Liver

Hepatorrhaphy / Liver Suture

Grade I, II and III hepatic injuries, constitute 80-85% of all liver injuries. They may be controlled by applying local pressure, with the use of local hemostatic agents, electrocautery or by bipolar devices, argon beam coagulators and other modern hemostatic techniques (1, 2, 3, 4). In practice, hepatorrhaphy represents the simplest and most successful surgical technique to obtain hemostasis of bleeding from deep liver lacerations (1, 2). Hepatorrhaphy is also performed in patients who underwent local excision of any mass located in the anterior surface of the liver. The hepatic trauma is sutured with absorbable sutures by a large curved blunt tip needle (hepatic needle). This needle minimizes the parenchymal damage, because of passing through the liver, and can be easily grasped without fear of a needle injury (1, 2, 3, 4). The placement of these sutures does not lead to a significant incidence of complications. The application of hemostatic agents (Tissue glue, Surgicel, TachoSil leaves etc.) on the sutured hepatic injury is of great value and strongly contributes to the safety of the hepatorrhaphy, as they reinforce the suture line (3, 4).

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Operative technique

Figure 1.

a. Opening and exploration of the abdomen, aspiration of the blood and removal of the clots. A midline laparotomy provides a good surgical exposure of the liver. The exposure may be improved by adding a right subcostal and occasionally a right thoracoabdominal incision. The blood is aspirated, the clots are removed, and the abdominal viscera are examined to find out possible additional injuries to the other intraabdominal organs.

b. Bleeding control by Pringle maneuver. Control of the bleeding from vessels of the injured liver is usually achieved temporarily by pressing on the sides of the wound. Additionally, the afferent blood supply to the liver can be occluded by using the left hand fingers or a non-crushing vascular clamp (Pringle maneuver).

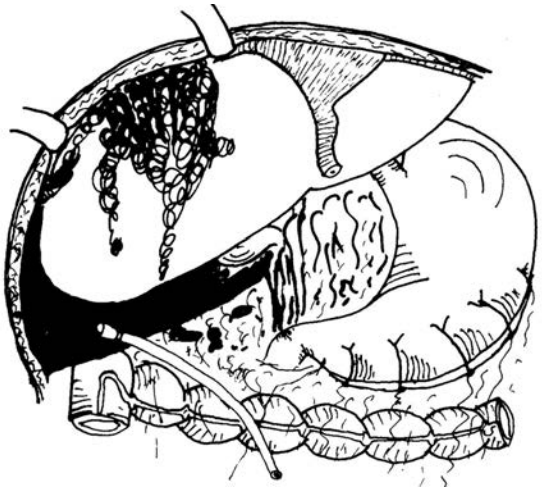
c. *Exposure of the hepatic trauma.* The traumatic area is washed with Normal Saline (NS) solution and cleaned well. The damaged and devitalized hepatic tissues are gently removed, and the vessels of the traumatic liver surfaces are ligated. In case the damaged area is difficult to be exposed, the lobe of the liver should be mobilized.

d. Hepatorrhaphy with interrupted sutures. Each knot penetrates a small piece of Surgicel before inserted into the liver. It is placed in a 2 cm distance from the edges of the wound deeply into the hepatic tissue in the form of a U, and goes out through an additional piece of Surgicel. Stitching should be tense enough so as to control the bleeding but not too tense to prevent tearing or strangulation of the hepatic tissue.

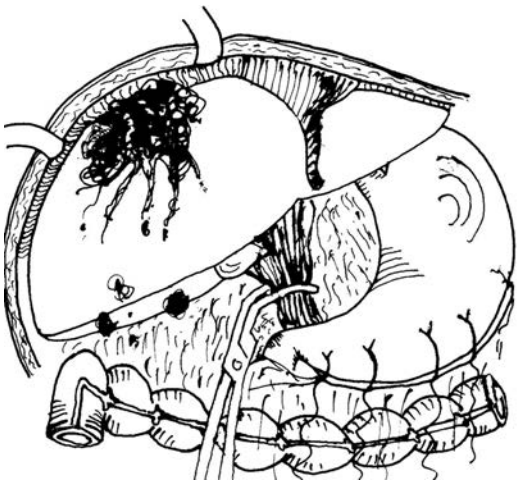
e. Hepatorrhaphy with "figure of eight" sutures. The hepatic injury is fixed with "figure of eight" absorbable sutures, placed at right angles to the rupture using a hepatic needle, in a 2 cm distance from the edge of the wound with such degree of tension that sutures will not cause necrosis of the hepatic substance. Small pieces of Surgicel are placed in each stitch in the way described above.

f. The final result of hepatorrhaphy. A thin layer of Surgicel or TachoSil leaves is placed over the laceration and beneath the sutures, covers the hepatic trauma completely and controls bleeding.

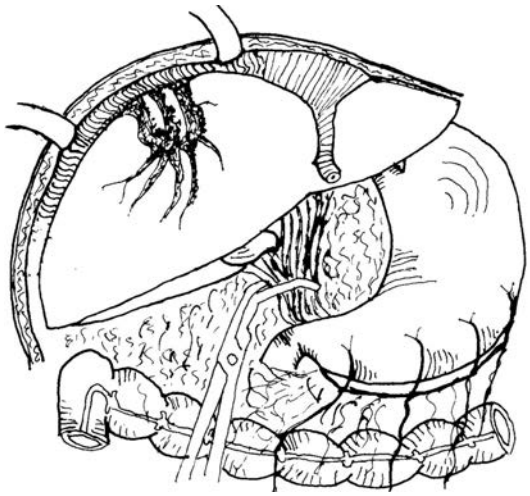
Figure 1



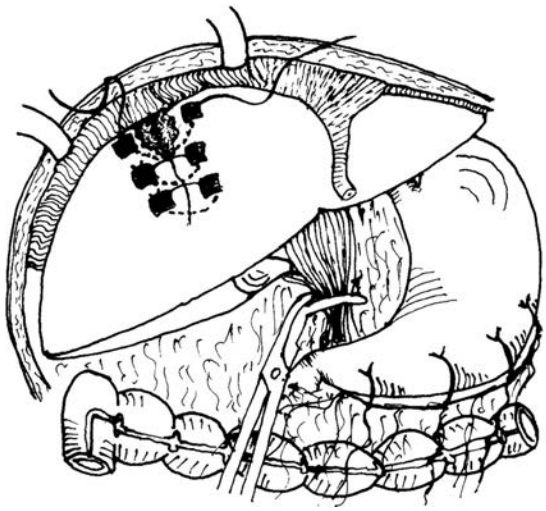
a. Opening and exploration of the abdomen, aspiration of the blood and removal of the clots.



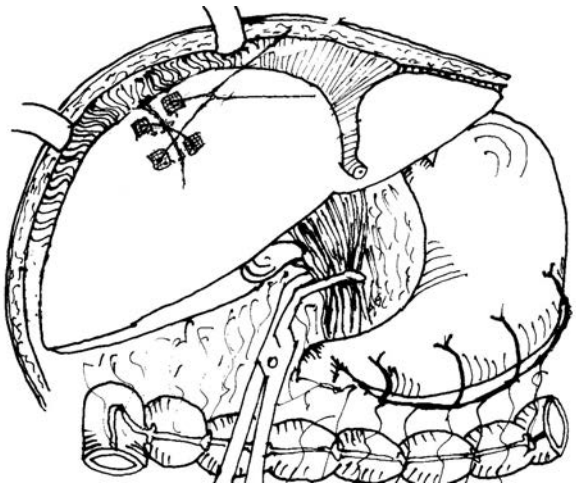
b. Bleeding control by Pringle maneuver.



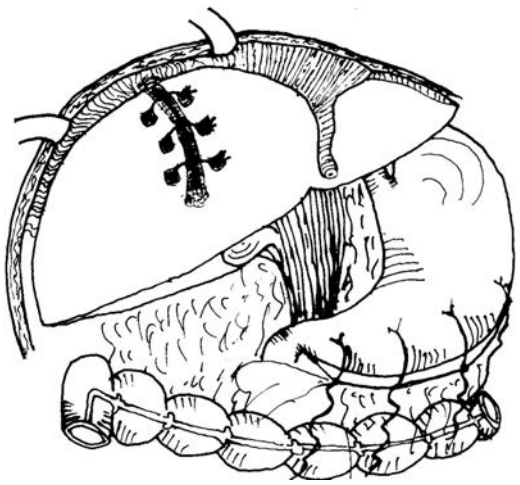
c. Exposure of the hepatic trauma.



d. Hepatorrhaphy with interrupted sutures.



e. Hepatorrhaphy with "figure of eight" sutures.



f. The final result of hepatorrhaphy.

Perihepatic Packing Procedure

This approach constitutes the basic "damage control" technique for the management of a severe hepatic bleeding (complex liver trauma, benign or malignant tumor rupture etc.); if performed properly, most hemorrhages will be controlled (1). The technique includes placing gauzes, gauze rolls, packing pads or other packing material (condom plugs, Kerlix rolls, a lap sponge, fine mesh gauzes, etc.) over or around the liver in order to pack liver injuries (2, 3). The existence of intact hepatic ligaments contributes to the effectiveness of packing, and they should not be divided (2). Good control of severe hepatic parenchymal hemorrhage seems to be achieved using perihepatic packing (1, 2, 3). The procedure can also be effective in some retrohepatic vena cava injuries, in major intrahepatic vascular injuries as well as in unstable patients in a hypodynamical state or patients suffering from hypothermia or coagulopathy (2, 3, 4). After packing, the abdomen is not closed primarily so as to prevent the development of the abdominal compartment syndrome. The packing should be removed within 24-72 hours, as the patient gets stabilized (2).

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Operative technique

Figure 2.

a. Opening of the abdomen and deciding on perihepatic packing. A midline laparotomy extended by a right subcostal incision constitutes the preferable incision. A right thoracoabdominal incision is also useful in some cases. The severity of hepatic injury is rapidly evaluated, and the surgeon makes the decision to perform perihepatic packing.

b. Bleeding control. Bleeding control can be achieved temporarily by the occlusion of the afferent blood supply (Pringle maneuver). Alternatively, clamping the aorta just below the diaphragm is essential and occasionally should be done to prevent hypovolemic shock. After bleeding control, the blood is sucked, the clots are removed, and the hepatic trauma is clearly viewed.

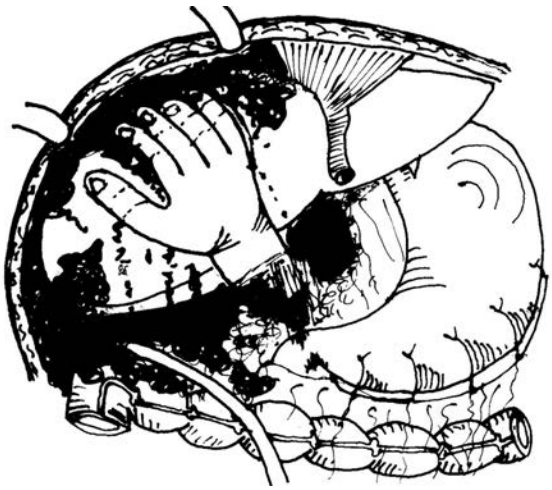
c. Mobilization of the liver. Mobilization of the injured lobe of the liver, if needed, offers a complete exposure of the trauma and may be done in patients with their trauma located on the posterior surface of the liver.

d. Hepatic packing: placement of gauzes, gauze rolls or packing pads. Hepatic packing gauzes, gauze rolls, packing pads or other packing material is placed over the hepatic injury, between the diaphragm and the injured lobe of the liver to tampon it. The packing is extended up to the hepatic ligaments, achieving a safe tamponade, effective in controlling life threatening hemorrhage in most severe liver injuries.

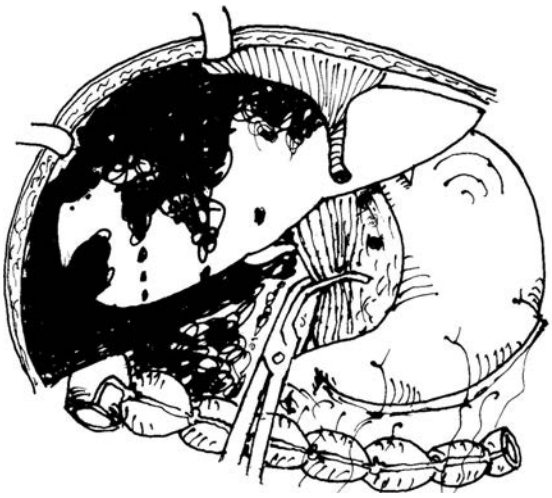
e. Perihepatic packing: placement of gauzes, gauze rolls or packing pads. If an injured lobe is mobilized, the packs are placed around the lobe so as to cover it completely and to tampon the injured lobe. In order to avoid bleeding during removal of the packs, some surgeons place temporarily an absorbable thin mesh strip on the surface of the liver before the gauze packing is put in place.

f. Leaving the abdomen open. The packs and the abdominal trauma are covered with a large gauze, and a plastic sheet is placed over it. Three or four sutures are placed to restrain the abdominal wall trauma, and the abdomen is left open to be closed later.

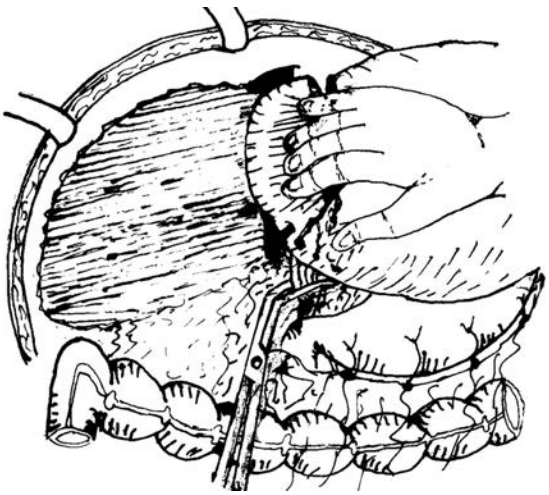
Figure 2



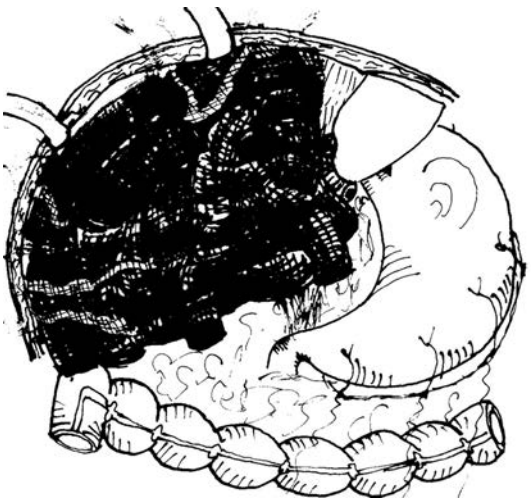
a. Opening of the abdomen and deciding on perihepatic packing.



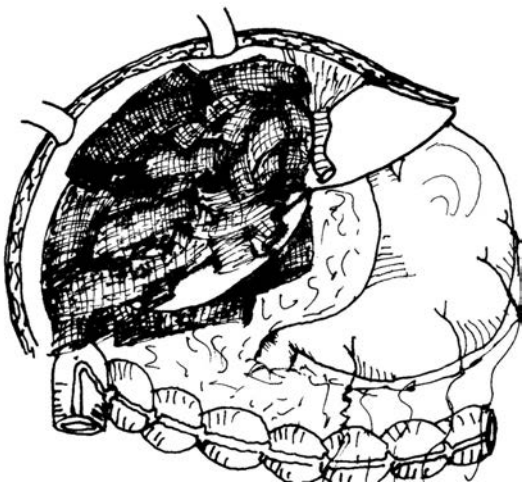
b. Bleeding control.



c. Mobilization of the liver.



d. Hepatic packing: placement of gauzes, gauze rolls or packing pads.



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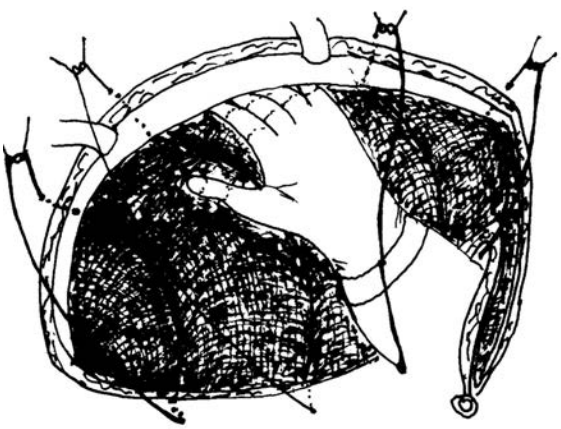

f. Leaving the abdomen open.

Alternative Hepatic Bleeding Control Techniques

Hepatic artery angiography and embolization seems to be a significant contribution to the management of active hepatic bleeding from the liver parenchyma (trauma, rupture tumor, NET, aneurysm, hemangioma, haemobillia etc.). Additionally, patients managed with perihepatic packing and patients with remaining or relapsing hemorrhage after surgical intervention should be evaluated angiographically (1, 2). Perihepatic absorbable mesh wrapping (3), balloon catheter plugs (4), Pringle maneuver (5), aorta clamping (6), liver isolation with multiple clamps, insertion of an endotracheal tube into the vena cava and resectional debridement (7) represent some alternative techniques to control hepatic haemorrhage.

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Operative techniques

Figure 3.

a. Absorbable mesh bag wrapping. Perihepatic absorbable mesh bag wrapping is occasionally applied in Grade 3 and 4 lacerations, instead of perihepatic packing. After liver mobilization, the mesh bag is wrapped around it in such a manner so as to compress the liver.

b. Balloon catheter plug. A balloon catheter (a vascular dilatation balloon or a sausage-shaped balloon) is placed along the whole length of the injury tract, resulting in bleeding control. It may be used in the case of a bullet or a knife having penetrated the liver deeply creating a tract where the tractotomy must be avoided.

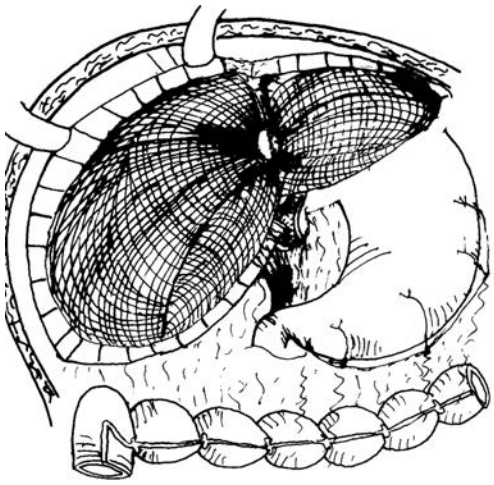
c. Pringle maneuver. This maneuver offers an occlusion of the afferent liver blood supply for 20 to 60 minutes, giving time to the surgeon to identify and manage the hepatic hemorrhage. The left thumb is placed on the anterior surface of the hepatoduodenal ligament, and the middle finger and the index are inserted into the foramen of Winslow. The structures in the porta hepatis are compressed, and a non-crushing vascular clamp is placed to occlude the blood vascular vessels.

d. Clamping of the abdominal aorta. The aorta is clamped just below the diaphragm with a supraceliac aortic clamp. Clamping can be achieved quickly with minimal dissection. It stops the peripheral arterial blood circulation and prevents the hypovolemic cardiac arrest.

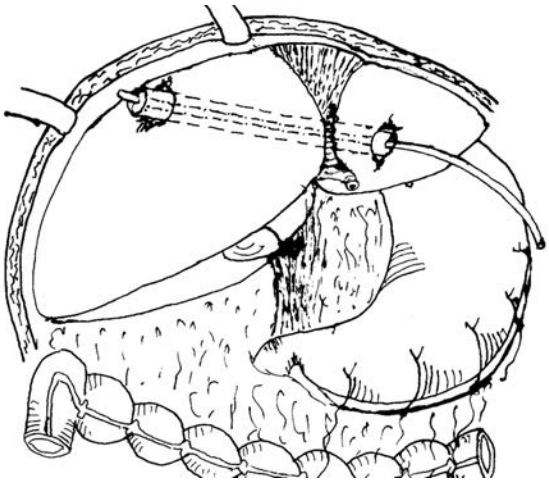
e. Isolation of the liver with multiple clamps. It may be performed in major hepatic venous or retrohepatic vena cava injuries. It includes the clamping of the aorta just below the diaphragm, clamping the vena cava below the liver and above the liver through the pericardium after thoracotomy. The Pringle maneuver is also performed.

f. Non anatomical liver resection. The Pringle maneuver is applied and resectional liver debridement is performed through the plane of the liver fracture or just outside the fracture line. The devitalized tissues are resected, and the bile ducts and vessels are occluded with stitches, clips, staplers or modern ways of cautery (ultrasonic, argon beam ones etc.). A tube drain is always placed.

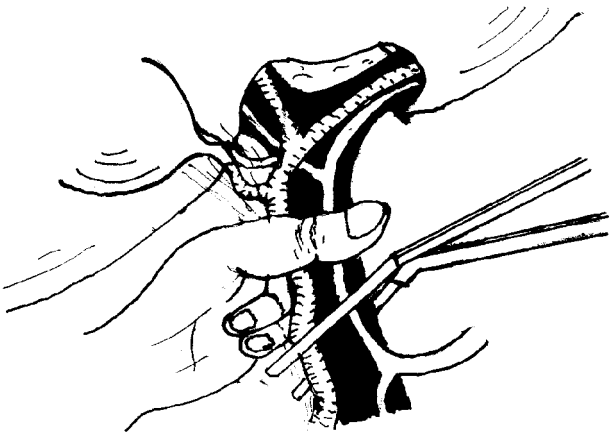
Figure 3



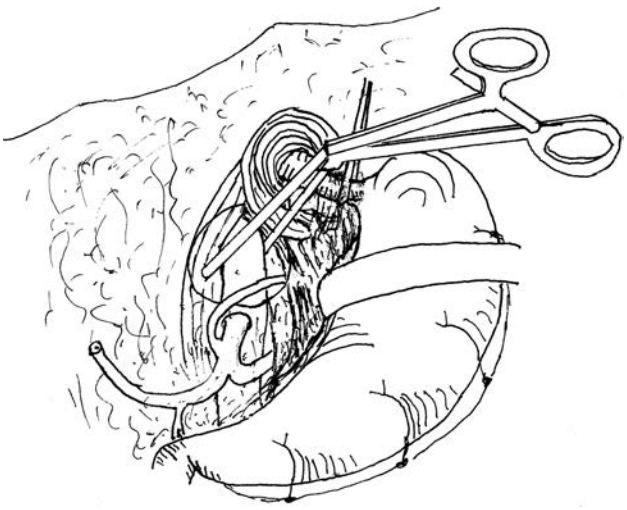
a. Absorbable mesh bag wrapping.



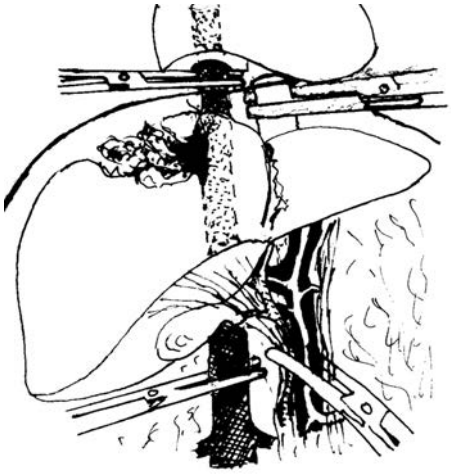
b. Balloon catheter plug.



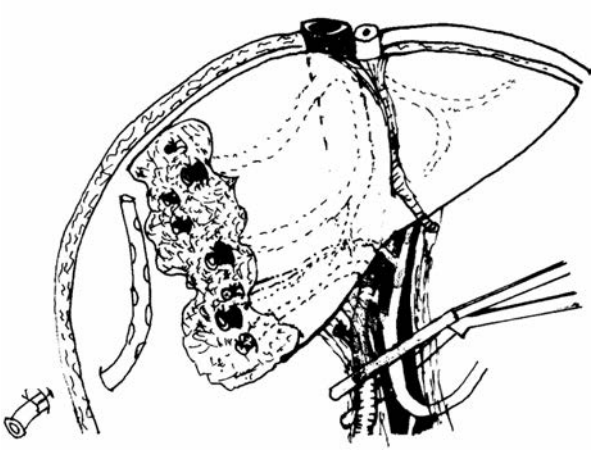
c. Pringle maneuver.



d. Clamping of the abdominal aorta.



e. Isolation of the liver with multiple clamps.



f. Non anatomical liver resection.