

Cardiovascular surgery during the first wave of COVID-19 pandemic

COVID-19 pandemisinin birinci dalgasında kardiyovasküler cerrahi

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ABSTRACT

Background: In this study, we aimed to evaluate primary outcomes and main characteristics of emergency and elective/urgent cardiovascular surgeries which were performed in the first three months of the novel coronavirus disease 2019 (COVID-19) pandemic in our center.

Methods: Between March 11th, 2020 and June 11th, 2020, a total of 209 patients (44 males, 165 females; mean age: 57.3±12.8 years; range, 20 to 80 years) who underwent emergency or elective/urgent surgery with cardiovascular pathologies were retrospectively analyzed. The patients were classified as emergency and elective/urgent according to the level of necessity of the surgical procedure at the time of hospital admission. Pre-, intra-, and postoperative data of the patients were recorded.

Results: During the study period, 156 elective/urgent and 74 emergency cardiovascular surgeries were performed. Six COVID-19 (+) patients were operated emergently. The number of acute aortic dissection and peripheral vascular surgery was higher in the emergency group (p<0.05). Two patients who were COVID-19 (-) preoperatively became COVID-19 (+) in the postoperative period. In these patients, acute respiratory distress syndrome developed, and extracorporeal membrane oxygenation support was needed. Four patients who needed post-cardiotomy extracorporeal membrane oxygenation support due to low cardiac output were COVID-19 (-) both in the pre- and postoperative periods. The overall in-hospital mortality rate was 9.1%.

Conclusion: Even during pandemic such as COVID-19, referral centers with experienced personnel can provide non-pandemic healthcare with a quality close to the daily routine.

Keywords: Cardiovascular diseases, COVID-19, outcome assessment.

ÖZ

Amaç: Bu çalışmada yeni koronavirüs hastalığı 2019 (COVID-19) pandemisinin ilk üç ayında merkezimizde yapılan acil ve elektif/yarı acil kardiyovasküler ameliyatların birincil sonuçları ve ana özellikleri değerlendirildi.

Çalışma planı: 11 Mart 2020 - 11 Haziran 2020 tarihleri arasında kardiyovasküler patolojiler nedeniyle acil ve elektif/yarı acil cerrahi yapılan toplam 209 hasta (44 erkek, 165 kadın; ort. yaş: 57.3±12.8 yıl; dağılım, 20-80 yıl) retrospektif olarak incelendi. Hastalar hastaneye başvurdıkları sırada cerrahi işlemin gereklilik düzeyine göre acil ve elektif/yarı acil olarak sınıflandırıldı. Hastaların ameliyat öncesi, ameliyat sırası ve ameliyat sonrası verileri kaydedildi.

Bulgular: Çalışma süresince 156 elektif/yarı acil ve 74 acil kardiyovasküler cerrahi yapıldı. Altı COVID-19 (+) hasta acil olarak ameliyat edildi. Akut aort diseksiyonu ve periferik vasküler cerrahi sayısı acil grubunda daha yüksekti (p<0.05). Ameliyat öncesi COVID-19 (-) olan iki hasta ameliyat sonrası dönemde COVID-19 (+) oldu. Bu hastalarda akut solunum distress sendromu gelişti ve ekstrakorporeal membran oksijenizasyon desteği gerekli oldu. Ameliyat öncesi ve sonrası COVID-19 (-) olan dört hastaya düşük debi nedeniyle post-kardiyotomi ekstrakorporeal membran oksijenizasyon desteği uygulandı. Genel hastane mortalitesi %9.1 idi.

Sonuç: COVID-19 gibi pandemilerde dahi, deneyimli personeli bulunan referans merkezlerde günlük rutine yakın kalitede pandemi dışı sağlık hizmeti verilebilmektedir.

Anahtar sözcükler: Kardiyovasküler hastalıklar, COVID-19, sonuç değerlendirme.

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Doi: 10.5606/tgkdc.dergisi.2023.23909

Received: May 30, 2022

Accepted: March 06, 2023

Published online: July 27, 2023

Cite this article as: Baş T, Çevirme D, Zengin A, Baltacı H, Aksoy R, Kırallı K. Cardiovascular surgery during the first wave of COVID-19 pandemic. Turk Gogus Kalp Dama 2023;31(3):309-316. doi: 10.5606/tgkdc.dergisi.2023.23909.

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Novel coronavirus disease 2019 (COVID-19) is a pandemic viral infectious disease caused by a novel beta-coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).^[1] The COVID-19 pandemic caused serious morbidity and mortality worldwide. Despite its devastating effect on the healthcare systems of the countries, urgent and elective surgical procedures continued in all branches; however, in major surgical areas such as abdominal, cardiothoracic, and vascular surgery, outcomes are known to be poor.^[2,3]

In the light of the recommendations of the World Health Organization (WHO) and within the scope of emergency measures, the Republic of Türkiye, Ministry of Health announced that elective surgical procedures were cancelled. This interruption lasted for two months (April and May 2020) and, in June, elective surgical procedures started in a controlled manner and in line with the directives of the Republic of Türkiye, Ministry of Health.^[4] Due to its nature, it was difficult to predict the consequences of postponing cardiovascular surgeries. As one of the high-volume hospitals on cardiovascular surgery in Türkiye, our center continued to serve either elective or emergency cardiovascular surgeries with general precautions for COVID-19 during the first wave of the pandemic.

In the present study, we aimed to evaluate primary outcomes and main characteristics of emergency and

elective/urgent cardiovascular surgeries which were performed in the first three months of the COVID-19 pandemic in our center.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Kartal Koşuyolu High Specialized Training and Research Hospital, Department of Cardiovascular Surgery between March 11th, 2020 and June 11th, 2020. A total of 230 operations that were performed as emergency or elective/urgent surgery with cardiovascular pathologies during the first wave of the pandemic were evaluated. Our center is one of the largest and most experienced high-volume heart centers in the country and was able to perform more than 15 open heart surgeries for a weekday before the COVID-19 pandemic. During the study period, a total of 209 patients (44 males, 165 females; mean age: 57.3±12.8 years; range, 20 to 80 years) who met the inclusion criteria were enrolled. Data including demographics, preoperative, operative, and postoperative data of the patients were retrieved from the hospital information management system and hospital database.

Evaluation of patients

The patients were classified as emergency, and elective/urgent according to the level of necessity

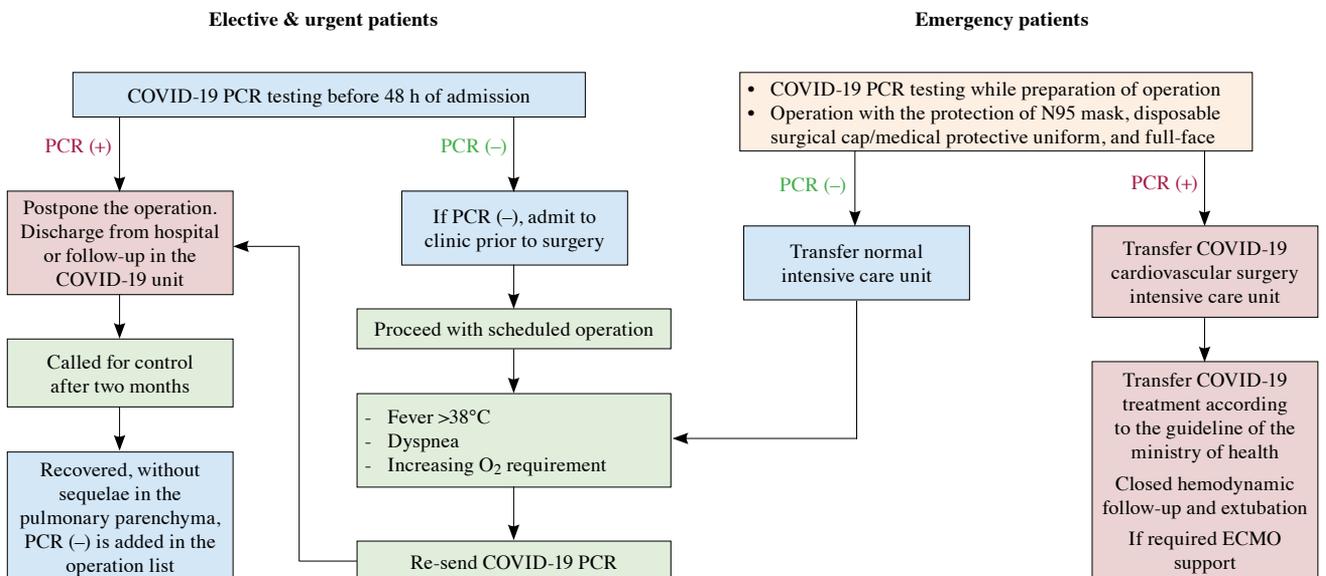


Figure 1. Screening and testing algorithm for COVID-19 for elective/urgent and emergency admissions.

Hydroxychloroquine sulfate and favipiravir were used in COVID-19 treatment according to the guideline of the Republic of Türkiye, Ministry of Health. Anticoagulation was performed with low-molecular-weight heparin. For ECMO support, bivalirudin is the first choice of anticoagulant strategy.

COVID-19: Coronavirus disease 2019; PCR: Polymerase chain reaction.

of the surgical procedure at the time of hospital admission. A detailed algorithm for COVID-19 testing is presented in Figure 1.

Elective patients: Symptomatic patients who were scheduled for cardiovascular surgery were listed as elective. The medical secretariat of the hospital reviewed the list on a regular basis and the patients were called by phone on a regular basis.

Urgent patients: These patients admitted to the hospital with active cardiovascular symptoms such as chest pain, dyspnea, and abdominal pain due to an aneurysm. After a short preparation period for surgery, with the absence of a COVID-19 infection as confirmed by diagnostic tools, the patients were operated without discharge.

Emergency patients: This group of patients had acute aortic syndromes, acute peripheral ischemia, serious chest pain or myocardial infarction, and acute valvular pathologies. The patients were operated immediately without any confirmation of the absence of COVID-19 infection due to the increased risk of mortality and morbidity. Emergency operations were performed with the protection of an N95 mask, disposable surgical cap/medical protective uniform, and full-face guard.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 27.0 software (IBM Corp., Armonk,

NY, USA). Descriptive data were expressed in mean \pm standard deviation (SD), median (min-max) or number and frequency, where applicable. The distribution of variables was checked using the Kolmogorov-Smirnov test. Independent sample t-test and Mann-Whitney U test were used to analyze quantitative independent data. The chi-square test was used to analyze qualitative independent data. The Fisher exact test was carried out, when the chi-square test conditions were not met. A *p* value of <0.05 was considered statistically significant.

RESULTS

During the study period, 156 elective/urgent and 74 emergency cardiovascular surgeries were performed in 209 patients. Of the patients, 10% had chronic obstructive pulmonary disease (COPD), 34% had hypertension (HT), 34% had diabetes mellitus (DM), 50.7% had coronary artery disease (CAD), 16.3% had peripheral arterial disease (PAD), and 11.5% had stroke. The mean preoperative white blood cell (WBC) count was $10.5 \pm 4.6 \times 10^3/\text{mm}^3$ and C-reactive protein (CRP) value was $22.2 \pm 41.9 \text{ mg/L}$. Preoperative characteristics of the patients and blood cell counts are presented in Table 1.

We performed heart transplantation in two patients and left ventricular assist device (LVAD) implantation in five patients. There were six COVID-19 (+) patients who underwent emergency operations: *n*=1 coronary

Table 1. Preoperative data of patients

	n	%	Mean \pm SD	Median	Min-Max
Age (year)			57.3 \pm 12.8	58.0	20.0-80.0
Sex					
Male	44	21.1			
Female	165	78.9			
Chronic obstructive pulmonary disease	21	10			
Hypertension	71	34			
Diabetes mellitus	71	34			
Peripheral arterial disease	34	16.3			
Coronary arterial disease	106	50.7			
Stroke	24	11.5			
White blood cell*			10.5 \pm 4.6	9.6	1.2-39.5
Platelet*			263.8 \pm 90.1	261.0	3.2-599
Neutrophile*			6.7 \pm 4.5	5.7	1.0-36.0
Lymphocyte*			2.0 \pm 1.3	1.8	0.1-10.1
C-reactive protein			22.2 \pm 41.9	5.2	0.3-256.0

SD: Standard deviation; * White blood cell, platelet, neutrophil, and lymphocyte counts were given in $1000 \times \text{cells}/\text{mm}^3$.

artery bypass grafting (CABG), n=2 endovascular aneurysm repair (EVAR) due to abdominal aorta rupture, n=2 femoral artery embolectomy, and n=1 brachial artery embolectomy. These patients with preoperative COVID-19 (+) were discharged with full recovery. All operations are listed in Table 2. Two patients (1%) who were COVID-19 (-) negative preoperatively became COVID-19 (+) at the first postoperative week and developed acute respiratory distress syndrome (ARDS) in these patients. Redo mitral valve replacement in a beating heart on the pump was performed to the first patient. The patient had dyspnea, cough, and fever in the service follow-up. She was readmitted to the intensive care unit (ICU) and received extracorporeal membrane oxygenation

(ECMO) support and died from cardiopulmonary failure. The second patient was the patient who had CABG. Similarly, this patient had dyspnea, cough, and fever in the ward follow-up and was readmitted to the ICU. The patient who could be weaned from the ECMO support died due to sepsis secondary to concomitant infection. The ECMO support was required in additional six (2.9%) patients. Other four patients were COVID-19 (-) pre- and postoperatively and administered post-cardiotomy ECMO support. All of these patients were discharged. Fifteen of 209 patients (7.2%) were readmitted to the hospital after discharge, and all of them were readmitted to the ICU. The overall mean length of first and re-admission hospital stay was 14±21.5 days with an in-hospital mortality of 9.1% (Table 3).

Table 2. Types of surgical procedures

Operations	n	%
CABG	90	43.1
Valvular operations	28	13.4
AVR	12	
MVR	6	
AVR+MVR	6	
MVR+tricuspid ring	4	
Combined operations	18	8.6
AVR+CABG	2	
MVR+CABG	3	
AVR+MVR+CABG	1	
AVR+MVR+PEA	1	
AVR+AAGI	2	
AVR+MVR+AAGI	1	
AAGI+CABG	4	
CAE+CABG	2	
Tricuspid ring+VSD closure	1	
Danielson operation+tricuspid ring+ASD closure	1	
Acute aortic dissection	15	7.2
AAGI	7	
AAGI+total arcus replacement	1	
David V operation	1	
TEVAR	1	
EVAR	2	
Abdominal AGI	2	
Aortobifemoral bypass	1	
LVAD	5	2.4
Heart transplantation	2	1
Peripheral vascular surgery	31	14.8
Others	41	19.6

AVR: Aortic valve replacement; MVR: Mitral valve replacement; CABG: Coronary artery bypass grafting; PAE: Pulmonary artery endarterectomy; AAGI: Ascending aorta graft implantation; CAE: Carotid artery endarterectomy; TEVAR: Thoracic endovascular aortic repair; EVAR: Endovascular aneurysm repair; LVAD: Left ventricular assist device.

The age of the patients in the emergency group was significantly lower than in the elective/urgent group (p<0.05). There were no statistically significant differences in sex between the emergency and elective/urgent groups (p>0.05). However, peripheral vascular surgery was significantly higher in the emergency group than in the elective/urgent group (p<0.05). Contrarily, CABG surgery was significantly higher in the elective/urgent group than in the emergency group (p<0.05). There were no statistically significant differences between the emergency and elective/urgent groups in terms of the rate of valvular operations, combined operations, LVAD implantation, or other types of surgery (p>0.05) (Table 4).

There were no statistically significant differences in the preoperative COPD, HT, cerebrovascular disease (CVD), platelet, lymphocyte, and CRP values between the emergency and elective/urgent groups

Table 3. Postoperative data of patients

	n	%
Cough	7	3.3
Dyspnea	29	13.9
High fever	10	4.8
Stroke	10	4.8
Hospital COVID transmission	2	0.9
ECMO	6	2.9
ARDS	2	1
Readmission to ICU	15	7.2
Mortality	19	9.1

COVID: Coronavirus disease; ECMO: Extracorporeal membrane oxygenation; ARDS: Adult respiratory distress syndrome; ICU: Intensive care unit.

($p>0.05$). The mean preoperative CAD rate, and WBC and neutrophil counts were significantly higher in the emergency group than in the elective/urgent group ($p<0.05$). The rate of DM and PAD in the elective/urgent group was significantly higher than in the emergency group ($p<0.05$) (Table 4).

The mean operation time in the emergency group was significantly shorter than in the elective/urgent group ($p<0.05$). There were no statistically significant differences between the emergency and elective/urgent groups in terms of the postoperative WBC and lymphocyte count, CRP values, and ARDS, dyspnea, CVD, fever, and cough rates ($p>0.05$). However, the postoperative neutrophil count and ECMO rates were significantly higher in the emergency group than in the elective/urgent group ($p<0.05$). The postoperative platelet count in the emergency group

was significantly lower than in the elective/urgent group ($p<0.05$) (Table 5).

There was no statistically significant difference in the rate of re-admission after ICU stay between the emergency and elective/urgent groups ($p>0.05$). The mortality rate in the emergency group was, however, significantly higher than in the elective/urgent group ($p<0.05$). On the other hand, the duration of hospitalization in the emergency group was significantly lower than in the elective/urgent group ($p<0.05$). The rate of re-admission after discharge in the emergency and elective/urgent groups did not differ significantly ($p>0.05$) (Table 5).

According to the European System for Cardiac Operative Risk Evaluation (EuroSCORE) system in patients who underwent open heart surgery, the scores

Table 4. Comparison of preoperative demographics and operations

	Emergency				Elective-Urgent				<i>p</i>
	n	%	Mean±SD	Median	n	%	Mean±SD	Median	
Age (year)			54.3±14.5	54.0			58.7±11.7	60.0	0.022
Sex									0.062
Female	19	28.8			25	17.5			
Male	47	71.2			118	82.5			
Operations									
CABG	11	16.7			79	55.2			0.000
Valvular operations	6	9.1			22	15.4			0.214
Combined operations	6	9.1			12	8.4			0.867
Acute aortic dissection	15	22.7			0	0			0.000
LVAD	1	1.5			4	2.8			1.000
Heart transplantation	2	3			0	0			0.099
Peripheral vascular surgery	20	30.3			11	7.7			0.000
Others	13	19.7			28	19.6			0.984
Preoperative									
COPD	6	9.1			15	10.5			0.755
Hypertension	25	37.9			46	32.2			0.418
Diabetes mellitus	14	21.2			57	39.9			0.008
Peripheral arterial disease	18	27.3			16	11.2			0.003
Coronary arterial disease	19	28.8			87	60.8			0.000
Stroke	5	7.6			19	13.3			0.229
White blood cell*			12.7±6.7	11.3			9.6±2.9	9.1	0.001
Platelet*			261.0±109.0	250.0			265.0±80.6	262.0	0.370
Neutrophile*			9.1±6.8	7.6			5.6±2.2	5.4	0.000
Lymphocyte*			2.1±1.6	1.7			2.0±1.1	1.8	0.219
C-reactive protein			35.7±55.9	6.9			16.8±33.4	5.0	0.184
Preoperative PCR									
+	6	8.1			0	0			
-	68	91.89			156	100			

SD: Standard deviation; CABG: Coronary artery bypass grafting; LVAD: Left ventricular assist device; COPD: Chronic obstructive pulmonary disease; PCR: Polymerase chain reaction; * White blood cell, platelet, neutrophil, and lymphocyte counts are given in $1000 \times \text{cells}/\text{mm}^3$.

Table 5. Comparison of postoperative data

	Emergency				Elective-Urgent				p
	n	%	Mean±SD	Median	n	%	Mean±SD	Median	
Operation time (min)			165.8±119.8	115.0			217.2±108.5	230.0	0.008
Postoperative									
White blood cell*			11.6±4.9	10.9			10.5±3.2	10.5	0.192
Platelet*			212.4±108.7	194.0			260.1±105.0	250.5	0.005
Neutrophile*			8.1±4.9	7.3			6.4±2.8	5.7	0.004
Lymphocyte*			1.7±0.9	1.5			1.8±0.9	1.6	0.638
C-reactive protein			71.6±87.1	35.7			66.8±57.5	43.0	0.347
ARDS	1	1.5			1	0.7			0.533
ECMO	5	7.6			1	0.7			0.013
Dyspnea	11	16.7			18	12.6			0.428
Stroke	3	4.5			7	4.9			0.912
High fever	2	3.0			8	5.6			0.420
Cough	3	4.5			4	2.8			0.514
Postoperative PCR (+)	6	8.95			2	1.2			0.230
Readmission to ICU	5	7.6			10	7			0.879
Hospitalization (day)			13.8±33.6				14.2±12.5		0.000
Readmission to hospital	6	9.1			9	6.3			0.466
Mortality	12	18.2			7	4.9			0.002

SD: Standard deviation; ARDS: Adult respiratory distress syndrome; ECMO: Extracorporeal membrane oxygenation; PCR: Polymerase chain reaction; ICU: Intensive care unit; * White blood cell, platelet, neutrophil, and lymphocyte counts are given in 1000 × cells/mm³.

of non-survivors and survivors were 6.6 (n=16) and 5.2 (n=114), respectively, indicating no statistically significant difference (p=0.73). However, non-survivors had significantly higher rates of COPD, HT, DM, PAD, and stroke than the survivors (p<0.05).

DISCUSSION

The COVID-19 pandemic is a global health issue preventing the delivery of healthcare appropriately. Although all the branches of the healthcare service were interrupted, postponement of elective surgeries was among the main problems. In this study, we present the results of elective/urgent and emergency cardiac operations performed in a cardiac referral center in Türkiye within the first three months of the pandemic. According to our results, even during the pandemic such as COVID-19, referral centers with experienced staff can provide non-pandemic healthcare with a quality close to the daily routine.

Since the commencement of the COVID-19 pandemic in Türkiye, the provision of non-pandemic

healthcare services has been limited in most countries to prevent the spread in line with the directives of the Republic of Türkiye, Ministry of Health.^[4,5] New health centers established for pandemic management have been put into service, and job descriptions and service management in healthcare centers have been organized. For this aim, our institution has been assigned the task of the COVID-19 ECMO center.^[6] Besides the precautions taken against the pandemic, cardiovascular diseases continued and the postponement of these patients were expected to cause life-threatening problems. Therefore, controlled cardiovascular surgery continued in our institution.

As the influence of COVID-19 increases all over the world, there is a 40% decrease in the number of patients admitted to hospitals with acute coronary syndrome.^[7] Due to the decrease in hospital admissions, fewer coronary surgeries were performed than usual, and the majority of elective surgeries were elective coronary surgeries in our institution. Emergency

operations mostly included acute aortic dissections and peripheral vascular surgeries. In our study, distribution of elective and emergency surgery was correlated with life-threatening conditions (aortic dissection classified as emergency surgery).

One of the major problems in the COVID-19 pandemic was in-hospital transmission of the virus. In the study conducted by Evans *et al.*,^[8] in-hospital transmission of COVID-19 was reported as 0.3% per day. During the three-month period in our study, two patients were exposed to postoperative in-hospital contamination. In these patients, contaminations were observed during the ward follow-up, but not in the ICU. The entity of such transmissions reveals the importance of precautions which should be taken by the hospital staff, patients, and companions in terms of COVID-19 control.

In particular, within the first three months of the COVID-19 pandemic, a change in the 30-day mortality rates was observed due to both the delayed admission of the patients to the hospital and the increase in the rate of emergency surgeries. In their study, Mullan *et al.*^[9] reported the mortality rate including all cardiac operations as 2.3% in 2,786,572 surgeries in the United States. The mortality was reported as 9.1% within the first three months of the pandemic in our study. We attributed this increase in the rate of mortality to late admissions to the hospital and a relatively high rate of emergency surgery (31%). Finally, Gupta *et al.*^[10] and Menekşe *et al.*^[11] reported poor outcomes of COVID-19 (+) patients who underwent cardiovascular surgery. Taken together, COVID-19 pandemic negatively affected cardiovascular surgery due to late hospital admission and pre- and perioperative contamination of the virus.

Nonetheless, this study has some limitations. First, the sample size is relatively small which may have underestimated the mortality rate. Second, classifying the patients at the beginning of the pandemic, the time when the information about the virus was unclear, may have precluded to obtain reliable conclusions regarding the postoperative follow-up compared to daily routine.

In conclusion, the COVID-19 pandemic appeared as a global problem that put the healthcare system under a heavy responsibility and disrupted many steps of the healthcare. Treatment of cardiovascular diseases, which is one of the main causes of death in the world, was postponed in many centers. Despite these postponements, elective operations continued in a controlled manner in the referral heart

institutions in Türkiye, as in our institution, with the regulation of the mission definitions of the hospitals by the Ministries of Health. Based on our study findings, we conclude that, even during pandemic such as COVID-19, referral centers with experienced personnel can provide non-pandemic healthcare with a quality close to the daily routine by establishing the specification of the mission.

Ethics Committee Approval: The study protocol was approved by the Kartal Kosuyolu High Specialization Training and Research Hospital Non-Interventional Clinical Research Ethics Committee (date: 24.04.2020, no: 2020.3/10-305). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept: T.B., D.C.; Design: T.B., D.C., A.Z.; Control/supervision: K.K.; Data collection and/or processing: H.B.; Analysis and/or interpretation: H.B., R.A.; Literature review: R.A., A.Z.; Writing the article: A.Z., D.C.; Critical review: K.K., D.C.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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