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Editorial

Clinical implication of hepatic volumetry for living donor liver transplantation

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See Article on Page 54

Liver transplantation is indicated for primary and salvage treatment of hepatic malignancies including hepatocellular carcinoma (HCC) and hepatic epithelioid hemangioendothelioma, end-stage liver diseases, acute liver failure, and congenital anatomical and metabolic liver diseases such as biliary atresia, Wilson's disease and hemochromatosis.[1] Living donor liver transplantation (LDLT) is more widely practiced in many Asian countries, rather than in Europe and the US, due to shortage of donors who have suffered brain death. In Korea, 75.4% of LT by 2016 was LDLT.[2] Pre-operative hepatic volumetry by using multi-detector row computed tomography (CT) or magnetic resonance imaging (MRI) is one of the most important step during the planning of LDLT[3] because hepatic reservoir after surgery could be estimated by the hepatic volumetry, which is an important factor for donor's and recipient's recovery after surgery.[4,5]

If the graft size is too small, and mismatched compared with the recipient's size, it is called as "small-for-size-graft (SFSG)". In that situation, even the small graft could be well adapted, but some recipient could have symptoms related to the graft size.[6] SFSG dysfunction was defined as 'dysfunction of a small partial liver graft during the first postoperative week after the exclusion of other causes'.[7] It means that the transplanted partial liver cannot satisfy metabolic demand of the recipient or can be prone to congest by excessive portal inflow before regeneration of the graft, and results in irreversible graft failure and death of the patient if there is no available organ for re-transplantation. In the general setting of LDLT, the graft volume of less than 40–50% of standardized liver volume (SLV), corresponding to a graft to recipient weight ratio (GRWR) of 0.8–1.0% could be associated with worse outcome.[8] The mechanism of SFSG syndrome is not clear. It could be related to the shortage of parenchymal cell mass required to metabolize, and persistent elevation of portal venous pressure which causes hyperperfusion graft injury.[6] SFSG get the entire volume of portal flow, and lead to higher portal pressure due to increased portal resistance.[9] Moreover, as the cirrhotic recipients demonstrate higher portal flow than normal subjects, this recipients' hemodynamics

Abbreviations:

CT, computed tomography; GRWR, graft to recipient weight ratio; HCC, hepatocellular carcinoma; LDLT, Living donor liver transplantation; MRI, magnetic resonance imaging; SFSG, small-for-size-graft, SLV, standardized liver volume

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with excessive portal flow is also important in the setting of partial transplantation. This situation can result in endothelial injury of hepatic sinusoids and damage of hepatocytes. According to the human study for SFSG syndrome, 80% of patients who had a graft volume of less than 40% of SLV showed the morphological hallmarks, accompanied by gaps in the sinusoidal endothelial lining and mitochondrial swelling as well as vacuolar changes in hepatocytes on electron microscopy.[10]

Especially, hepatic steatosis is spreading gradually and it is an important risk factor for post-operative complications after major hepatectomy and LDLT.[7,11] Though the precise effect of hepatic steatosis on graft function has not been understood yet, it is prudent to aim for a larger hepatic volume when considering using the partial liver with steatosis because the immediate functional capacity of the graft is important to tolerate the recipient.

As mentioned previously, hepatic reservoir is important to recover from post-operative state, and almost all transplantation centers measure the hepatic volume using pre-operative imaging studies. CT volumetry was first performed with cadaveric experiment in 1979, and the accuracy was higher than 95%.[12] The conventional method of segmentation for hepatic volumetry uses the anatomic landmarks according to Couinaud classification[13]: the imaginary plane between middle hepatic vein and the fossa for gallbladder divides into both hemilivers, and middle hepatic vein and its tributaries to segment IV are not included in the graft because they should be remained at operation for donor safety.

Kwon, et al. performed the hepatic volumetry using pre- and post-operative CT imaging data, and addressed that there was about 5% of discrepancy between the estimated volume measured by conventional method which divides as the anatomic landmark (prospective volumetry on pre-operative CT) and the volume of the graft measured after transplantation (retrospective volumetry on post-operative CT), and about 10% error between prospective volume and the weight of graft measured at operation.[14] It suggests the pre-operative volumetry could be overestimated compared with the weight of procured graft, and it is caused by the blood volume circulating in the large hepatic vessels.

These errors should be handled with caution, especially in the recipient with SFSG. The authors raised the issue which should be considered at pre-operative stage. As solutions to compensate, they mentioned applying an accurate conversion factor and computer-aided liver volumetry that can assess the bloodless liver volume.[15] In addition, the author highlighted that experienced operator should perform the volumetry to reduce the amount of error. The knowledge about hepatic anatomy and the communication to the surgeon are still necessary for accurate measurement.

Recent volumetric technique has been improved by various segmentation techniques with 3D-image data, such as manual segmentation with assisted contouring and assisted in-painting technique, intensity-based semi-automatic segmentation, graph-cut technique, and fully automated segmentation using statistical shape models and 3-D deformable models.[3] These novel techniques will provide the accurate and fast result of volumetry to the surgeons in the near future.

Conflicts of Interest

The authors have no conflicts to disclose.

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