THERAPY

Anaesthesia management of major hepatic resections without application of allogeneic blood

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Abstract

Background: **In a prospective study we used acute normovolemic haemodilution (ANH) together with low CVP anaesthesia in order to avoid allogeneic blood transfusion during major liver surgery.**
Material and methods: **With institutional approval, 20 patients, ASA classification I-III, undergoing hepatic lobe resection consecutively (18 for metastatic cancer, 2 for hepatocellular cancer) in 2002, were enrolled into the prospective study. A epidural catheter was inserted before surgery in the thoracic region. General anaesthesia was induced and maintained with sevoflurane and fentanyl. Invasive haemodynamic monitoring was instituted. Blood was removed for ANH and circulation volume was replaced by infusion of colloids and crystalloid. The CVP was maintained less than 5 mm Hg during hepatic parenchymal transection. After procedure the ventilated patients were transported to ICU.**
Results: **The preoperative haematocrit value (Hct) allowed performance of ANH with a blood removal (1025±357 g) in all patients. The estimated blood loss was 825±515 ml. None of the subject received allogeneic blood during surgery. One patient had transfusion of 2 units of allogeneic blood the fifth day after the right hepatectomy during a second look for perihepatic hematoma. The CVP was 3.8±0.4 mmHg during liver resection. Postoperative Hct was 0.31±0.02 and haemoglobin 108±11 g/L. All patients were extubated the first day after surgery. There was no hospital mortality.**
Conclusions: **We have shown that the routine use of new surgical techniques and low CVP anaesthesia in combination with ANH enabled avoidance of allogeneic blood transfusion in all patients during surgery.** ***(Tab. 3, Ref. 22.)***
Key words: hepatic resection, anaesthesia management, blood loss, low central venous pressure, acute normovolemic haemodilution.

The reduction of the risk of anaemia and the risk of allogeneic blood transfusion are basic principles of the anaesthesia management in large hepatic surgery. Multiple retrospective human studies have suggested a correlation between excessive bleeding with subsequent blood transfusion and postoperative morbidity (Yanaga, 1988; Nagao, 1986). The therapeutic use of allogeneic blood carries with it uncommon but potentially fatal complications. Improved understanding of hepatic physiology and segmental anatomy of the liver has led to advances in surgical and anaesthetic technique for hepatic resection. Recently several methods such as total hepatic vascular exclusion, intermittent vascular inflow occlusion, low central venous pressure anaesthesia and acute normovolemic haemodilution (ANH) have been shown to reduce blood loss during hepatic resection (Chen, 1997; Melendez, 1998). In our prospective study we used ANH together with low central venous pressure (CVP) anaesthesia in order to avoid allogeneic blood transfusion during major liver surgery for cancer.

Materials and methods

With institutional approval, 20 patients, ASA classification I–III, undergoing major hepatic resection consecutively in 2002, were enrolled into the prospective study. All patients were given diazepam 10 mg on the evening before surgery and atropine

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Tab. 1. Patient characteristics.

Age (yr)	60±4
Weight (kg)	78±12
Females	4
Males	16
Metastatic cancer	18
Hepatocellular cancer	2

0.5 mg plus promethazine 50 mg intramusculary 1h before arrival in the operating suite. The subjects had an epidural catheter via an 18-gauge Tuohy needle inserted before surgery in the thoracic region between T8 and T10. During the surgery sufentanil 10 μg was administered into the epidural space to facilitate analgesia and to lower CVP. After 3 min of preoxygenation general anaesthesia was induced with thiopenthal 5 mg/kg, fentanyl 2 μg/kg and midazolam 5 mg until loss of cousciousness. All patients received cisatracurium 0.15 mg/kg for muscle relaxation followed by continuous infusion 1–2 μg/kg/min. The trachea was intubated and ventilation was adjusted to maintain a normocapnia. Anaesthesia was subsequently maintained with oxygen 40 % in air, sevoflurane at inspired concentrations 1–1.5 MAC and supplemental boluses of fentanyl. The patient was placed in the 15-degree Trendelenburg position to improve venous return and minimize the risk of air embolism. Puncture of the right jugular vein was performed by three-way catheter. A left radial artery line was placed for invasive blood pressure monitoring and withdrawing blood for ANH. Monitoring of all patients included three-lead electrocardiography, central venous pressure via the internal jugular vein, oximetry, capnography, nasopharyngeal temperature and urine output. Four patients with associated cardiac disease were monitored cardiac output and saturation of oxygen by pulmonary artery catheterization. In advance a calculated amount of blood for ANH was removed and circulation volume was replaced by infusion of colloids and crystalloids.

Formula for calculating removal blood volume:

Haemodilution volume (in ml) = (Hs – Hr) x TBBV/Hs

Hs – started haematocrit (Hct), Hr – required Hct, TBBV – total body blood volume.

The CVP was maintained under 5 mmHg during hepatic parenchymal transection. Intraoperative fluid management was divided into two phases. During the prehepatic resection phase, the administration of fluids was generally reduced to maintain urine output above 25 ml/h and systolic blood pressure greater than 90 mmHg while keeping CVP at less than 5 mmHg. After the removal of the specimen and completion of haemostasis the second phase begun. During this phase an attempt was made to render the patients euvolemic with infusion of warmed crystalloids, colloids and retransfusion of the autologous blood gained from ANH. The haemoglobin and haematocrit were measured every hour. After surgery patients were transported to the intensive care unit for overnight care. Results are expressed as mean±SD.

Results

The patient characteristics are shown in the Table 1. The operation time averaged 328±84 min. The preoperative haematocrit value (Hct) allowed performance of ANH with a blood removal (1025±357 g) in all patients. Blood count values are in Table 1. The estimated blood loss was 825±515 ml. Two patients had blood loss greater than 1300 ml (both 1800 ml). Both these subjects received 1000 units of antithrombin III as its value decreased below 50 % postoperatively. The coagulation profile is shown in the Table 2. None of the patient obtained allogeneic blood during surgery and the first three postoperative days. One patient had transfusion of 2 units of allogeneic blood the fifth day after the right hepatectomy during a second look for perihepatic hematoma. The CVP was 3.8±0.4 mmHg during liver resection. Total vascular exclusion of the liver was used in 11 patients, but in one subject was impossible due to severe hypotension during the 5 minute test. The average time of warm ichaemia was 41±14 minutes. The entire amount of 1830±425 ml crystalloid and 540±120 ml colloids was administered. Total urine output was 354±73 ml. There were no overall changes in either creatinine or blood urea nitrogen values after hepatectomy. The liver function tests were transiently elevated in the initial postoperative period. The cardiac output was 6.2±0.5 l/min and the mixed venous oxygen saturation (SvO_2) was 77±4 % during the lowering of CVP below 5 mmHg and total vascular exclusion phase in patients with pulmonary catheter. All patients were extubated the first day after surgery. There was no hospital mortality.

Tab. 2. Blood count values.

Time	Preoperative	After ANH	Before retransfusion	Postoperative
WBC (10^9/l)	6.24±1.56	7.87±2.12	15.88±6.23	12.61±5.51
RBC (10^9/l)	4.38±0.40	3.72±0.32	3.07±0.17	3.71±0.21
HB (g/l)	139±9	102±16	92±11	108±11
HCT	0.42±0.03	0.33±0.03	0.28±0.03	0.31±0.02
PLT (10^9/l)	225±55	233±58	246±44	200±41

WBC – white blood cells, RBC – red blood cells, HB – hemoglobin, HCT – hematocrit, PLT – plateled

Tab. 3. Coagulation profile.

Time	Preoperative	After ANH	Before retransfusion	Postoperative
PT	1.02±0.02	1.12±0.08	1.25±0.13	1.08±0.03
APTT (sec)	33.7±3.4	34.9±2.3	35.7±5.7	34.3±3.8
AT III (%)	103±6	79±13	68±19	63±15

PT – prothrombin time, APTT – activated partial thromboplastin time, AT III – antithrombin III

Discussion

Blood loss and transfusion requirement are major determinants of mortality and morbidity following liver resection. The rationale to reduce the number of allogeneic blood transfusions in operative patients is due to the risk of transmission of infectious diseases, haemolytic and non-haemolytic transfusion reactions and possibly of cancer recurrence after allogeneic transfusion when compared with non-transfused patients (Heiss, 1998; Murphy, 1991; Landers, 1996; Avall, 1997; Hebert, 1998). Preoperative autologous blood donation, application of erytropoietin, intraoperative blood salvage and ANH are the routinely used methods for avoidance of allogeneic blood transfusions. According to some authors liver surgery is a simple procedure now, without neccessity of invasive monitoring and only requires cannulation of two peripheral veins. However approximatively 20 % to 40 % of patients in recent large studies needed blood transfusion (Melendez, 1998; Lentschener, 2002). We prefere invasive monitoring (right jugular vein, intraarterial line), because is it helpful for careful anaesthesia management with low CVP and to minimize blood loss. For patients with cancer this is more advantageous than the risks from possible allogeneic blood transfusion.

A basic part of anaesthesia management was intraoperative lowering of CVP. Because of the increased risk of hemorrhage and subsequent hemodynamic instability, hepatic surgery is commonly performed under fluid conditions consistent with euvolemia and in some cases, hypervolemia. The added volume increases CVP and distends the central veins (Blumgart, 1994). The resulting condition augments the difficulty in controlling blood loss from the major hepatic veins. Lowering the CVP to less than 5 cmH_2O is simple and effective way to reduce blood loss during liver surgery (Jones, 1999). Recent studies have shown that low CVP anesthesia can be safely used and results in reduced blood loss compared to other reported series (Cunningham, 1994). Maintenance of a CVP below 5 mmHg significantly reduces the pressure gradient across the hepatic veins and inferior vena cava resulting in a several-fold decrease in the blood loss associated with injuries to these vessels (Johnson, 1998). With a low CVP, however, openings in these veins can increase risk of air embolism. Therefore patients are placed in a 15-degree Trendelenburg position. This reduces the risk of air embolism and also improves venous return to the heart (Terai, 1994). Investigators have demostrated that prolonged head-down tilt produced up to a 70 % increase in plasma atrial natriuretetic protein, which could be combined with immediate reexpansion of the intravascular volume at the completion of resection responsible for the favorable renal outcomes (Hughson, 1995).

Another method by which the use of allogeneic blood can be minimized during hepatic surgery is ANH. This technique involves the removal of whole blood from a patient along with the restoration of circulating blood volume with acellular fluid shortly before an anticipated significant blood loss. According to some authors ANH can replace preoperative autologous blood donation as an autologous blood procurement strategy because it is less costly and equally effective. The haemoglobin level which can be tolerated, depends on many factors. Oxygen delivery to the tissues is influenced by the respiratory system, blood (the oxygen-carrying system) and the cardiovascular system. Anaemia results in a decrease in blood viscosity, with reduction of peripheral vascular resistance (Hocker, 1996). Compensatory mechanisms include both an increase in cardiac index and an increase in oxygen extraction (Spahn, 1997, 1998). Moderate ANH is even thought to increase oxygen delivery over baseline values. These proposals were confirmed by invasive haemodynamic monitoring in our study, where we used only a moderate degree of haemodilution to Hct of 0.33 too. Despite the lowering of CVP and total vascular exclusion the measured values were decreased, but still in normal range. There is no safe level of SvO_2. As a practical guideline, an increased risk for tissue hypoxia or inadequate perfusion should be considered when SvO_2 <60–65. A for the other oxygen transport related variables, the change in SvO_2 in response to therapy is more important than single values (Weissman, 1991; Ruokonen, 1991).

Maintenance of anaesthesia was accomplished with a combination of sevoflurane in oxygen and narcotics. Sevoflurane has been shown to provide vasodilatation with minimal myocardial depression. Fentanyl has been shown to provide analgesia with minimal hypotension (Rosow, 1982). The combination of these anaesthetics with epidural administration of sufentanil and moderate haemodilution provided a favorable environment for hepatic resection. None of the patients required intravenous vasodilatators to lower CVP below 5 mmHg. They did not require intraoperative norepinephrine for haemodynamic support.

Improved understanding of hepatic physiology and segmental anatomy of the liver has led to advances in surgical and anaesthesiologic technique for hepatic resection. Low CVP anaesthesia is a safe technique that facilitates operative control of haemorrhage, in particular from the major hepatic veins. In this report we have shown that the routine use of new surgical techniques and low CVP anaesthesia in combination with ANH significantly reduces blood loss following hepatic resections and enabled avoidance of allogeneic blood transfusion in all patients perioperatively. Neither the surgical nor the anaesthetic components of our approach may be applied alone. Close co-operation between the anaesthesiologist and surgeon is necessary.

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