Liver transplantation for severe hepatic trauma: Experience from a single center

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Abstract
Liver transplantation has been reported in the literature as an extreme intervention in cases of severe and complicated hepatic trauma. The main indications for liver transplant in such cases were uncontrollable bleeding and postoperative hepatic insufficiency. We here describe four cases of orthotopic liver transplantation after penetrating or blunt liver trauma. The indications were liver failure, extended liver necrosis, liver gangrene and multiple episodes of gastrointestinal bleeding related to portal hypertension, respectively. One patient died due to postoperative cerebral edema. The other three patients recovered well and remain on immunosuppression. Liver transplantation should be considered as a saving procedure in severe hepatic trauma, when all other treatment modalities fail.

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Key words: Liver injury; Orthotopic liver transplantation; Severe liver trauma; Hepatic coma; Hepatic trauma

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INTRODUCTION
The liver is the most commonly injured abdominal organ, despite its protected location under the rib cage. The therapeutic options for the management of both blunt and penetrating hepatic trauma include a range of operative and non-operative treatment modalities [1-3]. Currently available methods for the management of hepatic trauma include observation, laparotomy with direct suturing, perihepatic gauze packing, application of fibrin tissue glue, mesh hepatorraphy, limited debridement resection and partial lobectomy. Extensive surgical techniques, such as formal hepatectomy or total hepatectomy with liver replacement, have been documented only in selected patients [4,5]. The surgical aim is control of hemorrhage, preservation of sufficient hepatic function and prevention of secondary complications. Liver transplantation has a limited, though very important, role in specific life threatening cases, when all the above mentioned methods fail to control bleeding or when liver failure ensues. We here describe our experience over the course of 11 years (1996 through 2007) with four cases of severe hepatic trauma requiring liver transplantation.

CASE REPORT
Case 1
A 25-year-old Caucasian male presented with hypovolemic shock to the Trauma Center due to a gunshot wound to the abdomen. The patient was severely acidic, requiring intense fluid resuscitation. His Glasgow Coma Scale (GCS) score was 9/15 upon admission. The patient was initially managed according the “advanced trauma life support” (ATLS) guidelines and very shortly thereafter was transferred to the operating theatre, due to signs of active bleeding. During an exploratory laparotomy, a trajectory wound affecting segments VII and VIII of the liver was documented, with active bleeding. A Pringle manoeuvre was initially used...
along with repair of liver injury. The abdomen was then packed. On the first postoperative day the patient remained unstable and acidotic with further bleeding from the liver surface requiring re-exploration. Right hepatic artery ligation and packing were performed and the patient was transferred to the intensive care unit with a plan for a possible right hepatectomy. Liver and renal functions, however, deteriorated progressively, with persistent acidosis, prolonged prothrombin time, low fibrinogen level and acute renal failure. The patient was placed on the transplant list and two days later underwent an orthotopic liver transplant. A portal and systemic veno-venous bypass was utilized. During re-exploration of the abdomen, the native liver appeared necrotic; mass clamping of the hilum following by supra and infra-hepatic vena cava clamping was performed. The donor liver was implanted using a conventional method for the inferior vena cava. Postoperatively, the patient remained unstable, with progressive lactic acidosis, liver dysfunction and cerebral edema. Cerebral edema was managed with direct monitoring of intracranial pressure (ICP) and drainage of cerebrospinal fluid when decompression was necessary. Despite the above treatment and the complete support in the intensive care unit (ICU), with elevation of the patient’s head by 25 degrees and maintenance of cerebral perfusion pressure by supporting systemic arterial pressure, reducing central venous pressure and avoiding agitation, the patient’s condition gradually deteriorated and he died on the eleventh post-operative day.

Case 2
A 68-year-old white female developed a subcapsular hematoma of the right lobe of the liver due to blunt abdominal trauma. A right liver lobectomy was performed in another institution because of hematoma expansion. Liver function, however, continued to deteriorate after surgery. The patient was referred for further evaluation. GCS was 15/15 upon admission. Doppler ultrasound revealed main portal vein thrombosis. An exploratory laparotomy was performed to attempt portal vein thrombectomy through the right portal vein stump, but this was unsuccessful. The common bile duct was also found to be partially necrotic and external bile drain placement was performed. Due to postoperative liver failure, the patient was listed as a status 1 candidate for liver transplant. Transplantation was performed two days later using a veno-venous bypass, with caval reconstruction in a piggyback fashion. The patient recovered after prolonged hospitalization and remains on immunosuppression with tacrolimus and mycophenolate mofetil ten years after transplantation.

Case 3
A 58-year-old white female suffered a gunshot wound to the abdomen which resulted in a penetrating right lobe liver injury and a through-and-through injury of the duodenum. Suture ligation with packing and duodenal repair performed in another institution, were adequate to control initial bleeding. However, over the course of the following two years she experienced multiple episodes of cholangitis due to biliary strictures and she required a choledoco-duodenostomy. Additionally, she went on to develop an arterio-venous fistula between the right hepatic artery and the right portal vein, which resulted in the development of significant portal hypertension. She experienced multiple episodes of gastrointestinal bleeding related to secondary biliary cirrhosis and the portal hypertension. An attempt to embolize the arterio-venous fistula failed and orthotopic liver transplantation was then considered. Her GCS score was 15/15. The native liver was cirrhotic with partial main portal vein thrombosis and a dilated hepatic artery. Under venovenous bypass, a piggyback technique was used for the caval dissection and the recipient portal vein was thrombectomized. The spleno-portal junction was used for venous reconstruction. Due to intra-operative injury to the duodenum during the dissection, a Billroth II gastrojejunostomy was performed and a Roux-en-Y hepatico-jejunostomy was created for bile duct reconstruction. The patient recovered after an uneventful postoperative course. Explant pathology revealed cirrhotic liver with periportal abscess formation. Six months later, the patient developed cholestasis and hepatic artery thrombosis. He underwent re-transplantation and is alive and well 11 years later.

Case 4
A 35-year-old female was admitted to the casualty department with a gunshot injury. She presented in hypovolemic shock. Her GCS score upon admission was 9/15. After initial management according to ATLS guidelines she underwent exploratory laparotomy and segment II and III penetrating liver injuries with concomitant portal vein laceration were discovered. Longitudinal venorrhaphy of the portal vein, along with liver packing was performed without liver resection. She was then taken to angiography for embolization of the left hepatic artery. Two months later she developed liver gangrene with hepatic artery pseudo-aneurysm. Although septic, the patient was not excluded from evaluation for liver transplant due to the fact that the liver was primarily the source of infection. After removal of the native liver, the patient’s hemodynamic status markedly improved. During transplant, the liver was fragile and the hilar structures were impossible to identify. The hilum was mass clamped and the structures isolated in a serial fashion after hepatectomy. The portal vein was dissected free to the confluence with the splenic vein because of the associated fibrosis and the native hepatic artery was suture ligated after removal of the pseudo-aneurysm. Transplant was performed in a piggyback fashion using a supra-celiac jump graft for the arterial inflow. The patient was discharged on postoperative trauma day 85 and is currently doing well at home nine years after transplantation.

DISCUSSION
The overall mortality of hepatic trauma has declined
from 60% in the first half of the last century to approximately 6% today. As many as 90% of patients with liver trauma are non-surgically managed with a remarkably high success rate, with only 10% requiring surgical intervention. The American Association for the Surgery of Trauma classified liver trauma degree and reported a liver injury scale (Table 1). The need for orthotopic liver transplantation (OLT) after liver trauma is clearly restricted. However, since the mortality rate of severe and complicated hepatic injuries remains significantly high, reaching 40% for grade IV and 80% for grade V hepatic injury, OLT must be taken under consideration when all other methods to achieve hemostasis have failed or cannot be applied.

The indications for liver transplantation in the setting of severe and complicated liver trauma, reported in the literature are: (1) uncontrollable bleeding despite repeated previous surgical interventions; (2) postoperative evolution towards hepatic insufficiency (acute or progressive); (3) injuries of the portal vein that cannot be reconstructed. In our series, the indications for OLT were the following: portal hypertension due to portal thrombosis and arterio-venous shunt; liver failure from massive injury; and portal thrombosis and liver gangrene with pseudo-aneurysm formation (Table 2). The patient survival rate was 25% and involves a patient with significant hemodynamic instability. In agreement with previous reports, we feel that OLT might be contraindicated when patients do not show any signs of hemodynamic stabilization despite intensive medical support. In such cases, rapid clinical deterioration follows the transplant surgery, leading to multi organ failure and death.

Furthermore, all patients in these studies had undergone a primary or even secondary operation to control bleeding, before they were finally referred to a transplant center. All our patients had also been managed with more conservative surgical procedures to control bleeding prior to referral for OLT. In our cohort OLT was partly planned due to complications related to the initial surgical management in addition to the severity of the initial liver injury.

To our knowledge, this is the largest series from a single center reported so far. The postoperative mortality rate was 25% and involves a patient with significant hemodynamic instability. In agreement with previous reports, we feel that OLT might be contraindicated when patients do not show any signs of hemodynamic stabilization despite intensive medical support. In such cases, rapid clinical deterioration follows the transplant surgery, leading to multi organ failure and death.

Although liver transplantation can be life saving in selective cases with severe liver injury, the lack of immediately available liver grafts combined with the inability to keep a patient in an anhepatic state, are the main causes of why such a few cases have been reported. Patients have to be listed as status 1 and donors with expanded criteria may also be accepted (size mismatch or steatotic livers). Reduced liver grafts have also been used.

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**Table 1 Liver injury scale (AAST)**

| Grade | Description |
|-------|-------------|
| I     | Hematoma: Subcapsular, < 10% surface area |
| II    | Laceration: Capsular tear, < 1 cm parenchymal depth |
| III   | Hematoma: Subcapsular, 10%-50% surface area; intraparenchymal, < 10 cm in diameter |
| IV    | Laceration: Parenchymal disruption involving 25%-75% of hepatic lobe or 1-3 Couinaud’s segments within a single lobe |
| V     | Laceration: Parenchymal disruption involving > 75% of hepatic lobe or > 3 Couinaud’s segments within a single lobe |
| VI    | Vascular: Hepatic arterial or portal venous injury |

**Table 2 Type of injury, operations performed and patient outcome**

| Patient | Age | Injury | Primary operation | Indication for OLT | Re-transplant | Outcome |
|---------|-----|--------|-------------------|--------------------|---------------|---------|
| 1       | 25  | Gun shot wound right lobe | Packing, hepatic artery ligation | Acute liver failure | No | Died (cerebral edema) |
| 2       | 68  | Blunt trauma subcapsular hematoma right lobe | R lobectomy, failed portal vein thrombectomy | Portal thrombosis progressive liver failure | No | Discharged POD 45 |
| 3       | 58  | Gun-shot wound right lobe, A-V fistula | Hepatotraphy, duodenal repair, embolization | Portal hypertension (A-V fistula), left portal vein thrombosis | Yes | Alive at 11 yr |
| 4       | 35  | Gun-shot wound left lateral lobe, hepatic artery pseudoaneurysm | Packing, embolization | Liver gangrene | No | Discharged POD 85 |
in the literature but primary non-function is possible\textsuperscript{40}.

Preexisting sepsis and associated organ injuries are usual contraindications for liver transplantation for the management of severe hepatic trauma\textsuperscript{16,17}. Bowel perforation with peritonitis, severe pancreatic trauma and loss of a large portion of the abdominal wall increase the mortality rate and preclude liver transplantation. A severe closed head injury with associated cerebral edema is also an absolute contraindication for orthotopic liver transplantation\textsuperscript{17}. However, localized sepsis in the liver is a relative contraindication, since the septic focus can be eradicated by the transplant itself\textsuperscript{41}.

It is worth noting that from a technical point of view: (1) veno-venous bypass is favored due to absence of portal hypertension; (2) mass clamping of the hilum is advocated in situations of difficult dissection or need for rapid liver removal and (3) a piggyback technique is facilitated by the absence of pre-existing portal hypertension. \textit{Ex situ} liver surgery with subsequent auto-transplantation has been reported for the management of otherwise unresectable hepatobiliary malignancies, with good results\textsuperscript{18,19}. It could be a viable alternative option for severe liver trauma, especially if a liver graft is not immediately available. In our series \textit{ex vivo} liver repair was not performed. Patients with lethal injuries to the liver can survive only if they are referred to a transplantation center promptly as documented by our experience.

Liver transplantation is an acceptable surgical method for management of patients with severe traumatic liver injury, under the previously mentioned life-threatening conditions. Further reports are awaited, in order to support and expand the application of OLT in such devastating cases.

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