Hospital Preparedness for COVID-19: A Practical Guide from a Critical Care Perspective

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Abstract

In response to the estimated potential impact of coronavirus disease (COVID-19) on New York City hospitals, our institution prepared for an influx of critically ill patients. Multiple areas of surge planning progressed, simultaneously focused on infection control, clinical operational challenges, ICU surge capacity, staffing, ethics, and maintenance of staff wellness. The protocols developed focused on clinical decisions regarding intubation, the use of high-flow oxygen, engagement with infectious disease consultants, and cardiac arrest. Mechanisms to increase bed capacity and increase efficiency in ICUs by outsourcing procedures were implemented. Novel uses of technology to minimize staff exposure to COVID-19 as well as to facilitate family engagement and end-of-life discussions were encouraged. Education and communication remained key in our attempts to standardize care, stay apprised on emerging data, and review seminal literature on respiratory failure. Challenges were encountered and overcome through interdisciplinary collaboration and iterative surge planning as ICU admissions rose. Support was provided for both clinical and nonclinical staff affected by the profound impact COVID-19 had on our city. We describe in granular detail the procedures and processes that were developed during a 1-month period while surge planning was ongoing and the need for ICU capacity rose exponentially. The approaches described here provide a potential roadmap for centers that must rapidly adapt to the tremendous challenge posed by this and potential future pandemics.

Keywords: pandemics; SARS virus; ICUs

As the novel coronavirus disease (COVID-19) pandemic emerged as a cause of profound respiratory failure in Wuhan, China (1, 2), healthcare facilities in the United States took notice. When the United States first reported cases in Washington state (3, 4) and epidemiologists estimated the potential impact on New York City hospitals, our institution (New York Presbyterian Hospital), like many other centers, prepared for an influx of critically ill patients. Excellent reviews of approaches to ICU preparedness in the setting of pandemics have been published, generally focusing on broad concepts of infection control, ways to increase staffing capacity, and community engagement (5). Similarly, others have highlighted the difficult issues involved in allocating scarce resources (6), particularly mechanical ventilators, in these challenging settings (7) (Table 1).

Given rapidly evolving data on the infectiousness of COVID-19 (8, 9), including virus transmission from asymptomatic or paucisymptomatic individuals (10, 11), the initial highest priorities included obtaining an adequate supply of personal protective equipment (PPE) (12) for the staff and evaluating and expanding ICU and ventilator capacity (13), among numerous other measures. As of this writing, there has been a rapid increase in the number of new cases, deaths, and healthcare use in New York State (Figure 1).

As the first patients arrived soon after planning began at our institution, surge plans for this pandemic were highly dynamic and iterative, requiring frequent updates and clear communication of changes. Here, we describe the procedures that were implemented over a 4-week time frame as patient admissions for COVID-19 increased exponentially. These approaches provide a potential roadmap for centers that must rapidly adapt to the tremendous challenges posed by a pandemic. We hope that even for medical centers with a much

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Table 1. Solutions to Encountered Challenges

Challenge	Local Solution
Infection control	Define aerosolizing procedures; use guidelines to define appropriate PPE
Clinical challenges	
Decision to intubate	Evolving; determined by clinical judgment with no predefined criteria
Airway management	Intubation by RSI by most experienced operator; periintubation team to assist in gathering PPE and medications and to assist in transport
Engagement of infectious disease team	Universally consulted to assist with therapies and entry into clinical trials
Extracorporeal organ support	Patients evaluated by a multidisciplinary team on a case-by-case basis
Cardiac arrests	Policy limits the number of responders and promotes enhanced PPE
Standardization	Frequent conferences, daily e-mail updates, and shared files
Approaches to efficient use of time in the ICU	Create procedure team, proning team, and tracheostomy team; display results and patient data outside the room
Minimizing exposure	Bundle care, trial intravenous pumps, and ventilator monitors outside of the patient room
Education	Frequent, multidisciplinary conferences, and journal clubs
Communication with families	Daily calls to a patient surrogate; involvement of palliative care
ICU surge capacity	Increase COVID-19 capacity in multiple units simultaneously to expand expertise
Expansion to operating rooms	Multidisciplinary approach to understand differences between critical care ventilators and anesthesia machines
Efficient bed management	Appoint a clinical bed manager
Staffing	
Physician staffing	Create a model with ideal ratios of critical care physicians to ICU patients; use critical care experts from all backgrounds
Research faculty	Redeployed to clinical service if not doing COVID-19–specific research
Nursing and respiratory therapy	Rapid training in ICU skills; expedited recredentialing, education on newly introduced ventilators
Nonclinical staff	Acknowledge support from nonclinical staff
Ethical dilemmas	Use institutional ethics committees, with guidance from local laws, to approach each ethical decision
Staff wellness	Partner with mental health professionals for staff

Definition of abbreviations: COVID-19 = coronavirus disease; PPE = personal protective equipment; RSI = rapid sequence induction.

smaller footprint and lower surge capacity, some of the granular and practical advice provided here will aid others in rapidly adapting to this unprecedented challenge.

Background

Our campus of the greater New York Presbyterian system is jointly operated by physicians from Weill Cornell Medicine (medical college) and nurses, respiratory therapists, advanced practitioners, and nonclinical staff from New York Presbyterian Hospital. This campus is one of two quaternary centers within the hospital enterprise and receives transfers from smaller surrounding hospitals. We have six adult ICUs divided into subspecialties (medical, surgical, burn, cardiac, cardiothoracic, and neurosurgical), as well pediatric and neonatal ICUs and several step-down units.

Given previous recommendations (5, 6, 14), multiple categories were rapidly considered in preparation for a pandemic of massive scale, including infection control; clinical operational challenges; ICU bed surge capacity; adequate staffing of physicians, nurses, and respiratory therapists; complex ethical dilemmas; and staff wellness. Procedures to address these issues were created and implemented in collaboration with nursing, respiratory therapy, and hospital leadership.

Infection Control

Initial planning began in collaboration with hospital epidemiologists and infection control staff, and relied heavily on available information about the infectivity of COVID-19 (9, 15). These contributors, with guidance from the CDC (16), helped determine the appropriate PPE, define an "aerosol-generating procedure," and attempted to clarify and communicate the rapidly changing guidelines offered by the federal, state, and city governments. Importantly, hospital epidemiology personnel rapidly educated staff in COVID-19 units on the optimal format for donning and doffing PPE, and online videos and education materials were distributed hospitalwide.

Clinical Challenges

The Decision to Intubate

Given the initial impressions about the format for transmission of this novel coronavirus, the initial clinical approach was to avoid high-flow nasal cannula and noninvasive ventilation (9). When a patient who was under investigation or tested positive for COVID-19 experienced an oxygen saturation of ⩽88% on 6 L of oxygen via nasal cannula, intubation was recommended. Within 2 weeks, these

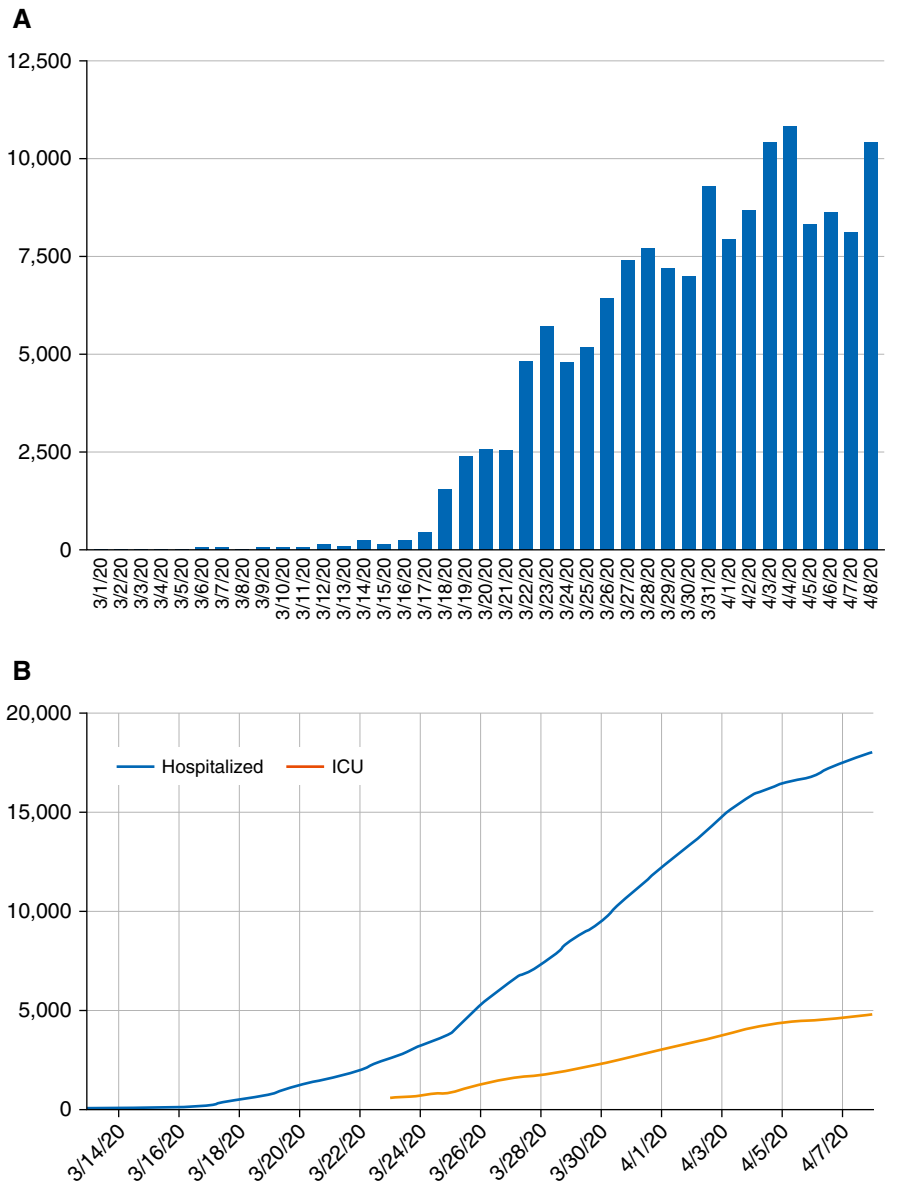

Figure 1. (*A*) New coronavirus disease (COVID-19) cases. (*B*) Total COVID-19 hospitalizations (blue) and ICU hospitalizations (orange) in New York State from March 14, 2020, to April 8, 2020. Reprinted by permission from Reference 34.

criteria were adapted to an oxygen saturation of <88% on 6 L of oxygen via nasal cannula in addition to a nonrebreather mask at 10 L of oxygen per minute. As the number of critically patients increased and international guidelines were refined, high-flow nasal cannula was increasingly used, preferably in a negative-pressure room (17), to possibly delay or avoid the need for intubation. The decision to intubate relies on the clinical judgment of the critical care physician and is based on factors such as hypoxemia, tachypnea, increased work of breathing, and gas exchange (18). These practices continue to develop as recommendations evolve.

Airway Management and the Intubation and Periintubation Teams

To maximize patient outcomes and minimize the risk to healthcare practitioners, a comprehensive airway policy was adapted from rapidly evolving international recommendations (19, 20). These procedures ensured that the most experienced operator would attempt intubation using rapid sequence induction (RSI) and a video laryngoscope. To enhance efficiency and optimize patient care, when a critical care physician identified a patient who required intubation, that physician notified the dedicated COVID-19 intubation team. Preparations included obtaining induction, sedation, and vasopressor medications; ensuring the use of appropriate PPE for this high-risk procedure (impervious gown, gloves, head covers, goggles or welder's mask, and optional shoe covers); and moving the patient to a negative-pressure room (with one reserved on each hospital floor) for intubation. The initial team included an anesthesiologist, a respiratory therapist, and a critical care nurse. The anesthesiologist intubated the patient using RSI and a video laryngoscope, and the multidisciplinary critical care team moved the patient to an ICU bed.

As the pace of hospital admissions and intubations accelerated, this process evolved. Two anesthesia airway teams were made available 24 hours a day, 7 days a week, dedicated to COVID-19 intubations. This team brought with them the appropriate PPE and a video laryngoscope. Hospital pharmacologists created virtual RSI kits, which could be rapidly accessed on every floor. Finally, a periintubation team led by certified registered nurse anesthetists assumed the role of coordinating periintubation procedures, including gathering medications and staff, and transporting patients to the negative-pressure room before intubation and to the ICU after intubation.

Engagement with Infectious Disease Consultants

Given the infectious nature of the disaster and the rapidly evolving therapeutic landscape, infectious disease consultants immediately established a dedicated COVID-19 team and pager. This team consults on every critically ill patient with COVID-19 daily to provide advice about available therapies (antiviral and antimicrobial) (21) and potential immunosuppressive approaches and innovative therapies (22, 23). Moreover, they serve as a gateway to rapidly evolving therapeutic trials (24).

Extracorporeal Organ Support

Institutional policies regarding extracorporeal membrane oxygenation are

evolving with the publication of efficacy and risk data (25). Although extracorporeal membrane oxygenation has potential benefit in a subset of patients with COVID-19, the decision to cannulate must include the ability to provide appropriate staffing and resources, in addition to the usual criteria. Potential patients are discussed on a case-by-case basis by a multidisciplinary team. Renal replacement has been offered to all patients with acute or chronic renal failure via traditional hemodialysis, continuous venovenous hemodialysis, or peritoneal dialysis, with an awareness of the resources involved in each scenario.

Cardiac Arrests

Given the highly infective nature of the novel coronavirus, approaches to resuscitation have evolved (26, 27). As such, institutional cardiac arrest policies were instituted that limited the number of responders to cardiac arrests outside the ICU. Mechanical compression devices were rapidly introduced to further reduce the number of medical and nursing staff responding to an arrest. Medical ICU nurses, who respond to every cardiac arrest in our institution, carried a COVID-19 backpack to every cardiac arrest, which included high-risk PPE (welder-style face shields, N95 masks, and impermeable gowns) given the aerosolizing nature of cardiopulmonary resuscitation. Resuscitations in the ICU continue to be conducted in a standard fashion, with attempts to minimize aerosolization by leaving the patient on the ventilator or, if absolutely necessary, using a bag valve mask with a high-efficiency particulate air filter attached to the expiratory port.

Standardization of Care across All Critical Care Delivery Areas

Given the rapid expansion of ICU space and the broad number of caregivers involved in the care of critically ill patients with COVID-19, frequent formal and informal communication among all the groups has been essential. This is particularly important because some clinicians do not routinely care for patients with acute respiratory distress syndrome. Daily evaluation by a member of the pulmonary and critical care division is provided to all of the locations outside the medical ICU now caring for these patients. The development and distribution of informal guidelines outlining the granular aspects of caring for critically ill patients with COVID-19 have proved to be invaluable tools for providing standardized care in all areas. Secure electronic file sharing and daily e-mail updates give providers easy access to the latest hospital statistics and guidelines.

Approaches to Efficient Use of Time in the ICU

Dedicated smart phones with chargers are placed in each patient room so that staff members inside the room can contact additional staff outside the room without doffing their PPE.

A dedicated procedure team comprised of surgeons and interventional radiologists was created to perform ICU procedures such as central line, arterial line, or nasogastric tube insertion around the clock. This freed the intensivists to facilitate critical patient care. A multidisciplinary tracheostomy team led by thoracic surgery, otorhinolaryngology, and critical care specialists provides a similar focused approach to another pivotal aspect of critical care. A dedicated proning team was formed by specialists in critical care medicine and physical therapy to minimize the unit-specific staff needed for pronation or supination of patients while providing a standardized approach to this therapeutic maneuver (28). In an innovative adaptation, current drips, ventilator settings, and arterial blood gas results were written on the glass doors of the room so that staff could be informed without having to enter the room (Figure 2). This technique was made possible by the restriction of visitors to the hospital.

Minimizing Exposure to Staff

Care has been bundled as much as possible. Laboratory sampling was timed with medication dosing. Larger bags of intravenous fluid or more concentrated solutions were used to limit the number of times a nurse had to enter the room. Imaging studies and ECGs were limited to those deemed absolutely necessary. In some (but not all) rooms, intravenous pumps were placed outside the room with the use of extra intravenous tubing (Figure 2). Although this approach allows medications to be managed outside the room, its limitations include the length of time required for a bolus to travel to the patient. A buddy system including one staff member by the medication pumps became necessary to allow delivery of boluses or adjustments of medication to be made from outside the room while staff inside the room turned or cleaned the patient. The monitor for the most frequently used ventilators was detached and similarly kept outside the room (Figure 2). The advantages and drawbacks of this system mirror those of the intravenous pumps.

Education

Led by pulmonary and critical care physicians, a rapid simulation curriculum focused on pronation and COVID-19 cardiac arrests was instituted and provided for both day- and night-shift nurses in nonmedical ICUs. Our provider teams have been monitoring the rapidly evolving diagnostic and therapeutic approaches in the global arena to improve and optimize

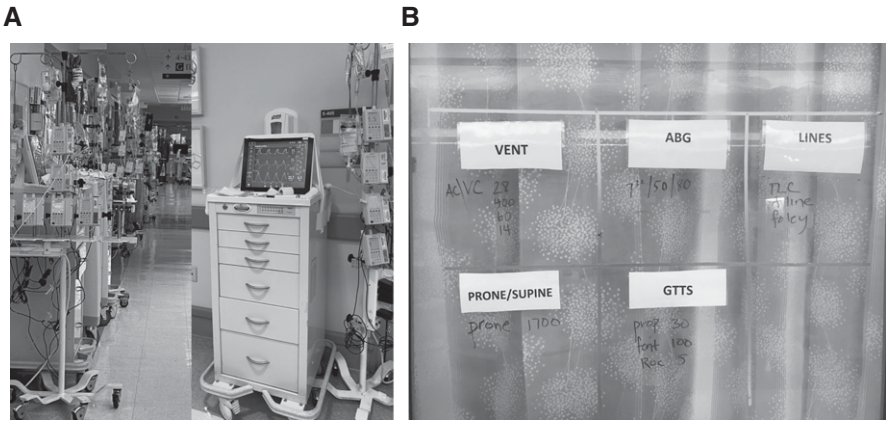

Figure 2. (*A*) Photos of ventilator screens and intravenous infusion pumps outside patient rooms. (*B*) Photo of patient data on the glass door of a patient's room. ABG = arterial blood gas; GTTS = guttae.

care on a local level. Remote-access conferences and journal clubs referencing seminal articles on acute respiratory distress syndrome continue to be conducted frequently. Topics have included fluid management, ventilator management, pronation, and sedation, among others. Recommendations from international colleagues are discussed in these multidisciplinary conferences.

Communicating with Families

The infectious nature of this pandemic has markedly impacted the ability of physicians and staff to communicate with patients' families, a key aspect of critical care. With limitations in visitation, family communication has become complex and fragmented. To address this aspect of patient care, a limited number of patient surrogates are designated to communicate with physicians. In addition, each family member is offered a second supportive call from a palliative care team member. The palliative care team discusses cases with each COVID-19 unit daily to assess for participating surrogates. In the setting of imminent death or immediately after death, a single family member in PPE is provided an opportunity to visit. If visitation is impossible, the staff can creatively use video conferencing to allow loved ones to visualize and speak to their dying family member.

ICU Surge Capacity

While creating ICU surge capacity, the first critically ill patients with COVID-19 were admitted to negative-pressure rooms divided among all of the ICUs. Initial surge plans were designed to accommodate an increased number of patients in the early stages (Figure 3), and later plans incorporated up to threefold higher numbers. Initially, for efficiency we designated half of the beds in multiple ICUs as COVID-19 units. This decision allowed units to acclimate to COVID-19 patients before the entire unit was filled, allowed staff members to perfect donning and doffing techniques, provided an opportunity to place pumps and ventilator monitors outside the room (Figure 2), and enabled multiple staff members to develop expertise in managing COVID-19. Having half of three separate ICUs simultaneously develop this expertise allowed a rapid doubling of ICU capacity.

Within 3 weeks of admitting our first critically ill patients with COVID-19, we had completely filled multiple ICUs. To respond to this challenge, less critical patients, when clinically feasible, were transferred to floor care, thereby freeing up the ICU beds. Subsequently, all critically ill patients without COVID-19 were grouped together in distinct or newly created ICUs. Elective surgeries were reduced to minimize surgical admissions and preserve PPE. As we entered the next phase of the surge plan, all cardiac patients without COVID-19 were grouped together in a new ICU. As units were opened and filled, additional units were rapidly identified. We began to care for patients with COVID-19 in operating rooms, with two ICU beds and two anesthesia machines per room. Similarly, step-down units and recovery rooms were rapidly converted to COVID-19 ICUs.

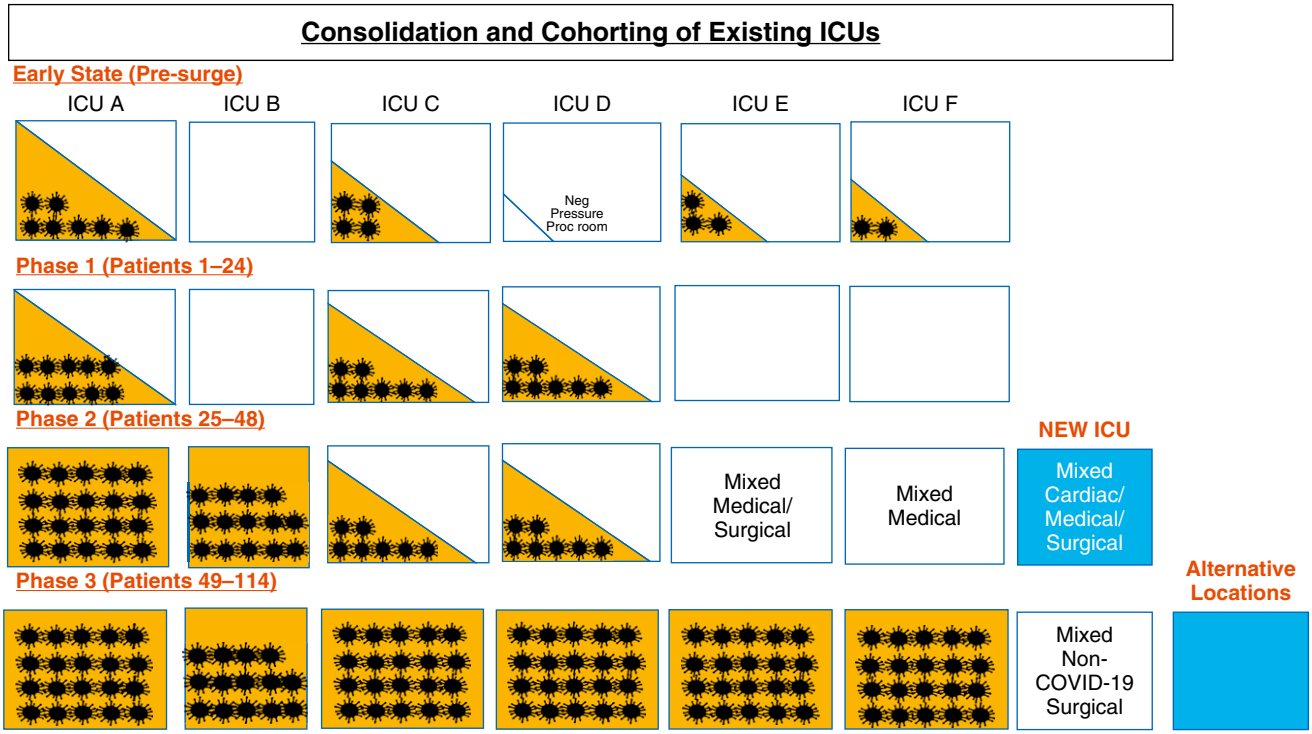

Figure 3. Each symbol denotes a patient with coronavirus disease (COVID-19). In the presurge period, patients were placed according to bed availability. Phase 1: unit readiness with partial COVID-19 census. Phase 2: start of ICU cohorting and creation of a new unit to displace patients without COVID-19 requiring specialty care. Phase 3: exhaustion of traditional ICU capacity. Patients who were not positive for COVID-19 were primarily postsurgical patients who were grouped together. Neg Pressure Proc room = negative pressure procedure room.

Expanding to Operating Rooms

Expanding to operating rooms has created unique challenges, distinct from standard staffing and supply issues. Few caregivers outside of anesthesiologists and certified registered nurse anesthetists understand the intricacies of an anesthesia machine. The maximum flow rate of 15 L/min of fresh gas became important in patients with respiratory failure and a high $\dot{V}_E$ requirement. The proportion of fresh gas flow to recirculated air impacts the ultimate delivered $F_{I_{O_2}}$. Heat moisture exchangers may be added to the circuit but may not provide sufficient moisture to prevent desiccated secretions from occluding endotracheal tubes. Measuring airway pressures is challenging. In addition, providing nebulizers and checking inspiratory pauses on these machines requires breaking the circuit, which in general has been avoided in the interest of infection control.

Efficient Bed Management

Bed assignments and unit-to-unit transfers are typically managed by a centralized group of nurses in our patient placement operations center. This group also works in close collaboration with our transfer center, which organizes the incoming transfer of patients from other hospitals. During this time of rapid expansion, one of our critical care physicians partnered with these nurses around the clock, on a rotating basis, to triage all critically ill patients to streamline bed assignments and facilitate transfers into the newly created ICUs.

Staffing

Physician Staffing

ICU physician staffing has been rapidly expanded, and additional pulmonary and critical care physicians and critical care anesthesiologists have been redeployed to units with the goal of achieving a ratio of two senior physicians (with at least one being an intensivist) to 20 patients. The number of intensivists and critical care fellows in house each night rapidly increased fourfold with strong collaboration among the pulmonary and critical care, cardiology, neurointensive care, surgical critical care, and anesthesia teams. Twice-daily huddles occurred among all in-house leaders in critical care, including the airway team, to coordinate care and facilitate interdisciplinary teamwork. Additional hospitalist, trainee, and physician-extender teams were redeployed to provide patient care around the clock, as well as to provide medical expertise to nonmedical intensivists.

Research Faculty

All research activities at the medical college have been drastically curtailed to free up caregivers for clinical work. Ongoing research is limited to that which is focused on COVID-19. In addition, multiple clinical trials for possible therapeutic agents have been approved by the institutional review board and are enrolling patients.

Nursing and Respiratory Therapy Staffing

In phase 1 of the surge plan, medical and step-down nurses began training and shadowing in ICUs. Training fairs to teach ICU skills were held daily to help prepare nurses for caring for the critically ill. To facilitate staffing, nurses who previously worked at our institution were contacted and offered expedited recredentialing if they were willing and available. Respiratory therapists are an invaluable part of the care team for patients with respiratory failure. Given the pressures on the healthcare system, it has been challenging to rapidly and adequately increase the number of respiratory therapists. Critical care faculty and trainees have assisted in ventilator management. As the standard fleet of critical care ventilators became limited, transport ventilators were obtained and operationalized for ICU care. Because intensivists are less familiar with these devices, respiratory therapists created innovative approaches to rapidly educate clinicians in their use.

Nonclinical Staff

Members of the institutional facilities staff have played a key role in rapidly creating innovative barriers and negative-pressure rooms. The environmental services staff members became expert at donning and doffing PPE and clearing refuse at an accelerated rate in COVID-19 rooms owing to the increased PPE requirements. They devised impressive approaches to rapidly turn over rooms that are vitally required for aerosolizing procedures. It is evident that every staff member plays a key role in rapidly expanding ICU capacity and care in the setting of a highly infective agent in the setting of a pandemic. Within days of the first COVID-19 admission to our institution, our colleagues in laboratory medicine implemented in-house testing, allowing us to rapidly scale the number of patients we could test each day.

COVID-19 poses a potential infectious risk to all personnel in the hospital, and protection of staff has remained a top priority. Adequate PPE has been provided to all staff. In collaboration with the Division of Infection Control and Prevention, the hospital and medical college have ensured appropriate education on donning and doffing of PPE and precautions regarding aerosolizing procedures.

Ethical Dilemmas

The rapid and unprecedented growth in the number of critically ill patients (Figure 1) raised the specter of difficult ethical decisions. Several groups globally have provided general guidelines regarding resource allocation in the setting of a challenging pandemic (14, 29, 30). Given the increased negative outcomes in older individuals or those with multiple comorbid illnesses (31, 32), the need for discussions with palliative care and ethics consultants has become more acute. We used the New York State guidelines as a framework for these conversations (33). We have encouraged our colleagues in emergency medicine and hospital medicine to pursue early, honest conversations with patients and families regarding goals of care and clarifying advance directives. A program that provides access to palliative care and ethics consultants, 24 hours a day, has helped facilitate these conversations.

Staff Wellness

This challenging pandemic has created tremendous moral distress among healthcare personnel. We pride ourselves on the personalized care of our patients. One challenging aspect of care in this pandemic is the inability to provide care in the usual manner, which normally involves including patients' families as their support system throughout their illness. Staff members have facilitated emotional, life-altering conversations over video chats with family members and have watched families say

goodbye to each other without the benefit of privacy; the staff cannot leave the room while they hold the phone or tablet. Physicians and nurses work to balance being present and offering comfort while minimizing their personal exposure to COVID-19. In addition to this heartbreaking reality, we work while watching this pandemic take over our city. Staff fear for their own health and that of loved ones. Many providers have isolated themselves from their families, either by staying in hotels or by sending their families away. Some have created or updated wills and advance directives. For all of these reasons and because of sheer exhaustion, we have seen our staff become overwhelmed with emotions ranging from anxiety to helplessness. To deal with these challenges, it has been vital to engage mental healthcare providers with expertise in the management of trauma and acute stress to offer individual and group support to our staff. Referrals have been made as needed for psychological support, and staff members have been given 24-hour direct access to a mental health professional.

Conclusions

As New York City has become the current global epicenter of the COVID-19 pandemic, our institution has creatively expanded our caregiving capabilities in multiple ways. This outline provides an understanding of how we, in collaboration with and appreciation of our colleagues in the departments and divisions of pulmonary and critical care, anesthesiology, cardiology, neurocritical care, surgical critical care, hospital medicine, infectious diseases, palliative care, ethics, nursing, physical therapy, and respiratory therapy, are meeting this challenge. We provide potential guidelines for other centers to adapt as needed to help further streamline this expansion. ■

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