The role of Doppler ultrasonography in monitoring the hepatic graft in the early post transplantation period

Maha K Abdel Ghaffar, *MD*[a]***; Mohamed Sobhy,*** *MD*[a]***;***
Mohamed Amin Nassef, *MD*[a]***; Mohamed Bahaa,*** *MD*[b]

a) Department of Radiodiagnosis, Ain Shams University, Cairo, Egypt.
b) Department of Surgery, Ain Shams University, Cairo, Egypt.

Purpose: *To distinguish the alarming from the non-alarming signs during immediate postoperative Doppler ultrasonography (US) follow up for liver transplantation cases.*

Patients and methods: *From March 2012 to June 2013, 36 patients of post living related donor liver transplantation where followed up in the first month after liver transplantation and the US and Doppler US changes were recorded together with their laboratory data. When there were alarming Doppler US signs CT angiography was done to confirm vascular complications.*

Results: *5 cases (13.8%) presented with hyperechoic segments due to segmental venous congestion, 12 cases (33.3%) showed raw surface collection, 15 cases (41.6%) presented with free peritoneal fluid and 18 cases (50%) had right pleural effusion. One patient (2.7%) presented with occluded hepatic artery and thrombectomy was done. 30 cases (83.3%) showed increased portal vein velocity. The mortality was 8.3% seen in 3 cases, two of them (5.5%) suffered from 7*th *day syndrome presented with abrupt sharp decrease in portal flow and one case (2.7%) had a small graft size and presented with marked slowliness of the portal flow on Doppler study and a venous infarct on CT.*

Conclusion: *The early monitoring of graft hemodynamic changes by Doppler sonography is of great importance as most of these changes revert to normal in the first postoperative week, however sharp decrease in arterial or portal flow indicates underlying grave vascular complications, some of them are correctable.*

Introduction:

End-stage liver disease (ESLD) and (HCC) have become the main cause of mortality in our country in patients with hepatitis B or C viruses.

Orthotopic liver transplantation (OLT) is the only definitive treatment for patients with irreversible acute and chronic liver disease.[1]

Patients should be considered for liver transplantation if they have evidence of fulminant hepatic failure, a life-threatening systemic complication of liver disease, or a liver-based metabolic defect or, more commonly, cirrhosis with complications such as hepatic encephalopathy, ascites, hepatocellular carcinoma, hepatorenal syndrome, or bleeding caused by portal hypertension. While the complications of cirrhosis can often be managed relatively effectively, they indicate a change in the natural history of the disease that should lead to consideration of liver transplantation.[2]

Ultrasonography (US) and Doppler examination is the preferred modality for postoperative imaging because it is portable, is readily available, and provides early detection of complications. Doppler US is used to detect treatable vascular complications and ensure graft survival. The first 24 hours after transplantation are referred to as the "hyperdynamic phase," in which the transplanted liver demonstrates disordered circulatory patterns and hemodynamic instability. The first postoperative Doppler US images are obtained fairly early on the first postoperative day, before surgical

wounds have been closed.[1]

The aim of our work is to highlight the alarming and non-alarming Doppler US findings in the immediate postoperative images, obtained when the effects of surgery are very recent. Most of these changes revert to normal in the first postoperative week; deterioration of transient changes requires further evaluation.

Methods:

During the period from March 2012 to June 2013, 36 adult patients (25 males, 9 females) ranging in age between 37 to 59 years with mean of 53.4 years underwent living related donor liver transplantation in Ain Shams University Specialized hospital (liver transplantation unit). Indication for transplantation was end stage liver disease for 27 cases and HCC in 9 cases. 7 of our patients had chronic portal vein thrombosis of variable extent and for all successful thrombectomy was done during surgery **Table (1)**.

Routine gray-scale US of the transplanted liver was performed with detailed vascular Doppler US. During the first week, patients were examined daily using Doppler US, then every other day till the third week and twice weekly for the rest of the 1st three months. The examination was done using a 5 MHz curved array transducer LOGIQ 500 (GE, YokogawaMedical System Ltd, Tokyo, Japan). All patients were examined in the supine position during quiet breathing. Doppler tracings of portal vein were obtained from the right branch of the portal vein in the case of right lobe graft and from umbilical portion of the portal vein in the case of left lobe graft. Doppler tracings of hepatic artery were obtained from the right hepatic artery in the case of right lobe graft and from the left hepatic artery in the case of left lobe graft. Veins of the graft were also examined.

During the Doppler US examination the following were observed:

-Homogenicity of the graft which was affected by the effect of reperfusion edema and fluid stasis in the extracellular compartments.

-Presence of collections or free fluid in pleura or peritoneum.

-Patency of hepatic artery and its wave pattern demonstrated normally by rapid systolic upstroke with systolic acceleration time of less 80 msec and continuous diastolic flow, and RI which ranges normally from 0.55 to 0.8.

-Patency of portal vein presented normally by a centripetal direction of flow and a mean portal velocity of 58 cm/sec at the anastomosis site.

-Patency of hepatic veins and its normal triphasic wave pattern.

In cases of persistent abnormality in Doppler US study or if there were laboratory abnormality as increased level of SGOT, SGPT, bilirubin, INR and serum lactate with no significant Doppler explanation, diagnostic CT angiography was recommended.

Results:

36 patients after living related donor liver transplantation were examined daily during the first week using US and Doppler US, then every other day till the third week and twice weekly for the rest of the 1st three months **Tables (2-3)**.

Five cases (13.8%) with segmental venous congestion presented with hyperechoic segments and had increased levels of SGOT and SGPT in the first week **Figure (1)**.

Twelve cases (33.3%) showed raw surface collection, 15 cases (41.6%) presented with free peritoneal fluid and 18 cases (50%) had right pleural effusion **Figure (2)**.

We had one patient with occluded hepatic artery in day 2, he presented with shooting liver enzymes and increased serum lactate. Occluded hepatic artery was confirmed by 3D CT MIP (maximum intensity projection) and the patient was explored and a thrombus was found in hepatic artery at anastomotic site. Thrombus was removed, anastomosis was revised and patency was regained **Figure (3)**.

The increased portal vein velocity was detected in 30 patients (83.3%) and was noticed to be the most frequent abnormality seen in the early post-operative period however it declined gradually through the first month **Figure (4)**.

Additionally 2 cases (5.5%) developed

Figure (1): Icreased liver enzymes in day 3 after LT in a 50 years old male. Gray scale US shows congested hyperechoic area at segment VII of the graft.

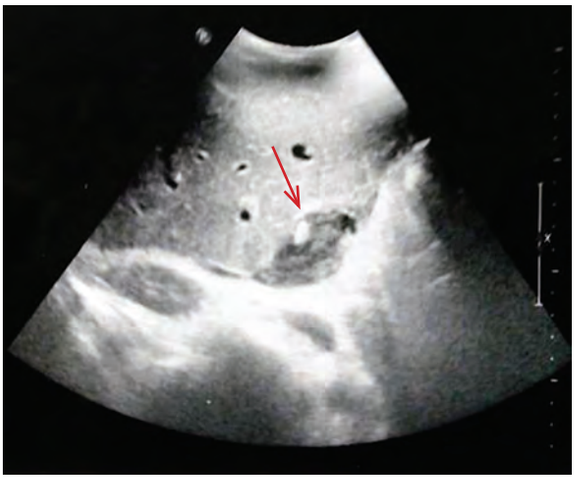

Figure (2): Organized haematoma in a 47 year old female. Gray scale US image obtained on the first day after LT shows organized collection (haematoma) at the raw surface of the graft.

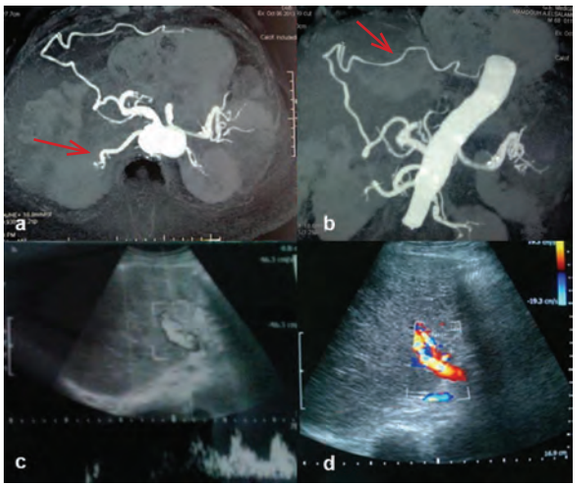

Figure (3): Shooting liver enzymes with increased serum lactate in the second day after LT in a 53 years old male. A and B: 3 D CT MIP showing abrupt occlusion of hepatic artery at the surgical anastomosis (arrow). C: Pulsed Doppler and D: Color Doppler showing patent hepatic artery after removal of thrombectomy.

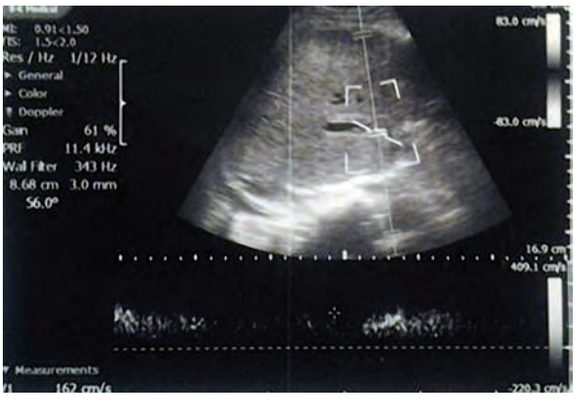

Figure (4): Increased portal venous flow in a 56 years old male patient. Pulsed Doppler US obtained on the third day after LT shows increased portal venous velocity (162 cm/ sec) due to presence of persistence portal hypertension before the surgery.

what is known as 7th day syndrome in which the portal flow showed abrupt sharp decrease in day 7 reaching to less than 5 cm/s and unfortunately both patients died in day 8 and day 9. They showed shooting levels in SGOT and SGPT as well as bilirubin and INR.

We also had one patient (2.7%) who presented with slowliness of portal flow at day 7 reaching 18 cm/s with shooting levels of SGOT, SGPT and bilirubin. CT was done because Doppler US alone could not explain the laboratory abnormalities and it showed a non-enhancing wedge shaped area around a patent right hepatic vein. This area was a venous infarct that occurred despite patency of the right hepatic vein due to the small size of the graft. The patient died on day 9 **Figure (5)**.

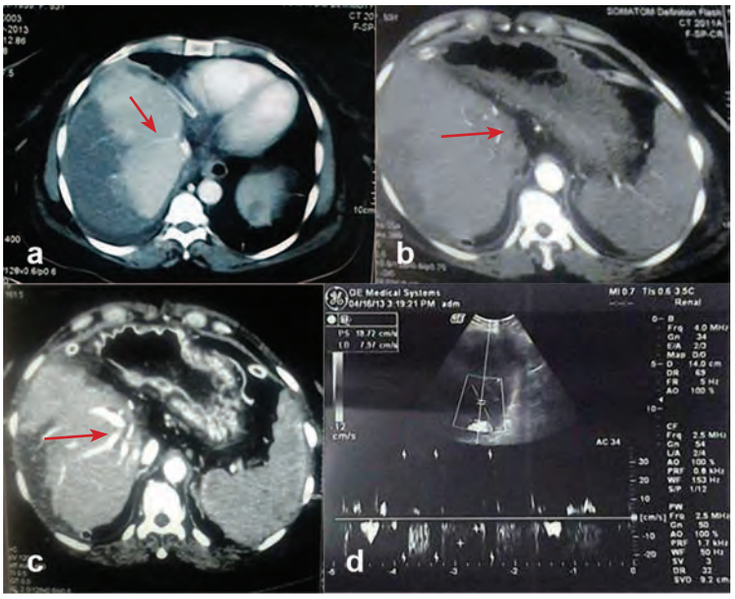

Figure (5): Shooting liver enzymes with increased serum bilirubin in day 7 after LT in a 48 years old female patient. A: CT scan shows a wedge shaped infarction oriented around a patent right hepatic vein (arrow).B: CT scan shows patent graft artery (arrow), C: CT Shows patent portal vein (arrow), D: Pulsed Doppler study of the right hepatic vein showing its patency with triphasic flow.

Table (1): Patient's clinical presentation before liver transplantation.

Patient's clinical presentation	Number	Percentage
End stage liver disease	27	75%
Hepatocellular carcinoma	9	25%

Table (2): Summary of ultrasonographic manifestations and the result of the patient's follow up.

US findings	Number	Percentage	Sequence
Congested segment	5	13.8%	Recovered
Raw surface collection	12	33.3%	Recovered
Free peritoneal fluid	15	41.6	Recoverd
Right sided pleural effusion	18	50%	Recoverd

Table (3): Summary of Doppler manifestations and the result of the patient's follow up.

Doppler findings	Number	Percentage	Sequence
Occluded hepatic artery	1	2.7%	Explored and patency regained
Increased portal vein velocity	30	83.3%	Recovered
Decreased portal velocity	3	8.2%	Died

Discussion:

Angiography is the standard of reference for exploration in the assessment of hepatic vessels patency; it is an invasive technique and requires intravenous administration of iodinated contrast, increasing the risk of renal function impairment, which is frequent during the early postoperative period in liver

transplanted patients.[3] DUS is the screening technique preferably used in the transplanted liver as it is a noninvasive procedure and very usefulness in the assessment of hepatic vessels patency.[4]

Routine gray-scale US of the transplanted liver is performed before detailed vascular Doppler US. It is fairly common for the effects of reperfusion edema and fluid stasis in the extracellular compartments to manifest as the so-called starry-sky appearance of reperfusion hepatic edema, which is characterized by visible portal venules and diminished parenchymal echogenicity that accentuate the portal venule walls. Other common gray-scale US findings include variable amounts of perihepatic hematoma, small fluid collections, and sympathetic right pleural effusion.[1] In our patient population, 5 cases (13.8%) with segmental venous congestion presented with hyperechoic segments and had increased levels of SGOT and SGPT in the first week. 12 cases (33.3%) showed raw surface collection, 15 cases (41.6%) presented with free peritoneal fluid and 18 cases (50%) had right pleural effusion.

Angeles García-Criado et al,[4] have performed DUS routinely in the first 3 days after OLT in all patients who have had liver transplants. In this early period it is common to detect a high RI (>0.8) that becomes normal a few days after transplantation if there are no abnormalities in the hepatic artery. Transient increased arterial resistance has been attributed to various causes, such as hepatic arterial spasm; increased portal flow, which inhibits the release of arterial vasodilators; tissue edema; increased cold ischemia time; and an older age in liver donors.[5-7] They had surmised initially that this high resistance would lead to an increased risk of HAT.[4] It has been reported that prompt diagnosis of HAT may be of great significance because retransplantation can be avoided by prompt revascularization.[8-10] Pulsed Doppler sonography is important since blood flow can be demonstrated. Findings indicative of anastomotic stenosis are normal flow proximal to the stenosis, high-velocity flow at the stenosis, and turbulence above the stenosis.[11-12] In our study, we had one patient with occluded hepatic artery in day 3, exploration was done immediately and a thrombus was found in the hepatic artery at the anastomotic site. The thrombus was removed, anastomosis was revised and patency was regained.

Immediately after OLT, reduced portal resistance in the presence of increased splanchnic flow leads to increased portal flow, which manifests as increased portal venous velocity at immediate post-OLT Doppler US. Another cause of increased portal venous velocity in the immediate post-OLT period is transient compression of the pliable portal vein by postoperative edema or fluid. Subsequently, the body adapts, and portal blood flow decreases, with an average decrease in portal venous velocity of 20% over the next few days.[1] In our study, The increased portal vein velocity was detected in 30 patients (83.3%) and was noticed to be the most frequent abnormality seen in the early post-operative period however it declined gradually through the first month.

Portal vein thrombosis (PVT) is a common complication of chronic liver disease with an incidence that varies between 0.6% and 15.8%.[13] In past years, PVT has been taken a contraindication for LT.[14] With improvement of surgical techniques and the use of aggressive approaches have made it possible to overcome PVT during LT, which is currently the only way to cure patients with end-stage liver disease and concurrent PVT[1-14]. Enhancement of post-transplant care made the outcomes of PVT patients very close to those of non-PVT patients.[15] In the present study, we had 7 patients with chronic portal vein thrombosis that was removed during surgery and they had high portal flow in the postoperative period declining gradually to the normal levels during the following weeks. On the other hand we had 2 patients (5.5%) with 7th day syndrome and one patient (2.7%) with small graft size who presented with abrupt decrease of the portal flow. In the latter case, the slowliness of the portal flow appeared at day 7 reaching 18 cm/s with shooting levels of SGOT and

SGPT and serum bilirubin. CT was done because Doppler US alone could not explain the laboratory abnormalities and it showed a non-enhancing wedge shaped area around a patent right hepatic vein. This area was a venous infarct that occurred despite the patency of the right hepatic vein due to the small size of the graft. The patient was lost on day 9. In these 3 patients the portal flow decreased abruptly due to marked increase of the portal flow within the graft and not due to an intraluminal cause.

Due to the limited number of patients and the relative short period of study, we agreed with Wozney et al[16] and Lerut et al[17] that thrombosis of the IVC and stenosis of the IVC anastomoses are rare vascular complications of orthotopic liver transplantation as we were not confronted with these complications. In the contrary, Yi-Ping Jia et al[15] recognize IVC thrombosis in 10 cases out of 284 LT on 5-13 days postoperatively. All were subhepatic IVC thrombosis, with 4 complete and 6 partial thromboses. Recanalization occurred in 9 cases after anticoagulation. One case with partial thrombosis got natural cure after 2 months.

Conclusion:

The early monitoring of graft hemodynamic changes by Doppler ultrasonography is of great importance as most of these changes revert to normal in the first postoperative week, however sharp decrease in arterial or portal flow indicates underlying grave vascular complications, some of them are correctable.

Reference

1- Sanyal R; Lall CG; Lamba R; Verma S; Shah SN; Tirkes T: Orthotopic liver transplantation: Reversible Doppler US findings in the immediate postoperative period. *RadioGraphics* 2012; 32: 199–211.

2- O'leary JG; lepe R; Davis GL: Indication for liver transplantation. *Gastoentrology* 2008; 134(6): 1764–1776.

3- Rimola A; Gavaller J; Schade R; El-Lankany S; Starzl TE; van Thiel DH: Effects of renal impairment on liver transplantation. *Gastroenterology* 1987; 93(1): 148–156.

4- García-Criado A; Gilabert R; Nicolau C; Real I; Arguis P; Bianchi L; et al: Early detection of hepatic artery thrombosis after liver transplantation by Doppler ultrasonography. *J Ultrasound Med* 2001; 20(1): 51–58.

5- Chezmar JL; Nelson RC; Bernardino ME: Portal venous gas after hepatic transplantation: Sonographic detection and clinical significance. *AJR Am J Roentgenol* 1989; 153(6): 1203–1205.

6- Chen W; Facciuto ME; Rocca JP; Marvin MR; Sheiner PA; Rachlin S; et al: Doppler ultrasonographic findings on hepatic arterial vasospasm early after liver transplantation. *J Ultrasound Med* 2006; 25(5): 631–638.

7- Sanyal R; Shah SN: Role of imaging in the management of splenic artery steal syndrome. *J Ultrasound Med* 2009; 28(4): 471–477.

8- Sheiner PA; Varma CVR; Guarrera JV; Garratti M; Emre S; Guy SR; et al: Selective revascularization of hepatic artery thromboses after liver transplantation improves patient and graft survival. *Transplantation* 1997; 64(9): 1295–1299.

9- Pinna AD; Smith CV; Furukawa H; Starzl TE; Fung JJ: Urgent revascularization of liver allografts after early hepatic artery thrombosis. *Transplantation* 1996; 62(11): 1584–1587.

10- Langnas AN; Marujo W; Stratta RJ; Wood RP; Shaw BW: Hepatic allograft rescue following arterial thrombosis: role of urgent revascularization. *Transplantation* 1991; 51(1): 86–90.

11- Longley DC; Skolnick ML; Zajko AB; Bron KM: Pictorial essay: Duplex Doppler sonography in the evaluation of adult patients before and after liver transplantation. *AJR* 1988; 151: 687–696.

12- Taylor KJW; Morse SS; Weltin GG; Riely CA; Flye MW: Liver transplant recipients: Portable Duplex US with correlative angiography. *Radiology* 1986; 159(2): 357–363.

13- Wu1 TH; Lin YS; Lee CF; Wu TJ; Yu MC; Chan KM; et al: Clinical analysis and strategy for liver transplantation in patients with pre-existing portal vein thrombosis. *Chang Gung Med J* 2011; 34(4): 426–433.

14- Langnas AN; Marujo WC; Stratta RJ; Wood RP; Ranjan D; Ozaki C; et al: A selective approach to preexisting portal vein thrombosis in patients undergoing liver transplantation. *Am J Surg* 1992; 163(1): c132–136.

15- Jia YP; Lu Q; Gong S; Ma BY; Wen XR; Peng YL; et al: Postoperative complications in patients with portal vein thrombosis after liver transplantation: Evaluation with Doppler ultrasonography. *World J Gastroenterol* 2007; 14; 13(34): 4636–3640.
16- Wozney P; Zajko AB; Bron KM; Point S; Starzl TE: Vascular complications after liver transplantation: a 5-year experience. *AJR* 1986; 147(4): 657–663.
17- Lerut J; Tzakis AG; Bron K; Gordon RD; Iwatsuki S; Esquivel CO; et al: Complications of venous reconstruction in human orthotopic liver transplantation. *Ann Surg* 1987; 205(4): 404–414.