Liver and Spleen Change in the Living Related Liver Donation


Due to the difficulty of obtaining organs from cadavers, living-related liver transplantation (LRLT) has been utilized for compatible children and adults with end-stage liver disease.1,2 The operation involves removal of left lateral segments (S2, S3), extend left lateral segment (S2, S3, and medial part of S4), left lobe (S2, S3, and S4), or right lobe of the liver without endangering the function of the remaining liver. After partial hepatectomy, liver regeneration leads to restoration of liver function. On follow-up computed abdominal tomography (CT), we noted spleen volume changes in the donors after operation, a finding which has not been mentioned in the previous literature. The purpose of this study was to evaluate liver regeneration and spleen volume changes in donors after LRLT using CT volumetry.

Materials and Methods

During a 7-year period, from December 1993 to November 2000, 53 donors underwent preoperative evaluation for LRLT. These 20 men and 33 women were aged 22 to 53 years (mean 32.98 ± 6.81) with a body weight of 44 to 89 kg (mean 60.37 ± 10.61 kg). The potential candidates underwent abdominal CT as a part of the pretransplantation survey. Measurement of the sizes of the spleen, whole liver, and graft was made using helical CT scanning of 10-mm slices from the dome of the liver to the most inferior part of the organ, with enhancement by an IV bolus injection of contrast medium. By using the mouse ball device, the area of the spleen (S2), whole liver volume (LV), left lateral segment (S2, S3), medial segment (S4), and right liver of each slice was outlined manually. A workstation computer calculated the enclosed areas. Using the slice thickness 10 mm, the summation of the areas was equal to the volume and the weight. The specific gravity of the normal liver is about 1.0, so that the volume is similar to the weight. We weighed the harvested graft (G) after resection. The regenerated liver remnants (LV6M) and spleen (S2) were calculated with the same method via CT performed 6 months after graft harvest. The 53 donors were divided into four groups according to the operative methods: those who donated a left lateral segmentectomy (group LLS; S2, S3; n = 17), an extended left lateral segmentectomy (group ELLS; S2, S3, medial part of S4; n = 23), a left lobectomy (group LL; S2, S3, S4; n = 3), or a right lobectomy (group RL; S5, S6, S7, S8; n = 10). We compared the mean ratio of recovery (or restoration) liver volume (LV6M/LV), graft weight (G), the mean ratio of graft to liver volume (G/LV), the mean ratio of liver regeneration (LV6M/LV-G), and the spleen hypertrophy ratio (S2/S1).

Results

The mean ratio of recovery (restoration) liver volume (LV6M/LV) was 95.0 ± 15.2% (Gr. LLS), 96.0 ± 16.7% (Gr. ELLS), 103.0 ± 17.5% (Gr. LL), and 96 ± 14% (Gr. RL), respectively. The mean ratio of recovery liver volume was not different between the four groups. The graft weight (G) was 279.3 ± 52.5 g (Gr. LLS), 279.3 ± 52.5 g (Gr. ELLS), 355.7 ± 29.4 g (Gr. LL), and 741.6 ± 71.4 g (Gr. RL) (*, P < .05). The mean ratio of graft to liver volume (G/LV) was 24.5 ± 3.5% (Gr. LLS), 26.4 ± 4.6% (Gr. ELLS), 32.4 ± 5.6% (Gr. LL), and 61.1 ± 10%* (Gr. RL). The mean ratio of liver regeneration (LV6M/LV-G) was 126.4 ± 23.9% (Gr. LLS), 131.1 ± 26.5% (Gr. ELLS), 154.3 ± 36.7% (Gr. LL), and 293.9 ± 156.1%* (Gr. RL). The spleen hypertrophy ratio (S2/S1) was 1.07 ± 0.17% (Gr. LLS), 1.14 ± 0.21% (Gr. ELLS), 1.28 ± 0.04% (Gr. LL), and 1.98 ± 0.84%* (Gr. RL). The graft weight (G), mean ratio of graft to liver volume (G/LV), mean ratio of liver regeneration (LV6M/LV-G), and spleen hypertrophy ratio (S2/S1) were significantly different between the right lobectomy (group RL) and the left hepatectomy (groups LLS, ELLS, and LL group), but there was no difference between the three left hepatectomy groups.

Discussion

Liver regeneration has been reported for hepatectomy after hepatocellular carcinoma, metastatic liver tumor, or liver trauma. Although livers with benign disease, such hepatolithiasis or traumatic injury, have been regarded to be almost normal functionally and anatomically, there may be certain pathologic factors that have already induced altered hemodynamics or vasculature at the time of liver resection.3 The liver of the donor for LRLT has been shown to be normal. Restoration of liver volume and associated changes

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in these healthy donors after graft harvest has been investigated.\textsuperscript{4} It has been reported that liver regeneration terminates after the liver achieves 75\% to 95\% of its original weight. There might be a certain redundancy of liver mass that would account for why regeneration halts before full recovery of the pretransplant volume.\textsuperscript{5} In our series, the mean ratio of recovery (or restoration) liver volume ($L_{V6M}/LV$) was not different between the four types of hepatectomy, i.e. independent of the size of the liver remnants. Nakagami et al.\textsuperscript{4} also reported that the same degree of liver volume restoration occurred at 28 days postoperatively in patients undergoing left lateral segmentectomy or left lobectomy. In the left hepatectomy groups, the remaining right lobes of liver with or without the medial segment, show no difference in the mean ratio of liver regeneration ($L_{V6M}/LV-G$), but there are significant differences compared with the right lobectomy group (only the left lobe of liver remains). Because more graft weight is harvested with less remnant in the right lobectomy procedure, the remnant left lobe of liver has to regenerate more liver mass to compensate for the functional demands; therefore the regeneration ratio is proportional to the amount of resection. Whereas in the recipient the left lateral segment graft has a more rapid growth ratio than the medial segment.\textsuperscript{6} The transplanted liver in the recipient regenerated much faster than the remnant liver in the donor, even though both consisted of genetically the same hepatocytes, which suggests that regeneration is regulated mainly by factors other than the hepatocytes themselves.\textsuperscript{7} In a review of the follow-up CT images, we noted an interesting phenomenon: The volume of the spleen displayed significant hypertrophy in the right lobectomy group. There was no difference between the different left hepatectomy group. Both the recovery liver volume ratio and the spleen hypertrophy ratio showed significant differences between the right lobectomy and the left hepatectomy groups: we postulate that common factors affect both left liver lobe regeneration and splenic hypertrophy.

**CONCLUSION**

After graft harvest from healthy liver donors, the remnant livers restore their volumes with no significant differences between the different methods of hepatectomy. There is a greater liver regeneration ratio after right than left hepatectomy. The splenic hypertrophy changes may be proportional to the size of the hepatectomy; more after right hepatectomy than after left, but some independent factors may affect both the left lobe of liver regeneration and splenic hypertrophy.

**REFERENCES**