliness. Equipped with toggle switches and variable potentiometers, users can experiment with ventilation settings to meet individual patient requirements. In addition, sensor integration enables continuous monitoring of vital signs such as blood oxygen levels and pulmonary pressure. Real-time feedback is easily displayed on the mini-screen, giving healthcare providers immediate information about the patient's condition.

VI. RESULTS AND DISCUSSIONS

Implementation of the Low-Cost Automated Resuscitator Bag model has shown promising results, demonstrating its effectiveness and potential impact in providing respiratory support. Extensive testing and evaluation revealed significant results. First, the mechanism based on the shell controlled by a pneumatic actuator demonstrates reliability and accuracy, ensuring the precise delivery of ventilation according to predetermined parameters. This ensures constant air flow for optimal
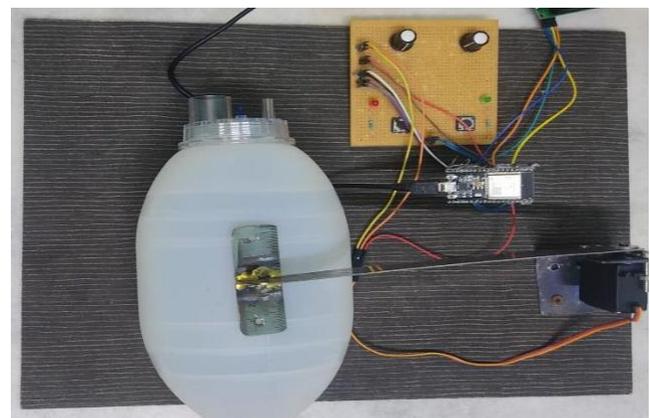

Fig. 7. Compression process of Resuscitated Bag

breathing support. Second, a user-friendly interface with toggle switches and variable potentiometers makes it easy to adjust ventilation settings smoothly. Healthcare providers can easily adjust parameters to meet specific patient needs, improving adaptability and usability. Air ducts are tested for proper compression and decompression and check if the Ambu bag has been compressed considered in the design. It has a 1600ml reservoir keep the air out of the bag. Compression and The decompression mechanism was successfully tested as described In Fig: 7, different input parameters are used in the system to test ventilation performance at different tide levels; different breathing rates and IE ratios for long-term work. This test shows the expected results.
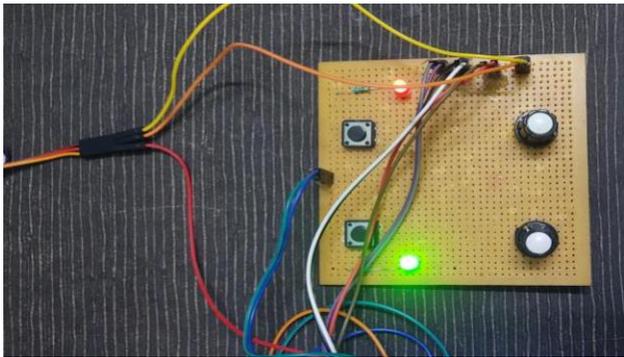

Fig. 8. Connections of Automated Resuscitated Bag

Fig. 9. Values on LCD Display

The above figure shows the user air channel interface with various input parameters. The Total system power consumption is very low.

VII. CONCLUSION

As a result, the development of the "Cost-Effective Resusci- tation Device with Real-Time Health Monitoring Capabilities" has made significant progress in addressing the critical need for an affordable and reliable respiratory support system, especially in emergencies such as the COVID-19 pandemic. Using NodeMCU technology, this innovative model offers a mechanism based on new equipment powered by pneumatic actuators that allow precise control of ventilation parameters. The addition of variable switches and variable potentiome- ters allow easy adjustment to meet individual patient needs, Thereby increasing ventilation efficiency. In addition, the inte- gration of sensors

for continuous monitoring of vital signs, real-time information displayed on a small screen, and an emergency alert system improve patient safety and facilitate timely intervention by healthcare providers. In particular, the system's remote monitoring capabilities allow doctors and caregivers to monitor the patient's condition in real time, reducing the need for constant physical presence. Offering a cost-effective solution without compromising function or relia- bility, this model holds great promise for resource-constrained settings, ensuring fair access to rescue breathing support.

The feature set includes a NodeMCUcontrolled mechanism, adjustable ventilation parameters, continuous monitoring of vital signs, real-time data display, an emergency alert system, and cost-effective respiratory support for emer- gency situations.

REFERENCES

[1] T. Ort et al., "MIT Emergency-Vent: An Automated Resuscitator Bag for the COVID-19 Crisis," 2021 43rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Mexico, 2021, pp. 4998-5004, doi: 10.1109/EMBC46164.2021.9630882.

[2] M. Kumar, R. Kumar, V. Kumar, A. Chander, V. Gupta and A. K. Sahani, "A Low-cost Ambu-bag Based Ventilator for Covid-19 Pandemic," 2021 IEEE Biomedical Circuits and Systems Conference (BioCAS), Berlin, Germany, 2021, pp. 1-5, doi: 10.1109/BioCAS49922.2021.9644985

[3] A. I. Abboudi, A. I. Alhammadi, K. M. Albastaki, N. u. M. Khanum and A. Jarndal, "Design and Implementation of Portable Emergency Ventilator for COVID-19 Patients," 2022 Advances in Science and Engineering Technology International Conferences (ASET), Dubai, United Arab Emi- rates, 2022, pp. 1-4, doi: 10.1109/ASET53988.2022.9734315.

[4] A. Thitirattanapong, S. Ongtrakul and C. Pintavirooj, "Low-Cost Blower-Based Ventilator," 2021 13th Biomedical Engineering International Conference (BMEiCON), Ayutthaya, Thailand, 2021, pp. 1-3, doi: 10.1109/BMEiCON53485.2021.974523.

[5] H. Vu et al., "Automatic Detection and Parameterization of Manual Bag-Mask Ventilation on Newborns," in IEEE Journal of Biomedical and Health Informatics, vol. 21, no. 2, pp. 527-538, March 2017, doi: 10.1109/JBHI.2016.2518238.

[6] Ø. Meinich-Bache et al., "Object Detection During Newborn Re- suscitation Activities," in IEEE Journal of Biomedical and Health Informatics, vol. 24, no. 3, pp. 796-803, March 2020, doi: 10.1109/JBHI.2019.2924808

[7] A. Vasan, R. Weekes, W. Connacher, J. Sieker, M. Stambaugh, P. Suresh, D. E. Lee, W. Mazzei, E. Schlaepfer, T. Vallejos et al., "Madvent: A low-cost ventilator for patients with covid-19", Medical devices sensors, vol. 3, no. 4, pp. e10106, 2020.

[8] Chang, Javier, Augusto Acosta, Jorge Benavides-Aspiazu, Jaime Reategui, Christiam Rojas, Jordi Cook, Richard Nole et al. "Masi: A mechanical ventilator based on a manual resuscitator with telemedicine capabilities for patients with ARDS during the COVID-19 crisis." Hard- wareX 9 (2021): e00187.

[9] Ranney, M.L., V. Griffeth, and A.K. Jha, Critical supply shortages— the need for ventilators and personal protective equipment during the Covid-19 pandemic. New England Journal of Medicine, 2020. 382(18): p. e41.

[10] Gattinoni, L., et al., Covid-19 does not lead to a "typical" acute respiratory distress syndrome. American journal of respiratory and critical care medicine, 2020. 201(10): p. 1299-1300.

[11] Yang, X., et al., Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retro- spective, observational study. The Lancet Respiratory Medicine, 2020.

[12] E. Calilung et al., "Design and Development of an Automated Com- pression Mechanism for a Bag-Valve-Mask-Based Emergency Ventilator," 2020 IEEE 12th International Conference on Humanoid, Nanotechnol-ogy, Information Technology, Communication and Control, Environment, and Management (HNICEM), Manila, Philippines, 2020, pp. 1-6, doi: 10.1109/HNICEM51456.2020.9400150.

[13] Wady, Heitham, David Restle, Juyeon Park, Aurora Pryor, Mark Ta-lamini, and Sherif Abdel-Misih. "The role of surgeons during the COVID-19 pandemic: impact on training and lessons learned from a surgical resident's perspective." Surgical endoscopy 35 (2021): 3430-3436.

[14] L. Hewing et al., "Volume Control of Low-Cost Ventilator with Automatic Set-Point Adaptation," 2021 European Control Conference (ECC), Delft, Netherlands, 2021, pp. 781-786, doi:

10.23919/ECC54610.2021.9655092.

[15] H. Li, E. Li, D. Krishnamurthy, P. Kolbay, B. Chacin, S. Hoehne, J. Cybulski, L. Brewer, T. Petelenz, J. Orr et al., "Utah-Stanford ventilator (Vent4US): Developing a rapidly scalable ventilator for COVID-19 patients with ARDS", medRxiv, 2020.

[16] C. Galbiati, W. Bonivento, M. Caravati, S. De Cecco, T. Dinon, G. Fiorillo, D. Franco, F. Gabriele, C. Kendziora, I. Kochanek et al., "Mechanical Ventilator Milano (MVM): A novel mechanical ventilator designed for mass scale production in response to the COVID-19 pandemics", 2020.

[17] Arnal, Jean-Michel, Aude Garnero, Mathieu Saoli, and Robert L. Chatburn. "Parameters for simulation of adult subjects during mechanical ventilation." Respiratory care 63, no. 2 (2018): 158-168.