THE EFFICACY OF AUTOLOGOUS TRANSFUSION OF POSTOPERATIVE MEDIASTINAL SHED (DRAINAGE) BLOOD

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Rondomly selected 416 patients that had undergone open heart surgery, were studied in two groups to asses the efficacy of autotransfusion of mediastinal shed blood. In Group I, 336 patients were included that received autotransfusion of mediastinal shed blood, whereas Group II were formed of 80 cases that postoperative autotransfusion was not used. Group I and Group II were identical in patient characteristics. Two further subgroups were formed to evaluate the hematological effects of postoperative autotransfusion. Group IA consisted of 15 cases that had undergone coronary artery bypass grafting which received postoperative autotransfusion, and in Group IIA 10 cases of coronary artery bypass patients were included from Group II. Hematological studies in Group IA after autotransfusion showed significant increase in hematocrit, fibrinogen levels, platelet counts. Prothrombin and bleeding times were significantly different from the pre-autotransfusion values. Post-autotransfusion studies of Group IA were also compared with Group IIA simultaneously. This resulted a significant difference between the subgroups in fibrinogen degradation product (FDP) levels and ß-thromboglobulin levels (ß-TGB). FDP levels were higher in Group IIA and ß-TGB levels were higher in Group IA. The hematological properties of mediastinal shed blood were in physiological limits. Postoperative autotransfusion of mediastinal shed blood reduced the bank blood requirements by 48% and altered the hematologic properties of patients in a favoring manner.

Key words: Autotransfusion, Open heart surgery.

Homologous blood transfusions in surgery and traumatology has gained wide acceptance with the introduction of blood groups by Landsteiner in 1990[1]. However, this wide-spread application of stored homologous bank blood led to some serious complications, which might end with fatality in some instances. These risks of homologous blood transfusions may be listed as follows: inappropriate group typing and cross matching, anaphylaxis, disseminated intravascular coagulation, transmittence of blood borne

infectious diseases such as hepatitis–B and AIDS, hypothermia, ventricular arrythmias, dilutional coagulopathies, hyperkalemia and pulmonary embolism [2-4]. It is also shown that, bacterial contamination might occur up to 4% in patients that are undergoing open heart surgical procedures who received homologous bank blood[3].

The increase in the number of open heart surgical procedures have also led to shortage of available bank blood and other blood products. This resulted with the concept of autologous blood transfusions (autotransfusion) which was actually brought to daylight by Blundell in 1818. Since that time, autotransfusion used and reported in vast amounts of clinical studies [5-9]. These works have shown that, autotransfusion does not carry the risks of bank blood, is almost equal to the quality of bank blood, can be life saving in emergency situations and has a lesser cost compared to bank blood [5,10-15].

The presented study was planned to show the efficacy of postoperative salvage of mediastinal shed blood.

Material and Methods

Patients: Randomly selected 416 patients who had undergone open heart surgery were included in this study. First group (n:336) (Group I) received autotransfusion and the second group (n:80) (Group II) did not receive autotransfusion as the control group of the study. Fifty six percent (n:233) of cases had undergone coronary bypass procedures, 31% (n:131) valvular operations, and 13% (n: 52) congenital heart defect corrections. Of the 233 cases that had undergone coronary bypass operations, 25 cases were randomly chosen from the two groups to form two other subgroups. These subgroups were formed to exclude the possible effects of valvular and congenital heart diseases on haemotological cascades. Group IA was formed from randomly chosen 15 coronary bypass patients who received mediastinal shed blood transfusions, whereas Group IIA was formed from randomly chosen 10 coronary bypass patients, who did not receive postoperative transfusion of mediastinal shed blood.

Postoperative autotransfusion system: The Sorenson's Autotransfusion System (ATS)*, that has been developed by Noon and colleagues, and first used after open heart surgical procedures by Schaff and colleagues was used in this study[8]. Sorenson ATS is formed by two connected parts: A canister that occupies the blood collecting bag is connected to a vacuum source through a device named recepteseal, which is actually a closed underwater manometer. The drainage tubes were connected to the blood collecting bag. The vacuum applied to the canister was 350 mmHg, and through the recepteseal this was reduced to -20 mmHg when applied to the drainage tubes. For every 500 ml of shed blood, 100 ml blood reservoir of the system has a 170 µ microparticulate filter of acid citrate dextrose solution was added. The shed blood was also filtered through a 40 µ filter during the autotransfusion.

Surgical Techniques: All patients were operated on standart techniques which are used rountinely in our clinic. A median sternotomy was done to enter the mediastinum. Cardiopulmonary bypass was established membrane oxygenators. Before the establishment of CPB, a unit of (400 ml) heparinized blood was withdrawn from the patient, which was administered back by the end of CPB. Heparinization was monitored according to activated coagulation times (ACT), by keeping the ACT over 400 seconds. Heparin reversal was accomplished by protamine, again monitored by reversal of ACT to pre-heparinization levels. After heparin reversal, the prime-mixed blood, that was left in the oxygenator and tubes were collected in blood bags, and transfused back to the patient primarily to overcome the volume deficits in the immediate postoperative period.

Autotransfusion in the postoperative period: As stated above, volume deficits of patients in the immediate postoperative period were replaced by with pump bloods primarily. If any more volume replacement was indicated, hemoglobin (Hb) and hematocrit (Hct) levels were taken as the main criteria in selection of the transfusion material. Volume deficits of patients that had Hct levels over 25% and Hb levels over 8.5 g/dl were mainly substituted with crystalloid or colloid solutions.

*: Sorenson ATS, Sorenson Research Corp., Salt Lake City, Utah, USA

Table I: Preoperative hematologic values of subgroups

	Group IA (n=15)	Group IIA (n=10)	p
Hct (%)	45.4±2	46.3±3	NS
Hb (g/dl)	14.7±0.9	14.8±1	NS
RBC (10^6/mm^3)	4.8±0.2	4.9±0.4	NS
Platelets (10^3/mm^3)	259.0±76	281.0±112	NS
FDP (µg/ml)	7.6±6	4.3±5	NS
Fibrinogen (g/l)	3.4±0.8	3.7±0.9	NS
PT (Sec)	9.8±0.4	9.6±0.3	NS
aPTT (sec)	21.0±2	23.8±2	NS
Bleeding Time (min)	1.8±0.9	1.9±0.5	NS
F VIII R: Ag (%)	15.0±50	114.0±20	NS
ß-TGB (IU/ml)	17.5±6.5	12.6±5.4	NS
Haptoglobin (g/l)	1.6±0.7	1.7±1.2	NS
ACT (sec)	157.0±17	149.0±29	NS

Hct: hematocrit; Hb: hemoglobin; RBC: red blood cell count; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin; ACT: activated clotting time

Within the first 4 postoperative hours, if the the a maunt of blood collected in the Sorenson ATS were more that 200 ml, it was autotransfused back to the patient. If it took more than 4 hours, this blood was discarded to eliminate the possibility of bacterial contamination.

Hematological studies: Pre and postoperative Hb, Hct levels, red blood cell counts (RBC), white blood cell counts (WBC) and platelet counts, amounts of transfused bank blood, pump blood, fresh frozen plasma, and autotransfused blood were recorded. Postoperative drainages were also recorded.

Hematological studies that are listed below are performed on the subgroups IA and IIA. The samples from these subgroups of patients were withdrawn from a central venous line preoperatively, immediately after the patient was transported to intensive care unit from the operating room (postoperative pre-autotransfusion), and 18-20 hours after the autotransfusion. Also blood samples of the mediastinal drainage were taken while being collected. The hematological studies were as follows: **1)** Hemogram (Hb, Hct, RBC, WBC, platelet counts) were studied automatically by Coulter Counter Model S-Plus VI*; **2)** Prothrombin Time (PT), activated Partial Thromboplastin Time (aPTT) and fibrinogen levels were measured automatically**; **3)** Fibrin degradation products (FDP) were studied with latex agglutination technique; **4)** Haptoglobin levels were studied with single radial immundiffusion technique; **5)** Beta - thromboglobulin levels were measured with ELISA immunoassay method; **6)** Factor VIII Related Antigen (F-VIII R: Ag) with ELISA immunoassay method; **7)** ACT with automated coagulation laboratory; **8)** 2-3, diphosphoglycerate (2-3DPG) with enzymatic colorimetric technique; **9)** pH with acid base laboratory†; **10)** Bleeding time with Ivy method.

Results

Patients characteristics of Group I and Group II were found to be identical. The patient characteristics of the two subgroups were also identical. Preoperative hematologic data of subgroups are given in Table I. These data did not reveal any statistically significant difference between the subgroups. Postoperative preautotransfusion studies of Group IA were significantly different from the preoperative values for all measurements except the FDP and haptoglobin levels (Table II). In Group IIA postoperative preautotransfusion studies were

*: Coulter Electronics, Inc, Hialeah, Florida, USA

**: Automated Coagulation Laboratuory, ACL, Instrumentation Laboratory, New Jersey, USA

†:ABL, Radiometer Corp. Copenhagen, Denmark

Table II: The effects of CPB in Group IA on hematological values

	Before CPB	After CPB	p
Hct (%)	45.4±2	26.9±3	0.0001
Hb (g/dl)	14.7±0.9	8.9±1	0.0001
RBC (10^6/mm^3)	4.8±0.2	2.9±0.4	0.0005
Platelets (10^3/mm^3)	259±76	160±50	0.0001
FDP (µg/ml)	7.6±6	8.6±6	0.4307
Fibrinogen (g/l)	3.4±0.8	2.1±0.7	0.0005
PT (Sec)	9.8±0.4	12±1.1	0.0001
aPTT (sec)	21±2	25±3	0.0001
Bleeding Time (min)	1.8±0.9	3.7±1.9	0.0001
F VIII R: Ag (%)	153±50	125±60	0.0001
ß-TGB (IU/ml)	17.5±6.5	27.6±9.8	0.0001
Haptoglobin (g/l)	1.6±0.7	0.7±0.5	0.2732
ACT (sec)	157±17	131±24	0.0002

CPB: cardiopulmonary bypass; Hct: hematocrit; Hb: acmoglobin; RBC: red blood cell counts; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin; ACT: activated clotting time

also significantly different from preoperative values, except FDP, aPTT, haptoglobin and ACT measurements (Table III). These changes indicative of the effects of CPB (in which the duration of CPB for Group IA was 79±24 min. and for Group IIA was 81±53 min., (p>0.005) were also compared between two subgroups (Table IV). The main difference between Group IA and Group IIA were in Hct and F VII R: Ag levels.

Hematologic studies of Group IA after autotransfusion were compared with the postoperative pre autotransfusion data. The statistically significant difference were obtained

Table III: The effects of CPB in Group IIA on hematological values

	Before CPB	After CPB	p
Hct (%)	46.3±3	30.0±4	0.0001
Hb (g/dl)	14.8±1	9.9±1	0.0001
RBC (10^6/mm^3)	4.9±0.4	3.4±0.7	0.0001
Platelets (10^3/mm^3)	281.0±112	160.0±66	0.0462
FDP (µg/ml)	4.3±5	19.0±30	NS
Fibrinogen (g/l)	3.7±0.9	2.3±0.4	0.0001
PT (Sec)	9.6±0.3	12.4±1	0.0001
aPTT (sec)	23.8±2	24.5±2	NS
Bleeding Time (min)	1.9±0.5	3.3±0.6	0.0001
F VIII R: Ag (%)	114.0±20	73.0±17	0.0103
ß-TGB (IU/ml)	12.6±5.4	26.4±9	0.0207
Haptoglobin (g/l)	1.7±1.2	1.1±1.2	NS
ACT (sec)	149.0±29	126.0±13	NS

CPB: cardiopulmonary bypass; Hct: hematocrit; Hb: hemoglobin; RBC: red blood cell counts; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thrombog' bin; ACT: activated clotting time

Table IV: The effects of CPB in subgroups on hematologic values

	Group IA	Group IIA	p
Hct (%)	26.9±3	30.0±4	0.046
Hb (g/dl)	8.9±1	9.9±1	NS
RBC (10^6/mm^3)	2.9±0.4	3.4±0.7	NS
Platelets (10^3/mm^3)	160.0±50	160.0±66	NS
FDP (µg/ml)	8.0±6	19.0±30	NS
Fibrinogen (g/l)	2.1±0.7	2.3±0.4	NS
PT (Sec)	12.6±1	12.4±1	NS
aPTT (sec)	25.8±3	24.5±2	NS
Bleeding Time (min)	3.7±1.9	3.3±0.6	NS
F VIII R: Ag (%)	125.0±77	73±17	0.0343
ß-TGB (IU/ml)	27.6±9	26.4±9	NS
Haptoglobin (g/l)	0.7±0.5	1.1±1.2	NS
ACT (sec)	131.0±24	126.0±13	NS
Total CPB time (min)	79.0±24	81±53	NS

CPB: cardiopulmonary bypass; Hct: hematocrit; Hb: hemoglobin; RBC: red blood cell counts; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin; ACT: activated clotting time

in Hct, Fibrinogen levels, platelet counts, prothrombin and bleeding times (Table V). Simultaneous studies were also made in Group IIA and compared with post autotransfusion values of Group IA (Table VI). These results showed differences in FDP and ß-TGB levels. FDP levels were higher in Group IIA whereas ß-TGB levels were higher in Group IA.

The hematological properties of mediastinal shed blood are given in Table VII. As it could be seen, these values were very close to normal physiologic properties of blood.

Table V: The effects of autotransfusion in Group IA on hematologic values

	Before Autotransfusion	After Autotransfusion	p
Hct (%)	26.9±3	28.9±2	0.0382
Hb (g/dl)	8.9±1	9.3±10.8	NS
RBC (10^6/mm^3)	2.9±0.4	3.1±0.3	NS
Platelets (10^3/mm^3)	160.0±50	129.0±25	0.0267
FDP (µg/ml)	8.0±6	6.2±5	NS
Fibrinogen (g/l)	2.1±0.7	4.3±0.7	0.0001
PT (Sec)	12.6±1	11.4±1	0.0029
aPTT (sec)	25.8±3	23.6±4.5	NS
Bleeding Time (min)	3.7±1.9	2.6±1	0.044
F VIII R: Ag (%)	125.0±77	128.0±64	NS
ß-TGB (IU/ml)	27.6±9	33.9±12.9	NS
Haptoglobin (g/l)	0.7±0.5	0.5±0.2	NS

Hct: Hematocrit; Hb: hemoglobin; RBC: red blood cell counts; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin; ACT: activated clotting time

Table VI: The comparison of Group IA after autotransfusion with Group IIA simultaneously

	Group IA (n= 15)	Group IIA (n=10)	p
Hct (%)	28.9±2.	30.0±4	NS
Hb (g/dl)	9.3±10.8	9.6±1.3	NS
RBC (10^6/mm^3)	3.1±0.3	3.2±0.4	NS
Platelets (10^3/mm^3)	129.0±25	136.0±44	NS
FDP (µg/ml)	6.2±5	13.0±4	0.0007
Fibrinogen (g/l)	4.3±0.7	4.9±1	NS
PT (Sec)	11.4±1	10.4±1.1	NS
aPTT (sec)	23.6±4.5	22.6±3	NS
Bleeding Time (min)	2.6±1	3.0±0.8	NS
F VIII R: Ag (%)	128.0±64	95.0±16	NS
ß-TGB (IU/ml)	33.9±12.9	24.8±0.4	0.0232
Haptoglobin (g/l)	0.5±0.2	0.8±0.6	NS

Hct: hematocrit; Hb: hemoglobin; RBC: red blood cell counts; FDP: fibrin degradation products; PT: prothrombin time; aPTT: activated partial thromboplastin time; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin.

Postoperative drainage, the amount of autotransfusion and transfused bank blood, pump blood and fresh frozen plasma are given Table VIII. Even though the drainage was higher in Group IA ($p > 0.0001$), the bank blood requirement in Group IA was much lesser ($p>0.05$). In Group IA, 0.69±1.1 units of blood were required whereas in Group IIA mean 1.07±2.2 units of blood were required. Bacterial contamination with staphylococcus albus was detected in two mediastinal shed blood samples without clinical reflection.

Table VII: The composition and the properties of mediastinal shed blood

Hematocrit (%)	20.1±4
Hemoglobin (g/dl)	7.2±1.3
RBC (10^6/mm^3)	2.2±0.5
Platelets (10^3/mm^3)	NS
F VIII R: Ag (%)	66.0±64
Haptoglobin (g/L)	0.68±0.4
pH	7.34±1.2
2-3 DPG	1.3±0.4

RBC: red blood cell counts; F VIII R: Ag: factor VIII related antigen; ß-TGB: beta thromboglobin; 2-3 DPG: 2-3 diphosphoglycerate

Discussion

Indications of autotransfusion can be listed as follows: **1)** to prevent tranfusion transmitted diseases, **2)** to stockpile rare blood types, **3)** to prevent alloimmunization, **4)** to transfuse patients with a history of previous severe transfusion reactions, **5)** to avoid problems in patients with alloantibodies, **6)** to permit transfusions of patients whose religious beliefs prohibit blood transfusions, **7)** to maintain blood supplies in isolated or remote communities, **8)** to improve transfusion practice in selected surgical procedures, **9)** to replace massive blood loss using intraoperative or postoperative blood salvage[16].

Four categories of autologous transfusions are generally recognized: **1)** preoperative, in which blood drawn before a planned surgery is stored until needed; **2)** intraoperative hemodilution, in which blood is collected at the institution of surgery (most of prior to a CPB procedure) and then stored for subsequent reinfusion after CPB; **3)** intraoperative salvage, in which blood is salvaged from the surgical fields and reinfused during or after the surgical procedure; and **4)** postoperative salvage, in which blood is collected postoperatively by salvage of shed blood[11, 16-18]. The properties of mediastinal shed blood has been well defined in many studies[5,8,10,19-21].

Table VIII: The composition of the usage of blood products between the groups

	Group IA	Group IIA	p
Drainage (ml)	1219.0±769	881.0±483	0.0001
Autotransfusion (ml)	591.0±378	0	0
Bank Blood (units)	0.6±1.1	1.0±2.2	0.0152
Pump Blood (units)	1.8±1.2	1.9±1.3	0.1628
FFP (units)	2.1±2	1.9±2.4	0.2336

* 1 unit of blood = 200 ml

* 1 unit of fresh frozen plasma (FFP) = 175-200 ml

In open heart surgery, all of the methods listed above for autotransfusion is generally used. Mainly, in our clinic, the last three methods are routinely used. In these series presented here, 39% of blood products transfused in the early postoperative period is made of concentrated pump blood.

Since 1988, we've started using autologous transfusion of mediastinal shed blood routinely in the way mentioned above. As it could be seen in Table VIII, 48% of the mediastinal drainage blood, approximately 590 ml were transfused back to the patients which is actually equal to 1.5 units of bank blood.

Homologous bank blood is actually different from mediastinal shed blood with its composition and functions. The number of living cells in bank blood is reduced as a matter of the storage time, as well as coagulation factors. But this blood has a higher viscosity. As Mc Namara and colleagues stated in their previous work, aggregation and rouleaux formation in bank blood can lead to lung injury [22]. Also bank blood needs 4 hours to achieve the oxygen carrying capacity after being transfused. Belcher and colleaques showed that, these properties of bank blood increases the cardiac work unfavouringly disturbing the cardiac oxygen supply/demand ratio due to increased peripheral vascular resistance and viscosity [23].

Bennett and colleagues pointed out theoretical risks of autotransfusion[24]. These risks could be listed as follows; induction of coagulopathies, thrombocytopenia, hemolysis, renal failure, microembolism and infection. However, these theoretical risks were not encountered in our series. As it could be seen in Table V, PT, aPTT or bleeding times were not altered by autotransfusion of mediastinal shed blood. Actually PT and bleeding times were shortened significantly ($p<0.001$ and $p<0.05$ respectively). Even though it seems strange to have higher levels of fibrinogen after autotransfusion, it might be due to fresh frozen plasma transfusions or relative haemoconcentration. Higher percentages of F VIII R: Ag, even though not significant, after autotransfusion can be commented as the preservation of some coagulation factors such as Factor VII and Factor IX.

Increased levels of ß-TGB in Group IA after autotransfusion (Table V) showed the activation of platelets on nonphysiological surfaces. But this increment was not significant and was still in the normal range. Parallel to this, the number of platelets were found to be decreased after autotransfusion significantly (Table V). In addition to this, this decrease in platelets were also noticed in Group IIA (Table III). In our belief these reductions in platelet counts were due to the effects of CPB rather than to the autotransfusion itself (Table VI).

FDP was not increased after autotransfusion (Table V). This is an important observation, indicating that, autotransfusion does not have a significant adverse effect on fibrinolysis. Haptoglobin levels were decreased after autotransfusion (Table V) which might be a sign of hemolysis, but as it could be seen in Table II, the decrease was mainly occured after CPB and when compared to Group IIA, the same amount of reduction in haptoglobin levels were achieved (Table VI). These results emphasized that hemolysis was mainly due to CPB, not due to autotransfusion.

No neurologic signs due to microembolization were not seen in Group I. Also there were not any signs of lung injury in Group I in the postoperative period. As stated above, there

were only 2 positive bacterial cultures in mediastinal shed bloods suggesting the contamination of the culture media.

Table VIII shows the efficacy of the autotransfusion of mediastinal shed blood in avoiding the usage of stored bank blood. As it could be seen, About 48% of the postoperative blood loss was salvaged with this method, and 36% reduction of bank blood consumption was reached. In various studies published previously, it was shown that, the savings of postoperative blood loss might be achieved between 30-80% [5,10,14,25].

In conclusion; autotransfusion of mediastinal shed blood can avoid the consumption of homologous bank blood effectively by eliminating the costs, potantial risks of transfusion, and the shortage of availibility, and can be life saving in emergency situations as being a good substitute of physiologic, intravascular normal blood.

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