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Critical care medicine in 2050: less invasive, more connected, and personalized

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Introduction

The specialty of critical care medicine can perhaps be said to date back as far as the 1850s when Florence Nightingale famously separated more seriously ill patients from other patients to bring them nearer to the nurses' station where they could be watched more closely. This model was adopted during the Second World War, notably in the postoperative care of military casualties requiring surgery. In the 1950s, greater use of mechanical ventilation outside the operating room, notably during and subsequent to the polio epidemics in some parts of Europe and the US, was associated with the need for specific areas to be set aside with the necessary equipment and specially trained staff. Coinciding with increased availability and complexity of monitoring equipment, intensive care units (ICUs) began to be created in countries around the world to care for the critically ill. Finally, in 1980, critical care medicine was recognized as a subspecialty in its own right in the US and soon after in multiple other countries. Postgraduate training programs in critical care medicine are now widely established, although they vary markedly in duration, content, and assessment techniques.

Critical care medicine as a specialty in its own right has therefore existed for less than 40 years, but the changes that this field has witnessed over that time span have been enormous as our understanding of pathophysiological processes [e.g., of sepsis, acute respiratory distress syndrome (ARDS), circulatory shock] has improved, technology has enabled equipment to become smaller and more user-friendly, and changes in societal norms have encouraged a more human approach to hospital treatment (1). Given the rapid changes in this field so far, it is likely that critical care medicine in 2050 will again bear little resemblance to the situation today. Here we will speculate, in general terms, on how we see the specialty and the ICU moving forwards over the next 30 years or so.

The ICU and the equipment

Although overall there will be fewer hospital beds in 2050, ICU beds will be responsible for a greater proportion of the total number of beds than is currently the case. There are multiple reasons for this, including improved primary and outpatient care and shorter post-intervention hospital stays. Halpern *et al.* reported that between 2000 and 2010, the number of hospital beds in the US decreased by 2.2% while ICU beds increased by 17.8%, giving a 20.4% increase in the critical care medicine-to-hospital bed ratio (2). A report from the UK showed that between 1987/8 and 2016/17, the total number of NHS hospital beds decreased by just over 50% whereas between 2011/12 and 2016/17, the total number of ICU beds increased by 9.5% (3).

As more patients are treated out of hospital or as day cases, the severity of illness of those patients who do require hospitalization will be higher than it is at present. It has therefore been suggested that all hospital beds should have the capacity to be an ICU bed. The ICU would then no longer be a physically isolated unit, but a collection of patients spread throughout the hospital. While this approach could facilitate continuity of care, limit the need for patient transfers between wards and effectively eliminate problems of ICU bed shortages, it would face other issues related to ensuring that all nursing staff were adequately trained to manage ICU patients and the potential need

for intensivists to cover considerable distances between patients (4).

Wherever the ICU beds are situated, they will likely be in large individual rooms with space for relatives to visit and even stay if wanted. The rooms will automatically control temperature, light, sound and air quality adapted to individual requirements and preferences (5). ICU rooms will be ultraconnected and interactive modules and screens will show patient results and monitored parameters. These will also be available real-time on the attending intensivist's smartphone or tablet. Alarms will remotely alert the intensivist and nursing staff of potential deterioration without disturbing the patient. Intelligent monitors will combine monitored values with other patient data (history, age, risk factors…) to set the most appropriate alarms and will learn to adjust them according to response. There will be less visible equipment and connecting tubes and cables as patient monitoring will all be achieved by one or two simple non-invasive wireless systems (6) and most blood parameters will be measured by percutaneous sensors or breath analysis thus eliminating the need for phlebotomy (7). Mechanical ventilators will be less abundant and when present much smaller than current respirators. Indeed, fewer patients will undergo endotracheal intubation and mechanical ventilation because extracorporeal membrane oxygenation (ECMO) and extracorporeal CO_2 removal ($ECCO_2R$) devices will have developed to such an extent that they can largely prevent the need for mechanical ventilation (8). These extracorporeal devices will be much smaller and more portable than current machines.

Patients, families and staff

In terms of patients, demographics will have changed considerably with the average patient age increasing as the population in general ages. Patients will also be sicker than is currently the case. On or even before ICU admission, patients will have undergone detailed omics testing to determine their individual critical illness phenotype, which, combined with monitored variables and other patient-specific data, will help provide the intensivist with an indication of the most appropriate treatment plan and likelihood of developing specific complications including ARDS, sepsis and renal failure. Patients will be better informed and have a more active role in decision-making about all aspects of their care. End-of-life plans and decisions will have been discussed and regularly updated at routine checks with their primary healthcare provider and will be available on the patient's instantly accessible e-health record, preventing any possible confusion or delay in respecting wishes. Organ donor registration will also be clearly visible on the record.

In terms of families, visiting hours will be unrestricted and family members will be welcome and more directly involved in patient care. An ICU stay can be a traumatic experience for family members and the ability to spend time with the patient without restriction can help reduce feelings of anxiety. For the patient too, the presence of family members can be reassuring.

In terms of healthcare staff, there will be fewer doctors and nurses physically present on the wards, but virtual consultations with patients and family members will be possible via the large interactive screens in the patient's room. Indeed, telemedicine will be widely used. Robots will be responsible for much of the routine administration and delivery of food, linen and other essential basics. They will also be involved in encouraging and performing patient mobilization and in stimulating patients and providing conversation (4,9), and in inserting intravenous lines and catheters when necessary (7). Almost all patients will be enrolled in at least one clinical trial and more of the doctor's time will be taken up with performing research. Teaching of junior staff will also be an important role, made easier as the increased use of technology for more routine tasks will free up time. Patient communication will also be improved as doctors and nurses will have more time to spend discussing individual concerns.

The process

Technology will continue to enhance and alter the structure and practice of intensive care over the next 30 years and more. But therapeutic advances are likely to be more limited. As such, improving the process of care must be a focus, and patient-centered, personalized care will be the model of critical care in 2050. Patients potentially needing intensive care will be identified much earlier as deterioration on the floor will be more closely observed and identified with more advanced non-invasive, mobile monitoring systems. ICU teams will rapidly attend to help diagnose and stabilize as necessary.

Each patient will be managed by a multidisciplinary team, ensuring all aspects of care are covered, including medical therapies, nutrition and psychological support (1). Patients will all be treated as individuals and therapies prescribed and administered according to their underlying

molecular and cellular characteristics. Syndromic "labels" such as sepsis and ARDS will no longer be used. Diagnosis will be facilitated by new panels of biomarkers, and it will be possible to identify the presence of infection and the infecting microorganism almost instantaneously without the need to wait for culture growth. Inclusion of patient characteristics and treatment response data into large datasets continuously analyzed with sophisticated statistical modeling will help determine which treatments are optimal for which patient. This approach is already being investigated. For example, using latent class analysis, different classes or phenotypes of patients with ARDS have been identified, with different responses to therapy and prognosis (10,11). Similarly, using microarray data in pediatric patients, two subclasses of septic shock were identified with different responses to corticosteroid administration (12).

With larger numbers of patients passing through our ICUs, the risk is that the numbers of patients with post-intensive care sequelae will also increase. Risk factors must be identified and methods put in place to limit the adverse physical and psychological effects of intensive care. Sedation will scarcely be used; indeed the need for sedation will be greatly reduced with increased use of non-invasive monitoring and interventions, including mechanical ventilation. Patients will be mobilized almost immediately, with in-bed exercises and out-of-bed movement as soon as is possible, assisted by specially programmed robots. As already mentioned, doctors and nurses will have the much needed time to communicate in greater depth with patients and their families providing all-important psychological support. Sleep quality and quantity will be improved because continuous monitoring systems feeding back to central desks and/or individual nurse/doctor tablets/smartphones will prevent the need for patients to be woken for tests during the night.

Conclusions

Predicting the future is always complex and rather subjective, but many of the devices and possibilities that we have discussed in this text already exist and some are already employed in certain ICUs. Moreover, with the rate of change we are currently seeing, particularly in terms of technology, it is quite possible that our predictions are even somewhat conservative. These advances are exciting for the future of critical care medicine and we must embrace them and learn how to work with them to improve patient care. It is up to today's doctors to shape the critical care medicine of tomorrow.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

References

1. Vincent JL. Critical care--where have we been and where are we going? Crit Care 2013;17 Suppl 1:S2.
2. Halpern NA, Goldman DA, Tan KS, et al. Trends in critical care beds and use among population groups and Medicare and Medicaid beneficiaries in the United States: 2000-2010. Crit Care Med 2016;44:1490-9.
3. Ewbank L, Thompson J, McKenna H. NHS hospital bed numbers: past, present, future. Available online: https://www.kingsfund.org.uk/publications/nhs-hospital-bed-numbers#hospital-beds-in-england-and-abroad
4. Vincent JL, Creteur J. The hospital of tomorrow in 10 points. Crit Care 2017;21:93.
5. Halpern NA, Anderson DC, Kesecioglu J. ICU design in 2050: looking into the crystal ball! Intensive Care Med 2017;43:690-2.
6. Michard F, Pinsky MR, Vincent JL. Intensive care medicine in 2050: NEWS for hemodynamic monitoring. Intensive Care Med 2017;43:440-2.
7. Vincent JL, Michard F, Saugel B. Intensive care medicine in 2050: towards critical care without central lines. Intensive Care Med 2018;44:922-4.
8. Brodie D. The evolution of extracorporeal membrane oxygenation for adult respiratory failure. Ann Am Thorac Soc 2018;15:S57-60.
9. Denis K, Bidet F, Egault J, et al. Utilization of Robo-K for improving walking and balance in patients affected by neurological injuries: A preliminary study. Ann Phys Rehabil Med 2016;59S:e88.
10. Zhang Z. Identification of three classes of acute respiratory distress syndrome using latent class analysis. PeerJ 2018;6:e4592.
11. Calfee CS, Delucchi K, Parsons PE, et al. Subphenotypes in acute respiratory distress syndrome: latent class analysis of data from two randomised controlled trials. Lancet

Respir Med 2014;2:611-20.
12. Wong HR, Cvijanovich NZ, Anas N, et al. Developing a clinically feasible personalized medicine approach to pediatric septic shock. Am J Respir Crit Care Med 2015;191:309-15.

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