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COVID-19 disease: a critical care perspective

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Abstract

COVID-19 is a new highly infectious disease with an incompletely described clinical course, which has caused a pandemic, with Europe being identified as the third epicentre. COVID-19 has placed unprecedented pressure on critical care services which is likely to stretch resources beyond capacity. The situation is exacerbated by increased staff absence from self-isolation and illness, increased referral of patients with suspected or confirmed COVID-19 who develop respiratory failure, and limited availability of Extra Corporeal Membrane Oxygenation (ECMO) services. In addition, there is the ongoing challenge of patients being transferred between departments and hospitals for ongoing care. In consequence, as current needs continue to rise, innovative approaches are needed to redress shortages and support the continuance of services. This article provides an overview of severe COVID-19 infection, outlining treatment strategies and nursing processes that will need to develop and extend in response to this evolving situation.

Keywords 2019-nCOV; COVID-19; critical care; pandemic; PPE; SARS-CoV2

Key points

- COVID-19 is a new virus, with an incomplete understanding of the clinical course.
- Patients who develop severe COVID-19 disease may require admission to critical care.
- Critical care services may become overwhelmed due to the high numbers of patients requiring critical care versus the resources available.
- COVID-19 has a high risk of transmission to staff, therefore, nurses need to have a good understanding of contagion and the processes of transmission of the COVID-19 disease.

The World Health Organization (WHO) has now declared COVID-19 as a pandemic, with Europe being identified as being another epicentre (after China, Italy and Iran).[1] For many countries, this is the worst public health emergency of a generation and has led to the implementation of widespread enforcement measures to help to reduce the spread of the virus. In response, healthcare systems have rapidly adapted services to focus efforts on dealing with the consequences of the COVID-19 pandemic, but it has to be recognized that as current needs continue to rise, existing resources are being stretched well beyond normal usage. As a result innovative approaches are needed to redress shortages and support the continuance of services. All hospitals have critically ill patients and critical care services, but these have been developed to reflect usual service need, and not the COVID-19 needs. Evidence from other countries estimates that 5% of patients who develop severe COVID-19 will require intensive care.[2] In consequence, critical care units will be subjected to extraordinary pressure, where patient demand may exceed the available critical care bed capacity.

Critical care before COVID-19 pandemic

The origins of critical care have been traced to the Crimean War in 1850 when Florence Nightingale separated seriously injured patients and nursed them in one area of the hospital, allowing for intensive observation and nursing care to be provided.[3] The practice of grouping the sickest patients nearest to the nurses' station and providing increased observation and intensive nursing care continued for many decades. But it was only during the polio outbreak in Copenhagen in 1952 when hundreds of patients developed respiratory failure that critical care emerged as a specialty. In response to this epidemic, Dr Bjorn Ibsen, a Copenhagen anaesthetist, successfully treated a 12-year-old girl with severe respiratory failure by inserting a tracheostomy and using positive pressure ventilation. Other polio patients were treated similarly, with medical students providing one-to-one care and resulted in the mortality decreasing from over 80% to approximately 40%.[4] Following the epidemic, Ibsen argued that a dedicated unit within a hospital with one nurse per patient should be developed.[4] This was deemed the start of the modern-day critical care speciality.

Advances in critical care over the past 20 years have led to greater recognition that the care of a critically ill patient often has to start before admission to intensive care, in emergency departments, wards and recovery areas. This has led to ward nurses and doctors becoming increasingly skilled in the recognition, prevention and escalation of care of a critically ill patient. In consequence, critical care units now admit patients who are no longer at the end stage of a disease process, who will have received time-critical interventions before transferring to critical

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Levels of Care

Level 0	Care can be met though acute ward-based care.
Level 1	Patients at risk of deterioration or recently re-located from a higher level of care. Additional input, advice and support from critical care may be required.
Level 2	Patients requiring more detailed observation and intervention including single organ support or post-operative care or patients 'stepping down' from level 3 care.
Level 3	Patients requiring advanced respiratory support and/or basic respiratory support with support of at least two organ systems.

Source: Ref[7]

Table 1

care. Critical care advances include better understanding of disease processes and evidence to support practices, lung protection mechanical ventilation strategies, and better technology including ventilators and monitoring.[4]

Intensive care tends to refer to a place within a hospital that provides highly specialized care to critically ill patients, whereas critical care refers to any area where acutely unwell or critically ill patients may be managed, for example, theatre recovery, emergency departments and acute wards. Today, intensive care provision and capacity varies drastically across the globe. In the United States, an estimated 4 million patients are admitted to critical care, compared to England, Wales and Northern Ireland where an estimated 184,000 patients are admitted annually.[5] The UK has one of the lowest numbers of critical care beds in Europe,[6] with critical care provision classified by levels of care (Table 1).[7] In consequence, critical care services vary between hospitals and may be purely intensive care (level 3) or incorporate coronary care and high dependency units (level 2), as part of the provision. Intensive Care Unit (ICU) use either operates an open or closed approach to admission. Open ICUs mean the admitting physician remains responsible for them during the patients' care on ICU, whereas a closed ICU means the patients' care transfers to the intensivist.

Responding to the COVID-19 pandemic

COVID-19 has placed unprecedented pressure on critical care services which is likely to continue for the near future. There will be ongoing increased staff absence from self-isolation and illness, and the need to refer patients with suspected or confirmed COVID-19 who develop respiratory failure. This will impact on the availability of Extra Corporeal Membrane Oxygenation (ECMO) services and extend the challenge of preparing and accompanying patients transferring between departments and hospitals for ongoing care. In addition to the relatively high numbers of COVID-19 patients developing severe respiratory failure resulting in acute respiratory distress syndrome (ARDS) and requiring intubation and ventilatory support, the current data suggests an average length of stay for COVID patients in intensive care of 8 days.[8]

The role of the critical care nurse & Re-deployed staff

Critical care nursing is not simply a list of skills or tasks provided to critically ill patients; it requires the nurse to understand the complex needs of each critically ill patient. The World Federation of Critical Care Nurse (WFCCN)[9] defines a critical care nurse as:

> *'A registered practitioner who enhances the delivery of comprehensive patient centred care, for acutely ill patients who require complex interventions in a highly technical environment, bringing the patient care team a unique combination of knowledge and skills. The role of critical care nurses is essential to the multi-disciplinary team who are needed to provide their expertise when caring for patients and their relatives'.*

Using this definition, the nurse is there to provide effective patient centred care, observing and being proactive in the patient's management, so that any deterioration or changes can be immediately identified and acted upon. This includes being able to cope with unpredictable and unexpected events, explaining all nursing procedures, providing emotional support to patients and their relatives and acting as advocate for the patient. S/he also has a key role in providing detailed information to other members of the healthcare team, raising concerns, while maintaining and respecting patient dignity and confidentiality.[9]

As a result of the COVID-19 pandemic, staff from across the hospital may be re-deployed to work in critical care units. To increase the nursing workforce, a pragmatic approach has to be taken, with the first tranche being volunteers, those with previous critical care experience or those with transferrable skills such as anaesthetic and recovery nurses. Staff should be identified early and orientated to critical care before capacity is exceeded and time for orientation becomes impossible. The aim must be to 'best match' the available skill mix to the acuity of patients, with supervision by a Critical Care Nurse, to maintain safe care, even if traditional critical care staffing ratio recommendations cannot be followed for a period.[10] Staff redeployed to critical care should not be expected to work outside their professional scope of practice, independently nursing level 3 patients unless they are deemed and have been assessed as competent.[10]

COVID-19

Coronaviruses (CoV) are large, enveloped, positive-strand RNA viruses, that can cause illnesses ranging from the common cold to more severe diseases.[11] They are zoonotic, meaning the virus is transmitted between animals and people. Severe CoV diseases include Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV). The novel coronavirus (nCoV) is a new strain that has not been previously identified in humans[12] and was first identified in Wuhan, China in late 2019. The virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causes coronavirus disease. The term COVID-19 was introduced by the WHO on 11 February 2020 and replaced previous terms such as '2019 novel coronavirus'.[13]

The incubation period remains unclear, with most estimates ranging from 1 to 14 days, with an average 5 days before symptoms.[12] COVID-19 is a highly contagious respiratory illness, currently thought to be spread through close contact and respiratory droplets. Severe COVID-19 disease causes an aggressive

pulmonary impact resulting in respiratory failure, similar to that of other viral pneumonias that cause respiratory failure.[14] However, due to its highly contagious nature, the risk of transmission is significant. It has to be accepted that in spontaneous self-ventilating patients, all oxygen administration strategies are at risk of aeroslization, which increases risk of transmission.[15] Aerosol Generating Procedures (AGP), are medical and patient care activities that can result in the release of airborne particles (aerosols), increasing the risk of airborne transmission of infections that are usually only spread by droplet transmission.[16] Examples of AGP include humidification, open suctioning, non-invasive ventilation and intubation. The highest risk of transmission of respiratory viruses is during AGPs of the respiratory tract.[15,16] Following identification by Li et al.,[17] that there was a lower risk of transmission when using Hudson, venturi masks and nasal cannulae, as compared with high-flow nasal oxygen (HFNO) and non-invasive ventilation (NIV) with facemasks or hoods, these are now being used.

The critical care nurse needs to recognize that patients who develop severe COVID-19 can rapidly develop Type 1 Respiratory Failure, ARDS and therefore require ventilatory support. In the UK, an estimated two-thirds of patients who required admission to critical care were intubated and mechanical ventilated within 24 h of admission.[18] In non COVID-19 patients with increasing respiratory failure the use of High Flow Nasal Oxygen (HFNO) or Non-Invasive Ventilation (NIV) such as Continuous Positive Airway Pressure (CPAP) may be used as a treatment strategy. However, evidence from the outbreak in Italy has shown NIV may be insufficient to manage COVID-19-induced respiratory failure.[19–21] In addition, NIV is not recommended for patients with viral infections complicated by pneumonia, as it may temporarily improve oxygenation, initially reducing the effort of breathing but does not change the natural disease progress.[22,23] Thus, the use of NIV and HFNO in COVID-19 patients remains controversial, but it has been suggested if used early in the disease progression, it may avoid the need for intubation and mechanical ventilation. The WHO[24] support the use of HFNO in some patients but recommend close monitoring for clinical deterioration that could result in emergency intubations, which in turn increases the risk of infection to healthcare workers.

With limited availability of ventilators, CPAP may be considered to improve oxygen, as anecdotal reports have suggested this may reduce the need for ventilation, but that there has to be increased monitoring, as the patient may be developing multi-organ failure. In addition, regular assessment should be undertaken to determine whether intubation is required. Emergency tracheal intubation maybe required, but is a high-risk procedure increasing the risk of transmission to healthcare workers and other patients. Although, increasingly, as a result of the rising demand for intubation, it has to be performed outside of the critical care unit, it is usually carried out by specially formed intubation teams, termed Mobile Emergency Rapid Intubation Teams (MERIT).[25] These teams have the requisite expertise to intubate patients in emergency departments and ward areas, then transfer them to the critical care units.

A common feature of severe COVID-19 disease is the development of ARDS: a syndrome characterized by an acute onset of hypoxemic respiratory failure with non-cardiogenic pulmonary oedema resulting in bilateral infiltrates.[15] Internationally recognized ARDS treatment guidelines include conservative fluid strategies for patients without shock following initial resuscitation, empirical early antibiotics for suspected bacterial co-infection until a specific diagnosis is made, lung-protective ventilation, prone positioning, and consideration of ECMO for refractory hypoxemia.[26] It is essential that fluid strategies must take account of the duration of the illness and the accompanying insensible fluid loss.

Access to specialized services such as ECMO may become increasingly difficult due to the to the relatively small number of units offering this services and increased pressure on beds. In consequence, the prone position may be used to improve oxygenation. Pan et al.'s[27] cohort study of 12 patients in Wuhan City, China, with COVID-19-related ARDS suggests the prone position may have improved lung recruitability and oxygenation if used early. Anecdotal experiences from centres suggest using the prone position while the patient is on CPAP on the ward, as this may improve oxygenation and prevent the need for intubation. Due to the high numbers of patients requiring prone position, 'proning teams' may be set up to improve efficiency.[25] Traditionally, in ARDS, partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FiO_2) is used as an indicator of lung function.[28] However, it is suggested in COVID-19, clinical performance using oxygen saturations, rather that the Pa02/Fi02 ratio should be used.[29]

At the time of writing, there is currently no vaccine or specific antiviral to prevent or treat COVID-19 and treatment focuses on supportive care. Several clinical trials are in progress for possible vaccines and specific drug treatments. For example, the Randomized Evaluation of COVID-19 Therapy (RECOVERY) Trial is testing the use of Lopinavir-Ritpnavir (HIV anti-retroviral treatment), low-dose dexamethasone (steroid anti-inflammatory), hydroxychloroquine (anti-malarial drug) and azithromycin (an antibiotic).[30] However, currently the use of high dose corticosteroids in COVID-19 have been found to be ineffective and are not recommended.[31,32]

COVID-19 is caused by a virus; therefore, antibiotics should not be used as a means of prevention or treatment. However, it is worth noting that empirical early antibiotics may be appropriate if bacterial co-infection is suspected. De-escalation of antibiotics should be based on microbiology results and clinical judgement.[12,25]

There have been concerns raised following advice by the French Health Minister regarding the use of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs).[33,34] From the current data available, there is no evidence that NSAID increase the chance of acquiring COVID-19. However, the use of NSAIDs in SARS 1 showed that there may be an adverse impact on pneumonia. In consequence, it is recommended that until more information is available, patients who have confirmed or suspected COVID-19, should use paracetamol instead of NSAIDs, unless they are currently on a NSAID for other medical reasons.[35]

Personal protective equipment

COVID-19 is a highly infectious respiratory illness, currently thought to be transmitted through close contact, respiratory droplets and through contact with contaminated surfaces.[17] With high rates of COVID-19 circulating in the community and patients requiring hospitalisation, healthcare workers are at repeated risk

Guidance on wearing a mask.

- Before touching the mask, clean hands with an alcohol-based hand rub or soap and water
- Take the mask and inspect it for tears or holes.
- Orient which side is the top side (where the metal strip is).
- Ensure the proper side of the mask faces outwards (the coloured side).
- Place the mask to your face. Pinch the metal strip or stiff edge of the mask so it moulds to the shape of your nose.
- Pull down the mask's bottom so it covers your mouth and your chin.
- After use, take off the mask; remove the elastic loops from behind the ears while keeping the mask away from your face and clothes, to avoid touching potentially contaminated surfaces of the mask.
- Discard the mask in a closed bin immediately after use.
- Perform hand hygiene after touching or discarding the mask — Use alcohol-based hand rub or, if visibly soiled, wash your hands with soap and water.

Source: Ref[12]

Table 2

FFP Protection Levels

Filter Standard	Filter capacity (removal percentage of all particles ≥0.3μm
FFP1	80%
FFP2	94%
N95	95%
FFP3	99%
N100	99.97%

Source: Ref[15]

Table 3

of contact and droplet transmission during their daily work. In addition, swab results may take 3—4 days, resulting in challenges in establishing whether patients meet the case definition for COVID-19 prior to a face-to-face assessment or care episode.[17] Therefore, the use of personal protective equipment (PPE) cannot be overstated, but it may not be 100% effective.

Specialist filtering face piece (FFP) face masks are recommended when dealing with high-risk COVID-19 patients (Table 2). FFP provides respiratory protection that is worn over the nose and mouth designed to protect the wearer from inhaling hazardous substances, including airborne particles (aerosols). There are three categories of mask: FFP1, FFP2, FFP3 (Table 3), with FFP3 respirator providing the highest level of protection, and is the only category of respirator legislated for use in UK healthcare settings.[16]

International, national and regional variations in PPE guidance and provision have been identified, providing conflicting information and confusion among healthcare professionals. In addition, potential supply issues with PPE and changes in FFP3 respirators due to the increasing demands, require staff to be 'fit tested' prior to using the new equipment. This may lead to further delays and concerns for staff who have not been trained or measured appropriately for masks and a sufficient variety of appropriately sized masks is not readily available.[36,37] This concern has already been raised by the WHO,[38] who have highlighted PPE may run out in some countries.

Regardless of the type of PPE worn, one of the greatest risks is prolonged wearing of PPE, as this has shown to increase fatigue over time, reduce visibility due to visor and mask and reduced dexterity due to wearing double or triple gloves.[39] Procedures such as breaking glass ampoules, drawing up medication, performing intravenous cannulation, and intubation whilst wearing several layers of gloves and PPE, have been shown to be slower which in turn impacts on practice.[40]

There is also a suggestion that an increased number of healthcare professionals is needed when providing care, particularly in critical care for procedures requiring two nurses to one patient (2:1) when PPE is worn. In addition, staff may need to be rotated to enable them to have time out of PPE and regular breaks, and additional staff may need to act as runners in the clean zone to prepare drugs and equipment and assist with the donning and doffing of PPE.[39,40]

The most significant risk of self-viral contamination is potential during the 'doffing stage' (removal of PPE) if this is done incorrectly. Doffing is a complex, high-risk skill which is often undertaken during periods of stress.[41] During the Ebola outbreak in 2015, studies undertaken during training with a fluorescent marker, showed complex PPE doffing procedures left contamination on hands after PPE removal.[42—45] In consequence, doffing procedures must be clear and simple to follow. Simulation training may provide additional confidence for practitioners to prepare and confirm their skills, as well as increasing expertise in wearing and removing PPE.

Delivery of critical care

To provide an effective critical care service, a specialist workforce, appropriate infrastructure and adequate resources are needed, with critical care units using a multi-disciplinary team approach to care. During the height of the COVID-19 pandemic countries coping with an unprecedented number of patients requiring critical care have to recognize that, as identified in Italy, a major challenge is the risk of collapse in the healthcare system due to difficulty in triaging, allocation, and too few critical care beds.[16] Should this occur, the current models of critical care will be unsustainable and a radical adaptation to the delivery of nursing care will be required. Then too, healthcare staff,

including physicians and nurses, becomes infected or exposed, quarantined and unable to work causing additional workforce pressures.[16] To support the requirement for expanded critical care services, staff from across the hospital may need to be re-deployed to work in the intensive care unit.

During the increased pressures on staffing and increased demand for critical care beds, traditional staffing models may not be able to be followed. However, safe care must always be delivered, even if staffing ratio recommendations need to be temporarily set aside. Many hospitals have followed a 'pod system' whereby a group of critically ill patients are supervised by one critical care nurse, with direct care delivered by registered nurses. Additional, support from physiotherapists, pharmacists, dieticians and support workers (including medical or nursing students) is used. This maintains a staff to patient ratio of 1:1, but the critical care nurse, may in reality be supervising 1:3, 1:4 and in extremis 1:6. With limited numbers of critical care nurses and doctors, the focus on care needs to be not 'who' does each aspect of patient care, but rather 'what' needs to be done. This teamwork approach and sharing of workloads improves effectiveness without placing the burden on one professional group.

An overall nurse-in-charge will manage the unit, with support from the critical care medical team. Due to increased pressure on hospital services, it may not be possible to maintain an open or closed unit. However, specialist medical input is likely to be required from respiratory, cardiology, surgical and medical teams as appropriate. Strategic leadership will be provided by the Matron (also termed Head Nurse, Lead Nurse) and the Clinical Director (lead doctor), who have overall responsibility for critical care services.

Policies & practice

With the rapid expansion of critical care services, current policies and guidelines may be unrealistic due to the differing levels of staffing, the large influx of new staff not familiar with critical care and the dynamic and rapidly evolving COVID-19 situation. In consequence, maintaining standardized practice and supporting staff in practice, means guidelines need to be developed, which can include the of flashcards and care bundles. Flashcards can be used to provide an aide-memoire of key guidelines and core standards relating to care and reflect changes in practice. They may also be displayed to remind all staff of core standards for example, shift safety checks, guidance for handover, admission process, syringe management and drawing up of infusions.

Care bundles are a series of proven evidence-based interventions relating to a condition or disease that when implemented together can significantly improve outcomes.[46] Each intervention must have a well-established scientific basis and direct the way care is provided. They are presented in practical and easy to use formats, which can be followed by all healthcare professionals. Examples of commonly used care bundles in critical care relate to ventilator care, central venous catheters and tracheostomy. Care bundles provide consistency in care and can be used as an audit tool to ascertain if they are being followed and the impact on care.

Care planning is an important part of nursing care and follows the nursing process (Figure 1). For COVID-19 patients, the care plan should involve a systematic assessment of the patient and

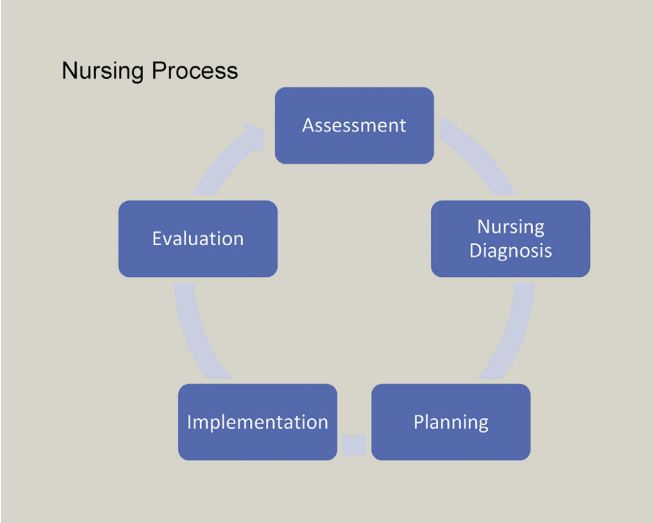

Figure 1

undertaken on admission and at the start of each shift. Goals and the nursing diagnosis are identified, but appropriate plans of care may need rapid revision due to the rate of progression of the disease. Evaluation at the end of the shift needs to review not only if goals have been met, but whether these need changing or adapting, and the best way to utilize the diluted skill-mix of healthcare professionals. Due to increased work pressure, such formalized care planning may be difficult, but the critical care nursing process documentation on the 24-h chart must accurately reflect the patient's changing status.

At the start of each shift, a general handover takes place, whereby all patients are handed over, as part of the process nurses are allocated to a specific group (pod) of patients and then a more detailed individual handover is taken. In COVID-19, as a minimum, the bed-side handover should include the patients name, age, past medical history, if the patient has any allergies, reason for admission, length of stay in critical care (number of days), key events that have taken place during the patient's critical care admission, system handover (respiratory, cardiovascular, neurological, renal, liver), next of kin details, a review of the patient's observation chart, drug chart and medical and nursing notes. In addition, a physical check of the patient's name band, infusions and ventilator settings by both the outgoing and oncoming nurse should be conducted to confirm all are correct.

Hospital infrastructures need to be adapted to respond to the increasing demands, which include oxygen, air and power supply and critical care equipment. Oxygen supplies are now under huge pressure, with increased use of ventilators and oxygen therapy being delivered across the hospital. Staff must be made aware of the need to conserve oxygen supplies, reduce hyperoxia and prevent unnecessary waste, for example switching off an oxygen supply when not in use.[27] Emergency portable oxygen cylinders need to be available. While it is accepted that they are unlikely to be able to sustain a critical failure in walled oxygen supply, they should be readily available to facilitate transfers and for emergency use. Then too, the increased use of ventilators means there is currently a likelihood of an 'enriched oxygen' atmosphere in clinical areas, increasing the risk of combustion

and fire.[47] Fire preventive checks must be carried out at regular intervals, and any necessary remedial action taken.

In many clinical areas, as a patient safety measure, air supply outlets have been restricted to reduce the risk of connecting oxygen tubing to air flowmeters.[48] Most ventilators require piped air supply, with the exception of ventilators used in transport, sufficient outlets and supply will need to be available in locations not traditionally used to provide invasive ventilation.

As the pandemic continues, healthcare services are likely to have to be re-configured and transformed to respond to the need for a greater focus on the COVID-19 to sustain care utilizing staff available for re-deployment. However, while this response is seen as crucial, the problem for care providers is that it is essential for healthcare services to be able to respond to non-COVID-19 patients such as those with Cerebrovascular Accidents (CVA), cardiac emergencies, maternity services, major trauma and cancer care.[49] For hospital managers, the differing needs and approach to services between COVID-19 and non-COVID-19 critical care availability and input will be an ongoing challenge when planning services and identifying how these patients will be managed.

Summary

Critical care is still a relatively new specialty, which has developed dramatically in the last two decades, and continues to be at the cutting edge of response to the current pandemic. COVID-19, as a new highly infectious disease with an incompletely described clinical course, results in perhaps the greatest challenge for intensive care since services were first initiated. However, it was developed in response to what was then an unprecedented need. It has become a highly skilled and expert workforce designed to advance care and cope with new and unknown situations. Yet it still retains the ability to transform itself as our understanding of disease processes increase. Treatment strategies will evolve and nursing processes will develop and extend, building on currently used treatments, to meet the unexpected and unprecedented number of patients needing their help, care and support. ◆

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