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*Original Article*

# Effects of blood transfusion, cardiopulmonary bypass time, and bypassed vessels on mortality following isolated and combined coronary artery bypass grafting

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**Abstract:** Objective: This study aimed to investigate the correlation between the number of bypassed vessels, the duration of Cardiopulmonary bypass, blood transfusion requirements, revision rates, and mortality outcomes. The objective was to get insights into the potential challenges that may arise during the postoperative phase. Methods: Our study covered a total of 677 patients from January 2015 to January 2021. The study and analysis focused on many factors including the surgical procedure, the number of bypassed vessels, transfusion requirements, comorbidities, revision rates, the administration of blood thinners, and early mortality. Results: Male patients numbered 513 and female patients 164. The combined coronary artery bypass grafting surgeries were 187, whereas the isolated ones were 490. Combination procedures traditionally used one- and two-vessel bypass grafting. 30.9% of patients had three vessels, while 31.6% had four. The typical blood transfusion has 4.2 erythrocytes. Fresh frozen plasma averaged 2.9 units, platelets 2.4 units, and whole fresh blood 2.6 units. The average cardiopulmonary bypass time was 145.1 and cross-clamp time was 89.3. Conclusion: Six vessel bypasses have the highest revision rate. Transfusion rises with longer cardiopulmonary bypass and cross-clamp periods. Using acetylsalicylic acid before surgery increases the need for fresh frozen plasma and platelets. However, warfarin sodium increases the need for fresh frozen plasma and increases mortality. The revision highly linked with total CPB, cross-clamp times, all blood transfusions, and mortality.

**Keywords:** Coronary artery bypass grafting, mortality, blood transfusion, cardiopulmonary bypass time, revision

## Introduction

Cardiovascular disorders, particularly coronary artery diseases, are the most common causes of mortality. Coronary artery bypass grafting (CABG) is a widely practiced surgical procedure that is frequently conducted on a global scale [1].

The American College of Cardiology (ACC) and American Heart Association (AHA) clarify CABG indications [3, 4]. CABG is recommended when the left main coronary artery narrowing is more than 50% when both the proximal LAD and circumflex arteries are more than 70% narrowed, or when there is a three-vessel disease with proximal LAD narrowing that causes LV dysfunction. When stable angina is combined with single- or double-vessel disease and substantial myocardial dysfunction in a high-risk zone. Ejection fraction (EF) below 50% or proximal left anterior descending artery (LAD) stenosis above 70% demand CABG. Additional CABG indications include persistent ischemia after a myocardial infarction (MI) without ST-segment elevation that does not respond to treatment. The left ventricle has a nonfunctional myocardium above the physical defect that may be revascularized. CABG may be done as an urgent treatment for ST-segment elevation myocardial infarction (STEMI) if percutaneous coronary intervention (PCI) is not possible or inefficient and pain with ischemia persists, threatening a major section of the myocardium despite pharmacological therapy [2, 3].

Many contraindications to CABG should be considered. These include patient refusal, coronary arteries that are not suitable for grafting, and the lack of healthy myocardium that can be grafted [5].

CABG surgery may cause a variety of cardiovascular system issues. Postoperative bleeding, graft obstruction, pericardial tamponade, and heart failure are possible risks. It is important to note that these disorders may affect other physiological systems other than the cardiovascular system. Respiratory failure, stroke, urinary tract infections, renal failure, coagulopathy, limb ischemia, wound dehiscence, pleural effusion, and hematologic abnormalities are common postoperative consequences of this surgery [6].

The majority of comparative studies comparing coronary artery bypass grafting (CABG) to percutaneous coronary intervention (PCI) or medical therapy consistently demonstrate not only improved survival outcomes associated with CABG, but also a lower incidence of myocardial infarctions. Therefore, coronary artery bypass grafting (CABG) may differ from percutaneous coronary intervention (PCI) by providing "surgical collateralization", thereby potentially extending life expectancy by reducing the incidence of myocardial infarctions [7].

In cases where additional cardiac pathologies coexist with coronary artery disease, cardiac surgeons attempt to treat these pathologies simultaneously with CABG whenever possible. The use of cardiopulmonary bypass (CPB) during open cardiac surgery is associated with a significant increase in the need for postoperative blood transfusion. Furthermore, the presence of comorbidities, such as blood and kidney diseases, among patients influences the need for blood transfusion [8]. There is a correlation between the number of grafts utilized in cardiac bypass procedures and an increase in both the cross-clamp and total CPB durations. This prolonged duration poses a risk of hemorrhage, which can be ascribed to multifactorial coagulopathy processes, such as systemic inflammation, coagulation alterations, and fibrinolytic activity [9].

Platelet abnormalities or dysfunctional platelets are significant contributors to post-CABG hemorrhage, in addition to thrombocytopenia. When patients are administered long-acting antiplatelet drugs, such as clopidogrel and ticlopidine, as well as anticoagulant therapies, such as warfarin sodium, the risk of postoperative hemorrhage increases [8].

Echocardiography (Echo) is commonly employed as a preoperative examination for patients undergoing open heart surgery to treat coronary artery disease. In the event of additional cardiac pathology, such as valvular disease, ventricular aneurysm, or aortic aneurysm, it is recommended to address these conditions concurrently during the surgical procedure. In contrast, individuals who are scheduled for cardiac surgery to address various cardiac pathologies may have undergone preoperative assessment for coronary artery disease by the use of coronary angiography. This diagnostic procedure is particularly common among older patients and those deemed to be at a heightened risk of developing coronary artery disease. Furthermore, it should be noted that emergent surgical procedures, such as those performed for aortic dissection, may require the implementation of one or two coronary artery bypass grafts as a result of either primary coronary artery dissection or complications arising from the surgical intervention or previously diagnosed by angiogram.

The primary objective of this study was to examine the correlation between coronary artery bypass grafting (CABG) with or without other cardiac surgical operations, as well as the specific kind and quantity of blood transfusion administered in conjunction with cardiopulmonary bypass (CPB), cross-clamp, and total circulatory arrest durations. In addition to the aforementioned factors, patients had assessments for blood laboratory values, demographic information, comorbidities, preoperative blood thinner usage, revision, and mortality.

Significant blood loss is anticipated during open-heart operations. The administration of blood transfusions has the potential to be a life-saving intervention; however, it is imperative to do a thorough assessment to determine whether the potential advantages of transfusions outweigh the associated dangers.

## Material and methods

This study involved the collection of data from all patients who underwent isolated coronary artery bypass grafting operations or combined operations involving valvular, aneurysms, and carotid endarterectomy procedures at our cardiovascular surgery center, which is affiliated with a university and referral hospital. The data collection period spanned from January 2015 to January 2021. A total of 677 patients were included in our investigation.

The objective of this research was to investigate the mortality rate and the kinds and quantities of blood transfusions in relation to the number of grafted blood vessels and the durations of cardiopulmonary bypass in both isolated and combined CABG procedures. During the course of this research, we also examined other blood laboratory tests, including hemoglobin, platelet count, and creatinine levels. Additionally, we investigated the preoperative administration of blood thinning drugs, as well as the presence of chronic diseases and smoking habits among the patients. Additionally, the potential problems, such as hemorrhage issues, and the need for revision operations were carefully considered.

In summary, this study aimed to provide an overview and emphasize the significance of many parameters influencing the effectiveness of CABG procedures, as well as the potential outcomes associated with these factors.

*The examined criteria*

*The following criteria were evaluated*: the type of surgical procedure performed, the number of coronary grafts bypassed, pre- and postoperative levels of hemoglobin, platelets, and creatinine, the types and quantities of blood transfusions administered intra- and postoperatively, the presence of comorbidities, the occurrence of revision surgeries, the use of blood transfusions, and mortality rates.

*Blood transfusion*

The patients had blood transfusions in two stages. The initial phase occurred subsequent to the completion of the procedure and the removal of the cardiopulmonary bypass cannulas. The second phase was when the patient was in the intensive care unit, and occasionally on the floor as required prior to being discharged. During the intraoperative management of hemostasis, it is necessary to assess the patient's blood with a complete blood count test and active clotting time analysis. Furthermore, ongoing monitoring of the patient's vital signs, including blood pressure, urine output, and central venous pressure, is conducted to assess the patient's fluid volume status. Typically, at our facility, there is a preference for blood donation when the hematocrit level falls below 25%.

Assume a scenario in which significant hemorrhaging occurs during the hemostasis phase, originating from the adjacent tissues rather than being attributed to the surgical approach employed. In instances of this nature, it may be necessary to administer additional quantities of blood components, particularly platelets and erythrocytes, in addition to fresh frozen plasma. Alternatively, the administration of fresh blood may also be considered. Furthermore, it is occasionally necessary, based on the presence of bleeding through drains, to conduct a re-exploration of the patient in the operating room to identify potential areas of active bleeding subsequent to their transfer to the critical care unit.

The subsequent phase of potential blood transfusion is typically conducted within the critical care unit within the initial one to two days, based on the hemoglobin and hematocrit outcomes, while considering the patient's left ventricle ejection fraction and overall health status.

Autologous transfusion is a viable option for patients exhibiting elevated hemoglobin levels, whereby a portion of the patient's own blood is collected and subsequently transfused back to the patient following the surgical procedure. As previously stated, hemorrhaging may occur as a result of surgical procedures, particularly at the sites of anastomosis and cannulation.

Furthermore, it is worth noting that within the field of cardiac surgery, the utilization of cardiopulmonary bypass circulation has a notable impact on both platelets and the inflammatory process, hence contributing significantly to postoperative bleeding.

*Pre-operative medications*

The administration of antiplatelet medications, such as clopidogrel, prasugrel, or Ticagrelor, prior to surgery has been found to elevate the likelihood of postoperative bleeding in patients.

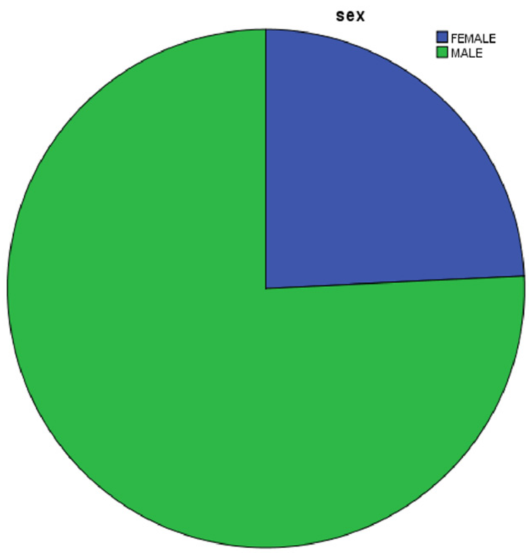


**Figure 1.** Pie chart of the gender distribution.

In such circumstances, the administration of these medications is halted for a period of 5 to 7 days, during which low molecular weight heparin is administered in preparation for the surgical procedure. Regrettably, in situations of urgency where discontinuation of such medications is not feasible, there is a potential for encountering heightened bleeding, necessitating a greater volume of blood transfusion than typically required.

This study aimed to gather data on the elements with the greatest impact and afterwards evaluate them to identify any existing relationships. Therefore, a comprehensive understanding of the potential necessity for blood transfusions can be obtained from the outset.

This study sought to analyze the occurrence of early mortality, both intra-operative and post-operative, in the intensive care unit or prior to discharge.

*Inclusion and exclusion criteria*

This research included individuals who had coronary artery bypass grafting (CABG), with or without additional cardiac surgical procedures, and whose detailed medical information were available inside our system. Patients who did not have data records in our system and those who had cardiac surgeries other than CABG were excluded from the research.

The primary objective of this research was to look at the relationship between the number of bypassed vessels, the period of cardiopulmonary bypass, the need for blood transfusions, revision rates, and mortality, in order to gain a better understanding of the possible repercussions and obstacles that may develop during the postoperative period. Proactively preparing for potential perioperative needs in advance would provide various benefits.

*Statisical analysis*

In order to conduct the analysis, the IBM SPSS Statistics 25 Windows Multilingual Assembly Editions application was utilized. The values for continuous variables are shown as the mean accompanied by the standard deviation, while the values for categorical variables are supplied as numbers and percentages. Chi-square analysis was used to investigate the differences that were found between the categorical variables. In addition, Pearson Correlation analysis were utilized in order to investigate the associations that existed between the continuous variables. When the two-tailed *P*-value was 0.05 or less, statistical significance was determined to have been attained.

## Results

*General information*

Between January 2015 and January 2021, a total of 677 coronary artery bypass graft (CABG) procedures and combination CABG surgeries were successfully performed. The number of male patients was 513, accounting for 75.8% of the total, whereas the number of female patients was 164, representing 24.2% (**Figure 1**). The average age of the entire patient population was 63.8 years, with a range of 22 to 87 years (see **Figure 2**). The average age of male patients was 63.2 years, while the average age of female patients was 65.8 years.

*Isolated and combined CABG operations*

A total of 490 isolated coronary artery bypass graft (CABG) surgeries were performed, accounting for 72.4% of the cases, while 187 combined CABG operations were conducted, representing 27.6% of the cases. In our study, a total of 90 combined coronary artery bypass graft (CABG) operations were performed with mitral valve replacement (MVR), 71 with aortic

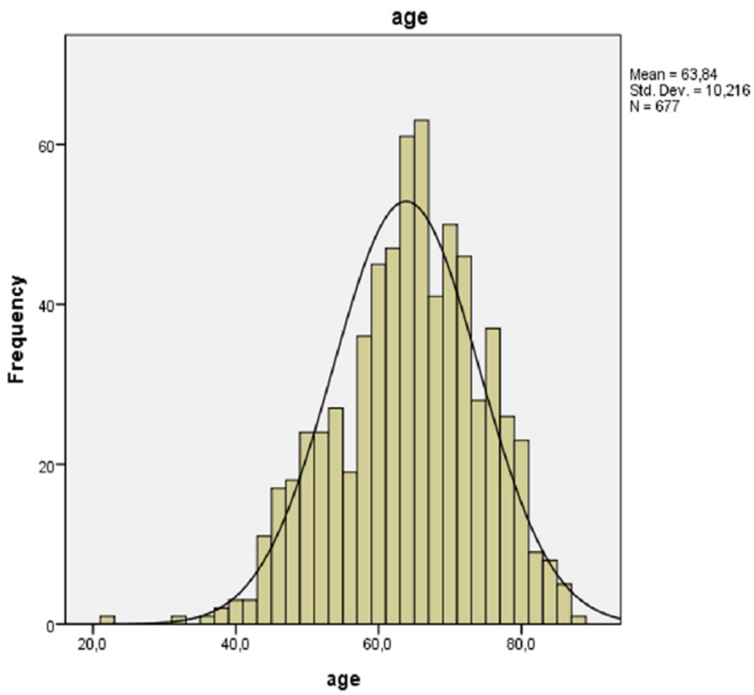


**Figure 2.** Bar graph of the age distribution.

valve replacement (AVR), 42 with tricuspid annuloplasty (TAP), 53 with ascending aortic aneurysm repair, 13 with left ventricle aneurysm repair, and 23 with carotid endarterectomy (**Table 1**).

*Number of grafts*

Based on the data regarding the number of grafts utilized in coronary artery bypass graft (CABG) procedures, it is evident that there were varying distributions among the patients. Specifically, 72 individuals (10.6%) underwent a single vessel bypass graft, while 78 patients (11.5%) received two vessel grafts. Furthermore, 209 individuals (30.9%) underwent three vessel grafting, while 214 patients (31.6%) received four vessel grafts. Additionally, 88 patients (13.0%) underwent five vessel grafting, while 14 individuals (2.1%) received six vessel grafts. Notably, one patient (0.1%) underwent seven vessel grafting, and another patient (0.1%) received nine vessel grafts, as outlined in **Table 1**.

*Chronic diseases and smoking*

A total of 387 patients were diagnosed with hypertension (HT), 303 patients with diabetes mellitus (DM), 46 patients with chronic obstructive pulmonary disease (COPD), and 49 patients with chronic renal failure (CRF). Additionally, 215 patients were identified as smokers, as shown in **Table 1**.

This study aimed to determine the average values of laboratory tests, specifically Hemoglobin, platelets, and creatinine, both before and after surgery. Additionally, we examined the durations of cardiopulmonary bypass, cross-clamp, and total circulatory arrest, and their correlation with the number of bypassed grafts. All of our procedures were performed utilizing the cardiopulmonary bypass approach, with none being conducted off-pump.

*Blood transfusions*

Blood transfusions were administered using various components such as erythrocytes, fresh frozen plasma, platelets, and fresh whole blood. The quantities of blood transfusion in units were examined and assessed, as depicted in **Table 4**. The average number of erythrocyte blood transfusions was determined to be 4.23 units, with a range of 0 to 44 units. Furthermore, the study found that the average quantity of fresh frozen plasma administered was 2.92 units, with a range of 0 to 24 units. Similarly, the mean amount of platelets transfused was 2.45 units, ranging from 0 to 14 units. Additionally, the average units of whole fresh blood transfused were 2.6 units, with a range of 0 to 8 units.

*Cardiopulmonary bypass (CPB)*

Consequently, the average duration of cardiopulmonary bypass (CPB) was found to be 145.1 minutes, with a range of 33 to 580 minutes. Similarly, the cross-clamp time was at 89.3 minutes, ranging from 18 to 334 minutes. Additionally, the total cardiac arrest time (TCA) was recorded as 32.6 minutes, with a minimum of 0 minutes and a maximum of 45 minutes.

**Table 1.** The type and disturbation of CABG operations and the data of the patients' co-morbidites

| *Types of CABG operations* | | | *Number of The Vessels* | | | *Co-Morbidity* | | | |
|---|---|---|---|---|---|---|---|---|---|
| OP | n | % | Vessel No | Frequency | % | Disease | Sex | Numb. | Total |
| Isolated CABG | 490 | 72.4% | 1 | 72 | 10.6 | HT | M | 106 | 387 |
| Combined CABG | 187 | 27.6% | 2 | 78 | 11.5 | | F | 281 | |
| CABG+AVR | 71 | 10.5% | 3 | 209 | 30.9 | DM | M | 85 | 303 |
| CABG+MVR | 90 | 13.3% | 4 | 214 | 31.6 | | F | 218 | |
| CABG+TAP | 42 | 6.2% | 5 | 88 | 13.0 | CRF | M | 12 | 46 |
| CABG+ASCEND. AORT. ANEURYSM | 53 | 7.8% | 6 | 14 | 2.10 | | F | 34 | |
| CABG+LV ANEURYSM | 13 | 1.9% | 7 | 1 | 0.10 | COPD | M | 9 | 49 |
| CABG+CAROTID EA | 23 | 3.4% | 9 | 1 | 0.10 | | F | 40 | |
| | | | | | 100 | SMOKING | M | 13 | 215 |
| | | | | | | | F | 202 | |

**Table 2.** Descriptive statistics of blood tests, cardiopulmonary bypass times, and amounts of blood transfusion

| | Minimm | Maximm | Mean ± St.dev. |
|---|---|---|---|
| Total CPB (mint) | 33 | 580 | 145.10 ± 67.29 |
| Crossclamp (mint) | 18 | 334 | 89.30 ± 48.87 |
| TCA (mint) | 0 | 45 | 32.60 ± 2.87 |
| Eritrblood (units) | 0 | 44 | 4.23 ± 3.95 |
| FFP (units) | 0 | 24 | 2.92 ± 2.52 |
| Platelets (units) | 0 | 14 | 2.45 ± 1.23 |
| Freshblood (units) | 0 | 8 | 2.60 ± 0.83 |
| preopHB (gr) | 7.90 | 18.30 | 12.65 ± 1.82 |
| postop HB (gr) | 4.80 | 9.00 | 9.75 ± 3.75 |
| preopPL | 57.00 | 781.00 | 253.33 ± 84.57 |
| postopPLT | 58.00 | 776.00 | 164.22 ± 65.34 |
| preopCreat (mg/dl) | 0.40 | 7.70 | 0.40 ± 0.78 |
| postopCreat (mg/dl) | 0.67 | 6.20 | 1.09 ± 0.69 |

*Laboratory tests*

The average hemoglobin level prior to the surgical procedure was recorded as 12.65 gr/dl, whereas the postoperative measurement indicated a decrease to 9.75 gr/dl. The average platelet count before the surgery was 253.33, which decreased to 164.22 after the surgery. Similarly, the average creatinine level before the surgery was 0.40 mg/dl, which increased to 1.09 mg/dl after the surgery (**Table 2**).

*Number of grafted vessels and blood transfusion*

Upon examining the same variables pertaining to the count of bypassed vessels, it was observed that surgical procedures involving one or two-vessel bypass grafts are often accompanied by further cardiac surgeries, such as valve replacement and ascending aortic repair, particularly in cases involving aneurysm or dissection. Hence, the blood transfusion in a single vascular bypass often exhibits a greater magnitude than first anticipated. The blood transfusion rate was seen to be greater in two-vessel grafting surgeries compared to three or four vessels bypassing grafting, owing to the same underlying cause. There was a singular instance of bypass grafting with a set of seven vessels, as well as another instance involving a set of nine vessels. In relation to the subject of vessels, it was seen that the bypasses involving vessels V2 and V9 exhibited the greatest rate of erythrocyte blood transfusion. Conversely, the bypasses involving vessels V6 and V4 had greater erythrocyte rates compared to those involving vessels V5 and V3. The study revealed that the levels of fresh frozen plasma transfusion were shown to be highest in V1, followed by V2, V6, V7, V9, V4, V3, and V5. The administration of platelets and fresh blood transfusions was not often practiced, although it was notably accomplished to a substantial extent in V1 and V2, as seen in **Table 3**.

*Blood transfusion and CBP*

Upon examining the association between blood transfusion and the cumulative durations of cardiopulmonary bypass, cross-clamp, and complete cardiac arrest, we observed noteworthy positive correlations between CPB and

**Table 3.** Descriptive statistics of the mean blood tests results, cariopulmonary bypass times and amounts of blood transfusion for all the patients and according to the vessels number

| | Minimm | Maximm | Mean ± S.d. |
|---|---|---|---|
| Total CPB (mint) | 33 | 580 | 145.10 ± 67.29 |
| Crossclamp (mint) | 18 | 334 | 89.30 ± 48.87 |
| TCA (mint) | 0 | 45 | 32.60 ± 02.87 |
| Eritrblood (units) | 0 | 44 | 04.23 ± 03.95 |
| FFP (units) | 0 | 24 | 02.92 ± 02.52 |
| Platelets (units) | 0 | 14 | 02.45 ± 01.23 |
| Freshblood (units) | 0 | 08 | 02.60 ± 00.83 |
| preopHB (gr/dL) | 7.90 | 18.30 | 12.65 ± 01.82 |
| postop HB (gr/dL) | 04.80 | 09.00 | 09.75 ± 03.75 |
| preopPL (K/uL) | 57.00 | 781.00 | 253.33 ± 84.57 |
| postopPLT (K/uL) | 58.00 | 776.00 | 164.22 ± 65.34 |
| preopCreat (mg/dL) | 00.40 | 07.70 | 00.40 ± 00.78 |
| postopCreat (mg/dL) | 00.67 | 06.20 | 01.09 ± 00.69 |

| | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V9 |
|---|---|---|---|---|---|---|---|---|
| Total CPB (minutes) | 200.23 | 138.90 | 128.19 | 170.96 | 179.47 | 226.00 | 213.00 | 118.00 |
| Crs.Clmp (minutes) | 126.50 | 78.40 | 80.00 | 100.07 | 105.20 | 122.30 | 160.00 | 70.00 |
| TCA (minutes) | 2.28 | 2.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Eritro (units) | 6.22 | 7.20 | 3.17 | 4.68 | 3.20 | 5.25 | 5.00 | 7.00 |
| FFP (units) | 5.44 | 4.10 | 2.96 | 3.68 | 2.93 | 4.00 | 4.00 | 4.00 |
| PLT (units) | 0.89 | 1.10 | 0.00 | 0.49 | 0.27 | 0.00 | 0.00 | 0.00 |
| F.BL (units) | 0.78 | 0.70 | 0.08 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 4.** Correlation between blood transfusion (erythrocyte suspension, fresh frozen plasma, platelets, and fresh blood) and total CPB time, Cross Clamp time, and TCA times

| | | Eritrblood | FFP | Platelets | Freshblood | CPB | x-clamp | TCA |
|---|---|---|---|---|---|---|---|---|
| Eritrblood | Pearson Corrln | 1.00 | 0.63** | 0.30** | 0.30** | 0.26** | 0.23** | -0.01 |
| | *p* | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.88 |
| FFP | Pearson Corrln | 0.63** | 1.00 | 0.32** | 0.37** | 0.24** | 0.26** | 0.02 |
| | *p* | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.63 |
| Platelets | Pearson Corrln | 0.30** | 0.32** | 1.00 | 0.22** | 0.15** | 0.11** | 0.09* |
| | *p* | 0.00 | 0.00 | | 0.00 | 0.00 | 0.01 | 0.02 |
| Frshblood | Pearson Corrln | 0.29** | 0.37** | 0.22** | 1.00 | 0.26** | 0.21** | 0.03 |
| | *p* | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.38 |
| Total CPB | Pearson Corrln | 0.23** | 0.24** | 0.15** | 0.26** | 1.00 | 0.92** | 0.21** |
| | *p* | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 |
| x-clamp | Pearson Corrln | 0.23** | 0.26** | 0.11** | 0.21** | 0.92** | 1.00 | 0.14** |
| | *p* | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | | 0.00 |
| TCA | Pearson Corrln | -0.01 | 0.02 | 0.09* | 0.03 | 0.21** | 0.14** | 1.00 |
| | *p* | 0.88 | 0.63 | 0.02 | 0.38 | 0.00 | 0.00 | |

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

cross-clamp durations with all categories of blood transfusion. Simultaneously, it can be shown that Total circulatory arrest (TCA) exhibited a significant correlation alone with platelet transfusion. Conversely, **Table 4** demonstrates significant positive correlations between Total CPB, Cross clamp, and TCA durations.

**Table 5.** Data of mortality according to the age, gender, vessels number of CABG and combined CABG operations

| | | | | | |
|---|---|---|---|---|---|
| Total patients | 677 | Survived | 584 (86.3%) | Mean age of survived patients | 63.0 years |
| | | Ex | 93 (13.7%) | | |
| | Male | Survived | 449 | Mean age of survived patients | 69.2 years |
| | | Ex | 64 (12%) | | |
| | Female | Survived | 135 | | |
| | | Ex | 29 (17%) | | |

| Vesse-l No | CABG type | Survived | Ex (%) | Total | | Data of combinded CABG operation mortality | |
|---|---|---|---|---|---|---|---|
| | | | | | | Survived | Ex |
| *1,0* | *Isolated CABG* | 11 | 4 | 15 | *CABG+AVR* | 53 | 18 |
| | *Combined CABG* | 48 | 9 | 57 | | | |
| | *Total* | 59 | 13 (18%) | 72 | *CABG+MVR* | 64 | 26 |
| *2,0* | *Isolated CABG* | 45 | 4 | 49 | | | |
| | *Combined CABG* | 20 | 10 | 30 | *CABG+TAP* | 28 | 14 |
| | *Total* | 65 | 14 (18%) | 79 | | | |
| *3,0* | *Isolated CABG* | 138 | 20 | 158 | *CABG+Ascend.aort.Aneyrsm* | 39 | 14 |
| | *Combined CABG* | 36 | 14 | 50 | | | |
| | *Total* | 174 | 34 (16%) | 208 | *CABG+LV aneurysm* | 12 | 1 |
| *4,0* | *Isolated CABG* | 162 | 15 | 177 | | | |
| | *Combined CABG* | 29 | 8 | 37 | *CABG+CEA* | 20 | 3 |
| | *Total* | 191 | 23 (11%) | 214 | | | |
| *5,0* | *Isolated CABG* | 71 | 5 | 75 | | | |
| | *Combined CABG* | 11 | 2 | 13 | | | |
| | *Total* | 82 | 7 (9%) | 88 | | | |
| *6,0* | *Isolated CABG* | 11 | 3 | 14 | | | |
| | *Combined CABG* | 0 | 0 | 0 | | | |
| | *Total* | 11 | 3 | 14 | | | |
| *7,0* | *Isolated CABG* | 1 | 0 | 1 | | | |
| | *Combined CABG* | 0 | 0 | 0 | | | |
| | *Total* | 1 | 0 (0%) | 1 | | | |
| *9,0* | *Isolated CABG* | 1 | 0 | 1 | | | |
| | *Combined CABG* | 0 | 0 | 0 | | | |
| | *Total* | 1 | 0 (0%) | 1 | | | |
| *Total* | *Isolated CABG* | 440 | 50 (11%) | 490 | | | |
| | *Combined CABG* | 144 | 43 (29%) | 187 | | | |
| | *Total* | 584 | 93 | 677 | | | |

*Mortality*

Based on the mortality rates seen among our patients. A total of 677 patients had surgery, of whom 93 individuals, accounting for 13.7% of the total, experienced complications. Patients who did not survive in the operating room, died in the critical care unit, or passed away on the floor before to discharge were classified as cases of mortality. The male mortality count was 64, and the female mortality count was 29. The average age at which individuals passed away was 63 years.

*Mortality and the number of grafted vessels*

The mortality rate of patients was also examined in relation to the number of bypassed blood vessels. In one vessel-isolated CABG (n=15), there were four ex-patients, while in combined-one vessel CABG (n=57), there were 9 ex-patients. There were four ex-patients in two vessels-isolated CABG (n=49) and ten in combined-two vessels CABG (n=30). Of 158 patients operated on with isolated-three vessels CABG, there were 20, and from three vessels-combined CABG, there were 14 ex-pa-

**Table 6.** Mortality, blood transfusion, and CPB, Coss-clamp, TCA times

| | | Total CPB | Cross Clamp | TCA | Eritro-cytes | FFP | PLT | F.BL |
|---|---|---|---|---|---|---|---|---|
| Ex | Mean | 153.31 | 92.45 | 0.42 | 8.69 | 6.62 | 2.23 | 1.00 |
| | Min | 63.00 | 26.00 | 0.00 | 3.00 | 2.00 | 0.00 | 0.00 |
| | Max | 340.00 | 214.00 | 23.00 | 19.00 | 24.00 | 14.00 | 8.00 |
| | Std.Dev. | 60.24 | 42.73 | 2.83 | 4.52 | 6.69 | 4.25 | 2.38 |
| Ex Male | Mean | 200.28 | 124.56 | 1.98 | 8.34 | 5.08 | 0.98 | 0.86 |
| | Min | 55.00 | 24.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Max | 440.00 | 334.00 | 45.00 | 44.00 | 24.00 | 13.00 | 8.00 |
| | Std.Dev. | 103.98 | 75.38 | 7.49 | 7.51 | 4.92 | 2.52 | 1.58 |
| Ex Female | Mean | 184.48 | 108.35 | 0.00 | 8.69 | 4.31 | 1.45 | 0.59 |
| | Min | 63.00 | 36.00 | 0.00 | 2.00 | 0.00 | 0.00 | 0.00 |
| | Max | 580.00 | 244.00 | 0.00 | 35.00 | 24.00 | 14.00 | 5.00 |
| | Std.Dev. | 97.62 | 50.79 | 0.00 | 6.53 | 4.45 | 3.31 | 1.21 |

**Table 7.** Correlation between vessels number and mortality

| Number of vessels | Correlation | Ex |
|---|---|---|
| 1 vessel | Pearson Correlation | 0.069 |
| | Sig. (2-tailed) | 0.074 |
| 2 vessel | Pearson Correlation | 0.100** |
| | Sig. (2-tailed) | 0.009 |
| 3 vessel | Pearson Correlation | 0.102** |
| | Sig. (2-tailed) | 0.008 |
| 4 vessel | Pearson Correlation | 0.004 |
| | Sig. (2-tailed) | 0.922 |
| 5 vessel | Pearson Correlation | 0.015 |
| | Sig. (2-tailed) | 0.697 |
| 6 vessel | Pearson Correlation | 0.100** |
| | Sig. (2-tailed) | 0.009 |
| 7 vessel | Pearson Correlation | 0.094* |
| | Sig. (2-tailed) | 0.014 |
| 9 vessel | Pearson Correlation | 0.094* |
| | Sig. (2-tailed) | 0.014 |

*Correlation is significant at the 0.01 level (2-tailed).
**Correlation is significant at the 0.05 level (2-tailed).

tients. In four vessels-isolated CABG (n=177), there were 15, while in four vessels-combined CABG's (n=37), there were eight ex-patients. there were four ex-patients in a total of 75 five vessels-isolated CABG and two ex-patients in 13 patients with five vessels-combined CABGs. All the six, seven, and nine vessels CABG operation were isolated. Three ex-patients from 14 patients had six vessels-isolated CABG and no mortality in seven and nine vessels CABG's which there was only one patient for each operation (**Table 5**).

Upon doing a correlation analysis between the number of bypassed vessels and mortality, a strong positive association was seen between the presence of two or three bypassed vessels and mortality. In contrast, the analysis revealed that the mortality rate was positively associated with six, seven, and nine vessel bypass procedures, although to a lesser extent (**Table 7**).

*Mortality and CBP durations*

Based on the mortality data, the average durations of cardiopulmonary bypass (CPB), cross-clamp, and total circulatory arrest (TCA) were recorded as 153.3, 192.45, and 0.42 minutes, respectively. Additionally, the quantities of erythrocyte transfusion, fresh frozen plasma transfusion, platelet transfusion, and fresh blood transfusion were reported as 8.69, 6.62, 2.23, and 1.00 units, respectively.

Ex male patients exhibited a mean cardiopulmonary bypass (CPB) duration of 200.3 minutes and a mean cross clamp time of 124.0 minutes. In contrast, ex female patients exhibited a mean CPB time of 184.45 minutes and a mean cross clamp time of 108.35 minutes.

*Mortality and blood transfusions*

Upon conducting an analysis of statistical data pertaining to mortality rates in relation to different types of blood transfusions, it was observed that individuals assigned ex-males had recieved an average of 8.34 units of erythrocytes transfusion, with a minimum of 3 units and a maximum of 19 units. Similarly, fresh frozen plasma transfusions averaged at 5.08 units, ranging from a minimum of 0 units to a maximum of 24 units. Platelet transfusions were found to average at 0.98 units, with a minimum of 0 units and a maximum of 13 units. Lastly, fresh blood transfusions were observed to average at 0.86 units, ranging from a mini-

**Table 8.** Data of the most used blood thinner drugs and their correlation with blood transfusion, revision and mortality

| Drugs | | Frequency | | Percent | | |
|---|---|---|---|---|---|---|
| | ASA | 161 | | 23.80 | | |
| | Clopidogrel | 57 | | 8.40 | | |
| | warfarin sodium | 8 | | 1.20 | | |
| | Clopidogrel+ASA | 1 | | 0.10 | | |
| | Rivaroksaban | 3 | | 0.40 | | |
| | Ticagrelor | 2 | | 0.30 | | |
| | Ticagrelor+ASA | 3 | | 0.40 | | |
| Correlation | Eritrblood | FFP | Platelets | Freshblood | Reveison | Ex |
| ASA | 0.07 | 0.10** | 0.09* | -0.05 | 0.02 | 0.02 |
| | 0.09 | 0.01 | 0.02 | 0.23 | 0.55 | 0.57 |
| Clopidogrel | 0.05 | 0.04 | -0.06 | -0.02 | -0.01 | -0.06 |
| | 0.17 | 0.31 | 0.14 | 0.61 | 0.88 | 0.11 |
| Warfarin sodium | 0.05 | 0.10** | -0.02 | -0.03 | -0.03 | 0.07* |
| | 0.25 | 0.01 | 0.57 | 0.38 | 0.42 | 0.05 |
| Ticagrelor | -0.00 | 0.02 | -0.02 | -0.03 | -0.02 | -0.03 |
| | 0.97 | 0.67 | 0.66 | 0.49 | 0.53 | 0.37 |
| Rivaroxaban | -0.00 | -0.01 | -0.01 | -0.02 | -0.02 | 0.04 |
| | 0.91 | 0.86 | 0.73 | 0.59 | 0.63 | 0.32 |

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

mum of 0 units to a maximum of 8 units. Female individuals in the study received an average of 8.69 units of erythrocyte suspension transfusion, with a range of 2 to 32 units. Additionally, they received an average of 4.31 units of fresh frozen plasma (FFP), ranging from 0 to 24 units. Platelet transfusions were administered at an average of 1.45 units, with a range of 0 to 14 units. Finally, female participants received an average of 0.59 units of fresh blood, ranging from 0 to 5 units, as shown in **Table 6**.

A total of 235 individuals had a history of blood thinner medication use prior to undergoing the surgeries. In the study, it was found that 161 individuals (23.8%) utilized asetisaliciclic acid (ASA), while 57 individuals (8.4%) used clopidogrel. Additionally, a small proportion of the participants, specifically 8 individuals (1.2%), reported using warfarin sodium. Furthermore, a minority of participants, specifically 3 individuals (0.4%), reported using rivaroxaban, while 2 individuals (0.3%) reported using ticagrelor. Moreover, a small number of participants, specifically 1 individual (0.1%), reported using clopidogrel in combination with ASA, and 3 individuals (0.4%) reported using ticagrelor in combination with ASA.

*Blood thinner medication, blood transfusion, revision, and mortality*

Upon doing a correlation analysis, we observed significant positive associations between the use of blood thinner medications and several factors including blood transfusion (kind and quantity), revision procedures, and mortality rates. Specifically, we identified strong positive relationships between the administration of ASA and the usage of fresh frozen plasma and platelets. Simultaneously, a significant association was observed between warfarin sodium and fresh frozen plasma as well as mortality, as shown in **Table 8**.

The study focused on the examination and analysis of revisions performed on patients who required a second procedure for hemorrhage control or other reasons shortly after their first surgery or during their hospital stay. Significant associations were seen between revision and mortality, total cardiopulmonary bypass (CPB) duration, cross-clamping durations, and blood transfusion, particularly in cases involving the transfusion of erythrocytes and fresh frozen plasma (as shown in **Table 9**).

## Discussion

Coronary artery bypass grafting (CABG) continues to be the primary therapeutic approach for patients with multivessel disease, with favorable long-term results and minimal incidence of complications. CABG is recommended in cases when the left main coronary artery exhibits stenosis over 50%, or when there is a presence of three-vessel disease with stenosis surpassing 70%, or alternatively, in instances of two-vessel disease involving the left anterior descending (LAD) artery and another major coronary artery.

**Table 9.** Data of revision, and correlation between revision and mortality, CPB, cross-clamp, TCA times and mortality

| Revision | n | % | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 7.3 | 6 (8%) | 8 (10%) | 19 (9%) | 12 (5%) | 3 (3.5%) | 2 (14%) | 0 | 0 |
| Correlation | | | | | | | | | | |
| | | Revision | Ex | Total CPB | Cross clamp | TCA | Eritro-cytes | FFP | Platelt | Fresh blood |
| Reveison | Pearson Correlation | 1 | 0.330** | 0.162** | 0.170** | 0.003 | 0.472** | 0.430** | 0.247** | 0.271** |
| | Sig. (2-tailed) | | 0.000* | 0.000* | 0.000* | 0.932 | 0.000* | 0.000* | 0.000* | 0.000* |

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

CABG is recommended in cases when there is a presence of one or more arteries exhibiting stenosis over 70%, accompanied with notable anginal symptoms that persist despite the implementation of medicinal interventions. Another indication for CABG in a survivor of sudden cardiac arrest with ischemia-related ventricular tachycardia is the presence of significant stenosis (more than 70%) in a single coronary vessel [4, 10].

Prior CABG surgery on a patient who presents with one or more indications for the procedure, echocardiography is conducted to assess the presence of any other cardiac pathologies that may need correction during the CABG operation. Conversely, in cases when a patient is being prepared for a cardiac pathological procedure and presents a risk of developing coronary artery disease, it is deemed necessary to conduct a cardiac angiography. As a result, a CABG surgery is done concurrently.

In urgent cases such as ascending aortic dissection, it is recommended that if any coronary artery is identified as being diseased, dissected, or damaged during the surgical procedure, CABG should be done concurrently. This approach ensures that both the aortic dissection and any compromised coronary arteries are addressed in just one operation [11]. In the case of patients who are at risk of carotid artery stenosis, particularly among the elderly population, it is recommended to do carotid doppler ultrasonography, computed tomography (CT), or magnetic resonance imaging (MRI) with contrast to assess the condition of the carotid arteries prior to surgical interventions. Assuming the presence of any indication for carotid endarterectomy. Subsequently, this procedure may be conducted before to CABG, after the surgery, or at the same session, based on the patient's medical condition and the surgeon's discretion [12]. For the purposes of this research, we only selected individuals who had carotid endarterectomy concurrently with CABG procedures.

CABG procedures may be conducted with either on-pump or off-pump techniques. In cases when there is a presence of multiple vessel disease, the use of on-pump procedures tends to occur with greater frequency [13]. In the conducted study, all surgical procedures were performed using the on-pump technique.

The duration of cardiopulmonary bypass (CPB) and cross-clamp periods might vary across different surgical procedures due to factors such as the kind of surgery, the patient's condition, the number of coronary arteries involved, and the level of expertise of the surgeons. When the duration of CPB and cross clamp exceeds a certain threshold, the adverse consequences of cardiopulmonary bypass circulation manifest, hence impacting the cardiac recovery, necessitating blood transfusions, and influencing the overall state of the patients [14].

Our objective was to investigate the correlation between mortality and several factors including cardiopulmonary bypass (CPB), cross-clamp duration, total circulatory arrest duration (if applicable), the number of coronary arteries bypassed, and the type and volume of blood transfusions.

A total of 677 individuals received CABG procedures, either as standalone operations or in conjunction with other cardiac or vascular surgeries. The number of male patients was 513, accounting for 75.8% of the total, while the number of female patients was 164, representing 24.2% (**Figure 1**). In a research done in the year 2021, a total of 6250 patients who had CABG were included. Among these patients, 4911 (78.6%) were identified as male, while 4339 (21.4%) were identified as female. The gender distribution observed in the aforementioned research closely resembled that of our own study [15].

*The average age of the patients* in our study was 63.8 years, with men having a mean age of 63.2 years and females having a mean age of 65.8 years (see **Figure 2**). A research done in 2018 examined the relationship between CABG and gender. The study findings indicated that the average age of male patients was 66, while female patients had an average age of 72 [16]. Based on the obtained findings, it is evident that the patients in our research, mostly females, exhibited a somewhat lower age at the time of undergoing CABG procedures. This observation might perhaps be attributed to the dietary habits and level of physical activity prevalent in the geographic region from which our study group was drawn.

A total of 490 individuals had isolated coronary artery bypass grafting (CABG) procedures in our study. In contrast, a total of 187 patients had surgical procedures including combined CABG with aortic valve replacement (AVR), mitral valve replacement (MVR), thoracic aortic aneurysm repair (TAP), ascending aortic aneurysm repair, left ventricular aneurysm repair, and carotid endarterectomy.

The highest number of combined CABG procedures was seen in patients undergoing mitral valve replacement (MVR), with a total of 90 cases. This was followed by aortic valve replacement (AVR) with 71 cases, and tricuspid valve repair or replacement (TAP) with 42 cases. The total number of surgeries performed with the combination of CABG with ascending aortic repair was 53. Additionally, there were 23 carotid endarterectomies and 13 left ventricular aneurysm repairs conducted.

Numerous research have been dedicated to examining the efficacy and outcomes of *combined coronary artery bypass graft (CABG)* procedures. In a research undertaken in 2010, a total of 120 combined coronary artery bypass graft (CABG) surgeries were examined, among which 45 cases had the contemporaneous performance of mitral valve repair (MVR). The research conducted included a total of 59 AVR surgeries, as well as two TAP operations [17]. In the conducted investigation, it was observed that the rate of MVR procedures was greater in the aforementioned case.

Typically, the performance of individual CABG procedures included their combination with other surgical interventions, most often valve replacements and repairs of aortic aneurysms. The procedure of nine-vessel bypass grafting is seldom seen and considered to be an uncommon occurrence. There was a singular instance in which we performed a surgical procedure known as CABG on a patient with nine vessels. Additionally, there was a single instance with a group of seven vessels. Hence, the most often conducted procedures were four-vessel CABG surgeries. A total of 214 CABG procedures were conducted, using four-vessel grafts.

As the quantity of bypassed vessels escalates, there is a corresponding increase in both the duration of cardiopulmonary bypass and cross-clamp times. Concurrently, the detrimental impacts of prolonged cardiopulmonary bypass time become more pronounced, particularly with regards to the hemostatic status. Consequently, there appears to be an augmented requirement for postoperative blood transfusions.

*The average cardiopulmonary bypass (CPB) duration* for all categories of coronary CABG procedures was found to be 145.10 minutes. Specifically, the mean duration of cross-clamp application throughout these procedures was 89.30 minutes, while the mean duration of total circulatory arrest (TCA) was 32.60 minutes. A present research included a comprehensive analysis of patient data spanning the period from 1990 to 2003, specifically focusing on individuals who had heart surgery. A total of 28,684 patients were included in the study cohort. The primary CPB duration was found to be 89 ± 30 minutes in patients with left ventricular ejection fraction (LV EF) more than 40, and 98 ± 32 minutes in patients with LV EF less than 40. Additionally, the primary cross-clamping time was observed to be 66 ± 22 minutes in patients with LV EF greater than 40, and 68 ± 20 minutes in patients with LV EF less than 40 [18]. There exist notable distinctions between our research and the aforementioned studies with regards toCPB and the duration of cross-clamping. The observed variations in outcomes might potentially be attributed to factors such as the quantity of blocked arteries during CABG procedures or the specific types of cardiac surgeries performed. In our investigation, the relationship between left ventricular ejection fraction (LV EF) and cardiopulmonary bypass (CPB) and cross-clamping periods has not been investigated.

*The administration of blood transfusion* included the provision of erythrocyte suspension, fresh frozen plasma, platelets, and fresh blood. The average quantity of erythrocyte suspension administered to the patients was 4.23 units. When comparing the quantities, it was seen that there were 2.92 units of fresh frozen plasma, 2.45 units of platelets, and 2.60 units of fresh blood transfusion. Based on the blood tests conducted before to and after the surgical procedures, it was determined that the average hemoglobin (HB) level prior to the surgery was 12.65 gr/dl, which decreased to 9.75 gr/dl postoperatively. Similarly, the mean platelet count was found to be 253.33 prior to the operation, which decreased to 164.22 postoperatively. During the literature review, a study done in 2018 including a sample size of 117 individuals was identified, whereby blood test data were also examined. The research revealed a preoperative mean HB value of 13.20, which decreased to 10.70 postoperatively. Based on our analysis of the blood transfusion data pertaining to quantities and kinds, it was observed that patients who had a combination CABG procedure involving two arteries received a greater volume of erythrocyte suspension compared to those who underwent a CABG procedure including nine veins. The administration of fresh frozen plasma and fresh blood was often seen in cases of combined CABG surgeries involving one or two arteries. In contrast, patients who had bypass grafting procedures involving six, seven, or nine vessels did not get platelet transfusions or fresh blood.

The average CPB time was recorded to be 144.04 minutes. The few variations seen in our research findings might perhaps be attributed to a smaller sample size [18]. The majority of single-vessel or two-vessel CABG procedures were performed in conjunction with other surgical operations. Consequently, it is evident that the durations of CPB, cross-clamp, and TCA were often longer in these cases compared to those with multiple vessel CABGs. In contrast, the average duration of CPB and cross-clamp time was seen to be longer in the sixth vessel CABG procedures compared to single vessel operations, as elucidated before. The duration taken for the TCA was shown to be the longest in both V2 and V1 due to same underlying factors.

There were notable associations between blood transfusion types and quantities and the durations of CPB, aortic cross-clamp, andTCA. An observed correlation exists between the administration of fresh frozen plasma and an increase in erythrocyte transfusion. Similarly, a similar relationship may be seen between platelet transfusion and the use of fresh blood. The most strong positive correlation was seen between erythrocytes and fresh frozen plasma blood transfusion. Conversely, as the duration of CPB and cross-clamping increases, there is a corresponding rise in the quantities of erythrocytes, fresh frozen plasma, platelets, and fresh blood.

*The in-hospital mortality rate* for patients who had CABG was found to be 13.7%, with a total of 93 out of 677 patients died during their hospital stay. The population of ex males accounted for 64 individuals, representing 12% of the total, whilst the female population consisted of 29 individuals, or 17% of the total. The average age at which individuals passed away was 63 years. A retrospective research conducted in 2007 examined a cohort of 215 patients who had undergone CABG procedures. The study found no statistically significant disparities in post-CABG mortality based on gender [19, 20]. In our investigation, we observed a greater mortality rate among females compared to men, despite a bigger number of male patients.

There is no exponential rise in mortality associated with the number of bypassed vessel grafts. When examining the relationship between the number of bypassed vessels and mortality, it was shown that patients with one, two, and three bypassed vessels had a significantly higher mortality rate throughout their hospital stay compared to those who underwent the more often conducted four-vessel bypass grafting procedure. However, it should be noted that the mortality rate among patients who had six-vessel coronary artery bypass grafting (CABG) was much higher. There were no instances of death seen in patients who had seven and nine vessel coronary artery bypass graft (CABG) procedures. However, it is important to note that the findings of this study may not accurately represent the true association owing to the limited sample size of patients included.

Patients with combined CABG operations had a higher mortality rate than those with isolated CABGs.

The mortality rate among patients who had undergone isolated and combined CABG procedures was shown to be elevated among those who had been prescribed blood thinning medications, particularly warfarin sodium, despite discontinuing the drug 3-5 days before to surgery. Additionally, the patients who were scheduled for revision surgery as a result of significant bleeding or other factors had a greater mortality rate compared to those who did not need revision. The data indicates a significant positive correlation between revision rates and CPB duration, cross-clamp periods, as well as all categories of blood transfusion. Moreover, a significant association was seen between mortality rates and the quantity of bypassed blood vessels. The revision rate was found to be greatest in the six-vessel CABG procedure, whereas the two and three-vessel CABGs exhibited greater revision rates compared to the four and five-vessel CABGs.

## Conclusion

The mortality rate and blood transfusion need are greater in combined CABG procedures compared to solitary CABG surgeries. There is often no correlation between the rise in the quantity of bypassed vessels and an increase in death rates. The rate of revision is found to be greatest in the context of six-vessel bypass procedures, although the magnitude of increase seen in two-vessel and three-vessel bypasses surpasses that of four-vessel and five-vessel bypasses. The use of ASA prior to surgery is often linked to an elevated need for fresh frozen plasma and platelets. Simultaneously, the administration of warfarin sodium necessitates an augmented need for fresh frozen plasma transfusion and is correlated with a heightened mortality risk in comparison to other anticoagulants.

There were notable associations seen between the kinds and quantities of blood transfusions and the cumulative durations of cardiopulmonary bypass (CPB), aortic cross-clamp, and total circulatory arrest (TCA) periods. An increase in both the duration of cardiopulmonary bypass (CPB) and the time taken for cross-clamping is associated with an elevation in the quantities of erythrocytes, fresh frozen plasma, platelets, and fresh blood transfusion required.

## Disclosure of conflict of interest

None.

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