Case Study: COVID-19 ICU Respiratory Simulator Training

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The Institute of Patient Safety and Simulation of the state of Grisons, Switzerland (Graubündner Institut für Patientensicherheit und Simulation, GRIPS) was commissioned to produce training programs in the application of respiratory care for patients with COVID-19 when the COVID-19 pandemic was first declared an emergency in Switzerland.

These training programs covered the safe use of intensive care ventilators, non-invasive ventilation techniques (NIV), and high flow oxygen therapy. Not only were trainees in these areas to be taught the basic skills in using those techniques, they were also to be taught how patients may or may not respond to those techniques.

Lung simulator design

GRIPS owns a fully featured TestChest® and a NASCO Life/form® Advanced "Airway Larry" Airway Management Simulator, and in order to create a lung simulator suitable for invasive and non-invasive respiratory therapy, these devices were combined.

Based on information from the on-site intensive care unit (ICU) and international recommendations (Gattinoni L, Chiumello D, Caironi P, Busana M, Romitti F, Brazzi L, Camporota L: COVID-19 pneumonia: different respiratory treatment for different phenotypes? (2020) Intensive Care Medicine; DOI: 10.1007/s00134-020-06033-2), it was possible to simulate three types of COVID-19 patient.

- Patient 1: Initial stage, responding to high-flow oxygen therapy
- Patient 2: A type H COVID-19 patient, paralysed to reduce the impact of respiratory activity on lung tissue
- Patient 3: A type L COVID-19 patient.

These cases were used in the trainings, and the respiratory care devices were

chosen according to availability in the departments and hospitals trainees were coming from.

Training goals

The goals of the training were to ensure that all trainees know the potential infection pathways and the principles of protecting staff in connection with high-flow oxygen therapy, NIV and invasive ventilation.

Additionally, all trainees would learn how to apply and control highy flow oxygen therapy, NIV, and invasive ventilation, concentrating on the application of these therapies specifically for COVID-19 patients. Once the training was completed, all trainees would be fully competent in the use and application of the devices available to them in their practicing healthcare institutions.

Implementing the training

A presentation was given to open the training program in order to give the trainees the necessary knowledge on the physiologic and pathophysiologic respiratory support needed for patients with COVID-19. Next, the recommendations in treating COVID-19, valid at the time of the program, were highlighted.

Trainees were then split into two to three groups and were asked to apply and explore the taught material on simulated patients. This collaborative work included applying their knowledge and skills to patient responses to therapy as well.

High flow oxygen therapy

After the function of the respiratory care device was explained, trainees were able to explore different flow-rates and how they affected the end-expiratory pressure and oxygen concentrations. They could immediately experience the impact on arterial oxygenation saturation as provided by the pulse-oximeter connected to the finger-simulator of TestChest.

NIV

The function of the respiratory care device was explained, after which trainees applied varying levels of pressure support, CPAP levels, and oxygen concentrations to the simulated patient. Again, they could experience the impact of their settings on arterial oxygenation saturation as provided by the pulse-oximeter connected to TestChest.

Invasive ventilation

A comprehensive introduction to invasive mechanical ventilation was provided, which then gave all trainees the opportunity to apply different ventilation settings and discover the best settings for both type H and type L simulated COVID-19 patients. Part of the training included the interpretation of ventilatory curves and the impact on arterial oxygenation.

Results

High flow oxygen therapy

All participants, nurses and physicians were new to high-flow oxygen therapy. Following the program introduction, all trainees installed the device themselves and used it directly on the simulator. The baseline was set before they started; in this case, the patient was set to present with low oxygen saturation.

Trainees became aware of the threat of hypoxemia immediately, which pushed them to quickly initiate high-flow therapy. After the initial application, trainees attempted to find the optimal settings for the patient.

The timeline was kept realistic as the TestChest reacted autonomously to the trainee's settings and inputs, based on the implemented physiological models (TestChest Physiological Model, neosim Chur, Switzerland, 2017, ISBN 978-3-9524884-0-9). As the TestChest's reactions were autonomous, there was no need for the instructor to intervene while trainees were operating the TestChest. Ad-hoc intervention from the instructor would have been technically possible, but was not necessary in any case.

One problem trainees faced was showing the effect on end-expiratory pressure when patients closed their mouth. The NASCO Airway Larry is not equipped with this kind of feature, meaning trainers had to close the patients'

mouth themselves. Although this intervention was not realistic, the demonstration could be carried out and the effect on end-espiratory pressure was clearly visible. It was also necessary to choose the right prone-size to fit Airway Larry's nostrils to avoid large leaks, which is a problem faced in real-world cases.

The trainer was able to carry out a wide range of failures to trigger a drop in arterial saturation, for example, caused by a disconnection of the oxygen hose to the device. This was facilitated by the TestChest's autonomous reactions. These types of incidents required the trainees to pay attention to problems not related to the patient, and with the physiology of TestChest acting as in reality, the trainees were put under realistic levels of stress to find the root cause of failures.

The success of the first sessions prompted the hospital administration to request repeats of the training session.

NIV

The NIV training program was aimed at pulmonary and sleep-medicine clinicians; both nurses and physicians. While the NIV was familiar to all trainees, they required training on a device they had not used before.

The application of the masks on the Airway Larry proved easier than applying the high-flow oxygen therapy. To start, a COPD patient was simulated and yielded faster response than with high-flow oxygen therapy.

The trainer challenged trainees with non-clinical incidents, with the TestChest reacting accordingly. This put stress on the participants to find the cause of the problem, to eliminate it, and to confirm resolution of the problem.

Invasive ventilation

The participants of this program were clinicians trained in anesthesia and intensive care medicine, again including both physicians and nurses. The ventilators used in the program were known to a portion of the trainee group.

Before patients were simulated, all trainees were briefed on the principles of lung-protective ventilation in patients with acute respiratory distress syndrome (ARDS). During the session, the two different types of COVID-19

patients were simulated in the chronological order, including both Type H and Type L patients. Trainees were able to explore a range of settings on the TestChest, which responded autonomously.

As part of the training, different devices and settings were explored. Trainees were impressed by the fact that there can be major differences between ventilators, despite the same settings being used.

Feedback

Participants

Participants were impressed by the autonomous reaction of TestChest, and agreed unanimously that without autonomous reactions as seen with the TestChest, it would not have been possible to achieve the ambitious goals of the training program. Trainees highlighted that it was possible to explore different settings on the same simulated patient and compare outcomes.

Trainers

Trainers were impressed by the real-time and physiological reactions of TestChest. The autonomous function allowed them to immediately respond to the needs of the trainee groups without having to influence the simulator unrealistically, a possibility that was, until now, unprecedented.

Final remarks

The unlimited possibilities of TestChest and its clinically plausible reaction to adequate respiratory support as well as inadequate support makes the TestChest simulator an indispensable tool to train healthcare providers in respiratory care.

Combined with an intubation head, the set-up used was very true to real life. Resistance, compliance, lung volumes and other respiratory system parameters can be set simply to represent any pathologies needed for training. The TestChest carries out the simulation accordingly and automatically, meaning it can be used by both experienced and inexperienced simulation trainers.

The cases used were provided by neosim as part of the package. However,

although the cases provided were highly realistic, trainers should ultimately become familiar with the settings of TestChest to create their own cases.

Acknowledgements

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About neosim AG

neosim is a Swiss company founded by experts with strong background in lung physiology and mechanical ventilation of intensive care patients. The mission of neosim is to bring high-fidelity physiology and pathophysiology to the patient simulator community.

For training and education of clinicians, especially respiratory therapists and intensive care professionals, neosim simulators create realistic breathing in health and disease. In contrast to other simulators, neosim's simulators can be treated with intensive care therapy methods and responds like a real human patient. The result manifests itself clinically and can be measured quantitatively with state-of-the-art monitoring in real-time.

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