Clinical Utility of Hepatic-Perfusion Computerized Tomography in Living-Donor Liver Transplantation: A Preliminary Study

M. Kantarci[a,*], B. Pirimoglu[a], G. Ozturk[b], B. Aydinli[b], H. Ogul[a], A. Okur[c], Y. Kizrak[a], O. Ozyigit[a], and M. Celik[d]

[a]Department of Radiology, School of Medicine, Atatürk University, Erzurum, Turkey; [b]Department of General Surgery, School of Medicine, Atatürk University, Erzurum, Turkey; [c]Department of Radiology, Yozgat, School of Medicine, Bozok University, Bozok, Turkey; and [d]Department of Anesthesiology and Reanimation, School of Medicine, Atatürk University, Erzurum, Turkey

ABSTRACT

Background. Vascular complications are a primary diagnostic consideration in liver transplant recipients, with an overall incidence of 9%. Cross-sectional imaging techniques provide information regarding vascular structure and luminal patency but can not quantitatively assess hepatocyte damage in the liver graft parenchyma. Perfusion computerized tomography (CT) is a recently developed method that allows for quantitative evaluation of hemodynamic changes in tissue. Our objective was to evaluate the clinical utility of perfusion CT in assessing vascular complications during living-donor liver transplantation (LDLT).

Methods. The 33 recipients were divided into 3 groups according to Doppler ultrasonographic findings: hepatic arterial complication group, portal venous complication group, and hepatic venous complication group. Blood volume (BV), blood flow (BF), arterial liver perfusion (ALP), portal venous perfusion (PVP), and hepatic perfusion index (HPI) were calculated for the affected vascular territory regions.

Results. Compared with normal liver parenchyma, BV, BF, ALP, and HPI were significantly lower in the hepatic arterial complication group. Although PVP and BV were significantly lower, ALP, HPI, and BF were higher in the affected vascular territory region than in normal liver parenchyma for the portal venous complication group. In the hepatic venous complication group, PVP was significantly higher and BF, ALP, and HPI significantly lower in the affected vascular territory regions than in normal liver parenchyma.

Conclusions. Perfusion CT imaging is a noninvasive technique that enables the quantitative evaluation of vascular complications in the graft parenchyma after LDLT and permits a quantitative evaluation of the treatment response.

LIVING-DONOR LIVER TRANSPLANTATION (LDLT) has become the treatment of choice for patients with end-stage acute or chronic hepatic disease [1–4]. Vascular complications are a primary diagnostic consideration in liver transplant recipients, with an overall incidence of 9% [4,5]. Doppler ultrasonography (US) is the preferred postoperative screening method to evaluate vascular complications because it is readily accessible, noninvasive, and easily performed at the bedside. However, Doppler US can not directly measure the blood inflow in the hepatic parenchyma itself. It can measure the inflow velocity only in large feeding vessels [6]. The method is also operator dependent with well known inherent limitations [7–9]. Cross-sectional imaging methods, such as computerized tomography (CT) and magnetic resonance imaging (MRI) have a greater overall sensitivity and specificity than Doppler US. However, MRI is not feasible in critically ill patients [10,11]. Furthermore, cross-sectional imaging techniques provide information regarding vascular structure and luminal patency but can not quantitatively assess hepatocyte damage in the liver graft parenchyma [9].

Perfusion CT is a recently developed method that allows for quantitative evaluation of hemodynamic changes in

*Address correspondence to Mecit Kantarci, MD, PhD, 200 Evler Mah, 14, Sok No 5, Dadaskent, Erzurum, Turkey. E-mail: akkanrad@hotmail.com

360 Park Avenue South, New York, NY 10010-1710

0041-1345/15
http://dx.doi.org/10.1016/j.transproceed.2014.11.038

Table 1. The Number of Recipients in Each Subgroup According to the Doppler Ultrasonographic and Computerized Tomographic Findings

	Thrombosis	Stenosis or Partial Occlusion
Hepatic arterial complication group ($n = 15$)	6 (40%)*	9 (60%)*
Portal venous complication group ($n = 10$)	4 (40%)*	6 (60%)*
Hepatic venous complication group ($n = 8$)	3 (37.5%)*	5 (62.5%)*

*Percentage of recipients in each subgroup.

tissue. In acute cerebral ischemia, cerebral-perfusion CT helps to detect the infarct core and the ischemic penumbra [12]. In the abdomen, particularly the liver, perfusion CT imaging also allows for a functional assessment of the perfusion of normal and pathologic tissues via parameters such as blood flow (BF), blood volume (BV), arterial liver perfusion (ALP), portal venous perfusion (PVP), and the hepatic perfusion index (HPI) [13,14]. Studies have also reported that perfusion CT demonstrates quantitative and functional evaluation of the affected areas in the liver graft parenchyma after vascular complications [6].

When vascular complications occur in the liver parenchyma, ischemic and necrotic parenchymal changes appear at the microscopic and macroscopic levels, similarly to what occurs in response to cerebral ischemia [14]. Functionally, the liver parenchyma of the acinus can be divided into 3 zones based on oxygen supply. Zone 1 encircles the portal tracts where oxygenated blood from the hepatic arteries enters, zone 3 is located around the central veins, and zone 2 is located between zones 1 and 3. Zone 1 is located in the periportal area. It is nearest to the entering vascular supply and receives the most oxygenated blood, making it the least sensitive to ischemic injury but making it very susceptible to viral hepatitis. Conversely, the centrilobular zone 3 has the poorest oxygenation and is the most affected during a period of ischemia. Functionally, zone 1 hepatocytes are specialized for oxidative liver functions, such as gluconeogenesis, β-oxidation of fatty acids, and cholesterol synthesis, and zone 3 cells are more important for glycolysis, lipogenesis, and cytochrome P-450–based drug detoxification [15,16]. Perfusion CT imaging is applicable in and valuable for exploring the hepatic hemodynamic perfusion changes in the functional zones of the liver parenchyma [6]. Functional perfusion CT imaging can identify an impaired zone after a vascular complication [17].

Although a few studies have reported on the normal hemodynamic changes of liver grafts [1–4], no studies have investigated the utility of perfusion CT imaging in evaluating vascular complications in LDLT. In the present study, we aimed to evaluate the diagnostic and prognostic value of perfusion CT in detecting vascular complications in liver grafts. To our knowledge, this was the first study to use perfusion CT imaging to assess vascular complications after LDLT.

MATERIALS AND METHODS

Patients

This prospective study was conducted from August 2012 to March 2014. Institutional Review Board approval was received, and every patient gave written informed consent. Thirty-nine right-lobe liver graft transplant recipients (21 men and 18 women; mean age, 53 ± 7.4 years; age range, 43–68 years) who had undergone transplantation in our hospital or outside institutions were referred to the diagnostic radiology department for further evaluation of vascular complications diagnosed by means of Doppler US, including thrombosis and/or stenosis of the hepatic artery or portal or hepatic veins (Table 1), and clinical and laboratory findings (including jaundice, pruritus, abdominal pain, and elevated total and direct bilirubin, alkaline phosphatase, and gamma-glutamyl transpeptidase levels). Six patients were excluded based on previous hypersensitivity to contrast media ($n = 2$), reduced glomerular filtration rate (<60 mL/min/1.73 m^2, $n = 3$), or excessive movement during the perfusion imaging ($n = 1$). The

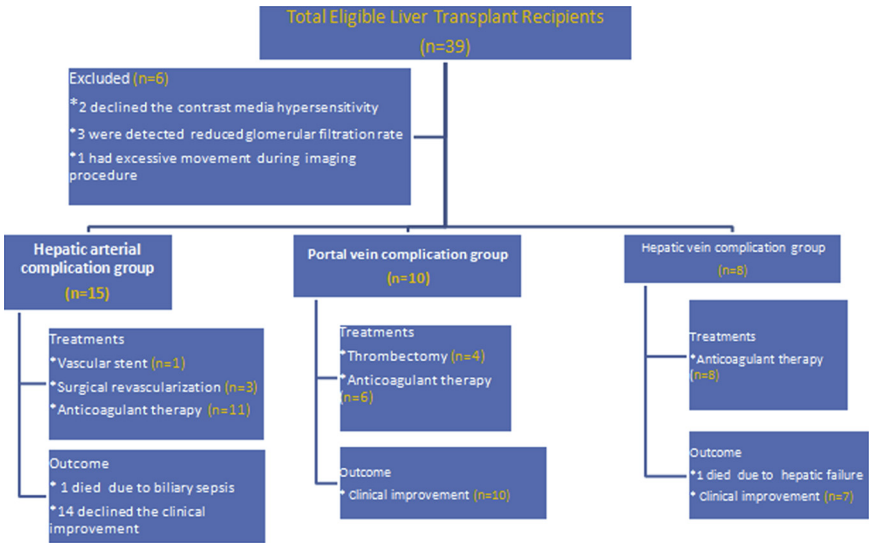

Fig 1. The flow diagram of our study.