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Surgical outcomes of isolated coronary artery bypass grafting for acute and chronic coronary artery syndromes: based on Sulaimani cardiac registry

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Background: The leading cause of death worldwide is coronary artery disease. Globally, coronary artery bypass grafting is among the most frequently carried out procedures. A number of factors, including but not limited to gender, age, comorbidities, duration of cardiopulmonary bypass time, and surgical urgency, influence the short-term mortality following Coronary Artery Bypass Grafting (CABG).

Patients and methods: 220 consecutive CABG patients who underwent surgery between January 2022 and December 2022 were included in a prospective comparative analysis carried out at a single location. Convenience sampling was the approach used to obtain the data.

Results: 60.4 ± 9.4 CI (95% 36–81) years was the average age of all patients. Just 32.3% of participants were smokers. In 15.5% of cases, patients had emergent surgery. There was no discernible correlation between the pre-operative and intraoperative composite score and early morbidities. However, emergency surgery had a significant value of (P = 0.018) in relation to hospital mortality. Additionally, there was a strong correlation between in-hospital mortality and the cross-clamp time and CPB (P = 0.000 and 0.05). Our subjects underwent survival analysis using Kaplan–Meier, with a mean follow-up duration of 50.43 ± 12.36 weeks. Eleven deaths were reported in the first year's results.

Conclusion: Survival is significantly impacted by CABG. If at all possible, it is preferable to improve a patient's condition before surgery in order to reduce mortality. The patient's chance of survival is impacted by complications including stroke and extended intubation. In some patients, re-examination should be allowed with a low barrier because the alternative might be fatal.

Keywords: bypass graft, coronary artery diseases, long-term outcome, mortality, short-term outcome

Introduction

Coronary Artery Syndrome (CAS) is the most common cause of death globally. According to the WHO, in 2019, up to 26% of all deaths were ischemic heart-related[1].

HIGHLIGHTS

- Coronary artery disease is a very common cause for emergency presentations.
- Prompt revascularization is crucial for preventing morbidity.
- Coronary Artery Bypass Grafting (CABG) is indicated in a wide variety of coronary lesions.
- CABG might have short and long-term adverse effects.
- Reporting the outcomes will significantly improve the future outcomes.

Atherosclerosis primarily causes the symptoms of CAS by decreasing blood flow through the coronary arteries[2]. Therapeutic strategies include the best medical treatment, Percutaneous Coronary Intervention (PCI), and Coronary Artery Bypass Grafting (CABG)[2-4]. Multiple vessel coronary artery disease is a common finding in both acute coronary syndromes (ACS) and chronic coronary syndromes (CCS)[3].

The ACS includes ST elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction, and unstable angina[2-4]. CABG is one of the most common operations performed worldwide. Surgery for coronary artery syndrome is either urgent or elective and carries relatively high morbidity and mortality in the short and long term[3,4]. CABG for ACS is

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considered a risk factor when compared with elective surgery for CCS[4].

Still, CABG is one of the best modalities to treat CAS, which provides better long-term survival and better quality of life compared to PCI[5,6]. One of the main indications of CABG, which sets it apart from its counterpart, is its ability to treat left main coronary artery disease, diabetic patients, and patients with poorer left ventricular function[6,7].

Patients with failed PCI, ongoing ischemia, and unsuitable anatomy for PCI undergo urgent CABG[7].

Diabetes and hypertension are known to be risk factors for patients developing CAS, and diabetes also carries a higher perioperative risk[4,8].

Short-term mortality after CABG depends on multiple factors, including but not exclusive to gender, age, comorbidities, length of cardiopulmonary bypass time, and urgency of the operation. Researchers recorded a mortality rate of 4.7% in emergency hospitals[5,9].

Morbidities after CABG, such as acute kidney injury (AKI) and stroke, impose a substantial burden on patients and hospitals. Stroke has been strongly associated with advanced age and calcified Aorta[10]. Up to one-fifth of patients undergoing pump CABG have reported experiencing AKI[11].

One of the most catastrophic complications after CABG is re-exploration for tamponade or bleeding, sometimes reaching 12% of CABG patients, which carries higher chances for developing crippling complications[12].

Our main objective is to investigate the factors affecting the outcome of patients undergoing CABG including short-term complications, early re-exploration and re-exploration threshold .And do short-term complications after surgery have an impact on survival? Is early re-examination merited?

Patients and methods

A single center conducted a prospective comparative study, sequentially including 220 patients who underwent CABG between January 2022 and December 2022. The study collected data using a convenience sampling method. We examined the results of individual CABG procedures carried out for both ACS and CCS.

Prior to the operation, all patients underwent conventional coronary angiography. Every patient had a coronary catheterization. We either administer medication to ensure the removal of the responsible lesions in Acute Coronary Syndromes, or direct patients to our facility for immediate CABG or diagnostic catheterization for stable heart conditions.

We performed transthoracic echocardiography as part of the patient preparation process to rule out congenital abnormalities and valvular disorders. We recorded demographic information for every patient, which included Age, Gender, BMI, comorbidities such as Diabetes and Hypertension, smoking status, and preoperative surgical risk assessed using the ASA Scoring system. Our work has been reported in line with the PROCESS criteria for case series[13]. This study was registered on ResearchRegistry.com

Technique

Every patient underwent a median sternotomy operation and received a central cardio-pulmonary bypass with an aortic artery cannula and a right atrium venous double-stage cannula.

Cardioplegia, a potassium-based cold saline infusion, arrested the heart in diastole and cross-canceled the aorta. In regards to the choice of the conduit, every patient had Left Internal Thoracic Artery (LITA) plus other conduits (which is discussed in our results); if LITA was not harvested for any reason, we excluded that patient from the study. Also, each patient had at least two vessels bypassed.

We accomplished total revascularization in all of the patients. Following the operation, we did not extubate any patient on the table and instead transferred them to the cardiac intensive care unit for intubation.

We measured the cardiopulmonary bypass and cross-clamp times intraoperatively. We recorded the number of coronary arteries grafted and the type of conduit for each patient. We conducted analysis on each patient's outcomes, including length of hospital stay, time of extubation after surgery, re-exploration, new-onset atrial fibrillation, stroke, acute kidney injury, and in-hospital mortality. We also examined a one-year follow-up to see if the patient had survived this time. Included in this study are on-pump CABG, solitary CABG, and adult patients.

This study excluded patients who underwent simultaneous valve surgery with CABG, patients who underwent CABG without using a BYPASS machine (OFF-Pump), and patients who underwent re-surgery for coronary artery disease (REDO-CABG).

Definitions

Acute Kidney Injury (AKI) following cardiac surgery is classified into three stages by the Acute Kidney Injury Network (AKIN), ranging from a rise in creatinine by 3 mg/dl in the first 48 hours to full renal replacement therapy[14]. The American Society of Anesthesiologists (ASA) provides clinicians with the perioperative risk for each patient based on their physiological state[15]. Though the main scoring system that is used for Cardiac interventions in the current era is EuroSCORE II, we have used ASA scoring system in our hospital as a backup for the fact that not every patient who undergoes CABG will have a high ASA grade also our patients data lacked some information including pulmonary systolic pressure and carotid Doppler, which is required to have a precise reading[16].

Current smoker is defined that a patient is smoking at the time or has smoked in the previous 12 months, never smoker is a person who has not reached 100 cigarettes in all their life[17].

Statistical analysis

We used the proper statistical validation techniques to assess the dataset for a normal distribution. We summarized the dataset using descriptive statistics, which included measurements like the mean, standard deviation, frequency, and percentage distributions. The study used the chi-square test and multiple regression analysis to make comparisons across several groups easier. The Kaplan–Meier approach was used for survival analysis of different covariates, which was crucial for determining how predictors affected the various survival outcomes. Every statistical analysis was carried out with a significance level of $P < 0.05$, guaranteeing a thorough and exacting evaluation and analysis of the research outcomes. The statistical software packages utilized for data analysis were IBM SPSS Statistics for Windows, Version 25 (IBM Corporation).

Results

This study included 220 participants who underwent isolated CABG. In the demographics of these participants, the mean age of all patients was (60.4 ± 9.4 CI 95% 36–81) years, and the mean BMI was (27.95 ± 4.8 CI 95% 18–45) kg/m^2.

Of all patients, the majority were male, accounting for 172 cases (78.2%). In regards to comorbidities among all participants, our results showed that 125 (56%) and 89 (40.5%) had hypertension and diabetes, respectively. In the matter of smoking, we labeled a patient a smoker. The patient smoked more than 100 cigarettes in their lifetime and currently smokes. A larger number of our patients were never smokers, 149 (67.7).

Regarding the patients who had or did not have chest pain prior to surgery, we divided them into three groups: those who did not have chest pain, those who had it during exertion, and those who had it during rest. The results showed that the majority of patients, 113 (51.36), experienced chest pain during exertion, 67 patients did not experience any chest pain, and 40 patients experienced chest pain during rest. In regards to the number of vessels that needed to be bypassed in our patients, we discovered 48 participants required two vessels bypassed, 140 participants required three bypasses, and 32 had four vessels bypassed. All our patients required LAD bypasses.

When using conduits for CABG, the first choice was the left internal mammary artery (LITA), and the second arterial graft was the radial artery (RA), followed by vein conduits, for which we used great Saphenous vein (GSV). Our results showed the vast majority only received one arterial graft with vein grafts, 167 (74.1), and only 57 (24.9%) of our patients received a second arterial conduit.

Our patients underwent surgery either on an elective schedule or on an urgent basis. Our findings revealed that only 15.5% of our patients underwent urgent surgery, while the remaining 84.5% underwent elective surgery. Our data showed the majority 105 (47.7) of the patients were ASA category 3, followed by ASA category 2, which were 9 (5, 43.2%) patients (Table 1). For the cardio-pulmonary bypass time and Aortic cross clamp time, the mean time in minutes was found to be 106.9 ± 29 minutes and 63.45 ± 19 minutes, respectively.

The ICU stay showed a mean stay of 1.2 ± 0.738 days and a stay in the hospital after surgery; the mean stay was 4.4 ± 1.1 days, with the maximum stay being 12 days after this operation in our center. About 181 (82.3%) of our patients underwent extubation less than 12 hours after surgery, while 39 patients experienced delayed extubation for various reasons.

After analyzing the causes, we found that respiratory failure delayed 14 (6.4%) patients, cardiogenic shock delayed 6 (2.7%), re-exploration for bleeding or tamponade delayed 10 patients, and neurological dysfunction and unsatisfactory power delayed 9 (4.1%) patients.

Over the first 30 days, the most common outcome among our patients was atrial fibrillation, which was present in 27 (12.3%) cases. It was followed by acute kidney injury (AKI), which was present in 8% of our patients after undergoing CABG who did not have any renal disease prior to surgery; none of these patients' needed dialysis, and all were treated conservatively. Twelve of our patients underwent re-exploration either for bleeding or tamponade within the first 24 hours; no patient underwent re-exploration beyond the first 24 hours. Nine (4.1%) of our patients received a diagnosis of a cerebrovascular accident (CVA) within the first 30 days following surgery, and five of them partially recovered with medication and physiotherapy within the first year (Table 2).

Table 1

Demographic characteristics of participants

Variables	Frequency N:220	Percentage %
Gender		
Male	172	78.2%
Female	48	21.8%
Hypertension		
Yes	125	56.8%
No	95	43.2%
Diabetes		
Yes	89	40.5%
No	131	59.5%
Smoker		
Yes	71	32.3%
No	149	67.7%
Chest pain		
No chest pain	67	30.46%
Exertional chest pain	113	51.36%
Resting chest pain	40	18.18%
Timing of surgery		
Elective	186	84.5%
Urgent	34	15.5%
Number of vessels required		
Bypass		
Two	48	21.8%
Three	140	63.6%
Four	32	14.5%
ASA classification:		
1	5	2.3%
2	95	43.2%
3	105	47.7%
4	15	6.8%
5	0	0%
Types of conduits:		
Single arterial graft plus	163	74.1%
Venous grafts		
Multiple arterial grafts	57	25.9%
Age/years	Mean + SD	CI 95%
	60.40 +- 9.4	36–81
BMI kg/m^2	27.95 +-4.8	18–45

BMI = body mass index; SD = standard deviation; CI95% = confidence interval; ASA = American Society of Anesthesiology.

We created a composite value of complications, such as re-exploration, stroke, AKI, atrial fibrillation, and delayed extubation, to analyze the determinants of morbidity and mortality. We also measured hospital mortality separately. We cross-tabulated risk factors such as age, gender, timing of surgery, ASA classification, comorbidities, smoking, number of bypassed vessels, types of conduits, CPB time, and cross-clamp time using multivariant regression analysis.

All pre-operative predictors, such as age, gender, BMI, and high ASA, have not demonstrated a significant relationship between intraoperative cross clamp and CPB time and postoperatively composed morbidity.

But in regards to hospital mortality, emergency surgery showed a significant value of (OR 0.088; CI 95% –.021 to –.100; SE 1.298; P = 0.018). The CPB and cross-clamp time also had a significant relationship with in-hospital mortality,

Table 2

Outcomes of all the patients after surgery in first 30 days

Variables	Frequency N:220	Percentage %
Re-exploration	12	5.5%
Stroke	9	4.1%
Atrial fibrillation	27	12.3%
Acute kidney injury	18	8%
ET Extubation time after surgery		
Less than 12 hours	181	82.3 %
More than 12 hours	39	17.7 %
Reasons of late extubation		
Respiratory	14	6.4%
Low blood pressure	6	2.7%
Re-exploration	10	4.5%
Unsatisfying neurological examination	9	4.1%
Cardiopulmonary bypass time/minutes	Mean ± SD	CI 95%
	106.9 ± 29	52–300
Cross clamp time/minutes	63.45 ± 19	28–142
Stay in hospital/days	4.4 ± 1.1	1–12
Stay in ICU	1.2 ± 0.763	1–8

showing *P* values of 0.000 and 0.05, respectively. Number of grafts had an impact on outcome in regards to in-hospital mortality when showed a significant relationship of (OR −0.196; *P* = 0.002; CI 95%). This has shown that the higher the number of bypassed vessels, the higher the chance of survival (Table 3).

We sought to compare the outcomes of surgery with observed mortality in hospitals, and our data suggested complications such as stroke, arrhythmia, and delayed extubation for any reason had a major impact on mortality in hospitals, as the results indicate. Stroke had a significant *P* value of 0.000, meaning that out of 7 patients who experienced a CVA attack, 2 of them died in hospital. Both arrhythmia and delayed extubation for more than 12 hours were associated with a *P* value of 0.000.

Acute kidney injury and re-exploration for bleeding or tamponade had no significant relationship with in-hospital mortality (*P* = 0.47 and 0.55, respectively) (Table 4; Fig. 1).

Survival analysis was measured in our participants with a mean follow-up time of 50.43 ± 12.36 weeks. The results of mortality in the first 30 days, 6 months, and first year total of 11 patients died within the first year are shown as the following graph: 6 patients died in the first 30 days; another 5 patients died in the first year of follow-up.

We added factors such as the timing of surgery, gender, and overall complications to the survival plot. There was not a significant relationship between gender and survival in weeks for our patients (*P* = 0.287 in log rank); however, there was a highly significant relationship between timing of surgery and survival (*P* value of 0.042; CI 95%). Additionally, there was a significant relationship between survival and composite complication value (*P* value of 0.000), indicating that hospital morbidities were linked to a higher risk of death within the first year of follow-up (Fig. 2).

Discussion

To the best of our knowledge, this is the largest case series of CABG outcomes in Sulaimani and one of the largest in Iraq. Outcomes of CABG operations depend on multiple patient

Table 3

Possible perioperative predictors relationship with both composed complication and in-hospital mortality

Variables	Odd's Ratio	CI 95%	Standard error	*P* value
Composite complications				
Age	.088	−.002 -. 011	.209	0.209
Gender	−.099	−.246—.041	.160	0.160
BMI	−.126	−.025- .003	.118	0.118
Urgent surgery	−.006	−.176—.163	.939	0.939
ASA class	.081	−.061—.163	.358	0.358
DM	.023	−.106 -,146	.755	0.755
Hypertension	.002	−.131- .134	.980	0.980
CPB time	.061	−.002- .004	.523	0.523
Cross clamp time	.045	−.003- .003	.635	0.635
Number of bypassed vessels	−.116	−.180-.013	.090	0.090
Types of conduits	−.014	−.151 − .123	.839	0.839
In-hospital mortality				
Age	−.110	−.004—.000	−1.681	0.094
Gender	−.023	−.060—.042	−.341	0.733
BMI	−.060	−.007- .003	−.791	0.430
Urgent surgery	.088	−.021—.100	1.298	**0.018**
ASA class	.024	−.035–047	.293	0.770
DM	.032	−.034—.055	.466	0.642
Hypertension	−.042	−.061—.033	−.581	0.562
CPB time	.397	.001 − .003	4.459	**0.000**
Cross clamp time	−.172	−.003—.000	−1.924	**0.05**
Number of bypassed vessels	−.196	−.088— − .019	−3.078	**0.002**
Types of conduits	−.033	−.061—.036	−.497	0.620

With multiple regression analysis testing calculating odd's ratio, standard error, coefficient interval of 95%, and *P* value.
BMI = body mass index, ASA = American Society of Anesthesia score; DM = diabetes mellitus; CPB = cardio-pulmonary bypass time.
Composed complication = (re-exploration, stroke, atrial fibrillation, delayed extubation).

Table 4

Frequency and significance relation of in-hospital complications when compared with in-hospital mortality

Variables	Number affected Total:220	Number of in-hospital deaths	*P* value
Re-exploration	12	0	0.55
AKI	21	1	0.47
Atrial fibrillation	21	6	**0.000**
Stroke	7	2	**0.000**
Extubation after 12 hours	34	5	**0.000**

characteristics and the events that happened in the perioperative period. In our study, most of our results are in accordance with the international literature, while some do not entirely follow the general knowledge. We observed that the majority of our patients are male, hypertensive, and nonsmokers (78.2%, 56.8%, and 67.7%, respectively). This data confirms that male gender and the presence of comorbidities like hypertension are significant risk factors for ischemic heart disease and CABG procedures[2,3,18]. But our data suggested the majority of our participants were non-smokers; this contradicts the common knowledge that the majority of patients undergoing CABG are smokers[15].

As stated by Kurki *et al*[4], the median length of stay in hospital after CABG for either elective or urgent cases was no less than 15 days (17.4 ± 15.8 days), while in our study the hospitalization was significantly lower (4.4 ± 1.1 days)) and there was no significant difference between urgent or elective operations. The lack of facilities to provide services primarily explains this short hospitalization, but we observed that our patients were clinically well enough to continue their care at home, negating the need for a longer stay.

We have established a group of outcomes, known as Composed Complications, to investigate the potential impact of preoperative situations on postoperative outcomes. Numerous studies indicate that the gender of the patient is a significant predictor of surgical complications. Kim *et al*'s study[9] suggests that females experience higher in-hospital mortality compared to males. Also, another study from the Islamic Republic of Iran suggested that women generally had a higher rate of complications, such as MACEs (major adverse cardiac events)[19]. However, our study found that female gender does not significantly influence early postoperative complications and mortality, with a non-significant result (p: 0.16, 0.73).

The timing of CABG surgery is a crucial factor that determines the perioperative outcomes. The percentage of urgent CABG varies between the centers. According to national trends in emergency CABG, the percentage of emergency CABG in 2017 was only 4.1% worldwide[4].

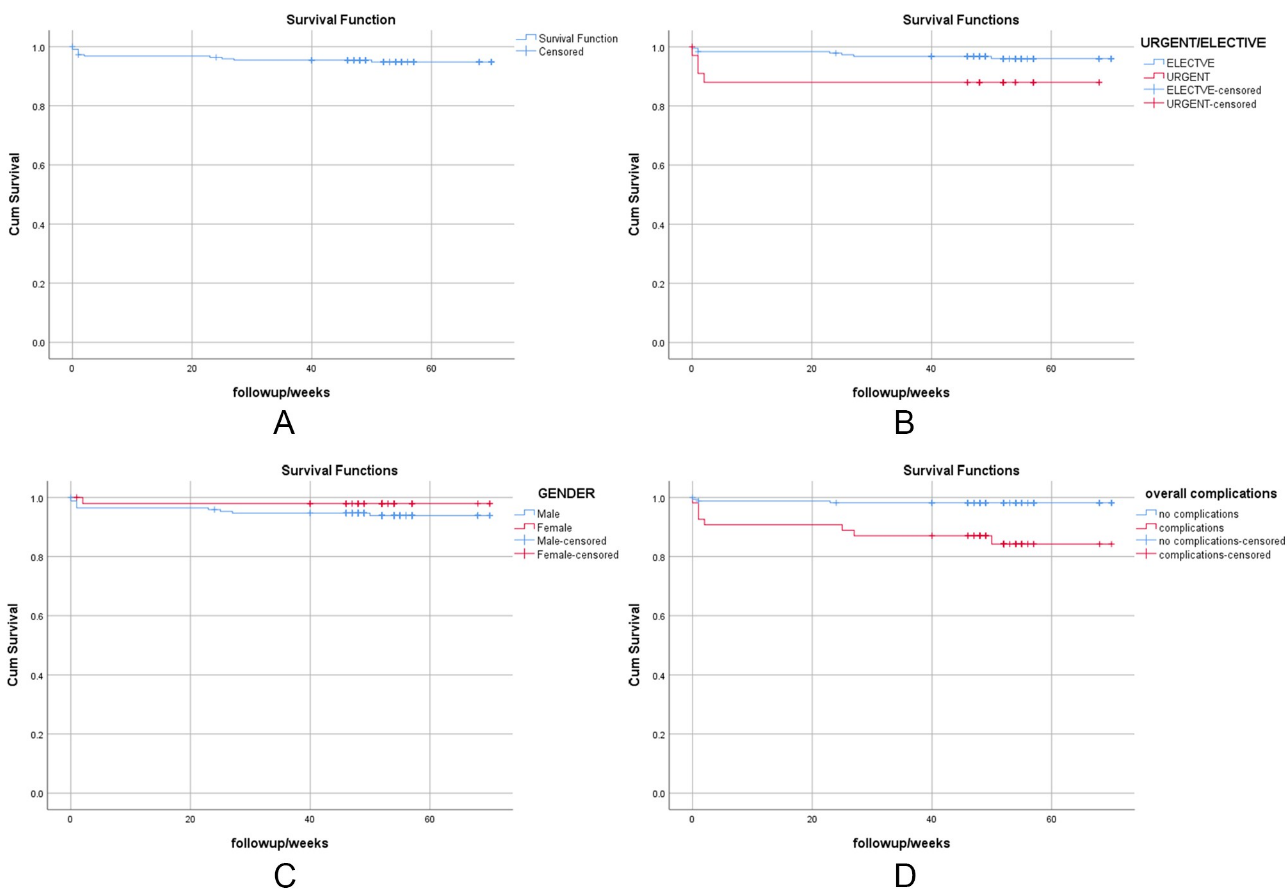

Figure 1. (A) Line graph showing relationship of cardio-pulmonary bypass time with in-hospital mortality. (B) Bar chart showing urgent surgery versus elective surgery in matters of in-hospital mortality. (C) Bar chart showing relationship of number bypassed vessels with in-hospital mortality.

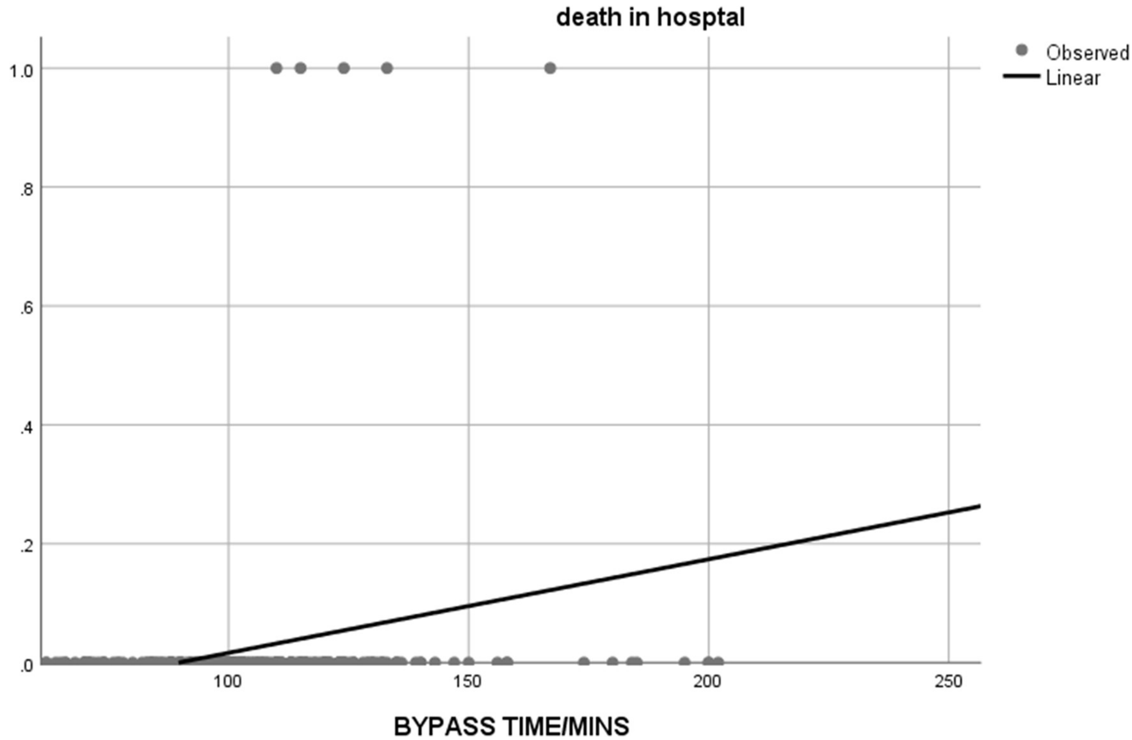

Figure 2. Kaplan–Meier graph showing survival in the first year after CABG in all of the patients.

According to Wei *et al*[20], patients who undergo CABG within the first two days of ACS experience a higher complication rate compared to those who undergo the surgery after three days or more. In our case series, the percentage of urgent CABG patients was 15.5%, and all of them underwent surgery within the first week following the onset of ACS. The overall morbidity of these patients was comparable with the patients who underwent the surgery on an elective basis. However, the hospital mortality rate was higher for the urgent patients, with a statistically significant P value of 0.018. ASA classification is one of the most widely used scoring systems to predict outcomes based on the physical status of the patient[14].

Wilkund *et al*[21] rejected the theory that every patient undergoing CABG should be ASA 4 and above.

We applied this classification to our patients in order to see if there is a relation between higher ASA and complication or mortality. The results showed there is no significant relationship (P = 0.37 and 0.7) for overall complications and mortality, respectively.

The ASA classification is used in this case series, because we think that in this locality EuroSCORE II could not be applied correctly, as some elements may not be applicable, and our data analysis suggests that our cases are not all belonging to category 4 of ASA, which is very interesting finding as well .

Gössl *et al*[22] have established and suggested that when more vessels bypass during a CABG operation, the overall survival rate significantly increases. As suggested, when more vessels bypass, complete revascularization is guaranteed.

Anatomical and functional complete revascularization, which involves bypassing all vessels with stenosis greater than 70% and reperfusing all ischemic and viable myocardium, are the two best definitions[23]. In our study, the number of vessels bypassed had a significant relationship (P = 0.002) with death in hospital, meaning the number of vessels bypassed and death in hospital was higher.

Prolonged Ischemic cross clamp time is an independent risk factor for morbidity and mortality also in turn Cardiopulmonary bypass time will be longer .In our patients, prolonged cross clamp time had significant relationship with in-hospital mortality (P = 0.05)[24]. Regarding the outcomes of patients who experienced unfavorable complications, such as stroke, delayed extubation, and atrial fibrillation, we found a significant correlation with mortality (P = 0.000), while re-exploration and AKI showed no significant correlation.

Multiple papers worldwide suggest that stroke alone is a risk factor for mortality, predicting a 2-fold increase in mortality risk compared to those without a stroke this evident especially in first year after surgery[10,25-27].

Early extubation is defined by the British Thoracic Society (BTS) as extubation prior to 6 hours after cardiac surgery, and prolonged intubation is beyond 24 hours[26]. We separated our patients into two groups, one before and one after 12 hours, and discovered that this marks the threshold for developing complications: patients who underwent extubation beyond 12 hours or remained intubated for more than 12 hours experienced a higher rate of hospital death (P = 0.000).

One of the main postoperative complications in cardiac surgery is re-exploration for bleeding or tamponade, which can lead to high mortality and morbidity. However, there is widespread consensus that a negative re-exploration is preferable to not re-exploring and risking a catastrophic outcome[26]. Generally, the accepted rate of re-exploration after CABG is up to 10% in some centers, but our results indicate a rate of 4.5%. While it is widely known internationally that re-exploration can lead to a three-fold higher mortality rate, our results suggest that the mortality rate is not different when compared to non-reexplored patients. Our patients' long-term survival in the first year after CABG was 95%. While this may not be as high as some other global centers, it is important to note that we included both urgent and elective patients in the same analysis pool (Fig. 2).

Conclusion

We have concluded that a short stay in the hospital could be beneficial for CABG patients as they could return to their daily activities sooner. Complications such as strokes and prolonged intubation influence the patient's survival. Re-exploration, a sinister complication of CABG, warrants a low threshold in certain patients, as the alternative may result in death.

Limitations

Our research is a single-center study. Additionally, our center's patient retention rate is significantly lower than that of highly developed and large centers. Lack of data was a major issue, as we were still using paper files to collect data for our patients, leading to a significant drop in patient follow-up.

Ethical approval

Ethical approval was obtained through the Research Protocol Ethics Committee of our Board of Medical Specialties.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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None.

Author's contribution

Y.N.O.: drafting, data analysis, statistical analysis, draft revision; S.R.S.: drafting, statistical analysis, draft revision, patient follow-up; A.B.: the surgeon in charge of study design, follow-up, data collection, manuscript revision, and statistical analysis.

Conflicts of interest disclosure

None.

Research registration unique identifying number (UIN)

This study was registered on ResearchRegistry.com: reviewregistry1903.

Guarantor

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Provenance and peer review

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Data availability statement

The data are available with the corresponding author and can be achieved on request.

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