Injuries of the Juxtahepatic Vena Cava

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10.1 Introduction

This chapter focuses on the treatment of blunt injuries of the retrohepatic portion of the vena cava and of the extrahepatic segment of the hepatic veins which raises similar management problems. Among injuries of the intra-abdominal vena cava, the retrohepatic location raises the most difficult management challenges and is associated with the highest mortality rate [1–6]. Injuries of the retro hepatic vena cava occur in up to 15 % of blunt liver traumas.

Despite advances in surgical techniques and intensive care management, mortality is still very high ranging between 50 and 80 % in patients that reach the hospital alive. Mortality is prohibitive after attempts at open repair in critically ill patients. Survival is closely related to conditions in which these patients can be managed. Hemodynamically stable patients eligible for computed tomographic (CT) evaluation and for management protocols, similar to those of vena cava tumors, fare better than patients requiring emergency surgery for bleeding control. In emergency conditions, awareness of the lethal triad of hypothermia, acidosis, and coagulopathy should prompt decision for damage control surgery in these patients. Under these dramatic circumstances, complex reconstructive procedures are usually futile, while simple gestures aiming at bleeding arrest may be the only chance for patient survival.

10.2 Pattern of Injuries

Mortality is particularly severe when mechanisms of injuries are blunt trauma and vascular avulsion. Injuries of the vena cava segment located between the heart and the hepatico-caval junction are uniformly fatal. Hepatic vein injuries have

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D. Azoulay et al. (eds.), *Surgery of the Inferior Vena Cava*,
DOI 10.1007/978-3-319-25565-1_10

previously been distinguished according to their location inside the liver parenchyma (type A) or outside it (type B) [5]. Nevertheless, these different types of lesions are frequently associated and such distinction doesn't have useful practical implications. In contrast, blood leak contention by adjacent retroperitoneal structures is a major prognostic factor; it may limit blood loss and allow prehospital survival. Immediate resuscitation usually fails in patients with free intracavity (peritoneal, pleural) bleeding.

10.3 Emergency Surgical Techniques in the Management of Retrohepatic Caval Injuries

10.3.1 Direct Suture

Bleeding control by direct suture necessitates surgical exposure of the vascular defect which allows direct repair. It usually requires right liver mobilization by section of its attachments if these are still intact. Direct suture should be avoided for the treatment of large vena cava or right hepatic vein defects because attempts at right liver mobilization under these circumstances may result in massive bleeding which is frequently fatal.

10.3.2 Vascular Exclusion of the Liver

Complete vascular exclusion of the liver has been proposed in order to limit the aforementioned risks of liver mobilization. Vascular exclusion of the liver includes successive clamping of the portal triad, the suprarenal IVC, and the suprahepatic IVC in its intrapericardial portion [7]. In the context of major bleeding, this maneuver may result in sudden decrease in the cardiac preload and cardiac arrest. Concomitant clamping of the supraceliac aorta (quadruple clamping) can restore the situation by improving coronary perfusion (Fig. 10.1). Nevertheless, uncontrollable fatal collapse has been reported at the moment of aortic unclamping after repair of venous injuries, rendering eventually unfeasible the release of the aortic clamp.

10.3.3 Cavo-Caval Venous Bypass Procedures

The common principle of cavo-caval bypass procedures is the maintenance of a caval venous return by securing the cardiac preload. In precarious hemodynamic situations, preservation of the caval flow aims to decrease the risks of cardiac collapse. This is in contrast to programmed liver surgery when interruption of caval flow is usually well supported and can most often be compensated by appropriate intraoperative anesthesia-reanimation management with no need for venous bypass [7].

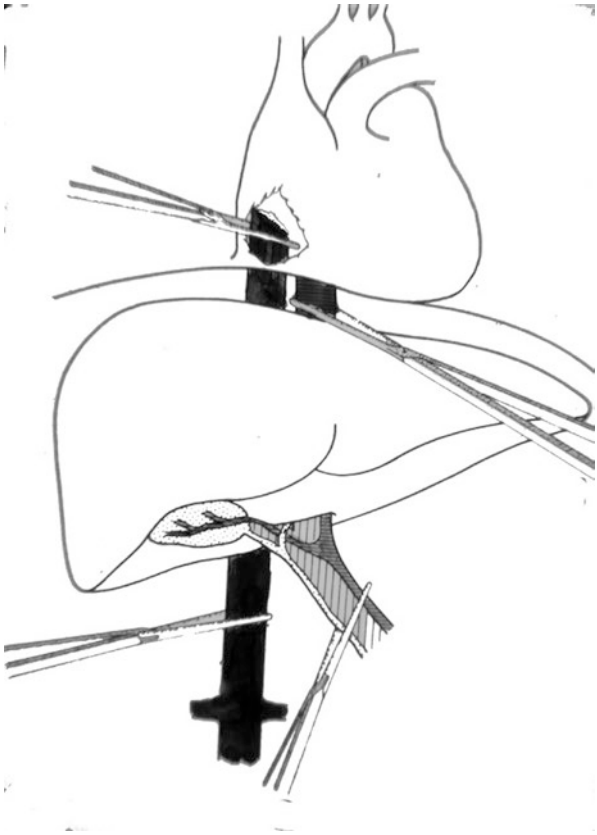

Fig. 10.1 Portal triad occlusion (Pringle maneuver) and clamping of supraceliac aorta (quadruple vascular clamping)

One of the first described procedures was the use of an endovenous shunt; the shunt is usually introduced through the right atrium and pushed down into the subhepatic vena cava (if it does not exit through the venous defect) (Fig. 10.2) [2, 8–11].

Successful use of endovenous shunts for the treatment of retrohepatic vena cava injuries is anecdotal in the literature. Outcomes of endovenous shunting seem less grim in the setting of open when compared to blunt traumatisms. Of note, some of the pioneers of the procedure in liver trauma have eventually abandoned endovenous shunts in favor of perihepatic packing (PHP) [1, 12–15].

The veno-venous bypass is another technique which was popularized by liver transplant surgeons. Veno-venous bypass has the theoretical advantage of remote cannulation sites at the level of the femoral vein and the internal jugular far from the injury site (Fig. 10.3) [16–20].

A sophisticated maneuver which is not always adapted to extremely urgent situations is the realization of a cardiopulmonary bypass. Theoretical advantages include proper blood oxygenation, adequate coronary perfusion, control of eventual cardiac arrest, and the ability of recirculation of blood loss collected by the operative field cannulas (Figs. 10.4 and 10.5) [21, 22]. Use of hypothermic cardioplegia has been

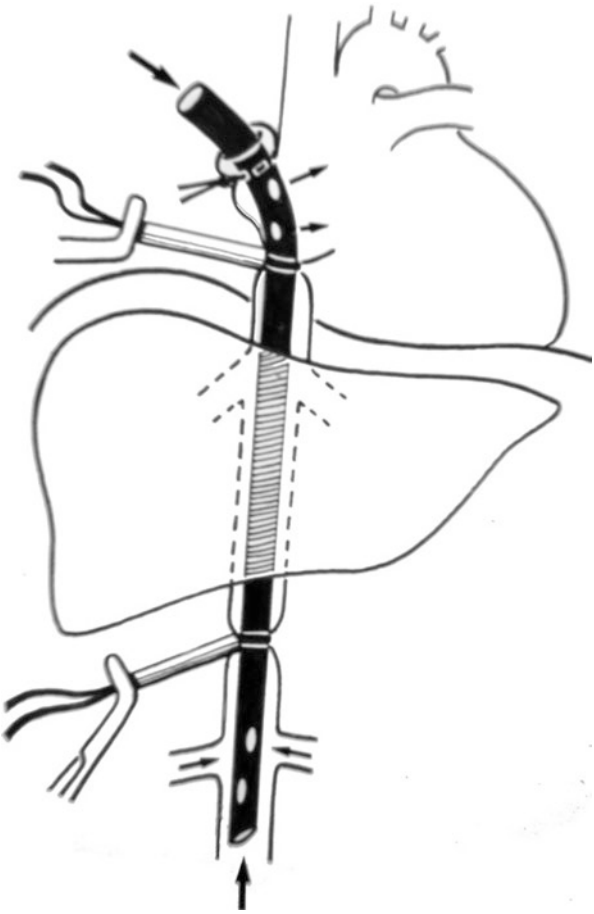

Fig. 10.2 Atrio-caval shunt

suggested to allow increasing the duration of surgery and performing more complex reparations [23]. Reconstruction of the hepatico-caval junction after complete avulsion, as well as liver autotransplantation after back-table repair, has been reported [19]. Nevertheless, such data remain anecdotal and include success-related publication bias.

The dogma of systematic immediate repair of hepatico-caval injuries assisted or not by bypass procedures has been recently challenged [5]. Thorough analysis of successful reports suggests that most patients were actually hemodynamically stable prior to surgery. Hemodynamic stabilization was the result of either spontaneous bleeding contention by retroperitoneal structures or by surgical packing performed prior to patient transferal to level I trauma centers. Thus, it is likely that attempting to perform the complex aforementioned techniques during emergency surgery in hemodynamically collapsed patients has very small chances of success. It is probable that compression of the liver on itself and against the diaphragm supported by the establishment of perihepatic packing (PHP) offers the best chances of survival in such desperate situations.

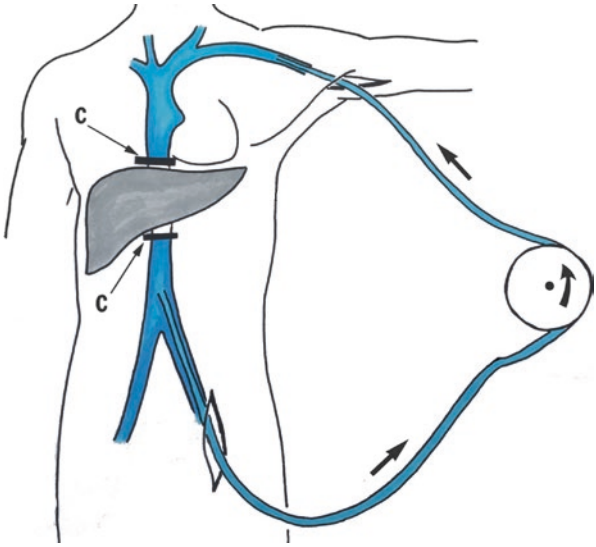

Fig. 10.3 Cavo-caval bypass

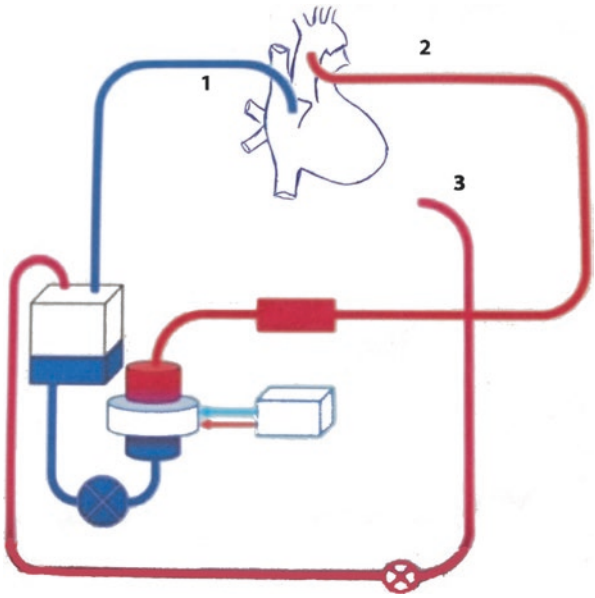

Fig. 10.4 Cardiopulmonary bypass: *1* atrial cannula, *2* aortic reinjection, *3* suction-reinjection cannulas in the thoracic and abdominal cavity

10.3.4 Liver Resection to Obtain Access to the Retrohepatic Vena Cava

Theoretically, performing a right hepatectomy procedure allows exposure of the retrohepatic vena cava and direct access to the vascular defect. Some authors have proposed performing right liver resection for this indication, most often under cover

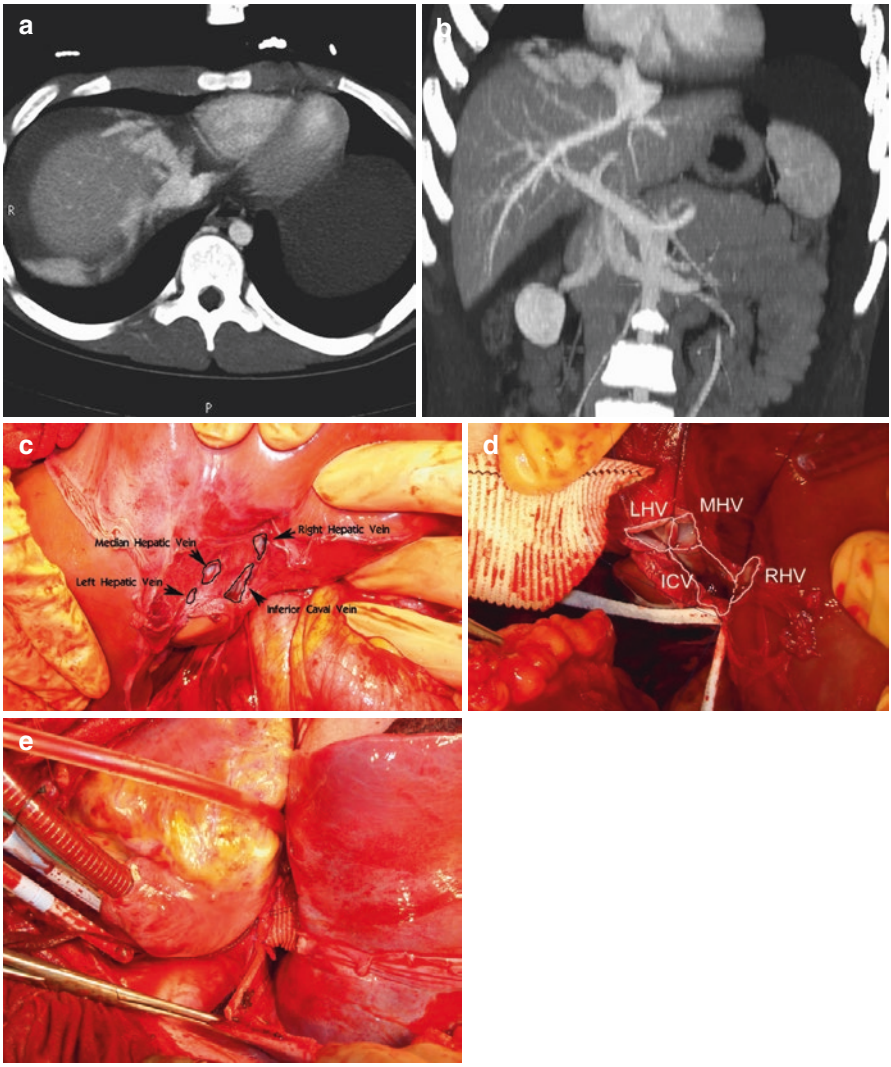

Fig. 10.5 High-velocity ski accident in a 14-year-old man. Transport of hemodynamically stable, hypothermic (33.3 °C) patient was made to trauma center; intubation on arrival motivated by extreme agitation. CT scan showed blood extravasation at the level of the suprahepatic IVC and the absence of associated injuries (**a, b**). Sternotomy, CBP, and laparotomy were successively done and confirmed complete disjunction of the vena cava and of the three suprahepatic veins (**c**). After complete liver vascular exclusion, the suprahepatic veins were anastomosed together and then on a 30 mm diameter Dacron graft (Hemashield®) (**d**), the graft was then sutured to the subdiaphragmatic IVC (**e**)

of vascular exclusion of the liver [24]. Mortality of right hepatectomy performed on an emergency basis for bleeding control is prohibitive. Again, published successes correspond mostly to long management delays suggesting a contained bleeding

pattern of the initial injury [25–27]. Exposure of right hepatectomy for retrohepatic caval injuries cannot be recommended in the presence of active bleeding [13].

10.3.5 Perihepatic Packing (PHP)

This technique has proven its effectiveness in the treatment of very severe blunt hepatic trauma. Complete liberation of the right liver is unnecessary, avoiding risks of massive intraoperative bleeding. Freeing adhesions located at the inferior part of the right lobe may be required occasionally, with no major risk. Compression of the right liver on the diaphragm is performed at the beginning by the surgeon's hand and then progressively by pads leaning on the right kidney on the right side and on the stomach on the left side. Placing pads on the superior surface of the liver should be avoided as this might open the suprahepatic region (Fig. 10.6). PHP enables control of severe injuries of the retrohepatic IVC and of the hepatico-caval junction; performed as a step of damage control surgery, PHP may save the life of these patients in the emergency setting (Fig. 10.7). Over the last two decades, the literature on this topic is particularly compelling and justifies systematic use of PHP in the emergency setting. Emergency PHP should be performed without trying to understand the type of lesions, with the hope that bleeding control without definitive repair would allow resuscitation in the operating room at first, followed by transfer in the ICU and/or CT scan [13, 23, 28–31].

10.3.6 Nonoperative Management

CT performed in hemodynamically stable trauma patients may show injuries of the retrohepatic vena cava or of the hepatico-caval junction which are contained to the retroperitoneum or do no longer bleed. In circumstances when secondary alteration of the hemodynamical condition requires surgical exploration (Fig. 10.7), information provided by CT is particularly useful for subsequent intraoperative decision-making. The monitoring of nonoperated patients can lead to discovery of partial or total thrombosis of hepatic veins: usually this does not justify complex desobstruction procedures but warrant secondary anticoagulation treatment [32].

10.3.7 Liver Transplantation

Liver transplantation is situated at the upper end of aggressive therapeutic means available for the management of hepatico-caval vein injuries. In rare cases acute liver failure has been reported after a more or less effective and more or less stricturing control of suprahepatic vein bleeding. In most reported LT cases, venous injuries were part of severe liver trauma. The majority of published cases include patients who developed liver insufficiency after failure of a previously attempted lifesaving strategy [33].

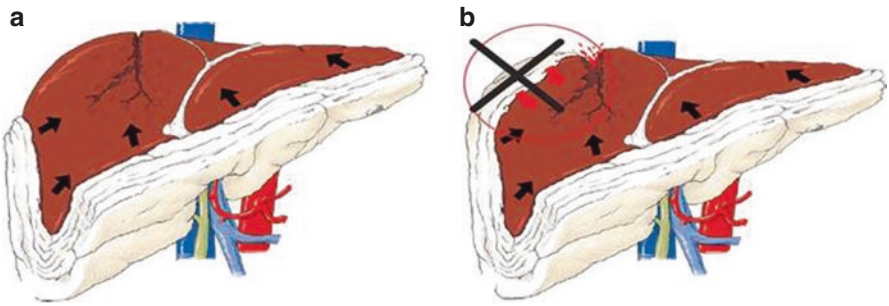

Fig. 10.6 Perihepatic packing of hepatico-caval junction injuries. Upward hand compression that "closed" the liver fracture has been replaced by subhepatic pads (**a**). Pad positioning above the liver should be prohibited as it may open liver injuries and aggravate bleeding (**b**)

10.4 Management Strategies

10.4.1 Hemodynamically Unstable Patient: Emergency Laparotomy Mandatory

As soon as it becomes obvious that the bleeding originates from the supra-/retrohepatic area, the surgeon should realize a compression of the liver against the diaphragm. In case of hemodynamic collapse, the surgeon may be constrained to transiently associate an aortic compression against the vertebral block to allow resuscitation and recover an acceptable arterial pressure. Attempts should not be made to "look and see" the supra-/retrohepatic injuries which implies hazardous hepatic mobilization, source of uncontrollable bleeding. After rapid exploration of the abdomen, manual compression is progressively replaced by pads firmly pressed against the right kidney and the stomach. In most cases this maneuver is sufficient to stop the bleeding. At this point consultation with the anesthesiologist allows identification of the lethal triad (hypothermia, acidosis, coagulopathy) which should prompt adopting an abbreviated laparotomy strategy. In favorable situations the patient can stand exclusive skin closure and transfer to the intensive care unit (ICU) improving conditions to control the lethal triad; if the patient condition allows, angiography-CT scan (with late-passage sequences) should be performed at this point to evaluate the extent of anatomical venous damage. This is the type of situation described in the literature in which patients can be transferred in level I trauma centers and benefit of specific expertise (vascular exclusion repair, venous bypass techniques, liver resection, transplantation); in some cases PHP suffices and further injury repair may prove unnecessary [27, 29].

If PHP does not contain the bleeding, the surgeon must try to improve its effectiveness by increasing the compression of the liver alongside with intensification by the anesthesiologist of resuscitation means on table. In specific situation when hepatic pedicle clamping clearly improves the hemodynamic condition (evoking associated injuries of the hepatic artery and/or its branches), the extremity of the

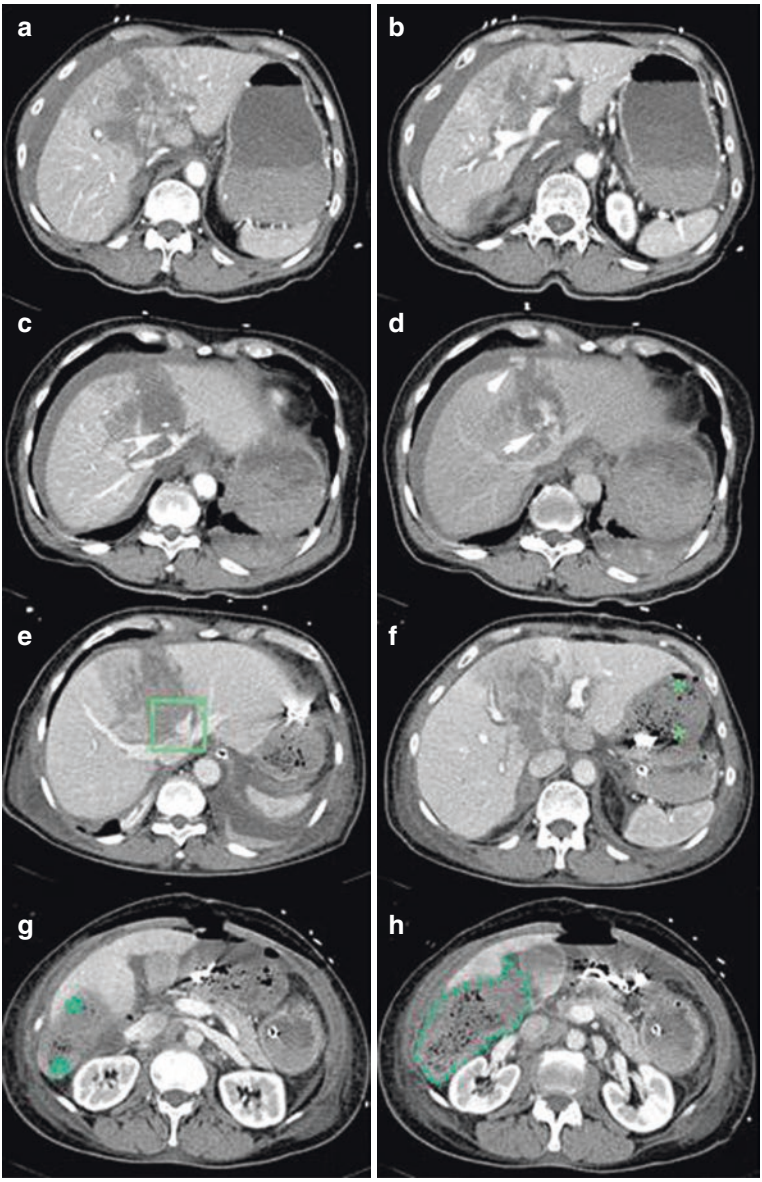

Fig. 10.7 Ski accident in a 62-year-old hemodynamically stable woman. CT shows grade IV liver injuries and absence of vascular extravasation on the arterial and portal acquisition phases (**a, b**). There is important blood leakage from the middle suprahepatic vein on the late acquisition phase and intraperitoneal blood leakage (**c, d**). Hemodynamic deterioration during the procedure prompted immediate damage control laparotomy with "blind" PHP positioning. CT performed 2 days later shows bleeding cessation (**e**); subhepatic pads press the stomach and "wrinkle" the left liver lobe (**f**); on the right side it is almost exclusively under the liver and pushing on the kidney (**g**, **h**)

turnstile can be exteriorized through the skin closure to allow attempting extreme emergency arterial embolization; if interventional radiology is unavailable, clamping or definitive ligation of the hepatic artery can be attempted.

In rare cases when PHP fails, the surgeon may attempt one of the "dangerous methods": if expertise is available, complete vascular exclusion of the liver should be performed associating when possible venous bypass and/or cardiopulmonary bypass techniques; afterward, liver mobilization and repair of the injuries should be done as quickly as possible. If expertise with these techniques is not available, further liver compression (complementary PHP) may allow survival during transfer to a higher-level trauma center.

10.4.2 Hemodynamically Stable Patient

CT scan is performed following initial resuscitation. The anatomy of the hepatico-caval venous system, the type of venous injury, and the active character of venous leak can be reliably assessed during the late venous acquisition phase; CT also helps evaluate the importance of hemoperitoneum and detect associated injuries. CT examination can guide embolization of intra-abdominal arteries allowing control of associated arterial bleeding. Secondary degradation of the patient condition prompts emergency laparotomy which is usually easier and quicker to organize in the emergency setting than interventional radiology.

If the patient condition remains stable, nonoperative management should be pursued if active bleeding has been controlled; the desire to "repair" lesions is often dangerous and may be detrimental for the patient. Some patients might nevertheless benefit of a delayed operation limited to extensive lavage and drainage of the abdominal cavity [34]. In the uncommon situation when vascular reconstruction is still necessary, delayed operation after control of the lethal triad offers adequate conditions for the use of more complex surgical procedures in expert centers. Under these circumstances and if possible, cardiopulmonary bypass can be prepared to back up eventual deficiencies of veno-venous bypass. Repair of the hepatico-caval confluent may be performed by large-diameter vascular prosthesis (Fig. 10.5). In case of isolated laceration of one of the three hepatic veins, simple ligation can be performed [20].

Localized venous thrombosis can occur after both vascular reparation (direct suture, vascular reconstruction) and more conservative treatments (PHP, nonoperative management). Management does not necessarily require the use of aggressive surgical procedures as cure might be obtained by effective anticoagulant treatments [32] or interventional radiology techniques [35, 36].

Conclusions

The injuries of the retrohepatic vena cava more can be associated with hepatic vein involvement and represent a difficult surgical challenge. Mortality of blunt trauma caval vein injuries that require immediate surgery for bleeding control is extremely high. The concept of contained venous bleeding, the liberal use of PHP, and the timely application of damage control surgery principles improve patient outcomes. Stabilization of the patient condition should be the main purpose in the

emergency setting. Anatomical vascular reconstruction should be delayed and preferentially undertaken in expert centers; more often, in surviving patients such reconstruction is eventually unnecessary. Secondary use of interventional radiology techniques may be helpful under these circumstances.

Key Points

1. Injuries of the retrohepatic inferior vena cava are almost always lethal if not contained by surrounding tissues.
2. If an emergency operation is unavoidable, containing blood leakage by perihepatic packing may be lifesaving.
3. If patient hemodynamics allow, emergency multidetector CT angiography is helpful in establishing the diagnosis and guiding management.
4. Attempts to expose and repair the injuries should be avoided before mastering the conditions of vascular exclusion of the liver.
5. Most frequently liver vascular exclusion requires maneuvers such as veno-venous bypass or cardiopulmonary bypass.
6. If bleeding could be contained either spontaneously or by perihepatic packing, emergency transfer to a level I trauma center that offers expertise for further management is advisable.
7. Major exposure liver resections are not recommended under these circumstances because mortality rates are extremely high.
8. If the patient condition remains stable and active bleeding has been contained, nonoperative management can be pursued with success.

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