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# Verification of Inferior Right Hepatic Vein–Conserving Segments 7 to 8 Resection of the Liver

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**This study aims to investigate the safety of inferior right hepatic vein (IRHV)–conserving surgery by comparing the surgical data and postoperative complications between IRHV-conserving segments 7 to 8 (S7 to S8) resection and conventional right hemihepatectomy (RH). Five patients who underwent IRHV-conserving S7 to S8 segmentectomy between 2007 and 2011 (IRHV group) and 25 liver cancer patients who underwent RH without biliary tract reconstruction during the same period (RH group) were investigated. The surgical data, postoperative complications, and duration of hospital stay were compared. The IRHV and RH groups included 2 (40%) and 13 (52%) hepatocellular carcinoma patients, respectively. There were no significant differences in liver function before surgery between the groups. The presence of the IRHV did not adversely affect the processing of the short hepatic vein or frontal dissection of the inferior vena cava. The operative time was shorter (median, 366 minutes versus 501 minutes; $P = 0.0001$), the postoperative bilirubin level was lower (12 mg/dL versus 1.8 mg/dL; $P = 0.037$), and the duration of hospital stay was shorter (10 days versus 14 days; $P = 0.002$) in the IRHV group. No significant differences were noted in the intraoperative blood loss, postoperative transaminase levels, or the incidence of severe complications (Clavien grade IIIb or higher) between the groups. IRHV-conserving resection of the liver is a safe surgical procedure that is useful in preventing postoperative elevation of bilirubin level and in shortening the duration of hospital stay.**

*Key words:* Inferior right hepatic vein – Liver resection – Segmentectomy – 3D-CT

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*Table 1 Baseline characteristics of patients undergoing IRHV-conserved or nonconserved liver resection*

| Parameters | IRHV group (n = 5) | RH group (n = 25) | *P* |
|---|---|---|---|
| Age, y (range) | 64 (61–76) | 65 (37–79) | 0.589 |
| Male sex, n (%) | 4 (80) | 17 (68) | 0.593 |
| HBs antigen$^+$, n (%) | 0 | 5 (20) | 0.273 |
| HCV antibody$^+$, n (%) | 0 | 3 (12) | 0.414 |
| Diagnosis, n (%) | | | 0.210 |
| Hepatocellular carcinoma | 2 (40) | 13 (52) | |
| Cholangiocellular carcinoma | 0 | 6 (24) | |
| Colorectal metastasis | 3 (60) | 6 (24) | |
| Preoperative laboratory data | | | |
| Total bilirubin, mg/dL (range) | 0.58 (0.45–0.73) | 0.58 (0.27–1.24) | 0.957 |
| Albumin, g/dL (range) | 4.0 (3.9–4.2) | 4.0 (3.0–4.4) | 0.416 |
| Prothrombin time, % | 100 | 95 (62–100) | 0.059 |
| ICG-R15, % (range) | 9.9 (6.0–21.1) | 11.4 (2–25.1) | 0.448 |
| Child-Pugh class, A:B | 5:0 | 24:1 | 0.472 |
| Preoperative volumetry[a] | | | |
| Right lobe, mL (range) | 696 (430–1086) | 453 (190–900) | 0.057 |
| Perfused area of IRHV, mL (range) | 474 (417–659) | 0 | |
| Perfused area of RHV, mL (range) | 260 (160–427) | 450 (190–910) | |
| Left lobe, mL (range) | 557 (339–572) | 537 (311–754) | 0.787 |

HBs, hepatitis B surface; HCV, hepatitis C virus; ICG-R15, indocyanine green retention rate at 15 minutes; IRHV, IRHV-conserved S7 to S8 resection; RH, right lobe hemihepatectomy.

[a]Liver volumetry does not include tumor volume.

Liver resection is the most effective and radical treatment for hepatocellular carcinoma and metastatic liver cancer.[1,2] When performing radical and safe liver resection, it is necessary to secure a sufficient surgical margin[3] and set the resection range in consideration of the residual liver volume to preserve liver function.[4,5] In order to ensure the liver volume remains sufficient to prevent postoperative liver failure, the surgical procedure is frequently selected based on evaluation of liver function through assessment of the retention of indocyanine green after 15 minutes (ICGR15 test).[6]

For cancer with hepatocaval confluence involving the right hepatic vein, although right hemihepatectomy [RH; resection of liver segments 5 + 6 + 7 + 8 (S5+ S6 + S7 + S8)] or vascular reconstruction is generally selected,[7,8] liver resection conserving the caudal region of the right lobe (S5 and S6) is considered an option for patients with an inferior right hepatic vein (IRHV).[9] Makuuchi *et al*[10] proposed 4 surgical procedures for IRHV-conserving liver resection. Various researchers have described IRHV-conserving surgery, in which they reported that the technique to expose blood vessels around the inferior vena cava is complex and may have an associated risk.[11–14] However, in our experience, the blood vessels may be exposed safely—similar to the exposure applied in the series of liver mobilization techniques accompanying conventional RH—by securing a visual field in which the right wall of the inferior vena cava is observed directly by applying thoracolaparotomy.[15] In addition, it has not been fully evaluated whether IRHV-conserving liver resection is as complex as previously reported. In this study, we compared the surgery-related factors and parameters that are related to postoperative complications between IRHV-conserving S7 to S8 resection and conventional RH, in order to investigate the safety of IRHV-conserving surgery.

## Patients and Methods

Five patients who underwent IRHV-conserving S7 to S8 segmentectomy between 2007 and 2011 (IRHV group) and 25 liver cancer patients who underwent RH without biliary tract reconstruction during the same period (RH group) were investigated retrospectively. The selection criteria of the surgical procedure were decided based on the tumor location and/or the tumor invasion of the right hepatic vein (RHV). When the tumor invasion range was large, right hemihepatectomy or S7 to S8 segmentectomy was indicated. There were no significant differences in liver function before surgery between the IRHV and RH groups (Table 1). The IRHV and RH groups included 2 (40%) and 13 (52%) hepatocellular carcinoma patients, respectively. In the IRHV group, 2 liver metastasis cases

were metachronous and the patients were treated with chemotherapy (uracil and tegafur/leucovorin chemotherapy) before hepatectomy, and 1 case was synchronous. The preoperative ICGR15 value was 21.1% in 1 hepatocellular carcinoma patient in the IRHV group, on the basis of which the right lobectomy was considered excessively invasive. In the other patients, right lobectomy was not expected to cause liver failure based on the balance between the left lobe volume on volumetry and liver function.

The surgical procedure was selected according to the Makuuchi *et al*[6] criteria. IRHV-conserving surgery was indicated for the following conditions: the residual liver volume after RH was estimated to be insufficient based on preoperative evaluation of the hepatic functional reserve using the ICGR15 test, and extended hepatectomy was judged as having the risk of causing postoperative liver failure in consideration of liver tissue fibrosis and fatty degeneration based on intraoperative liver biopsy. Different kinds of hepatectomy, the risks and complications of surgeries, and treatment with other modalities were explained to each patient before surgery, and treatment was performed after obtaining informed consent. To investigate the positional relationship among the tumor, portal vein, and hepatic veins, 3-dimensional (3D) images were constructed from multidetector computed tomography images using the volume analyzer of a 3D image analysis system (Synapse Vincent, Fujifilm Medical Co, Tokyo, Japan). The right and left liver lobe volumes were determined using volumetry, and the volume of the IRHV-drainage region was calculated in patients undergoing IRHV-conserving surgery.

*Surgical procedure*

**Initial opening**

A J-shaped incision was made to apply thoracolaparotomy. The surgical field was exposed by attaching retractors to the right costal arch and to the left medial wound. The locational relationship among the main hepatic vein, IRHV, and tumor was investigated using ultrasonography during surgery.

**Liver mobilization and processing of the IRHV**

In dissection of the bare area, the right hepatic lobe was gradually dissociated by continuous shallow dissection from the left triangular ligament. The right adrenal gland and liver share the capsule, and the adrenal gland is adhered to the liver in 19% of patients.[16] Forceps were passed between the right adrenal gland and inferior vena cava from the caudal side, a silk thread was passed to the medial side of the adrenal gland, and the adhesion between the liver and adrenal gland was slowly divided using electric cautery. Because the IRHV flows into the inferior vena cava at the level of the right adrenal gland in many cases, the position was confirmed in preoperative 3D imaging (Fig. 1) and by intraoperative ultrasonography. The blood vessel was exposed safely and reliably by careful dissection, leaving no connective tissue around the blood vessel, and taping was applied to this vessel. The same process was performed in patients in whom a middle right hepatic vein circulating in the right lateral region was present between the right hepatic and inferior right hepatic veins (Fig. 2a).

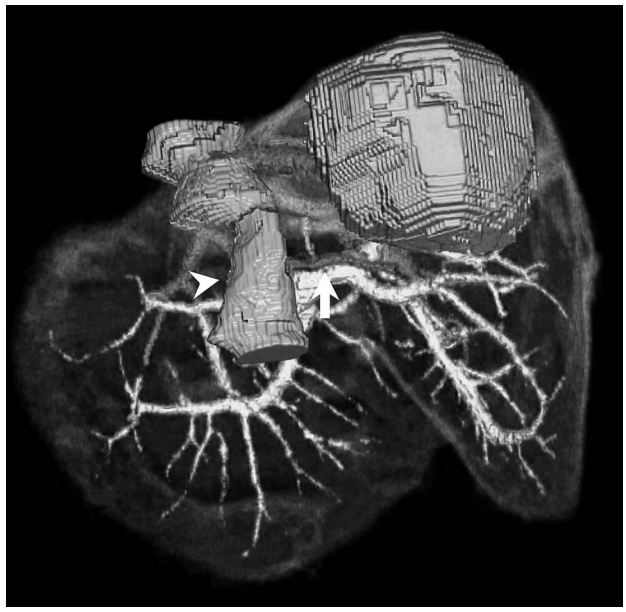

**Fig. 1** Hepatocellular carcinoma with a diameter of 8 cm occupying S 7 and 8 of the liver on 3D imaging. The IRHV (arrow) was observed on the dorsal side of the inferior vena cava (arrow head).

**Evaluation of the perfusion area of the RHV and liver transection**

Because the tumor invasion of the RHV was recognized with intraoperative ultrasonography in all cases, the RHV was clamped and resected. In the IRHV group, when the RHV and right hepatic artery were clamped, the surface of the congested area was observed, along with the area of RHV that was discolored for perfusion.[17] Based on these perfusion

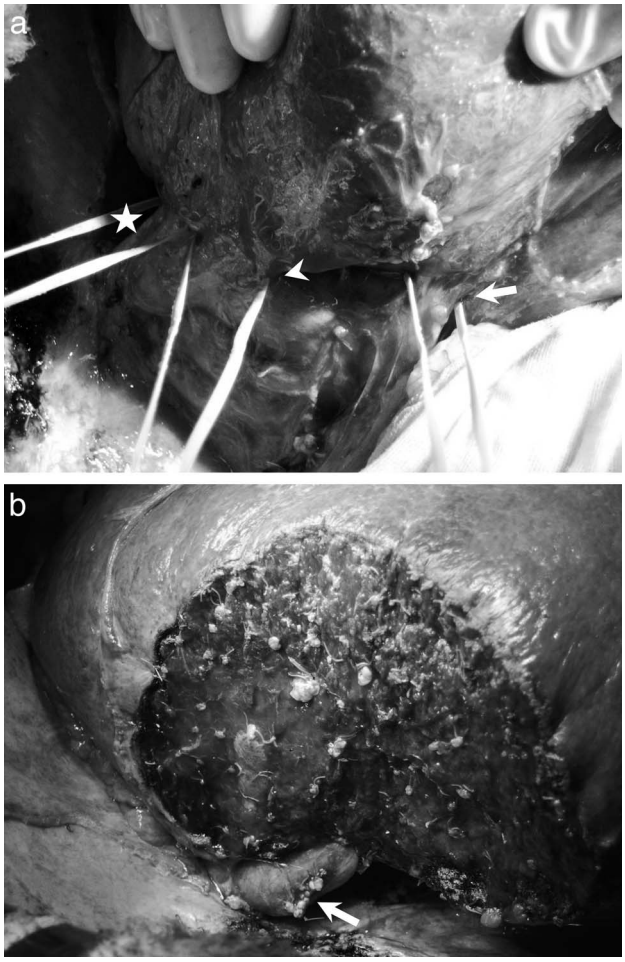


**Fig. 2** (a) IRHV + middle right hepatic vein–conserving S7 to S8 resection. Taping was applied individually to the right hepatic vein (star), middle right hepatic vein (arrowhead), and IRHV (arrow). (b) The stump of the resected liver. The stump of the right hepatic vein (arrow) was closed by a continuous double suture.

areas, preoperative 3D imaging, and intraoperative ultrasonography, an adequate resecting live area was decided. The liver was transected employing the clamp crushing method, and the hepatic blood flow was blocked using the Pringle method. The stump of the RHV was closed by continuous double suture using an atraumatic needle and thread (Fig. 2b).

*Statistical analysis*

The surgical data (operative time and intraoperative blood loss and transfusion), postoperative complications based on the Clavien grade,[18] and duration of hospital stay were compared between the IRHV and RH groups. Analyses were performed using a commercially available statistical package (IBM SPSS Statistics Version 20.0, IBM, Armonk, New York), employing the $\chi^2$ test and the Mann-Whitney $U$ test. $P$ values less than 0.05 were regarded as significant.

## Results

In both groups, thoracolaparotomy, complete dissection of the liver bare area, transection of the right adrenal gland, ligation and cutting of the short hepatic vein at the anterior surface of the inferior vena cava, exposure of the root of the hepatic vein, and taping of the right hepatic vein were performed. In the IRHV-conserving patients, taping was applied in the frontal dissection of the inferior vena cava. The presence of the IRHV did not adversely affect the processing of the short hepatic vein or frontal dissection of the inferior vena cava. The operative time was shorter (median, 366 minutes versus 501 minutes; $P = 0.0001$), the postoperative bilirubin level was lower (12 mg/dL versus 1.8 mg/dL; $P = 0.037$), and the duration of hospital stay was shorter (10 days versus 14 days; $P = 0.002$) in the IRHV compared with the RH group. No congestion appeared in the liver in any of the patients in the IRHV group. One intraperitoneal drain was placed in the stump of the resected liver in each of 4 patients, and drains were placed in the liver stump and the right subphrenic fossa in 1 patient in the IRHV group. No significant difference was noted in the intraoperative blood loss between the groups. The patient with an ICGR15 value of 21.1% in the IRHV group developed bile leakage, underwent surgical bile duct repair on day 2 after the surgery, and was discharged on day 12. Chronic hepatitis was noted in noncancerous liver tissue in 2 hepatocellular carcinoma patients, and mild fatty liver was noted in 2 liver metastasis patients treated with chemotherapy in the IRHV group. No significant differences were noted in the postoperative aspartate aminotransferase or alanine aminotransferase levels, or in the incidence of severe complications (Clavien grade III or higher) between the groups.

## Discussion

RH was applicable based on liver function in 4 of the 5 patients in IRHV group. However, we selected

*Table 2 Characteristics of the operative and postoperative variables in patients undergoing liver resection*

| Parameters | IRHV group (n = 5) | RH group (n = 25) | *P* |
|---|---|---|---|
| No. of liver tumors (range) | 1 (1–2) | 1 (1–24) | 0.787 |
| Diameter of the largest tumor, cm (range) | 5.5 (2.4–12.3) | 9.0 (3.0–19.0) | 0.169 |
| Blood loss, g (range) | 333 (62–701) | 430 (108–4491) | 0.385 |
| Operative duration, min (range) | 366 (320–423) | 501 (390–803) | 0.0001 |
| Blood transfusion, mL (range) | 0 | 0 (0–1680) | 0.416 |
| Surgical margin, mm (range) | 3 (1–10) | 1 (0–25) | 0.121 |
| Highest postoperative level of total bilirubin, mg/dL (range) | 1.2 (0.72–1.75) | 1.8 (0.53–4.5) | 0.037 |
| Highest postoperative level of aspartate aminotransferase, IU/L (range) | 361 (112–389) | 374 (172–1178) | 0.108 |
| Highest postoperative level of alanine aminotransferase, IU/L (range) | 236 (105–385) | 276 (74–798) | 0.300 |
| Postoperative hospital stay, d (range) | 10 (8–12) | 14 (8–40) | 0.002 |
| Complication | | | |
| Clavien grade ≥III, n (%) | 1 (20) | 6 (24) | 0.847 |
| Mortality, n | 0 | 0 | 1.00 |

IRHV, IRHV-conserved S7 to S8 resection; RH, right lobe hemihepatectomy.

IRHV-conserving surgery because the surgical procedure is superior in balancing the safety and postoperative course of the liver function based on the imaging diagnosis and improvements of the surgical technique.

Some previous reports have warned that IRHV conservation requires more delicate[11] and complex surgical techniques,[12] whereas others have reported that it can be performed safely, showing that there is controversy regarding the safety of IRHV-conserving surgery. In another report, liver tumor involving the right hepatic vein was treated with right lobectomy employing portal venous embolization within the acceptable range for liver function.[19] In our study, IRHV-conserving liver resection was as simple as conventional RH because the operative time was short and the blood loss was minimal. One factor contributing to this may have been the wide visual field secured by thoracolaparotomy, that is, to conserve the IRHV it is necessary to ensure the right hepatic lobe can be lifted and a wide view of the right side of the inferior vena cava can be achieved. After detaching the right adrenal gland from the liver, the inferior vena cava could be viewed from the front, and taping could be applied atraumatically without damaging the IRHV wall. In addition, IRHV-conserving surgery exhibited a short-term beneficial effect because the increase in the postoperative total bilirubin level was small and the duration of the hospital stay short, compared with after RH. Although we fully recognize that the postoperative bilirubin level and duration of hospital stay after RH would not necessarily be worse, our selection of this surgical procedure may have further improved the safety, providing greater benefit to the patients.

The IRHV branches from the right side of the inferior vena cava and circulates in the caudal region (particularly S6) of the right lobe, and it has been reported to occur in about 20% of patients.[20] Normally, the right lobe is perfused by the right hepatic vein, but in many cases it exhibits poor development when the IRHV is present. On ultrasonography, the IRHV is visualized as a blood vessel distributed in parallel with the branch of the portal vein in S6,[9] but its identification is difficult when a large tumor is present in the right hepatic lobe because the inferior vena cava and hepatic blood vessels are excluded. Current advances in 3D imaging techniques have facilitated clear visualization of the hepatic veins as well as simulation of the perfused region.[21] Consideration of the perfused region in the estimation of the residual liver volume corresponding to the hepatic functional reserve is important for safe liver surgery. Resection was performed after identifying the route of IRHV distribution and the perfused region by 3D imaging in our patients, and the 3D images were considered useful for IRHV-conserving surgery.

## Conclusion

IRHV-conserving S7 to S8 segmentectomy of the liver is a safe surgical procedure that is useful in preventing postoperative elevation of the bilirubin level and in shortening the duration of hospital stay.

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