# Acute Blood Utilization in Adult Open Heart Surgery

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## ABSTRACT

**Background:** Cardiopulmonary bypass affects the homeostatic system of the body through the effect of heparinization, hemodilution and hypothermia, which represent the major challenges on the homeostatic system .Other factors, like pre-operative aspirin use, old age and cardiopulmonary bypass time, also affect the homeostatic system.

**Objectives:** To find factors which are related to excessive blood loss following open-heart surgery and to study pre-operative and post-operative blood transfusion practice in these patients. The importance of fresh blood transfusion, especially autologous blood, in open-heart surgery was also studied.

**Methods:** Forty-eight adult patients, who underwent open-heart surgery over the period of 3 months, were studied. Data were collected from the charts of these patients to study their effects on the degree of post-operative blood loss.

**Results**: Thirteen patients (27%) had excessive blood loss (more than 1000 ml within the first 24 hours post-operatively). The incidence of excessive blood loss was related to the number of units of fresh blood which were given to the patients post- operatively. It was found to be related to patient's age, cardiopulmonary bypass time, also type of surgery and preoperative aspirin use. Two complications of blood transfusion post-operative were noted; allergic and pyrogenic reactions.

**Conclusions:** Fresh blood transfusion showed great effect in reducing post-operative blood loss. Factors that may increase the possibility of excessive bleeding are pre-operative aspirin use, age more than 40, prolonged cardiopulmonary bypass time and surgery for double valve replacement.


**Keywords: Blood utilization, Open heart surgery, Postoperative bleeding, Fresh blood transfusion.**

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Cardio-pulmonary bypass (CPB) imposes extremes on the homeostatic system[1]. Despite efforts aimed at improving biocompatibility, the cardiopulmonary bypass surface is generally perceived as foreign by circulating blood elements, which attempt to clot it and reject by mounting an inflammatory attack[2,3]. Ideally, complete arrest of coagulation and inflammation would be maintained throughout the bypass period, then separation from CPB would be accompanied by the full return of coagulation function. In reality, the coagulation arrest achieved by current anticoagulation technique is partial, and the subsequent restoration of coagulation is frequently suboptimal, resulting in excessive blood loss and the need for blood and products transfusion[4,5].

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The post-perfusion syndrome is characterized by a diffuse whole body inflammatory reaction with elements of increased capillary permeability, extravasation of plasma, increased interstitial fluid, leukocytosis, fever, peripheral vasoconstriction, breakdown of red blood cell (RBC) and a diffuse body diathesis[6-8]. Some risk factors for an adverse clinical response to CPB have been identified. In most adults, the probability of structural or functional damage seems to increase as the perfusion time extends beyond three hours[9]. Another risk factor is age. The susceptibility to organ dysfunction after CPB appears to increase in neonates. The very elderly also appear less tolerant to the damaging effects of CPB, particularly in the presence of pre-existing renal dysfunction[10]. Other factors undoubtedly interact, including the type of oxygenator, the composition of the

perforate, the perfusion flow rate, the presence or absence of pulsatile flow and patient's temperature[11]. There are three major challenges imposed on homeostatic system during CPB[1,12,13]:

Heparinization: which represents the major alteration in coagulation imposed by CPB. Heparin binds to circulating antithrombin and causes a conformational change that accelerates its binding to and inactivation of three critical coagulation factors: thrombin, factor Xa and factor IXa. Heparin also has both direct and indirect antiplatelet effects, and despite post-CPB neutralization, residual heparin may contribute to post-CPB bleeding. Among its antiplatelet actions, heparin binds to Von-Will brand factor platelet interaction site and can impair initial platelet rolling and adhesion to the sub endothelium.

Hemodilution: owing the large volume of the circuit, which must be primed to with blood-compatible fluid, hemodilution is the next challenge imposed on the homeostatic system. The degree of hemodilution varies with the institution, type of CPB circuit and size of the patient. Coagulation factors can be diluted to 20 to 40% of normal values before symptoms of bleeding are manifested or clotting times are prolonged. Similarly, most normal platelet counts can be halved without an increase in tendency to bleed. Therefore, the anticoagulant effect of hemodilution is generally mild.

Hypothermia inhibits platelet activation and the platelet aggregation in response to thrombi. In addition, hypothermia may adversely affect the kinetics of the coagulation cascade and even impair the ability of local vasculature to constrict in response to bleeding.

There are, also, some other factors which contribute to post-open heart surgery bleeding. These may include, preoperative aspirin use, old age, increased CPB time, type of the surgery and excess heparin dose[14]. Autologous blood is superior to allogeneic blood transfusion, because it avoids the risk of transmission of viral and other infectious diseases, it reduces the cost of preparation of blood unit (in USA preparing one unit of allogeneic blood costs $200) and it reduces the complications of blood transfusion[15]. Also, it has been shown that transfusing autologous blood reduces the subsequent allogeneic blood requirements. Yet, the advantage of autologous blood transfusion is limited by the fact that large number of patients who are presented to cardiac surgery are anemic which may increase the risk of autologous blood transfusion[16,17]. The aim of this study is to find factors which are related to excessive blood loss following open-heart surgery, and to study pre-operative and post-operative blood transfusion practice in those patients.

## Methods

In this study, 48 adult patients, whom underwent open-heart surgery at Ibn -Al nafees teaching hospital over the period of 3 months (April-June 2014), were studied retrospectively. Age of the patients ranged from 20-50 years. Variable operations had been including coronary artery bypass grafting (CABG), double valve replacement (DVR), mitral valve replacement (MVR), aortic valve replacement (AVR), atrial septal defect (ASD) repair and excision of left atrium (LA) myxoma. Usage of blood and its products within the first 24 hours post-operatively was retrospectively studied. The data used in the study were patient's age, blood group, CPB time, number of units of fresh blood (FB), banked blood and blood products, which were given to the patients, and their complications. The total drainage of the tube drains within the first 24 hours post-operatively was collected from each patient and excessive post CPB blood loss was considered equal to or more than 1000 ml in the first 24 hours post-operatively, pre-operative aspirin use, and the time of its stoppage before the date of surgery, were also studied.

## Results

In his study, the most common blood group found was O +ve, followed by B +ve, and the least common was A –ve, (Table 2). All patients (48 patients) (100%) had FB

transfusion post-operatively, and about half of them (26 patients) had banked blood transfusion. The total number of FB units used was 81 units, an average of 1.68 unit per patient. The total number of banked blood units used was 54 units. An average of 1.12 unit per patient, (Table 3). The total number of fresh frozen plasma (FFP) units used was 187 units, an average of 3.89 unit per patient. The total number of platelets used was 179 units, an average of 3.72 unit per patient. The total number of cryoprecipitate used was 10 units, an average of 0.2 unit per patient. Thirteen patients (27%) had excessive blood loss. Ten of them received only one unit of FB (only one needed re-exploration which revealed no surgical bleeding). The other 3 patients received two units of FB (only one needed re-exploration which revealed a surgical bleeding), (Table 4). Of these 13 patients with excessive bleeding, 7 of them were males and 6 were females. It was shown that about half of patients who had excessive blood loss post-operatively, underwent DVR, which is usually associated with long CPB time, (Table 5). Of the 13 patients who had excessive blood loss 10 patients (76.9%) aged 40 years and more, and 9 patients (69.2%) were exposed to CPB time of 165 minutes or more. Of the 13 patients who had excessive post-operative bleeding, 8 patients received pre-operative aspirin, (Table 6). Of these 8 patients, 2 of them stopped aspirin 10 days before date of surgery, and the other 6 patients stopped aspirin 2-3 days before the date of surgery. Two complications of blood transfusion were identified in the study; allergic and pyrogenic reactions. Most of the allergic reactions and all pyrogenic reactions were secondary to banked blood transfusions, (Table 7).

**Table 1: Number and percentage of the operations.**

| | DVR | CABG | MVR | AVR | ASD Repair | LA myxoma excision | Total |
|---|---|---|---|---|---|---|---|
| **Number of Operations** | 14 | 12 | 11 | 5 | 5 | 1 | 48 |
| **Percentage** | 29.1 | 25 | 22.9 | 10.4 | 10.4 | 2.08 | 100 |

**Table 2: The Percentage of blood groups.**

| | O +ve | B +ve | A +ve | AB +ve | O -ve | A -ve | B -ve | AB -ve |
|---|---|---|---|---|---|---|---|---|
| **Number of Patients** | 16 | 15 | 9 | 5 | 2 | 1 | 0 | 0 |
| **Percentage** | 33.3 | 31.2 | 18.7 | 10.4 | 4.1 | 2 | 0 | 0 |

**Table 3: Blood transfusion in this study.**

| | 4 units | 3 units | 2 units | 1 unit | zero | Total |
|---|---|---|---|---|---|---|
| **Patients who received FB** | - | - | 33 | 15 | - | 48 |
| **Patients who received banked blood** | 2 | 8 | 6 | 10 | 22 | 48 |

**Table 4: Patient with excessive postoperative blood loss (n=13) according to number of FB units given to the patients.**

| | 2 Fresh Blood usage | 1 Fresh Blood usage | Total |
|---|---|---|---|
| **Patients with excessive blood loss** | 3 (23%) | 10 (76.9%) | 13 |
| **who needed re-exploration for excessive blood loss** | 1 (50%) surgical bleeding found | 1 (50%) no surgical bleeding found | 2 |
| **Patient with no excessive blood loss** | 30 | 5 | 35 |

**Table 5: Patient with excessive post- operative blood loss according to type of the surgery.**

| | DVR | CABG | MVR | AVR | ASD repair | LA myxoma excision | Total |
|---|---|---|---|---|---|---|---|
| **Number of patients with excessive blood loss (n =13)** | 6 (46.15%) | 3 (23.07%) | 2 (15.38%) | 1 (7.69%) | 1 (7.69%) | 0 (0%) | 13 |
| **Number of patient with no excessive blood loss** | 8 (22.85%) | 9 (25.71%) | 9 (25.71%) | 4 (11.42%) | 4 (11.42%) | 1 (2.85%) | 35 |

**Table 6: Patient with excessive post- operative blood loss according to pre-operative aspirin usage.**

| | Excessive blood loss (n=13) | No excessive blood loss (n=35) |
|---|---|---|
| **Patients whom received aspirin pre-operatively (n= 18)** | 8 (44.44%) | 10 (55.56%) |
| **Patients whom didn't receive aspirin pre-operatively (n=30)** | 5 (16.66%) | 25 (83.34%) |

**Table 7: Complications of blood transfusion.**

| | Allergic reactions | Pyrogenic reactions |
|---|---|---|
| **Patients who received banked blood (n= 26)** | 3 (11.53%) | 3 (11.53%) |
| **Patients received FB (n =48)** | 1 (2.08%) | Non |

**Table 8: Patient with excessive post-operative blood loss according to age of patients.**

| Patient's age | Excessive blood loss | No excessive blood loss | Total |
|---|---|---|---|
| **20-40 years** | 3 (18.75%) | 13 (81.25%) | 16 |
| **41-50 years** | 10 (31.25%) | 22 (68.75%) | 32 |

**Table 9: Patient with excessive post-operative blood loss according to cardiopulmonary bypass time.**

| Cardiopulmonary bypass time | Excessive blood loss | No excessive blood loss | Total |
|---|---|---|---|
| **1-165 minutes** | 4 (13.793%) | 25 (86.207%) | 29 |
| **166-220 minutes** | 9 (47.369%) | 10 (52.631%) | 19 |

## ——————————Discussion

Aggressive blood conservation techniques and the use of autologous blood transfusion have reduced the average number of allogeneic blood transfusions[18]. In the present study, banked transfusion reached 54%, with a mean of 1.12% unit per patient, 27% of patients bled 1 liter or more in the first 24 hours post-operatively, with no obvious sex relation. Pre-operative aspirin use related to excessive post-operative blood loss, as 8 patients of those who received pre-operative aspirin had excessive post-operative blood loss, and most of these 8 patients, stopped aspirin 2-3 days before surgery. This emphasizes the importance of stoppage of aspirin at least 10 days before the date of surgery, so that the dysfunctional platelets get enough time to regain their normal function. No preoperative hematologic variable reliably identified patients at risk for bleeding[19].

It is evident that blood loss following open-heart surgery was almost a constant finding, for this reason, blood transfusion is very important post-operatively, especially FB transfusion, which contains all the coagulation factors, has increased survival of RBC and has increased oxygen- carrying capacity of hemoglobin[20,21]. In addition to FB, blood products like FFP, platelets and cryoprecipitate are also of importance in reducing the amount of post-operative blood loss[22]. There are two sources for providing FB, autologous and allogeneic blood. In this study, the type of FB used is allogeneic blood. The number of FB units used was related to degree of post-operative blood loss. The patients whom received two units of FB post-operatively had less incidence of excessive blood loss than those whom received only one unit of FB (3 vs. 10 out of 13). Hence, the importance of giving more than one unit of FB to the cardiac surgical patient postoperatively, because it may reduce the amount of blood loss and, thus, reduce the subsequent banked blood usage and reduce its complications.

The study also showed that the largest number of banked blood units used (38 units), were given to patients who had excessive post-operative blood loss. Patient's age and CPB time do influence the degree of post-operative blood loss. It was shown that patients aging more than 50 years are usually less able to tolerate the damaging effects of CPB, especially those with pre-existing renal dysfunction [23] .Also, the injurious effects of CPB on blood elements and different body organs increase as the CPB time increases beyond 180 minutes[24]. Therefore, the incidence of excessive blood loss is high in these two conditions. In this study, similar findings were seen. Patients aged 40 years and more (32 patients) were more liable to have excessive post-operative blood loss (31.25%), the incidence of excessive post-operative blood loss was high also, in patients who were exposed to CPB time of 165 minutes and more (47.3%). Double valve replacement with long CPB time, therefore, is usually associated the damaging effects of CPB and the incidence of excessive post-operative blood loss would be high[24]. This fact was clear in our study where about half of patients who had excessive post-operative blood loss, underwent DVR. In this study, there was no complete documentation of the use of autologous blood, thus, its effect couldn't be studied.

There are other methods to reduce allogeneic blood transfusion. The blood drained into the tube drains is passed through a special cell-saver, so that it can be filtered and cleaned from any particle, and then, can be infused to the patient; but the facilities for such technique is not available in our center .

In conclusion: Some degree of post-operative bleeding in open-heart surgery, is almost a constant and acceptable finding. Patients aging more than 40 years and those who undergo DVR, are at risk for excessive bleeding post-operatively. Prolonged CPB time is associated with increased risk of excessive post- operative blood loss. Aspirin should be stopped before the date of surgery, otherwise, the risk of excessive bleeding post-operatively would be high. The cardiac surgical patient should receive more than one unit of FB postoperatively, because this may reduce the amount of blood loss and, thus, reduce the subsequent use of banked blood and reduce its complications.

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