LOW CENTRAL VENOUS PRESSURE ANAESETHESIA IN MAJOR HEPATIC RESECTION

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ABSTRACT

Blood loss and transfusion requirements are major determinants of morbidity and mortality following liver resection. This study evaluates the association of low central venous pressure [LCVP] with blood loss and blood transfusion during liver resection.

Thirty consecutive hepatic resections were studied prospectively concerning CVP, volume of blood loss and volume of blood transfusion and renal outcome. Data were analyzed for those with a CVP ≤ 5mmHg, and > 5 mmHg. A multivariate analysis assessed potential confounding factors in the comparison.

The mean blood loss in patients with a CVP of 5 mmHg or less was < 500 ml and that in those with a CVP > 5 mmHg was > 2000 ml. (p <0.0001). Only two patients with a CVP of ≤ 5mmHg had a blood transfusion whereas 11 patients with a CVP >5 mmHg required transfusion. No incidences of air embolism or permanent renal shutdown have been reported.

In conclusion: The volume of blood loss and blood transfusion during liver resection correlates with the CVP during parenchymal transection. Lowering the CVP to less than 5 mmHg is a simple and effective technique to reduce blood loss during liver resection and delete the need for blood transfusion with its hazards.

INTRODUCTION

Hepatic resection surgery can be associated with significant intraoperative blood loss, the need for transfusion of blood and blood products, and exposing the patients to the hazards of transfusion. Recent publications suggest that blood loss and transfusion requirement is extremely important determinants of morbidity and mortality following liver resection. This is because of the risk of coagulopathy and the immunosuppressive effects of transfused blood. Additionally, blood transfusion may increase transmission of pathogens, unwanted reactions and cost.(1)

Significant bleeding prolongs liver dissection, portal occlusion time, and increasing the hepatic ischaemia-reperfusion injury. Any strategy that reduces blood loss during liver resection would benefit the patient, anaesthiologist and surgeon. Clamping of the structures in the lesser omentum, which occludes the inflow of blood through the hepatic artery and the portal vein to the liver, can be performed safely, quickly and is used widely. However, the hepatic veins remain patent and bleeding may continue from them and from the hepatic sinusoids. The pressure within the sinusoids of the liver parenchyma is directly related to the pressure in the hepatic veins, which is directly related to the pressure in the central veins.(2)

Because of the increased risk of haemorrhage and subsequent haemodyna-mic instability, hepatic surgery is commonly performed under anaesthetic and fluid conditions consistent with euvolemia and in some cases, hypervolemia. Before parenchymal transection, often during and shortly after anaesthetic induction, the intravascular volume is expanded with crystalloid or blood products to provide a safety cushion for the anticipated blood loss.(3) The added volume increases CVP and distends the central veins. The resulting condition augments the difficulty in controlling blood loss from the major hepatic veins. This is particularly true for resections performed for large tumors compromising the vena cava or the major hepatic veins or, by their size, limiting access for precise intrahepatic control of veins.(4)

In recent years, hepatic vascular exclusion has been developed to circumvent this difficulty. This approach has the disadvantage of being complex, not well tolerated by some patients, and may be hazardous to those with jaundice or cirrhosis. Moreover, although blood loss is controlled during the resection phase of the operation, release of the clamps and restoration of blood flow may be followed by haemorrhage from vessels transected but undetected during the resection phase, which are then subjected to the high CVP engendered by the fluid load necessary to maintain haemodynamics during vascular exclusion.[5,6]

The aim of the present study was to investigate the implication of low central venous pressure (LCVP) anaesthesia combined with extrahepatic control of portal vein and hepatic artery on the overall blood loss and blood transfusion during major hepatic resection. In addition, we evaluated whether there was any adverse effect of this technique on renal function.

PATIENTS AND METHODS

Thirty four consecutive patients scheduled to undergo major liver resection were studied. Four patients were found to have inoperable tumors following a trial dissection and were thus excluded; the remaining 30 patients were studied. All resections were of similar magnitude either hemihepatectomy or bi or trisegmentectomy. Data collected prospectively included age, sex, duration of operation, length of portal vein and hepatic artery occlusion, CVP, volume of intraoperative blood loss, and intraoperative and postoperative blood transfusion. All patients were cirrhotic and were class A or B according to Child-Pugh classification.

Patients were analyzed into two equal groups 15 each, according to whether their CVP was greater or less than 5 mmHg.[6] Group A, patients with CVP > 5mmHg and group B, patients with CVP > 5 mmHg. Moreover both groups are further subdivided according to the technique used in resection whether it was with or without portal venous occlusion.

The preoperative laboratory data were; total bilirubin 0.5-1.3 mg/dl (0.9±0.1), albumin 3.0-4.2 mg/dl (3.6±0.1), prothrombin time 10.8-13.0 sec (11.6 ± 0.7), AST 17-74 IU/L (51±7.8) and ALT 21-117IU/L (43.8±6.4).

Anaesthesia was induced with midazolam 0.05 mg/kg, thiopental 2-4 mg/kg and fentanyl 2 ug/kg, and maintained with 0.5-1.5 % end tidal isoflurane, 50% nitrous oxide in oxygen and fentanyl 1-2 ug/kg/h. Muscle relaxation was maintained with atracurium 0.5 mg/kg at induction and 0.12 mg/kg/h for maintenance. Mechanical ventilation was set at a frequency of 10-14/min with tidal volume of 4-6 ml/kg (60% of normal) to reduce the thoracic and right atrial pressure and, consequently, back-bleeding from the heaptic veins and their tributaries. PaCO2 was maintained at 34-40 mmHg.[7]

Arterial and central venous accesses were used in all patients. Central venous line was introduced via cannulation of the right internal jugular vein in all cases. The CVP was monitored continuously from a zero point at mid-atrial level using a Drager-Cicero EM-Anesthesia Machine (with built in drager monitor).[7]

The CVP was measured as the mean CVP during liver parenchymal transection only. The blood loss was measured by the volume in the suction bottles combined with the increase in weight of the surgical packs.

Patients were transfused perioperatively as indicated on clinical grounds to maintain a haemoglobin level above 10 gm/dl. Intraoperative fluid management was divided into 2 phases:[8]

1- The prehepatic resection phase: It began at induction of anaesthesia and ended at completion of parenchymal transection and haemostasis. During this phase, the vena cava and hepatic veins were dissected. Hepatic parenchymal transection was performed, during which intermittent inflow occlusion of portal vein and hepatic artery (pringle's) was applied in some patients of either group A (CVP > 5 mmHg) or B (CVP > 5 mmHg). During this phase, the administration of maintenance fluid was generally reduced to 3 ml/kg/hr. in group A and intermittent fluid boluses were administered to maintain urine output to above 0.5ml/kg/hr and systolic blood pressure greater than 90 mmHg while keeping the CVP at less than 5mmHg. This fluid challenge was sufficient to achieve CVP ≤ 5 mmHg in 12 patients, while IV nitroglycerin (0.5-1 µg/kg/min) was needed for 3 patients. In group B administration of maintenance fluid was generally at 8 –10 ml/kg/hr.

2- The posthepatic resection phase: It began after the removal of the specimen and the completion of haemostasis. During this phase, an attempt was made to render the patients euvolemic with the aid of crystalloid and 6% hetastarch. Packed red blood cells were transfused to achieve haemoglobin greater than 10g/dl. Upon the completion of the operation ,all patients were transferred intubated to the ICU and were ventilated postoperatively until deemed stable for extubation. An increase in serum creatinine by more than 0.5 mg/dl was considered clinically significant.

Patients having wedge resection were excluded. The surgical aspects of the resectional technique have been described previously.[9] Inflow control was obtained by extrahepatic dissection or by pedicle ligation. The hepatic veins were generally controlled extrahepatically. Transection of the liver parenchyma was performed by a crushing technique with intermittent inflow occlusion [Pringle maneuver].Inflow was occluded for 5 min periods with 1 min intervals, and no patients had occlusion for more than 20 min.[6]

The liver parenchyma was dissected using blunt dissection and with the help of the Cavitron Ultrasonic Surgical Aspirator (CUSA; Valleylab, Boulder, Colorado, USA).[9] 15º head down position was applied during the resection phase of hepatectomy.[10]

STATISTICAL ANALYSIS

Changes in blood loss for the two levels of CVP in the two groups were analyzed using student-t test. Changes regarding portal occlusion and non-occlusion were analyzed using regression techniques fitting an interaction between CVP and portal occlusion. The factors that may have contributed to blood loss, presence or absence of portal occlusion, operation type, operating time, method of liver dissection and cirrhosis were analyzed by analysis of variance (ANOVA).

RESULTS

Patients characteristics, and the procedures performed were comparable between both groups, while the duration of surgery showed significant increase in group B (380 78.9) compared to group A (288 70.9) (table 1). The correlation between mean CVP pressure and total blood loss during liver resection was strong (Pearson corre-lation coefficient 0.93, $P < 0.001$). When CVP pressure was 5 mmHg or less, blood loss was less than 500 ml (490 ± 115), and, when mean CVP was more than 5 mmHg, blood loss was excessive at over 2000 ml (2200±460), (table 2), (fig 1). Blood transfusion requirements were significantly less in patients with a CVP less than or equal to 5 mmHg during liver resection than in those with a pressure greater than 5 mmHg. Only two patients in group A had a blood transfusion (500 ml, 1000 ml), while eleven patients in group B required a blood transfusion (mean transfusion 1500 ml {range 1000 – 5000 ml}).

With portal triad occlusion, the mean blood loss in patients with a CVP of 5 mmHg or less was 486±85 ml and in those with a CVP of greater than 5 mmHg it was 1585±220 ml ($P < 0.001$). Similarly, without portal occlusion there was a significant difference in the mean blood loss between the two groups; 410±120 and 2340±425 ml respectively ($P < 0.001$), (fig 2). No complication was observed in any patient as a result of cannulation of the internal jugular vein for CVP monitoring or resulting from a low CVP. There were no deaths in this study. But a difference in morbidity was noted between patients with a CVP (<5mmHg), and those with a CVP (>5mmHg), (table 3).

There was no overall statistical change in either creatinine or BUN after LCVP-aided hepatectomy. Serum creatinine increased by less than 0.5mg/dl in five patients in group A and three patients in group B, but this elevation was subsided by 24 hr.

Table (1): Patient's characteristics, duration of surgery and the procedures performed.

	Group A, CVP ≤ 5 mmHg. (no.15)	Group B, CVP > 5 mmHg. (no. 15)
Age (year).	51.9 ± 7.8	52.1 ± 9.1
Body weight (kg).	62.8 ± 10.1	61.6 ± 9.0
Male/female.	7/8	8/7
Duration of surgery (min).	288 ± 70.9*	380 ± 78.9
Occlusion technique (Pringle's maneuver).	9/15	8/15

*P < 0.05

Table (2): Mean blood loss and number of patients transfused in both groups.

	Mean blood loss (ml).	Number of patients transfused.
CVP (mmHg).		
Group A (CVP ≤ 5)	490 ± 115*	2/15 (500, 1000 ml).
Group B (CVP > 5)	2200 ± 460	11/15 (1000-5000 ml).

* *P < 0.001*

Table (3): Postoperative morbidity and mortality in the first 5 postoperative days.

	Group A (15), CVP ≤ 5 mmHg.	Group B (15), CVP > 5 mmHg.
Death.	0/15	0/15
Pulmonary complications: (pneumonia, atelectasis, pleural effusion).	4/15	8/15
GIT bleeding.	0/15	1/15
Wound infection.	3/15	7/15
Renal shutdown.	0/15	0/15
SICU stay (days).	5 (4-7).	9 (7-16)

SICU, Surgical intensive care unit.

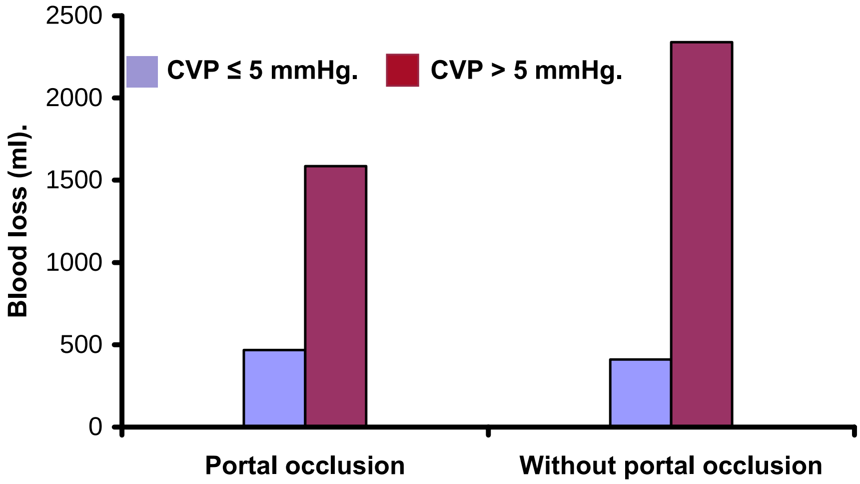

Figure 1: Blood loss during liver resection with and without portal triad occlusion.

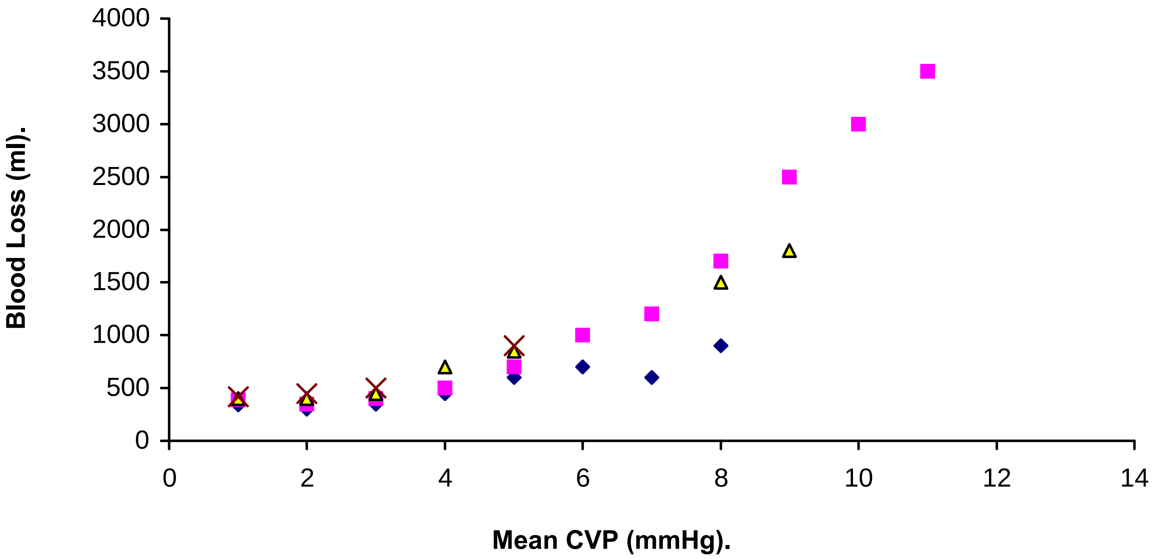

Figure 2: Distribution of the studied patients according to their CVP and correlation between blood loss and CVP pressure during liver resection.

DISCUSSION

The precise finding of this study is the significant reduction in blood loss and blood transfusion requirements in Patients undergoing liver resection when the CVP was maintained at or less than 5 mmHg, during parenchymal dissection (table 2) where the blood losses were 490 ± 115, and 2200±460 ml in group A and B respectively. The maintenance of LCVP during the operation precludes vena cava distention and facility-ates mobilization of the liver and dissection of the retrohepatic and major veins. More important, the approach minimizes hepatic venous bleeding during parenchymal trans-ection and facilitates control of inadvertent venous injury, particularly of the intrahepatic course of the middle hepatic vein.[11] The blood loss resulting from a vascular injury is directly proportional to both the pressure gradient across the vessel wall and the fourth power of the radius of the injury. If the CVP is lowered from 15 to 3 mmHg, the blood loss through a vena caval injury will consequently fall by a factor greater than 5. Lowering CVP not only lessens the pressure component of the equation but also minimi-zes the radial component of flow by reducing vessel distention.[12]

Hepatic vascular isolation typically cau-ses a decrease in venous return with a resulting decrease in cardiac index and an increase in systemic vascular resistance. Mean arterial blood pressure is maintained by infusing large volume of fluids to keep CVP high. Most patients tolerate these haemodynamic changes reasonably well, although in some cases persistent hypo-tension or low cardiac index demands that the procedure be abandoned[13,14] and many patients might require pulmonary artery catheters during the procedure. Our results were not influenced by the presence or absence of portal occlusion. Where the blood loss for those with CVP ≤ 5mmHg (group A) was 486 ± 85 ml and 410 ± 120 ml with and without portal occlusion respect-tively, whereas blood loss with CVP > 5 mmHg (group B) was 1685 ± 220 ml and 2340 ± 425 ml with and without portal occlusion respectively (fig.1).

Rees et al[15] achieved similar blood loss results using a more complex LCVP management technique. They used a com-bination of epidural anaesthesia and IV nitroglycerin to provide LCVP. Their patients required intraoperative dopamine while in the present study no inotropic support was used. Their technique is cumbersome and adds an unnecessary level of complexity to an already challenging situation. The techniq-ues we report take advantage of fluid restriction and the vasodilatory effects of standard anaesthetics. In the present study, the combination of isoflurane in oxygen and fentanyl with the fluid restriction manage-ment was found sufficient to provide LCVP in the majority of patients.[8] We took the advantage of the vasodilatoty properties of fentanyl to aid in lowering CVP. Fentanyl reduced CVP by inducing venous vaso-dilatation caused by histamine release and µ3 receptor activation.[16] Only 3 patients required IV nitroglycerine (1.1±0.3 ug/kg/min) to lower CVP below 5 mmHg.

Investigators[17] have described short episodes of oliguria during LCVP aided hepatic resection. In the current study 3 patients in group A showed insignificant transient increase in BUN and creatinine after LCVP -aided hepatectomy. Blumgart et al[18] reported a 13% incidence of renal compromise after hepatic resections. They found marked reduction of renal morbidity when they used LCVP-aided technique compared with standard practice.

The potential for air embolism, while maintaining a low CVP during resection of the liver is expected to be significant as a negative CVP can allow air to pass rapidly through small or unrecognized laceration of the hepatic veins and this unlikely with a positive CVP.[19] This would explain why it was standard practice to make the patients hypervolaemic before starting parenchymal transection. However, the use of 15º head down position in this study avoided these side effects. Johnson et al[20] found that LCVP allows the immediate oversewing of any holes in the hepatic veins due to the significant reduction in blood loss and this observation was supported by our results, where we did not reported any case of air embolism.

This study and results of other investigators [12,20] had proved the relation between the extent of intraoperative blood loss and morbidity. The overall low blood loss in LCVP group clearly contributed to the low rate of postoperative morbidity.

We concluded that, LCVP – aided heap-tectomy (with 15º head down position) is a simple and safe technique with excellent outcome in regard to blood loss, blood transfusion, renal outcome, and overall postoperative morbidity and mortality.

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