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Routine Doppler ultrasound for the detection of clinically unsuspected vascular complications in the early postoperative phase after orthotopic liver transplantation

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Abstract To assess the role of routine Doppler ultrasound in the detection of clinically unsuspected vascular complications in the early postoperative phase after orthotopic liver transplantation (OLT), the findings of 858 routinely performed Doppler ultrasound examinations were analyzed in 268 transplants. At various time intervals after OLT, we encountered 46 abnormal Doppler findings: hepatic artery (thrombosis), portal vein [anastomotic stenosis, (non)occlusive thrombosis or reversed flow], inferior vena cava [anastomotic stenosis with reversed flow, no flow, or (non)occlusive thrombosis], and hepatic veins (to-and-fro flow or stenosis with reversed flow) in 14, 20, 9, and 2 transplants, respectively. Most of these abnormal Doppler findings were confirmed by angiography, cavography, or surgery. The positive predictive value for hepatic artery thrombosis (HAT) was 12 out of 14, or 86%. In the first 2 weeks after OLT, routine Doppler ultrasound revealed 20 of the 46 abnormal findings (43%). Clinically unsuspected complications of the hepatic artery, portal vein, inferior

vena cava, and hepatic veins were found in 9 of the 14 (64%), 6 of the 20 (30%), 3 of the 9 (33%), and 2 of the 2 (100%) transplants, respectively. The highest incidence – nine vascular complications – was found on the 1st day. On each of the remaining days (except for the 2nd and 9th days), one or two vascular complications were detected. HAT was found mainly in the 1st week. Vascular complications developed independently or concomitantly. We conclude that routine Doppler ultrasound is very important for the detection of clinically unsuspected vascular complications, particularly HAT, in the first 2 weeks after OLT. We recommend routine Doppler ultrasound of all hepatic vessels every 3 days in the early postoperative phase after OLT. Special attention should be paid to the 1st day.

Key words Liver transplantation, hepatic artery, ultrasound · Hepatic artery, liver transplantation, ultrasound · Ultrasound, hepatic artery, liver transplantation

Introduction

Vascular complications are a common cause of post-transplant hepatic dysfunction. Thrombosis and stenosis of the hepatic artery, portal vein, or inferior vena cava

may develop independently or concomitantly [2, 11, 12]. Prompt detection, diagnosis, and treatment of vascular complications are crucial for graft and patient survival. However, vascular complications may be clinically unsuspected [4, 8]. Doppler ultrasound is now the meth-

od of choice for the initial postoperative evaluation of the vasculature of the transplanted liver [1, 6, 10].

The purpose of this study was to assess the role of routine Doppler ultrasound in the detection of clinically unsuspected vascular complications in the early postoperative phase after orthotopic liver transplantation (OLT).

Materials and methods

From 1989 to 1995, 1333 Doppler ultrasound examinations were performed after OLT in 268 transplants (239 primary transplants and 29 retransplants). There were 245 patients (99 males and 146 females). The group included 177 adults, ranging in age from 16 to 64 years (median 43.5 years), and 68 children, ranging in age from 1 month to 16 years (median 2.5 years). Fourteen adults and 15 children underwent retransplantation.

In our series of 268 transplants, 858 of the 1333 Doppler ultrasound examinations were performed routinely (64%) and 475 on clinical demand (36%). Patients were scanned an average of 5.4 times (range 1–34), depending on the findings and clinical course. Doppler ultrasound was performed from 1 day to more than 10 years after OLT. Most Doppler ultrasound examinations were performed in the first 2 weeks after OLT (44%).

Doppler ultrasound examinations were performed with a real-time sector scanner (Acuson 128, Mountain View, Calif., USA, or only for ultrasound examinations Sonoline SX, Siemens, Erlangen, Germany). A 3.5-MHz transducer was used for the imaging, pulsed, or color Doppler procedures.

Spectral Doppler examination was performed on the hepatic artery, portal vein, inferior vena cava (IVC), and hepatic veins. Analysis included confirmation of vascular patency, detection of nonocclusive thrombosis or stenosis, and determination of the direction of flow. Angiography, cavography, or surgery was done if the Doppler ultrasound findings indicated vascular complications. Subsequently, the abnormal Doppler ultrasound findings were correlated with the available angiographic, cavographic, and surgical data, and with the clinical course or follow-up Doppler ultrasound examinations, when possible.

Results

Routine Doppler ultrasound revealed 46 abnormal findings at various time intervals after OLT in 40 of the 268 transplants (15%). In 5 of these 40 transplants, more than one abnormal Doppler ultrasound finding was encountered (two in 4 transplants and three in 1 transplant).

Hepatic artery complications

In 14 of the 268 transplants (5%), routine Doppler ultrasound could not demonstrate an arterial signal, which led us to suspect hepatic artery thrombosis (HAT). In 9 of these 14 transplants (64%), the Doppler ultrasound diagnosis of HAT was made in the first 2 weeks after OLT (Fig. 1).

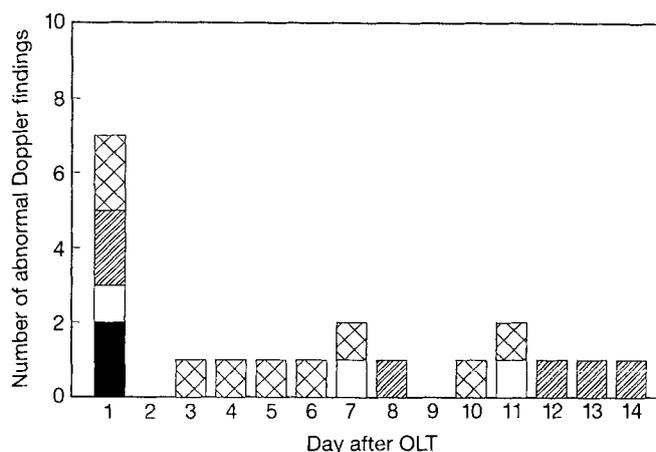


Fig. 1 Abnormal routine Doppler ultrasound findings in the first 2 weeks after OLT. ■ Hepatic vein; □ inferior vena cava; ▨ portal vein; ▩ hepatic artery

The Doppler ultrasound diagnosis of HAT was confirmed by angiography (Fig. 2) in 11 transplants and by surgery in 1 transplant. In the remaining 2 transplants, routine Doppler ultrasound did not detect an arterial Doppler signal, while angiography demonstrated a patent hepatic artery. The positive predictive value was 12 out of 14, or 86% (Table 1).

Portal vein complications

In 20 of the 268 transplants (7%), 21 routine Doppler ultrasound examinations of the portal vein were abnormal. In one transplant, routine Doppler ultrasound demonstrated reversed flow in the left branch and stenosis at the anastomotic site of the portal vein after different time intervals.

Anastomotic stenosis and thrombosis of the portal vein were the most frequent complications (Table 1). Six of the 21 abnormal Doppler ultrasound findings of the portal vein (29%) were encountered in the first 2 weeks after OLT (Fig. 1). Sixteen of the 21 abnormal Doppler ultrasound findings of the portal vein (81%) were confirmed by angiography and 1 by surgery.

In one transplant, which was treated with intravenous heparin, follow-up Doppler ultrasound demonstrated resolution of a nonocclusive thrombus of the portal vein. In another transplant, a nonocclusive thrombus of the portal vein disappeared without any antithrombotic therapy at follow-up Doppler ultrasound. In two transplants, abnormal Doppler ultrasound of the portal vein could not be confirmed due to limiting factors of angiography, such as moderate opacification, over-projection of clips, and peristaltic bowel loops (Table 1).

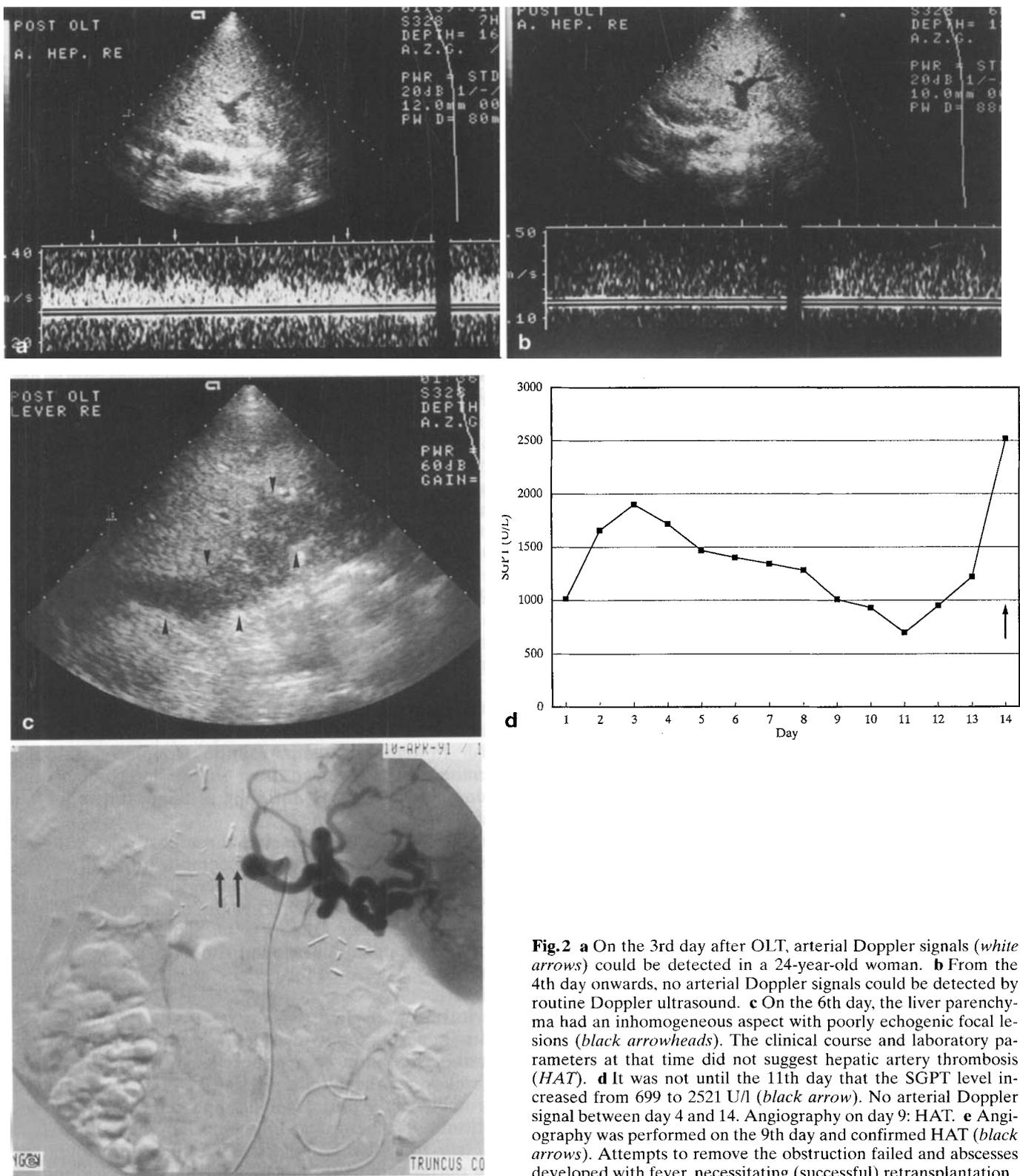


Fig. 2 **a** On the 3rd day after OLT, arterial Doppler signals (*white arrows*) could be detected in a 24-year-old woman. **b** From the 4th day onwards, no arterial Doppler signals could be detected by routine Doppler ultrasound. **c** On the 6th day, the liver parenchyma had an inhomogeneous aspect with poorly echogenic focal lesions (*black arrowheads*). The clinical course and laboratory parameters at that time did not suggest hepatic artery thrombosis (HAT). **d** It was not until the 11th day that the SGPT level increased from 699 to 2521 U/l (*black arrow*). No arterial Doppler signal between day 4 and 14. Angiography on day 9: HAT. **e** Angiography was performed on the 9th day and confirmed HAT (*black arrows*). Attempts to remove the obstruction failed and abscesses developed with fever, necessitating (successful) retransplantation

Table 1 Abnormal routine Doppler examinations ($n = 46$) after orthotopic liver transplantation (OLT)

	Time after OLT		Confirmation					Total
	≤ 2 weeks	> 2 weeks	Angiography	Cavography	Surgery	Follow-up	?	
Hepatic artery:								14
Thrombosis	9	5	12					
Portal vein:								21
Thrombosis							1	
– Intrahepatic	1	2	2					
– Extrahepatic		5	5					
Nonocclusive thrombus	3				1	2		
Reversed flow	1	1	1		1			
Stenosis	1	7	7				1	
Inferior vena cava:								9
Thrombosis		5		4			1	
Nonocclusive thrombus	2			1			1	
Stenosis/reversed flow	1	1		1	1			
Hepatic vein:								2
To-and-fro flow	1				1			
Reversed flow	1						1	
Total	20	26						46

IVC complications

In 9 of the 268 transplants (3%), routine Doppler ultrasound of the IVC was abnormal. Thrombosis was the most frequent complication (Table 1). Three of the nine abnormal IVC Doppler ultrasound findings (33%) were encountered in the first 2 weeks after OLT (Fig. 1).

Six of the nine abnormal Doppler ultrasound findings of the IVC (67%) were confirmed by cavography and one by surgery. In the two remaining patients, confirmation was not obtained by cavography or surgery (Table 1). One patient died before further investigation could be done. In the second patient, a combination of reversed flow in the IVC distally and visualization of the azygous vein was considered to be compatible with thrombosis.

Hepatic vein complications

In 2 of the 268 transplants (< 1%), routine Doppler ultrasound of the hepatic veins was abnormal. The complications were to-and-fro flow in one patient and reversed flow in the other patient due to venous outflow obstruction or stenosis. Both abnormal Doppler ultrasound findings of the hepatic veins were encountered in the first 2 weeks after OLT (Fig. 1).

The first abnormal Doppler ultrasound examination was confirmed by surgery. Confirmation of the second abnormal Doppler ultrasound examination could not be obtained by cavography or surgery because of the site of stenosis (Table 1).

Discussion

Nowadays, Doppler ultrasound is generally considered an efficient, noninvasive screening method for detecting vascular complications after OLT, particularly if there is clinical concern about the patency of vessels supplying or draining the liver, especially the hepatic artery [1, 2, 6, 9, 10]. However, in the early post-transplantation period, vascular complications can also be asymptomatic. In three previous studies [3, 5, 8], clinically unsuspected hepatic artery thrombosis (HAT) was diagnosed with routine Doppler ultrasound in the first 2 weeks after OLT. Our findings confirm that routine Doppler ultrasound plays a major role in the early detection of HAT before any clinical symptoms or laboratory data indicate this serious vascular complication. Early diagnosis of HAT allows retransplantation before the development of severe hepatic failure or sepsis [9]. In one of our patients, the early diagnosis of HAT was crucial because urgent, surgical, hepatic arterial thrombectomy successfully restored the blood flow. This observation argues in favor of close monitoring of the patency of the hepatic artery.

The question arises as to whether routine Doppler ultrasound should be performed daily in the first 2 weeks, as has been suggested by others [3, 5, 8]. In our series, clinically unsuspected HAT was found almost every day in the 1st week. In the 2nd week, a random distribution of different vascular complications was observed. In this period, however, only 36 of the 580 Doppler ultrasound examinations (6%) were abnormal. Moreover, 18 of these 36 examinations were performed on clinical demand. We agree that serial Doppler examinations have a considerable impact on patient management by

shortening the time between discovery and treatment of clinically unsuspected vascular complications. Nevertheless, it seems unwise to perform routine Doppler ultrasound daily. We recommend routine Doppler ultrasound every 3 days in the first 2 weeks after OLT as a suitable alternative. Special attention should be paid to the 1st day because of the highest incidence of vascular complications in patients without symptoms. Daily Doppler ultrasound should only be performed in high-risk patients, such as young children, after complex vascular reconstruction, or in the case of thrombectomy.

Obviously, Doppler ultrasound is always indicated if clinical symptoms or laboratory parameters are consistent with HAT. In addition, serial Doppler ultrasound examinations are necessary if an initially normal arterial Doppler waveform changes into absent diastole flow or dampening of the systolic peak. This change has been called the "syndrome of impending thrombosis" and proves to be a strong predictor of HAT [7].

In our study, clinically unsuspected complications of the hepatic artery, portal vein, or IVC that occurred more than 2 weeks after OLT in patients with a good clinical condition and normal liver function did not have any impact on the therapeutic policy. Therefore, routine Doppler ultrasound after 2 weeks does not seem to be necessary.

In support of previous reports [2, 11, 12], we found that complications of the hepatic artery, portal vein, IVC, and hepatic veins may develop independently or concomitantly. Consequently, Doppler ultrasound should include the systematic evaluation of all these hepatic vessels. Furthermore, this approach can be used to determine the cause of vascular complications.

Another important point is that the patency of the main hepatic artery and portal vein, as well as their right and left intrahepatic branches, need to be evaluated. On the one hand, the demonstration of flow within intrahepatic branches in the early postoperative period confirms a patent main hepatic artery or portal vein. On the other hand, isolated thrombosis of intrahepatic branches may be detected and treated in asymptomatic patients before more serious sequelae develop.

It could be argued that our study is limited by the fact that several abnormal and almost all normal Doppler ultrasound findings were not confirmed by other imaging modalities such as angiography and cavography. However, this limitation does not appear to have influenced our results. First, surgical exploration and the clinical course of the patient proved to be compatible with abnormal Doppler ultrasound findings. Second, only a few cases could not be confirmed at all. Third, Doppler ultrasound is a noninvasive imaging technique that can be used to follow-up abnormal Doppler ultrasound findings, monitoring the effect of anticoagulation therapy on the resolution of a thrombus or indicating the progression of stenosis. Finally, the normal Doppler ultrasound findings regarding the patency of the hepatic artery and portal vein correlated well with routine angiographic examinations performed later.

In summary, routine Doppler ultrasound plays a very important role in the detection of clinically unsuspected vascular complications, particularly HAT, in the first 2 weeks after OLT. We recommend routine Doppler ultrasound of all the hepatic vessels on the 1st day after OLT and, subsequently, every 3 days in the early postoperative phase.

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