

The comparison between characteristics and outcomes of elective adult cardiac surgeries during the COVID-19 pandemic and the previous year: a cross-sectional study of an early experience in a COVID-19 epicenter



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Abstract

Background: COVID-19 led to an outbreak making surgeons doubt continuing elective surgeries during the pandemic. There is little evidence about the outcomes of elective cardiac surgeries during the pandemic. Questions exist regarding a higher prevalence of perioperative complications and mortality rates. This study aims to evaluate the outcomes of elective cardiac surgeries during the pandemic in comparison to the previous year. **Method:** This cross-sectional study discusses elective cardiac surgeries performed during the COVID-19 peak from March 2020 to March 2021 at the Shahid Modarres Hospital and compares the outcomes (mortality, infection, and stroke) with the previous year. We included all candidates over 20 years old after evaluating them for COVID-19 with polymerase chain reaction and chest computed tomography scan. We collected the data from our institutional database and performed data analysis. **Results:** We performed 184 adult open-heart surgeries during the COVID-19 peak. The male-to-female ratio was 50.5% to 49.5% with a mean age of 61. 9 patients died in total during the peak compared to 17 patients out of 341 surgeries in the previous year. 2 patients were involved with sternal wound infection and 3 with stroke. We recognized no significant difference in mortality, sternal wound infection, and stroke between the two periods. **Conclusion:** Although we should consider the probable complications of the infection during the pandemic, cardiac surgery can be performed safely in COVID-19 centers. Effective protocols are required to create an environment free of infection to alleviate the burden of perioperative complications during this period.

Keywords: COVID-19; cardiac surgical procedures; mortality; postoperative complications; elective cardiac surgery; elective heart surgery

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INTRODUCTION

Coronavirus disease-2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), spread worldwide rapidly turning into the most concerning health crisis globally since the pandemic of influenza in 1918. (1) Surgical procedures during the COVID-19 pandemic have been an issue for debate. Although elective surgeries that required surveillance in the intensive care unit (ICU) were postponed immediately, emergent and urgent surgeries could not undergo such cancellation. As well as limiting staff in the operating room to save personnel required to be in direct contact with COVID-19 patients in wards, operating rooms could be considered as spaces to deliver services such as ventilators and compressed oxygen to COVID-19 patients.

Furthermore, the staff started getting involved with the disease, causing a shortage of doctors and nurses, especially in the operating room. Among surgical fields affected by the pandemic, cardiac surgery was considered one of the most affected specialties, especially due to its long postoperative follow-ups in ICUs; (2) probably because ICUs admitting post-cardiac surgery patients were significantly affected during the pandemic with a reduction in beds by around 35.4%. Overall, the redistribution of beds, the hospital structure, and the number of staff altered during this period leading to health consequences. (3)

Although some postoperative burdens such as atrial fibrillation, pneumonia, and operative mortality were significantly increased during the pandemic era, others i.e., deep sternal wound infection,

surgical site infection, permanent stroke, deep vein thrombus, and major morbidity did not significantly differ before and after the pandemic. (4) However, reports vary among different studies.

Myriad of protocols developed during this period for the patients who were candidates for elective surgery to reduce viral transmission, perioperative complications, and mortality rates. Besides, specific guidelines helped recognize the critical cases for the surgery. (5, 6) Surgeries had to be performed during emergent situations without considering the polymerase chain reaction (PCR) and chest computed tomography (CT), but elective surgeries remained an essential challenge with limited data regarding adult cardiac surgery. (7)

Our study aimed to comprehensively gather data surrounding elective cardiac surgery candidates at our center, their characteristics, and outcomes during the COVID-19 peak period; compared it with the previous year; and discussed the issue in light of the available literature.

MATERIAL AND METHODS

STUDY DESIGN

This is a retrospective observational study that aimed to compare characteristics and outcomes of elective cardiac surgery cases during the COVID-19 peak with the previous year to evaluate the impact of the COVID-19 pandemic on cardiac surgery. The Declaration of Helsinki was adequately addressed, and the study was approved by the institutional ethics committee (IR. SBMU.RE-TECH.REC.1401.459). This research did not contain any studies involving animal or human participants, and it has not been done in any private or protected areas. No specific permissions were required for corresponding locations.

SETTING

We conducted the study in 2022 and retrospectively reviewed our institutional database for patients undergoing elective cardiac surgeries from March 2020 to March 2021, encompassing the peak of the COVID-19 pandemic, and compared their variables with the corresponding period a year prior (from March 2019 to March 2020).

PARTICIPANTS

We included all patients over 20 years old undergoing different types of elective cardiac surgeries at the Shahid Modarres Hospital, an educational hospital of the Shahid Beheshti University of Medical Sciences in Tehran, Iran. All patients underwent routine perioperative laboratory testing such as complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and precautions for COVID-19 i.e., PCR test, chest CT scan, and infectious disease consultation by a specialist. In case the patient was in favor of infection, we deferred the surgery. We excluded all patients with emergent cardiac surgery and without PCR or chest CT scans.

VARIABLES

We collected data including patient demographics, the total number of elective cardiac surgeries, and their outcomes (postoperative complications i.e., mortality, sternal wound infection, and stroke),

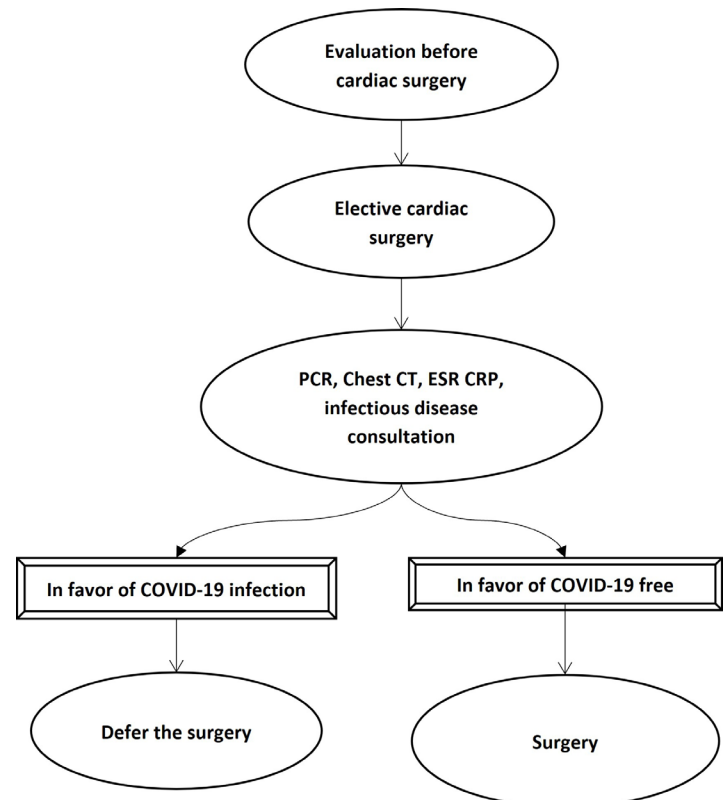


Figure 1. Preoperative evaluation

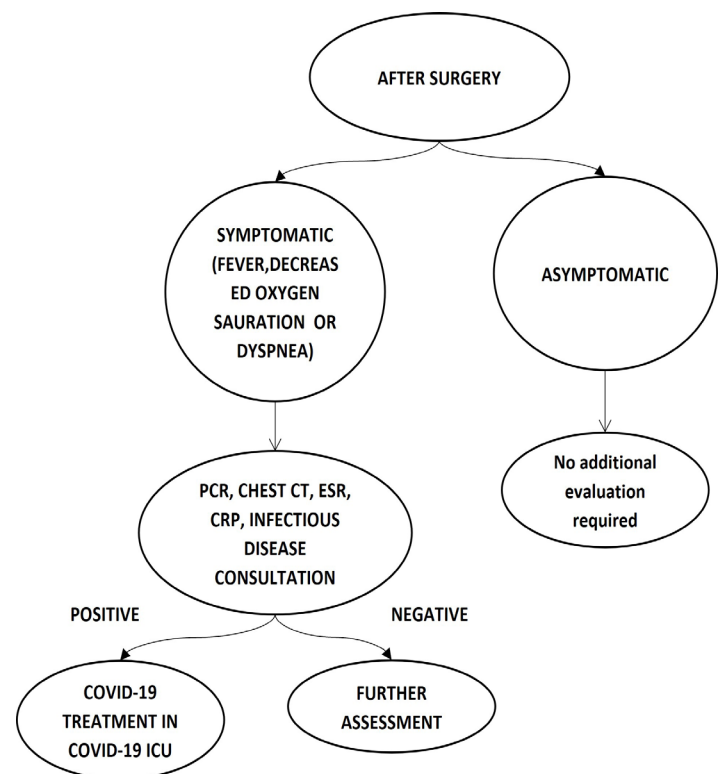


Figure 2. Postoperative evaluation

PCR: polymerase chain reaction, CT: computed tomography, ESR: erythrocyte sedimentation rate, CRP: C-reactive protein

and compared them with the same period a year before. In addition, the number of PCR positives, chest CT scan involvements, and the total and COVID-19-associated mortalities after surgery were counted as well. The authors had access to data identifying participants during and after collecting the data.

PERIOPERATIVE MEASURES

During anesthesia, the staff protected COVID-19 transmission. We inserted arterial and central venous lines in all patients. The method of anesthesia during the pandemic was not different from before and we intubated patients after hyperventilation. We used cardiopulmonary bypass for surgery in all patients and the method of surgery was on-pump which was the same as before. The patients were admitted to the cardiac surgery department if all the test results were negative, but they had to transfer to the COVID-19 ward if any of the tests were positive before or after the surgery.

POSTOPERATIVE MEASURES

After the operation, we did not further evaluate asymptomatic patients. We requested a chest CT scan and PCR in cases with decreased blood oxygen saturation or fever. Patients who had a progressive fever or oxygen saturation below 90% after the surgery with positive PCR or chest CT scan for COVID-19, were immediately transferred to the COVID-19 intensive care unit (ICU) and specific medication based on COVID-19 treatment protocols were administered. However, we considered patients with the same symptoms but negative results, who were probably in their incubation period, for further evaluation.

BIAS

We attempted to minimize biased data as much as possible by considering all adult patients in a precise period as mentioned above. Secondly, all patients were assessed with precautionary tests for COVID-19 before undergoing surgery. Moreover, this was a single-centered study occurring at the Department of cardiac surgery in Shahid Modarres Hospital meaning that the staff, equipment, and surgical setting were almost the same during these periods.

STATISTICAL ANALYSIS

Results were reviewed: numerical variables were expressed as counts and percentages, and continuous variables as mean and standard deviation. We performed data analysis with T-test using IBM SPSS statistics 20.

RESULTS

PARTICIPANTS

From March 2020 to March 2021, during the COVID-19 pandemic, 184 adult cardiac surgeries were performed at our center compared to 341 surgeries during the same period a year before, representing a significant drop of 46% in cardiac surgeries. (Table 1.) Of these, 137 were coronary artery bypass graft (CABG) cases, 13 were CABG+ mitral valve replacement (MVR), 14 were aortic valve replacement (AVR), 10 were CABG+AVR, 8 were Bentall surgeries and 2 were atrial septal defect (ASD) closure. (Table 2.)

DESCRIPTIVE DATA

The mean age of patients from 2020 to 2021 was 61.93 and the male-to-female ratio was 50.5% to 49.5%. There were no sig-

Table 1. Demographic characteristics of the patients undergoing cardiac surgery in two periods of time and their outcomes

	2020-2021 period	2019-2020 period
Number of surgeries	184	341
Mean age, years	61.93	62.02
Gender M/F, (%)	50.5 /49.5	51.3 /48.7
Mortality, No (%)	9 (4.9)	17 (5)
Sternal wound infection, No (%)	2 (1.1)	4 (1.2)
Stroke, No (%)	3 (1.6)	7 (2.1)

Table 2. Types of elective cardiac surgeries during the peak (2020-2021) at our center

	CABG, n = 137	Bentall surgery, n = 8	ASD closure, n = 2	CABG+MVR, n = 13	AVR, n = 14	CABG+AVR, n = 10	Total, n = 184
Age, years	60.1	56.3	40.5	64.5	68.4	59.6	??
Gender M/F	68/69	5/3	0/2	7/6	6/8	7/3	93/91
Positive PCR after surgery	6	0	0	1	0	0	7
Chest CT involvement after surgery	8	0	0	2	0	0	10
Mortality due to COVID-19	3	0	0	1	0	0	4
Total mortality	7	0	0	1	0	1	9

CABG: coronary artery bypass graft, ASD: atrial septal defect, MVR: mitral valve replacement, AVR: aortic valve replacement, PCR: polymerase chain reaction, CT: computed tomography, M: male, F: female

nificant differences between the mean age and the gender of the patients from 2020 to 2021 and 2019 to 2020. ($P=.72$ and $p=.86$ respectively) (Table 1).

MAIN RESULTS

Ten patients were in the incubation period of COVID-19 infection during the surgery and were diagnosed by PCR or chest CT scan after the cardiac surgery due to the worsening of the symptoms. Unfortunately, 4 patients were intubated and expired due to COVID-19. (Table 2.) Patients' death patterns were not the same. In 2 patients, the symptoms started gradually 3 days after the cardiac surgery and patients developed symptoms after diagnosis and treatment. In 2 other patients, COVID-19 symptoms had a fulminant onset after 3 days and the patients expired within 24 hours after reintubation.

OUTCOME DATA

Out of 184 surgeries during 2020-2021, 9 led to death, 2 to sternal wound infection, and 3 to stroke; whereas in the same period a year

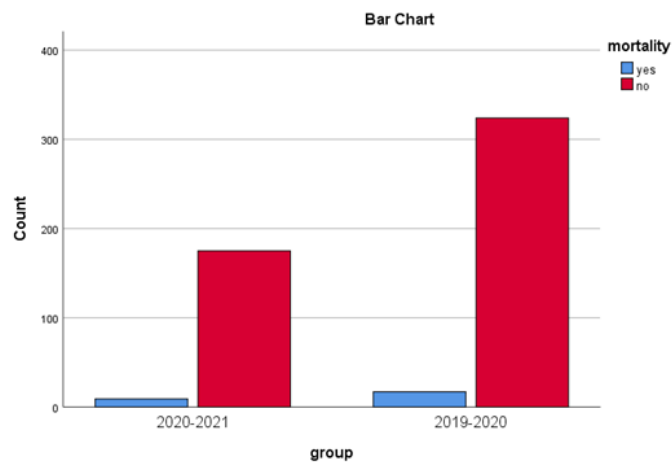


Figure 3. Comparison between the total mortality in the peak and the previous year

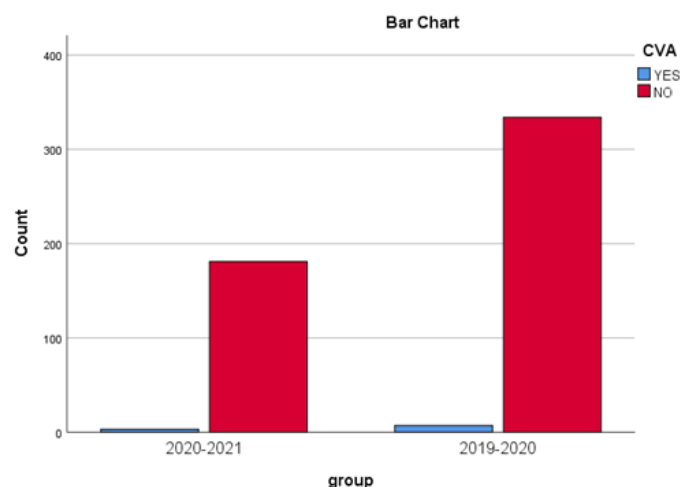


Figure 4. Comparison between the rate of postoperative stroke before and after the COVID-19 pandemic

before out of 341 surgeries, 17 led to death, 4 led to sternal wound infection, and 7 led to stroke.

The mortality rate was not significantly different compared to the patients undergoing open cardiac surgery before the COVID-19 pandemic. ($P=0.962$) (Fig 3.)

New changes have been applied to the brain CT scan and sensory-motor disorders for diagnostic criteria of stroke. The prevalence of stroke during the COVID-19 period was not significantly different from the same time in the previous year. ($P=0.73$) (Fig 4.)

DISCUSSION

Evidence about the decision to perform cardiac surgery during the COVID-19 pandemic is scarce. (7) According to the Latin American Association of Cardiovascular and Endovascular Surgery (LACES), the best timing for surgery depends on the symptoms of COVID-19, the vaccination, and whether or not the surgery could be postponed. (8) American College of Surgeons as well, has given recommendations for emergent and non-emergent cases in general surgery, trauma, and some other surgical groups such as thoracic

surgery. (9) Furthermore, referring to the protocol of the Iranian Society of Cardiac Surgeons, in the absence of obvious symptoms of COVID-19 disease, elective cardiac surgery can be performed with one negative PCR and one negative chest CT. (10) The Society of Thoracic Surgeons (STS) and the Canadian Society of Cardiac Surgeons also suggested an algorithm for cardiac surgery procedures in an individualized way and give guidance towards optimal timing and triage. (11)

Although the ideal test for screening before cardiac surgery has yet to be determined, preoperative evaluation of patients is an important issue. (12) Usual screening protocols such as the use of PCR swabs can be ineffective due to various reasons such as improper sampling technique, low viral load, or mutations in the viral genome. (13) However, it appeared to be quite an accessible and reliable diagnostic tool at our center alongside CT scans. Similarly, another center in Stockholm managed to safely operate on COVID-19 patients without resulting in outbreaks of COVID-19 among patients and staff by performing PCR tests with nasopharynx swabs preoperatively on each patient undergoing cardiac surgery from March 2020 to December 2021. (14) Antibody screening has also been recommended especially in the presence of a COVID-19 history. (15) In addition, screening by non-contrast CT of the chest for ground glass opacities -as a marker for COVID-19 infection- has been used in some centers, but the validity and feasibility of this test as a screening tool is yet to be validated. (16) Postoperative screenings are as important as well, mainly because patients undergoing cardiothoracic surgeries can exhibit symptoms of normal inflammatory response postoperatively mimicking those in the acute phase of COVID-19. (17)

We conducted this study to compare elective cardiac surgeries in the pandemic period with the previous year. Our results showed a reduction of 46% in cardiac surgery cases during the pandemic. Likewise, based on a multicenter national survey in Italy, there was a reduction of 53.5% in cardiac surgery cases during the lockdown, and most specifically a significant decrease in elective surgeries was noted enforcing 22 centers to completely stop their elective surgeries. (3) In Germany, the rates differed among variants of procedures in a study in 2020; for instance, surgical aortic valve replacements (sAVR) were reduced by 24.63% while transcatheter aortic valve replacements (TAVR) were reduced by 16.42%. (18)

In our center, we found out that postoperative complications such as mortality and stroke were not significantly different between the two periods of time, however; many studies pointed out the higher mortality and complications of the infected ones during surgery. As an example, in a retrospective study of 755 individuals in the UK, COVID-19 resulted in a five times higher mortality rate in patients undergoing cardiac surgery. The difference could probably be because of a larger sample size, screening of 9 centers rather than just one as in our study, and the duration of surveillance which was from the first of March to 30th April 2020 unlike our study which encompassed a total year; and finally, we compared mortality rates between the two periods while this study compared mortality rates in cardiac surgery cases with and without concomitant COVID-19. As well as this, postoperative COVID-19 patients needed more mechanical ventilation and had a longer hospital stay

compared to preoperative COVID-19 positives. Therefore, the main burden of COVID-19 in recovering from surgery is related to those with a postoperative diagnosis of COVID-19 while preoperative COVID-19 patients recover similarly to those without COVID-19. (19) However, we didn't investigate preoperative and postoperative COVID-19 separately to differentiate between the outcomes of each.

In a systematic review of 44 COVID-19 patients undergoing cardiac surgery from the first of January 2019 to 24 February 2022, 27.3% of the patients experienced mortality up to 1 month postoperatively, and the mean time for hospital stay was longer about a week to two as well, while in our center the total mortality rate was 4.9% starting in 3 days of operation with either gradual or fulminant onset. (20)

An epicenter of the COVID-19 pandemic in New York City, similarly to our results reported a 62% decline in surgical volume from March 16 to May 15 2020 compared with the same period a year before. They stated 1.9% mortality, no cerebral vascular accidents, and deep sternal wound infections out of a total of 54 patients undergoing cardiac surgery during this period. (17) On the contrary, in New Zealand from March to April 2020 during the lockdown, cardiac surgeries per month rose compared to the same period a year before. As well as this, emergency surgeries with acute conditions peaked in September to December 2020 with more than two times higher rates compared with the corresponding time in 2019. (21) A national trend with a larger sample size to assess the impact of the pandemic on cardiac surgeries was observed in a study of 434630 admissions for structural heart disease interventions (TAVR, left atrial appendage occlusion (LAAO), and transcatheter end-to-end repair (TEER)) in the United States from 2016 up to 2020. They demonstrated a decline in admissions from April to June 2020 followed by a return to the pre-pandemic rates afterward. Another point to mention was the lack of difference in the major complications and mortality rates during the pandemic. Median LOS was also significantly declined in TAVR and TEER procedures, unlike LAAO. This showed that hospitals gradually got adapted to the burden of the pandemic and managed to deliver adequate cardiac care despite the unpredicted challenges. (22)

Other postoperative complications would be pneumonia and ARDS in COVID-19 patients undergoing surgery even if they were asymptomatic. (23) A comprehensive review showed 63.6% of the patients with concomitant COVID-19 and surgery to experience postoperative complications; with 27.3% of them experiencing ARDS, 13.6% cerebrovascular complication and lesser rates requiring extracorporeal membrane oxygenation (EMCO), nevertheless at our center, only 1.6% of patients suffered from stroke postoperatively. (20) The postoperative chest X-rays of the patients were seemingly involved with pneumonia even if the patients were asymptomatic. This rose the probable advantages of preoperative scanning to assess the surgery risks and decide the best time for surgery.

Other differences worth mentioning between the two periods were the more significant risk of immunodeficiencies, preoperative arrhythmias, end-stage renal diseases, congestive heart failure, and prior myocardial infarction in populations referred for cardiac

surgery. However, the pandemic era was followed by a lesser burden of reoperation and more nonelective and isolated CABGs. (4) Similarly, as it was demonstrated in Table 2, 137 out of 184 surgeries were isolated CABGs.

The decision to perform the surgery in spite of the disease varies per case and study. In a study, 5.68% of patients undergoing surgery during the pandemic had confirmed COVID-19, 84.5% of whom were diagnosed before being hospitalized for the surgery. This study just like ours, did not result in a significant association of COVID-19 history with morbidity and mortality during the operation. (4) At our center, however, in case of suspicion of COVID-19 in patients, we deferred the surgery until they recovered fully from the disease; meanwhile, ASA-APSF joint statement suggested that patients with mild or no symptoms at all should wait for at least 4 weeks for elective surgeries; non-hospitalized symptomatic patients for at least 6 weeks and hospitalized patients for at least 8-10 weeks. However, in some cases with more critical underlying cardiac conditions, the surgery must be performed earlier than the median optimal time of waiting. (23) In this regard, urgent cases such as postinfarction ventricular septal defects, type A dissections, and cardiac disorders with symptoms can't be delayed because of their life-threatening nature.

At last, as we know patients with congenital heart diseases face higher risks when infected with this virus, and many of our surgeries i.e., valve replacement and ASD closure were performed on these patients.

As well as these, COVID-19 itself can be a threat to the cardiac tissue in an otherwise healthy patient including induction of thrombi, disruption of gas exchange, endothelitis, and myocardial infarction, let alone a patient undergoing the stress of these types of surgeries. (2) Mechanisms vary from stress cardiomyopathy to MI and from fever-induced arrhythmia to cardiogenic shock. (24)

The pandemic resulted in the deferral of many cardiac surgeries bringing up anxiety for both patients and surgeons. (20) On one hand, hospital shortages during the pandemic prioritized and limited staff and facilities to emergent cases. On the other hand, deferring elective cardiac surgeries would result in prolonged waiting lists leading to higher morbidities and worse outcomes than their starting points. Prolonged waiting lists across seven UK cardiac surgery centers in March 2020 up to March 2021, significantly delayed treatment for elective cardiac surgery cases. Although this delay had low mortality risks, it could be associated with adverse outcomes i.e., perioperative risks and lower quality of life. (25)

Overall, it appeared that several centers including ours, as mentioned above, managed to deliver safely the care of cardiac surgery amid the pandemic. This emphasized the importance of expeditious and comprehensive testing and validated protocols. (17) A solution would be creating checklists considering patients' comorbidities and types of surgeries to decide whether to proceed or postpone the surgery. (26) In fact, the decision to perform surgery should be based on the patients' factors, hospital capacity, and the severity of sickness in the community (7).

LIMITATIONS

To the best of our knowledge, this is one of the first studies comparing cardiac surgeries before and after the pandemic, however; some limitations occur that need to be justified in future studies. This is a single-center study; therefore, it can't be representative of other centers as well. As a result, larger sample sizes and studies in different sites are recommended to allow us to make more accurate decisions about this matter. Furthermore, in some cases, preoperative testing might have led to false negative or positive results due to a lack of laboratory facilities, sampling errors, the inappropriate timing of sampling, and low sensitivity or specificity, especially PCR tests. Moreover, as COVID-19 symptoms comprise a wide spectrum of presentations and clinical signs, it was difficult to fully detect all true COVID-19 patients in the first place. In addition, the study was done when vaccination was new and all patients weren't vaccinated. The outcome would probably be different if vaccination was fully conducted. It is recommended to construct better the infrastructure of centers dealing with this pandemic and dedicate specialized and isolated rooms for these patients. As well as this, suitable measures are required to carry out the surgery on an infected patient to lower the possibility of transmission as much as possible. (27)

CONCLUSION

It can be concluded that performing open cardiac surgery in the centers with concomitant hospitalization of COVID-19-infected patients in other wards can be safe. The total mortality rate or post-surgical complications may not be different by following the protocols, controlling the infection, isolating properly, and diagnosing the patients appropriately.

CONFLICT OF INTERESTS:

None.

ABBREVIATIONS

COVID-19; Coronavirus disease-2019, SARS-CoV-2; severe acute respiratory syndrome coronavirus 2, ICU; intensive care unit, PCR; Polymerase chain reaction, CT; chest computed tomography, CBC; complete blood count, ESR; Erythrocyte Sedimentation Rate, CRP; C-reactive protein, CABG; coronary artery bypass graft, MVR; mitral valve replacement, AVR; aortic valve replacement, ASD; atrial septal defect, STS; Society of Thoracic Surgeons, sAVR; surgical aortic valve replacements, TAVR; transcatheter aortic valve replacements, LAAO; left atrial appendage occlusion, TEER; transcatheter end-to-end repair, EMCO; extracorporeal membrane oxygenation.

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