




## Interventions to improve the mechanical ventilation fidelity of the Laerdal SimMan® 3G simulation mannequin

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### To the Editor,

The Laerdal SimMan® 3G mannequin (Laerdal USA, Wappingers Falls, NY, USA) is widely used for high-fidelity simulation. Nevertheless, providers familiar with mechanical ventilators commonly notice a lower lung compliance, necessitating lower set tidal volumes ( $V_T$ ) to reduce airway pressure. SimMan 3G is 180 cm tall, which corresponds to an ideal body weight of 75 kg (according to <http://www.ardsnet.org/tools.shtml>) and a  $V_T$  of 600 mL at 8 mL·kg<sup>-1</sup>. This “normal”  $V_T$  without positive end-expiratory pressure (PEEP) results in a peak airway pressure of 34 cmH<sub>2</sub>O. For a  $V_T$  of 500 mL, the peak airway pressure was 28 cmH<sub>2</sub>O and the static airway compliance was 24 mL·cmH<sub>2</sub>O<sup>-1</sup>. This static airway compliance of the stock mannequin is about 30–50% of typical human values.<sup>1</sup> These values are reproducible among six SimMan 3G mannequins to which our group has access. Adding PEEP exacerbates problems with high-pressure alarms, and a PEEP above 5 cmH<sub>2</sub>O and  $V_T$  of 500 mL results in an air leak greater than 2 L·min<sup>-2</sup> (ventilator bellows cannot be driven with 2 L·min<sup>-1</sup> flow).

The high peak airway pressures and air leak are frequently noticed in simulation sessions for maintenance of certification in anesthesia done for the American Board of Anesthesiology. High airway pressures may mislead participants by suggesting acute lung injury, endotracheal tube kinking, or a mucus plug. This causes trainee

confusion and frequent intervention and interruption by the simulation team, making it difficult for participants to be fully engaged in the scenario.<sup>2</sup> To circumvent these problems, we investigated fitting larger, more elastic reservoirs (Rusch 500-mL ventilator test lungs) inside the mannequin. The stock Laerdal SimMan® 3G mannequin has 350-mL reservoir bags (part 212-11150). We also attached satellite reservoirs (Siemens Maquet ventilator test lungs; Maquet, Rastatt, Germany) with a Y connector to the circuit outside the mannequin. A third modification was to extend the internal connection tubing to avoid disconnections.

Replacement of the stock reservoirs (Figure A) inside the mannequin with a 500-mL Rusch ventilator test lung (Teleflex, Wayne, PA, USA) (Figure B) resulted in higher fidelity in  $V_T$ , peak airway pressure, and calculated compliance.<sup>3,4</sup> For a 500-mL  $V_T$ , peak airway pressure was 12 cmH<sub>2</sub>O and static compliance was 50 mL·cmH<sub>2</sub>O<sup>-1</sup>.

The fitting of an external “satellite” bag (Figure D) was done with 250-, 500-, and 1000-mL Siemens Maquet ventilator test lungs. Using the 1000-mL bag and a 500-mL  $V_T$ , peak airway pressure was 8 cmH<sub>2</sub>O and static compliance was normal at 83 mL·cmH<sub>2</sub>O<sup>-1</sup>. Additionally, we were able to achieve a PEEP of 15 cmH<sub>2</sub>O and a  $V_T$  of 400 mL without high pressure alarms (peak airway pressure was 38 cmH<sub>2</sub>O).

High airway pressures combined with chest compressions in simulation scenarios contribute to frequent tubing disconnects and ventilation reservoir ruptures. Replacement of the internal connection tubing with a longer piece of tubing and stronger cable ties abolished further occurrences of tubing disconnect (Figure C).

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Exchange of the lungs with Rusch test lungs required one to two hours of work and minimal cost, was reversible, and was invisible to participants. After exchange, the possibility to adjust resistance and compliance with the mannequin controls was partially preserved. Nevertheless, modifying the mannequin does compromise the manufacturer's warranty. This can be avoided by

attaching a satellite ventilator test bag externally to the circuit, resulting in physiologic values for compliance. Unfortunately, resistance and compliance of the satellite lungs cannot be adjusted by the mannequin software.

These interventions enhance the fidelity of the SimMan 3G mannequin for mechanical ventilation substantially. This expands the usability of the mannequin to more



**Figure** Mannequin modifications to improve mechanical ventilation fidelity A) The stock Laerdal SimMan® 3G mannequin has 350-mL reservoir bags, part 212-11150. B) Modification of the Laerdal SimMan® 3G mannequin with 500-mL Rusch ventilator test lungs,

which are more elastic. C) Modification of the Laerdal SimMan® 3G mannequin with a longer piece of internal connection tubing (red arrow) and stronger cable ties. D) Fitting of external “satellite” Siemens Maquet ventilator test lungs to the ventilator

advanced and specialized participants and improves its reliability.

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