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Original Article

Comparison of platelet activation in patients undergoing coronary bypass surgery with conventional and mini extracorporeal systems

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Abstract

Aim: The aim of this study was to compare platelet activation in patients undergoing coronary bypass surgery with conventional and mini extracorporeal systems.
Material and Methods: Our study is a retrospective study and a total of 116 patient data were obtained. Patients were divided into two groups as conventional extracorporeal and mini extracorporeal system bypass patients. Equal numbers of patients (n=58) were included in both groups. The data of patients who underwent coronary bypass surgery with conventional and mini extracorporeal systems between January 2022 and December 2022 were included in the study.
Results: In our study, no significant difference was found between patients bypassed with conventional and mini extracorporeal system in terms of pump time and cross-clamp time. Although the duration of intensive care unit stay and total hospitalization were found to be shorter in patients bypassed with the mini-extracorporeal (MECC) system than those bypassed with the conventional method, the difference between the groups was not significant. As a result of our study, it was observed that postoperative ejection fraction (EF) values significantly increased and hematocrite (HTC), hemoglobin (Hb), platelet (PLT) and procalcitonin (PCT) values significantly decreased in both groups of patients who underwent bypass with conventional and MECC system, and no significant difference was found between pre- and postoperative mean platelet volume (MPV) and platelet distribution width (PDW) values. As a result of our study, postoperative PLT and PCT values in the MECC group were found to be significantly higher than those in patients who underwent bypass with the conventional method.
Conclusion: Considering the results obtained in our study, it is seen that the values in patients bypassed with the MECC system are more favorable than those bypassed with the standard method, but more studies on the subject are needed.

Keywords: Coronary bypass surgery, platelet activation, mini extracorporeal system, convantional system

INTRODUCTION

In order to treat patients with coronary artery disease, coronary bypass surgery is frequently performed to open up new blood vessels that supply the heart muscle (1). Blood is redirected using an extracorporeal circulation system to get around the clogged arteries during this treatment. Since platelets are essential for both thrombosis and hemostasis, platelet activation is a significant part of this process (2). Excessive activation of platelets, however, might result in problems like embolism and thrombosis (3). Thus, enhancing patient outcomes after cardiac bypass surgery requires an understanding of how platelets are triggered.

Conventional and micro extracorporeal systems are the two primary types of extracorporeal systems utilized in coronary bypass surgery (4). Smaller cannulas and tubing are used in mini extracorporeal systems compared to bigger cannulas and tubing in conventional extracorporeal systems (5). Because larger extracorporeal systems may cause higher shear stress and inflammation, which can activate platelets, the size of the system can have an impact on platelet activation during surgery.

Research on cardiovascular disease has demonstrated interest in platelet activation when using tiny and traditional extracorporeal systems in patients undergoing coronary bypass surgery (6). For use in coronary artery bypass grafting (CABG), mini

extracorporeal circulation (MECC) systems were developed with the intention of lowering the morbidity linked to conventional cardiopulmonary bypass (CPB) and offering benefits for technical surgery (7).

Research contrasting regular CPB with the novel mini-extracorporeal circulation Jostra System for CABG has produced encouraging outcomes. According to one study, patients receiving CABG using the mini-extracorporeal system had reduced platelet activation as determined by platelet count as opposed to traditional CPB (7). According to this, using MECC may result in less platelet activation during surgery, which could have an impact on how patients heal thereafter.

Another study, however, did not discover a statistically significant difference in platelet counts between patients receiving traditional CPB and those undergoing CABG using the mini-extracorporeal system (8). This suggests that the effects of various extracorporeal systems on platelet activation may vary, and more investigation is required to completely comprehend the ramifications.

The aim of this study was to compare platelet activation in patients undergoing coronary bypass surgery with conventional and mini extracorporeal systems.

MATERIAL AND METHODS

Before the study ethics approval was taken from Gaziantep University Clinical Researches and Ethics Committe (Protocol Number: 2022/455 Date: 04.01.2023)

Researh Group

Our study is a retrospective study and a total of 116 patient data were obtained. Patients were divided into two groups as conventional extracorporeal and mini extracorporeal system bypass patients. Equal numbers of patients (n=58) were included in both groups.

The inclusion criteria are as follows:

1. Files of patients over 18 years of age who underwent coronary artery bypass surgery under elective conditions

The exclusion criteria are as follows:

1. Patients undergoing emergency coronary artery bypass surgery
2. Patients with preoperative thrombocytopenia

Data Collection

The data of patients who underwent coronary bypass surgery with conventional and mini extracorporeal systems in the Cardiovascular Surgery Clinic of Gaziantep University Şahinbey Research and Application Hospital between January 2022 and December 2022 were included in the study. The files of patients over 18 years of age who underwent coronary bypass surgery under elective conditions in cardiovascular surgery were scanned from the archive and divided into two study groups as those who underwent bypass surgery with conventional and mini extracorporeal system.

For patients bypassed with conventional system, a roller pump, softline-coated hollow fiber membrane oxynergizer, heparin-coated 3/8x3/32-inch arterial and 1/2x3/32-inch venous lines were used. Prime volume was prepared as 100 mL mannitol + 1000 mL ringer. Heparin 300 U/kg was administered. Activated clotting time (ACT) value was measured between 450-500 seconds.

Centrifugal pump, bioline (albumin and heparin coated) membrane oxygenator, heparin coated 3/8x3/32 inch arterial and venous lines were used for patients bypassed with mini extracorporeal system. Prime volume was prepared as 100 mL mannitol+500 mL ringer+500 mL blood (retrograde autologous after cannulation). Heparin 150 U/kg was administered. Activated clotting time was measured between 250-300 seconds.

Since the platelet index parameters (PLT, PDW, MPV) taken as the basis of the study were routinely studied in the preoperative and postoperative period, patient follow-up was performed from the electronic file section of the hospital medula system. In addition, mean age, gender, comorbidity status, number of coronary bypasses, pump duration, cross-clamp duration, intensive care unit stay, total hospital stay, body surface area (BSA), heparin, ACT, ejection fraction (EF), hemoglobin (Hb), hematocrit (HTC) and procalcitonin (PCT) values were also recorded from patient files.

Statistical Analyses

The data obtained from our study were analyzed using SPSS 21.0 program. Mean, standard deviation and percentage values were given as descriptive statistics. Comparisons between groups were made by independent sample t test/Mann Whitney U test and chi-square analysis. The results obtained were evaluated at 95% ($p<0.05$) significance level.

RESULTS

The mean ages of patients who underwent coronary bypass surgery with conventional and mini extracorporeal systems were similar ($p>0.05$). When determining the patients to be included in the study, equal gender distribution was taken into consideration. In this context, the ratio of men and women was equal in patients who underwent coronary bypass surgery with conventional and mini extracorporeal systems. Although the BMI of patients undergoing coronary bypass surgery with the mini extracorporeal system was higher than that of patients undergoing coronary bypass surgery with the conventional system, the difference between the groups was not significant ($p>0.05$). Although the proportion of patients with comorbidities was higher in patients who underwent coronary bypass surgery with the conventional system than in patients who underwent coronary bypass surgery with the mini extracorporeal system, there was no significant relationship between the groups ($p>0.05$). Although pump time, cross-clamp time, intensive care unit stay, total hospitalization time and body surface area (BSA) were found to be lower in patients who underwent coronary bypass surgery with the mini extracorporeal system compared to those who underwent surgery with the conventional method, the difference between the groups

was not significant (p>0.05) (Table 1).

As a result of our study, postoperative EF value was significantly higher (p<0.05) and postoperative HTC, Hb, PLT and PCT values were significantly lower (p<0.001) in patients who underwent bypass operation with conventional system. Similarly, in patients who underwent bypass operation with mini extracorporeal system, postoperative EF values were significantly higher (p<0.001) and postoperative Hb, PLT and PCT values were significantly lower (p<0.001). As a result of intergroup comparisons, postoperative PLT and PCT values in patients who underwent bypass operation with mini extracorporeal system were significantly higher than those in patients who underwent bypass operation with conventional system (p<0.05) (Table 2).

Table 1. Comparison of the demographic and clinical properties of the patients with conventional and mini extracorporeal surgery

	Conventional	Mini extracorporeal	p
Age (Mean±St.D)	60.03±10.61	60.82±9.44	.672*
Gender n (%)			
Female	29 (50)	29 (50)	1.000**
Male	29 (50)	29 (50)	
BMI (Mean±St.D)	27.81±5.85	31.45±23.35	.251*
Comorbidity n (%)			
No	16 (27.6)	8 (13.8)	.267**
Yes	42 (72.4)	50 (86.2)	
Number coronary bypass (Mean±St.D)	3.13±.34	3.18±.39	.456*
Pomp duration (min) (Mean±St.D)	74.37±22.86	69.31	.247*
Cross-clamp duration (min) (Mean±St.D)	42.84±16.99	39.13±13.36	.194*
Duration of intensive care hospitalization (day) (Mean±St.D)	3.18±1.45	3.05±2.61	.726*
Total hospitalization (day) (Mean±St.D)	11.53±4.61	10.32±5.32	.195*
Body surface area (BSA)	5.34±26.40	1.87±0.17	.318*
Heparin (Mean±St.D)	7456.14±331.13	7329.54±637.42	.199***
ACT (Mean±St.D)	671.87±178.84	673.89±172.73	.951***

*Independent samples t test, **Chi-square, ***Mann Whitney U Test, St.D: standard deviation, BMI: body mass index, ACT: activated clothing time

Table 2. Intragroup and intergroup comparison of preoperative and postoperative values in patients undergoing bypass operation with conventional and mini extracorporeal system

	Conventional	Mini extracorporeal	p
Preop EF	52.24±9.00	52.58±7.32	.822**
Postop EF	53.79±6.30	53.87±5.62	.938**
	p=.002*	p=.000	
Preop HCT	39.97±4.89	38.13±5.36	.056**
Postop HCT	29.05±3.67	29.72±3.62	.323**
	p=.000*	p=.000	
Preop Hb	13.65±1.87	13.01±1.97	.075**
Postop Hb	10.08±1.35	10.32±1.23	.332**
	p=.000*	p=.000*	
Preop PLT	245.55±94.38	264.98±84.64	.246***
Postop PLT	175.12±64.51	203.87±61.45	.015***
	p=.000*	p=.000*	
Preop MPV	11.08±1.08	10,83±1.03	.216**
Postop MPV	11.18±1.02	10,89±.97	.119**
	p=.237*	p=.513*	
Preop PCT	0.26±.09	0.28±.07	.318**
Postop PCT	0.19±.06	0.22±.06	.017**
	p=.000*	p=.000*	
Preop PDW	13.65±2.69	13.10±2.28	.242**
Postop PDW	13.64±2.80	13.01±2.33	.192**
	p=.980*	p=.570*	

*Paired samples t test, **Independent Samples t Test, ***Mann Whitney U test, PLT: platelet, Hb: hemoglobin, HCT: hematocrite, EF: ejection fraction, MPV: mean platelet volume, PCT: procalcitonin, PDW: platelet distribution width

DISCUSSION

Cardiopulmonary bypass (CPB) is an indispensable component of open heart surgery. Although extracorporeal circulation (ECC), which is widely used for CPB, causes dysfunction in tissues and organs, it is a method that has no alternative for open heart surgery and enables the treatment of cardiac diseases (9). During ECC, body temperature changes, reperfusion injury, endotoxin release, contact of blood with the artificial surface and surgical trauma activate complement and cytokine-like proinflammatory mediators, leading to a systemic inflammatory response. Postoperative mortality and morbidity are observed in more than one third of patients undergoing coronary artery bypass surgery (10). The use of off-pump is an option to prevent complications. If patient needs cannot be met with off-pump surgery, the mini extra corporeal system can be considered for ECC (11). There are studies showing that systemic inflammatory response and transfusion rates decrease when ECC systems with reduced foreign surface contact area and hemodilution amount are used (12,13).

Platelet activation and aggregation play a crucial role in the pathogenesis of atherothrombosis leading to acute coronary syndrome and after percutaneous coronary interventions (14). Platelets are megakaryocyte-derived, nucleus-less cells with a life span of 7-10 days. They encounter the endothelial layer of the vascular bed without any significant interaction. In the event of vascular damage, platelet adhesion, activation and aggregation are initiated. When the atherosclerotic vessel is mechanically opened (e.g. by percutaneous coronary intervention) or plaque rupture occurs, blood is exposed to thrombogenic substances and platelets are involved in this pathophysiologic process (15). After vascular injury, platelets are directed to the site of endothelial damage and form a hemostatic plaque. From then on, it depends on the ability of platelets to bind to the subendothelial matrix and on the rapid conformational and biochemical changes of platelets. The process will continue with platelet adhesion, platelet aggregation and finally stable plaque formation (16).

The aim of our study was to compare platelet activation in patients undergoing bypass with conventional and mini extracorporeal system.

In our study, no significant difference was found between patients bypassed with conventional and mini extracorporeal system in terms of pump time and cross-clamp time. Although the duration of intensive care unit stay and total hospitalization were found to be shorter in patients bypassed with the mini-extracorporeal system than those bypassed with the conventional method, the difference between the groups was not significant. In a study conducted by Philipp et al. (17) in 2001, 395 CABG patients were retrospectively analyzed in four groups: off-pump, standard CBP, MECC and MECC in the working heart. As a result of the study, it was found that the number of grafts performed in the off-pump patient group and the need for blood product use was less in both MECC groups. In the MECC-only group, the duration of intensive care unit stay and mechanical ventilation were reported to be significantly shorter. Similarly, Puehler et al. (18) reported that the duration of intensive care unit stay was shorter in patients bypassed with the MECC system compared to standard CBP.

When both groups were compared within themselves, it was observed that EF value increased significantly in both groups postoperatively, while HTC, Hb, PLT and PCT values decreased significantly. Pre- and postoperative MPV and PDW values did not change significantly in both groups. It is well established that platelet function and reactivity are related to MPV (19-21). In addition, PDW has also been reported to increase in patients with platelet activation (22).

As a result of intergroup comparisons, postoperative PLT and PCT values were significantly higher in patients bypassed with the MECC system than in patients bypassed with the conventional system. However, we cannot clearly say whether the difference between the groups is related to the method used. Because when the preoperative PLT values are analyzed, the PLT value of the patients in the MECC group is higher than that of the patients in the conventional system group. However, when the literature is examined, it is seen that similar results were obtained with our study. Remadi et al. (7) compared the MECC Jostra system with the standard CBP system. As a result of the study, HTC and Hb values were found to be higher in the MECC group compared to the standard CABG group. Similar to our study, Alevizou et al. (23) found that postoperative PLT values were significantly higher in the MECC group than in the standard CABG group.

CONCLUSION

In conclusion, MECC circulatory system is an extracorporeal circulatory system with increased biocompatibility, reduced blood surface contact and less prime solution. Pre- and postoperative MPV and PDW values did not change significantly in both groups. However, in our study, no significant difference was found between MECC and conventional system in terms of PLT, MPV and PDW values which are used in the evaluation of platelet activation. Therefore, it can be said that more comprehensive studies including a larger number of patients are needed to evaluate both systems in terms of platelet activation.

Conflict of Interests: The authors declare that there are no conflict of interests.

Financial Disclosure: The authors declare that there is no financial support.

Ethics Committee Approval: This is a retrospective study with ethics committee approval being taken from Ethics Committee, Gaziantep University (Protocol Number: 2022/455 Date: 04.01.2023).

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