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COMBINATION OF CONTROLLED HYPOTENSION AND CELL SALVAGE AS A TRIAL TO REDUCE ALLOGENEIC BLOOD TRANSFUSION DURING MAJOR ELECTIVE ORTHOPEDIC SURGERY

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Abstract

This study was designed as a trial to evaluate the combined use of both hypotensive anesthesia and autotransfusion strategies for reduction of allogeneic blood transfusion during surgical correction of scoliosis. Twenty (ASA I-II) patients were randomly allocated in two equal groups, group I received normotensive anesthesia and group II received hypotensive anesthesia and underwent intraoperative autotransfusion using cell saver (Haemacell System 350), both groups were assigned to receive allogeneic banked blood if they required. During surgery patients were monitored for heart rate (HR), mean arterial pressure (MAP), core temperature, central venous pressure (CVP) and urine output. Intraoperative blood loss (IOBL), postoperative blood loss (POBL) and total blood loss (TBL) were defined and calculated as a percentage of estimated blood volume (EBV) and amount of blood transfusion required was recorded, transfusion trigger hemoglobin concentration was considered to be <7 gm/dl. There was a significant decrease of IOBL, POBL, and TBL in group II compared to group I. All patients included in group I and 8 patients in group II required allogeneic blood transfusion. Moreover, there was a significant (P<0.05) decrease of the total number of blood units consumed in group II. There was a positive significant correlation (r=0.696, P=0.025) between the duration of surgery and the IOBL in group I, and between MAP and total number of blood units used (r=0.716, P=0.02) and both IOBL (r=0.716, P=0.02) and TBL (r=0.845, P=0.002) in group II. We can con-

clude that combination of controlled hypotension and cell salvage was effective in reducing allogeneic blood transfusion during surgery for scoliosis correction and can be applied as blood conservation strategy during major surgery predicted to require excessive amount of allogeneic blood transfusion.

Introduction

Blood loss during and after spinal fusion surgery for correction of spinal scoliosis is high (Guay et al., 1992). The anesthetic and surgical techniques have been cited as possible factors influencing blood loss during surgery, including the extent of dissection, number of vertebrae to be fused, duration of surgery, surgical techniques, type of instrumentation and size of bone graft, use of epinephrine, degree of relaxation and mean arterial blood pressure, (Phillips & Hensinger, 1988).

Allogeneic blood transfusion is associated with the risk of transmission of viral diseases, greater immunosuppression and more postoperative infection than autologous blood transfusion, (Avall et al., 1997). Several blood conservation strategies have been introduced with the aim of reducing allogeneic blood transfusion, (Landers et al., 1996).

Lowering arterial pressure is an old method of reducing blood loss and there is considerable renewal of interest in this strategy (Lawhon et al., 1984). Lowering of cardiac output versus lowering peripheral resistance is an important factor in the efficacy of hypotension on the reduction of intraoperative bleeding in patients undergoing posterior spinal fusion, (Grundy et al., 1981). Knight et al., (1980), reported that the sole hemodynamic variable related to intraoperative bleeding was the left ventricular stroke work index. Since it is possible that hypotension increases the risk of neurological sequelae, particularly if one uses an agent, which lowers spinal blood flow, the risk:benefit ratio of the various hypotensive techniques needs to be clearly defined (Brodsky et al., 1991).

Intraoperative autotransfusion is an established method to reduce the need for homologous blood transfusion. During an operation, salvaged blood is aspirated from the wound site and collected in a reservoir. The blood processing procedure of autotransfusion devices is based on the principle of centrifugation, in which denser particles i.e., red blood cells are separated and washed with saline to obtain washed packed red blood cells for reinfusion (Healy et al., 1994). Blood collected especially during orthopedic surgery often contains nonemulsified fat derived from bone marrow and/or subcutaneous fat depots, which if entered circulation it may initiate a fat embolism syndrome, which is characterized by pulmonary dysfunction, (Henn-Beilharz et al., 1990).

This study was designed as a trial to evaluate the combined use of both hypotensive anesthesia and autotransfusion strategies for reduction of allogeneic blood transfusion during surgical correction of scoliosis.

Patients & Methods

After obtaining approval from the Ethics Committee and getting an informed parental consent, 20 (ASA grade I-II) patients scheduled for elective correction of spinal scoliosis (2 segments) in Electricity Hospital, Vertebral Column Surgery Department between October 1998 up to March 2000 were included in the study. Exclusion criteria were renal insufficiency (serum creatinine >1.2 mg/dl), history of Hematologic or coagulation disorders, hematocrite value <30%, or ingestion of salisylates or anticoagulant therapy during the last week prior to surgery.

Patients were scheduled for spinal correction and fusion by the same surgeon using a Cottrel-Dubousset surgical technique with harvesting bone graft from the iliac crest. Patients were randomly allocated in two groups, (n=10, each), group I, included patients assigned to receive allogeneic banked blood if they required blood transfusion. Group II included patients assigned to receive hypotensive anesthesia and to undergo intraoperative autotransfusion using cell saver (Haemacell System 350) and to receive allogeneic banked blood if they required additional blood transfusion.

For patients included in group I, general anesthesia was induced using medazolam, fentanyl, atracurium and thiopental to facilitate endotracheal intubation and anesthesia was maintained with isoflurane 1-1.5% and increments of fentanyl and atracurium. The lungs of all patients were ventilated mechanically with 60% nitrous oxide in oxygen to maintain SaO_2 >95%. Ventilation was adjusted to maintain end-expiratory carbon dioxide at 30-35 mmHg (continuous capnography). For patients included in group II, controlled hypotension was used to maintain the mean arterial pressure (MAP) lowered to approximately 70mmHg during surgery by continuous infusion of sodium nitroprusside using infusion pump. A radial artery catheter and right internal jugular vein central venous catheter were placed. Also, a urinary bladder indwelling catheter and a nasopharyngeal thermistor were applied.

The Haemacell System 350 (Haemacell plc, Barton Lane, Abingdon) is designed to work efficiently in procedures with potential blood loss of 2-4 blood units. The system utilizes a patented membrane filter to remove the majority of protein and plasma contaminants. This process allows highly efficient separation of the liquid and cellular elements under low pressure. Vortex mixing aids the filtration process by swirling the blood across the membrane and reducing the tendency of the cells to bind to the membrane surface. Full-wash processing was applied, the blood is pumped through the membrane filter and the concentrated red cells suspended in saline before passing the filter membrane a second time to remove plasma. Intraoperative collection set consists of a collection reservoir, vacuum tubing, aspiration line, yankauer, a patented anticoagulant control layer and re-infusion bag. This two-stage process is a simple procedure that was carried out by the anesthetist without the need of requesting a dedicated technician.

Once skin was infiltrated with epinephrine 1:200,000, Haemacell 350 was primed with saline to remove the residual air from the system. During surgery, the sterilized suction tubing was connected and the anticoagulated shed blood was aspirated to a 3-liter collection reservoir, which contains a 20-mm filter. During processing, blood was passed through a series of filters and the washed blood is delivered from the cartridge to the re-infusion bag. Irrigants, anticoagulants and cell degradation products were directed to the washing bag. A standard 20-40 mm filter was used during re-infusing blood to the patient.

During surgery patients were monitored for ECG, heart rate (HR), MAP, core temperature, and urine output. Maintenance fluid therapy using lactated Ringer's solution (5 ml/kg/hr) in order to maintain central venous pressure (CVP) between 5-10 cmH_2O and hourly urine output of >30 ml. Intraoperative blood loss was measured by weighting sponges (=wet-dry sponge) and defining the amount of blood present in the suction-draining container. Postoperative blood loss throughout the first 24-hr was also defined. Both intra- and postoperative, and total blood loss was calculated as a percentage of estimated blood volume (EBV) (EBV=60ml/kg and 65ml/kg for female and male, respectively), and amount of blood transfusion required was recorded, transfusion trigger hemoglobin concentration was considered to be <7gm/dl.

Data were analyzed using paired t test. Possible relationships were investigated using Pearson linear regression. Statistical analysis was conducted using the SPSS (Version 7) for Windows statistical package. A P value <0.05 was considered statistically significant.

Results

Patients' demographic and surgical data were presented in Table (1) and showed a non-significant (P>0.05) difference between both groups. Also, there was a non-significant difference between both groups as regards core temperature and urine output. On the other hand, hemodynamic changes showed a significant decrease ($P<0.05$) in group II compared to group I, (Table 2).

Estimated blood volume of patients included in both groups showed a non-significant difference ($P>0.05$). Mean IOBL was 1424±132 ml; 37.4±5.3% of EBV, in group I and 1224±108 ml; 31.9±4.4% of EBV, there was a significant decrease of IOBL in group II compared to that occurred in group I ($P<0.05$). Moreover, mean POBL was 980±142 ml; 26.2±6.9% of EBV, in group I and 765–123 ml; 20.2±5.4% of EBV, also there was a significant decrease of POBL in group II compared to that occurred in group I, ($P<0.05$). As a total blood loss, group II showed a significant decrease ($P<0.05$) compared to that occurred in group I, (Table 3, Fig. 1).

There was a positive significant correlation ($r=0.696$, $P=0.025$) between the duration of surgery and the IOBL in group I, (Fig. 2), while there was a positive non-significant correlation in group II. There was a positive significant correlation ($r=0.716$, $P=0.02$) between the mean decrease of IOBL and MAP in group II, (Fig. 3a), while there was no correlation was noticed in group I. Moreover, there was a positive significant correlation ($r=0.845$, $P=0.002$) between TBL and MAP in group II, (Fig. 3b), while there was no correlation in group I.

All patients included in group I and 80% of patients in group II required allogeneic blood transfusion. However, there was a significant ($P<0.05$) decrease of the total number of blood units consumed in group II, (mean=1.3±0.9; range, 0-3 units) compared to that administered to patients in group I, (mean=4.2±1.3; range 1-6 units), (Fig. 4). In group II, two patients did not require allogenic blood transfusion, and no patient needed transfusion of more than 3 units, only one patient required transfusion of 3 units, 3 patients required 2 units and the other 4 required only 1 unit, (Table 4). There was a positive significant correlation ($r=0.833$, $P=0.003$) between the total number of blood units used and MAP in group II, while there was no correlation in group I.

Table (1): Patients' demographic data

Parameter	Group I (n=10)	Group II (n=10)
Age (years)	21±2 (18-24)	21.1±1.7 (19-24)
Sex, M:F	8:2	7:3
Wt (Kg)	60.4±9.3 (49-74)	61.5±9.5 (50-72)
Duration of surgery (min)	195±30 (150-255)	200±30 (165-240)

Data are presented as mean±SD, ranges are in parenthesis

Table (2): The mean hemodynamic changes occurred in patients included in both groups

Parameter	Group I (n=10)	Group II (n=10)
HR	68.9±4.9 (61-79)	73.5±5.8 (60-82)
MAP	86.7±5.5 (78.3-96.7)	73.4±2.5 (68.3-77)†
CVP	8.5±1.1 (7-10)	5.8±0.6 (5-7)†

Data are presented as mean±SD, ranges are in parenthesis
† means significant decrease versus group I

Table (3): The mean estimated blood volume (EBV), and blood loss, intraoperative (IOBL), postoperative (POBL) and total blood loss (TBL) in both groups

Parameter		Group I (n=10)	Group II (n=10)
EBV		3855±513 (3185-4680)	390 0±590 (3060-4680)
IOBL	Amount (ml)	1424±132 (1280-1680)	1224±108 (1040-1400)
	% to EBV	37.4±5.3 (30.5-49)	31.9±4.4 (27.6-39)†
POBL	Amount (ml)	980±142 (825-1200)	765±123 (562.5-900)†
	% to EBV	26.2±6.9 (17.6-37.7)	20.2±5.4 (13.1-29.4)†
TBL	Amount (ml)	2402±171 (2180-2760)	1990±102 (1762-2145)†
	% to EBV	81.7±14.9 (66.7-111.5)	52.1±8.6 (41-63.5)†

Data are presented as mean±SD, ranges are in parenthesis
† means significant decrease versus group I

Table (4): The number of allogeneic blood units required in both groups

Number of units	Group I (n=10)	Group II (n=10)
1	0	4
2	1	3
3	2	1
4	3	0
5	2	0
6	2	0
Mean±SD	4.2±1.3 (1-6)	1.3±0.9 (0-3)†

† means significant decrease versus group I

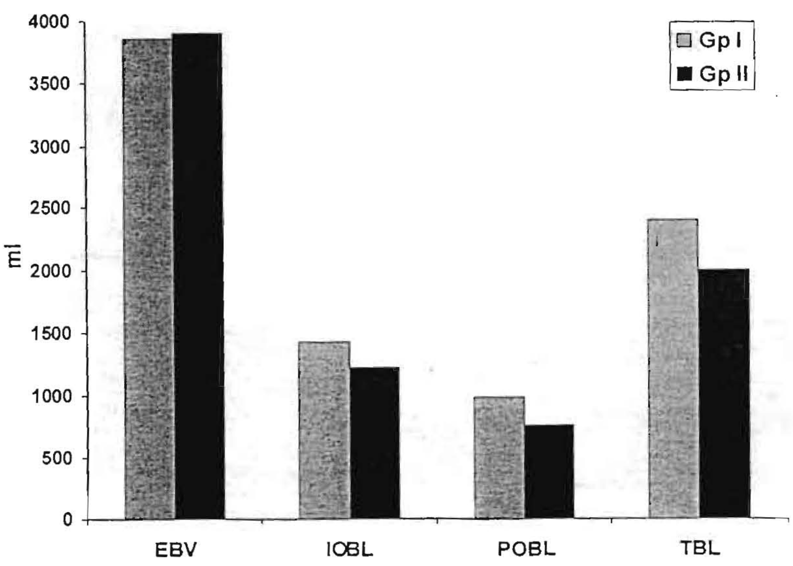

Fig. (1): The mean EBV and blood loss during and after surgery in both groups

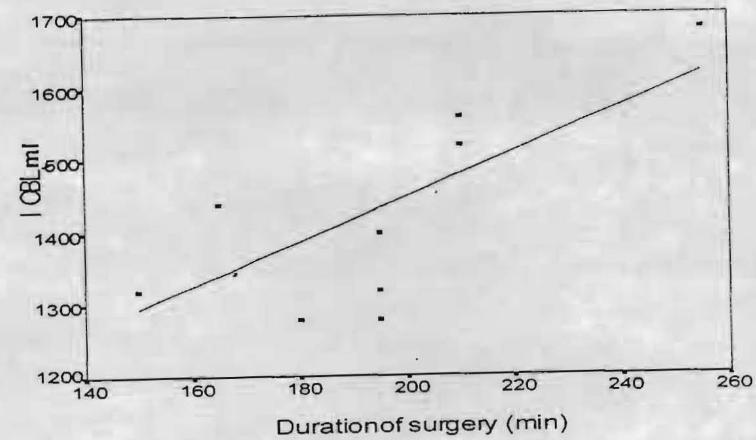

Fig. (2): shows the correlation between duration of surgery and IOBL in group I.

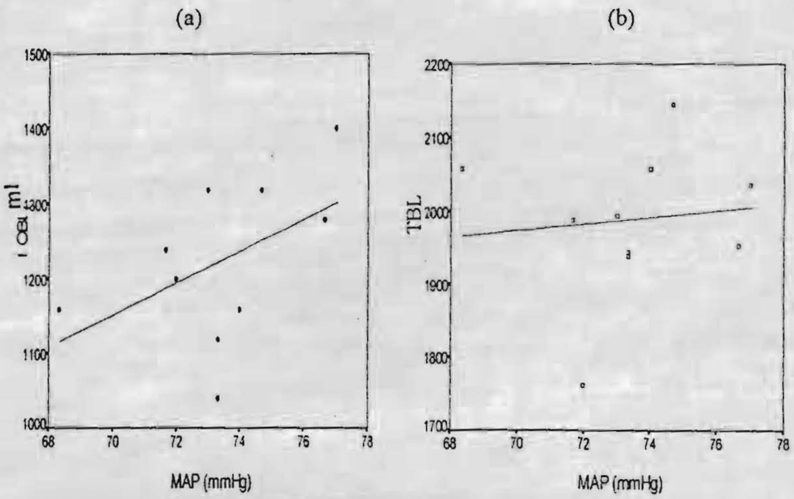

Fig. (3): shows the correlation between MAP and both IOBL (a) and TBL (b) in group II.

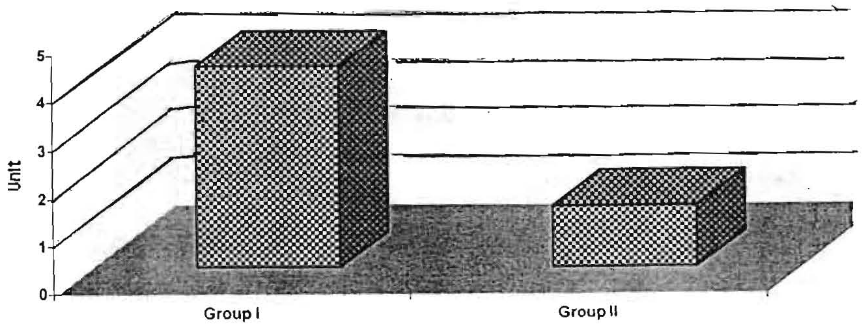

Fig. (4): The mean number of allogeneic blood units administered to patients included in both groups

Discussion

The requirement for blood transfusion during surgery depends on two major variables: (1) the volume of perioperative blood loss, which is related to the type of surgery, the adequacy of surgical hemostasis, and the surgical and anesthetic techniques used; and (2) the volume of blood loss that the patient can tolerate before transfusion is indicated, (Mercuriali & Inghilleri, 1998).

Our results demonstrated a significant reduction (P<0.05) of blood loss, IOBL, POBL, and TBL, in group II compared to that occurred in group I. Also, there was a positive significant correlation between MAP and blood loss. These results agreed with Knight et al., (1980), Grundy et al., (1981), Brodsky et al., (1991), Sharrock et al., (1993) and Guay et al., (1994), who reported that lowering the systolic blood pressure reduced bleeding during major orthopedic surgery. Also, Boldt et al., (1999) reported reduction of blood loss during radical prostatectomy using controlled hypotension during the operation. This signified that controlled hypotensive anesthetic techniques allowed the performance of major surgeries with the least possible blood loss. The decreased IOBL can be attributed to the decreased stroke volume induced by decreased peripheral resistance and thus decreased venous return as manifested by the decreased CVP measures in group II. Furthermore, the use of salvaged blood that transfused as washed packed red cells improved the oxygen carrying capacity of circulating blood without inducing volume preload. Moreover, the reduced intraoperative bleeding of the hypotensive group might have resulted in less dilutional thrombocytopenia and higher level of coagulation factors in the immediate postoperative period thus reducing the POBL and thereby the TBL.

There was a positive significant correlation between the amount of blood loss and the duration of surgery in group I, but no correlation in group II. These results coincided with that reported by Guay et al., (1994) who found a correlation between the duration of surgery for scoliosis and amount of blood loss. This can be attributed to the fact that major bleeding during surgery could slow the progress of surgery, and this factor was eliminated to a great extent in hypotensive group, thus allowing comfortable surgical circumstances.

Our study demonstrated a significant reduction in allogeneic blood transfusions and no patients, in group II, required transfusion of more than three units of blood. Since we decided to use a hemoglobin concentration of < 7 gm/dl as a trigger for blood transfusion, this illustrates the beneficial role of autotransfusion of the washed packed red blood cells that maintained hemoglobin concentration as more as possible above the trigger level so decreased the need for allogeneic blood transfusion. These results agreed with Napier et al., (1997) who used cell salvage as a trial for autologous blood transfusion so as to decrease the need for allogeneic blood transfusion.

We can conclude that combination of controlled hypotension and cell salvage was effective in reducing allogeneic blood transfusion during surgery for scoliosis correction and can be applied as blood conservation strategy during major surgery predicted to require excessive amount of allogeneic blood transfusion.

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