Learnings from critical care on COVID-19

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COVID-19 shone a bright light on the work of intensive care units in UK hospitals, where much of what we know about the virus was learned in a very short time. The knowledge prompted a rethink about the way the service is delivered and how those with the infection are managed.

Before COVID-19, intensive care medicine (ICM) was a poorly understood specialty. A critical care unit was perceived as a place to support the delivery of complex interventions, to care for sick patients by putting them on a ventilator, and (occasionally) a place to die.

Due to the lack of recognition of the pivotal role ICM plays in secondary care, the UK entered 2020 with only around 4000 critical care beds, significantly fewer per 100 000 population than the majority of other European countries (see Figure 1). As 5% of patients infected with COVID-19 were expected to require admission to critical care,[1] ICM was put immediately under the spotlight while our ability to expand the critical care bed base became the *de facto* overall capacity of the NHS.

There are more women than men in the UK's general population, but more males are admitted to critical care.[2] Fifty-four per cent of patients admitted with viral (non-COVID) pneumonia are male, but for COVID-19 this rose to 70%.[3]

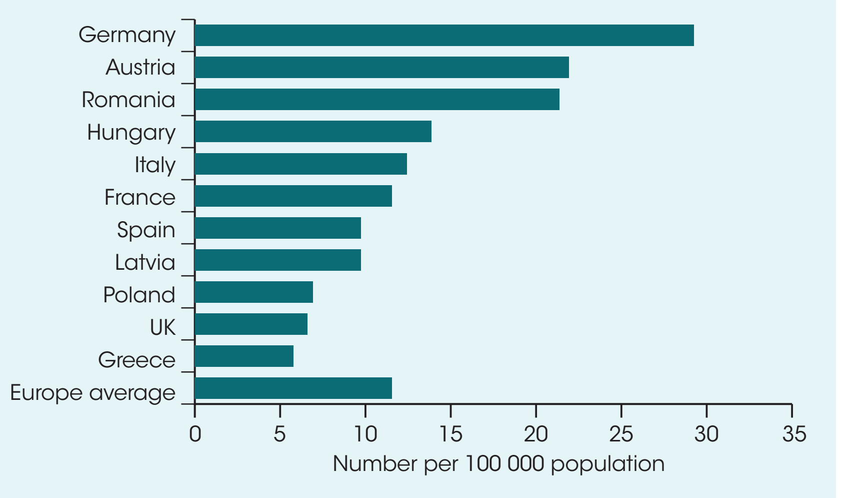

Figure 1. Total number of critical care beds per 100 000 population

The reasons for this are still not entirely understood, but there have been a number of theories postulated, including differences in immune response and higher concentrations of angiotensin converting enzyme 2 (ACE2).[4]

In mid-April, at the peak of the pandemic, most critical care units were running at twice normal capacity, managing significantly sicker patients with double the mortality rate of those with non-COVID pneumonia. This massive expansion was facilitated by the cessation of most planned activity, liberating space and staff to support critical care.

As of 31 July 2020, there have been 13 379 admissions to critical care with confirmed COVID-19.[2] As a result, we changed the model of critical care delivery and learned to work in different ways. We also learned a lot about the disease process as our own and others' experience around the world evolved. Although any organ can be involved as a result of COVID-19 infection, those that behaved differently were the respiratory, the renal and haematological systems. This article will cover how critical care teams adapted to the COVID-19 situation and its impact in these systems of the body.

Respiratory system

Initial presentation

The hypoxaemia seen in patients with pneumonia is most commonly due to ventilation:perfusion (VQ) mismatch, with or without shunt, secondary to alveolar consolidation (see Figure 2). A degree of associated alveolar collapse results in a reduction in lung compliance and increased work of breathing.

In February, numerous images appeared in media outlets from Italian hospitals overwhelmed by the number of patients requiring ventilatory support. Their advice to us at the time was to intubate early, as delaying resulted in increased instability, and this is what we did. UK data show that, compared with non-COVID pneumonia, patients with COVID-19 were intubated and ventilated earlier in the disease process, without a trial of non-invasive ventilation (NIV). There were also concerns as the use of high-flow oxygen, with or without continuous positive airway pressure (CPAP), was considered to generate an aerosol and therefore have implications for infection prevention and control.

Once ventilated, we would expect to see a gradual increase in a patient's oxygen levels as collapsed airways open up and improve secretion clearance helping to reduce VQ mismatch. To our surprise we found that lung compliance was relatively normal and patients were easy to ventilate but their hypoxaemia did not improve. These patients were sicker than any we had experienced before and we did not understand why.

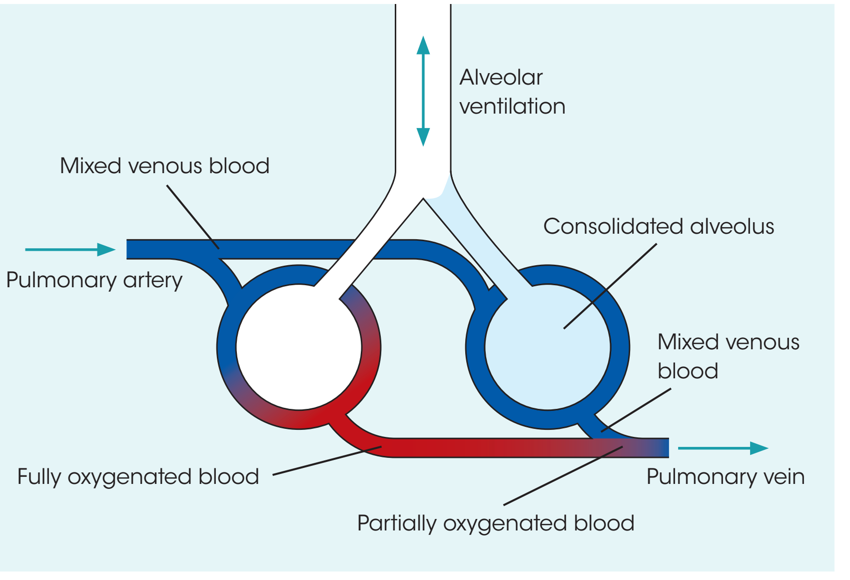

Figure 2. Diagram showing how alveolar consolidation, secondary to pneumonia, results in hypoxaemia

Rapid learning

As cases in the UK began to rise, we saw the Italian hospitals running out of critical care capacity, with reports that they were forced to manage patients in hospital corridors.[5] Images of patients in what looked like space helmets (see Figure 3) in evident respiratory difficulty were distressing to see.

In the UK, in an attempt to treat patients with COVID-19 the same way as non-COVID pneumonia, some patients were managed with NIV. Initially this was either because we did not understand the underlying pathophysiology, or it was felt to be an appropriate ceiling of care. This practice was particularly prevalent in locations where there was support from respiratory physicians. Although many patients still deteriorated to the point of needing invasive ventilation, others did not require this intervention.

The experience in Italy was similar and we began to see a shift in our approach to respiratory support. In mid-March 75% of patients were invasively ventilated, but three weeks later this had fallen to 59%[3] as more received CPAP or high flow oxygen therapy first. This had an impact on the requirement for personal protective equipment (PPE) and the need to either isolate or cohort these patients.

Novel approaches

Prone positioning is used to improve hypoxaemia in patients with respiratory distress due to the physiological effect on ventilation and perfusion.[6] We found that placing patients in the prone position, once sedated and ventilated, was one of the few manoeuvres that improved hypoxaemia.

A study from China suggested that combining NIV with prone positioning in awake non-COVID patients reduced the requirement for invasive ventilation.[7] In April, a study from the USA reported a benefit for patients with COVID-19 adopting the prone position.[8] This resulted in the adoption of conscious 'proning' in hospitals, and was also advocated by some for use by patients at home after a video was posted on YouTube.[9]

Renal system

Most critical care units have the ability to provide acute renal replacement therapy (RRT) for their patients. An acute kidney injury (AKI) occurs in around 17% of patients who are critically ill with non-COVID viral pneumonia. However, over 25% of patients with COVID-19 admitted to critical care required RRT. We assumed this increase to be mainly pre-renal, as we tried to keep patients in a negative fluid balance to 'protect' the lungs. The effect of this on the kidney was compounded by insensible losses secondary to pyrexia.

Within critical care we normally provide RRT via continuous venovenous haemo(dia)filtration, which is managed by trained critical care staff. As more COVID-19 patients required RRT there was concern that we would exhaust available equipment. In order to cope with this we developed a programme of mutual aid, transferring equipment between organisations, and considered other methods of RRT such as intermittent haemodialysis

(IHD) and peritoneal dialysis (PD). Basic forms of PD are often low tech and not particularly efficient; however, it was used successfully by some. IHD requires specially trained staff and its use put extra demands on renal services, but the intermittent nature meant that multiple patients could be treated each day.

Understandably, it became a theme that we had to rapidly adopt new ways of managing patients as we learned more about the disease. As soon as one problem seemed to have been overcome it was replaced by another. In one particular example, just as we managed to increase the provision of RRT it was discovered that the filter circuits were clotting more often than usual, needing repeated replacement and adding to the pressure on availability of consumables. We were about to find out more about COVID-19.

Coagulation system

The effects of COVID-19 were initially thought to be limited to the lungs, but the severity of illness and the emerging appreciation that patients were in a hypercoagulable state led us to question this conclusion.[10]

In sepsis, for example, the cellular response includes the release of inflammatory mediators and activation of coagulation. A consumptive coagulopathy – disseminated intravascular coagulation (DIC) – is typically seen, resulting in microthrombi and multiple organ failure, which might account for the unusual clinical picture we were seeing. The resistant hypoxaemia may be due to poor perfusion secondary to thromboemboli, rather than inadequate ventilation. This would explain the 'silent hypoxia' observed in many patients, who easily tolerated extreme hypoxaemia as CO2 removal was relatively spared. It also explained why lung compliance was preserved, which led to a change in the specification for the rapidly manufactured ventilators (RMVs) and an appreciation that anaesthetic machines may not be as useful as first thought.

This prothrombotic state added another dimension to the AKI that we saw and which led us to change our approach to anticoagulation in patients with COVID-19 and venous thromboembolic (VTE) prophylaxis. It also explains the increased incidence of ischaemic stroke associated with severe COVID-19 pneumonia.[11]

Organisational issues

The pandemic has been challenging for a range of medical specialties, especially critical care. After having spent the last 10 years trying to highlight the lack of critical care resource, banging on closed doors, we were asked to quadruple our physical capacity overnight. We did not have enough staff to support our baseline capacity, but following the removal of some bureaucracy and red tape, the rapid upskilling of non-critical care staff, a blurring of professional boundaries and amazing collaboration, we have managed. This crisis has enabled us to restore services with a better understanding of the work of colleagues in different disciplines, and an awareness for the need to be flexible.

The constant evolution in managing the critically ill patients added its own pressures. The increased use of high-flow oxygen and CPAP put an excessive load on hospitals' oxygen supply, risking complete shutdown. A rapid response to this avoided any patient harm but highlighted the lack of system resilience.

There was a huge geographical variation in the incidence of COVID-19, with London bearing the brunt of the caseload in the initial stages of the pandemic. Although overall critical care capacity in the UK was never exceeded, this did happen in some regions while other hospitals waited for their first patient.

It is many years since the critically ill have been transferred outside of a region for non-clinical reasons, but the benefits of this during periods of unprecedented demand are apparent and, in order to make it safe, a national transfer service is currently being explored.

Figure 3. StarMed CPAP hood (©Intersurgical Ltd, 2020)

Overall learning

We have experienced a new disease that has required us to rapidly adapt to emerging evidence and fast publication of new research. The speed with which we have embraced telemedicine would have been inconceivable at the beginning of the year. Our healthcare system has become very nimble and I hope we can harness this going forward. Our country will never be the same again; nor will our NHS. We must make sure that this is a positive change.

Declaration of interests: *none declared.*

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