

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 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, intensive care unit surge capacity, staffing, ethics and maintenance of staff wellness.

Protocols developed focused on clinical decisions around intubation, the use of high-flow oxygen, infectious disease consultation and cardiac arrest. Mechanisms to increase bed capacity as well as increase efficiency in intensive care units 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 attempting to standardize care, stay apprized on emerging data as well as to review seminal literature on respiratory failure. Challenges were encountered, and overcome through interdisciplinary collaboration and iterative surge planning as intensive care unit 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 developed during a one month period while surge planning was ongoing and the need for intensive care unit capacity rose exponentially. The approaches described provide a potential roadmap for centers that must rapidly adapt to the tremendous challenge introduced by this and potential future pandemics.

Introduction

As the novel Coronavirus (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 (3, 4) and epidemiologists estimated the potential impact on New York City hospitals, we, like many other centers, prepared for an influx of critically ill patients. Excellent reviews of the approach to intensive care unit preparedness in the setting of pandemics have been published; these have generally focused on broad concepts of infection control, increasing staffing capacity, and community engagement.(5) Similarly, others have highlighted the difficult issues of 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 from asymptomatic or paucisymptomatic patients,(10, 11) initial highest priorities included obtaining an adequate supply of personal protective equipment (PPE)(12) for the staff and evaluating/expanding intensive care unit (ICU) and ventilator capacity,(13) among numerous other measures. As of the writing of this piece, there has been a rapid increase in the number of new cases, deaths, and health care utilization in New York State (Figure 1).

As the first patients arrived soon after planning began at our institution, surge plans during this pandemic were highly dynamic and iterative, requiring frequent updates and clear communication of changes. This document will describe the procedures implemented over a four week timeframe as patient admissions for COVID-19 increased exponentially. The approaches implemented provide a potential roadmap for centers that must rapidly adapt to

the tremendous challenge introduced by a pandemic. Even for medical centers with a much smaller footprint and lower surge capacity, it is hoped that some of the granular and practical advice contained 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. These procedures 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, relying heavily on available information about the infectivity of COVID-19.(9, 15) These contributors, with guidance from the Centers for Disease Control and Prevention (CDC)(16),

helped determine 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 units on the optimal format for donning and doffing PPE; online videos and education materials were distributed hospital-wide.

Clinical Challenges

The Decision to Intubate

Given the initial impressions on 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 under investigation (PUI) or tested positive for COVID-19 experienced an oxygen saturation of 88% or less on 6 liters of oxygen via nasal cannula intubation was recommended. Within two weeks these criteria were adapted to an oxygen saturation of less than 88% on 6 liters of oxygen via nasal cannula *in addition to* a non-rebreather mask at 10 liters of oxygen per minute. As the number of critically patients increased and international guidelines were refined, high-flow nasal cannula has been 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 judgement 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 Peri-intubation Team

To maximize patient outcomes and minimize risk to health care practitioners, a comprehensive airway policy was adapted from rapidly evolving international recommendations.(19, 20) These procedures assure that the most experienced operator attempts 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; assuring 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. That 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 the process evolved. Two anesthesia airway teams were made available 24 hours a day, seven days a week dedicated to COVID-intubations. This team brings 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 peri-intubation team led by certified registered nurse anesthetists (CRNA) assumed the role of peri-intubation coordination, from gathering meds and staff to

transporting patients to the negative pressure room pre-intubation and to the ICU post-intubation.

Infectious Disease Engagement

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

Extra-corporeal Organ Support

Institutional policy regarding extra-corporeal membrane oxygenation(ECMO) has evolved as efficacy and risk data are published.(25) Although ECMO has potential benefit in a subset of patients with COVID, the decision to cannulate must include the ability to provide appropriate staffing and resources, in addition to 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 veno-venous hemodialysis (CVVHD) 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 limiting 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; these contain high-risk PPE (welders style face shields, N95 masks, impermeable gowns) due to the aerosolizing nature of CPR. 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 (HEPA) 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 COVID patients, frequent formal and informal communication among all the groups has been essential. This is particularly important as some clinicians do not routinely care for ARDS patients. 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. Development and distribution of informal guidelines outlining granular aspects of caring for critically ill COVID patients have proven invaluable tools to provide standardized care among all areas. Secure, shared electronic file sharing and daily email updates allow providers easy access to the latest hospital statistics and guidelines.

Approaches to Efficiently Use Time in the ICU

Dedicated smart phones with chargers are placed in each patient room, so staff members inside patient rooms 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 multi-disciplinary tracheostomy team led by thoracic surgery and otorhinolaryngology and critical care provides a similar focused approach to another pivotal aspect of critical care. A dedicated proning team was formed by 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 are written on the glass doors of the room to easily communicate changes made without having to enter the room (Figure 2). This technique was made possible due the restriction of visitors to the hospital.

Minimizing Exposure to Staff

Care has been bundled as much as possible. Laboratory sampling has been timed with medication dosing. Larger bags of intravenous (IV) fluid or more concentrated solutions are used to limit the number of times a nurse has to enter the room. Imaging studies and electrocardiograms have been limited to those absolutely necessary. In some, but not all rooms, IV pumps are placed outside the room with use of extra IV tubing (Figure 2). Although

this allows medications to be managed outside the room, limitations include the length of time a bolus takes to travel to the patient. A buddy system including one staff member by the medication pumps became necessary to allow boluses or adjustments of medication from outside the room, while staff inside the room turns or cleans the patient. The monitor of most frequently used ventilators has been detached and similarly kept outside the room. (Figure 2) Advantages and drawbacks to this system mirror those with the IV pumps.

Education

Led by pulmonary and critical care physicians, a rapid simulation curriculum focused on pronation and COVID cardiac arrests was instituted and provided for both day and night shift nurses in non-medical ICUs. Our provider teams have been monitoring the rapidly evolving diagnostic and therapeutic approaches in the global arena in order to improve and optimize care on a local level. Remote-access conferences and journal clubs referencing seminal articles on ARDS 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 to communicate with the patient's family, a key aspect of critical care. With limitations in visitation, family communication became complex and fragmented. To address this aspect of patient care, a limited number of patient surrogates were designated to communicate with physicians. In

addition, each family member was offered a second supportive call from a palliative care team member. Palliative care discusses cases with each COVID 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 the opportunity to visit. If visitation is impossible, staff have creatively used 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 admitted with COVID-19 were admitted to negative pressure rooms divided among all ICUs. Initial surge plans were designed to accommodate an increased patients in early stages (Figure 3) and up to three fold higher in later surge plans. Initially, for efficiency we designated one half the beds in multiple ICUs as COVID-19 units. This decision allowed units to acclimate to COVID-19 patients before their 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 rapidly built expertise among multiple staff members. Second, having half of three separate ICUs simultaneously develop expertise in COVID-19 management allowed a rapid doubling of ICU capacity.

Within three weeks of admitting our first critically-ill COVID patients we had completely filled multiple ICUs. To rapidly respond to this challenge, less critical patients, when clinically feasible, were transferred to floor care, thereby freeing ICU beds. Subsequently, all critically ill patients without COVID-19, were cohorted distinct or newly created ICUs. Elective surgery has

been reduced to minimize surgical admissions and to preserve PPE. As we entered the next phase of the surge plan, all cardiac patients without COVID-19 were cohorted in a new ICU. As units were opened and filled, additional units were rapidly identified. Operating rooms, with 2 ICU beds and 2 anesthesia machines per room began caring for COVID-19 patients. Similarly, step down units and recovery rooms were rapidly converted to COVID-19 ICUs.

Expanding to Operating Rooms (ORs)

Expanding to ORs has created unique challenges, distinct from standard staffing and supply issues. Few caregivers outside of anesthesiologists and CRNAs understand the intricacies of anesthesia machine. The reality of a maximum flow rate of 15 liters per minute of fresh gas became important in patients with respiratory failure and a high minute ventilation requirement. The proportion of fresh gas flow to recirculated air impacts the ultimate delivered fraction of inspired oxygen. 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 assignment 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 the bed assignment and facilitate transfers into the newly created ICUs.

Staffing

Physician Staffing

ICU physician staffing has been rapidly expanded with additional pulmonary and critical care physicians and critical care anesthesiologists redeployed to units to achieve a goal of achieving a ratio of 2 senior physicians with at least 1 intensivist to 20 patients. The number of intensivists and critical care fellows in house each night rapidly increased fourfold with strong collaboration among pulmonary and critical care, cardiology, neuro-intensive care, surgical critical care and anesthesia. Twice daily huddles occur among all in-house leaders in critical care, including the airway team, in order 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 providing medical expertise to nonmedical intensivists.

Research faculty:

All research activities at the medical college have been drastically curtailed to liberate care givers to clinical work. Ongoing research is limited to that which is COVID-focused. 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 one 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 of patients with respiratory failure. Given the pressures on the health care system, it has been challenging to rapidly, 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. Since intensivists are less familiar with these devices, respiratory therapists created innovative approaches to rapidly educate clinicians in their use.

Nonclinical Staff

The institutional facilities staff have proven their known key roles as they rapidly created innovative barriers and negative pressure rooms. The environmental services staff members became expert at donning and doffing and clearing refuse at an accelerated rate in COVID-19 rooms due to the increased PPE requirements. They have devised impressive approaches to rapidly turnover rooms 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 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; and precautions around aerosolizing procedures.

Ethical Dilemmas

The rapid and unprecedented growth in 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 role of palliative care and ethics consultants has become more acute. We have 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 available 24-hours a day which provides access to palliative care and ethicists has helped facilitate these conversations.

Staff Wellness

This challenging pandemic has created tremendous moral distress among health care 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 our usual manner, with patients' families as their support system throughout their illness. Staff have facilitated emotional, life-altering conversations over video chat with family members, and watch families say goodbye to each other without the benefit of privacy; 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 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 staying in hotels or sending their families away. Some have created or updated wills and advance directives. For all of these reasons and due to sheer exhaustion, we have seen our staff overwhelmed with emotions from anxiety to helplessness. To deal with these challenges, it has been vital to engage mental health care 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 were given 24-hour direct access to a mental health professional.

Conclusion

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 regards. 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, neuro-critical 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 for others.

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Figure Legends.

Figure 1. A) New COVID-19 Cases; B) Total COVID-19 hospitalizations (blue) and ICU hospitalizations (orange) in New York State from 3/14/2020 to 4/8/2020. Accessed 4/8/2020 from <https://gothamist.com/news/coronavirus-statistics-tracking-epidemic-new-york>.

Figure 2. A) Photos of ventilator screens and intravenous infusion pumps outside patient rooms. B) Photo of patient data on glass door of patient room.


Figure 3.  denotes a patient with COVID-19. In the pre-surge period patients were placed according to bed availability. Phase 1: Unit readiness with partial COVID census. Phase 2: Start of ICU cohorting and creation of new unit to displace Non-COVID-19, specialty care. Phase 3: Exhaustion of traditional ICU capacity. Non-COVID positive patients were primarily post-surgical patients that were cohorting together.

Figure 1. Panel A

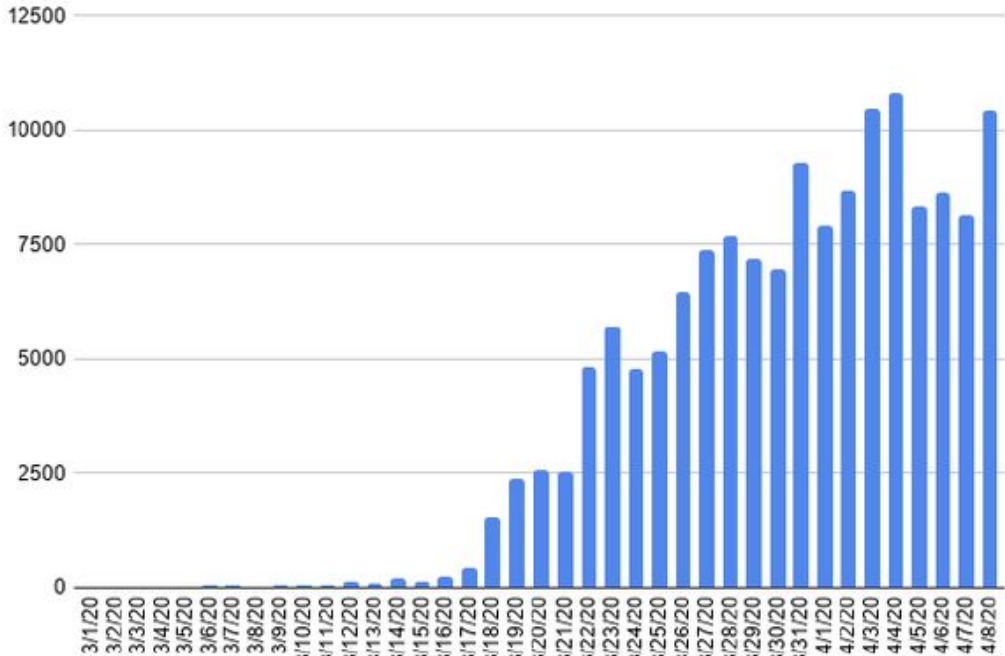


Figure 1. Panel B.

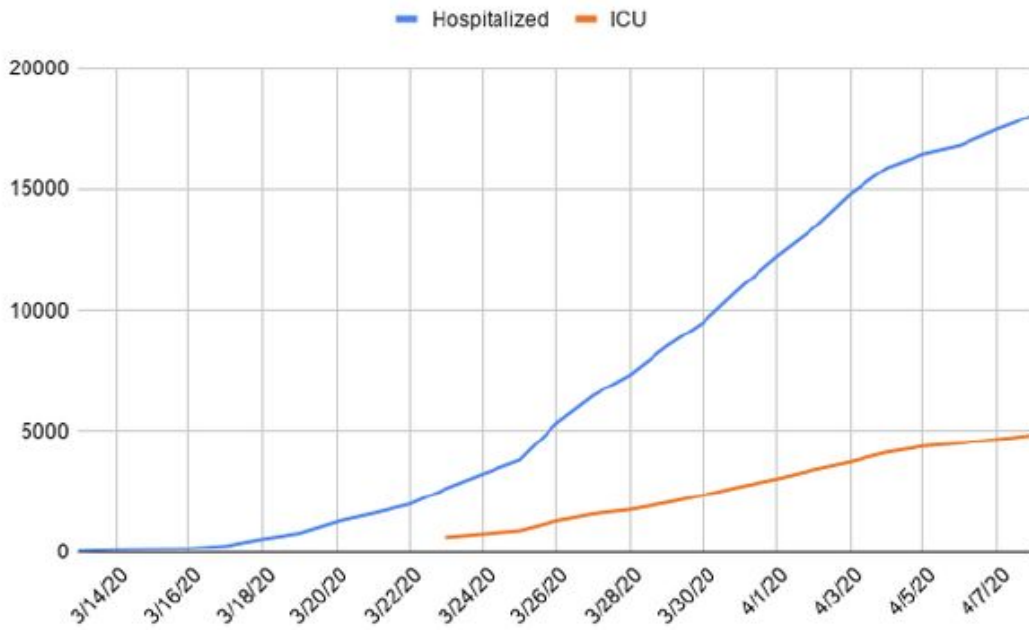


Figure 2. Panel A.



Figure 2. Panel B.

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Figure 3.

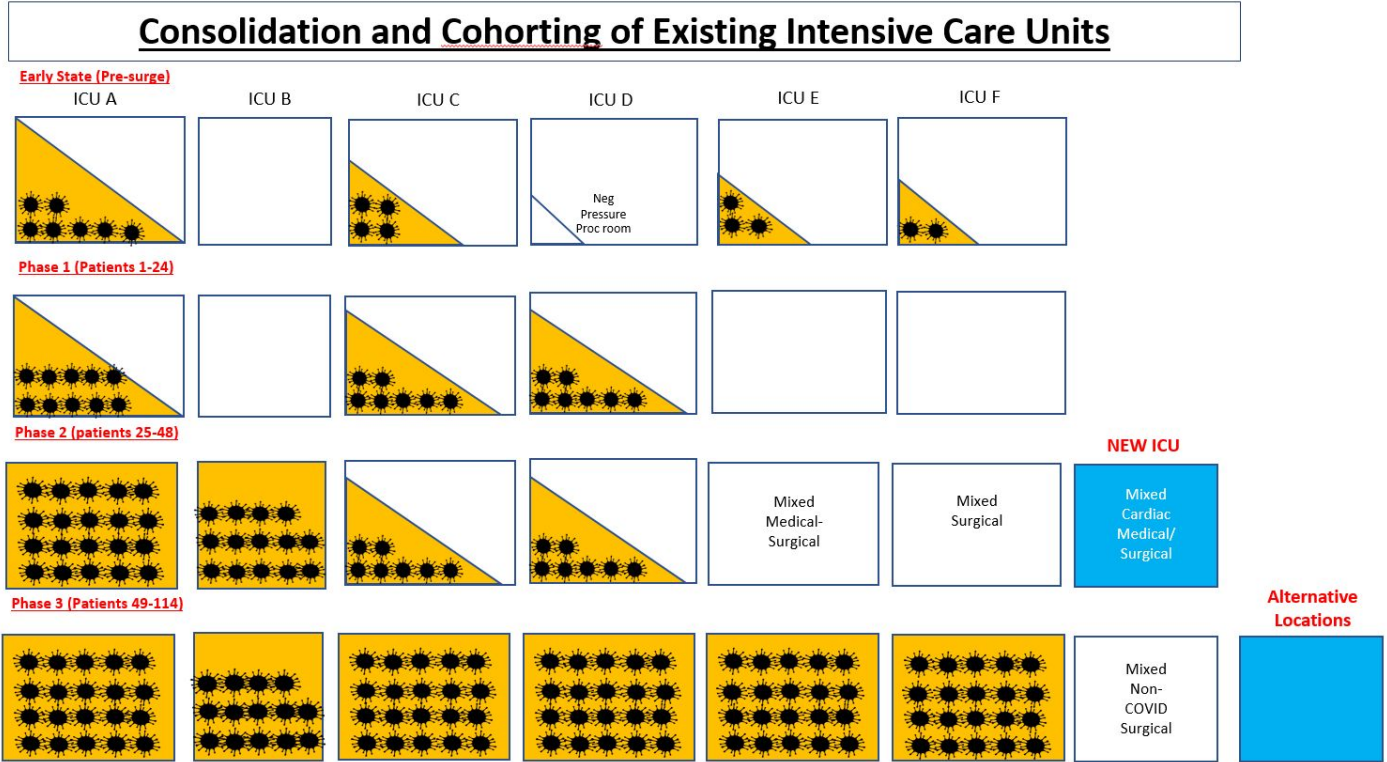


Table 1

Challenge		Local Solution
Infection Control		Define aerosolizing procedures; use guidelines to define appropriate PPE
Clinical Challenges	<i>Decision to Intubate</i>	Evolving; determined by clinical judgment with no predefined criteria
	<i>Airway Management</i>	Intubation by RSI by most experienced operator; peri-intubation team to assist in gathering PPE, medications and to assist in transport
	<i>Infectious Disease Engagement</i>	Universally consulted to assist with therapies and entry into clinical trials
	<i>Extra-corporeal Organ Support</i>	Patients evaluated by a multidisciplinary team on a case-by-case basis
	<i>Cardiac Arrests</i>	Policy limits number of responders and promotes enhanced PPE
	<i>Standardization</i>	Frequent conferences, daily email updates and shared files
	<i>Approaches to Efficiently Use Time in the ICU</i>	Create procedure team, proning team, tracheostomy team. Display results and patient data outside the room.
	<i>Minimizing Exposure</i>	Bundle Care, trial IV pumps and ventilator monitors outside of the patient room
	<i>Education</i>	Frequent, multidisciplinary conferences, journal clubs
	<i>Communication with Families</i>	Daily calls to a patient surrogate; involvement of palliative care
ICU Surge Capacity		Increase COVID capacity in multiple units simultaneously to expand expertise
	<i>Expanding to ORs</i>	Multidisciplinary approach to understanding differences between critical care ventilators and anesthesia machines
	<i>Efficient Bed Management</i>	Appoint a clinical bed manager
Staffing	<i>Physician Staffing</i>	Create a model with ideal ratios of critical care physicians to ICU patients; utilize critical care experts from all backgrounds
	<i>Research Faculty</i>	Redeployed to clinical service, if not doing COVID-specific research
	<i>Nursing and Respiratory therapy</i>	Rapid training in ICU skills; expedited recredentialing, education on newly introduced ventilators
	<i>Nonclinical Staff</i>	Acknowledge support from nonclinical staff
Ethical Dilemmas		Utilize institutional ethics committees, with guidance from local laws to approach each ethical decision.
Staff Wellness		Partner with mental health professionals for staff