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Adult Cardiovascular Surgery During COVID-19 Pandemic: A Retrospective Single Center Experience

COVID-19 Pandemisi Sırasında Erişkin Kardiyovasküler Cerrahi: Retrospektif Tek Merkezli Deneyim

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ABSTRACT Objective: Coronavirus disease-2019 (COVID-19), caused by a novel coronavirus, has become a worldwide pandemic. In order to control the global spread of this contagious disease, elective surgeries including cardiac and vascular procedures were postponed. In this article we present our experience during the initial phase of the pandemic in view of safety protocols. **Material and Methods:** The study included all elective, urgent, and emergent procedures that were performed from March 11, 2020 to June 30, 2021 at the department of cardiovascular surgery. Patients' demographics, preoperative COVID-19 (reverse transcription-polymerase chain reaction) test results, surgical procedures, complications and outcomes were prospectively collected. We also developed our own protocol to proceed with our surgical activity without delay. **Results:** A total of 86 cardiac and vascular procedures were performed during the study period. The median age was 64 years (range 23-79), 59 (69%) were males. There were 42 (48%) elective procedures, and 13 (15%) patients had emergency procedures. 57 (66%) patients underwent coronary artery bypass graft surgery. 10 (12%) patients underwent valvular procedures. Peripheral vascular surgeries were performed in 18 (21%) patients. The median length of stay in the hospital was 9 days (range 1-60). A positive COVID-19 test was identified in 4 patients, two of them were detected in the immediate postoperative period and died. In-hospital mortality was 9%. **Conclusion:** Cardiovascular procedures could be performed safely with a relatively low risk during the outbreak, particularly for elective patients with proper management and strict infection control and isolation protocols.

Keywords: COVID-19; coronary artery bypass; infection control; pandemics

ÖZET Amaç: Koronavirüs hastalığı-2019 [coronavirus disease-2019 (COVID-19)], dünya çapında bir pandemi hâline geldi. Bu bulaşıcı hastalığın küresel yayılımını kontrol altına almak için alınan tedbirlerden biri; kalp ve damar cerrahi prosedürlerini de içeren elektif ameliyatların ertelenmesidir. Bu yazıda pandeminin ilk aşamasındaki deneyimlerimizi kendi kliniğimizin protokolleri ışığında sunuyoruz. **Gereç ve Yöntemler:** Çalışma, kardiyovasküler cerrahi bölümünde 11 Mart 2020-30 Haziran 2021 tarihleri arasında gerçekleştirilen tüm elektif, acil ve acil işlemleri içermektedir. Hastaların demografik bilgileri, preoperatif COVID-19 (ters transkriptaz-polimeraz zincir reaksiyonu) test sonuçları, cerrahi prosedürler, komplikasyonlar ve sonuçlar prospektif olarak toplandı. Ayrıca cerrahi faaliyetimize gecikmeden devam etmek için kendi protokolümüzü geliştirdik. **Bulgular:** Çalışma süresi boyunca toplam 86 kardiyak ve vasküler girişim gerçekleştirildi. Medyan yaş 64 yıl (23-79 arası) olup, 59'u (%69) erkekti. Kırk iki (%48) elektif ameliyat, 13 (%15) hastaya acil prosedür uygulandı. Elli yedi (%66) hastaya koroner arter baypas greft ameliyatı yapıldı. On (%12) hastaya kapak ameliyatı uygulandı. On sekiz (%21) hastaya periferik damar cerrahisi uygulandı. Hastanede medyan kalış süresi 9 gündü (1-60 arası). Dört hastada pozitif COVID-19 testi tespit edildi, 2'si ameliyattan hemen sonra tespit edildi ve hayatını kaybetti. Hastane içi mortalite %9 idi. **Sonuç:** Kardiyovasküler prosedürler, özellikle uygun yönetim ve sıkı enfeksiyon kontrolü ve izolasyon protokolleri ile elektif hastalar da salgın sırasında nispeten düşük bir riskle güvenli bir şekilde gerçekleştirilebilir.

Anahtar Kelimeler: COVID-19; koroner arter baypas; enfeksiyon kontrolü; pandemik

The novel severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), or coronavirus disease-2019 (COVID-19), has been declared a global pandemic by the World Health Organization (WHO). To date, COVID-19 has affected over 220 countries, with over 386 million confirmed cases and 5 million

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associated deaths have been reported worldwide, whereas the first case of COVID-19 was detected on March 11th, 2020 in Türkiye and over 11 million cases have been reported at the time of writing this document.[1]

Cardiac surgery had an essential and crucial category in pandemic management.[2] Due to the obvious risk of exposure from invasive, aerosol-generating procedures, the likely prolonged intensive care unit (ICU) and in-hospital stay, and the intense consumption of healthcare resources, patients requiring cardiovascular interventions are at increased risk of severe outcomes from COVID-19, such as myocardial injury, acute coronary syndrome, severe arrhythmia, pulmonary dysfunction, and thromboembolic events, on the other hand, the underlying comorbidities in those patients may increase the risk of sudden death due to myocardial infarction (MI) or other cardiovascular complications if required interventions are not performed in time.[3] As a result, cardiac surgeons have expressed an interest in developing, and applying algorithms and protocols to be followed for elective, urgent, and emergent cardiovascular procedures during the current pandemic.

Currently, evidence-based data to support or contradict any suggested approach for the care of patients requiring cardiac surgery is not available. Therefore, this study aims to share our own experience and outcomes throughout the outbreak period, by emphasizing the risks and benefits of continuing elective adult cardiac and vascular surgery procedures.

MATERIAL AND METHODS

ETHICAL APPROVAL

Board of ethics approval of this study was obtained from the Yozgat Bozok University Clinical Research Ethics Committee in accordance with the Declaration of Helsinki under approval number 2017-KAEK-189_2021.09.22_06, date: 22.09.2021.

STUDY DESIGN

This observational retrospective study analyzed all the patients who underwent cardiac and vascular interventions at our university hospital after the first official COVID-19 case was detected in Türkiye between March 11, 2020, and June 30, 2021. All elective, urgent, and emergent procedures were included in the study. The evaluated parameters were the demographic data of the patients, comorbidities, perioperative COVID-19 reverse transcription-polymerase chain reaction (RT-PCR) test results, surgery indications, complications, length of stay in the hospital, and postoperative mortality.

OUR PROTOCOLS DURING THE ADAPTATION PROCESS TO THE PANDEMIC

During the initial period, we proceeded with our routine surgical practice without modifications, we established various precautions before, during and after the interventions, patients who were referred to our center or came through the outpatient department were hospitalized in a COVID-19 free area at the ward or the ICU according to the patient's preoperative condition as per responsible physician's advice. All the patients who required any surgical intervention were tested for COVID-19 by nasopharyngeal swab using (RT-PCR) and chest computed tomography, the patients were examined with en-forced social distancing and mandatory mask-wearing, and patients who tested negative for COVID-19 were prepared for surgery after completing the preoperative investigations while patients required emergency surgery; were taken for surgery without waiting for the test results.

In September 2020, we decided to modify our approach after the spread of the infection among the healthcare workers inside the hospital and especially upon the death of two of our patients after the surgery, those patients tested positive for COVID-19 despite being tested negative on admission. We developed a COVID-19 screening protocol for all the patients admitted to our unit for any surgical intervention as described in Figure 1, we classified the patients' priority according to our national and international guidelines, and the patients were selected based on requiring elective, urgent interventions or emergency as reported by the guidelines and as per the responsible physician's advice (Table 1).[4,5]

Patients who were identified as electives were discharged with optimum medical therapy and added

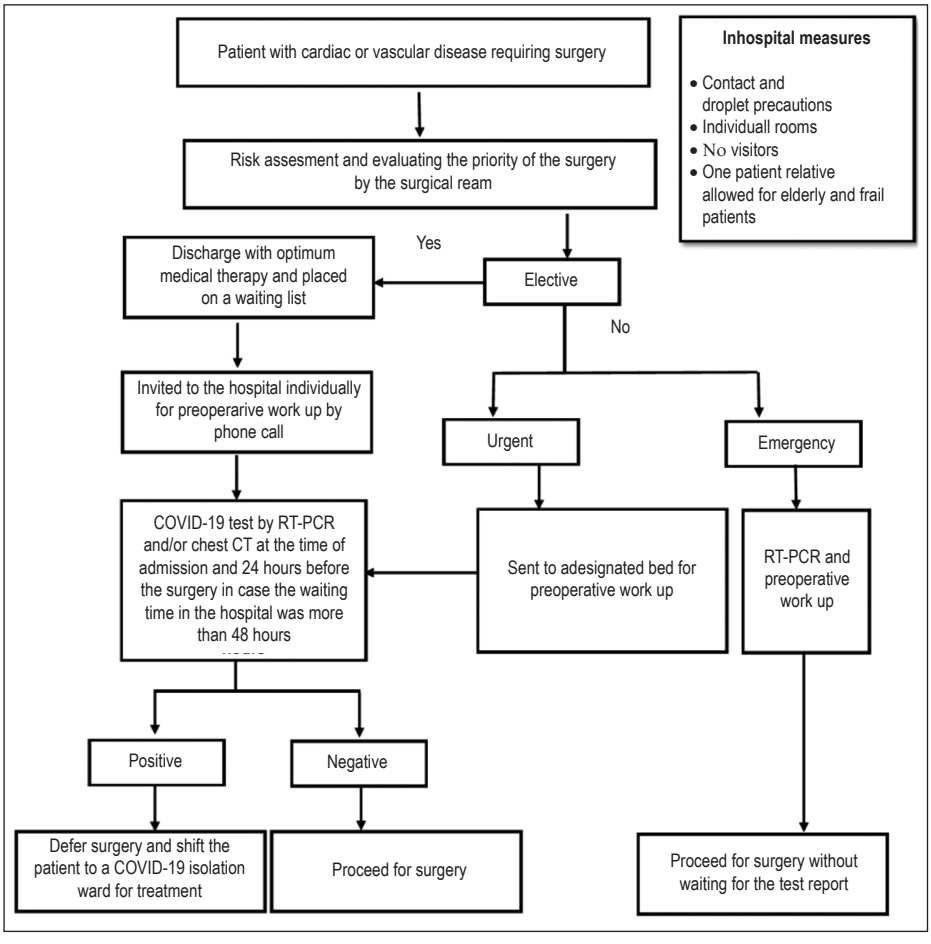

FIGURE 1: Flowchart for levels of priority and screening patients referred for surgery.
RT-PCR: Reverse transcription-polymerase chain reaction; CT: Computed tomography.

to a waiting list for scheduled surgeries and were asked to isolate themselves socially and comply with the confinement rules, then we invited them to the hospital by phone call 24-48 hours before the planned procedure for preoperative investigations, at the time of admission nasopharyngeal swab for COVID-19 test was obtained, in addition; all the patients were evaluated by a pulmonologist and infectious diseases specialist. Patients who reported negative were taken up for surgery while patients who reported positive were shifted to a COVID-19 isolation area and treatment was initiated. Patients who needed urgent intervention were sent to a designated bed in a COVID-19 free area for preoperative evaluation, RT-PCR test was done and according to the report we proceeded to the next steps as previously explained in the elective cases. In case the preoperative waiting time for patients lasts more than 48 hours, a second RT-PCR test was done 24 hours before the surgery. To prevent the nosocomial transmission of the infection among the patients and the healthcare workers we operated on just one patient every week. For emergency cases, the patients were sent to a designated bed at the ICU, a nasopharyngeal swab was obtained and after the initial workup, the patient was taken for the surgery without waiting for the test result using full personal protective equipment (PPE) and other necessary precautions.

ANESTHESIA PROTOCOL

All the patients underwent bedside evaluation by the anesthesiologists, and all required precautions were followed to avoid the aerosol-based spreading of the virus, for example, the use of face masks (N95), and

TABLE 1: Definition of LoP for cardiovascular procedures in the COVID-19 pandemic.a

Elective surgery	LoP I (Routine admission for surgery that can be delayed) • Asymptomatic or stable angina • Chronic hemodynamically stable valvular heart disease • Unruptured and hemodynamically stable aneurysms • Patients with chronic limb ischemia • Vascular Access for hemodialysis
Urgent surgery	LoP II (Surgery required on the current admission) • Severe left main or three vessel CAD involving proximal LAD • Acute aortic and mitral regurgitation • Severe aortic stenosis • Obstructive prosthetic valve thrombosis • Active endocarditis • Aortic aneurysm based on size and familial association • Cardiac tumors at risk of obstruction or embolization • Acute contained, hemodynamically stable, ruptured aneurysm • Acute limb ischemia with preserved neurological functions • Amputations for non salvageable limbs • Symptomatic acute mesenteric ischemia • Severe internal carotid artery stenosis • Pericardial tamponade in hemodynamically stable patients
Emergency	LoP III (Operation required before next working days) • Acute coronary syndrome not suitable for percutaneous intervention • Ongoing ischemia with hemodynamic instability and ventricular arrhythmia • Mechanical complications of myocardial infraction • Aneurysm rupture with hemodynamic instability • Acute limb ischemia with neurological deficit • Acute Type A and complicated Type B aortic dissection • Pericardial tamponade with hemodynamic instability
Salvage procedures	LoP IV (Requires cardiopulmonary resuscitation on the way to operation theater or before induction of anesthesia)

[a]Adapted in part from Mavioğlu HL, Ünal EU, Aşkin G, Küçüker ŞA, Özatik MA. Perioperative planning for cardiovascular operations in the COVID-19 pandemic. Turkish J Thorac Cardiovasc Surg. 2020;28(2):236-43; LoP: Level of priority; CAD: Coronary artery disease; LAD: Left anterior descending.

face shields, donning the complete PPE, use of video-assisted laryngoscopy with rapid induction and without mask ventilation, clamping the endotracheal tube before intubation. Only one physician and one technician were allowed in the operating room and they were not permitted to change or leave until the patient was transported to the ICU.

SURGICAL PROTOCOL

In all patients except for atrial septal defects (ASD), a standard median sternotomy incision was made. For patients who underwent coronary artery bypass graft (CABG), we preferred off-pump surgery to prevent the immunosuppressive effect of the cardiopulmonary bypass (CPB) and extracorporeal circulation (ECC), however, in patients with poor ejection fraction (EF) and severe left coronary artery lesions or if the patient's hemodynamics deteriorated, we proceed with the on-pump procedure. Myocardial protection was provided with combined antegrade and retrograde blood cardioplegia. Valvular and other cardiac surgeries were performed using ECC. ASD procedures were performed via right anterior thoracotomy with femoral artery cannulation. The operating surgeons and scrub nurses wore only a sterile surgical gown with N95 mask with a surgical mask over it.

POST-SURGICAL PROCEDURES

After the operation, patients were treated in a COVID-19 free ICU, once transferred to the ward, they were placed in the rooms individually, contact and droplet measures were performed, and physical contact with the patients was minimized by reducing the number of healthcare workers. Using hand sanitizer was mandatory before and after each visit, visitors were not allowed, however, only one patient relative was allowed to stay in the room after being screened and tested for COVID-19 and was not allowed to leave the room as possible.

STATISTICAL ANALYSIS

A descriptive analysis was performed, and the data obtained were presented as numbers and percentages for categorical variables, continuous variables were presented as median and range, mean and standard deviation according to their distribution. The data were analyzed using IBM SPSS statistics (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) predictive analytics software.

RESULTS

A total of 86 patients were admitted to our clinic during the study period, with a median age of 64 years old (range 23-79), 69% were males. 42 (48%) patients underwent elective procedures, urgent interventions were conducted in 31 (36%) patients, and 13 (15%) patients required emergency treatment. The

most common comorbidity was smoking 44%, followed by diabetes 36%, hypertension 21%, dyslipidemia 10%, and 5% had a pulmonary disease like chronic obstructive pulmonary disease and asthma. Three of the patients had previous cardiac surgery (3.5%). The calculated median EF was 55%. The main indications for urgent surgeries were left main coronary artery (LMCA) lesion in 7 (8%) patients, LMCA equivalent lesion in 11 (13%) patients, severe left anterior descending (LAD) stenosis in 23 (27%) patients, LAD stent thrombosis in 11 (13%) patients, and severe aortic valve stenosis in 2 (2.3%) patients. We performed emergent surgeries on 2 patients with ruptured abdominal aortic aneurysm (AAA) by open repair, three patients underwent thromoboembolectomy due to acute ischemic peripheral arterial disease, and five patients were admitted with vascular injuries (Table 2).

Among patients who required isolated CABG (n=57), we performed off-pump surgery in 25 (44%) patients. Isolate and combined Mitral valve replacement (MVR) was performed in 5 patients. Aortic valve replacement (AVR) was performed in 3 patients. One patient had tricuspid valve replacement (TVR). One patient underwent CABG with post-MI ventricular septal defect (VSD) closure. Two patients underwent primum-type ASD closure. Three patients underwent carotid artery endarterectomy. One patient had pericardial window creation due to chronic cardiac tamponade after AVR which was performed before the pandemic. The calculated median for the cross-clamp time was 85 minutes (45-180), median CPB time was 130 minutes (55-357). Peripheral vascular procedures were performed in 18 (21%) patients (Table 3).

TABLE 2: Perioperative characteristics of the patients.

	(n=86)
Age, (years), median (range)	64 (23-79)
Sex	n (%)
Male	59 (69)
Female	27 (31)
Comorbidities	n (%)
Diabetes mellitus	31 (36)
Hyperlipidemia	9 (10)
Hypertension	18 (21)
Smoking	38 (44)
Obesity	14 (16)
Chronic renal disease	1 (1.2)
Previous cardiac surgery	3 (3.5)
COPD	2 (2.3)
Asthma	2 (2.3)
Malignancy	1 (1.2)
Positive COVID-19 (RT-PCR) test	4 (5)
Left ventricular EF (%) median (range)	55 (29-62)
Level of priority	n (%)
Elective	42 (48)
Urgent	31 (36)
Emergency	13 (15)
ASA classification	n (%)
ASA 1	1 (1.2)
ASA 2	12 (14)
ASA 3	65 (76)
ASA 4	5 (6)
ASA 5	3 (3.5)
Indication for surgery	n (%)
LMCA	7 (8)
LMCA equivalent	11 (13)
Severe LAD stenosis	23 (27)
LAD stent thrombosis	11 (13)
Severe aortic valve stenosis	2 (2.3)
Other valvular disease	10 (12)
Euroscore II (%), median (range)	1.2 (0.55-6.15)

COPD: Chronic obstructive pulmonary disease; RT-PCR: Reverse transcription-polymerase chain reaction; EF: Ejection fraction; ASA: American Society of Anesthesiologists; LMCA: Left main coronary artery; LAD: Left anterior descending.

EARLY OUTCOME

Major complications included one postoperative stroke without sequela (1.2%), 11 patients required reopening for bleeding (13%), three patients (3.5%) required postoperative hemodialysis (one after the ruptured AAA, one underwent CABG and the other was the patient who underwent TVR), two (2.4%) had wound infections. One patient had mediastinitis and required sternal fixation and long-term in-hospital antibiotherapy (Table 3).

During follow-up at the ICU, 37 patients required inotropic support (43.5%), and 14 patients required Intra aortic balloon pump support (16.5%). The median time of mechanical ventilation was 10 hours (6-120). Median red blood cell transfusion was 3 units ranged from 0 to 40 units, and median transfusion of fresh frozen plasma was 5 units ranged from 0 to 40 units.

Hospital mortality was 9% (n=8), two patients died due to postoperative COVID-19 infection, two patients underwent urgent CABG, one patient under-

TABLE 3: Postoperative characteristics of the patients and surgical details.

	(n=86)
Operation	n (%)
Isolated CABG	57 (66)
On-pump	57/32 (62.7)
Off-pump	57/25 (44)
Valvular surgery	10 (12)
MVR	1 (1.2)
MVR+tricuspid ring annuloplasty	1 (1.2)
AVR	1 (1.2)[a]
TVR	1 (1.2)
Other	2 (2.3)
Combined procedures (CABG+other procedures)	5 (6)
CABG+MV repair+tricuspid annuloplasty	1 (1.2)
CABG+MVR+tricuspid annuloplasty	1 (1.2)
CABG+AVR	1 (1.2)
CABG+AVR+MVR	1 (1.2)
CABG+post MI VSD	1 (1.2)
ASD closure	2 (2.3)
Carotid endarterctomy	3 (3.5)
Peripheral vascular surgery	18 (21)
Ruptured abdominal aortic aneurysm	2 (2.4)
DVT (farmacomechanic thrombectomy)	1 (1.2)
Subclavian pseudoaneurysm	1 (1.2)
Endovascular arterial procedures	2 (2.3)
Thrombosed AVF resection, new AVF creation	2 (2.3)
Infected permanent dialysis catheter removal, new AVF creation	2 (2.3)
Arterial thromboembolectomy	3 (3.5)
Peripheral vascular injuries	5 (6)
Pericaridal window creation	1 (1.2)
Complications	n (%)
Stroke	1 (1.2)
Re-opening for bleeding	11 (13)
Renal failure requiering dialysis	3 (3.5)
Wound infection	2 (2.3)
Mediastenit	1 (1.2)
Pulmonary embolism	1 (1.2)
Respirtory failure	1 (1.2)
Ionotrope support, n (%)	37 (43)
Intraaortic balloon pump support, n (%)	14 (16)
Mechanical ventilation time (hour), median (range)	10 (6-120)
Cross clamp time (minute), median (range)	85 (45-180)
CPB time (minute), median (range)	130 (55-357)
PRBC transfusion (unit), median (range)	3 (0-40)
FFP transfusion (unit), median (range)	5 (0-40)
Length of hospital stay, (day), median (range)	9 (1-60)
Hospital mortality, n (%)	8 (9)

[a]Aortic valve prosthesis paravalvular leak repair, MVR and tricuspid ring annuloplasty and aortic valvuloplasty; CABG: Coronary artery bypass grafting; MVR: Mitral valve replacement; AVR: Aortic valve replacement; TVR: Tricuspid valve replacement; MI: Myocardial infarction; VSD: Ventricular septal defect; ASD: Atrial septal defect; DVT: Deep venous thrombosis; AVF: Arteriovenous fistula; CPB: Cardiopulmonary bypass; PRBC: Packed red blood cell; FFP: Fresh frozen plasma.

went open repair of ruptured AAA, one patient underwent TVR, and the remaining 2 patients died intraoperatively, one underwent a combined procedure of MVR with CABG and the other one was the patient with post-MI VSD. The median length of hospital stay was 9 days (range 1-60). All the patients discharged home were well and alive at 30 days follow-up.

COVID-19 INFECTIONS

Four patients tested positive for COVID-19, two of them underwent CABG in the incubation period and tested positive postoperatively despite being tested negative at admission, one of them started developing symptoms of fever and pulmonary infiltration on X-ray (Figure 2, Figure 3) and died on the 4th postoperative day due to severe respiratory failure, the other patient who was operated the next day, similarly had symptoms of respiratory failure and required reintubation, the course of the disease was difficult, he required reopening due to cardiac tamponade two times and he died on the 20th postoperative day (Figure 4). One patient who needed an elective CABG procedure tested positive on RT-PCR and was sent to the isolation unit for treatment, after one week he was discharged and then was operated on after two subsequent negative nasopharyngeal swabs, the postoperative course of this patient was uneventful. The other patient who tested positive was admitted due to wound infection and also transferred to the COVID-19 isolation unit and subsequently discharged after 5 days of treatment.

Despite preventive measures, three physicians and four nurses from our department who came in contact with the previously mentioned patients tested positive for COVID-19. One physician required hospital admission while the others were treated at home and after ten days of isolation they were all reported negative and allowed to continue their duties.

DISCUSSION

The third, SARS-CoV-2, is a new coronavirus isolated from airway epithelial cells for the first time in the Wuhan region of China in the last month of 2019, and it continues to spread. On March 11, 2020, WHO declared COVID-19, a highly contagious disease, as

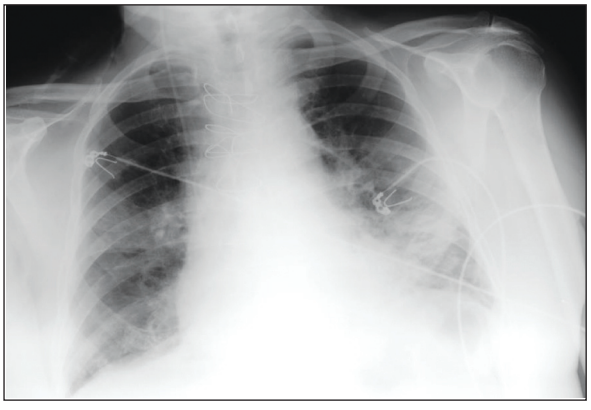

FIGURE 2: Chest radiogram shows reticular and patchy opacities.

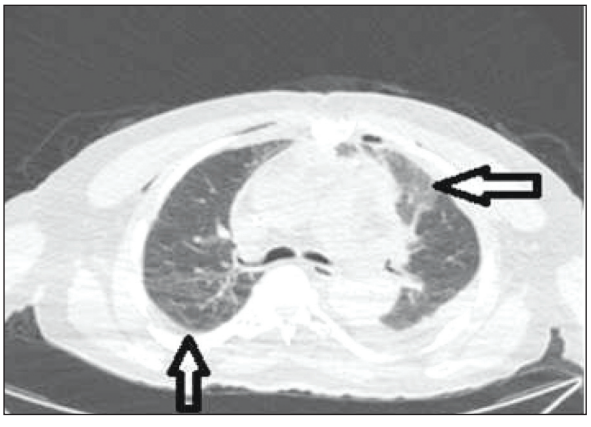

FIGURE 3: The postoperative thoracic computed tomography of the same patient in Figure 2 shows bilateral ground-glass opacities and bronchiectasis areas observed in the lower right lobe. The black arrows indicate the location of the abnormalities.

a pandemic.[1] On the same date, the Turkish government passed a nationwide emergency legislation law to contain the spread of this infectious disease and to provide adequate services to COVID-19 patients, since then, the pandemic has continued to deplete health care and economic resources. The outbreak has had a particularly negative impact on cardiac surgery, as hospital critical care and intensive care resources were limited, which prompted elective intervention to be postponed, and even patients requiring urgent or emergent procedures confront difficulties due to a rising shortage of resources.

Since the majority of patients admitted for surgical intervention in the cardiovascular department are at greater risk of infection and death from COVID-19 due to several comorbidities in those patients, and because it is unclear when the COVID-19 pandemic will end, delaying cardiovascular interventions can increase the risk of complications due to MI in those with coronary artery disease or deterioration of functional capacity in those with valve pathologies and also in patients with chronic ischemic peripheral vascular disease.[6] Several observational studies showed that patients with left ventricular dysfunction and severe angina have higher mortality, and nonfatal MI while waiting for CABG or percutaneous coronary intervention.[7] Another prospective cohort study of mortality rates in patients waiting for cardiac surgery demonstrated that patients waiting for valve

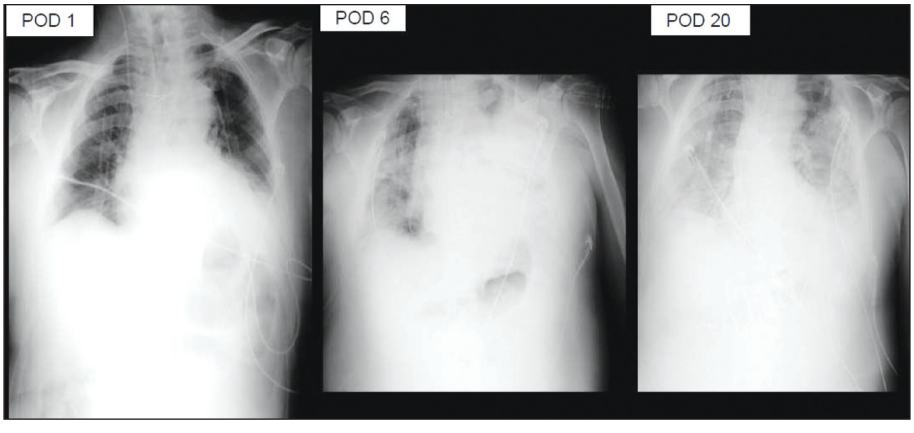

FIGURE 4: Progression of COVID-19 and acute respiratory distress syndrome development in one of the patients after coronary artery bypass grafting, the image of POD 6 shows the development of cardiac tamponade.
POD: Postoperative day.

surgery are at a greater risk of death than patients who require CABG.[8] Moreover, sudden death is known as the second leading cause of mortality in individuals with severe aortic stenosis.[9] For these reasons, we decided to proceed with elective cardiac and vascular interventions in our department.

In the present study, a total of 86 patients underwent several cardiac and vascular interventions during the confinement period at our department. We identified a considerable decrease in surgical procedures during this period, which is consistent with what has been observed elsewhere.[10] This reduction of surgery, primarily the cessation of elective surgery, will have a negative effect on both patients' and health care systems' ability to handle the accumulation of patients, especially if other COVID-19 surges occur. As a result, while we have to live with COVID-19, it is critical for patients to be aware of risks and also for cardiac surgery units to adapt, not only to confront the challenges of the pandemic but also to allow cardiac surgery to continue as safely as possible.

Although there was a decrease in patients undergoing CABG, there was an increase in cases of vascular trauma and thromboembolic events. Regardless, we have continued surgical treatment of patients requiring vascular surgical interventions and provide patent vascular access for patients with end-stage renal disease. We also continued with our routine endovascular intervention for patients admitted with chronic arterial occlusions or deep venous thrombosis.

We also developed our own protocol to decide when to proceed or postpone which depends on prioritizing patients according to the acuity of the required surgical procedures. Patients requiring emergency surgery were operated on without waiting for RT-PCR test report while taking all precautions. Patients requiring urgent interventions were sent to a COVID-19 free area to wait for the test report, patients who tested positive were sent to a COVID-19 isolation ward for treatment. Otherwise, they were scheduled for surgery if reported negative. We also developed a priority list for elective patients, taking into account the patient's comorbidity and type of surgery. Both urgent or elective patients were tested twice, once at admission and once 24 hours before the surgery in case the preoperative hospital stay lasts more than 48 hours. Besides, patient visits were canceled and only one patient relative was allowed to stay after being tested and reported negative and was not allowed to leave the room. Similar approaches to prioritize patients undergoing cardiac surgery and their preoperative screening for COVID-19 have also been recommended, Keskin et al., developed a different screening system to decide when to postpone or proceed with elective cardiac or vascular interventions based on a checklist containing relevant symptoms and signs of the disease, history of traveling or patient contact to determine the risk of COVID-19 transmission.[11-13]

Our study showed that elective cardiovascular surgery procedures could be performed with acceptable mortality rates. Although our mortality rate was 9% during the study period, this result must be interpreted with caution because none of those patients had an elective procedure, in addition, their euroscores were relatively high, two patients who underwent urgent CABG had poor left ventricular function and died with low cardiac output syndrome, the patient who underwent open repair of ruptured AAA died due to acute renal failure, the patient with TVR died also due to renal failure and severe thrombocytopenia which leads to cerebral and massive gastrointestinal system hemorrhage, the remaining two patients died intraoperatively, one had fragile aorta which ruptured after the cross-clamp was removed, the other one was the patient with post-MI VSD, the last two patients who also underwent urgent CABG procedure, died due to postoperative COVID-19 infection. Lower mortality rates were reported in previous studies, however, similar to our results all the reported cases were either urgent or emergent procedures.[13,14]

During the study period, 4 patients developed COVID-19, one required elective CABG and was sent to the isolation ward, after the treatment he was operated on with an uneventful postoperative course, the other patient required intravenous antibiotherapy due to wound infection after being discharged. As previously mentioned, at the initial phase of the pandemic only two patients who underwent urgent CABG procedures tested positive for COVID-19 in

the early postoperative period, one of them died on the 4th postoperative day, and the other one was operated on the next day died after 3 weeks of treatment. Both of them were asymptomatic and tested negative at admission, yet the preoperative waiting time was more than one week which suggests the possibility of contracting a nosocomial infection, there is also a possibility of false-negative results due to incorrect or insufficient sampling. Besides, three physicians and four nurses who got in contact with those patients tested positive. Those patients were a victim of our initial inadequate knowledge of handling this disease. This prompted us to alter our approach to manage the patients throughout this period as demonstrated in Figure 1. Particularly for elective and urgent cases, we operated on just one patient every week to prevent nosocomial transmission among patients and healthcare workers, however, this approach was continued until February 2021 when the vaccination campaign began.

In light of this issue, cardiac patients are at increased risk of contracting COVID-19 during the perioperative period. Although the numbers in our series lack statistical significance, they are consistent with the findings of Lei et al., who reported increased mortality and morbidity if patients were operated on during the incubation period.[2] However, modifying infection control measures and adjustment of conventional approaches is required during the pandemic which has been proven to reduce the nosocomial spread of COVID-19. On a special note, most of our patients were referred to our center from another hospital, and after we modified our management as described in Figure 1, none of them developed COVID-19 during the hospital stay and no transmissions were identified among patients and healthcare workers. These observations are considerably more encouraging regarding the safety of our protocol.

Patients requiring cardiac surgery are likely to have pre-existing comorbidities. Furthermore, the necessity for invasive mechanical ventilation and the use of CPB which are risk factors for lung disease, make them more vulnerable to severe complications of COVID-19.[12,15] Besides, aerosolization or contamination of the virus through the CPB machine or chest tubes may be a potential problem putting health workers at risk during on-pump cardiac surgery, although most membrane oxygenators manufactured today are surface coated, there is no evidence in the literature that viruses cannot penetrate these hollow fiber materials.[16] Therefore, if possible, we prefer to perform off-pump CABG to avoid viral spread and also to prevent the inevitable harmful effect of CPB in patients at risk of exposure to COVID-19, particularly if they were silent carriers. Some other reports recommended the use of cell saver, cytokine filtre, and minimal invasive ECC to reduce the inflammatory response.[17]

Recent literature has suggested that the tendency to thrombosis increased in COVID-19 patients due to increased inflammation, thrombocyte activation, endothelial dysfunction, and stasis due to immobilization.[18] In our series, we noticed an increase in patients who required urgent CABG due to stent thrombosis during the study period, even though, this situation might not be related to COVID-19 since the history of infection in these patients was unknown.

CONCLUSION

Our purpose with this article was to share our experience as cardiovascular surgeons during the COVID-19 outbreak. We highlighted that cardiovascular surgery can safely be performed with reasonable complications and mortality rates, particularly in elective patients. Thorough management of patients in need of surgery before, during, and after the procedures are critical, as is a careful review of patients' history, testing patients at admission, and measures taken by healthcare providers.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise,

working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Sameh Alagha;* ***Design:*** *Sameh Alagha, Zafer Cengiz Er;* ***Control/Supervision:*** *Ferit Çiçekçioğlu;* ***Data Collection and/or Processing:*** *Hasan Ekim, Veysel Başar;* ***Analysis and/or Interpretation:*** *Meral Ekim, Sameh Alagha;* ***Literature Review:*** *Veysel Başar, Zafer Cengiz Er;* ***Writing the Article:*** *Sameh Alagha, Hasan Ekim;* ***Critical Review:*** *Ferit Çiçekçioğlu.*

REFERENCES

1. Genel Koronavirüs Tablosu [Internet]. [cited 2023 Jan 24]. Available from: [Link]
2. Lei S, Jiang F, Su W, Chen C, Chen J, Mei W, et al. Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. EClinicalMedicine. 2020;21:100331. [Crossref] [PubMed] [PMC]
3. Zheng YY, Ma YT, Zhang JY, Xie X. COVID-19 and the cardiovascular system. Nat Rev Cardiol. 2020;17(5):259-60. [Crossref] [PubMed] [PMC]
4. Mavioğlu HL, Ünal EU, Aşkin G, Küçüker ŞA, Özatik MA. Perioperative planning for cardiovascular operations in the COVID-19 pandemic. Turkish J Thorac Cardiovasc Surg. 2020;28(2):236-43. [Crossref] [PubMed] [PMC]
5. American College of Surgeons. COVID 19: Emergency General Surgery [Internet]. Vol. March 24, American College of Surgeons. 2020 [cited 2022 Jan 23]. p. 2020. Available from: [Link]
6. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497-506. Erratum in: Lancet. 2020. [Crossref] [PubMed] [PMC]
7. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. Br J Surg. 2020;107(11):1440-9. [PubMed] [PMC]
8. Morgan CD, Sykora K, Naylor CD. Analysis of deaths while waiting for cardiac surgery among 29,293 consecutive patients in Ontario, Canada. The Steering Committee of the Cardiac Care Network of Ontario. Heart. 1998;79(4):345-9. [Crossref] [PubMed] [PMC]
9. Minamino-Muta E, Kato T, Morimoto T, Taniguchi T, Shiomi H, Nakatsuma K, et al. Causes of death in patients with severe aortic stenosis: an observational study. Sci Rep. 2017;7(1):14723. [Crossref] [PubMed] [PMC]
10. 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;142(3):300-2. [Crossref] [PubMed] [PMC]
11. Salmerón Jiménez M, Hermoso Alarza F, Martínez Serna I, Marrón Fernández C, Meneses Pardo JC, García Salcedo JA, et al. Clinical features and outcomes of thoracic surgery patients during the COVID-19 pandemic. Eur J Cardiothorac Surg. 2020;58(4):738-44. [Crossref] [PubMed] [PMC]
12. Patel V, Jimenez E, Cornwell L, Tran T, Paniagua D, Denktas AE, et al. Cardiac surgery during the coronavirus disease 2019 pandemic: perioperative considerations and triage recommendations. J Am Heart Assoc. 2020;9(13):e017042. [Crossref] [PubMed] [PMC]
13. Keskin G, Khalil E, Uysal A. Should we postpone elective cardiovascular procedures and percutaneous coronary interventions during the COVID-19 pandemic? Heart Surg Forum. 2021;24(1):E022-E030. [Crossref] [PubMed]
14. Nader J, Anselmi A, Tomasi J, Martin A, Aymami M, Rouze S, et al. Adult cardiac surgery during COVID-19 lockdown: impact on activity and outcomes in a high-volume centre. Arch Cardiovasc Dis. 2021;114(5):364-70. [Crossref] [PubMed] [PMC]
15. Cheng VCC, Wong SC, Chen JHK, Yip CCY, Chuang VWM, Tsang OTY, et al. Escalating infection control response to the rapidly evolving epidemiology of the coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. Infect Control Hosp Epidemiol. 2020;41(5):493-8. [Crossref] [PubMed] [PMC]
16. Günaydın S. Perioperative planning in the COVID-19 pandemic: cardiovascular perfusion and device-related issues. Turk Gogus Kalp Damar Cerrahisi Derg. 2020;28(2):247-9. [Crossref] [PubMed] [PMC]
17. Bauer A, Hausmann H, Schaarschmidt J, Scharpenberg M, Troitzsch D, Johansen P, et al. Shed-blood-separation and cell-saver: an integral Part of MiECC? Shed-blood-separation and its influence on the perioperative inflammatory response during coronary revascularization with minimal invasive extracorporeal circulation systems-a randomized controlled trial. Perfusion. 2018;33(2):136-47. [Crossref] [PubMed]
18. Khan IH, Savarimuthu S, Leung MST, Harky A. The need to manage the risk of thromboembolism in COVID-19 patients. J Vasc Surg. 2020;72(3):799-804. [Crossref] [PubMed] [PMC]