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Design and implementation of a modular ECMO simulator

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Background: Extracorporeal membrane oxygenation (ECMO) is a high-complexity life-saving procedure riddled with mechanical complications that can place the patient in a critical state where fast and coordinated actions are required to avoid mortality. Thus, patients on ECMO are supervised round the clock by highly trained nurses and perfusionists. Currently, ECMO training programs include patient emergency simulations performed with different levels of success. Some training facilities use mannequins that have computer-controlled physiological parameters such as heart rate and oxygen saturation. The circuit parameters such as pressure are manually adjusted per scenario; air and artificial blood are manually injected to indicate problems such as air embolism, and hypovolemia.[1] Despite being realistic, using an actual ECMO circuit for simulation training purposes has disadvantages such as the use of expensive disposable equipment (oxygenation membrane), lack of oxygenation color differentials, and manual circuit adjustments and injections.
Methods: This paper describes the design of a modular ECMO simulator centered on the use of thermochromic ink and instructor/clinician interface. The goal is to re-create the ECMO circuit and its functionalities using affordable, reusable, and extensible mechanisms that do not require the presence of a real ECMO machine.
Results: Oxygenation is visually simulated by heating and cooling thermochromic ink, allowing it to switch between dark and light red. A replica of an ECMO machine's console interface allows manual adjustment of parameters wirelessly through a tablet instructor application. Furthermore, the visual and audio cues of mechanical complications such as access line shattering can be easily implemented using mechanical vibrators. See proposed simulator design in Figure 1.

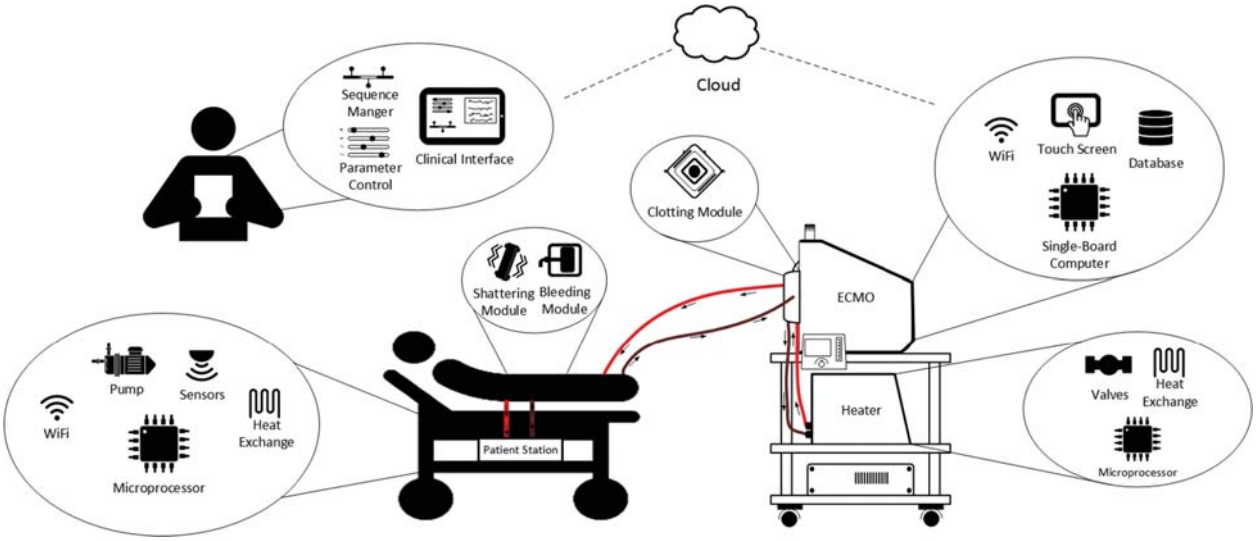

Figure 1. Block diagram of the simulator.

Conclusions: Advantages of the proposed system include the removal of the cost barrier and inconvenience of current ECMO simulators, while adding modularity and customizability to simulate a multitude of emergency scenarios, thus increasing the accessibility, fidelity, and versatility of ECMO patient management training.

Keywords: extracorporeal membrane oxygenation (ECMO), medical training, ECMO simulation, thermochromic Ink, modular system

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