


Exploring the impact of the COVID-19 pandemic on cardiac surgical services: A scoping review

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Abstract

Cardiac surgery was severely affected by the COVID-19 pandemic. Reallocation of resources, conversion of surgical intensive care units and wards to COVID-19 facilities, increased risk of nosocomial transmission to cardiac surgery patients, lead to reduced accessibility, quality, and affordability of health care facilities to cardiac surgery patients. Increasing the mortality and morbidity rate among such patients. Cardiac patients are at an increased risk to develop a severe illness if infected by COVID-19 and are associated with a high mortality rate. Therefore, measures had to be taken to reduce the spread of the virus. Various approaches such as the hubs and the spokes centers, or parallel system were enforced. Elective surgeries were postponed while urgent surgeries were prioritized. Use of personal protective equipments and surgeries performed by only senior surgeons became necessary. Surgical trainees were also affected as limited training opportunities deprived them of the experience required to complete their fellowship. Some of the trainees were reallocated to COVID-19 wards, while others invested their time in research opportunities. Online platforms were used for teaching, meetings, and workshops across the globe. Although some efforts have been made to reduce the impact of the pandemic, more research and innovation is required.

KEYWORDS

cardiac, cardiac surgery, coronavirus-2 (SARS-CoV-2), heart, severe acute respiratory distress syndrome, training

1. INTRODUCTION

Coronavirus pandemic continues to spread during its second wave, infecting over 73 million people around the world. The pandemic has taken over 1.6 million lives with a mortality rate of 3%.¹ Apart from the reported mortality rate, this pandemic has affected health care in almost every possible way. With all the focus shifted towards COVID-19, deferring of patients has decreased the quality, accessibility, and affordability of health care facilities, impacting the mortality rate inevitably.

The SARS-COV-2 virus has a high affinity for the vascular endothelium and myocardium cells due to the presence of angiotensin-converting enzyme II (ACE-II) receptors.² Myocardial injury can present as electrocardiogram changes and elevations in troponin levels, and so forth. Even after adjusting for major complications of COVID-19, one study found high mortality in patients affected by myocardial injury.³

Numerous studies on hospitalized patients with COVID-19 displayed that patients with the greatest threat of death are

those who are remarkably older and have pre-existing pathologies especially cardiovascular disease, hypertension, and diabetes. It was also noted in these studies that cardiac injury played its part in the disease development of COVID-19 as raised cardiac biomarkers were observed in COVID-19 patients especially those who were hospitalized.⁴ There is also a risk of indirect myocardial injury due to acute plaque rupture leading to the acute coronary syndrome.⁵ In a study of 416 patients with COVID-19, cardiac injury prevailed in 19.7%.⁵ Therefore, patients with cardiac diseases have shown to have a high risk of developing severe disease and so a greater mortality rate.

With the focus of every country's health services towards COVID-19, less priority has been given to major cardiac surgery. This is compounded by the reduction in cardiac emergency cases and the utilization of as much as 60% of the beds of the cardiology unit for COVID-19, according to one study.⁶ One proposed tier-based triage system called for a deferral of all patients who are outpatient at a 60%–80% inpatient COVID-19 load and saved essential services only for inpatients who could not be safely discharged without surgical intervention.⁷ In this review we present our finding of the impact of COVID-19 over the provision of cardiac surgery, cardiac surgery training, and the efforts made by health care professionals to tackle these challenges, ensuring the best health care facilities.

2. MATERIALS AND METHODS

An extensive literature search was conducted using the PUBMED/MEDLINE and Google Scholar databases from its inception to December 2020. The following keywords were employed as a search string: ("SARS-CoV-2") AND ("Cardiac surgery") OR ("Heart") OR ("preoperative screening") OR ("Cardiac fellows") OR ("Cardiac surgical training") OR ("Cardiac surgical education"). All articles in a language other than English were excluded from our review. Articles that had explored impact of COVID-19 pandemic on Cardiac Surgical Services were included. Related content of the articles that met this inclusion criterion were reviewed and organized in tables.

2.1. Global impact of COVID-19 on the provision of cardiac surgery

The existence of cardiovascular comorbidities also served as a hazard for more serious COVID-19 complications. Patients with hypertension or any other cardiovascular comorbidity were at a greater risk of developing cardiovascular pathology due to SARS-CoV-2 infection. Hypertension was associated with 27% of COVID-19 patients who developed a severe form of the disease.⁸

COVID-19 patients having cardiovascular complications have been observed in a remarkable percentage of cases. In a general study of COVID-19 patients undergoing surgery, there were greater cases of intensive care unit (ICU) readmission in COVID-19 cardiac surgery patients (16%) than non-COVID-19 patients (0%). The total

death rates in COVID-19-positive cardiac surgery patients were 16% which is greater than non-COVID-19 cardiac surgery patients.⁹ Shi et al. conducted a study on 416 COVID-19-positive hospitalized patients. They reported cardiac injury to be present in 19.7% of the patients. Patients with cardiac injury also needed more noninvasive ventilation (46.3% vs. 3.9%; $p < .001$) and invasive mechanical ventilation (22.0% vs. 4.2%; $p < .001$) and also had higher death rate (51.2% vs. 4.5%; $p < .001$) as compared to those without cardiac injury.¹⁰

The findings of a study performed in Ireland's National Centre, demonstrated a significant fall in major cardiac surgery procedures. There was a 50% reduction in cardiac and transplant surgery for March and April 2020 compared to the previous years' activity for March and April 2020. Coronary artery bypass surgery was performed at 61% of the expected rate and major aortic surgery at 22%.¹¹

Another study detected a significant drop in the number of cardiac surgeries conducted in two hospitals of Greece during the period of COVID-19 pandemic, when compared to an equivalent time period of 2019. With 67% reduction in coronary artery bypass grafting (CABG), 75% reduction in valvular heart disease, 78% reduction in aortic aneurysm, and 45% reduction in aortic dissection.¹²

A study conducted in England showed an overall deficit of 45,501 procedures during the COVID period compared to the monthly averages (March–May) in 2018–2019. Surgical procedures such as mitral valve replacement, other valve replacement/repair, trial septal defect and ventricular septal defect repair and CABG came out to be most affected when compared to previous years' percentage difference averages, while transcatheter aortic valve replacement was the least affected.¹³

The resulted delays and reduced overall number of cardiac surgical procedures in this pandemic because of the implementation of restrictive measures in the healthcare facilities calls for some major restriction of cardiac services.¹³

Increasing evidence attribute, the cause of acute respiratory distress syndrome (ARDS) in COVID-19 to cytokine storm syndrome, especially that patients with COVID-19 have been found to have high levels of pro-inflammatory cytokines (tumor necrosis factor α [TNF- α] and interleukin-10 [IL-10]), which is also associated with the disease severity. Thus, the exposure of blood to the nonendothelial surfaces during CPB which activates the inflammatory response by via coagulation pathways, complement system, and increasing the level of TNF- α and IL-10, can have detrimental effect in those high-risk patients for COVID-19 infection, especially in the case of silent carriers.¹⁴

Right ventricular dysfunction due to severe respiratory failure commonly causes late cardiovascular collapse in COVID-19 and constitutes end-stage disease which is unmanageable with mechanical circulatory support. Thus, mechanical circulatory support with venoarterial extracorporeal membrane oxygenation (VA-ECMO) is contraindicated in most patients with COVID-19 due to the presence of multiorgan dysfunction and is extremely resource-intensive.¹⁵

Moreover, cardiac complications like myocardial damage, low cardiac output, and arrhythmia may occur due to COVID-19. In this condition, called noncoronary myocardial infarction, extracorporeal membrane oxygenation (ECMO) is needed. However, the associated significant risks with the use of ECMO such as bleeding (most common), infection, transfusion requirements, stroke, micro thrombus, or air bubbles passage from the patient line to the circulatory system, can result in increased mortality, morbidity, long-term disability, and a decreased quality of life.¹⁶

After restrictions were implemented due to COVID-19 pandemic, the drop in cardiac surgery volumes was 54% of baseline according to a study. With either June 1 or July 1 as being the assumed service restoration date, the calculated need to perform was 216% or 263% of monthly baseline volume, respectively, to clear the backlog in 1 month. The accurate duration to clear the backlog ranges from 1 to 8 months and depends on degree of hospital capacity, and when services are restored.¹⁷ Unpreparedness for post-COVID period may result in substantial delays, severely affecting the mortality and morbidity.¹⁷

Another study in Ontario reported 42% fewer cardiac surgeries, 73% fewer vascular surgeries, 81% fewer transplant surgeries, 38% fewer cancer surgeries, 94% fewer pediatric surgeries and 96% fewer other adult surgeries in April 2020 compared with April 2019. Between March 15 and June 13, 2020, for all above-mentioned surgery types, the estimated backlog was 148 364 surgeries, with an average weekly increase of 11,413 surgeries. The estimated backlog clearance time is 84 weeks, with an estimated weekly throughput of 717 patients, requiring 719 operating room hours, 265 ward beds, and 9 ICU beds per week.¹⁸

In a survey of cardiac surgery centers, the reported median reduction in cardiac surgery case volume was by 50% to 75%. The widespread interruption in cardiac surgery due to COVID-19 can thus result in a backlog of patients, with consequences of increased morbidity and mortality in patients due to longer wait times.¹⁹

The magnitude of the cardiac surgical backlog from COVID-19 raises serious implications for the recovery phase. Hence, a proper framework for designing surgical backlog recovery is needed to assist with planning.¹⁹

2.2. Resources and their effect on affordability

There have been limitations in resources for cardiac surgery as a result of this pandemic. Due to the cancellation of elective surgery and redistribution of beds to COVID-19 patients originally dedicated to cardiac surgery, 16 of the 20 cardiac surgical units in Lombardy had to suspend their activities with the remaining 4 units functional for cardiac surgery patients catering to urgent cases.²⁰ The reallocation of resources within these centers decreased cardiac surgical services.²¹ Trinidad and Tobago had remarkably low COVID-19 cases (142 cases per one million population) due to which a new strategy was introduced to reconfigure healthcare into "parallel systems" (COVID-19 proven) and "cold" (COVID-19 negative) centers. This design has however not been fruitful

in Low and Middle-Income Countries due to finite accessibility and border closures.²¹

Redistribution of human resources to COVID-19 wards in hospitals have led many cardiac surgeons to bluntly divert their roles from surgical orientated to new completely undefined roles. Many cardiac surgery units and cardiac ICUs were transformed into COVID-19 units.²² Cardiac operations were temporarily suspended to conserve intensive care unit beds, mechanical ventilators, circuitry for extracorporeal membrane oxygenation, pharmaceuticals, personal protective equipment (PPE), and health care staff with advanced expertise to come in handy for the ever-growing numbers of COVID-19 cases. Volunteers are reluctant to donate under the recommendation of avoiding close contact. Moreover, blood transfusions are also restricted due to a finite number of blood donations following national and regional lockdown.²¹ Not only this, but the accessibility of heart transplant was also restricted in number.²³

Doctors, including cardiac surgeons, have also died due to the coronavirus.²⁴ Lack of enough PPE, and absences due to illness or isolation can further aggravate work pressure. The availability of hospital beds has been limited, and ICUs have collapsed because of the massive influx of patients with severe pulmonary disease.²³ As resources become limited for cardiac surgery, hospital costs for cardiac procedures would rise to affordability problems.

2.3. Risk of transmission

Patients with normal postoperative courses were to be dismissed without any delay. Whereas patients with complexities in their postoperative course required hospitalization, on different modes of support, for example, intra-aortic balloon pump and continuous venovenous hemofiltration, and were neither dismissible nor likely to be shifted into other ICUs. Such patients had a poor prognosis and were at an increased risk of nosocomial infection of SARS-COV-2.²⁵ Guo et al.²³ collected and analyzed swabs taken in different hospital locations and reported a greater risk of SARS-COV-2 in ICU than in general wards. In Maria Eleonora Hospital, Italy, 20 patients were found positive for SARS-COV-2 post-surgery among the 55 inpatients, of these 20 patients, 18 underwent cardiac surgery while 2 of them underwent trans catheter aortic valve replacement.²⁶

The Society of Cardiothoracic Surgery (SCTS) classified cardiothoracic patients in four areas, the obligatory in patients subjected to surgical intervention, the alternative (nonsurgical) pathways including inpatients and those to be managed by ambulatory base services, the day-cases and lastly the outpatients whose hospital visits were to be kept at the minimum safe level.²³ There is an equilibrium of risk, as patients with relevant cardiovascular disease have their treatments deferred versus increasing the possibility of contracting nosocomial COVID-19 infection. Increased fear of nosocomial infection has led to a reduced number of admissions at hospitals with myocardial infarctions or stroke.²⁷ There has been a 40% decline in patients presenting to the hospital with an ST-elevation myocardial infarction during COVID-19.²⁸

Nevertheless, deferring surgeries could also worsen the patient's conditions such that they may not be fit for delayed procedures. In a survey where data was collected from four cardiac surgery programs across two health systems, reported mortality rate while awaiting surgical or TAVR can be as high as 3.7% at 1 month and 11.6% at 6 months. For patients awaiting coronary surgery, median waiting list mortality rates of 2.6% per month have been reported, while mortality risk increasing 11% per month. Moreover, 12% of patients experienced a myocardial infarction while on the waiting list.²⁹

2.4. Quality

There have also been modifications in surgical practices to prevent the risk of contracting the infection via intraoperative generation of fomites. Due to this reason, standard procedural activities such as the opening of pressurized cavities and apertures, for example, in the thorax in a CABG are labeled dangerous.²⁷ This could however inadvertently compromise the quality of treatment offered to cardiac surgery patients. Most cardiac surgeries are confined to cases such as aortic dissection, emergency coronary artery bypass not amenable to percutaneous coronary intervention (PCI), or valve surgery unamendable to trans catheter aortic valve replacement.²⁴ In North America, nonurgent surgery was stopped during March 2020 in 96% of health centers resulting in a drop to 45% of baseline. As a ratio of total surgical volume, there was a relative rise in coronary artery bypass grafting surgery, ECMO, and heart transplantation, and a drop in valvular cases.²⁸ Moreover, Reduced effectiveness of treatment to overcome the risk of performing aerosol-generating procedures, along with increased running costs may descend the cost-effectiveness of cardiac care during COVID-19.

2.5. Accessibility

An US study by Solomon et al.²⁷ reported that the weekly rates of hospitalization from myocardial infarction dropped by 43% during the pandemic. In London, the service was rearranged to operate in only two units among the combined seven NHS centers forming the Pan London Emergency Cardiac Surgery. The prime motive of this was to provide a COVID-19 free environment for patients undergoing cardiac surgeries. But there was a remarkable reduction of 83% in the operational activities.³⁰

In Liverpool Heart and Chest Hospital (LHCH), the activity was reduced from five cardiac theatres and 10 cases per day to four theatres and four cases per day. Elective cases were given priority via RAG rating, that is, red, amber, green with red being characterized as "urgent elective." In the North-West of England, four major cardiothoracic units used to be operational: Black Pool, Manchester Royal, Manchester, Wythenshawe, and the LHCH. LHCH was chosen to be the central unit for cardiac and aortic surgery and led the development of North-West Urgent Cardiothoracic Service.³⁰ Furthermore, a recent survey has

shown 36% of primary PCI centers have closed during the pandemic.²⁷ Due to a shortage of nasopharyngeal swab facilities for testing and lack of PPE, much urgent cardiac surgery and cardiac interventions were rejected.²⁶

Hospital case volumes for adult cardiac surgery declined to 60% of baseline in March 2020, and then to 45% of baseline in April 2020. The decline was greatest in adult cardiac surgery case volumes, in the northeast region of United States in April 2020: 36% of baseline, southeast 50% of baseline, southwest 37% of baseline, midwest 39% of baseline, west 46% of baseline, Canada: eastern 51% of baseline, western 62% of baseline.²⁸

An international survey conducted of 77 vascular surgeons suggested that 89.6% stopped outpatient services, 79.2% stopped inpatient services, 90.9% suspended elective cases, and 92.2% performed only emergency vascular operations.²³ A dramatic reduction in the weekly clinical and surgical volume of 96.5% (from 43.1 patients to 1.5 per week) and 71.7% (from 14 patients to 5.25 per week) was noted, respectively.²³ Decreasing the number of cardiac surgeries, conserved logistical, and human resources that could be used for COVID-19 patients. Most hospitals became centers of COVID-19 and surgeons and doctors irrespective of their specialty are serving COVID-19 patients.²³

Not only hospitals but doctors and health care team for cardiac surgery are also not accessible. The hazard of doctors becoming infected when coming in close contact with cardiac surgery patients who are COVID-19 positive is real.³¹ However, this is also determined by the type of invasiveness of the treatment, faulty utilization of PPE, and inability to oblige to hospital instructions. The usage of the individuals of the cardiac team for nonurgent operations would increase the risks of contracting the virus, which further risks their availability for future more urgent procedures.

Under such grave circumstances of limited accessibility, the use of telemedicine is being encouraged for regular communication with patients to monitor the development of disease and progression of symptoms but there are obvious limitations such as lack of physical examination of patients to measure real-time basic observations like heart rate and blood pressure. Even though Peripheral examination devices like electronic stethoscope, electronic blood pressure apparatus, and pulse oximeter can be employed for the use in these patients, however, it is important to determine their accuracy and effectiveness before endorsing them.³²

Some cardiac surgeons might also lose their skill during this process and become rusty. Connectivity issues impose another hurdle in accessibility via telemedicine.²⁸ Patients with linguistic barriers have trouble communicating with the doctor. Telemedicine was used only in 27% of institutions in the northeastern United States and 22% of institutions in Eastern Canada.²⁸

There is a need to increase capacity with collateral adjustments in resources such as operating rooms, ICU, and telemetry beds and hospital staff. Modifications like early telemetry discharge, decreasing the duration of stay at ICU, balancing the load of elective cases in the operating room, and adjusting staffing models could help increase capacity.²⁹

2.6. Impact of COVID-19 on cardiac surgical training

Practicing is the most efficient way to learn and improve surgical skills in the operating room. However, in most of the university hospitals worldwide, training has been disrupted.³³ The training was put on hold in the UK due to multiple reasons.³⁴ First, in areas with more cases, the cardiac surgery trainees were redeployed to the front line mostly due to their exceptional abilities. While in the less affected areas, lack of critical care beds ultimately led to a decline in training opportunities.³⁴ The lack of ventilation sites and ICU beds due to the surge in COVID-19 patients, has led to the training activity being relayed towards most urgent and nondelayable cases only and due to the risk of nosocomial transmission of COVID-19, the number of doctors has been limited.³³ Few of the health care workers had to quarantine themselves due to possible contact with a COVID-19 patient.³⁵ The redeployment, although beneficial for health care service provision, will reduce opportunities for surgical training.³⁶

COVID-19 patients with comorbidities such as cardiac issues, are at a higher risk, and due to a decline in case volume, urgent and high-risk cases are taken up mostly by consultants. Due to only consultants and senior surgeons being allowed to operate on patients at a higher risk, the number of available opportunities for trainees has been seriously affected.³⁵

Additionally, to deal with the tremendous surge in cases, a few countries such as Spain, Italy, Portugal, and the United Kingdom (UK), have appointed fresh medical graduates into the health force at an early stage of their healthcare career.³⁶ Compromise training to provide urgent service, is impacting both the quantity as well as the quality of training. Future elective work would also be affected. As in the UK, cardiothoracic training has been reduced from an 8-year-long program to a 7-year long program, all trainees especially those in their penultimate and ultimate years of practice will face challenges in training which would raise questions and difficulties in their certification.³⁵ This could lead to a possible lack of trust by the patient as well as a potential negative impact on patient outcomes. The decline in cardiac surgery has consequently affected training.³⁵

Due to the crisis, it was decided by the majority of the cardiothoracic surgery units in the UK that they would follow a consultant-led model as the results could be expected to be better. There would be less time spent in critical care which would reduce the chances of becoming infected. It might also be more challenging for a trainee to perform the procedure wearing a PPE than a consultant.³⁴ It was also made public by The Joint Committee on Surgical Training (JCST) in the UK that rotations would be put on hold due to the current situation as it will further burden the health care system.³⁵ However, it was also announced by the JCST that trainees requiring additional time to finish their training will be provided with an extra amount of time after the COVID-19 crisis is averted.³⁵

The competition to secure a place amongst cardiothoracic surgery trainees is very high and trainees must spend a few years in research positions and other nontraining posts. Any pause in their

training would potentially be intimidating.³⁴ The impact on the motivation of these cardiothoracic surgery trainees would be massive.³⁴

Furthermore, to minimize the risk of transmission and to make sure that trainees are available to help with health care service provision, clinical and educational meetings are being delayed. Even though this step may decrease the threat of negative impact on health care staff and patients, the impact on training would be extended further.³⁵

The impact of the COVID-19 pandemic on cardiac surgical training has been widely acknowledged, even though poorly quantified. Some efforts to gather data on this impact have been made, nonetheless. In the UK, to establish the impact of COVID-19 on the health, training, and development of all trainees in cardiothoracic surgery, a 31-item questionnaire was planned and sent to all trainees via a messaging application.³⁷ Of the 76 trainees who answered the questions, 63% had concerns about their physical while 32% had concerns regarding their mental health. 33% of trainees chose to stay at home due to COVID-19, 86% had worked on COVID-19 patients 54% of whom were anxious regarding the PPE provided to them by the hospital.³⁷ In the outpatient clinic, the amount of time spent also was impacted (44% decline).³⁷ There was a 79% decline in time spent at team meetings and a 78% decline in time spent in operation theaters.³⁷ To conclude, 88% of those who answered, were anxious regarding the effect on their training while 71% thought that the delay would result in them requiring extra time in their training.³⁷

As established, this pandemic has changed the way of training for the current generation of thoracic surgery trainees. Hence to establish a relationship between the two, a survey was carried out in the United States. The survey was meant to define how program directors (PDs) are adjusting to training the residents.³⁸ According to the data collected in the survey, the 23 institutions involved, had put elective courses on hold and a majority had reformed to telemedicine clinic visits. 91% of the programs had initiated online virtual educational courses.³⁸ 82.7% of trainees were reported to be on a schedule that was nonspecific. For both junior and graduating trainees, the number of cases was also affected but PDs reported that graduating trainees were to graduate according to the normal timeline without any impact on their training.³⁸

Moreover, a prospective survey was carried out to assess the impact of the COVID-19 pandemic on interventional cardiologists in training (ICTs).³⁹ 61.6% of the participants reported a modification of the training, 98.8% of these participants reported that the reason for the modification of training was the lack of urgent and elective coronary and structural practices.³⁹ 56.6% of the cases reported that the decrease in practices was because the senior operators chose to conserve personal protection equipment and be more time-efficient.³⁹ ICT's were also assigned to COVID-19 units due to which, 1 of 4 ICT's chose to withdraw from the training.³⁹ The survey also successfully highlighted that there is a potential threat to the health of ICTs. From the total of 174 ICTs who contributed to the survey, the majority (85.6%) were working at hospitals with COVID-19

TABLE 1 Major concerns amongst trainees and their respective retort⁴⁰

Concern of trainees	Response
Provision and use of PPE	Provision of PPE by the institute along with outpatient department supply Practicing use of Powered Air-Purifying Respirators Strict rules regarding usage of PPE according to CDC guidelines
Exposure to COVID-19 patients	Plan trainee health triage in case of exposure Ascertain the time period of quarantine in COVID-19-positive trainees
Elective surgical procedures and hospital timetable	Delaying the surgical cases which are not urgent. Devising rotating surgical teams and back up teams Shifting outpatient departments online in absence of residents
Mental Health	Daily pause for mental wellbeing Weekly checks by program directors Provision of support groups and mental health professionals

patients. 57.5% of the ICTs tested for the virus, out of which 2.9% tested positive.³⁹

Apart from all the negative effects faced by trainees, a pause in their training presented a chance for them to focus on working on research papers or take part in local management ventures.³⁴ Even though not a part of their surgical training, working under extreme pressure, amongst the front-line workers during the pandemic was a rare opportunity, teaching resilience and skills for disaster management. Most of the trainees, in these circumstances, were able to work on research papers that had the potential to shape their future.³⁴ Few of the trainees collected data for research being conducted internationally that helped explain COVID-19 outcomes. However, this came at a high price as one cardiac surgical trainee, unfortunately, died due to COVID-19.³⁴

2.7. Efforts made to minimize this impact

Amongst the most concerning issues faced by the residents were, the provision of PPE, restricting COVID-19 exposure, the negative effects on surgical training and mental health (Table 1).⁴⁰

It is really important to ensure evidence-based, necessary cardiac surgeries for the general public when required while also ensuring that the burden of these procedures is not extraordinary for the health care workers.

2.8 Implementation of triage to prevent a backlog of cases/patients

To successfully achieve that goal, some of the efforts which could be made to minimize the impact of COVID-19 on cardiac surgery are to stop routine elective cardiac surgery in hospitals and clinics with the ever-increasing number of cases but urgent cases requiring immediate cardiac operations might still be carried out while bearing in mind, the possibility and risk of infection.⁴¹ This would be according to the recommendations made to implement triage for cardiac surgery patients during the pandemic, as shown in Table 2.

This triage system has many benefits such as, reducing the risk of potential transmission of COVID-19 to the surgical staff while

TABLE 2 Recommendations made to implement triage for cardiac surgery patients during the pandemic⁴²

Recommendations	
1. Preoperative testing for COVID-19 so that the patients are dealt in a suitable way to minimize the risk of transmission during the ICU stays of patients undergoing cardiac surgery ⁴²	
2. :Triage ⁴²	
• High-acuity cases	Urgent cases which must not be delayed
• Immediate-acuity cases	Cases which can be delayed for 4–12 weeks
• Lower acuity cases	Nonurgent cases which can be delayed for more than 12 weeks
3. All delayed cases would have a follow up strategy through online appointments or through telephone calls ⁴²	

handling patients which are not known COVID-19 patients. It will also help reduce risk of transmission of COVID-19 to all other individuals in the hospital including the surgical patients.⁴³ Furthermore, by the use of this triage system the important limited supplies including PPE and equipment could be relayed for the use on the most urgent cases and for the COVID-19 patients, helping in conserving these supplies for essential use.⁴³ Also, since the blood supplies have become low during this pandemic, there is urgent need to conserve blood supplies for the most essential procedures hence delaying nonurgent cases would prove beneficial.⁴³ The ICU bed availability has also been low and by stopping some elective cases, we can keep the space for the most urgent cases.⁴³

2.8. Preoperative testing protocols and postoperative care after cardiac surgery

During this pandemic, the health care department has been under a lot of pressure. Some of the issues include arranging pandemic management, improving infection prevention policies, and establishing a system for treatment, regulating the use of PPE, and managing blood resources. In the wake of these issues, serious alterations have been made to bring the health care services back to norm.⁴⁴ At Ankara Hospital these adjustments included preoperative

testing and postoperative care after cardiac surgery, which means COVID-19 patients were isolated in a separate OR and all patients were taken to be positive, the surgical and anesthesia teams expected to perform invasive practices used level 3 protection measures, and the teams comprised of least number possible to minimize contact.¹⁶ Furthermore, due to a shortage of blood supply, some operations were postponed many times. In case of an operation, the patients were transferred to pediatric cardiovascular surgery ICU while in PPE postoperation.¹⁶ The follow up of patients was performed in separate rooms which had the doors properly closed. After evaluating hemodynamic stability and after stopping inotropic supports, the neonatal patients were transferred to neonatal ICU where their follow-up was resumed.¹⁶

In case of postoperative care, 4 of 29 patients, at Ankara Hospital Pediatric Cardiovascular Surgery patients, were COVID-19 suspects. Two of the patients had ARDS and were treated as positive even though their PCR tests were negative.¹⁶ The infant patients were extubated as urgently as possible while using PPE and following all steps for intubation.¹⁶ Once hemodynamic stability was attained, the patients were transferred to the ward after ICU stay was over.¹⁶ Before the transfer however, chest draining tubes and urinary catheters were removed and keeping in mind the possibility of transmission, all social isolation rules were abided by.¹⁶

2.9. Structural organization to accommodate patients

Furthermore, since developing COVID-19 post-surgery is associated with high mortality, patients with elective cardiac procedures must be managed by delaying their care for a few weeks to months.⁴¹ For smaller cardiac surgery units, staff management divided the cardiac surgeons and workers into groups so that quarantines can be applied to each unit separately when needed rather than the whole cardiac unit. The workers in the operative theatre (OT) are equipped with PPE, including an N95 mask. OT doors must remain closed throughout, with negative pressure rooms being best provided and health care workers must follow proper hand hygiene.⁴¹

As of now, the efforts already being made to minimize the impact of COVID-19 on cardiac surgery include the health organizations banning travel to medical conferences and meetings, limiting the meetings overall, and stopping cardiac surgery training and education for residents temporarily.⁴¹

To address these concerns, the reliability of surgical training and feasibility of health care staff must be conserved.³⁴ To help minimize the impact on surgical training, redeployment of work staff, and alteration in educational requirements would prove beneficial.³⁴

In Italy, according to Lombardy Region's guidelines, cardiac surgery hospitals are categorized into "Hub Centers" and "Spoke Centers," which are outposts for patient enrollment for cardiovascular issues. An assigned Hub Hospital must guarantee that there is a certain room to accept patients.³⁵ All patients entering the emergency room must be treated as COVID-19-positive patients and hence must follow proper protocol for COVID-19 patients. These

patients must be tested for COVID-19 and both classes of patients (COVID-19 positive and negative) must follow two different paths. Provision of a full-time on-call team consisting of a hub and spoke surgeons and on duty physicians must also be guaranteed.³⁵

While in the UK most of the Cardiac Surgery Units have reformed their staff to meet COVID-19 patients' requirements.⁴⁴ The units, mostly one major unit, are centralized, to better utilize the available resources and manage emergency cases properly while the other hospital departments are looking after COVID-19 patients.⁴⁴

Finally, after the cessation of elective cardiac surgeries, cardiothoracic surgeons with years of experience and expertise in procedures such as ECMO and cardiac imaging had been idled. Hence, they were redeployed in other intensive care units to take command of the increasing COVID-19 chaos.⁴⁵

2.10. Implementation of telemedicine for cardiac surgery

The use of E-learning, including online lectures and webinars, and simulations could also potentially reduce the impact on surgical training.³⁴

Telemedicine in the context of cardiac surgery entails cardiac specialists offering diagnoses and patient assessment by looking at patient history, live biodata and cardiac imaging, without being in the same space.⁴⁶ Cardiac surgery patients are also being triaged by analyzing echocardiograms and hand-held ultrasounds online. Likewise, congenital heart disease in children has successfully been evaluated by the use of isolated transmission of cardiac magnetic resonance imaging.⁴⁶

Wide range of research is being conducted into the use of telemedicine for cardiac surgery. One of these research groups successfully created a telemonitoring system connecting wearable sensors via Bluetooth to android mobile phones, that helped upload clinical data onto a webpage which could be used by the doctors.⁴⁷ Hence, doctors are going to be able to use this data to monitor the heart rate, blood pressure and body temperature of patients remotely as all these can be measured by the patients at home once they are taught how to accurately measure these values. The data from these devices can be transmitted to the doctors via wireless transmission.⁴⁷

Moreover, considering the impact of COVID-19 on cardiac surgical training, the JCST in the UK has announced that the Annual Review of Competency Progression, whereby trainees are assessed and reviewed every year to make sure that they are providing safe and proper care to their patients, would review trainee's progress online.³⁵

To further minimize the concerns of the impact COVID-19 have on cardiac surgical training, the majority of the institutions involved have made attempts to implement block working schedules to ensure social distancing from both biological and emotional burdens.³⁷ To make up for the lost time for surgical training, various measures have been taken such as, providing isolated guidance by trainers, online

conferences, and lectures, providing increased support for grant applications, COVID and non-COVID related research projects, and delaying examinations after completion of training.³⁷ In the United States, hospitals also try and keep Wednesday mornings for normal educational time and hold daily hour-long didactics via the Cisco WebEx platform. They also hold oral board-style questions for all nonclinical residents and for the in-house residents who are willing to join.⁴⁰

Furthermore, considering the likely effect of delayed cardiac surgical operations to save health care workers for the treatment of COVID-19 patients, most institutions have devised a way to ensure the cardiac patients are given an expert's opinion without having to appear in the emergency department.²⁸ This includes following ups where the institutions provide the patients with a contact number for them to reach out in case of any alarms, while some other institutions contact the patients every 1 to 2 weeks to check the patient's cardiovascular symptoms.²⁸

2.11. Management of resources

Furthermore, to minimize the impact, the general surgery residency program at Houston, United States responded early on, forming a thorough and revised training pattern, which would reduce the impact of COVID-19 on resident surgical training and also reduce the risk to the trainees.⁴⁰ The institutions ensured the availability of PPE and determined ways to save PPE. It was ensured that all trainees knew the proper use of extended PPE like power air-purifying respirators. Additionally, residents were kept from participating in high-risk procedures and only senior surgical residents were allowed to operate but with N95 masks and respirators.⁴⁰

2.12. Recommendations to follow guidelines to reduce aerosolization and for transfusion management

Since minimizing the risk of transmission is a priority at the moment, it is recommended that all patients as well as health care workers follow the guidelines for social distancing. Hence, reducing aerosolization is very crucial. Aerosolization of coronavirus through the gas exhaust port of the oxygenator may possibly happen and to deal with this problem, a filter may be placed on the gas exhaust port of the oxygenator or the membrane oxygenator's gas exhaust port may be searched by using gas scavenging system.⁴⁸ However, the filter can also prove damaging as the filter would increase the resistance and pressure of the gas phase of the device which would lead to the gas being shifted to the blood phase causing emboli to form.⁴⁸

While in case of transfusion management, even though it is not established that COVID-19 is transmitted through blood, the possibility is undetermined.⁴⁸ Furthermore, there is an increasing need to manage health resources optimally to reduce the burden on the blood transfusion.⁴⁷

Clotting factors like prothrombin complex concentrate or fibrinogen concentrate could be put to use instead of transfusion therapies, but the coagulation agents need to be studied in case of COVID-19 patients because of their prothrombotic nature.⁴⁷ Antifibrinolytic agents must not be used in case of COVID-19 patients either. To administer blood products using laboratory results an acceptable system includes, platelet concentrate to keep platelet count above 109/L in Disseminated Intravascular Coagulation patients or above 109/L in case of patients with high chance of bleeding. Fresh frozen plasma must be in the range of 15–25 ml/kg in patients with prolonged prothrombin time or activated partial thromboplastin time ratios.⁴⁷

3. CONCLUSION

As the influx of COVID-19 patients increased, several changes had to be made in hospital management including reallocation of resources and redeployment of health care professionals. Many problems like scarcity of PPE and the rapid exhaustion of resources such as ventilators and intensive care units contributed to the overwhelming nature of the disease. Cardiac surgery being resource-sensitive was affected to a great extent with only urgent surgeries being performed and all elective procedures were canceled or postponed. The outpatient department was severely affected as social distancing was deemed necessary for the containment of the virus. The use of technology like telemedicine was one of the major options considered to bridge the gap between physicians and patients. Cardiac surgical training was also impacted by the transmissible nature of the disease as training opportunities were greatly reduced. Additional measures need to be employed to conduct timely cardiac surgeries and minimize the risk of infection to the patients. Innovation in the cardiac fellowship training sector also needs to be made to maintain the quality of the healthcare sector.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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REFERENCES

1. Coronavirus Update (Live): 73,190,427 Cases and 1,627,900 Deaths from COVID-19 Virus Pandemic—Worldometer. 2020. <https://www.worldometers.info/coronavirus/>. Accepted December 15, 2020.
2. Basso C, Leone O, Rizzo S, et al. Pathological features of COVID-19-associated myocardial injury: a multicentre cardiovascular pathology study. *Eur Heart J*. 2020;41.39:3827-3835.
3. Giustino G, Croft LB, Stefanini GG, et al. Characterization of myocardial injury in patients with COVID-19. *J Am College Cardiol*. 2020; 76(18):2043-2055.

4. Karbalai Saleh S, Oraii A, Soleimani A, et al. The association between cardiac injury and outcomes in hospitalized patients with COVID-19. *Intern Emerg Med*. 2020;15(8):1415-1424.
5. Alwaqfi NR, Ibrahim KS. COVID-19: an update and cardiac involvement. *J Cardiothorac Surg*. 2020;15(1):239.
6. Lurz Philipp, Senni Michele, Guérin Patrice. Patient with valvular disease: evolving care patterns. *Eur Heart J Suppl*. 2020;22:P42-P46.
7. Haft JW, Atluri P, Ailawadi G, et al. Adult cardiac surgery during the COVID-19 pandemic: a tiered patient triage guidance statement. *Ann Thorac Surg*. 2020;1102:697-700. <https://doi.org/10.1016/j.athoracsur.2020.04.003>
8. Shafi AMA, Shaikh SA, Shirke MM, Iddawela S, Harky A. Cardiac manifestations in COVID-19 patients—a systematic review. *J Card Surg*. 2020;35:1988-2008.
9. Barkhordari K, Khajavi MR, Bagheri J, et al. Early respiratory outcomes following cardiac surgery in patients with COVID-19. *J Card Surg*. 2020;35:2479-2485.
10. Kochi AN, Tagliari AP, Forleo GB, Fassini GM, Tondo C. Cardiac and arrhythmic complications in patients with COVID-19. *J Cardiovasc Electrophysiol*. 2020;31:1003-1008.
11. Casey L, Khan N, Healy DG. The impact of the COVID-19 pandemic on cardiac surgery and transplant services in Ireland's National Centre. *Ir J Med Sci*. 2021;1901:13-17. <https://doi.org/10.1007/s11845-020-02292-6>
12. Lazaros G, Oikonomou E, Theofilis P, et al. The impact of COVID-19 pandemic on adult cardiac surgery procedures. *Hellenic J Cardiol*. 2020;S1109-9666(20):30161-30165. <https://doi.org/10.1016/j.hjc.2020.07.001>
13. Mohamed MO, Banerjee A, Clarke S, et al. Impact of COVID-19 on cardiac procedure activity in England and associated 30-day mortality. *European heart journal. Quality of care & clinical outcomes, qcaa079*. 2020;7:247-256. <https://doi.org/10.1093/ehjqcco/qcaa079>
14. Shehata IM, Elhassan A, Jung JW, Urits I, Viswanath O, Kaye AD. Elective cardiac surgery during the COVID-19 pandemic: proceed or postpone? *Best Pract Res Clin Anaesthesiol*. 2020;343:643-650. <https://doi.org/10.1016/j.bpa.2020.07.005>
15. McLean Duncan J, Henry Mark. Con: Venoarterial ECMO should not be considered in patients with COVID-19. *J Cardiothorac Vasc Anesth*. 2021;353:707-710. <https://doi.org/10.1053/jjvca.2020.11.029>
16. Atalay A, Soran Türkcan B, Taşoğlu İ, et al. Management of congenital cardiac surgery during COVID-19 pandemic. *Cardiol Young*. 2020;3012:1797-1805. <https://doi.org/10.1017/S1047951120002760>
17. Salenger R, Etchill EW, Ad N, et al. The surge after the surge: cardiac surgery post-COVID-19. *Ann Thorac Surg*. 2020;110(6):2020-2025. <https://doi.org/10.1016/j.athoracsur.2020.04.018>
18. Wang J, Vahid S, Eberg M, et al. Clearing the surgical backlog caused by COVID-19 in Ontario: a time series modelling study. *Can Med Assoc J*. 2020;192(44):E1347-E1356. <https://doi.org/10.1503/cmaj.201521>
19. Gaudino M, Chikwe J, Hameed I, Robinson NB, Fremes SE, Ruel M. Response of cardiac surgery units to COVID-19: an internationally-based quantitative survey. *Circulation*. 2020;1423:300-302. <https://doi.org/10.1161/CIRCULATIONAHA.120.047865>
20. Bonalumi G, di Mauro M, Garatti A, Barili F, Gerosa G, Parolari A. The COVID-19 outbreak and its impact on hospitals in Italy: the model of cardiac surgery. *Eur J Cardiothorac Surg*. 2020;57:1025-1028.
21. Harky A, Poole G, Axiaq A, Kirmani BH. COVID-19 and cardiac surgery: do outcomes differ? *J Card Surg*. 2020
22. Bakaeen FG, Gillinov AM, Roselli EE, et al. Cardiac surgery and the coronavirus disease 2019 pandemic: what we know, what we do not know, and what we need to do. *J Thorac Cardiovasc Surg*. 2020;1603:722-726. <https://doi.org/10.1016/j.jtcvs.2020.04.101>
23. Donatelli F, Miceli A, Glauber M, et al. Adult cardiovascular surgery and the coronavirus disease 2019 (COVID-19) pandemic: the Italian experience. *Interact Cardiovasc Thorac Surg*. 2020;31(6):755-762. <http://www.ncbi.nlm.nih.gov/pubmed/33099647>
24. Fudulu DP, Angelini GD. Cardiac surgery in the time of the coronavirus. *J Card Surg*. 2020;35:1177-1179.
25. Casey L, Khan N, Healy DG. The impact of the COVID-19 pandemic on cardiac surgery and transplant services in Ireland's National Centre. *Ir J Med Sci*. 2020;190:13-17.
26. Fattouch K, Corrao S, Augugliaro E, et al. Cardiac surgery outcomes in patients with coronavirus disease 2019 (COVID-19): a case-series report. *J Thorac Cardiovasc Surg*. 2020.S0022-5223(20):32872-32875.
27. Osman F, Caplin N, Bashir M. COVID-19: The true cost of cardiac surgery and disease. *J Card Surg*. 2020;36:1593-1596.
28. Ad N, Luc JGY, Nguyen TC, COVID- North American Cardiac Surgery Survey Working G. Cardiac surgery in North America and coronavirus disease 2019 (COVID-19): Regional variability in burden and impact. *J Thorac Cardiovasc Surg*. 2020;S0022-5223(20):31983-31988.
29. Salenger R, Etchill EW, Ad N, et al. The Surge After the Surge: Cardiac Surgery Post-COVID-19. *Ann Thorac Surg*. 2020;110(6):2020-2025.
30. Harky A, Harrington D, Nawaytou O, et al. COVID-19 and cardiac surgery: The perspective from United Kingdom. *J Card Surg*. 2020;36:1649-1658.
31. Di Mauro M, Barili F, Bonalumi G, Garatti A, Parolari A, Gerosa G. Chirurgia cardiaca e pandemia COVID-19: note operative della task force COVID-SICCH per la fase 2. *G Ital Cardiol*. 2020;21(8):589-593.
32. Mahajan V, Singh T, Azad C. Using Telemedicine During the COVID-19 Pandemic. *Indian Pediatr*. 2020;577:652-657.
33. Ricciardi G, Biondi R, Tamagnini G. Go back to the basics: cardiac surgery residents at the time of COVID-19. *J Card Surg*. 2020;35:1400-1402.
34. Fudulu DP, Angelini GD. The COVID-19 crisis: reflections on cardiothoracic surgery training. *J Card Surg*. 2020;35:1765-1766.
35. Shafi AM, Atieh AE, Harky A, Sheikh AM, Awad WI. Impact of COVID-19 on cardiac surgical training: our experience in the United Kingdom. *J Card Surg*. 2020;35:1954-1957.
36. Blanco-Colino R, Soares AS, Kuiper SZ, Zaffaroni G, Pata F, Pellino G. Surgical training during and after COVID-19: a joint trainee and trainers manifesto. *Ann Surg*. 2020;272:24.
37. Caruana EJ, Patel A, Kendall S, Rathinam S. Impact of coronavirus 2019 (COVID-19) on training and well-being in subspecialty surgery: a national survey of cardiothoracic trainees in the United Kingdom. *J Thorac Cardiovasc Surg*. 2020;160(4):980-987.
38. Cohan GN, Aranda-Michel E, Kilic A, et al. The impact of COVID-19 on thoracic surgery residency programs in the US: a program director survey. *J Card Surg*. 2020;35(12):3443-3448.
39. Roffi M, Capodanno D, Windecker S, Baumbach A, Dudek D. Impact of the COVID-19 pandemic on interventional cardiology practice: results of the EAPCI survey. *EuroIntervention*. 2020;16:247-250.
40. Adesoye T, Davis CH, Del Calvo H, et al. Optimization of surgical resident safety and education during the COVID-19 pandemic—lessons learned. *J Surg Educ*. 2020;78:315-320.
41. Cardiac Surgery and the COVID-19 outbreak: what does it mean? 2020. <https://www.pconline.com/News/Whats-new-on-PCRONline/2020/Cardiac-Surgery-and-the-COVID-19-outbreak-what-does-it-mean>
42. Patel V, Jimenez E, Cornwell L, et al. Cardiac surgery during the coronavirus disease 2019 pandemic: perioperative considerations and triage recommendations. *J Am Heart Assoc*. 2020;9(13):e017042.

43. COVID-19 Guidelines for Triage of Cardiac Surgery Patients. <https://www.facs.org/covid-19/clinical-guidance/elective-case/cardiac-surgery>. Accessed February 26, 2021.
44. Mohamed Abdel Shafi A, Hewage S, Harky A. The impact of COVID-19 on the provision of cardiac surgical services. *J Card Surg.* 2020; 35:1295-1297.
45. George I, Salna M, Kobsa S, et al. The rapid transformation of cardiac surgery practice in the coronavirus disease 2019 (COVID-19) pandemic: Insights and clinical strategies from a center at the epicenter. *J Thor Cardiovasc Sur.* 2020;58(4):667-675.
46. Ajibade A, Younas H, Pullan M, Harky A. Telemedicine in cardiovascular surgery during COVID-19 pandemic: a systematic review and our experience. *J Card Surg.* 2020;35(10):2773-2784.
47. Gunaydin S, Alfred H S. Perioperative management of COVID-19 patients undergoing cardiac surgery with cardiopulmonary bypass. *Perfusion.* 2020;35.6:465-473.

How to cite this article: Shah SMI, Bin Zafar MD, Yasmin F, et al. Exploring the impact of the COVID-19 pandemic on cardiac surgical services: A scoping review. *J Card Surg.* 2021; 36:3354-3363. <https://doi.org/10.1111/jocs.15746>