What You See Is What You Get—But Not Always

Medicine in the modern era is transforming faster than many had likely anticipated, literally opening doors to types of care previously unimagined. Six years ago, a group of medical professionals with interests in austere medicine attending a Special Operations Medical Association Conference demonstrated remote operation of a mechanical ventilator in Israel, with the same accuracy as if controlled at the location. As advanced as that may have seemed, the technical aspects were largely commonplace, if not rudimentary given today's wireless communication capabilities. What is not as simplistic are the challenges posed by critical care medicine and the safeguards required when one cannot physically see a device, as in the aforementioned scenario.

The prospects of telemedicine continue to enhance and confound the delivery of health care, asserting more efficient, timely, less costly care, while the potential pitfalls are yet to be fully elucidated. It is certain that, in many cases, delivery of care would be minimized, if not inaccessible, due to a variety of constraints, which makes providing health care from a distance that much more attractive. For many, it is likely a life-sustaining mediation, as is the case for those requiring mechanical ventilation in the home, relying on caregivers from afar to ensure the safety and efficacy of interventions.

Executing good medical interventions assumes the plan is appropriate, accurate, and reproducible. The introduction of remote/telemedicine requires additional measures to ensure the "medicine" we intend to deliver is the medicine received. Despite advances in mechanical ventilation coupled with oxygen delivery, the onus still rests with the provider for accurate delivery, and in the absence of visual assurance, not everything is intuitive.

Lewarski and Gay[1] indicated that evidence-based standards of care for the application of invasive mechanical ventilation in the home are nonexistent. It is difficult to ascertain the impact of mechanical ventilation in homes because data are limited, absent any significant central accounting for either invasive or noninvasive ventilation. A consensus report generated by the American College of Chest Physicians in 1998 estimated that 10,000–20,000 patients utilized mechanical ventilation in their homes.[1]

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In a small prospective trial evaluating 12 ventilator dependent children discharged from a pediatric ICU, Muñoz-Bonet et al[2] surmised a potential value in telemedicine, expressing its utility in early discharge to home without compromising quality of care. Of particular note was their inclusion of the families' characterization of tending to a loved one at home. Though all conveyed that their training was sufficient, half expressed apprehension; this is a potential gap, given that the surrogate caregiver (eg, a parent or a spouse) assumes a certain safety capacity to reassure the patient that he or she is not going without the attention of a medical professional.

Oxygen delivery during mechanical ventilation at home commonly requires an oxygen concentrator and a low-flow source delivered into the circuit or the inlet of the driving system. The addition of oxygen into the inspiratory limb of the circuit is commonly accomplished, but it has well-known effects on the delivered tidal volume (V_T). Others have sought to maximize oxygen efficiency and limit the impact on V_T delivery.[3] Rodriquez et al[4] illustrated a potential solution for incorporating pulse dose oxygen delivery into the ventilator circuit considered for home ventilation applications; at least one commercial device utilizes this technology (VOCSN, Ventec Life Systems, Bothell, Washington).

In this issue of the Journal, d'Aranda et al[5] highlight augmentation of the set V_T, the well-documented consequence of adding oxygen into the inspiratory limb. They further describe the impact of various flows at the ventilator inlet, which had not been published previously. As noted, flow introduced into the inspiratory limb of the ventilator circuit may introduce unintentioned consequences, in this case as much as a 29% increase in v for the highest oxygen flow tested (ie, 8 L/min). This flow is likely not commonly observed in home care, but it might be seen in austere environments including military and disaster

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response. The results of the study are not unique, unexpected, or particularly complicated. The addition of flow into the circuit might also adversely impact triggering.

What the work by d'Aranda et al[5] does bring to light is the impact of oxygen delivery practices on "data" and "information" available remotely to caregivers. This is a very basic type of telemedicine, where the caregiver can evaluate the ventilator settings, measured values, and infer the status of the patient. The information transferred remotely to providers would be assumed to be accurate. However, without an awareness of how the oxygen was delivered, medical decisions could be made with an inappropriate and incomplete understanding of delivered V_T. Evidence-based practice is only possible when the health care system is cognizant of reliable data, and making a decision as to whether to adjust ventilatory support requires a reasonable accounting of dose-specific interventions. In this case, "what you see is what you get" is not operable. Even in cases where oxygen does not supplement mechanical ventilation delivery, accuracy of the data may be suspect. A bench study by Luján et al[6] evaluated the operational characteristics of 5 commercial ventilators providing noninvasive ventilation under varying conditions of leak and ventilatory pattern. Their efforts resulted in identifying an underestimation of delivered V_T in all systems by as much as 15%.[6] It is important to note that, in their work, at least one system capitalized on the utility of a predictive algorithm for pressure loss in the circuit, resulting in a disparity in volume estimation of only 0.3%.

A hallmark of respiratory therapy beginning with the origins of the profession is problem-solving. In many instances, this involves the modification of devices to address shortcomings related to design and site of care. Consider only the early continuous positive airway pressure and intermittent mandatory ventilation systems to remind you of the ingenuity of early therapists. This study by d'Aranda et al[5] demonstrates that, depending on the site of oxygen supplementation, the site of V_T measurement, and the accuracy of the sensor, important differences in actual and reported V_T may occur. In the current regulatory and legal environment, modification of devices is less commonplace. However, necessity is the mother of invention, and caregivers are challenged in home and austere environments to meet patient requirements. This paper highlights a concern with the use of telemedicine to transmit inaccurate data.

The promise of telemedicine and "big data" relies on a host of complex factors. Importantly, the accuracy of the reported data are paramount. These issues can inform our practice and serve as a cautionary tale for unintended consequences of modifications to existing devices. Medical errors are often described using the "Swiss cheese" model.[7] That is, there is typically not a single factor resulting in an untoward outcome. This issue is no different. The use of oxygen added to the inspiratory limb, the position of the flow sensor in the circuit, training of the caregivers, and the transfer of inaccurate data have the potential to lead to inappropriate decisions. The role of the respiratory therapist in home ventilation is to close the holes in the Swiss cheese.

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