Liver resection is the first line treatment for both primary liver cancer and selected liver metastases. However, this is mainly limited by inadequate volume and function of the future liver remnant (FLR), which determine whether liver resection is safe or not. The adequate volume of FLR is generally considered as more than 30% in a normal liver, whereas 40% or greater in the condition of chemotherapy-related injury or cirrhosis(1). Several strategies have been developed to induce compensatory hypertrophy of the FLR, which results in increasing the chance of resectability and decreasing the risk of postoperative liver failure. Herein, we review two procedures for two-stage approach with extended hepatectomy including portal vein occlusion and associating liver partition with portal vein ligation.

**Portal vein occlusion (PVO)**

Portal vein ligation (PLV) was first clinically implemented in 1975. PVL has been routinely used in two-stage hepatectomy. Resection of metastases in the FLR is sometimes performed along the PLV during the first hepatectomy. Portal vein embolization (PVE), by injecting embolizing agents in one of the portal branches, was introduced in the late 1980s. The hypertrophy of the FLR after PVL and PVE showed controversial results from several studies, however a recent meta-analysis demonstrated comparable increase in the volume of the FLR(2). PLV requires the dissection of the liver hilum and operative ligation of the portal vein, which may increase the difficulty of the second operation due to the adhesion of the liver hilum. A recent meta-analysis showed that the morbidity and mortality rates after liver resection is similar between the 2 techniques(2). The benefit of PVL is that it allows resection of metastases in the FLR. Therefore, PVL may be a preferred option in patients with synchronous colorectal cancer and multiple, bilateral liver metastases requiring a two-stage hepatectomy. PVE should be considered in patients that have the only insufficient volume of the FLR. The main problem of these two techniques is the potential drop-out of up to 35% of patients due to either insufficient liver hypertrophy of the FLR or tumor progress between PVO and the second liver resection.(3)

**Associating liver partition with portal vein ligation for staged hepatectomy (ALPPS)**

ALPPS is a novel technique of two-stage hepatectomy, combining PLV and transection of the liver between the FLR and the deportalized part of the liver. It was first performed in 2007 by Dr. Hans Schlitt from Regensburg, Germany in a patient with hilar cholangiocarcinoma. ALPPS, which was named by de Santibanes and Clavien in 2012, has adapted by many centers around the world.(4)

ALPPS has been reported to induce hypertrophy of the FLR of up to 80% in a shorter time than PVO. However, it seems to accompany with increased surgical morbidity and mortality rates of up to 40% and 15%, respectively.(5)
Comparison between PVO and ALPPS

A recent meta-analysis including nine studies reported on comparisons with PVO demonstrated that ALPPS was associated with a greater increase in the FLR (76 versus 37 %; P<0.001) and more completion of the second stage (100 versus 77 %; p<0.001). However, ALPPS showed a trend toward higher morbidity (73 versus 59%; p=0.16) and mortality (14 versus 7 %; p=0.19) after the second stage compared with PVE.(4)

As for the hypertrophy of the FLR, Shindoh et al showed a comparable increase in the FLR after the ALPPS procedure and PVE with segment IV embolization(5). Even though spillage of embolizing material in the FLR during segment IV embolization might comprise completion of the second step, more prospective studies about the hypertrophy of the FLR between ALPPS and a right liver plus segment IV PVE should be performed.

Conclusions

PVL and PVE result in comparable increase in FLR with similar morbidity and mortality rates. ALPPS is associated with greater future liver remnant hypertrophy and a higher rate of completion of the second stage, but has a trend of higher morbidity and mortality rates. Until now, the recommendations regarding ALPPS versus PVE or PVL are less clear, and ALPPS was defined only as a viable alternative to PVE or PVL. A future study is required to support the superiority of one strategy over the other.

References