Opinion Paper

Steven Liu*, Cara Sweeney, Nalinee Srisarajivakul-Klein, Amanda Klinger, Irina Dimitrova and Verity Schaye

Evolving oxygenation management reasoning in COVID-19

https://doi.org/10.1515/dx-2020-0099
Received July 10, 2020; accepted July 13, 2020; published online August 24, 2020

Abstract: The initial phase of the SARS-CoV-2 pandemic in the United States saw rapidly-rising patient volumes along with shortages in personnel, equipment, and intensive care unit (ICU) beds across many New York City hospitals. As our hospital wards quickly filled with unstable, hypoxemic patients, our hospitalist group was forced to fundamentally rethink the way we triaged and managed cases of hypoxemic respiratory failure. Here, we describe the oxygenation protocol we developed and implemented in response to changing norms for acuity on inpatient wards. By reflecting on lessons learned, we re-evaluate the applicability of these oxygenation strategies in the evolving pandemic. We hope to impart to other providers the insights we gained with the challenges of management reasoning in COVID-19.

Keywords: coronavirus; COVID-19; management reasoning; oxygenation.

Introduction

The height of the COVID-19 pandemic in New York City brought 1,700 new hospitalizations daily. Similar surges have been seen since in other cities, with similar shortages in medical equipment and access to care. To date, Bellevue Hospital has cared for nearly 1,500 inpatients diagnosed with COVID-19. At our peak, our hospital census doubled, with quintuple our typical medical intensive care unit (ICU) census. Over two-thirds of our ward service required supplementary oxygen, ranging from nasal cannula (NC) to non-invasive ventilation (NIV).

Rising patient volumes coupled with higher acuity altered our management reasoning during this period. Cook, Sherbino and Durning described management reasoning as a cognitive process similar to diagnostic reasoning, but focused mainly on choices regarding treatment, testing, and resource allocation [1]. Limited resources and evidence hampered our management of COVID-19. We describe how our group developed and implemented guidelines for hypoxemia management, adapting to changing norms for acuity on inpatient wards. We reflect on how fluctuating prevalence and systems-based improvements influenced our practice.

Delaying actions

Our experiences with the COVID-19 pandemic in Bellevue began in early March. One of our initial cases was a 43-year-old man who presented to our hospital with multifocal pneumonia and progressive hypoxemia, with symptoms for five days. He had several risk factors for worsening disease: morbid obesity, elevated inflammatory markers, and bilateral infiltrates. His hypoxemia and tachypnea steadily worsened. On hospital day 3 his COVID-19 test returned positive. The following day, he required escalation from NC to a non-rebreather mask (NRB) over 2 h while under monitoring on the inpatient medicine unit. Despite the use of an NRB, he remained unstable. We intubated him on the ward with the assistance of our ICU and anesthesia teams.

As the pandemic progressed, we reconsidered our management of hypoxic respiratory failure. We first examined if intubation on the ward was the optimal strategy. Intubating patients on the wards created several problems due to viral aerosolization. Immediately after intubation, entire rooms would be unusable until cleaned,

***Corresponding author: Steven Liu**, MD, Clinical Assistant Professor, NYU Grossman School of Medicine, NYC Health and Hospitals, Bellevue Hospital Center, 550 First Avenue, New York, NY 10016, USA. Phone: +1 212 562 4100, E-mail: steven.liu@nyulangone.org. https://orcid.org/0000-0002-7681-1518
Cara Sweeney, Nalinee Srisarajivakul-Klein, Amanda Klinger, Irina Dimitrova and Verity Schaye: NYU Grossman School of Medicine, NYC Health and Hospitals, Bellevue Hospital Center, New York, NY, USA

and transporting intubated patients to the ICU exposed bystanders along the way. ICUs also proved better equipped for peri-intubation complications.

Prior to the outbreak, our threshold to intubate severely hypoxemic patients similar to this one was comparatively low. We presumed that the window for intervention in respiratory failure was narrow and early intubation was preferred in acute respiratory distress syndrome (ARDS) [2]. The COVID-19 outbreak fundamentally challenged these assumptions. Alarming degrees of hypoxemia and respiratory distress were regularly seen in hospitalized patients with SARS-CoV-2. As our ICUs reached capacity and bed wait times lengthened, we were increasingly forced to maintain severely hypoxemic patients on the ward, despite the scarcity of data to support alternatives to intubation in ARDS [3]. These delays led us to observe that patients could be stabilized for days using oxygenation modalities previously considered only temporizing.

These experiences informed our oxygen titration protocol (Figure 1), in which intubation is employed judiciously and preferably in an ICU setting. The titration protocol was developed out of an imminent need to manage escalating acuity on the floor.

The addition of NC to NRB to improve oxygenation runs contrary to the accepted idea that NRB delivers close to 100% fractional inspired oxygen. Pre-COVID-19 literature supports the combination of NC and NRB to improve oxygenation. Small trials explored the use of combined therapy in peri-intubation pre-oxygenation. One compared pre-intubation end tidal oxygen in NRB, NRB and NC, and bag-valve mask, finding NRB and NC comparable to bag-valve mask and superior to NRB alone [4]. While the physiology dictating this effect exceeds the scope of this perspective, it is hard to discount clinical observations which confirm the efficacy of adding NC to NRB.

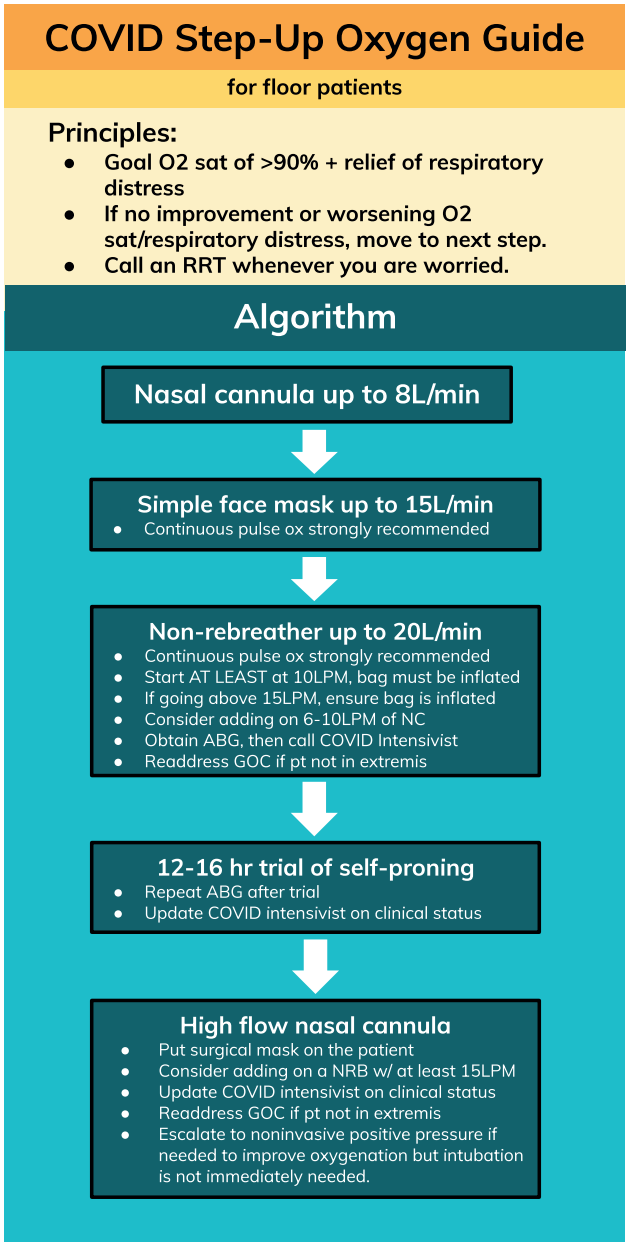

Figure 1: Oxygen titration protocol for floor patients.

Avoiding intubation

Two weeks after our initial patient, we admitted a 32-year-old obese man with rapidly worsening hypoxemia requiring escalating oxygen support. By the second day of hospitalization, he required NRB and proning to maintain oxygen saturations greater than 90%. He exhibited mild tachypnea and no significant signs of accessory muscle use. He remained on NRB with continuous oxygen monitoring for 4 days, after which he recovered.

Most COVID-19 patients' hypoxemia is due to ARDS causing ventilation and perfusion mismatch rather than hypercarbic respiratory failure. Our aforementioned protocol focused on escalation of oxygen supplementation. Further interventions for persistent hypoxemia included advancing to high flow nasal cannula (HFNC), sometimes pairing HFNC with NRB to further augment oxygenation.

As our patient volumes increased and ICU beds became scarce, we utilized self-proning on our wards. For the past decade, proning has been a recommended treatment for intubated patients in ARDS [5]. The traditional physiologic explanation of increased alveolar recruitment should hold true in non-intubated patients. Similar to a

recently published case series [6], we found that proning improved hypoxemia and respiratory distress, avoiding the immediate need for intubation. For patients on maximal NRB and NC, proning allowed us to safely raise our threshold for intubation or avoid intubation altogether.

Lessons learned

Epidemiologists caution that the United States is still in the midst of its first surge of COVID-19. There is potential for resurgence in areas where disease activity is low. For those of us bracing for more patients, we should take this moment to re-evaluate our practices developed in the midst of high patient volumes. We bear the responsibility of teaching new trainees recently matriculated into schools and residencies across the US. The lessons we teach whether cognizantly or not, will impact the management reasoning that future providers employ.

We will treat COVID-19 in different conditions from those present in the early pandemic. Amidst the initial wave of COVID-19 patients, our hospital increased availability of centralized continuous pulse oximetry, rolled out a COVID-19 step down unit, and created an intermediate-level ICU adjacent to our hospital wards for rapid escalation of care, all while improving access to NIV. With these improvements, we can titrate our levels of care and access to resources for any future surges in COVID-19.

With the changing landscape, falling local prevalence and our experience with COVID-19, we should reconsider our previous management protocol. Given the prevalence of asymptomatic hypoxemia, an approach that utilizes centrally monitored pulse oximetry can be readily paired with escalation of NC and various facemasks. Combining modalities like NC with facemasks further increases the strategies available to manage hypoxemia. Non-invasive modalities such as HFNC are highly effective in improving oxygenation and are safely employed with expanded access to monitored settings.

In deciding what management strategies to carry forward, it is important to recognize that unintentional harms may arise. While we found that a subset of patients avoid intubation, delaying intubation in ARDS is controversial [7]. In our experience, delaying intubation was imperative to locate ICU beds, improve procedural safety, increase monitoring, and minimize risk of clinician exposure.

Our later steps of self-proning and utilizing HFNC were aimed at supporting unstable patients. In cases of resource availability, we recommend that self-proning and non-invasive modalities should be employed for use either in a step down unit or for immediate stabilization prior to transfer. Judicious adoption of these practices should depend on local prevalence, acuity, and resources.

With the continued SARS-CoV-2 pandemic, we must rapidly adapt our management paradigms to continuous changes in patient volumes and resource availability. The key lesson is a familiar one, even pre-COVID-19: to be flexible in the face of uncertainty while maintaining as high a standard of care as possible.

Research funding: None declared.
Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.
Competing interests: Authors state no conflict of interest.

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