Retrospective Comparison of the Effects of Centrifugal and Roller Pump Heads on the Hemostatic System During Open Heart Surgery

Açık Kaş Cerrahisinde Sentrifugal ve Roller Pompa Başlıklarının Hemostatik Sistem Üzerine Etkilerinin Retrospектив Olarak Karşılaştırılması

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ABSTRACT

Background and Aim: Technological developments and enhancement of knowledge level enable heart surgery with low mortality and morbidity rates in most centers. On the other hand, hemostasis management during cardiopulmonary bypass (CPB) plays a critical role in development of postoperative complications. We aimed to compare the effects of centrifugal pump and roller pump techniques on hemostatic system during CPB.

Material and Methods: One hundred patients, who underwent coronary artery bypass surgery by the same surgical team with CPB pump using either roller or centrifugal pump, at Department of Cardiovascular Surgery of Gazi University between June 2012 and June 2013 were enrolled. Patients over 40 years old and without any known immunologic, infectious or inflammatory diseases and hematological problems for the last 6 months were included. Two study groups (Group R: Roller pump group and Group C: Centrifugal pump group) were created. Platelet counts, albumin levels were measured before and after CPB (pump); the amount of blood used during CPB, total blood amount used, percentage of patients using five or more units of blood during CPB, percentage of patients without any known immunologic, infectious or inflammatory diseases and hematological problems for the last 6 months were included. Two study groups (Group R: Roller pump group and Group C: Centrifugal pump group) were created. Platelet counts, albumin levels were measured before and after CPB (pump); the amount of blood used during CPB, total blood amount used, percentage of patients using five or more units of blood during CPB, percentage of patients who didn’t receive fresh frozen plasma (FFP) or apheresis platelet concentrates were recorded.

Results: The amount of blood transfused during CPB was significantly lower in Group C than in Group R (0.28 ± 0.08 U; 0.68 ± 0.13) (p=0.001). Preoperative and postoperative platelet levels were similar between groups, but platelet levels were significantly lower in both groups compared to their preoperative levels (Group C, p=0.0001, Group R, p=0.0001). When the preoperative albumin levels were compared, the patients in Group R had higher albumin levels than in Group C, whereas postoperative albumin levels were significantly higher in Group C than Group R (p=0.0001). The percentage of patients who didn’t receive blood transfusion during CPB was significantly higher in Group C (p=0.011). While the percentage of patients who didn’t receive FFP transfusion was significantly higher in Group C (p=0.002), the percentage of patients who didn’t receive apheresis platelet transfusion was similar.

Conclusion: Our findings indicate that usage of centrifugal pump has clear superiority in terms of effects on hemostatic system during CPB when compared to roller pump. Nevertheless, we believe that our results should be supported by advanced clinical and experimental studies.

Key Words: Cardiopulmonary bypass (CPB), Centrifugal pump, Roller pump, Hemostatic system

Anahtar Sözcüklер: Kardiyopulmoner baypas (KPB), Sentrifugal pompa, Roller pompa, Hemostatik sistem

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INTRODUCTION

Cardiac surgery is being performed with low mortality rates in many surgical centers. However, hemostasis management during cardiopulmonary bypass plays a critical role in development of postoperative complications. There are multiple factors in the etiology of coagulopathy, inflammatory response and hemostatic system disorders during cardiopulmonary bypass (CPB) (1-4). A roller pump contributes to these adverse effects more common as the centrifugal pumps are known to damage red blood cells (RBC), platelets, and plasma proteins less than the conventional roller pumps (5-8).

Cardiopulmonary bypass (CPB) provides a bloodless field for cardiac surgery. CPB pumps send gravitational blood pooling in vena cava to a reservoir, oxygenate and send back to the body and maintain a certain pressure and flow velocity during this process. There are two types of pumps: 1–centrifugaland 2–roller pumps (9). Centrifugal pumps may improve platelet preservation, renal function and neurological outcomes in longer cases (10).

We aimed to compare the effects of centrifugal pump -where it is claimed that blood of patients is exposed to minimal trauma- and roller pump techniques on hemostatic system during CPB.

MATERIAL and METHODS

After obtaining ethical committee approval from Clinical Investigations Ethical Committee of Gazi University and written consent from all patients, we included 100 patients undergoing coronary artery bypass surgery by same surgeon team with CPB pump between June 2012 and June 2013. Patients aged over 40 years, without any immunological, infectious or inflammatory diseases history in last 6 months and without any known hematological disorders were enrolled into the study.

Premedication was made with Diazepam 10 mg orally one night before surgery and 5 mg morphine subcutaneously in the operation morning. Following routine monitoring (EKG, SpO₂), peripheral venous cannulation was made. Invasive blood pressure, radial artery cannulation was made for monitoring (B-Cat 2 22G, Bıçakçılar Medical Devices Company). Standard anesthesia protocol was carried out. Monitoring of body temperature was made using nasopharyngeal probe. Venous blood samples were drawn from 18G catheter (Scolon T², BD Medical, Singapore) placed in right internal jugular vein. Exact localization of tip of catheter was confirmed with X-ray after operation.

Following skin antisepsis surgical site was covered with sterile drapes. After making skin and subcutaneous incisions median sternotomy was performed and pericardium was opened. After preparing vascular grafts anticoagulation was made with heparin at a dose of 4 mg/kg. Priming fluid was prepared using 1 g cefazolin plus 50 mg heparin added into 1500 cc of lactated ringer. ACT levels were maintained above 410 s in order to proper anticoagulation. After obtaining ethical committee approval from Clinical Investigations Ethical Committee of Gazi University and written consent from all patients, we included 100 patients undergoing coronary artery bypass surgery by same surgeon team with CPB pump between June 2012 and June 2013. Patients aged over 40 years, without any immunological, infectious or inflammatory diseases history in last 6 months and without any known hematological disorders were enrolled into the study.

Demographical data of patients in study groups [Mean ± SD, n ]

| Variable       | Group C (n=50) | Group R (n=50) | P     |
|----------------|----------------|----------------|-------|
| Age (year)     | 58.22±9.21     | 59.66±8.35     | 0.415 |
| Weight (kg)    | 78.00±10.67    | 76.58±11.74    | 0.525 |
| Height (cm)    | 168.50±7.74    | 168.46±7.16    | 0.928 |
| Sex (M/F)      | 37/13          | 36/14          | 0.822 |
Table 2. Operative data of the groups [Mean ± SD, n]

|                         | Group C (n=50) | Group R (n=50) | P     |
|-------------------------|----------------|----------------|-------|
| Cardiopulmonary bypass time (min) | 110.76±35.84   | 101.30±36.95   | 0.197 |
| Aortic cross-clamping time (min)    | 69.04±24.31    | 60.02±23.86    | 0.064 |
| Number of vessels bypassed (n)      | 3.00±1.09      | 2.90±1.05      | 0.642 |

The amount of blood transfused during CPB was significantly lower in Group C than in Group R (0.28±0.08 U; 0.68±0.13) (p=0.010), while the total amount of blood transfused was significantly higher in Group R compared to Group C (p<0.0001). The total amount of blood used was recorded as 4.78 U in Group R and 3.08 U in Group C.Preoperative and postoperative platelet levels were similar between groups, but platelet levels were significantly lower in both groups compared to their preoperative levels (Group C, p<0.0001, Group R, p<0.0001).

Table 3. Used blood products and albumin and platelet data [Mean ± SD]

|                         | Group C (n=50) | Group R (n=50) | P     |
|-------------------------|----------------|----------------|-------|
| Pump blood (U)          | 0.28±0.08      | 0.68±0.13*     | 0.010 |
| Total Blood (U)         | 3.08±0.18      | 4.78±0.24*     | <0.0001 |
| Preoperative platelet   | 226924.00±11728.36 | 245268.00±12403.95 | 0.285 |
| Postoperative platelet  | 150686.00±7622.34+ | 140366.00±6829.63+ | 0.316 |
| Preoperative albumin    | 3.86±0.08      | 4.12±0.08*     | 0.016 |
| Postoperative albumin   | 2.54±0.06+     | 2.16±0.06*,+   | <0.0001 |
| Apheresis (U)           | 0.08±0.03      | 0.18±0.07      | 0.205 |
| FFP                     | 1.06±0.18      | 1.70±0.16*     | 0.009 |

*: p<0.05 (when compared with Group C)
+: p<0.05 (when compared with data achieved before pump)

When the preoperative serum albumin levels were compared, Group R had higher albumin levels than Group C (p=0.016), whereas postoperative albumin levels were significantly higher in Group C than Group R (p<0.0001). In both groups, albumin levels were significantly decreased compared to their preoperative values (Group C, p<0.0001; Group R, p<0.0001) (Table 3). The percentage of patients who didn’t receive blood transfusion during CPB was significantly higher in Group C (p=0.011). While the percentage of patients who didn’t receive FFP transfusion was significantly higher in Group C (p=0.002), the percentage of patients who didn’t receive apheresis platelet concentrates transfusion was similar.

78% of the patients in Group C and 54% of the patients in Group R did not receive blood transfusion during CPB. The percentage of patients who did not receive blood transfusion during CPB was significantly higher in Group C (X²=6.496, p=0.011) (Table 4). 14% of the patients in Group C and 46% of the patients in Group R received total blood transfusion of 5 U and more.

The percentage of patients receiving five units and more blood was significantly higher in Group R (X²=33.165, p<0.0001) (Table 4). FFP was not used in 46% of patients in Group C and 12% of patients in Group R. The percentage of patients who received no FFP transfusion was significantly higher in Group C (X²=6.896, p=0.002) (Table 4). Apheresis platelet concentrates were not used in 92% of patients in Group C and in 86% of patients in Group R, the rates were similar (Table 4).
REFERENCES

Nevertheless, we believe that our results should be supported by advanced clinical and experimental studies.

Table 4. Percentage of blood products used in patients [%]

|                   | Group C (n=50) | Group R (n=50) | P     |
|-------------------|---------------|---------------|-------|
| Pump blood (0-4)  | 39(78)/8(16)/3(6)/0(0)/0(0) | 27(54)/15(30)/6(12)/1(2)/1(2) | X²=6.496 p=0.011 |
| Total Blood (1-9) | 4(8)/13(26)/17(34)/9(18)/5(10)/2(4)/0(0)/0(0)/0(0) | 0(0)/2(4)/9(18)/16(32)/10(20)/5(10)/12(1)/6(12)/1(2) | X²=33.165 p<0.0001 |
| Apheresis (0-2)   | 46(92)/4(8)/0(0) | 43(86)/5(10)/2(4) | X²=2.985 p=0.204 |
| FFP (0-4)         | 23(46)/13(26)/5(10)/6(12)/3(6) | 6(12)/18(36)/15(30)/7(14)/4(8) | X²=16.896 p=0.002 |

*: p<0.05 (when compared with Group C)

DISCUSSION

In this study, we retrospectively compared the changes in hemostatic system in 100 adult patients undergoing coronary artery bypass surgery by the same surgical team with CPB pump using roller versus centrifugal pumps. Improved clinical outcome with centrifugal pumps has been reported in pediatric and adult patients before (11-13). Centrifugal pump has been found to be related to less postoperative mediastinal bleeding and reduced transfusion requirements. Although we found that blood transfused during CPB was significantly lower in Group C than in Group R, while the total amount of blood transfused was significantly higher in Group R compared to Group C. In addition, the percentage of patients who didn't receive blood transfusion during CPB was significantly higher in Group C. In terms of hemolysis, complement activation and platelet activation the superiority of a centrifugal pumpover a rollerpump in adults has been shown by a number of in-vitro and clinical (5,14–17). In our study, preoperative and postoperative platelet levels were similar between the groups, but postoperative platelet levels were significantly lower in both groups compared to their preoperative levels (Group C, p<0.0001, Group R, p>0.0001) and the percentage of patients who didn't receive apheresis platelet transfusion was similar also. In CPB patients, increased platelet activation (expressed by beta-thromboglobulin) has been reported 1–24 h after bypass with roller compared with centrifugal pumps by some authors (7,18), but not by others (19, 20). The superiority of a centrifugal pump over a roller pump in terms of hemolysis, complement activation and platelet activation have been shown by a number of in-vitro and clinical studies in adults (5,14–17). In our study, we additionally found out that when the preoperative albumin levels were compared, Group R had higher albumin levels than Group C, whereas postoperative albumin levels were significantly higher in Group C than in Group R.

Our findings indicate that usage of centrifugal pump when compared to roller pump has clear superiority in terms of effects on hemostatic system during CPB. Nevertheless, we believe that our results should be supported by advanced clinical and experimental studies.

Conflict of interest

No conflict of interest was declared by the authors.

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