

CASE REPORT

Acute Normovolemic Haemodilution for Management of Blood Loss during Radical Prostatectomy

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Abstract: *Introduction:* The reduction of the risks of anemia and allogeneic transfusion is one of the basic parts of the anaesthesia management in large urological procedures. We used acute normovolemic haemodilution (ANH) as a technique of autologous blood procurement in patients scheduled for radical prostatectomy.

Methods: 15 patients undergoing radical prostatectomy were enrolled in our study. After starting general anaesthesia the left radial artery line was placed for invasive blood pressure monitoring and withdrawing blood for ANH. The restoration of circulated volume was instituted by infusion of crystalloids and colloids. Reinfusion of gained blood was started after transfusion trigger was reached (Hct 0.25).

Results: The average total blood loss was in amount of 2393 ± 238 (ml), autologous blood was infused in amount of 1919 ± 220 (ml). The preoperative haematocrit was 41 ± 3 , after ANH 29 ± 2 and 31 ± 3 (%) postoperatively. One unit of allogeneic blood was transfused in 2 patients only. All patients were hemodynamically stable during the entire surgery, with minimal systolic blood pressure of 100 mmHg and were extubated in the operation room with no complications.

Conclusions: This study demonstrated the effectiveness and safety of ANH as a method for avoiding the allogeneic blood transfusion in patients undergoing radical prostatectomy (Tab. 1, Ref. 10). Full Text (Free, PDF) www.bmj.sk.

Key words: anaesthesia management, acute normovolemic haemodilution, radical prostatectomy.

The therapeutic use of allogeneic blood brings uncommon but potentially fatal complications. In addition to the well-known infectious and haemolytic transfusion complications, clinical evidence suggests that blood transfusions can as well cause significant immune effects (1). Multiple retrospective human studies proved a correlation between allogeneic blood transfusion and both recurrence and decreased survival (2, 3). These well-documented risks have entailed re-evaluation of the current transfusion practice (4). One of the primary goals in urological surgery, as well as other surgical specialties, is to minimize blood loss and application of allogeneic blood. In our prospective study we use acute normovolemic haemodilution (ANH) as a solely method of autologous blood procurement in patients scheduled for radical prostatectomy.

Methods and materials

After the approval by both Ethics Committee of our hospital and Internal Grant Agency of the Czech Ministry of Health the 15 patients undergoing radical prostatectomy successively from

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April to November 2006 were enrolled in our study. The low-molecular-weight heparin (dalteparinum natrium according to the weight) was administered 12 hours before operation to all patients. After the application of antihypertensive drugs the patients were premedicated orally with midazolam 2 hours before surgery. General anaesthesia was induced with midazolam, propofol, sufentanil and muscle relaxation was provided by cisatracurium. The trachea was intubated, and ventilation was adjusted to maintain a normal $PETCO_2$. Anaesthesia was subsequently maintained with sevoflurane (end-tidal concentrations of 1 to 1.5 %) and further doses of sufentanil and cisatracurium. Except cannulation of two veins in upper extremities, puncture of the right jugular vein was performed by three-way catheter. The left radial artery line was placed for invasive blood pressure monitoring and withdrawing blood for haemodilution. Electrocardiogram, SaO_2 , $PETCO_2$, SvO_2 , central venous pressure, cardiac output (Vigileo, Edwards Lifesciences) and urine output were monitored continuously too.

After the induction of anaesthesia ANH was started with the removal of blood (target haematocrit 0.30) from radial artery into transfusion bags with 70 ml of CPDA solution in each of them. The amount of blood to be taken was calculated in advance according to the formula:

Haemodilution volume (in ml) = $(H_s - H_r) \times TBBV / H_s$

H_s – starting haematocrit (Hct), H_r – required Hct, TBBV — total body blood volume.

Tab. 1. Blood count values.

Time	Preoperative	After ANH	Before retransfusion	Postoperative
Hct (%)	42±3	29±2	24±3	31±3
Hb (g/l)	142±12	98±11	87±7	108±9
Plt (10 ⁹ /l)	221±19	195±16	158±14	208±13

ANH – acute normovolemic haemodilution, Hct – haemocrit, Hb – haemoglobin, Plt – platelets

Circulation was restored with a volume of crystalloids (Plasmalyte, fy B Braun) and colloids (Tetraspan 5 %, B Braun). In course of ANH (60 minutes in general) the systolic blood pressure was maintained above 100 mmHg. The starting blood loss was compensated by a supply of further infusion of warmed crystalloid and colloids solutions. Retransfusion was started when the calculated transfusion trigger (Hct 0.25) was reached. The collected blood was returned to circulation in a volume equal to that of subsequent blood loss in the reverse order of collection. Haemoglobin, haematocrit, haemocoagulation values and thrombelastography were set before operation, after withdrawing the blood for ANH and after surgery.

Results

All values are expressed as mean + standard deviation. The general blood loss was 2393±238 (ml) during 4 hours and 20 minutes of operation time. In the course of operation, infused were altogether 1500 ml of colloids, 3500 ml of crystalloid and 1919±210 g of blood gained from ANH. All patients were hemodynamic stable during the entire surgery, with minimal systolic blood pressure 100 mmHg and measured cardiac output was in normal values. The trachea was extubated in the operating room in all patients and thereafter the patients were transferred to the intensive care unit for postoperative monitoring. After ANH we recorded a reduction in haematocrit value from 0.42±3 to 0.29±3 and decline in haemoglobin value from 142±12 to 98±11. One unit of allogeneic blood was transfused in 2 patients only. Measured values including coagulogram were stable during the whole operation time and stayed stable as well after the operation. The thrombelastography values proved mild hypercoagulation with slight shortening reaction time. The main values corresponding to mathematical calculations are shown in Table 1.

Discussion

Bloodless medicine and surgery programs have been developed mainly to meet the needs of Jehovah's Witness, but they also apply to non-Witness patients who desire to avoid or minimize their exposure to allogeneic blood products. Preoperative autologous blood donation, application of erythropoietin, intraoperative blood salvage and ANH are the routinely used methods for avoiding the allogeneic blood transfusions.

ANH is a technique that comprises the removal of whole blood from a patient along with the restoration of circulating

blood volume with acellular fluid shortly before the anticipated significant surgical blood loss. Blood is collected into standard blood bank bags containing citrate anticoagulant. The blood can then be stored at room temperature for up to 8 hours, or at 4 °C for up to 24 hours under routine conditions. Blood is returned to the patient in the operating room as soon as major blood loss is ceased, or sooner if indicated. Subsequent intraoperative fluid management is based on the usual surgical requirements. Blood units are returned in the reverse order of collection. The first unit collected, and therefore the last unit transfused has the highest haematocrit and concentration of coagulation factors and platelets. The benefit of haemodilution resides in the reduction of red cell losses when whole blood is shed perioperatively at lower haematocrit after ANH is completed.

The haemoglobin values that can be tolerated depend on many factors. Oxygen delivery to the tissues is influenced by respiratory system, blood (the oxygen-carrying system) and cardiovascular system. Anaemia results in a decrease in blood viscosity with reduction of peripheral vascular resistance (5). Compensatory mechanisms include an increase in both cardiac index and oxygen extraction (6, 7). According to some authors ANH can replace preoperative autologous blood donation as an autologous blood procurement strategy in patients undergoing radical prostatectomy because it is less costly and equally effective (8, 9). Although safer than allogeneic blood, the transfusion of preoperatively deposited autologous blood is still associated with potential risk of error in administration and of bacterial contamination due to improper handling of blood. As opposed to the latter, the blood units obtained by haemodilution remain in the operating room during the operation; therefore the cost of blood testing and the risk of administrative error are eliminated. The elimination of blood wastage and provision of fresh, whole blood for safe use during surgery are also important advantages of procuring the autologous blood by haemodilution rather than preoperative donation (10).

Our study demonstrated the effectiveness and safety of ANH as a method for avoiding allogeneic blood transfusion in patients undergoing radical prostatectomy. In 13 of 15 patients undergoing radical prostatectomy it enabled an absolute avoidance of allogeneic blood application. In the other two cases it was necessary to use allogeneic blood, but only in amount of one unit. The thrombelastography clearly confirmed safety of ANH and their mild hypercoagulation effects as opposite to already mentioned risks of hypocoagulation during surgery. It is important as well that ANH is cheaper in comparison with other blood sparing methods.

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