REVIEW

Lessons for intensive care units in COVID-19 pandemic-moving towards sustainability

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ABSTRACT

The Coronavirus disease-2019 (COVID-19) pandemic has inundated critical care services globally. The intensive care units (ICUs) and critical care providers have been forefront of this pandemic, evolving continuously from experiences and emerging evidence. In this review, we discuss the key lessons from the ongoing wave of COVID-19 pandemic and preparations for a future surge or second wave. The model of sustainable critical care services should be based on 1) infrastructure development, 2) preparation and training of manpower, 3) implementing standard of care and infection control, 4) sustained supply-chain and finally, and 5) surge planning.

Key Words: COVID-19, Learnings from SARS-CoV-2 pandemic, Preparation for second wave, Preparation of ICU for COVID-19, Surge planning, ICU preparedness for an outbreak

1. INTRODUCTION

The pandemic of coronavirus disease 2019 (COVID-19) has an unprecedented need of intensive care units (ICU) beds globally. The pandemic first wave is still going strong with daily addition of more than 200,000 cases daily and total number of cases as of 29^{th} July 2020 are in excess of 17 million and 665,700 deaths.[1] The mortality data is also striking with more than 60% of all deaths reported so far are from developed countries in Europe and North America.[1] The incidence of critical cases in severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection varies from 10%-23% of hospitalized patients.[2–7] This wide variation of incidence among countries may be due to various factors like different rate of diagnostic testing, surveillance measures adopted, and place of initial management of the patients. Despite varying incidence of critical cases, the ICUs are being overwhelmed globally with shortages of beds and critical equipment like mechanical ventilation.[6, 8]

ICUs are challenged during COVID-19 pandemic on multiple fronts. Firstly, limitation of the available resources including ICU beds, secondly, nosocomial transmission to healthcare workers (HCWs), and finally communication restriction among stakeholders. Clearly, there is an urgent need of overhauling and preparedness for critical care services in near future. In this review we tried to enumerate the impact of COVID-19 on ICU and future preparedness required in ICU for either a second wave or another pandemic.

The model of sustainable critical care services in time of pandemic is based on five pillars: 1) Space, 2) Staff, 3) Standards, 4) Supplies and finally, 5) Surge planning (see Figure 1).

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Figure 1. Five areas of focus in preparedness for sustainable critical care during pandemic

2. Space (Infrastructure) development

The 4%-5% of COVID-19 patients require ICU, with overall median ICU length of stay is 8 days; 13 days for patients requiring respiratory support.[9,10] These large number of patients with long ICU stay overwhelm infrastructure rapidly. The infrastructure of ICU should have provision for upsurge during infectious disease outbreak. The rapid identification and segregation of suspected and/or confirmed cases, critical care triage, adequate isolation facility and a plan to increase in capacity during surge.

Rapid Screening and segregation of suspected or confirmed cases

An efficient screening, identification and isolation of suspected COVID-19 patients is a key for successful initial management of COVID-19. The screening should be at the port of entry in hospitals whether in emergency department or outpatient wards. The screening questionnaire (based on symptoms, travel or contact history) should be regularly updated as per regional or international guidelines. The stratification based on severity of illness and place of admission is the next step after screening. The diagnostic testing and isolation should also be offered in non-COVID areas in case of a suspicion.

3. Critical care triage

The early recognition of the critically ill patient and immediate care is the basic principle of intensive care. The critical care resources in last few months of COVID-19 pandemic were unfortunately offered by "first come-first served." The triage of ICU instead need to be based on patient frailty, chances of survival and support system after discharge. There are few resources tools available for deciding optimal triage.[11–13] They either used tools like performance score, premorbid status using American Society of Anesthesiologist (ASA) classification, organ failure and predicted survival rate or decide admission based on a need of intervention like mechanical ventilation and/or vasopressors.[11–13] Whatever the triage criteria is used it should be dynamic, and patients should be reassessed after 48-72 hours of ICU admission for the response to treatment and/or deterioration. The end-of-life decisions in the time of pandemic can be modified and decided by treating physician with best available care (like palliative care, pain relief and non-invasive oxygen support). The pathway for such decisions should be audited during and after pandemic.

4. ICU designing and cohorting

ICUs construction and designs in future should include dedicated isolation unit for infectious patients. The design of cubicles within ICU should be based on standards of airborne infectious isolation rooms (AIIRs), separate Heating, ventilation, and air conditioning units (HVAC) with at least 6-12 fresh air exchange per hour and provision for air filtration of recycled air[14] (see Figure 2). The patient flow should be based on infection control standards with separate corridor for patient and HCWs, dedicated area for donning and doffing of personal protective equipment (PPE) and physical transparent barrier for patient monitoring (see Figure 2). The remote access (tele-monitoring) to ventilator, multipara monitor, and syringe infusion pump should be considered to reduce HCW-patient contact.

4.1 Surge capacity planning

Surge capacity planning is the blueprint for rapid mobilization of resources to manage an unexpected acute increase in patient load beyond the usual capacity of a facility. The planning for surge is a critical element of disaster preparedness. The Mass Critical Care task force classification on differing levels of surge is helpful in resource planning[15] (see Table 1).

The surge capacity planning starts with optimization of available resources, including staff, equipment like ventilators and/or PPE. The ICU beds are limited in capacity, alternative arrangements in case of crisis to manage critically ill patients must be planned. This may involve the use of beds in high dependency units and/or intermediate units adjacent to ICU. The surge capacity planning should target for contingency capacity and avoid crisis situation where the risk to patients

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and HCWs is high. The cancellation of all elective non-essential services including surgeries must be done early in contingency (to ensure resource optimization) and resources are directed to surge of patients.

Respiratory support may be required in more than 70% of ICU patients including high flow oxygen masks, non-invasive ventilation (NIV), high frequency nasal oxygen (HFNO) and more than half may require invasive ventilation.[16] The surge capacity planning should include these resources along with plan to increase the bed capacity. The central command center for bed management and resources for public and private health should be established. This may help in optimization of resources like PPE, ICU beds and equipment and reduce cost, in situation of surge.

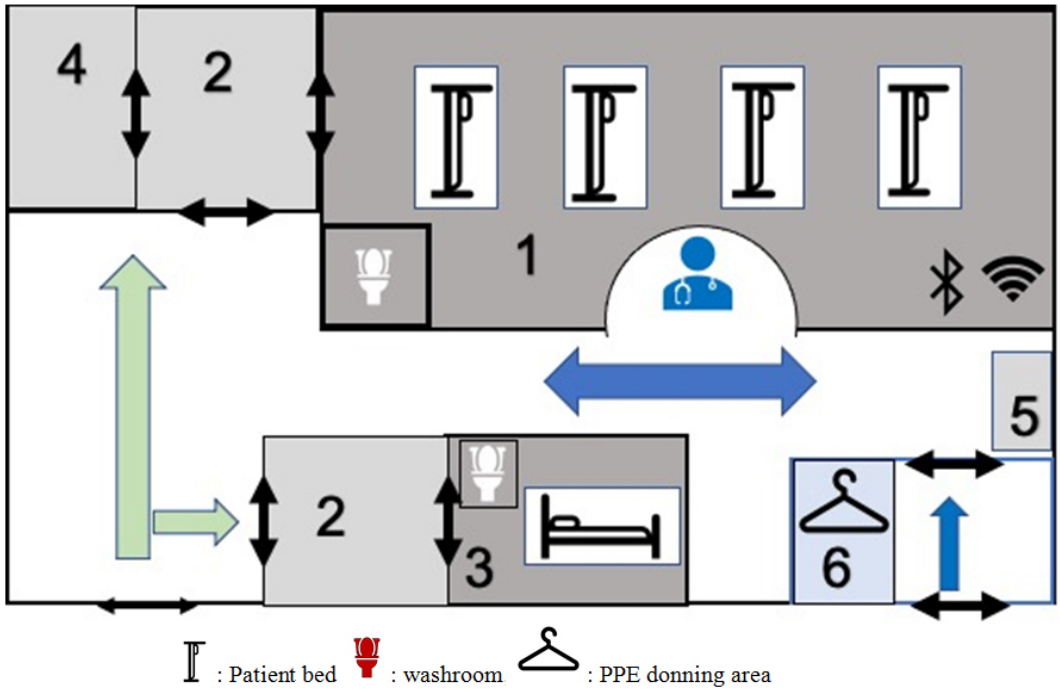

Figure 2. Suggested Model of ICU for airborne illness pandemic like COVID-19

Green arrow: Patient entry, Blue arrow: Healthcare worker (HCW) entry. Black arrows: Self-sliding automated doors. 1. Dark grey area: negative pressure isolation area for confirmed COVID-19 patients, 2. Light grey area: Buffer zone, need full personal protective equipment (PPE), 3. Dark grey area: Suspected COVID-19 patients holding unit (negative isolation room), 4. Common utility area, 5. PPE Doffing area, 6. PPE Donning area.

4.2 Staff preparedness

The HCWs were never been as vulnerable as seen in COVID-19 pandemic. The HCWs not only faced the physical brunt of the disease by cross- infection but also emotional and social breakdown in case of global uncertainty.

4.3 Infection control

World Health Organization (WHO) recommended on continued use of droplet precautions (surgical mask, physical distancing of at least one meter and hand hygiene) for all HCWs in the hospital premises and airborne precautions (N95 mask or equivalent) for aerosol generating procedure (AGP).[17]

The continuous availability of PPE is another big challenge which needs to be addressed especially with ongoing supply-chain disruptions. The plan of surge capacity must include PPE and critical trigger of escalation to higher step must be identified (see Table 1).

4.4 Human resource planning

The expert human resource in critical care and emergency department is in huge demand during this pandemic especially during surge. The increased capacity of beds further multiplies this demand and need of inclusion of staff from non-critical areas. The identification of staff from these non-critical areas and their hands-on training for critical care services should be prioritized. The enrollment of hospital and patients in clinical trials is encouraged globally to find evidence-based treatment. There is also need of intra and interhospital chain of communication to share knowledge, experience, and resources like extracorporeal membrane oxygenation (ECMO).

Table 1. Surge planning for infrastructure and personal protective equipment (PPE)[27]

Level of Surge	Containment Planning	Contingency Planning	Crisis Planning
Definitions	Measures taken without any change in daily contemporary practices	Measures which can impact usual standard of care but without significant impact on the patient care and the safety of HCW	Measures may significantly impact usual standards of care and would be implemented in catastrophic situations only.
Infrastructure expansion	20% increase in capacity	Up to 100% increase with expanding or modification of existing spaces and involving staff from non-critical areas.	More than 100% increase mainly by expansion of current facility and modification based on cohort principle.
PPE	Physical barriers between patient and HCWs. Limit number of patients entering hospital (through appointment /tele-medicine). Limit HCWs in hospital not directly involved in patient care. No visitors for suspected/confirmed COVID-19. Cohort suspected patients and/or HCW.	Cancel elective and non-urgent procedures Cancel outpatients high risk of exposure (dental, ENT, etc.). Daily review of hospital stays of COVID-19 and non- COVID-19 patients for discharge.	Cancel all routine outpatients appointment for which PPE is typically used by HCP. Mobilisation of staff and resources to COVID areas.
N95 Masks	Regular fit-test can be replaced by qualitative (seal test) testing at time of use. Procure and training on alternatives like reusable elastomeric respirators and powered air purifying respirators. Processes on appropriate use and regular monitoring/audit.	Rationing the use with one mask per shift. Extended use of N95 respirators by review of HCWs duty rota. Review of supply-chain with alternatives like reusable elastomeric respirators. Daily monitoring of use by task force.	Re-Use of N95 policy implementation. Alternatives to N95 masks which are not FDA approved. Prioritize the use of N95 facemasks by activity producing aerosols.
Gowns	Coverall only for HCWs involved in direct patient care. Isolation gowns for visitors or doctor who are not directly posted in ICU.	Extend duration of coverall or gown use for whole shift. Use gowns or coverall conforming to international standards. Daily monitoring by task force.	Consider re-usable cloth isolation gowns or other alternatives. Prioritize gowns only for activities where splashes are anticipated or during high-contact patient care.
Googles (Eye protection)	Use eye protection googles conforming to international standards.	Shift from disposable to re-usable devices. Extended use of eye protection. Consider using safety glasses that cover the sides of eyes.	Extended use of eye protection devices beyond manufacturer recommendations. Prioritize for activities where splashes are anticipated or during face-to-face contact.
Gloves	Use double layer of gloves with external glove change after patient contact/care. Use gloves conforming to international standards	Use non-sterile gloves disposable instead of sterile for routine patient care.	Use gloves beyond normal recommended shelf life. Single layer of gloves. Consider glove alternatives, e.g., nonhealthcare gloves.

Note. PPE: personal protective equipment, HCW: healthcare worker, ENT: ear nose throat, ICU: Intensive care unit.

4.5 Standards of care

In absence of any evidence-based treatment, repurposed drugs based on experience from previous similar outbreaks like SARS or MERS were used in first few months of pandemic. The rise and fall of Hydroxychloroquine (HCQ) in this pandemic have affected the core of evidence-based medicine.[18,19] The standard of care for acute respiratory distress syndrome (ARDS) were over-ridden either by lack of resources or non-evidence based expert opinions. Cummings et al., in there study reported only 17% of the patients with ARDS could receive prone ventilation and only 3% ECMO because of resource limitation. In absence of any substantial evidence conventional lung protective ventilatory management of ARDS should not be changed.[20] The improved understanding in the pathophysiology of COVID-19, has realized the role of inflammation and corticosteroid in pulmonary phase of illness. The only therapy which has shown so far outcome benefit in critically ill patients is low dose corticosteroids.[21,22] The resources optimization, and staff training on basic management of ARDS like prone ventilation may help in providing better care to patients.

The evidence on antivirals is emerging and it is important to keep abreast with emerging evidence for choosing appropriate treatment.[23] The modification of airway protocols to prevent aerosolization will be "new normal" both inside and outside ICU (e.g., operation theatres). Similarly modified cardiac arrest algorithm with focus on staff safety (using full PPE) are also going to be continued.[24]

4.6 Supply-chain

The requirement of resources especially consumables and medicines during pandemic increased tremendously. On the other hand, lock-down disrupted the supply-chain of these critical supplies. The sustainability in critical care has to overcome these vulnerabilities of supply channels wherever feasible. There is need of regional and international harmony for supplies of the essential equipment, and pharmaceutical products. Single-use items are always preferable in view of infection control but reusable items, (based on protocols for effective disinfection and sterilization) can ensure continued availability in some areas.[25] Rational use of PPEs have with extended use or limited re-use wherever feasible. N95 masks and alternatives (like elastomeric respirators) must be rationalized by risk profiling (e.g., AGP), use limit (extended reuse or disinfection) and regular monitoring.[26]

4.7 Communication

The SARS-CoV-2 infection transmission risk has caused precautions of physical distancing and lockdown. This has caused social and emotional distancing among humans and communication has been its biggest victim. The successful response to pandemic is dependent on two-way communication (may be virtual if not physical) between key stakeholders nursing, infection control, medical supplies stores, biomedical/engineering, cleaning services and other departments. The central response command centre should be core of this communication and should address HCWs for new challenges and regular medical updates. The patient-family members communication because of no visitors' policy in hospitals also need to be addressed.

5. Conclusion

The pandemic of COVID-19 has been challenging so far to critical care services. The critical care providers on one hand bear the brunt of illness and on other thorough innovations showed a zeal to fightback. The pandemic is far from over, ICU physicians have to take a lead in strategy and planning with now experience at hand. The sustainable critical care services with aim to provide equal chance of healthcare to all, protecting HCWs, and delivering standard of care with emotional connect is the lesson of this pandemic.

Conflicts of Interest Disclosure

The authors declare they have no conflicts of interest.

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