Pandemic Surge, Well-Intended Responses, and Unintended Consequences

Over the past 2 years, health systems have been challenged by the surge of patients with severe respiratory failure as a consequence of SARS CoV-2 respiratory infection. Shortages of ventilators, personnel protective equipment, intensive care beds, oxygen, and, finally, staff have played out in the lay press nightly. As 2022 begins, we continue to face challenges related to COVID-19 despite all we have learned and the efforts by many to publish guidelines for best practices in this unprecedented time.[1,2]

Early in the pandemic, overwhelmed hospitals, faced with a novel, contagious, febrile respiratory illness resulting in severe hypoxemia and ARDS, were forced to make treatment decisions based on little evidence. Often these changes were made in an earnest effort to reduce caregiver exposure and risk. A common decision included avoiding the use of both noninvasive ventilation and high-flow nasal cannula for fear of spreading infectious aerosols.[3,4] These concerns turned out to be overstated.[5]

Similarly, there were calls for de novo development of new simple-to-use ventilators by first-time manufacturers, use of anesthesia ventilators in the ICU, shared ventilation between 2 or more individuals, and the use of the Defense Production Act to empower automobile manufacturers to make ventilators.[6-11] The first 3 of these solutions were never realized and proved unnecessary despite the attention each received.[6,11,12] The Defense Production Act mass produced nearly 100,000 ventilators, far exceeding the number required. The fate of this new stockpile and the capital to maintain it remain to be determined: unintended consequences.

Strategies for increasing ICU bed capacity included repurposing operating theaters, post-anesthesia care units, and nonpatient care areas into temporary care sites.[1] This included in-house creation of negative flow rooms using available equipment. Over time, the remoteness of some of these sites proved to create new challenges. The operating theater was remote from the traditional ICU, and the ability to hear and respond to alarms was a concern. The use of anesthesia ventilators further complicated this problem owing to the alarm volume related to the expectation that these devices would always be attended.[13,7] Expansion of ICU capacity also placed a demand on the oxygen systems and required respiratory therapists and clinical engineering departments to rediscover the intricacies of hospital oxygen systems. Oxygen shortages and excessive demands were unintended consequences.[14]

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Throughout the pandemic, there have been a number of reports of endotracheal tube obstruction in patients with COVID-19, far in excess of the normal reported occurrence.[15-17] At least in one case, heated humidifiers were turned off in an effort to reduce aerosolization of contaminated condensate. Of course, the result was an epidemic of plugged endotracheal tubes and retained secretions requiring the use of bronchoscopy, airway clearance maneuvers, and instilled sodium bicarbonate to loosen mucus plugs.[3] It could be argued that the additional therapies required increased the risk to caregivers far beyond the risk of aerosolized condensate. In this case, an unintended but predictable consequence.

In this issue of the Journal, Lavoie-Bérard and others describe an increased incidence of endotracheal tube obstruction in a group of subjects with COVID-19 receiving heated humidification with a heated-wire circuit.[18] This observation is striking in that during the same time frame patients using a passive humidifier had no observed increases in airway obstruction. This is in direct contradiction to the literature on this subject, where heat and moisture exchanger use is more commonly associated with luminal narrowing of the endotracheal tube and airway obstruction.[19,20] Potential causes of increased endotracheal tube occlusions in COVID-19 include excess secretion production, high minute ventilation, avoidance of airway clearance maneuvers to reduce staff exposure, reduced airway care related to the volume of patients, staff shortages, and sloughing of airway mucosa.[15,17]

Lavoie-Bérard et al[18] hypothesized that the function of heated humidifiers was impacted by the change in ambient

Mr Branson discloses relationships with Engineered Medical Systems, Mallinckrodt, Pfizer, Vyaire, and Ventec Life Systems.

Supplemental material related to this paper is available at http://rc.rcjournal.com.

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DOI: 10.4187/respcare.09929

temperatures created when ICU rooms were modified to allow for negative flow introduced to reduce caregiver exposure. They confirmed in the bench study that excessive ambient temperatures (28–30°C) resulted in a decreased humidifier output. Of note, these authors had previously shown that ambient temperatures and high gas temperature from ventilators using turbine systems altered humidifier output in 2004.[21]

The authors proposed a solution consisting of 3 measures. The first was activation of the humidifier's compensation algorithm when heater plate temperature was < 62°C. Second, heater plate temperature was monitored by respiratory therapists and adjusted as needed. Note this required some effort in the specific model of humidifier, where other devices have these settings more readily available. Finally, an air conditioning system compatible with a negative pressure room was installed. Please view the supplemental content available at the Journal's web site (see related supplemental material at http://rc.rcjournal.com) for details on these methods. Of note, the study was performed in Quebec, where air conditioning is not commonly required owing to the northern latitude.

The work here demonstrates the unintended consequences of a well-intended and necessary intervention. In this case, the addition of negative flow systems to reduce caregiver and patient risk. This work also demonstrates the importance of ongoing research during a pandemic. The authors should be congratulated for quick recognition of the problem and their expertise in ferreting out the etiology. Their exploration of humidifier operation and modification should also be recognized.

As the pandemic continues and we prepare for what will undoubtedly be the next pandemic, we should be cautious in our well-intended solutions and cognizant of unintended consequences. Careful observation and ongoing data collection are critical to safe introduction of emergency measures. As Shakespeare reminds us,

"Striving to better, oft we mar what's well."

King Lear Act I, Scene 4.

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