

Fast reshaping of intensive care unit facilities in a large metropolitan hospital in Milan, Italy: facing the COVID-19 pandemic emergency

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In December 2019, an outbreak of atypical pneumonia caused by a novel coronavirus — the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) — started in the Chinese province of Hubei. On 20 February 2020, the first Italian case of the coronavirus disease 2019 (COVID-19) was reported in the city of Codogno, in northern Italy. The infection rapidly spread across the country, and by 28 March 2020, a total of 92 472 official cases with 10 023 deaths (10.8%) were reported in Italy. Of these cases, 39 415 were reported in the region of Lombardy.^{1,2}

An emergency task force was promptly formed by the local government to manage the response to the outbreak. Considering the epidemiological data reported from China,^{3,4} it was immediately clear that the number of patients with COVID-19 requiring intensive care unit (ICU) admission would quickly outnumber the total ICU capacity of the public and private hospitals managed by the national health care system (*Servizio Sanitario Nazionale*) in Lombardy.⁵ Therefore, the regional government developed a plan to increase ICU capacity and implement containment measures.

In this article, we describe the experience of a large hospital facing a major public health crisis of ICU beds shortage during the COVID-19 pandemic.

San Raffaele Scientific Institute before 20 February 2020

The San Raffaele Scientific Institute is a tertiary care 1318 bed university hospital in Milan. Even though it is a private institution, most of its medical services are provided under the national health care system. San Raffaele was founded in 1969, and it is at present the largest centre in Italy for major surgery and the research institute with the highest

ABSTRACT

At the end of 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outbreak spread from China all around the world, causing thousands of deaths. In Italy, the hardest hit region was Lombardy, with the first reported case on 20 February 2020.

San Raffaele Scientific Institute — a large tertiary hospital and research centre in Milan, Italy — was immediately involved in the management of the public health emergency. Since the beginning of the outbreak, the elective surgical activity of the hospital was rapidly reduced and large areas of the hospital were simultaneously reorganised to admit and assist patients with coronavirus disease 2019 (COVID-19).

In addition, the hospital became the regional referral hub for cardiovascular emergencies in order to keep ensuring a high level of health care to non-COVID-19 patients in northern Italy.

In a few days, a COVID-19 emergency department was created, improving the general ward capacity to a total number of 279 beds dedicated to patients with COVID-19. Moreover, the number of intensive care unit (ICU) beds was increased from 28 to 72 (54 of them dedicated to patients with COVID-19, and 18 to cardiology and cardiac surgery hub emergencies), both converting pre-existing areas and creating new high technology spaces.

All the involved health care personnel were rapidly trained to use personal protection equipment and to manage this particular category of patients both in general wards and ICUs.

Furthermore, besides clinical activities, continuously important research projects were carried out in order to find new strategies and more effective therapies to better face an unprecedented health emergency in Italy.

scientific output in terms of impact factor per year in Italy. As of 20 February 2020 (Day 0), the hospital had a total of 28 ICU beds divided into three units (cardiothoracic ICU, 14 beds; general ICU, eight beds; and neurosurgical ICU, six beds) and four additional single rooms in the coronary care unit (CCU) equipped with ventilators. In addition, our hospital had a 137-bed internal medicine ward and 24 beds dedicated to the infectious diseases department in a separate campus. The emergency department (ED) was divided into medical, surgical, orthopaedic, obstetric and gynaecological, and paediatric units, with two shock rooms for major medical and surgical emergencies. A medical emergency team composed of an anaesthesiology/intensive care consultant, an anaesthesiology/intensive care or emergency medicine trainee, and a registered nurse provided 24/7 support for acutely deteriorating patients on the wards. The hospital had 36 operating rooms dedicated to major and minor surgery pertaining to more than ten surgical specialties. In Italy, anaesthesiology and intensive care are joint specialties with a common training pathway, and more than 90 anaesthesiology/intensive care consultants and about 20 senior residents are employed at San Raffaele Scientific Institute.

Reorganisation of clinical and surgical activity in the Lombardy region

From the beginning of the COVID-19 outbreak, the Lombardy region set up a coordinating centre dedicated to the strategic management and reorganisation of medical activity. The purpose was to continue to ensure health care to the general population while facing the increasing demand on resources for the COVID-19 public health emergency.^{6,7} The clinical and surgical activity was promptly reorganised in different hubs for acute diseases. San Raffaele Hospital was selected as the referral cardiovascular hub. A network of spoke hospitals refers to San Raffaele for cardiological, vascular and cardiac surgery urgencies and emergencies. If necessary, surgeons from spoke hospitals move to hub hospitals to perform procedures. Other hubs have been created in other hospitals in the whole Lombardy territory for stroke, oncology, trauma and general emergencies.

Elective surgical activity was progressively reduced, ultimately performing only urgent oncological and emergency (eg, bowel perforation) surgeries. Every day, a special crisis unit — headed by the hospital executive board with the participation of intensive care specialists, anaesthesiologists, surgeons and chief nurses — meets to set the priority of surgical procedures. This strategy has relieved several units of both San Raffaele and other hospitals from treating ordinary diseases and has helped reallocate resources to continuously growing COVID-19 units.

At our centre, after analysing the first trends of COVID-19 admissions, an expected demand for ward and ICU beds was estimated and a plan for gradual increase in ward and ICU capacity was set. This strategy was chosen because an immediate conversion of surgical and medical wards into dedicated and isolated COVID-19 wards and ICUs would have been impossible. A smoother transition translated into adequate staff training and reallocation and also facilitated moving or discharging non-COVID-19 patients from their original units without forcing discharges or inter-hospital transfers.

For cardiovascular patients referred to the regional hub, a separate entrance was identified and a new ED area was created using outpatient clinics, while the original ED was dedicated to patients with COVID-19.

Moreover, the intensive haematology bone marrow transplant and chimeric antigen receptor T cells (CAR-T) program was continued, with dedicated rescue ICU beds as recommended.

Creation of dedicated pathways for patients with COVID-19

One of the first measures was to provide separate access to the ED to patients with suspected or confirmed COVID-19. This action was aimed at minimising contacts between patients, thereby limiting the spread of the disease. Patients are screened for infection and clinically evaluated in a new triage area with skilled health care providers. All patients presenting with respiratory symptoms are considered to be SARS-CoV-2-positive until proven otherwise. After the first screening and based on vital signs, laboratory tests and physical examination, patients are gradually allocated according to the severity of their condition, ranging from home discharge to ICU admission.

At present, this area of the hospital consists of 75 beds, all of which are fully equipped for oxygen therapy up to 15 L/min and non-invasive ventilation. Furthermore, seven beds are reserved for highly unstable or acutely deteriorating patients requiring immediate intubation and invasive mechanical ventilation while waiting to be transferred to an ICU.

Within 48 hours from ED admission, patients are assigned to dedicated wards or ICUs, which they join following protected routes in the hospital.

Increasing intensive care unit and general ward capacity

As an initial measure, the four-bed CCU was converted into a dedicated COVID-19 ICU isolated from the rest of the hospital, with dedicated filter zones and with health care personnel wearing personal protective equipment. The

CCU was selected because it was separated from other wards, it provided the possibility of isolating patients, and it had ICU ventilators and single, closed rooms. Furthermore, the nursing staff already had ICU-level training. This new COVID-19 ICU was opened on 24 February and the first patient was admitted on 25 February 2020. The unit was managed by medical staff of the general ICU, with additional help from anaesthesiologist/intensivists of other ICUs and operating theatres, which were partially relieved of elective cases.

During the next weeks, further 44 ICU beds were made available in the hospital.

At first, the general ICU was converted into a COVID-19 unit, with its capacity increased to ten beds. Meanwhile, an additional ICU with nine beds was created from an empty space previously dedicated to preoperative clinics and discontinued at the time. This space was selected because it could provide isolated, single rooms already equipped with oxygen and air supply.

In addition, three operating theatres normally dedicated to ophthalmological procedures were converted into an ICU with seven beds. Finally, when all elective surgical activity ceased, the neurosurgical ICU was also converted into a COVID-19 unit, increasing the total number of COVID-19 ICU beds to 37. All non-COVID-19 patients requiring intensive care are currently transferred to the 14-bed cardiothoracic ICU. On 14 March 2020, we started the construction of two new ICUs dedicated to critically ill patients with COVID-19 with a total of 24 beds. The two new ICUs were organised in a makeshift structure next to the hospital, in an area formerly used as basketball and tennis courts. In fewer than 10 days, these structures were furnished with high technology ICU beds and ventilators, a dedicated operating room, and a computed tomography scanner. On 23 March, the first 14 extra beds were opened, and one week later, ten more beds were ready to admit patients. The availability of 24 new ICU beds permitted the relocation of patients from other COVID-19 ICUs of the hospital, specifically from the CCU and part of the ophthalmological operating room-ICU. Thus, the CCU returned to its original function. As a result, the total number of available ICU beds increased to 72, 54 of which were dedicated to patients with COVID-19.

From 20 February, we also progressively reorganised 12 general wards for a total number of 279 beds for patients with COVID-19, with the possibility to increase the capacity in the near future with an area dedicated to rehabilitation. To staff these units, personnel were recruited from non-COVID-19 and non-cardiovascular units and from surgical units, which were relieved from most elective activities. These wards are all under the management of a multidisciplinary team of different specialists, supported by an anaesthesiologist/intensivist of the medical emergency

team. This measure allows the provision of non-invasive ventilation on the ward to patients with mild or moderate acute respiratory distress syndrome without overloading the ICUs. Patients receiving non-invasive ventilation on the ward are reviewed by the medical emergency team, which has now been increased to four teams including anaesthesiologists, who are now not performing elective surgical activity. Of note, the use of non-invasive ventilation outside the ICU is already a well established practice in our hospital.⁸⁻¹²

Major challenges

In the first weeks, we admitted several ICU patients from other hospitals that were overloaded with critical cases. In addition, our ICU physicians helped the same peripheral hospitals with clinical rotations.

Nonetheless, after the first few weeks, retrieving personnel to manage the newly opened ICUs was a major challenge that San Raffaele Hospital had to face.

Due to the progressive global reduction of non-COVID-19 activity during the first 3 weeks after 20 February, human resources were concentrated on the management of patients with COVID-19. More than 90 anaesthesiologists, who are also trained in ICU care (as it is usual in Italy), work in the institution, and they were supported by about 20 senior anaesthesiology/intensive care residents. Most of them have been progressively included in pathways of care for critical patients with COVID-19. On the contrary, finding nursing staff for COVID-19 ICUs was more challenging. Registered nurses were recruited from anaesthetic nurses who were usually working in operating rooms and nurses who had background training in the ICU. Training courses on management of critically ill patients and appropriate use of personal protective equipment were quickly organised. The progressive opening of new ICUs enabled the gradual introduction of new nurses into ICU practice. Staff were organised in order to mix experienced with less experienced personnel to provide training while maintaining an adequate level of quality of care.

The clinical management of patients with COVID-19 was another major challenge, as we had to face a new disease the pathophysiology of which is not yet fully understood and high quality data to guide treatment are still lacking. A multidisciplinary team of physicians from intensive care, infectious diseases, internal medicine and immunology developed homogeneous treatment algorithms based on available evidence to standardise the management of patients with COVID-19, including ward-based and ICU-based management, and administration of antiviral and immunomodulatory drugs. Protocols are periodically reviewed and updated as new evidence becomes available.¹³

Moreover, through social media platforms (@SRAnesthCU on Twitter, Facebook and Instagram), we shared our early experiences in treating patients with COVID-19 and answered questions and requests for information from colleagues around the world by recording podcasts or replying to tweets and comments.

Conclusion

Since the beginning of the SARS-CoV-2 emergency in Italy, San Raffaele Scientific Institute has played a major role in supporting the national health care system and containing the outbreak, and a significant reorganisation of the hospital was urgently required.

Differentiated routes were planned and promptly implemented in order to isolate patients with COVID-19, and specific pathways of care and internal management guidelines have been developed for this new patient group. In this way, the hospital was able to provide health care to patients with COVID-19 and continued to ensure high quality assistance to non-COVID-19 patients, in particular for cardiovascular emergencies.

Despite the rapid changes, both structural and logistical, all the involved personnel were adequately trained to face an unprecedented public health crisis in Italy.

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Competing interests

None declared.

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