15 Radiology of the Normal Transplanted Liver

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15.1 Introduction

Over recent years, progress in ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) has contributed significantly to improved and less invasive assessment of vascular, biliary, and parenchymal complications after liver transplantation. Thus, diagnostic control and regular follow-up of patients with a normal liver transplant are based on noninvasive approaches, i.e., ultrasound and color Doppler ultrasound (CDUS), and, where T-tubes are used for biliary reconstruction, on T-tube cholangiography 9 and 14 days after liver transplantation. In addition, spiral CT and MRI should be employed when US is inconclusive. In this context, more recent approaches, including CT angiography, MR angiography, and MR cholangiography (MRC), have been demonstrated to have excellent potential in the identification of vascular and biliary complications, and may help in the planning of further diagnostic and therapeutic measures (Reinhold et al. 1995; Wallner et al. 1991; Vogl et al. 1998). This chapter will summarize currently available diagnostic imaging modalities and discuss characteristic findings of the normal transplanted liver on CDUS, T-tube cholangiography, spiral CT, MRI, MRC, and invasive digital subtraction angiography (Bismuth et al. 1988; Fleischmann et al. 1996; Reuther et al. 1996; Robledo et al. 1996; Sheng et al. 1996).

15.2 Imaging Modalities: Indications and Limitations

15.2.1 Ultrasound and Color Doppler Ultrasound

Ultrasound is the noninvasive imaging method of choice to document regular liver graft function, and to assess complications after liver transplantation. The liver can best be imaged with the patient in the supine position. The initial B-mode examination allows the assessment of both hepatic parenchymal or biliary abnormalities and intra-abdominal fluid collections. In addition, patency of the hepatic artery, portal vein, and hepatic veins must be documented. Evidence of parenchymal infarcts, intrahepatic bilomas, or multifocal biliary dilatation should give rise to suspicion of hepatic graft dysfunction due to hepatic artery thrombosis. The examination should be started employing 3- to 5-MHz curved linear or linear array transducers, and sector transducers should be used for areas inaccessible to other transducers.

Additional CDUS is the primary screening method for postinterventional vascular complications, including arterial stenoses or thromboses and venous thromboses of the liver. Normally, CDUS examinations should be performed with the patient in the supine and right anterior oblique position using 2- to 5-MHz curved linear or linear array transducers. By this means, the flow in the main and intrahepatic portal veins and in the hepatic artery and hepatic
veins is assessed. For vascular CDUS examinations, a region of interest box is positioned over the corresponding area. Based on a magnified image, the Doppler is employed, and one should start the examination with scan parameters set for highest sensitivity, i.e., relatively low frequency (2 or 3 MHz), low filter, low pulse repetition frequency, and low scanning angle. For documentation of the hepatic artery, a small gate must be used to exclude misleading signals from the portal vein.

**15.2.1.1 Portal Vein**

The extrahepatic part of the main portal vein is usually 8-10 cm long. Its diameter shows wide interindividual variation, from 8 to 14 mm. The intrahepatic part frequently contains two main portal branches, the right and the left; however, partition into three main portal branches is observed in a minority of patients.

For CDUS, initially a magnified region of interest is placed over the porta hepatis; subsequently, the Doppler system is applied to identify the flow in the main portal vein. The normal blood flow in the portal vein is directed towards the liver with insignificant cardiac and respiratory modulation (Fig. 15.1). The flow velocity for the portal vein is usually between 15 and 25 cm/s. However, it displays considerable variability; thus, a postprandial velocity of up to 50 cm/s may be normal.

**15.2.1.2 Hepatic Artery**

The hepatic artery can be identified along its course in the direct vicinity of the portal vein. The examination should be started in the area of the porta hepatis. After magnification of the region of interest, the hepatic artery can be identified by its characteristic arterial signal. If no signal can be obtained in the porta hepatis, the procedure is repeated along the main right and left portal branches. Figure 15.2 demonstrates a characteristic flow profile of the hepatic artery with positive diastolic flow; however, in a previous study, Propeck and Scanlan (1992) evaluated the diastolic flow pattern 1 day after liver transplantation in 160 patients and observed no significant difference in the subsequent frequency of hepatic artery thrombosis between patients who presented with and those who presented without an initial reversed diastolic flow pattern. Evaluation of velocities depends on the angle of insonation, and resistive indices (RI) may vary owing to a variety of factors, including cardiac output, surgical technique of anastomosis, and quality of the hepatic artery and celiac artery. Therefore, RI usually has little impact on establishing the diagnosis of hepatic artery thrombosis. In patients with clinical evidence of hepatic artery thrombosis and inconclusive CDUS results, further diagnostic measures, including CT angiography or angiography, are warranted (Nolten and Sproat 1996).

**15.2.1.3 Hepatic Vein**

The initial B-mode US demonstrates the hepatic veins with a hypoechoic signal character, which can be followed by a harmonic decline from the periphery towards the inferior vena cava. The hepatic veins usually consist of three main intrahepatic veins (left, middle, and right hepatic veins); however, certain variants, including more than three main hepatic veins or a missing middle hepatic vein, may be observed. Although hepatic vein thrombosis following orthotopic liver transplantation is a rare event, additional CDUS is mandatory to confirm the regular flow direction, and frequency analysis characteristically exhibits two peaks corresponding to a minor reflux during atrial contraction (Fig. 15.3).