https://doi.org/10.48047/AFJBS.6.7.2024.1042-1058

An On-Pump Versus Off-Pump Coronary Artery Bypass Graft Regarding Postoperative bleeding and need for Blood Transfusion.

Mahmoud Gamaleldin Ali[1], Ahmed Adas[2], Mohamed Allam[1], Mohamed Mohamed Abdelraouf Khalil[1], Ahmed Mohamed El-Ashkr[2], Ibrahim Ahmed[1]

[1] Cardiothoracic Surgery Department, Faculty of Medicine, Cairo University, Cairo

[2] Cardiothoracic Surgery Department, Faculty of Medicine, Benisuef University, Giza
Corresponding Author: Ahmed Adas

Email:
Dr.ahmed_cts@hotmail.com

Volume6, Issue7, June 2024

Received: 25 April 2024

Accepted: 03 june 2024

Published:20 June2024

doi:10.48047/AFJBS.6.7.2024.

1042-1058

Abstract:

Background: When performing coronary artery bypass grafting (CABG) surgery, the utilization of cardiopulmonary bypass (CPB) is included, the rate of blood transfusions is higher than when off-pump CABG. (Few research, meanwhile, have explicitly looked at intraoperative hemodilution as a potential contributory factor. **Aim**: Examining the effects of off-pump coronary artery bypass grafting and cardiac pulmonary bypass grafting, two alternatives to traditional CABG, on postoperative hemorrhage and the need for RBC transfusions is the primary goal of this research. **Patients and methods.** Two hundred patients who had isolated coronary artery bypass graft (CABG) procedures performed by the Cardio-Thoracic Surgery Department at Benisuef University's Faculty of Medicine from August 2018 through September 2023 were the subjects of this retrospective study. **Results:** Statistical analysis including (age, sex distribution, BSA, and history of HTN and DM) demonstrated no statistically significant difference in demographics between the two groups. When comparing group 1 off-pump CABG to group on-pump CABG, our data indicated that there was a significant decrease in intensive care unit and hospital stays, with a p-value of less than 0.001. Furthermore, statistically insignificant differences were reported between both groups regarding the incidence of re-opening (4% in group 1 vs 5% in group 2), infection (3% vs. 4%), and mortality (1% vs 2 %). **In conclusion,** CPB does not operate as an independent variable that increases the likelihood of receiving more transfusions of blood and is not linked to heightened postoperative bleeding in cases of solitary CABG. Nevertheless, an elevated intraoperative hematocrit (Hct) level is linked to a decreased need for red blood cell (RBC) transfusions, a lower likelihood of reoperations due to bleeding, and decreased postoperative drainage. Effectively managing the dilution of blood during surgery is a critical consideration for minimizing problems associated with cardiopulmonary bypass.

Keywords: cardiopulmonary bypass, coronary artery bypass grafting, hemodilution, off-pump coronary artery bypass, blood transfusion

Introduction:

Cardiopulmonary bypass (CPB) has been used to perform most heart surgeries. By allowing the heart to stop beating and creating a bloodless field, The primary objective of cardiopulmonary bypass is to enable cardiac and thoracic aortic surgeries by temporarily removing the heart and lungs from circulation while ensuring sufficient gas exchange and systemic organ perfusion. Carrying out CABG operations when the individual's heart continues to pump blood with no cardiopulmonary resuscitation (CPB). In regards to postoperative complications, there's no substantial difference between patients receiving on-pump CABG and those getting off-pump CABG, adequate restoration of blood flow to the heart, and quality of blood vessels used for grafting, studies generally show that patients operated using CPB receive more blood transfusions.[1]

Potential complications of transfusions include transfusion responses, wound infections, sepsis, and an elevated risk of mortality during hospitalization due to homologous blood products are linked to morbidity. Due to these concerns, there are broad guidelines to reduce the need for blood transfusions.[2]

The cause of the higher transfusion rate seen with CPB is uncertain, as it is not obvious whether it is due to more dilution of blood during surgery or increased bleeding after the operation. There is a lack of research explicitly investigating the impact of intraoperative hemodilution on transfusion rates in CABG surgery.[3]
Comparing on-pump vs off-pump coronary artery bypass grafting (CABG) procedures in terms of blood transfusion and bleeding rates was the primary goal of this research. Postoperative bleeding and the need for red blood cell (RBC) transfusions were also intended to be examined in relation to the use of cardiopulmonary bypass (CPB) or off-pump coronary artery bypass grafting (CABG).

Patients and Methods:

This study looked back at two hundred individuals who had isolated CABG procedures done at the cardiothoracic surgery department, Faculty of Medicine, Benisuef University, from August 2018 to September 2023.

Inclusion criteria:

Patients who underwent isolated CABG.

Exclusion criteria:

Patients with Reduced systolic LV function (EF less than 40%)

Redo cases, concomitant cardiac surgery.

history of anemia or Bleeding tendency,

Emergency CABG

Chronic kidney diseases stage III or above

The patient has liver disease, specifically active chronic hepatitis or cirrhosis. In all, 200 individuals who were able to meet the requirements were enrolled in the research. The participants were divided into two groups using a random assignment.

Group 1: patients who underwent off-pump CABG comprised 100 patients.

Group 2: One hundred individuals had coronary artery bypass grafting by CBP.

- The preoperative factors studied included the patient's age, gender, body surface area (BSA), and Euroscore II.
- The intraoperative data included the count of grafts, the duration of bypass, and the coronary computed tomography (CCT) measurements.
- Postoperative variables included chest tube drainage, blood transfusion, ventilation time, and CICU stay.
- Postoperative hospital stays.
- Complication rates (dialysis, stroke, reoperations, Infections, operative mortality).

Anesthesia Management

Cardiopulmonary bypass (CPB) and off-pump groups of patients having bypass grafting of the coronary arteries had identical anesthetic regimens. A combination of oral lorazepam, morphine, and metoclopramide was prescribed prior to treatment. The patient was given oxygen through a facemask while being administered fentanyl, pancuronium, and midazolam to induce sedation. The patients were provided with mechanical ventilation using pure oxygen until the level of carbon dioxide in their exhaled breath reached 30–35 mmHg. Anesthetic maintenance before and after cardiopulmonary bypass (CPB) involved the use of either isoflurane or sevoflurane. The utilization of whole intravenous anesthesia was infrequent.

Anticoagulation Management

Before starting cardiopulmonary bypass (CPB), patients were given a bolus dose of 300-400 IU/kg of heparin to achieve an active clotting time (ACT) of 400 seconds or above. In cases when more heparin was required, it was given during cardiopulmonary bypass. In order to keep the active clotting time (ACT) of the OPCAB group between 250 and 350 seconds, 150 IU/kg of heparin had to be administered prior to the internal mammary artery separation. To counteract the anticoagulant qualities of heparin, protamine was administered after CPB was stopped or anastomoses were finished in patients receiving OPCAB.

Surgical Technique:

A sternotomy incision was used to perform the off-pump CABG surgery. Octopus was used to stabilize the target coronary artery. A perfusionist was available in case the emergency institution of CPB was necessary.

On pump CABG, the patient was routinely prepped on the table, following the WHO checklist. Median sternotomy was performed, and the conduits were harvested. The aorta and right atrium were cannulated following heparin. Once on full bypass, the ventilation was discontinued. We kept the patient warm for the bypass.
Easy diastolic cardiac arrest was achieved by inserting the cross-clamp and injecting 1 liter of warm blood cardioplegia into the aortic root.
Further, antegrade doses were given every 20 minutes or so.
The findings were as above. The bottom end grafts were performed with 7/0 Surgipro and the top ends were performed once the cross clamp was removed, with 6/0 Surgipro using a side-biting clamp applied to the aorta.
Once the clamp was removed, sinus rhythm and hemodynamic stability were observed.
The heart was weaned easily off bypass once ventilation was recommenced, and atrial pacing wires were applied to the heart.
Protamine was then given, followed by generalized hemostasis of the mediastinum. The chest was closed routinely with a left pleural drain and a mediastinal drain. The sternum was closed with sternal wires.

Postoperative Care

. Our routine post-operative CICU Protocol was followed regardless of the technique used for the grafting.

Transfusion protocol

Patients having Pump CABG and off-Pump CABG surgery were considered for the administration of homologous packed red blood cells (RBCs) based on their clinical status and hemoglobin levels.

Results:

At the Cardio-Thoracic Surgery department of Benisuef University's Faculty of Medicine, This study comprised a total of 200 individuals who underwent isolated coronary artery bypass grafting (CABG). A total of one hundred patients received off-pump coronary artery bypass grafting (CABG), whereas another one hundred patients underwent on-pump CABG. The assignment of patients to each group was done randomly. During the follow-up period, a statistical analysis was conducted on every patient. [Figure 1]

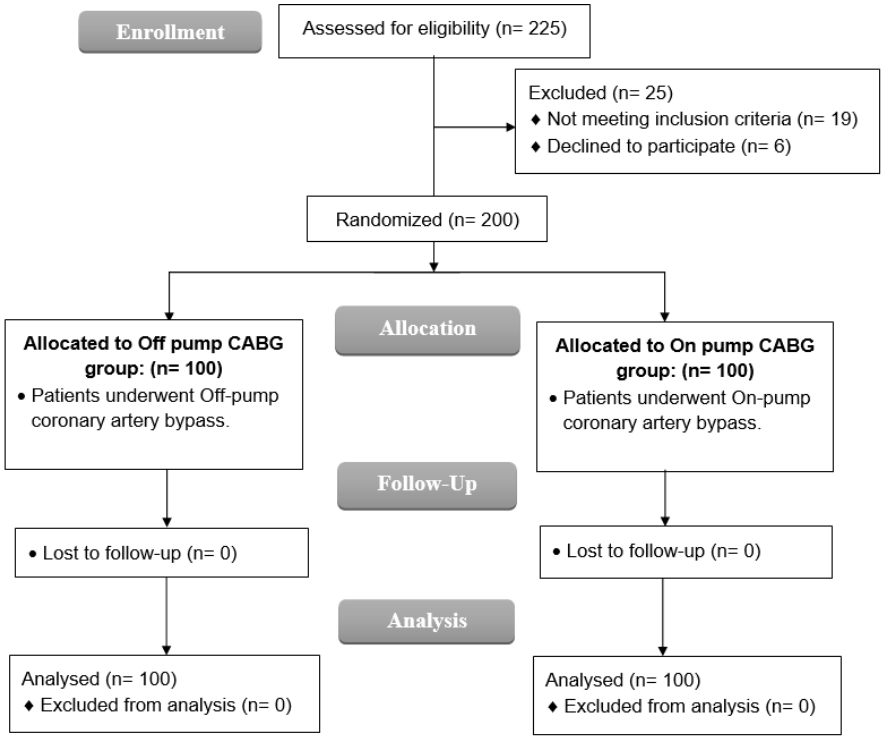

Figure 1: CONSORT flowchart

Table 1: Baseline features of the organizations under investigation

Item		Off-pump CABG (n=100)	On-pump CABG (n=100)	P-value
Age (years)		57 (49 - 62)	58 (48 - 66)	0.528
Sex	**Male**	67 (67%)	55 (55%)	0.082
	Female	33 (33%)	45 (45%)	
BSA (m^2)		1.9 (1.8 - 2)	1.9 (1.8 - 2)	0.446
HTN		49 (49%)	53 (53%)	0.572
DM		61 (61%)	56 (56%)	0.473
Pre Echo EF (%)		48 (44 - 52)	46 (43 - 52)	0.304
Pre Hb (g/dL)		12 (11 – 12.75)	11.5 (11 - 13)	0.239
Pre HCT (%)		36 (33 - 39)	35.5 (33 - 39)	0.067

Body surface area (BSA) is a measure of a person's surface area, and numerical data is shown as median (IQR) and categorical data as frequency (%). HT: High blood pressure, diabetes mellitus (DM), and Ejection fraction; Hb stands for hemoglobin, while HCT stands for hematocrit.

Table 1 shows that Regarding demographics, including age, sex distribution, body surface area (BSA), and history of hypertension (HTN) and diabetes mellitus (DM), There were insignificant differences of statistical significance seen between the two groups. Furthermore, there was statistically insignificant disparity observed between the two groups when examining baseline EF, Hb, and HCT.

Table 2: Operative data of the studied groups

Item	Off-pump CABG (n=100)	On-pump CABG (n=100)	P-value
Cross clamp time (min)	---	60 (45 – 60)	---
Bypass time (min)	---	80 (65 – 90)	---
Grafts	3.07 (2 - 4)	3.31 (2 - 4)	**0.4224**
Total operative time (min)	190 (180 - 200)	222.5 (210 - 260)	**<0.001***
Lowest Hb (g/dL)	9 (8 - 10)	8 (7 - 9)	**0.001***
Lowest HCT (%)	27 (24 - 30)	24 (21 - 27)	**0.001***

On pump, the CABG group had a median cross-clamp time of 60 (IQR 45, 60) min and bypass time of 80 (IQR 65, 90) min.

There was statistically insignificant difference in the total number of grafts between the two groups when comparing the Off-pump CABG group to the on-pump CABG group (P=0.4224). The off-pump CABG group also required much less time to complete the procedure compared to the on-pump CABG group (P<0.001). In addition, the off-pump CABG group showed substantially greater hemoglobin (Hb) and hematocrit (HCT) levels during the entire surgical operation in compared to the on-pump CABG group (P=0.001). **[Table 2, Figure 2 - Figure 5]**

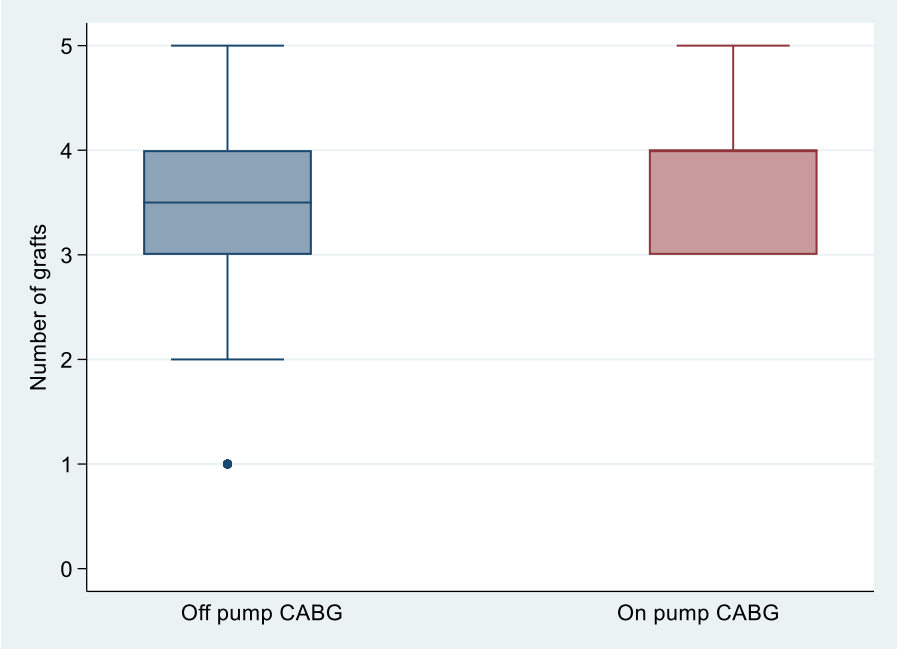

Figure 2: Number of grafts used in the studied groups

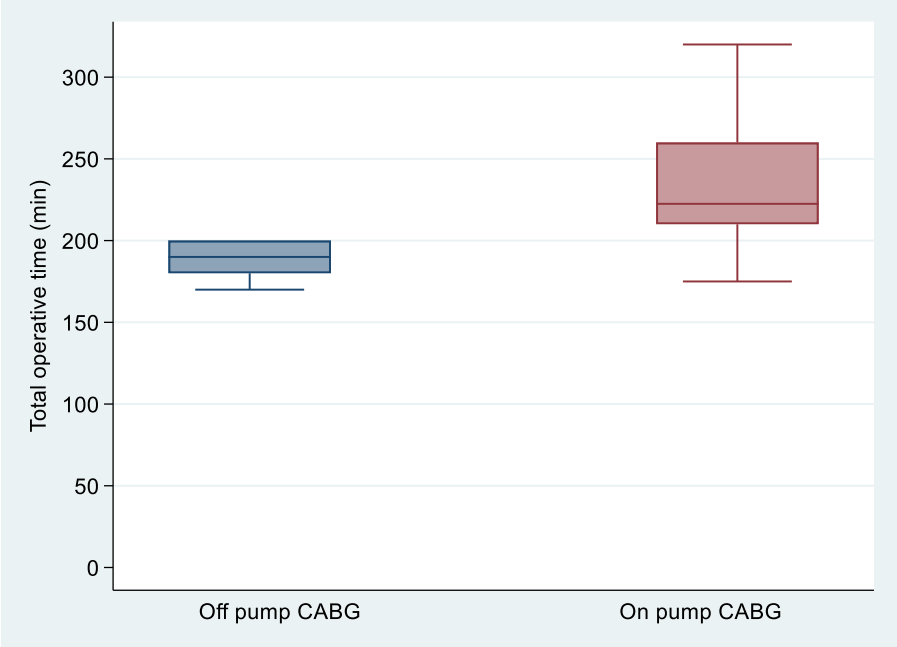

Figure 3: Total operative time of the studied groups

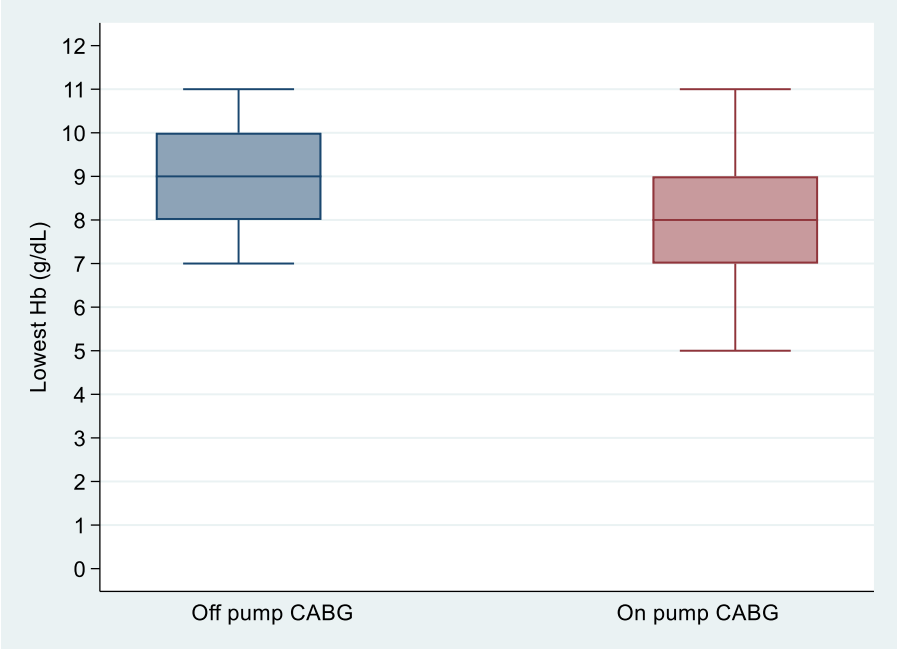

Figure 4: Lowest intraoperative Hb of the studied groups

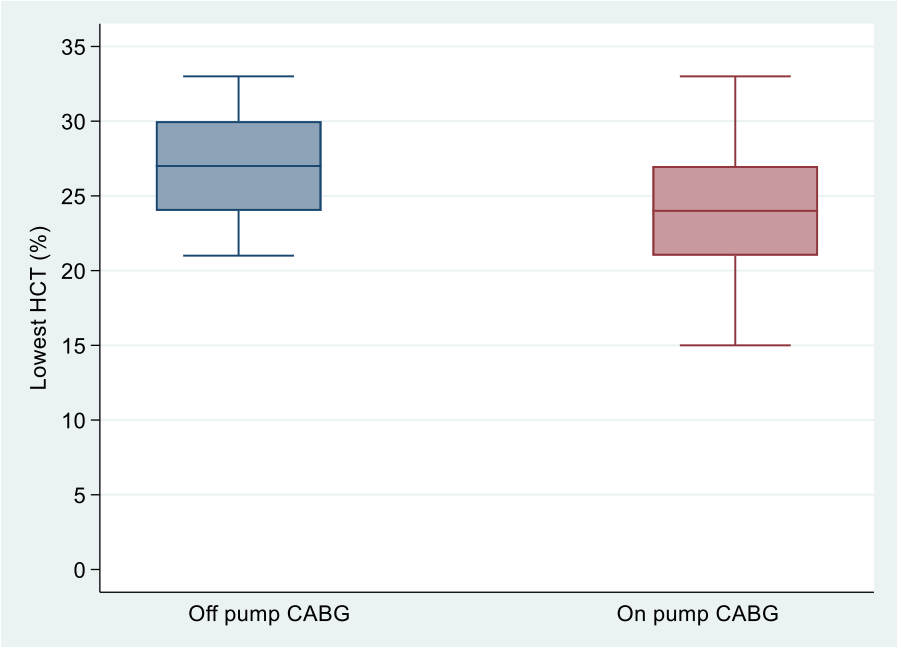

Figure 5: Lowest intraoperative HCT of the studied groups

Table 3: Postoperative data of the studied groups

Item	Off-pump CABG (n=100)	On-pump CABG (n=100)	P-value
Chest tubes drain (ml)			
6 h	300 (200 - 400)	400 (300 - 500)	**<0.001***
12 h	450 (400 - 500)	650 (500 - 700)	**<0.001***
Total drain	600 (500 - 700)	825 (600 - 900)	**<0.001***
Hb (g/dL)	9 (8 - 9)	9 (8 - 10)	0.575
HCT (%)	27 (24 - 27)	27 (24 - 30)	0.485
Blood product transfusion			
Fresh blood	80 (80%)	82 (82%)	0.718
	1 (1 - 2)	2 (1 - 2)	0.4
Packed	70 (70%)	58 (58%)	0.077
	1 (1 - 2)	2 (1 - 2)	**0.001***
FFP	12 (12%)	39 (39%)	**<0.001***
	2 (2 - 2)	2 (1 - 2)	**0.011***
Platelets	11 (11%)	27 (27%)	**0.004***
	24 (12 - 24)	12 (12 - 24)	0.328

In comparison to the on-pump CABG group, the off-pump group experienced a significant decrease in chest tube outflow at six and twelve hours post-surgery (P<0.001). When compared to the on-pump CABG group, the off-pump group showed significantly less total drainage (P<0.001). Both groups had similar hemoglobin and hematocrit levels. The percentage of patients requiring packed red blood cells (70% vs. 58% in the on-pump CABG group) or fresh whole blood (80% in the off-pump CABG group vs. 82% in the on-pump CABG group) did not differ statistically. Transfusions of packed red blood cells were significantly lower in the off-pump CABG group compared to the on-pump CABG group (P=0.001). In addition, when comparing the Off-pump CABG group to the on-pump CABG group, there was a notable decrease in the percentage of patients needing Fresh Frozen Plasma (FFP) and Platelets (PLT) (12 percent vs. 39 percent) and 27 percent, respectively (P<0.001, 0.004). The amount of FFP units delivered was also considerably higher in the Off-pump CABG group (P=0.011). **[Table 3, Figure 6 - Figure 7]**

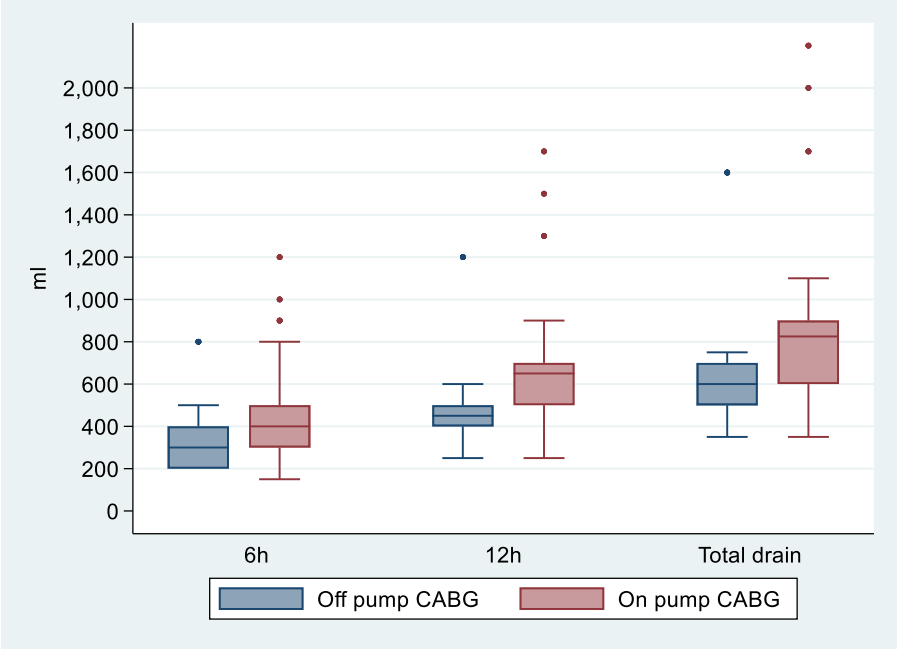

Figure 6: Chest tubes drain in the studied groups

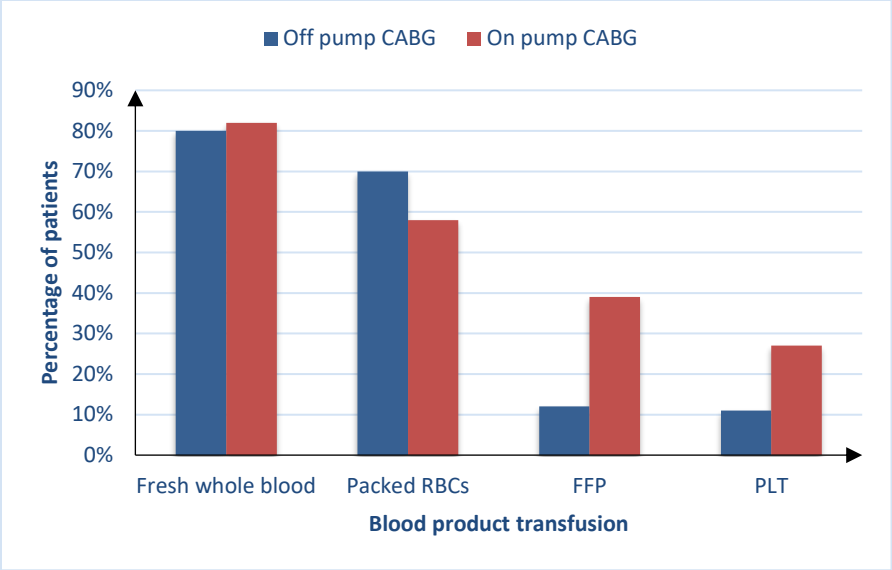

Figure 7: Blood product transfusion in the studied groups

Table 4: Outcome of the studied groups

Item	Off-pump CABG (n=100)	On-pump CABG (n=100)	P-value
ICU stay (days)	2 (2 - 3)	3 (2 - 3)	**<0.001***
Hospital stay (days)	3 (3 - 4)	7 (6 - 9)	**<0.001***
Re-opening	4 (4%)	5 (5%)	>0.999
Deep sternal wound infection	3 (3%)	4 (4%)	>0.999
Mortality	1 (1%)	2 (2%)	>0.999

The off-pump CABG group had considerably shorter hospital and ICU stays than the on-pump CABG group (P<0.001). Death rate, reopening, deep sternal wound infections, and mortality were insignificantly different between the two groups. **[Table 4, Figure 8]**

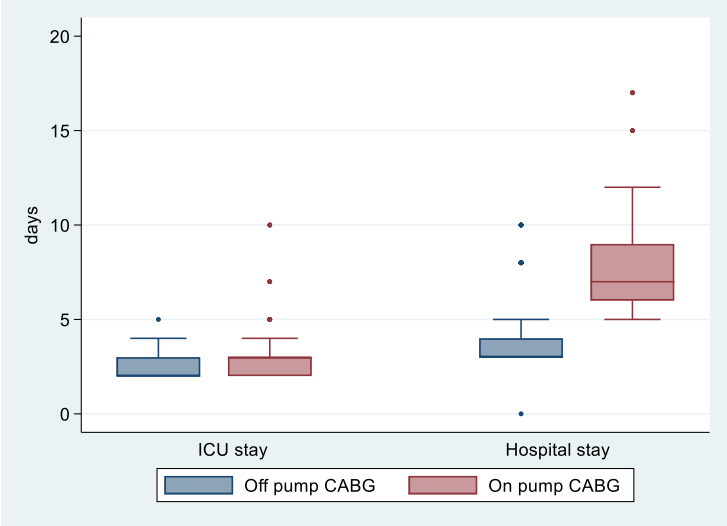

Figure 8: ICU and hospital stay of the studied groups

Table 5: Overall survival analysis of the studied patients according to type of CABG surgery

	N of events (%)	N censored (%)	Mean (days)	HR (95%CI)	Log-rank P value
Off pump CABG (n=100)	1 (1%)	99 (99%)	9.9	0.97 (0.08 to 11.68)	0.978
On pump CABG (n=100)	2 (2%)	98 (98%)	16.18	Ref	

HR: Hazard ratio, CI: Confidence interval

Kaplan-Meier analysis using a log-rank test yielded these findings. The type of CABG surgery had no statistically significant impact on the survival of patients. **[Table 5, Figure 9]**

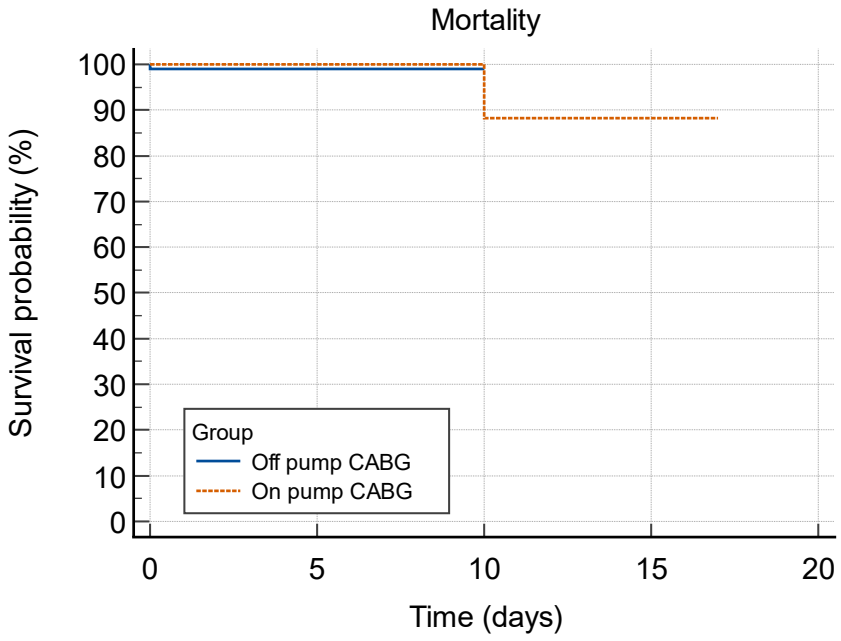

Figure 9: Kaplan Meier curve for overall survival analysis according to type of CABG surgery.

Discussion:

Cardiothoracic surgeons fervently debate the use of cardiopulmonary bypass or cardioplegia in coronary artery bypass grafting (CABG) surgeries, as opposed to those that do not. The main point of this discussion is to evaluate the effectiveness of two types of bypass coronary artery grafting: on-pump CABG, which uses a heart-lung machine, and off-pump CABG, which does not. This analysis synthesizes information from a large number of clinical trials that compare two surgical approaches: Off-pump coronary artery bypass grafting (OPCABG) and standard coronary artery bypass grafting (CABG) are two surgical procedures used to treat coronary artery disease. Trials encompass several research methodologies, including large retrospective studies, randomized trials, and meta-analyses. These investigations analyze different facets of both processes.4

The two groups were insignificantly different on the following variables: age, gender distribution, body surface area (BSA), and prior experience with hypertension (HTN) or diabetic mellitus (DM). Before an echo happened, Both of the groups did not vary in

terms of EF. Further, the pre-operative hemoglobin (Hb) and hematocrit (HCT) levels of both groups were not significantly different (p=0.016); the first group had off-pump bypass grafting of the coronary arteries (OPCAB), and the second group had on-pump coronary artery bypass grafting (CBP). The age, gender, and distribution of risk factors were not significantly different between the two groups, which is in line with the findings of El Naggar et al. 5.

The ongoing inquiry Group 2 (CBP) patients required an average of 60 minutes (IQR 45-60) to cross-clamp and 80 minutes (IQR 65-90) to bypass. The second group on-pump CABG and the first group off-pump CABG had the same number of grafts (P=0.4224), and Group One had a much shorter overall operating time (P<0.001). Furthermore, when contrasted with the second group, group 1 generated higher intraoperative hemoglobin and hematocrit (HCT) levels (P=0.001). El Naggar et al.5 found that the on-pump group received more blood transfusions, arterial grafts, total transfusions, and colloids and crystalloid transfusions than the off-pump group. The number of anastomoses was equal across the two groups, but the operating times for the off-pump CABG group were somewhat longer (183 vs. 169 min), according to Carmona et al. 10. Operating time had no effect on mortality rate in the off-pump CABG group, despite the fact that total operating time is a demonstrated independent predictor of cardiac operation mortality. This is probably due to the extensive multi-vessel revascularization and the presence of several peripheral anastomoses. The off-pump group had a much higher chance of serious adverse events (SAE) than the on-pump group (11.7 percent vs. 1.7 percent, P=0.030), even though there was no change in the death rate after 30 days.

Compared to group 2 on-pump CABG, group 1 off-pump CABG had less chest tube drainage after 6, 12 hours and total drain (P <0.001 correspondingly)). The two groups' hemoglobin and hematocrit levels were similar. Group 2 had an 82% higher rate of fresh entire blood transfusion and a 70 percent lower rate of packed red blood cell (RBC) transfusions. Nonetheless, the amounts and percentages of packed red blood cell (RBC) transfusions required by patients in the two groups differed significantly from one another. Significant (P=0.001). Alternatively, when compared to group 2, group 1 had a reduced percentage of patients requiring FFP (12% vs. 39%) and PLT (11% vs. 27%) (P<0.001, 0.004), while group 1 had a significantly larger number of FFP units transfused (P=0.011). Remarkably, research by Potger et al.8 showed that surgical blood loss is independently associated with the lowest intraoperative hematocrit (Hct) level. Lower rates of bleeding were shown to be related to greater intraoperative Hct values, which suggest less blood dilution. Platelets, plasma proteins, coagulation factors, and all other components of blood are diluted when hemodialysis is performed. This could exacerbate coagulopathies that develop after surgery. Patients who had on-pump or off-pump treatments did not have significantly different amounts of chest drainage after surgery,

according to Potger et al. 8. Blood loss was lower in OPCAB patients after 12 hours. One probable reason might be that the off-pump group had lower heparin levels.

The first group of people who had off-pump coronary artery bypass grafts spent a lot less time in a hospital and critical care unit than the second group ($P<0.001$). Neither group differed significantly from the other with respect to mortality, re-opening, infection rates, or dialysis. (El Naggar et al., 2015). The off-pump group discharges patients from the hospital at a faster rate (4.5 ± 3 days) when contrasted with the on-pump group (9 ± 5 days, $P < 0.01$). Postoperative problems were more common in the on-pump CABG group compared to the off-pump CABG group overall. Also, 200 patients were randomly assigned to either on-pump or off-pump CABG in a single institutional experiment carried out at Emory University. Overall trial quality, surgery time, wound infection, failure, and dialysis were insignificantly different between the two groups. The off-pump CABG group received an average of 3.4 ± 1.0 grafts (P: NS), in contrast to the standard CABG group which, on average, received 3.4 ± 1.1 grafts per patient. As a result, there was little to no difference in the amounts of revascularization between the research groups. Compared to the conventional CABG group, patients undergoing off-pump CABG were less likely to require red blood cell transfusions following surgery (26% vs 44%, P: 0.07). Complete revascularization was achieved by the authors using the OPCABG method with reduced myocardial damage, transfusion requirements, and duration of hospital stay. According to research by Carmona et al. 10, patients who underwent off-pump coronary artery bypass grafting had shorter hospital and critical care unit stays and needed fewer blood transfusions. Additionally, these results are backed by our findings.

Both forms of CABG operations did not correlate with patient survival in a statistically meaningful way. Consistent with these results, Lamy et al.7 reported greater death rates in the CBP group. Yet, within two days following myocardial infarction, the majority of deaths in the On Pump group occurred. However, there was no statistically significant difference in mortality rate among patients who underwent surgery more than 2 days following a myocardial infarction. However, those who underwent standard CABG had a substantially reduced risk of dying later on. If a patient needs emergency surgery and can get the treatment done within 48 hours of their symptoms starting, the off-pump CABG technique is better than the usual one. There was no difference in the groups' postoperative survival rates, which is in agreement with our findings and those of Zubarevich et al. 9. For different patient populations, the off-pump CABG method proved just as safe, if not safer, in terms of mortality. After analyzing nearly 2,000 individuals in a propensity score-matching analysis, Carmona et al. found no statistically significant difference in death.

When deciding between on-pump and off-pump CABG surgery, it is essential to weigh the benefits and dangers of each method for each individual patient, taking into account

factors such as postoperative bleeding and the necessity of blood transfusions. When determining whether to use on-pump or off-pump techniques for coronary artery bypass grafting (CABG), it is crucial to take into account each patient's specific clinical circumstances and treatment goals. A possible advantage of off-pump CABG is a decrease in bleeding and transfusion need.

References:

1. Zubarevich A, Kadyraliev B, Arutyunyan V, Chragyan V, Askadinov M, Sozkov A, Ponomarev D, Zyazeva I, Sá MP, Osswald A, Tsagakis K. On-pump versus off-pump coronary artery bypass surgery for multi-vessel coronary revascularization. Journal of thoracic disease. 2020 Oct;12(10):5639.
2. Lu L, Che J, Cheng W, Dong R, Huang J, Yang Z, Lu J. A retrospective study of the relationship between blood transfusion and 30-day postoperative outcomes in patients undergoing isolated off-pump coronary artery bypass grafting—Brazilian Journal of Cardiovascular Surgery. 2022 Nov 14;37:663-73.
3. Yu LI, Xing WA, Zi-Ying CH, Zhang WL, Lin GU, Yong-Quan SU, Hong-Zhan CU, Ji-Qiang BU, Jian-Hui CA. Severe bleeding following off-pump coronary artery bypass grafting: predictive factors and risk model. Journal of Geriatric Cardiology: JGC. 2021 Jun 6;18(6):449.
4. Sheshagiri N, Cheruvathur AV. Factors determining blood transfusion in patients undergoing off-pump coronary artery bypass graft (OPCABG) surgery: A prospective cross-sectional study. Indian Journal of Clinical Anaesthesia. 2021;8(3):452-9.
5. El Naggar A, Abou El Magd M, El Hoseiny R, Mohamed Y. Off-pump vs on-pump coronary artery bypass grafting: Perioperative AFs and early clinical outcomes. The Egyptian Heart Journal. 2012 Mar 1;64(1):43-7.
6. Al-Ruzzeh S, George S, Bustami M, Wray J, Ilsley C, Athanasiou T, Amrani M. Effect of off-pump coronary artery bypass surgery on clinical, angiographic, neurocognitive, and quality of life outcomes: randomized controlled trial. Bmj. 2006 Jun 8;332(7554):1365.
7. Lamy A, Devereaux PJ, Prabhakaran D, Hu S, Piegas LS, Straka Z, Paolasso E, Taggart D, Lanas F, Akar AR, Jain A. Rationale and design of the coronary artery bypass grafting surgery off or on pump revascularization study: a large international randomized trial in cardiac surgery. American Heart Journal. 2012 Jan 1;163(1):1-6.
8. Potger KC, McMillan D, Southwell J, Connolly T, Smith KK. Transfusion and bleeding in coronary artery bypass grafting: an on-pump versus off-pump comparison. The Journal of Extracorporeal Technology. 2007 Mar 1;39(1):24-30.
9. Zubarevich A, Kadyraliev B, Arutyunyan V, Chragyan V, Askadinov M, Sozkov A, Ponomarev D, Zyazeva I, Sá MP, Osswald A, Tsagakis K. On-pump versus off-pump coronary artery bypass surgery for multi-vessel coronary revascularization. Journal of thoracic disease. 2020 Oct;12(10):5639.
10. Carmona P, Paredes F, Mateo E, Mena-Durán AV, Hornero F, Martínez-León J. Is the off-pump technique a safer procedure for coronary revascularization? A propensity score analysis of 20 years of experience. Interactive CardioVascular and Thoracic Surgery. 2016 May 1;22(5):612-8.