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ORIGINAL ARTICLE

Evaluation of intrahepatic, extra-Glissonian stapling of the right porta hepatis vs. classical extrahepatic dissection during right hepatectomy

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Abstract

Background: Control of hepatic inflow is a key manoeuvre during right hepatectomy and has traditionally been achieved by extrahepatic dissection of the component right portal inflow structures at the hepatic hilum. An alternative technique is the anterior intrahepatic approach (AIA), in which the Glissonian sheath is isolated within the substance of the liver during parenchymal transection and secured using an endovascular stapling device. This study evaluates the intrahepatic, extra-Glissonian technique in comparison with classical extrahepatic dissection (EHD) in right hepatectomy.

Methods: A retrospective case-controlled study referring to a 20-year period identified 342 consecutive patients who underwent right hepatectomy for colorectal liver metastases from a prospectively compiled database. The AIA to right hepatectomy was used in 182 of these patients and the extrahepatic approach in 160. The two groups were matched for age, gender, stage of primary tumour and number and size of metastases. Outcome measures included safety factors (bleeding, bile duct injury and gun failure), operative duration, oncological margin, morbidity and mortality.

Results: There were no significant differences between the two groups in terms of operative duration (240 min vs. 260 min) or postoperative change in haemoglobin (1.3 g/dl vs. 1.4 g/dl). The AIA was associated with lower operative blood loss (355 ml vs. 425 ml; $P \leq 0.001$), a reduced rate of significant morbidity (14.6% vs. 23.1%; $P = 0.005$), better R0 resection rates (93% vs. 89%; $P = 0.014$) and a lower 90-day mortality rate (3% vs. 7%; $P = 0.046$). There was one minor bile leak in each group, two clinically significant bile leaks requiring endoscopic retrograde cholangiopancreatography and stenting in the extrahepatic group, and a further persistent bile leak requiring biliary reconstruction in each group. In two instances the endovascular stapler misfired. Both cases were dealt with at the time of surgery with no further sequelae. The length of hospital stay was equivalent in the two groups (8 days vs. 9 days).

Conclusions: In selected patients, intrahepatic, extra-Glissonian stapled right hepatectomy is feasible, safe and avoids the need for EHD. The anterior approach to right hepatectomy may achieve outcomes at least as good as those associated with the classical extrahepatic approach.

Keywords

liver resection, right hepatectomy, surgical approach, inflow control

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Introduction

Major hepatectomy may be divided into the key stages of liver mobilization, vascular inflow control, parenchymal transection and hepatic venous outflow control. Although the order of these steps may vary, a safe means of control of the right-sided inflow structures represents a vital aspect of right hepatectomy.

The classical approach to right hepatectomy involves extrahepatic dissection (EHD), ligation and division of the right hepatic artery and right portal vein (with a more recent trend towards

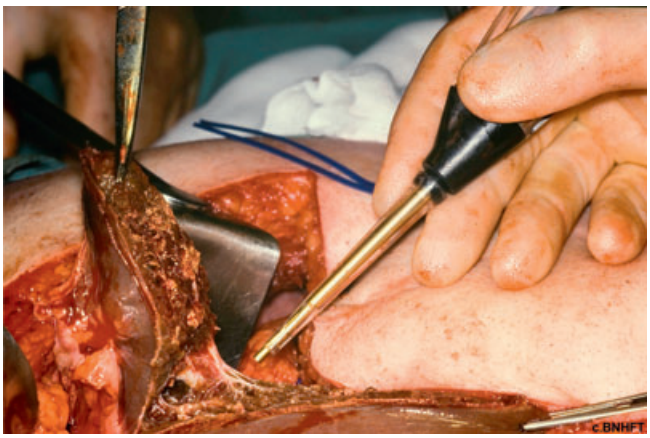

Figure 1 Cavitron ultrasonic surgical aspirator (CUSA) dissection of the inflow portal pedicle

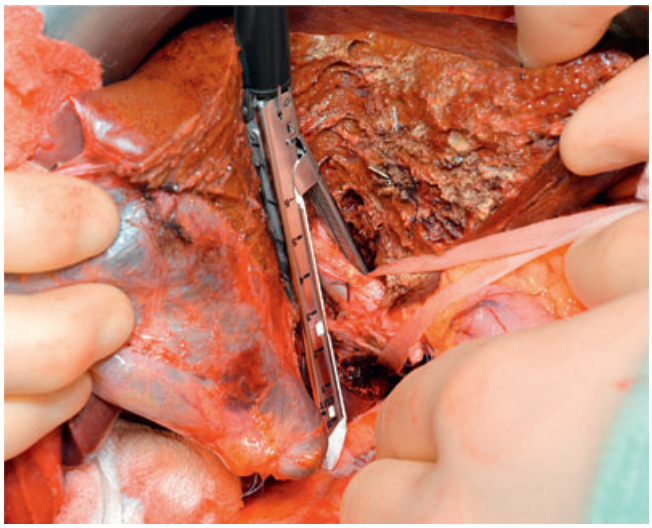

Figure 2 Application of an endovascular stapling device for control of the right main inflow pedicle. The nylon tape is retracted firmly to the left during application of the stapler to protect the left-sided portal structures

division of the right hepatic duct within the hilar sheath during parenchymal transection in an attempt to minimize the risk of damage to the biliary confluence). It offers potential advantages by providing a line of vascular demarcation to guide parenchymal division and selective inflow control to facilitate transection, particularly when the Pringle manoeuvre is not utilized. The first classical right hepatectomy, attributed to Lortat-Jacob and Roberts,[1] was performed in 1952 and heralded a new era in liver surgery.[2]

An alternative technique comprises control and division *en masse* of the inflow structures within the Glissonian sheath inside the substance of the liver itself, known variously as the anterior intrahepatic or 'pedicle ligation' technique. This concept was first established in 1965 in a seminal report by Ton That and Nguyen Duong on the 'anterior transparenchymatous approach'[3], provoking debate with contemporaneous surgical anatomists such as Couinaud.[4] The intrahepatic approach has since been popularized by others such as Takasaki *et al.*[5] and Launois and Jamieson ('posterior intrahepatic approach').[6]

The perceived advantage of the anterior intrahepatic approach (AIA) is that it avoids the need for EHD within the hepatic hilum, which potentially reduces both operative time and the risk of iatrogenic injury to the left-sided structures, a problem that is particularly pertinent given the numerous anatomical variations that can be found in this region. Additionally, the intrahepatic approach may be extended to achieve more selective distal control of the sectional and segmental inflow pedicles, providing greater flexibility for parenchymal sparing resections. This aspect may become more important with wider uptake of multiple or staged resections against a background of chemotherapy-associated hepatotoxicity.

Two major technological advances have facilitated the AIA. Ultrasonic dissection[7] (Fig. 1) permits precise and accurate parenchymal dissection to facilitate isolation of the inflow pedicles, and modern endovascular stapling devices[8] provide a rapid and secure means for transection *en masse* of the vascular and biliary structures within the Glissonian sheath (Fig. 2). As a result, our preferred approach is to avoid EHD of the inflow structures and to secure the inflow pedicle within the liver substance. The current study compares the AIA with classical EHD in right hepatectomy, with particular reference to feasibility and safety.

Materials and methods

A retrospective, case-controlled study derived from a prospectively collected database was performed. The target population included patients who underwent right hepatectomy for colorectal liver metastases and comprised two subgroups identified by either of two surgical techniques: the AIA or classical EHD. The choice of operative technique was not randomized, but fell according to individual surgeon preference. The preferred approach within the Basingstoke Hepatobiliary Unit has generally evolved towards the AIA during the last decade. Patients who underwent EHD did so either because their surgery pre-dated the introduction of modern endovascular stapling devices or because of the proximity (approximately 1–2 cm) of tumour to the portal bifurcation, which precluded the use of a stapling device as a result of limited access and/or concerns regarding resection margin involvement (Fig. 3).

The primary outcome measures were operative duration, safety (in terms of bleeding, bile duct injury and stapling device failure), morbidity, mortality and oncological margin.

A total of 342 consecutive right hepatectomies for colorectal liver metastases were included in the study, with two similarly sized and well matched groups. Parenchymal transections were

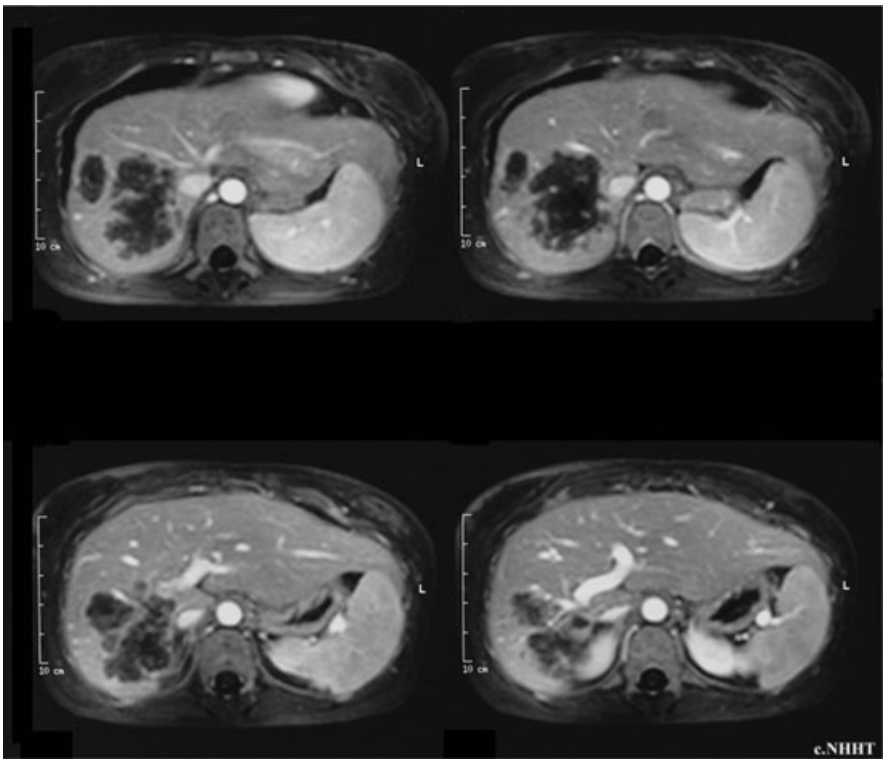

Figure 3 A tumour in close proximity to the portal confluence requires an extrahepatic dissection of the inflow structures to ensure a radical margin

performed with intermittent inflow occlusion, generally comprising cycles of 20 min inflow occlusion alternating with 5 min reperfusion. The stapling device used throughout the study period was the Auto-suture Endovascular Device (Covidien UK, Gosport, UK), with cartridge sizes as appropriate to the structures being secured.

Data were tested for normality of distribution using a Kolmogorov–Smirnov test; age was the only continuous variable found to be normally distributed. The groups were therefore compared by means of descriptive statistics, *t*-test for age, Wilcoxon's signed rank test for all other continuous variables and Cochran's Q test for binary categorical variables. All statistical analyses were performed using SPSS Version 15 (SPSS, Inc., Chicago, IL, USA).

Results

Demographics

For the period of the study, the Basingstoke Liver Database held details of 1605 liver resections, of which a total of 342 were right hepatectomies for colorectal liver metastases. Mean patient age at the time of surgery was 62 years (range 30–84 years). A total of 182 procedures were performed using the AIA and 160 using EHD. The two groups were well matched for age, sex, ASA (American Society of Anesthesiologists) grade, hepatic tumour burden, stage of primary tumour, exposure to preoperative chemotherapy and quality of background liver parenchyma (Table 1).

The distribution of hepatic disease was similar in the two groups (Table 2), although significantly more patients in the EHD group underwent additional procedures such as wedge excision or further segmentectomy (63.1% vs. 37.4%; $P = 0.023$) at the time of right hepatectomy. There were also significantly more extended resections in the EHD group (43.1% vs. 15.4%; $P = 0.016$).

Operative duration

Median operative duration (measured from entry to the anaesthetic room to application of dressings at the end of the procedure) was 260 min in the EHD group compared with 240 min in the AIA group ($P = 0.476$).

Safety

Median blood loss was significantly higher in the EHD group than the AIA group, at 425 ml vs. 355 ml ($P < 0.001$; range 75–5344 ml vs. 80–1188 ml). Intraoperative transfusion was performed in 6.3% patients undergoing EHD, with a further 4.4% transfused within the first 48 h, compared with 0.6% and 1.1%, respectively, in the AIA group.

In the EHD group, there were no significant problems with intraoperative bleeding from the stapled portal pedicle and the

Table 1 Background demographics of study groups

	AIA group	EHD group	*P*-value
Mean age, years	62	62	0.953
Age range, years	29–84	30–84	
Sex			
Male, *n* (%)	108 (59.3%)	101 (63.1%)	
Female, *n* (%)	74 (40.7%)	59 (36.9%)	
ASA grade, *n* (%)			0.467
1	5 (2.7%)	0	
2	138 (75.8%)	126 (78.8%)	
3	38 (20.9%)	34 (21.2%)	
4	1 (0.6%)	0	
5	0	0	
Background liver, *n* (%)			0.768
Cirrhosis	1 (0.6%)	0	
Steatosis/steatohepatitis	44 (24.2%)	40 (25%)	
Normal	134 (73.6%)	114 (71.2%)	
Other (fibrosis, sinusoidal dilatation or unknown)	3 (1.6%)	6 (3.8%)	
Pringle time, min			0.533
Median	45	42	
Operative duration, min			0.476
Median	240	260	
Dukes stage of primary, *n* (%)			0.381
A	4 (2.2%)	9 (5.6%)	
B	59 (32.4%)	53 (33.1%)	
C	118 (64.8%)	95 (59.4%)	

AIA, anterior intrahepatic approach; EHD, extrahepatic dissection; ASA, American Society of Anesthesiologists

Table 2 Details of colorectal liver metastases

	AIA group	EHD group	*P*-value
Distribution of disease, *n* (%)			–
Right side only	144 (77.5%)	125 (78.1%)	
Both sides	41 (22.5%)	33 (20.6%)	
Caudate	0	2 (1.3%)	
Number of lesions, *n* (%)			0.461
Solitary	70 (38.5%)	63 (39.4%)	
2 or 3	64 (35.2%)	54 (33.8%)	
4–10	43 (23.6%)	38 (23.7%)	
>10	2 (1.1%)	4 (2.5%)	
Tumour diameter, cm			0.216
Median	4	4	
Range	0.5–15	0.6–20	
Histology, *n* (%)			0.117
R0	169 (92.8%)	142 (88.7%)	
R1	12 (6.6%)	15 (9.4%)	
R2	1 (0.6%)	3 (1.9%)	

AIA, anterior intrahepatic approach; EHD, extrahepatic dissection

majority of cases were completed with one (73%) or two (22%) firings of the staple gun. Two minor bile leaks were identified at the time of division, both of which were controlled with suture reinforcement of the staple line and no subsequent postoperative bile leak. One of these cases may have resulted from operator error as a result of the stapling device being pushed too firmly onto the portal pedicle and causing the tissue to bunch at the angle of the gun.

There were two instances of stapling device failure. In one, the tissue being stapled was too bulky and the stapling cartridge was unable to fully deploy. In the other case, the stapler deployed but locked and could not be released from the pedicle. In both instances, a vascular clamp was placed proximally and the pedicle controlled by sutures.

Morbidity and mortality

Overall 90-day mortality was 3.4%. There were three deaths in the AIA group (1.6%) and seven deaths in the EHD group (4.4%); thus mortality in the EHD group was significantly higher ($P = 0.046$). Seven deaths were caused by non-surgical complications, such as myocardial infarction, pneumonia and thromboembolic events. There was one case of fatal hepatic insufficiency in the

EHD group and one case of multiple organ failure resulting from a small bowel leak in the AIA group. There was a single late death at 4 months, attributable to a surgical complication, in the AIA group, whereby a biliary stricture that had been stented and subsequently reoperated led to late-onset uncontrolled sepsis.

Overall morbidity was comparable between the groups at 31% in the AIA group and 40% in the EHD group. Overall, the majority of complications were treated conservatively in both groups (73.2% in the AIA group vs. 67.2% in the EHD group) and around a quarter required admission to the intensive therapy unit (25% in the AIA group vs. 26.6% in the EHD group).

There was a single minor bile leak in each group, both of which settled conservatively within 12 days. Two persistent bile leaks in the EHD group required endoscopic stenting for resolution (one in conjunction with percutaneous drainage of a collection) and two further ongoing leaks (one in each group) required surgical reconstruction. As mentioned above, one of these patients developed a biliary stricture and an episode of late sepsis leading to death. The other was noted to have established cholangitis and pus in the ducts at the time of the initial hepatectomy and endoscopic treatment was unsuccessful.

Oncological outcome

Factors relating to the hepatic tumour, its distribution and oncological outcome are reported in Table 2. All lesions were histologically confirmed colorectal liver metastases. The number of metastases reported relates to the number of lesions identified by the pathologist at the time of sectioning, rather than the radiological burden of disease on preoperative imaging.

The overall R0 resection rate for hepatic disease was 93% in the AIA group and 89% in the EHD group. The incidence of positive margins was similar in both groups, with R1 rates of 6.6% and 9.4% and R2 rates of 0.6% and 1.9% in the AIA and EHD groups, respectively. Three patients in the EHD group underwent excision of localized nodal disease at the time of liver resection and a further seven patients (four AIA and three EHD patients) underwent clearance of peritoneal or omental nodules. Eleven patients (seven AIA and four EHD patients) underwent liver resection prior to planned excision of pulmonary disease.

Discussion

The study is a non-randomized, retrospective review and is not designed to demonstrate the superiority of one technique over the other. Rather, it is the authors' intention to demonstrate that the anterior intrahepatic approach to right hepatectomy offers a viable alternative to the classical technique of extrahepatic dissection which is feasible in the majority of cases and is at least as safe.

The two groups were well matched in terms of baseline demographics, although the EHD group showed a predilection for more complex and involved resections. It is accepted that a direct comparison of techniques is inevitably confounded by some patient selection issues.

The observed median difference of 20 min in operative duration reflects a combination of the additional time required to perform EHD of the inflow and the higher rate of additional resections (wedges or segmentectomies) performed in the EHD group. Similarly, the higher blood loss associated with EHD may have been influenced by both the additional hepatic resections performed and the potentially difficult transection associated with more unfavourable disease distribution close to the hepatic hilum.

The stapling device was safe and reliable. Technical pitfalls identified from the episodes associated with minor intraoperative complications include attempting to offer too substantial a tissue load which exceeds the capabilities of the stapling device. It is essential to have a fall-back plan and the immediate availability of vascular clamps is important.

The overall mortality rate of 3.4% is comparable with that reported elsewhere for right hepatectomy[9,10] and reflects a practice that strives to maximize operability, even in cases of multiple or widely distributed disease. Differences in reported mortality and morbidity rates between the two groups probably reflect differences in the extent and complexity of the surgery performed, as described.

There were no instances of postoperative bile leak that could be related to the use of endovascular stapling devices during AIA and there were no postoperative sequelae in patients in whom the staple line required suture reinforcement. The reported incidence of biliary complications lies well within the expected range.[9,10]

The observed number and distribution of hepatic metastases and general approach to the management of extrahepatic disease reflects a philosophy supporting an aggressive approach to resection in such patients; no difference in oncological outcome was demonstrated between the two study groups. This suggests that the adoption of AIA is compatible with an aggressive approach to multiple and bilobar disease and is associated with oncological outcomes equivalent to those observed following the use of classical EHD in right hepatectomy.

Conclusions

Ultimately, the choice of surgical approach to right hepatectomy will be determined by the surgeon's individual preference, according to his or her experience and training, as well as by the anatomical constraints presented by the volume and distribution of hepatic disease. The data presented reflect extensive experience with the AIA to right hepatectomy in patients with colorectal liver metastases and demonstrate levels of safety and feasibility at least equivalent to those of the classical extrahepatic approach. The AIA's potential advantages include its avoidance of time-consuming and risky EHD, as well as the greater flexibility it affords in parenchymal transection. We suggest that the anterior intrahepatic approach should form part of the armamentarium of the modern hepatobiliary surgeon.

Conflicts of interest

None declared.

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