

Traumatized liver grafts for organ donation?

A single-center experience

Because the number of patients on waiting lists increases each year, new strategies are urgently needed to expand the donor pool. The use of traumatized donor livers for orthotopic liver transplantation at a transplant center is described. After transplantation, no increased incidence of perioperative complications such as bleeding, bile leakage, or liver graft dysfunction were observed and the transplanted livers exhibited appropriate long-term function. Thus, the use of injured livers may offer new opportunities in transplantation. (*Progress in Transplantation*. 2009;19:349-353)

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Despite many efforts in the conservative treatment of end-stage liver diseases, liver transplantation remains the only curative treatment option for many patients.¹ According to the United Network for Organ Sharing (UNOS), about 6300 liver transplantations were performed in the United States in 2008, with another approximately 15 800 patients waiting for a donor organ.² In the United Kingdom, about 6% of the patients on the waiting list die before a suitable organ becomes available and another 6% are removed from the waiting list because they are too sick to survive liver transplantation.³

Facing these facts, one has to conclude that the main problem in liver transplantation today is the shortage of donated organs. Because the number of patients on waiting lists increases each year,² new concepts are urgently needed to expand the donor pool. Since the late 1990s, liberalization of donor criteria has had

some beneficial effects, but a solution to this problem has not been found yet.⁴⁻⁶

Part of the solution could be the acceptance of the use of traumatized liver grafts. Thus in this article, we describe our single-center experience with the use of traumatized donor organs.

Patients and Methods

Between September 1988 and August 2007, a total of 2126 orthotopic liver transplantations were performed at our center. Among these, a total of 6 livers from deceased multitrauma donors were macroscopically identified as injured liver grafts by the procurement team but were still regarded as suitable for transplantation. The stage of the liver trauma was classified according to the Moore classification.⁷

We retrospectively reviewed the medical records of all recipients of traumatized donor liver grafts who

Table 1 Donor, graft, and recipient-specific demographic data

Donor-specific data	Patient 1	Patient 2	Patient 3
Age, y	14	6	46
Sex	Male	Male	Male
Cause of death	Unknown	Car accident	Defenestration
Biochemistry			
Alanine aminotransferase, U/L	43	23	41
Aspartate aminotransferase, U/L	58	95	29
γ -Glutamyltransferase, U/L	6	504	38
Alkaline phosphatase, U/L	NA	NA	63
Lactate dehydrogenase, U/L	473	NA	517
Sodium, mmol/L	172	132	152
Bilirubin, mg/dL	1	1	0.5
Amylase, U/L	18	NA	NA
Hemoglobin, g/dL	14.1	10.3	4.9
Hematocrit, %	24	NA	22
Leukocytes, $\times 10^3/\mu\text{L}$	NA	15	NA
Platelets, $\times 10^3/\mu\text{L}$	63	91	NA
Prothrombin time, s	42	25	NA
Creatinine, mg/dL	1.2	0.3	1.2
Urea nitrogen, mg/dL	14	21	66
Graft-specific data			
Kind of liver trauma	Unknown	Hematoma	Unknown
Cold ischemic time, h	4	11	13
Preservation solution	UW	UW	UW
Quality of the liver	Steatotic (20%)	Normal	Normal
Maximal injury (Moore)	I	I	II
Concomitant injuries	Multiple rib fracture, pelvic injury, splenic rupture	Multiple rib fracture, pelvic injury	Unknown
Recipient-specific data			
Age, y	42	3	54
Sex	Female	Male	Male
Height, cm	162	Unknown	172
Weight, kg	54.7	Unknown	71.9
First transplant?	Yes	Yes	Yes
Indication for liver transplantation	Cirrhosis of the liver due to alcohol addiction	α_1 -Antitrypsin deficiency	Cirrhosis of the liver due to alcohol addiction
Progress after operation	Dead	Alive	Alive

Abbreviations: HTK, histidine-tryptophan-ketoglutarate; NA, not available; UW, University of Wisconsin.

SI conversion factors: To convert bilirubin to $\mu\text{mol/L}$, multiply by 17.104; to convert creatinine to $\mu\text{mol/L}$, multiply by 88.4; to convert urea nitrogen to mmol/L, multiply by 0.357.

^a Abnormal laboratory values in italic.

underwent full-size, orthotopic liver transplantation at our department. Follow-up ranged from 1 to 12 years.

Results

Donor Data

Our study included 5 male donors and 1 female donor with a mean age of 28.3 years (range, 6-50 years). Cause of death was a car accident in 4 cases,

defenestration in 1 case, and unknown in 1 case. Blood samples showed slightly elevated levels of transaminases in 4 patients and of bilirubin in 2 patients (see Table).

According to the Moore classification, 2 livers showed grade I injury and 4 showed grade II injury (see Table). One donor liver had injuries in both lobes, grade I in the right lobe, and grade I and II in

Patient 4	Patient 5	Patient 6
50	17	37
Male	Male	Female
Car accident	Car accident	Car accident
NA	75	31
14	66	93
3	33	14
45	260	42
10	645	472
152	145	150
0.4	3.7	4
6.6	401	164
3.5	9.2	9.7
16	27	28
8.9	7.2	NA
180	34	108
44	NA	37
1.3	0.8	1.3
NA	40.8	49
Hematoma	Unknown	Hematoma, rupture
16	14	10
UW	UW	HTK
Steatotic	Normal	Normal
II	II	II
Unknown	Multiple rib fracture, splenic contusion	Unknown
45	57	59
Female	Male	Male
159	107	172
63	72.4	77.9
Yes	Yes	No
Autoimmune hepatitis	Cryptogenic cirrhosis	Ischemic type biliary lesions
Alive	Alive	Alive

the left-lateral (segments II and III) liver (see Figure). The mean amount of red blood cells transfused until recovery of organs was 15 units.

Recovery of Organs and Liver Transplantation

In 5 of 6 cases, University of Wisconsin solution was used for organ preservation; histidine-tryptophan-ketoglutarate was used in 1 case. The livers were

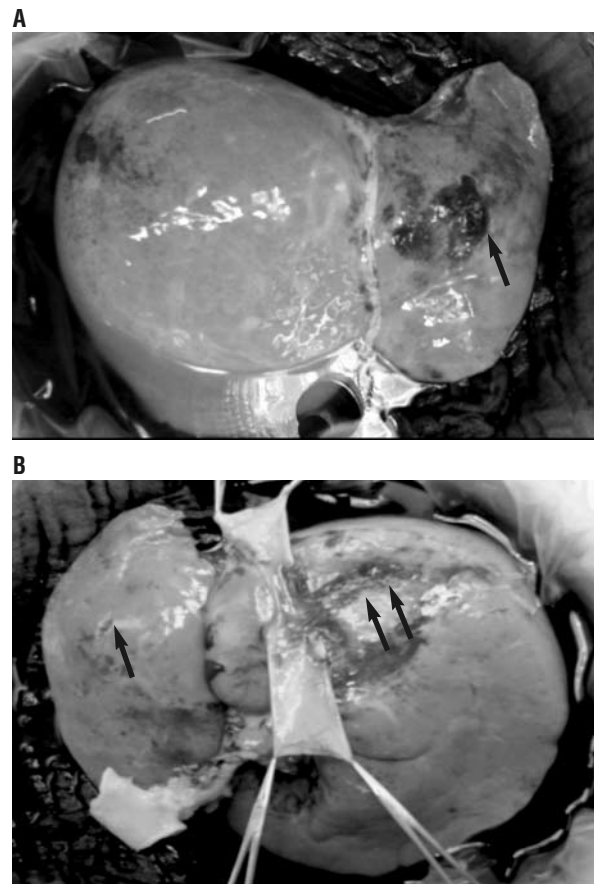


Figure 1 Traumatized donor liver during back-table preparation. (A) Front side of the donor organ shows liver injury (Moore I, arrow) on the left side (following local electrocoagulation during recovery of organs). (B) Rear of the same liver with a small rupture (Moore II) on the left side (single arrow) and a paracaval hematoma (Moore I) on the right side (paired arrows).

recovered by experienced transplant surgeons and judged as suitable for orthotopic liver transplantation. Because 2 livers showed fatty infiltration, histologic examination was performed to confirm this subjective impression in 1 of the livers (20% fat content). Mean cold ischemic time was 11.3 hours, and duration of liver transplantation was 6 hours. On average, 6 units of red blood cells and 10 units of fresh frozen plasma were transfused during transplantation.²

Recipient Data

A total of 4 male and 2 female patients (5 adults, 1 child) received traumatized donor livers. Mean age was 43.3 years (range, 3-59 years). Indications for transplantation were alcoholic cirrhosis in 3 cases, autoimmune hepatitis, α_1 -antitrypsin deficiency in 1 case, and ischemic-type biliary lesions (retransplantation) in another case (see Table).

Postoperatively, no complications such as bleeding, bile leakage, or liver graft dysfunction occurred.

After a mean follow-up of 8.2 years (range, 1-12 years), 3 patients did not show any complications, whereas 1 patient required renewal of the hepatic arterial anastomosis because of kinking on postoperative day 28. Another patient had a cytomegalovirus infection that was treated successfully. Both patients with complications recovered well and did not show any further problems. In addition, a 42-year old female recipient who had needed a transplant because of alcoholic cirrhosis died 11 years after transplantation because of a pulmonary embolism that could not be linked to the liver disease.

Discussion

The current shortage of donor organs is a severe problem in organ transplantation. In an effort to increase the number of available organs, 2 different approaches have been developed since the late 1990s: living donor and split liver transplantation have become more common, and a liberalization of donor criteria has led to higher numbers of liver transplantations.

Although living donor liver transplantation has proven advantages and therefore is an established treatment option for patients with end-stage liver disease, it is also well-known that this procedure has a higher rate of complications for both donors and recipients.⁸⁻¹¹ A similar strategy that has been used to increase the donor pool is split-liver transplantation, in which 2 grafts are taken from 1 deceased donor liver. Because of technical and logistic problems, this procedure is used in only about 4% of all liver transplantations^{12,13} and therefore remains a rare option. In contrast to this, several reports of studies on extension of the donor pool by liberalization of the donor criteria seem to include promising results. Unfortunately, these studies cannot be compared because no consensus has been reached on the definition of a marginal graft and the donor criteria.

Although several studies have been published about expansion of the donor pool, hardly any of these reports describe the possibility of transplanting injured livers. In 1999, Broering et al¹⁴ presented 28 donated organs that were harvested from trauma patients and were regarded as injured. Half of these livers were regarded macroscopically as injured whereas the remaining livers did not show macroscopic changes. Patient survival was 86% in the macroscopically injured group and 79% in the other group, but the incidence of primary graft nonfunction was higher in the first group (21 vs 0%). This result cannot be confirmed by the present data, because primary nonfunction was not observed in our 6 recipients.

The possibility of performing a successful transplantation with an injured liver was emphasized in another case report.¹⁵ After abdominal trauma due to a motor vehicle accident, the explanted organ displayed

3 lesions, which were classified as Moore grade I (1 lesion) and Moore grade II (2 lesions). Because vascular and biliary structures were not involved, the injured organ could be transplanted. Intraoperatively, lesions could be treated by manual compression and electrocautery. After an uneventful postoperative recovery, the patient did not show any complications and was in excellent health after a follow-up of 26 months.

Similar results were published by Tector et al.¹⁶ In that study, a total of 15 donated organs with injury worse than grade I were transplanted without any postoperative complications. Unfortunately, that report does not give further information on the postoperative course. However, those results confirm the results of the present series, which show that transplantation of organs with minor injuries can be performed with good short- and long-term results.

In the same line, Tucker et al¹⁷ presented the first transplantation of a traumatized liver explanted from a controlled donation after cardiac death. After a blunt abdominal trauma, the donor underwent laparotomy because of a hemoperitoneum. Intraoperatively, perihepatic packing was performed in order to achieve hemostasis. Postoperatively, irreversible neurological injury of the patient became apparent, although brain death criteria were not fulfilled at that time. In accordance with the patients family, ventilatory support was stopped and the liver was procured immediately after the donor's death. Macroscopically the liver had a grade II injury but was considered suitable for transplantation. The recipient recovered well after the operation and did not show any complications despite a short period of rejection.

With regard to these reports and according to our experience, traumatized liver grafts are suitable for transplantation if they have only a mild form of organ injury. Indeed, no increased incidence of perioperative complications such as bleeding, bile leakage, or liver graft dysfunction occurred. Moreover, appropriate long-term function of these livers may be comparable to that for nontraumatized donor organs.¹⁴ As the liver is the most commonly involved organ in abdominal trauma,¹⁸ new chances might evolve from the use of injured livers in transplantation.

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