Background: Segment-oriented liver resections can be performed effective by posterior intrahepatic approach. A significance of such resection is that they are oncologically radical as well as parenchyma-sparing.

Methodology: Segmental liver resections were performed in 102 patients with liver tumors. Suprahilar control of the appropriate glissonean pedicle was achieved by the posterior intrahepatic approach. Liver parenchyma was transsected by ultrasonic dissector, under intermittent vascular occlusion (IVO). Pedicle was divided at the end of resection using "endo-GIA" vascular stapler.

Results: The overall transection time was 30.14±12.56 min. The amount of blood loss was 285.59±129.92 ml. The postoperative complication rate was 25.49%. R0 resection had 94 (92.16%) patients. There was no liver failure or perioperative death.

Conclusions: Posterior intrahepatic approach for segmental resection is safe, can expedite the liver transection and reduce intraoperative hemorrhage. This approach provides adequate tumor clearance with preservation of normal parenchyma, as well as the vascularature or the biliary drainage of the contralateral liver.

Key words: Liver resection, Glissonean approach (GA), Liver tumors

INTRODUCTION

Thanks to the knowledge of the liver segmental anatomy and the increased use of intra-operative ultrasonography (IOUS), surgeons have become able to perform segment-oriented liver resections without disrupting the vascular inflow and outflow flow or the biliary drainage of the residual liver. Improvements in liver surgery techniques continues to achieve the main goals of liver resection: to preserve the maximum amount of liver parenchyma with minimum blood loss. Liver resection is now performed with a mortality rate of less than 5%, but bleeding during hepatectomy is still a problem. Surgical complications or hepatic insufficiency remains the main predictors of both morbidity and mortality after liver surgery. Intermittent Vascular Occlusion is a safe and well tolerated technique of warm ischemia to minimize intraoperative bleeding during hepatectomy. Segment-oriented liver resection offers a chance of anatomically resecting the tumor while preserving most of the liver tissue, allowing a decrease in intraoperative blood loss, providing adequate resection margins, and affording a low rate of postoperative complications.

The fibrous sheath of Glisson encircles the hepatic artery, portal vein, and bile duct at the hilum and continues as the liver capsule. This observations of Glissonean pedicle were the basis for the initial proposal by Couinaud, Takasaki and Launois that suprahilar vascular control of Glissonean pedicle could serve as an alternative to classical hilar dissection for controlling vascular inflow to the liver. This technique includes the extrafascial dissection of the whole sheath of the pedicle and its division "en masse". The Glissonean pedicle approach at the hepatic hilus without liver dissection was previously reported by Couinaud in 1985 and Takasaki et al. in 1986. Galperin and Karagiulian in 1989 described a digital "hooking" technique for the isolation of portal pedicles through an extrafascial-intrahepatic approach after division of a substantial amount of the hepatic tissue. In 1992 Launois and Jamieson proposed the posterior intrahepatic approach to the appropriate glissonean pedicle, through the dorsal fissure of the liver. Machado’s modification of the posterior approach include making a small incisions around the hilar plate and strictly instrumental isolation of the pedicle.

The Glissonean approach can reduce the portal triad closure time, can expedite the transection of the liver and reduce intraoperative hemorrhage, as well as the risk of in-
jury to the vasculature or the biliary drainage of the con-
tralateral liver.13-16

We report our experience with segment-oriented resec-
tion using the intrahepatic Glissonean pedicle approach
(GA), in a single-institution.

METHODOLOGY

Patients

Between January 2007 and January 2012, 102 patients
underwent segment-oriented liver resection for benign
and malignant liver tumors, using the posterior intrahepa-
tic Glissonean pedicle approach (GA). The protocol re-
ceived the approval of the Ethical Committee of our hos-
pital, and informed written consent was obtained from
each patient before surgery. All the procedures were per-
formed by the same surgical team. Patients who were en-
rolled in this study fulfilled the following inclusion crite-
ria: elective liver resection for liver tumors and Child-
Pugh (CP) classification Child A and B. Exclusion criteria
were: other major associated surgical procedures, chronic
hepatitis and cirrhosis Child C. Patient demographic data,
postoperative evolution, hospital stay, morbidity, mortal-
ity and results of histopathologic study were prospectively
introduced in a medical database.

Pre-operative imaging studies including abdominal ul-
trasonography and helical contrast enhanced computed to-
mography (CT), were performed in all patients. Accord-
ing to Couinaud’s nomenclature, the eight anatomic seg-
ments of the liver are defined by the distribution of the he-
patic and portal venous systems.17 Each liver segment has
an independent biliary drainage and vascular inflow and
outflow and it is possible to remove an individual segment
without disrupting the blood flow or biliary drainage of
the remaining segments. Liver resections were defined ac-
cording to International Hepato-Pancreato-Biliary Asso-
ciation terminology and the Brisbane classification.18
Based on the Brisbane 2000 Terminology of Hepatic
Anatomy and Resection, the liver can be divided into four
sections: the right anterior section (segments V and VIII),
right posterior section (segments VI and VII), left medial
section (segment IV), and left lateral section (segments II
and III).18

The preoperative laboratory tests were used to calculate
the CP score.19 Intraoperative data were operative time
(min; measured from skin incision to the end of the proce-
dure), transaction time (min), Intermittent Vascular Oc-
cclusion duration (IVO, min), intraoperative blood loss
(mL), intraoperative transfusion requirement (mL, ex-
pressed as the amount of blood volume). The amount of
intraoperative blood loss was measured from the volume
(mL) of blood collected in the container of the aspirator
and from the weight of the soaked gauze (assuming that
1mL of blood=1g). Postoperative liver function was as-
sessed by daily measurements of liver function tests in-
cluded blood biochemistry. Although we do not present
longterm followup, we examine the oncologic efficacy of
segmental liver resection in terms of tumor clearance by
histology margine (R0,R1). Morbidity was classified ac-
of bile in the drainage fluid (bilirubin levels at least three times higher than serum levels) for more than 2 days postoperatively. Liver failure was determined as: bilirubin $>$ preoperative levels x 10, lasting for more than three days unrelated to biliary obstruction leak and/or INR $>$ preoperative levels x 2 for more than 2 days after resection and/or significant ascites/encephalopathy.

**Surgical Technique**

The approach was a Makuuchi’s "J"-incision, which allows a good exposure to the whole liver.

Following mobilization, the liver was assessed with intraoperative ultrasound (IOUS) to define segmental liver anatomy and the tumor localization, in relation to the major vascular and biliary structures.

Extra hepatic "outflow" control was performed after dissection of major hepatic veins. Ischemic preconditioning (IP, mode 5/5 minutes) was done to minimize ischemic-reperfusion injury of the liver (IRI). The liver tissue was transected under intermittent hepatic inflow vascular occlusion (IVO, mode 15/5 minutes), or hemi-hepatic selective vascular clamping in order to minimize blood loss. Clamping of the portal triad was performed with the "tourniquet technique" using a rubber tape. Central venous pressure (CPV) was maintained at 0-5 mmHg to help reduce back bleeding from hepatic veins. Transection of the liver tissue was performed using the ultrasonic dissector (Cavitron Ultrasonic Surgical Aspirator, "CUSA Excel"; Valleylab Inc., Boulder, CO).

Suprahilar vascular control of the appropriate glissonian pedicle was achieved by Machado’s modification of the posterior intrahepatic approach. After cholecystectomy, "detachment" of the medial section of the liver (S4) was performed, by lowering the hilar plate. For the right main Glissonian pedicle (RMP) isolation maneuver, a small anterior hepatotomy was made in front of the hilum. The liver parenchyma is divided by CUSA to disclose right glissonian pedicle and its limits. A second vertical incision was performed perpendicular to the hepatic hilum, between segment S7 and caudate lobe (S1). Curved clamp then was inserted through the first hepatotomy with a 30° angle reaching the second incision. Vascular tape is then placed around the right main glissonian pedicle. Tape can be pulled down and medially to provide better exposure of the intrahepatic pedicle and to retract the left biliary tree and portal vein away from the area to be clamped or stapled. A third incision performed on the right edge of the gallbladder bed permits access to the sectional pedicles, by combining the previously mentioned incisions. When a clamp is passed from anterior incision to third incision,
can be accessed to the right anterior (RAP) sectional pedicle. This maneuver was used for en bloc resection of segments S5 and S8, or resection of segment S5 or S8 alone. When a clamp is passed from third incision to vertical second incision, can be accessed to the right posterior (RPP) sectional pedicle (Figure 1a,b). This maneuver was used for en bloc resection of segments S6 and S7 or resection of segment S6 or S7 alone.

For the left main glissonean pedicle (LMP) isolation, left liver lobe is pulled upward, and the lesser omentum is divided, exposing the Arantius ligament venosum, which is then dissected and divided. The proximal stump enabling infero-posterior approach to the left hepatic vein and common trunk. The caudal stump of the ligament is dissected toward the left portal vein. This maneuver discloses the posterior aspect of the left glissonean pedicle. A small anterior incision (4-5 mm) is performed on the left side of the hilum, and a curved clamp is introduced behind the caudal stump of the Arantius ligament, allowing the encircling and exposure of the left main pedicle (LMP). This approach spares the caudate lobe (S1) portal branches.

The round ligament was retracted upward, exposing the umbilical fissure between segments S3 and S4. If a parenchymal bridge connecting these 2 segments, it must be divided. Using the round ligament as a guide, 2 small incisions are performed on the left and right margins of the round ligament where it is possible to identify the anterior aspect of the glissonean pedicle of segment S4 on its right side and segment S3 on its left side. With a clamp introduced through the anterior incision in front of the hilum and the basis of the round ligament on the right side, it is possible to isolate the glissonean pedicle of the left medial sector or segment S4.

By combining incisions from the caudal stump of the Arantius ligament to the left side of the basis of the round ligament, it is possible to isolate the glissonean pedicle of the left lateral sector (segments S2 and S3) (Figure 2a). Another small incision can be performed midway between the left side of the basis of the round ligament and the caudal stump of the Arantius ligament, permitting individual access either to segments S2 or S3, allowing monosegmentectomies (Figure 2b).

Clamping the isolated and taped glissonean pedicle, demonstrates the further demarcation of the appropriate anatomical territory of the liver, as well as delineation of resectional plane.

During pedicle clamping, the color of the area changes and the tumor location is confirmed by IOUS. Pedicle is divided at the end of resectional procedure using vascular surgical stapler (Endo GIA Ultra stapler 3.0; Covidien) (Figure 1a). Firm countertraction on the tape must be applied during application of the stapler to ensure that the confluence of the bile duct is not accidentally ligated.

The major hepatic veins (the right, middle or left hepatic vein) were divided extrahepatically using vascular surgical stapler or continuous Prolene 4.0 suture above the vascular clamp. Hemostasis was obtained with a monopo-

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number (%) n=102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)⁴</td>
<td>64.37±10.78</td>
</tr>
<tr>
<td>Male sex</td>
<td>62 (60.78%)</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>54 (52.94%)</td>
</tr>
<tr>
<td>Child-Pugh score B</td>
<td>28 (27.45%)</td>
</tr>
<tr>
<td>Malignant liver tumors</td>
<td>79 (77.45%)</td>
</tr>
<tr>
<td>Benign liver tumors</td>
<td>23 (22.54%)</td>
</tr>
</tbody>
</table>

⁴The results are expressed as mean±SD (standard deviation)

<table>
<thead>
<tr>
<th>Resection</th>
<th>Number (%) n=102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 1 (caudate lobectomy)</td>
<td>2 (1.96%)</td>
</tr>
<tr>
<td>Segment 2</td>
<td>4 (3.92%)</td>
</tr>
<tr>
<td>Segment 3</td>
<td>6 (5.88%)</td>
</tr>
<tr>
<td>Segment 4a</td>
<td>2 (1.96%)</td>
</tr>
<tr>
<td>Segment 4b</td>
<td>2 (1.96%)</td>
</tr>
<tr>
<td>Segment 5</td>
<td>5 (4.90%)</td>
</tr>
<tr>
<td>Segment 6</td>
<td>4 (3.92%)</td>
</tr>
<tr>
<td>Segment 7</td>
<td>4 (3.92%)</td>
</tr>
<tr>
<td>Segment 8</td>
<td>2 (1.96%)</td>
</tr>
<tr>
<td>Right posterior sectionectomy (S6, S7)</td>
<td>13 (12.74%)</td>
</tr>
<tr>
<td>Right anterior sectionectomy (S5, S7)</td>
<td>12 (11.76%)</td>
</tr>
<tr>
<td>Left lateral sectionectomy (S2, S3)</td>
<td>8 (7.84%)</td>
</tr>
<tr>
<td>Left medial sectionectomy (S4)</td>
<td>13 (12.74%)</td>
</tr>
<tr>
<td>Right cranial sectionectomy (S7,S8)</td>
<td>5 (4.90%)</td>
</tr>
<tr>
<td>Right caudal sectionectomy (S5, S6)</td>
<td>9 (8.82%)</td>
</tr>
<tr>
<td>Bisegmentectomy S4b, S5</td>
<td>3 (2.94%)</td>
</tr>
<tr>
<td>Polysegmentectomy S4b, S5, S6</td>
<td>4 (3.92%)</td>
</tr>
<tr>
<td>Polysegmentectomy S3, S4b, S5</td>
<td>4 (3.92%)</td>
</tr>
</tbody>
</table>
After resection, biliostasis was achieved with the aid of dye injection in the biliary tree through the catheter of the cystic duct. The raw surface of the liver was sealed using fibrin glue (Beriplast) (Figure 3). Closed suction drainage was used in all patients.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS statistical software (SPSS for Windows, release 17.0, SPSS, Chicago, IL). Data are expressed as mean values with standard deviations or as medians with interquartile ranges. Categorical data are presented by absolute numbers with percentages.

RESULTS

Preoperative characteristics of 102 patients undergoing segment-oriented liver resection and indications for liver resection were presented in Table 1. More than 50% of patients suffer from one or more co-morbidities (Table 1). Hypertension is the most common disease (25.49%), followed by chronic obstructive pulmonary disease (13.72%), coronary artery disease (7.84%) and diabetes (5.88%).

Indications for segment-oriented liver resection were Metastases of colorectal carcinoma (CRC) in 50 (49.02%), Hepatocellular carcinoma (HCC) in 10 (9.80%), Cholangiocellular carcinoma in 4 (3.92%), Non-colorectal liver metastases in 8 (7.84%), Gall bladder carcinoma in 7 (6.86%), Hemangioma hepatitis in 13 (12.74%) and Adenoma hepatitis in 10 (9.80%) patients.

The types of segment-oriented liver resection performed using the GA are shown in Table 2.

Segmental resection included 31 (30.39%) monosegmentectomy, 63 (61.76%) bissegmentectomy/sectionectomy and 8 (7.84%) polysegmentectomy.

Intraoperative data for patients undergoing hepatectomy are shown in Table 3. The overall operative time was 140.12±31.10 min. The liver transection duration was 30.14±12.56 min. The ischemic duration due to pedicular clamping (IVO) was 25.03±10.27 min. Intraoperative blood loss was 285.59±129.92 ml. Intraoperative transfusion was performed in 23 (22.55%) patients. The blood transfusion volume was 302.86±99.59 ml.

Outcomes of patients undergoing hepatectomy, ICU stay (intensive care unit) and hospital stay are shown in Table 4. The postoperative complication rate was 25.49%. Sixteen patients (15.69%) experienced specific surgery complications. The majority of complications were treated conservatively and no patients underwent re-operation. In cases of the biliary fistula there was two minor bile leaks with spontaneous healing. Intrabdominal subphrenic collections were successfully treated with percutaneous drainage. There was no incidence of postoperative massive bleeding (>1000 ml), liver function failure or death.

DISECUSSION

During the last decades, better understanding of liver anatomy and advances in imaging and surgical technology have made segmental anatomic liver resections easier by allowing a decreased intraoperative hemorrhage and increased rate of morbidity and mortality. Our results demonstrate that segmental liver resection using the intrahepatic Glissonean approach with "en bloc" stapling transection of the pedicle can be performed efficient and safe, with an acceptable surgery duration, liver transection time, and intraoperative blood loss.

Segmental resections offer a variety of advantages over the nonanatomic wedge resections. Segmental hepatectomy is a superior oncologic operation with decreased a positive margin in patients with malignant liver tumors. The De Matteo et al have proven its oncologic superiority.
Liver resections may be accompanied by severe complications, such as uncontrolled bleeding, injury of the biliary ducts and liver failure. The main risk of bleeding is when performing the hepatotomy to surround the right or left pedicle. Careful dissection between the sheaths of the pedicular structures and the liver parenchyma avoids breaching the boundaries of the liver parenchyma with minimum blood loss and "en-bloc" stapling transection of pedicle contributes to the safety. We demonstrated that Glissonean approach with vascular stapling may establish a good control of bleeding, and there was no case of massive hemorrhage, liver failure or dead, among our patients. Some authors previously reported that one of the potential risk of Glissonean pedicle approach presents an increase bile leaks rate. In left hepatectomy, if all the branches of the caudate lobe are not preserved, ducts from the segment S1 which frequently drain into the left bile duct, may be injured by stapler. In order to avoid injuries, the stapler must be correctly positioned depending if a left hepatectomy is performed with or without caudate lobe resection, or the branches of segment S1 can be simple ligated before introducing the stapler. To avoid severe complication due to the accidental ligation of the biliary confluence when stapling the right pedicle, firm countertraction on the tape should be applied during application of the stapler. Injury of the biliary ducts is usually manifested as biliary fistula or obstructive jaundice. Severe injury of the biliary ducts should be considered as potentially lethal complication due to the high risk of sepsis and liver failure. Bile leaks from small subsegmental branches are usually self-limited, while bile leaks from segmental bile ducts or the stump of the transected hepatic duct are difficult to heal and may require endoscopic stenting or re-operation. The aberrations of the biliary system are not infrequent and preoperative imaging of the biliary tree is useful in planning the operative strategy.

CONCLUSION

Intrahepatic Glisssonian approach for anatomic segment-oriented liver resection is safe, oncologically radical and effective technique with preserving functioning liver parenchyma. This approach can expedite the transection of the liver and reduce intraoperative hemorrhage, as well as the risk of injury to the vasculature or the biliary drainage of the contralateral liver. En-masse transection of Glissonean pedicle, as well as hepatic veins, using endo-GIA vascular stapler could be performed safely with adequate hemorrhage control.

SUMMARY

Segment-oriented liver resections based on posterior intrahepatic Glissonian approach

izvodjena je ultrasoničnim disektorom, pod intermitentnom vaskularnom okluzijom (IVO). Pedikl je presećen vaskularnim staplerom na kraju resekcije.


Zaključak: Posteriorski vaskularni pristup segmentnim resekcijama jetre je bezbedan, može da ubraza transekciu i smanji intraoperativno krvenje. Ovaj pristup obezbeđuje adekvatan tumorskog klirensa, uz čuvanje normalnog tkiva jetre, kao i vaskularne i bilijarne drenaže kontralaterale jetre.

Ključne reči: resekcija jetre, glisonijanski pristup, tumor jetre

REFERENCE


Abbreviations: Glissonean approach (GA), Cavitron Ultrasonic Surgical Aspirator (CUSA), Intraoperative Ultrasound (IOUS), Intermittent Vascular Occlusion (IVO), Right anterior pedicle (RAP), Right posterior pedicle (RPP), Left main pedicle (LMP), Right main pedicle (RMP).