The Comparison of Acute Normovolemic Hemodilution with Allogenic Blood Transfusion in Patients who Underwent Femoral Fracture Surgery

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Background: Acute normovolemic hemodilution is an available technique to decrease the side effects of allogenic blood transfusion. The aim of this study was to compare acute normovolemic hemodilution with allogenic blood transfusion in adult patients who were scheduled for femoral fracture surgery.

Methods: In this randomized controlled trial, 50 patients were randomly allocated into two equal groups. General anesthesia was induced in all patients. After induction of anesthesia in case group (n=25) 500 ml blood was taken from patients, while the circulating blood volume was restored by ringer solution (3ml ringer for each 1ml of blood withdrawn). The blood extracted was re-infused during or after surgery according to the patient's hemoglobin and hemodynamic parameters. In case there was further need for blood, allogenic blood was transfused. In the control group (n=25), only allogenic blood was transfused according to estimated patient's blood loss. Patients' assessment was performed by an anesthesiologist who was blinded to the patients' allocation.

Results: Demographic and laboratory data were similar between both groups. Pre- and postoperative laboratory tests were similar in both groups except in mean platelet count (p=0.001). The patients in the two groups were comparable regarding hemodynamic parameters. In the control group, 11 patients needed allogenic blood transfusion and in the case group, allogenic blood was transfused in 4 patients (p=0.03).

Conclusion: This study suggested that acute normovolemic hemodilution autotransfusion reduced allogenic blood transfusion in patients who underwent femoral fracture surgery.

Keywords: allogenic blood transfusion; autologous blood transfusion; hemodilution

The risks of allogenic blood transfusion are increasingly known. To decrease the risk of transmitted diseases during transfusion and also the costs, anesthesiologists prefer to use autotransfusion strategy [1]. Acute normovolemic hemodilution (ANH) perform by removal of patient blood after induction of anesthesia and replacing it with crystalloid or colloid solution simultaneously to render an isovolemic condition. The blood will then be collected in standard blood bags containing anticoagulant [2].

Dilution of blood in normovolemic conditions will

enhance the venues return and improve the capillary blood flow significantly. The dilution of the whole blood leads to a decrease in hematocrit and blood viscosity. In normovolemic conditions when cardiorespiratory system works adequately, the acute dilution of blood will improve the venous return to the heart and enhance the total and capillary blood flow significantly, that compensate the diminished oxygen content of the blood [2-3]. It is reported that the hemodilution technique could reduce intraoperative blood loss and allogenic blood transfusion in normovolemic children with cancer [3]. It was shown that the ANH could enhance the cardioprotection by reducing the blood viscosity in patients who underwent coronary artery bypass graft surgery (CABG) [4]. The aim of this study was to compare the ANH with allogenic blood transfusion in adult patients who were scheduled for femoral fracture surgery.

Methods

The protocol of this study was approved by the ethics committee of Hamadan University of Medical Sciences and registered in clinical trial registration center of our country (ID: IRCT201012045313N1).

In this randomized prospective clinical trial, 50 patients with American Society of Anesthesiologists Physical Status (ASA) class1 or 2, with random block were allocated in two

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equal groups as case (n=25) and control group (n=25). Written informed consent was obtained from the patients after explaining the purpose and process of the research. Routine laboratory tests including prothrombin time (PT), partial thromboplastin time (PTT), blood urea nitrogen (BUN), creatinine, hemoglobin (Hb) and hematocrit (Hct) were requested in the day of surgery in all patients.

Patients with cardiac, pulmonary and liver diseases, impaired renal function, preoperative hemoglobin<11 g/dL, coagulation disorders, inadequate vascular access, severe hypertension and patients with infection disorders were excluded. The baseline demographic of both groups such as age, sex and weight were recorded.

General anesthesia was induced with fentanyl (100 μg), thiopental (3-5mg/kg), and atracurium (0. 5 mg/kg) for all patients in two groups. After tracheal intubation, anesthesia was maintained by isoflurane 0.4-1.5 vol% in a 50% oxygen-nitrous oxide in all patients. Intraoperative monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, repetitive determinations of hemoglobin concentration and hematocrit (at least every 30 min), and arterial blood gas measurement. Additional fentanyl and atracurium were given intraoperatively. Urinary catheter was inserted to measure the urine output in all cases.

After anesthesia that established in the case group, we inserted a large bore IV catheter for withdraw the blood. The volume of blood that might be withdrawn was calculated using the following formula:

$$V = EBV \frac{Hct_p - Hct_e}{Hct_{av}}$$

V (blood volume withdrawn), EBV (estimated blood volume of patient), Hctp (patient's hematocrit), Hcte (desired hematocrit), Hctav (average of patient's hematocrit and desired hematocrit).

In our protocol desired Hb was considered as 10 g/dl. We withdrew 500 ml of blood from the patients with the rate of 40 ml/min and simultaneously we infused ringer solution. Thirty minutes after withdrawing the blood, another blood sample for measuring Hb and Hct was sent to the laboratory. Each blood unit was labeled with the patient's name, hospital ID, and time of withdrawal. According to the American Association of Blood Bank standards, the units collected by ANH can be stored at room temperature in the operating room for up to 8 hours [5]. Estimation of blood loss and serial hematocrit determinations served as a useful guide for transfusion requirements. The amount of intraoperative crystalloid infusion was continuously adapted to the current estimated surgical blood loss and the current urine output using the following formula; target amount of crystalloid infusion = estimated blood loss × 3 + urine output.

The anesthetist estimated the blood loss by assessment of draping sheets, and the suctioned blood. If the patients' hemodynamic variables altered suggesting hypovolemia (such as tachycardia more than 20% of base or hypotension more than 20% of base) 500-1,000 ml of crystalloid solution were infused additionally. If the patient's hematocrit dropped to 20% of baseline, we re-transfused the patient's own withdrawn blood. If more blood was needed, allogenic blood was administered. In the control group only allogenic blood was transfused according to blood loss in case of necessity.

The collected data were analyzed using SPSS software, version 13. Normally distributed data confirmed by Kolmogorov-Smirnov test were presented as means ± standard deviation (SD). The amount of blood removed and ringer solution supplied during ANH, as well as estimated and calculated blood loss, were compared using paired student's t-test. One-way analysis of variance was used for comparing intergroup differences. The Student-Newman-Keuls method was used for multiple comparisons of postoperative data. A p-value < 0.05 was considered as statistically significant.to the parents and then they were sent home. One of the nurses of anesthesia contacted with parents by telephone the day following sedation and asked them if the child remained well and had any complications of CH ingestion at home. Statistical analysis was performed using the SPSS 13 statistical software. Continuous variables were analyzed using the t-test. Categorical data were analyzed with a chi-square test or Fisher exact test as appropriate. P-value < 0.05 was considered significant.

Results

The demographic variables including sex, age, weight, and mean operation time were similar in both groups (Table 1). Pre- and postoperative laboratory tests were similar in both groups except in mean platelet count (275480 versus 297720 in case group and 220360 versus 241720 in control group, respectively) which was statistically significant (P=0.001). Mean PTT time before and after operation was similar in case group but not in the control group (P=0.001), which might be caused by allogenic blood transfusion (Table 2). The patients in the two groups were comparable regarding hemodynamic parameters (Table 3). Only four (16%) patients in the case group needed allogenic blood transfusion but in the control group, 11 (44%) patients received allogenic blood (p=0.03). Mean estimated blood loss, fluid replacement, and operating time were similar in both groups (Table 4). No complication was reported in both groups.

Table 1- Patients' demographic data presented in both groups

Variables	Case group (N=25)	Control group (N=25)	P value
Age (years)	60.44±13.09	55±18.25	0.232
Sex (M/F)	15/10	17/8	0.565
Weight (Kg)	65.76±6.60	65.84±3.46	0.957
Mean operation time (min)	100.60±21.22	98.80±21.17	0.286

Discussion

We found that acute normovolemic hemodilution can be reduce the need to allogenic blood transfusion perioperatively. Postoperative platelet count and PTT in both groups increased versus baseline characteristic. While postoperative Hb and Hct in both groups reduced relative to preoperative. Preoperative and postoperative hemodynamic parameters in case and control groups were similar.

Estimated blood loss in both groups did not have significant difference.

Table 2- Pre- and postoperative biochemical data in both groups

Variables	Before operation		After operation		P Value	
	Case	Control	Case	Control	Case	Control
Mean of platelet (count/mm3)	275480±73051.42	220360±65852.6	297720±68942.9	241720±67654.4	0.001	0.001
Mean of PT (sec)	15.80(±3.14)	14.16(±2.54)	16.88(±2.26)	14.44(±2.75)	0.679	0.232
Mean of PTT(sec)	38.28(±4.09)	36.96(±5.07)	38.76(±3.01)	39.04(±5.60)	0.334	0.001
Mean of Hb (gr/100)	12.36(±2.19)	11.84(±1.22)	12.17(±1.05)	11.58(±1.19)	0.644	0.123
Mean of Hct (%)	37.44(±3.26)	35.84(±4.26)	35.92(±1.97)	35.80(±4.24)	0.002	0.844

Table 3- Pre- and postoperative hemodynamic data in both groups

	Mean MAP (mmHg)		Mean PR (p/min)		Mean Spo2 (%)	
	Before	After	Before	After	Before	After
Case	110±28	101.88±30	102.04±28	94.33±38	97.80±2.1	95.79±4.4
Control	105±42	106.84±44	97.80±40	100.804±26	96.72±30	95.89±4.6
P-value	0.086	0.148	0.290	0.078	0.164	0.921

Table 4- Comparative data of blood and fluid transfusion and mean operation time in both groups

	Case	Control	P-value
Received allogenic transfusion (n)	4	11	0.039
Mean estimated blood loss (ml)	1314±285	1340±220	0.324
Mean crystalloid replacement (ml)	3596±886	3660±996	0.413
Mean operative time (min)	92.60±28	95.04±34	0.286

Some investigations could not show the benefits of autotransfusion [5-7]. There are also some concerns about the possible need for increased personnel for aggressive monitoring of patients during acute normovolemic hemodilution autotransfusion. Other reports showed a potential risk for increased blood loss, resulting from dilution of coagulation factors [8], although in another study this method was safe in selected patients [9].

A meta-analysis of some English language studies with strict inclusion criteria has shown that the efficacy of ANH is likely to be small, bleeding and allogenic blood requirements are only modestly reduced, efficacy is unproven, and safety has not been confirmed adequately [10]. This report mandates more definitive studies prior to recommending widespread use of ANH, although our results showed some benefits for using this method. A study done by Thomas and coworkers on patients scheduled for total knee replacement surgery showed that only 7% of patient who infused autologous blood needed allogenic blood while in their control group 28% of patient needed allogenic blood [8]. Their finding was similar to our results. In a similar reported by Radmehr and colleagues showed that patients who received autologous blood needed less allogenic blood than the control group [11]. Minor reductions of the individual coagulation factors in the immediate postoperative course were seen in a study reported by Rosberg [9].

In our study the PTT time was prolonged in control group after operation but this prolongation was not clinically important. In a recent investigation researchers showed that patients in ANH group received less allogenic blood compared with patients received standard protocol in liver resection [12]. In conclusion this study was suggested that acute normovolemic hemodilution autotransfusion reduces allogenic blood transfusion in patients who underwent femoral fracture surgery.

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