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Selection of the Occlusion Type of Hepatic Blood Inflow: A Prospective Study

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Abstract: Background: The Glissonean pedicle method in liver surgery enhances the technique of liver surgery while introducing fresh information about the surgical anatomy of the liver. The hepatic artery, portal vein, and bile duct are parts of the Glissonean pedicles, which are wrapped in a connective tissue known as the Glisson's capsule. Both intrahepatic and extrahepatic approaches can be used to access the Glissonean pedicles. Couinaud refers to the extrahepatic route at the hepatic hilus as the extra-fascial access. Without requiring the liver to be dissected, the secondary Glissonean pedicles are encircled and tied at the hepatic hilus. The angle of approach should be above the hilar plate to spare the surgeon from having to account for variations in the arteries or bile ducts. The hepatic hilus, which separates the regions nourished by the secondary Glissonean pedicles, can be used to access the tertiary branches either intrahepatically or extrahepatically. This method enables a quick, safe, easily performed liver resection and can be used for any anatomical hepatectomy. Thus, liver surgeons should be aware of the fundamental concept behind the Glissonean pedicle transection technique.

Objectives: In this study, we aim to describe the application of Glissonean pedicle approach in three groups: extrahepatic extrafascial, extrahepatic intrafacial and intrahepatic extrafascial and evaluate the results, focusing on intraoperative and postoperative complications, amount of bleeding, operative times.

Patients and Methods: This prospective clinical study conducted in the Department of Surgery in Gastroenterology and Hepatology Teaching Hospital in Medical City/Baghdad from 14th of December 2020 to 21th of December 2022. Sixteen patients with different type of presentation were included in this prospective study. Liver resection due to trauma was excluded from this study. All patients with liver disease referred from other hospitals in Baghdad and other Iraqi governorates. In all patients, the prospective diagnosis of liver problem was correctly made on history, clinical presentation, blood investigation, ultrasound (US), computed tomography scan (CT), magnetic resonance imaging (MRI).

Results: The age of the participants ranging from 2 to 71 years old (mean age 36.19±23.7 year), 7 (44%) males and 9 (56%) females. We classified the patients in to two groups: extrahepatic extrafascial 4 (25%), extrahepatic intrafascial 5 (31%) and intrahepatic extrafascial 7 (44%). The average operation time was 235.0±51.5 minutes and the mean of blood loss was 287.5±117.6 ml. Total blood transfusion proportion during and after surgery was 37.5%. The number of patients who unreceived blood was more in the selective inflow control group (seven patients). Complications accounted for 50% of the patients in which the bleeding was the most common

(25%). There were no pleural effusion and ascites after surgery. One death was recorded postoperatively due to sepsis. Type of resection, resected volume (minor and major), blood loss and operation time were the factors significantly affecting the percentage of complications after surgery in our study. Furthermore, the mean of blood loss and the mean of operation time were more in the group of patients who underwent intrafascial approach.

Conclusion: In Extrafascial approach, there was less blood loss and transfusion, and the duration of surgery was shorter. Extrafascial approach is safe, feasible and effective method to resect precisely liver masses and less complications in the remnant liver. Hilar dissection is preferred in hepatic masses in porta hepatise.

Keywords: liver resection, major hepatectomy, Pringle (clamping) manoeuvre, vascular division techniques.

Introduction:

In the past decade, resection of the liver has become safer due to the surgical techniques' refinements, also the improvement in selection of specific patients for these surgery and advanced post-operative nursing (1). Simultaneously, many complex resections of liver are performed currently with expand the indications for these types of surgeries. Although the rate of mortality has declined, the morbidity is considered in patients who suffer from underlying parenchymal liver disease; for example; the steatosis and cirrhosis and in patients undergoing extended liver resection (2).

Unquestionably, one of the main causes of mortality and morbidity in massive liver resections is haemorrhage and the number of resected segments during the operation(3). The techniques of liver resections are developed to reduce the volume of losing blood and that was very useful in reduction of post- operative complications.

There are three considerations should be studied to control blood loss. The first one is the awareness and understanding of liver surgical anatomy (4). The intersegmental planes are approximately avascular in compared with the segmental borders and this allow the surgeon to minimize the blood loss during anatomical resections. The second consideration is developing new procedures for parenchymal dissection which helped the surgeon to transect the hepatic tissue without numerous losses of blood (1). Additionally, temporarily clamping the portal vein and hepatic artery with or without accompanied control of inferior vena cava vein back flow through the hepatic vein (5).

Vascular clamping techniques that can be used to minimize blood loss during liver resection A. Continuous or Intermittent Pringle Manoeuvre (clamping)

When the hepatoduodenal ligament is clamped during partial liver resections, the portal vein and hepatic artery are temporally occluded (1). There is debate about whether clamping should be done continually or sporadically(6). In contrast to intermittent clamping, which causes several short episodes of ischemia that are all followed by a reperfusion event, continuous clamping causes a one prolonged period of ischemia followed by reperfusion. The question is whether a single prolonged period of ischemia followed by eventual reperfusion is more harmful to the liver than several short episodes of ischemia and reperfusion (7). Animal research, primarily involving rats, and a small number of clinical investigations have also addressed this issue. Hepatocellular damage and survival were measured in rat experiments as indicators of liver injury, however no one approach was consistently supported (8). Intermittent hepatic vascular clamping was beneficial in studies in rats employing cirrhotic liver models or prolonged durations of ischemia (9). We examined continuous and intermittent clamping utilizing measures of microvascular and parenchymal damage in a therapeutically applicable pig model of hepatic pedicle clamping combined with partial liver resection (10). In hemi hepatectomized pigs, we were able to show that post ischemic reperfusion damage was less severe after prolonged

(120min) intermittent vascular inflow clamping than after continuous occlusion. Nevertheless, continuous clamping led to reduced microcirculatory and hepatocellular damage when vascular inflow clamping lasted less than 90 minutes. Intermittent clamping may be advantageous in difficult liver resections when the clamping time is predicted to exceed 60 minutes, according to the practical application of these tests' findings (1). There is minimal benefit to intermittent clamping in simple liver resection situations when parenchymal transection can be finished in less than 30 minutes. Intermittent clamping involves periods of ischemia lasting 15–30 minutes in a clinical setting, followed by reperfusion lasting 5–15 minutes(11). The duration of total ischemia is reduced, despite the cost of prolonged times for bleeding, reperfusion, and parenchymal transection of the liver. By intermittent clamping, it is possible to examine the liver's cut surface's haemostasis step-by-step throughout each cycle of reperfusion (1). In randomized research, Belghiti et al. compared 44 patients who underwent intermittent clamping (15 min of clamping and 5 min of unclamping) to 42 patients who underwent continuous clamping and the patients with abnormal liver parenchyma had considerably greater postoperative serum bilirubin and liver enzymes in the continuous group compared to patients with intermittent intraoperative blood loss, which was significantly higher (steatosis and cirrhosis) (6) . Overall, intermittent clamping is the recommended technique, especially in patients having complicated liver resections and patients with sick livers, since it increases the safe ischemia period up to 322 min in normal livers and 204 min in impaired livers (12).

B- Hemi hepatic or Segmental Vascular clamping

It is possible to obstruct just the vascular supply to the hemi-liver or one or two segments rather than the entire vascular inflow to the liver (5) . When a bi- segmentectomy is carried out, as in a segment 2/3 or segment 6/7 resection, the half-Pringle technique (clamping) is effective in dealing with peripherally situated tumours(13). Full segmentectomy is possible following selective clamping of the supplying portal branch with a balloon catheter inserted under ultrasound guidance (while clamping the ipsilateral hepatic artery) (1). The liver parenchyma can be used to mark the segment's borders, or they can be highlighted by injecting mythelene blue into the portal branch after closure (14). One or two segments can also be isolated using Launois' Extra-Glissonian posterior method (15). This method avoids opening the Glissonian sheath by dissecting the segmental pedicles of the resected liver segments in the liver hilum (15) . The liver parenchyma is divided along the segmental margins by clamping the segmental pedicle. When doing central liver resections or segment 5/8 resections, this parenchyma- sparing technique is especially helpful (7) .

C- Total Hepatic Vascular Exclusion

Total hepatic vascular exclusion (THVE), in which the supra- and infrahepatic caval veins are clamped in addition to the portal vein and hepatic artery, might be used if backflow from the hepatic veins still leads to significant blood loss following vascular inflow division (16). Above the renal veins and right adrenal vein, the infrahepatic caval vein is clamped. THVE may also be utilized to resect the tumor together with segment of the caval vein when the tumour has invaded the IVC or caval-hepatic junction (16). Due to the decreased venous return and consequent decrease in cardiac output, THVE is strongly associated with hemodynamic intolerance in 10–20% of individuals. Hence, careful patient hemodynamic monitoring and anaesthetic knowledge are required for the application of THVE (17). However, significant morbidity and hospital stays in patients undergoing THVE have been recorded even in the presence of sufficient surgical and anaesthetic experience (17).

D- Selective Hepatic Vascular Division

Selective extra parenchymal division of the main hepatic veins in conjunction with vascular inflow division (selective hepatic vascular occlusion, SHVE) has been proposed to prevent the hemodynamic complications of THVE(18) . The right hemi-liver must be mobilized, and all short hepatic veins must be taken down before using this approach (19). Although SHVE and

THVE have both been proved to be similarly successful in controlling blood loss, SHVE was found to be more tolerable, resulting in fewer complications and a shorter hospital stay (20).

PATIENTS AND METHODS

Methodology and Methods

An overview of the study's objectives and purposes will be provided in this chapter. Moreover, a thorough description of the methodology and methodological approach is provided.

Study Design and Data Collection

In this prospective study, groups of patients with liver masses who were treated at the Gastroenterology and Hepatology Teaching Hospital in Baghdad's Medical City participated. 16 patients who underwent liver resection procedures were the subject of the study. A multidisciplinary team assessed these surgeries and decided on the most appropriate approach. The purpose of the study was to evaluate how different liver resection procedures affected patients. From December 14, 2020, to December 21, 2022, a prospective study was carried out in the Gastroenterology and Hepatology Teaching Hospital in Medical City, Baghdad, with the previous consent of the local institutional committee for human research. The participants' names were coded with numbers. With the help of the statistical program (statistical package for social sciences SPSS), the data was statistically analysed (SPSS version V.26). Chi-square test and t-test were employed for categorical and parametric variables, respectively, to determine if a difference was statistically significant (P-value 0.05). The categorical variables were described using number and percentage, whilst the continuous variables were reported as mean and standard deviation (SD). A Shapiro-Wilk test looked at the sample size distribution with less than 50 participants. The distribution of the sample for the current investigation has revealed no non-significant differences for each point (P 0.05). In addition, the data set was roughly normally distributed (42). For all the results, a sensitivity analysis was also carried out to see if the results were impacted by the limited sample size and potentially skewed data. Thus, the Wilcoxon signed rank test, a non-parameter test, was conducted(43) this revealed no change in the outcomes. linear regression analysis test was also used to identify if the type of resection (variable) can predict the other variables like blood loss, postoperative complication and the time of operation.

Inclusion and Exclusion Criteria

This prospective analysis comprised 16 patients having liver resection, ranging in age from 2 to 71 (mean age 36.19 years), including 7 (43%) men and 9 (56.2%) females. In our hospital, all patients had surgery. We divide the patients into three groups based on vascular transection: extra fascial intrahepatic, extra fascial extrahepatic, and intrafascial extrahepatic. The incidence of liver resection varies depending on the patient's medical history, physical examination results, blood tests that include tumour markers, imaging tests (US, CT, and MRI), and in certain cases, liver biopsy results and biochemical test with chest X-ray and ECG.

➢ **Inclusion criteria:**

1. All patients in our hospital with liver mass that candidate for resection.
2. Any comorbidities.

➢ **Exclusion criteria:**

Include liver resection due to trauma.

Surgical Techniques

Position of the Patients:

Patients were lying supine with their right arm or both arms horizontally perpendicular to their bodies. On the right side are the primary surgeon and technician, while others are on the left and the patients are received single dose of antibiotic about half to an hour before skin incision. Also, prophylactic against DVT is provided for high risk patient including elastic stocking devices.

Surgical Procedure.

Step1: laparotomy: performing midline, roof top, Makuuchi or Right subcostal incision. The size and location of the lesion determine the type of incision.

Step 2: Abdominal exploration and tumour evaluation: We palpate and visually assess tumours for their number, size, and location; assess the type of liver parenchyma (fibrosis, fibrose, or steatosis); evaluate other abdominal organs such as the stomach, small intestine, colon, and spleen; and determine a preliminary evaluation of the presence of enlarged lymph nodes or adhesion in the hepatic pedicle.

Step 3: In the liver mobilization process, we separate the round and falciform ligaments, exposing the anterior surface of the suprahepatic inferior vena cava and the roots of three hepatic veins.

Step 4: we use abdominal U/S to localize the size of the mass and its relation to hepatic vein and portal branches.

Step 5: we proceed to do liver resection using either extrafascial or intrafascial approach.

RESULTS

Presentation of the participants

16 patients with various complaints were recruited and underwent liver resection at the Gastroenterology and Hepatology Teaching Hospital in Baghdad's Medical City over the period of two years, from December 14, 2020, to December 21, 2022. Seven out of sixteen (43.8%) patients had abdominal masses, four (25%) had abdominal pain. one patient (6.3%) had jaundice and the incidental findings were 4 patients with (25%) (table 3.1).

Table (3.1): Presentation of the participants

Type of the presentation	**No (%)**
Abdominal mass	**7 (43.8%)**
Jaundice	**1 (6.3%)**
Abdominal pain	**4 (25%)**
Incidental	**4 (25%)**

Demographic and Clinical Characteristics, Surgical data during surgery

Table (3.2) provides a summary of the sample's demographic and clinical characteristics. Nine of the participants (56.3%) were female, compared to seven (43.8%) men. The sample's average age was 36.19 (range, 2-71 years old). Midline and roof top incisions were most frequently utilized during operations, with percentages of 44.8% and 37.5%, respectively. About the type of retractor, we use Morrison retractor in 50% of the patients and the same percentage with Thompson retractor (50%). 13 (81.3%) patients had no outflow control during surgery (intrahepatic control), whereas 18.8% of participants received extrahepatic outflow control (3 patients). The most common type of Pringle manoeuvre (clamping) was selective type (12 patients (75%)) while the non-selective type was only (25%) percentage with 4 patients. There was also a description of Glissonean pedicle techniques; Eleven patients (68.8%) had extrafascial approache, whereas five (31.3%) had intrafascial approach. Then, the extrafascial approach was classified in to extrafascial intrahepatic with 7 patients (63.6%) and extrafascial extrahepatic with 4 patients (36.4%). The volume of the resected segment was either minor resected segment (<3 segment) which done for 10 patients (62.5%) or major resected segment (≥3 segment) which done on 6 patients (37.5%). In term of the type of resection, more than half of patients underwent anatomical resection (56%) and 6 patients underwent non-anatomical resection and wedge resection was done only for one patient (6.3%). In all operations, the average operating duration was 235 minutes, and the average intraoperative blood loss was 287.5 ml. Just 6 out of 16 patients (37.5%) had blood transfusions.

Table (3.2): Demographic and Information on the surgery approach of the participants

Variable	
Sex No (%)	Male 7(43.8%) Female 9 (56.3%)
Age (Mean ±SD)	36.19±23.7
Age group <60 ≥60	 12 (75%) 4 (25%)
Type of incision Roof top Makuuchi Midline RT.subcostal	 6 (37.5%) 2 (12.5%) 7 (43.8%) 1 (6.3%)
Type of retractor Morrison Thompson	 8 (50%) 8 (50%)
Type of Pringle manoeuvre No (%) Selective Non-selective	 10 (62.5%) 6 (37.5%)
Type of Glissonean approach Total intrafacial Total extrafascial : A-Extra fascial intrahepatic B-Extra fascial extrahepatic	5 (31.3%) 11 (68.8%) 7 (63.6%) 4 (36.4%)
Type of outflow control Intrahepatic Extrahepatic	 13 (81.3 %) 3 (18.8%)
Resected volume Minor <3 Major ≥3	 10 (62.5%) 6 (37.5%)
Type of resection Anatomical Non-anatomical Wedge	 9 (56.3%) 6 (37.5%) 1 (6.3%)
Intraoperative blood loss (Mean ±SD((ml)	287.5±117.6
Need transfusion No (%) Yes No	6 (37.5%) 10 (62.5%)
Time of operation (Mean ±SD) (min)	235.0±51.5

Indication of liver resection

According to the preoperative diagnosis, most patients were diagnosed with liver metastasis (37.5%). Three patients (18.8%) had hepatoblastoma. while the other diagnosis had an equal proportion 6.3% (table 3.3).

Table (3.3) Preoperative Diagnosis

Type of preoperative diagnosis	No.	Percentage
Liver metastasis	6	37.5%
hepatoblastoma	3	18.8%
Liver sarcoma	1	6.3%
Biliary cyst derma	1	6.3%
Atypical haemangioma	1	6.3%
FNH	1	6.3%
HCC	1	6.3%
Fibrolamellar HCC	1	6.3%
Adenoma	1	6.3%

Clavien-Dindo's classification of complications after surgery Degree

According to Dindo-Clavien's classification of surgical complications(44) Grade 3.1 complications were the most common, affecting 8 individuals (50%) While 25% of patients had grade 2 complication and only 2 patients were detected as grade 3 (12.5%). At grades 4a and 5, there is just one patient. Also, we observed no grade 4b postoperative complications (table 3.4).

Table (3.4): Clavien-Dindo's classification of complications

Grade of complication	NO (percentage)
Grade 1	8 (50 %)
Grade 2	4 (25%)
Grade 3	2 (12.5%)
Grade 4 Grade 4a Grade 4b	1 (6.3%)
Grade 5	1 (6.3%)
Total	16 (100 %)

Types of Complication after Surgery

In terms of postoperative complications, half of the patients (50%) reported no complications, while the other half reported a variety of issues, including 4 patients (25%) who experienced bleeding, 2 patients (12.5%) who experienced bile leaks, and 1 patient (6.3%) who experienced liver failure. Just one patient (6.3%) died after surgery due to sepsis. Ascites, pleural effusions, wound infection were not detected in any cases (table 3.5).

Table (3.5): Complications and Death

Complications and death	Number of patients (percentage)
Bleeding	4 (25%)
Bile leak	2 (12.5%)
Liver Failure	1 (6.3%)
Death	1 (6.3%)
No complication	8 (50%)

DISCUSSION

In a liver resection, blood loss and blood transfusions during and after surgery are crucial prognostic outcomes. As a result, several authors have suggested vascular control techniques to limit blood loss during liver resection. Pringle conducted complete inflow control (clamping of the whole hepatic pedicle) for the first time in 1908 to reduce blood loss (45). Unfortunately, this action resulted in bowel congestion and complete hepatic parenchymal ischemia. Longer pedicle clamping times increased parenchyma damage, particularly in individuals with chronic liver disorders and cirrhosis. In order to avoid intestinal congestion and total liver ischemia, particularly in the remnant of the liver, Bismuth and Makuuchi et al. launched temporary SHVO for both the hepatic portal vein and the hepatic artery of the right or left Glissonean pedicle (intrafascial extrahepatic hepatic pedicle approach) based on the principles of the Lortat-Jacob and Ton That Tung methods (46,47). Moreover, Yamamoto et al., Galperin and Karagiulian, Launois and Jamieson defined the Glisson capsule, which is now known as the extrafascial Glissonean approach, and explained how it covers the portal vein, biliary tree, and all hepatic arteries (34,48) Takenaka (1996), Malassagne et al., Wu et al., and more recently Tanaka et al., Fu et al. and Ji et al. (49–51) were among the numerous researchers who (34) announced liver resection studies after SHVO. This technique helps to precisely identify the hepatic transection lines based on the ischemia and nonischaemic area (demarcation line) while conducting selective hepatic inflow vascular control and occlusion. It also lessens blood loss during liver resection.[i]

In this study, we would like to share our experience in applying the vascular control in liver resection and evaluate the outcomes. We evaluate the Glissonean pedicle in two ways: the extrafascial extrahepatic and intrafascial extrahepatic glissonean pedicle clamping. (Table 2,8). Among 11 patients with extrafascial technique, there were 4 patients (25%) received right or left glissonean pedicle technique and 7 (43.8%) patients with right or left Glisson pedicle dissection and sectional or segmental Glisson pedicle.

For intrafascial approach, for right or left Glisson pedicle dissection (right or left portal vain and hepatic artery was separately dissected) was achieved in 5 patients accounting for (31.3%).

Two patients (28.6%) underwent non-anatomical 6,7 among 7 (43.8%) patients with extrafascial intrahepatic dissection. 5 patients (31.3%) had intrafascial extrahepatic approaches, and 3 of those patients had anatomical 4,5,8 resections (60%) done. Moreover, a 25% extrafascial extrahepatic technique was only used on 4 patients.

For liver resection, we prefer extrafascial approach because it is saving time and decrease the amount of blood loss. Average operative time of extrafascial technique for right or left Glisson pedicle was 208.18±36.556 minutes including resection, statistically significantly shorter than intrafascial technique (294.00±16.733) minutes. In addition, the mean of blood loss in extrafascial approach was significantly less than intrafascial technique (236.36±89.696, 400.00±93.541 respectively).

There are two points on the division and ligation of the Glissonean pedicle. One should always clamp, ligate and divide the Glissonean pedicle before transecting the parenchyma when doing Glissonean pedicle dissection (36). This will prevent injury to the remaining Glissonean pedicle. Glissonean pedicle was transected following parenchymal transection since the others were worried about anatomical variance and the likelihood of remaining bile duct damage (especially for major liver resection) (51). This is consistent with our findings, since we usually dissect the Glissonean pedicle first (either using an intrafascial or extrafascial method to regulate and occlude the inflow), then transected the liver parenchyma, and last divided the Glissonean pedicle for either a right- or left-sided liver resection, or for segmental resection. Therefore, we are more assured than transecting the related pedicle right after finding them as the first opinion, based on the 2 following evidence (36). First, by separating the Glissonean pedicle intrahepatically, the anatomical variance of the biliary tract will be better regulated, limiting the risk of bile duct damage to the remaining liver. Second, following parenchyma transection, the pedicle will be clearly exposed, providing a favourable working area for the surgeon to manipulate. Additionally, the larger length of the resected pedicle will make pedicle ligation safer and simpler (36) .

Conclusion:

1. In Extrafascial approach, there was less blood loss and transfusion, and the duration of surgery was shorter.

2. Extrafascial approach is safe, feasible and effective method to resect precisely liver masses and less complications in the remnant liver.
3. Extrafascial intrahepatic approach is preferred in hepatic masses in porta hepatize.

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