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## Case report

# The role of cardiopulmonary bypass in the management of retrohepatic vena cava injury – A case report and review of the literature



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## ABSTRACT

Injuries to the retrohepatic vena cava are extremely rare and are associated with an operative mortality of up to 50% even in high volume trauma centres. We present a patient with such an injury who underwent successful repair using cardiopulmonary bypass and deep hypothermic circulatory arrest.

A 23 year old male was transferred to our unit following laparotomy with packing of the abdomen after uncontrolled haemorrhage from the retrohepatic vena cava was experienced. The patient was placed on full cardiopulmonary bypass and cooled to 20 °C before clamping of the supraceliac aorta and inferior vena cava. This facilitated exposure of the retrohepatic cava and allowed successful primary repair of a 5 cm laceration.

Other techniques to allow repair of these injuries, such as atriocaval shunts and total vascular exclusion of the liver, are associated with a high mortality. We believe the technique described in this case report is an alternative strategy that can be used successfully to manage life threatening from the retrohepatic vena cava.

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## 1. Introduction

Within western European populations the reported incidence of liver trauma is 2.5–3/100,000 population per year with approximately two thirds of cases being attributable to blunt trauma [1,2]. Major vascular injury involving the either the cava/hepatic veins or portal inflow structures (i.e. AIS Grade 5 & 6 injuries) are extremely rare constituting only 3% of all liver trauma in a multicentre UK series of 783 patients [1].

The inaccessibility of the retrohepatic vena cava means that injuries to it are extremely challenging to manage and, even in high volume trauma centres, are associated with an operative mortality of up to 50% [3–6]. In this paper we present a patient who underwent successful repair of such an injury with the aide of cardiopulmonary bypass and deep hypothermic partial circulatory

arrest followed by a review of the literature regarding the management of such injuries.

## 2. Case report

A 23 year old male presented to his local hospital with a stab wound to his right flank sustained whilst under the influence of alcohol. No other injuries were evident. He was haemodynamically stable and a decision was therefore made to proceed with a CT scan of the chest, abdomen and pelvis. Imaging revealed the presence of thrombus within the lesser sac surrounding and abutting the retrohepatic IVC and caudate lobe of the liver (Fig. 1). In addition free intraperitoneal blood was noted within the pelvis (Fig. 2). The calculated injury severity score was 25.

Approximately 4 h after his presentation the patient developed signs of haemodynamic instability and a decision was made to proceed to laparotomy. On opening the abdomen blood was noted in the pelvis and retroperitoneum. There was no evidence of injury to the hollow viscera or mesenteric vessels and a decision was therefore made to explore the retroperitoneum. On Kocherising the duodenum profuse bleeding from the retrohepatic IVC was encountered and the

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**Fig. 1.** CT scan demonstrating significant thrombus within the lesser sac which was abutting the retrohepatic vena cava and caudate lobe of the liver.



**Fig. 2.** CT scan demonstrating free intraperitoneal blood within the pelvis.

patient briefly lost cardiac output. At this point the abdomen was packed and the patient transferred to our unit.

On arrival in the operating theatre the patient was re-explored using both a midline laparotomy and median sternotomy. Prior to removing the abdominal packs control of the supradiaphragmatic IVC was obtained and the right atrium cannulated to facilitate rapid volume replacement. On removing the abdominal packs catastrophic haemorrhage was encountered and the patient was therefore placed on full cardiopulmonary bypass with cannulation of the aorta and right atrium via the right atrial appendage. Rapid cooling was commenced to 20 °C and the left ventricle was vented via the left superior pulmonary vein to avoid distension whilst in hypothermic ventricular fibrillation. The inferior vena cava was clamped within the chest and the supraceliac aorta was occluded. With infradiaphragmatic hypothermic circulatory arrest the intra-abdominal haemorrhage was controlled and these conditions permitted full exposure of the retrohepatic vena cava. The brain

and upper body remained perfused through the bypass circuit from the venous return from the superior vena cava alone.

The retrohepatic cava was exposed revealing a 5 cm laceration on both its anterior and posterior walls which were closed by primary suture repair. Bleeding was encountered from a laceration to the caudate lobe which was controlled with a radiofrequency tissue sealing device (Aquamantys, Medtronic, Minnesota, USA). In addition bleeding was also encountered from the right adrenal gland necessitating partial adrenalectomy. The aortic cross clamp was removed (total clamp time 30 min) and the inferior vena cava released in the chest. The patient was re-warmed on cardiopulmonary bypass and the heart defibrillated into sinus rhythm as normothermia was regained. After successful weaning from cardiopulmonary bypass and administration of protamine, the abdomen was packed with gauze rolls. Following placement of mediastinal drains and pacing wires the chest was closed with sternal wires and the patient transferred to the intensive care ward.

On the third post-operative day the patient returned to theatre and the abdominal packs were removed with no evidence of ongoing haemorrhage. Because of marked hepatic congestion a decision was made to leave the upper abdomen open which was subsequently managed with a negative pressure dressing system (V.A.C., KCI Ltd., Texas, USA). Unfortunately the patient developed a transfusion associated lung injury and subsequent ventilator associated pneumonia which necessitated a prolonged respiratory wean over a period of 3 weeks following which he was fit to be transferred to the ward. At this point he underwent secondary closure of his laparotomy wound and was fit to be discharged home 27 days following his injury.

### 3. Discussion

Traumatic injury to the abdominal inferior vena cava, particularly the retrohepatic IVC, is associated with a poor prognosis. In a series of 47 patients with IVC injuries those whose injury was located in the suprarenal/retrohepatic IVC were associated with a mortality of 71% as compared to 23% in those with injuries to the infrahepatic IVC [7].

For patients presenting with injuries to the infrarenal IVC the surgical exposure is relatively straight forward and where primary repair is not feasible, or in the context of exsanguinating haemorrhage, ligation of the vessel at this level is a feasible damage control strategy associated with minimal long term morbidity [8]. In injuries to the retrohepatic IVC however ligation is clearly not an option and therefore more elaborate strategies may be required to facilitate repair.

In 1968 Schrock et al. described the use of an atriocaval shunt, in combination with a pringle manoeuvre, as a manner of creating a bloodless field in which direct retrohepatic caval repair can be carried out [9]. In this technique a wide bore tube is placed via the right atrial appendage into the IVC such that it sits just above the level of the renal veins with a side hole sitting within the right atrium to enable blood to fill it. The tube is then secured with Rumel tourniquets and clamped where it exits the atrial appendage [10]. In a series of 31 patients treated using this technique Burch et al. describe an operative mortality of 81% with technical difficulties with shunt placement occurring in 7 patients [10]. Similarly in a series of 34 patients treated by Cogbill et al. with caval shunting an operative mortality of 90% was reported [11].

Total vascular exclusion of the liver i.e. application of a prolonged pringle manoeuvre combined with clamping of the infrahepatic and suprahepatic IVC has been proposed as an alternative strategy to the management of these injuries [12]. In a series of 12 patients with retrohepatic IVC injury the majority ( $n = 10$ ) were able to be managed with either partial (e.g. use of a side biting caval clamp) or total hepatic vascular exclusion. Only 2

patients required the use of an aortocaval shunt. The overall mortality in this series was 42% [5]. This technique is also associated with a high failure rate – in one series 14 patients with retrohepatic caval injuries vascular isolation could only be achieved in 9 patients. Of these 9 patients in whom vascular isolation was achieved it was not possible to maintain this for long enough to facilitate vascular repair in 3 giving an overall failure rate of 57%.

The high failure rate and poor survival associated with both atriocaval shunting and total vascular exclusion has led to the search for alternative strategies. One such approach is that of cardiopulmonary bypass and infra-diaphragmatic hypothermic circulatory arrest. To our knowledge there are 5 case reports relating to the use of this technique in the published literature [13–17]. Whilst clearly not applicable to all patients this technique does provide an alternative strategy for those patients in whom other methods of vascular control are not feasible.

We would therefore advocate that in patients in whom exsanguinating haemorrhage is encountered from the region of the retrohepatic IVC during resuscitative laparotomy that careful packing is carried out and that these packs are not then removed until the chest has been opened and facilities for cardiopulmonary bypass are available. This may require, as in the case of our patient, rapid transfer to a tertiary unit with an appropriate multidisciplinary team available.

#### 4. Conclusion

In summary we have demonstrated that the use of cardiopulmonary bypass and hypothermic circulatory arrest can serve as a useful adjunct to the management of patients with injuries to the retrohepatic IVC. Where possible patients with such injuries should be transferred to units with the facilities to provide this prior to attempts at definitive surgical repair.

#### Conflict of interest

None of the authors have any relevant conflicts of interest to declare.

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