International Journal of Surgery 25 (2016) 172–177

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

Redefining major hepatic resection for colorectal liver metastases: Analysis of 1111 liver resections

Gareth Morris-Stiff [a, b], Gabriele Marangoni [a], Abdul Hakeem [a], Shahid G. Farida [a], Dhanwant Gomez [a], Giles J. Toogood [a], J. Peter A. Lodge [a], K. Raj Prasad [a, *]

[a] Departments of Hepatobiliary and Transplant Surgery, St James' University Hospital, Leeds, LS9 7TF, UK
[b] Department of General Surgery, Division of Hepato-Pancreato-Biliary Surgery, Digestive Disease Institute, A100 Cleveland Clinic Foundation, Cleveland, OH, 44195, USA

HIGHLIGHTS

- With the evolution of hepatic surgery, the current definition of a major resection namely ≥3 Couinaud segments is now inadequate.
- Morbidity and mortality data indicate that only when ≥5 segments are excised should a liver resection be termed "major".
- 30 days is inadequate to assess perioperative mortality, and a 90-day follow-up should be adopted to standardise reporting.

ARTICLE INFO

Article history:
Received 19 April 2015
Received in revised form
9 July 2015
Accepted 29 July 2015
Available online 8 September 2015

Keywords:
Colorectal liver metastases
Resection
Morbidity
Liver failure

ABSTRACT

Introduction: A major hepatic resection is currently defined as resection of 3 or more segments. The aim of this study was to analyse the post-operative morbidity and mortality of hepatic resections in relation to the number of segments excised.

Patients and methods: From January 2000 to December 2010, 1111 liver resections were performed for colorectal liver metastases (CRLM). Data were collected from a prospectively maintained database and analysed according to the extent of resection performed.

Results: 457 patients had 1–2, 362 had 3–4 and 292 had 5–6 segments resected respectively. In comparing 1–4 vs. 5–6 segments, overall morbidity (16.7% vs 40.7%; $p < 0.001$), hepatic failure (0.6% vs 10.6%; $p < 0.001$); mean hospital stay (8 vs 13.5 days; $p = 0.000$), mean ICU stay (4.4 vs 6.5 days; $p = 0.01$), 60-day mortality (0.7% vs 3.4%; $p = 0.002$), and 90-day mortality (0.7% vs 3.4%; $p = 0.002$) were significantly different. When analysing the 3–4 vs 5–6 segment resections, morbidity (21.8% vs 40.7%; $p < 0.001$), hepatic failure (1.4% vs 10.6%; $p = 0.000$), 60-day mortality (0.7% vs 3.4%; $p = 0.002$), and 90-days mortality (0.8% vs 3.4%; $p = 0.023$) remained statistically significant.

Conclusions: Differences in outcome would suggest a revision of the current classification. Only when 5 or more segments are excised for CRLM should a liver resection be considered "major".

1. Introduction

Hepatic resection for colorectal liver metastases has shown a significant evolution since the first successful resection was performed by von Langenbuch in 1888 1. Adson and Van Heerden reported the results of the Mayo Clinic experience in 1980, and were the first to demonstrate in a series of patients the value of 'major' liver resection for single colorectal liver metastases (CRLM) [1]. They defined a 'major' resection in their series to be a 'segmentectomy done close to the hepatic hilus'. Scheele and colleagues expanded the concept of resection from a single metastasis to the resection of up to three metastases in 1 lobe in the absence of extrahepatic disease as long as a safe margin was achievable [2]. In 1986, Ekberg et al. concluded that resection for CRLM was indicated in patients with less than four liver metastases including bilobar cases, no evidence of extra-hepatic disease and when a resection margin of at least 10 mm could be achieved [3].

Following the universal acceptance of the Couinaud classification of segmental hepatic anatomy [4], it was Bismuth and Chiche

* Corresponding author. Hepatobiliary and Transplant Unit, St James' University Hospital, Beckett Street, Leeds, Yorkshire, LS9 7TF, UK.
E-mail address: raj.prasad@leedsth.nhs.uk (K. Raj Prasad).

http://dx.doi.org/10.1016/j.ijsu.2015.07.711
1743-9191/

who defined a major resection as resection of 3 or more hepatic segments in 1993, and this definition has been applied in almost all major series to date [5]. With advances in peri-operative techniques, the safety of liver resection has improved in terms of both morbidity and mortality [6–12] allowing removal of larger volumes of hepatic parenchyma without significant impairment of synthetic function thus raising the question as to whether the classification of liver resections should now be modified. Indeed, it was our clinical suspicion that the morbidity of a left or right hemi-hepatectomy was not much different to a lesser resection, and that the majority of morbidity is encountered with resections of 5 or more segments.

The aim of this study therefore was to determine, in a contemporaneous population of patients undergoing resection of CRLM, the post-operative morbidity and mortality of hepatic resection in relation to the number of segments resected. Furthermore, in the light of these findings, whether the existing definition of a major resection remains appropriate.

2. Materials and methods

2.1. Patients

All patients undergoing hepatic resection for CRLM at St. James's University Hospital (SJUH), Leeds, United Kingdom, during the period January 2000 to December 2010 were identified from a prospectively maintained hepatobiliary database. Patients undergoing resection of other malignant and benign pathologies were excluded.

Pre-operative radiological assessment included thoracic, abdominal and pelvic computed tomography (CT), and magnetic resonance imaging (MRI) of the liver. All patients were reviewed in a multi-disciplinary meeting and the extent of the resection, and assessment of functional residual volume made at this time.

Standard demographic data including age, gender, patient co-morbidities, and American Society of Anaesthesiologists (ASA) were extracted from the database.

2.2. Surgery

Intra-operative ultrasound was performed to confirm the findings of pre-operative imaging and to assist in surgical planning. Parenchymal transection was performed using the Cavi-Pulse Ultrasonic Surgical Aspirator (CUSA, Model 200T, Valley Lab., Boulder, Colorado, USA). All resections were performed with the aim of achieving a negative margin. Anatomical resections were performed and documented according to the Brisbane classification [13]. When non-anatomical resections were performed, the consultant surgeon present (GJT, JPAL or KRP) determined the equivalence of the liver volume excised in relation to hepatic segment size rounding to a whole number. The number of Couinaud segments resected was then calculated and recorded [4]. The traditional classification of minor and major resections (1–2 vs. ≥3 segments) was compared to segment duplets (1–2 vs. 3–4 vs. ≥5), and also to an alternative classification 1–4 vs. ≥5 segments.

2.3. Post-operative care

Post-operative data collated from the database included: morbidity rate; hepatic impairment rate; requirement for intensive care unit (ICU) stay; 30-day, 60-day and 90-day mortalities. The severity of post-operative complications was graded according to the Clavien-Dindo system [14]. Post-operative liver failure was defined according to the International Study Group of Liver Surgery (ISGS) guidelines and classified into grades A, B and C respectively [15].

2.4. Statistical analysis

Continuous variables were expressed as means with standard deviations, and compared using the Student's unpaired t test. The Mann–Whitney U test was used when the data was non-parametrically distributed. Categorical variables were compared using the chi-square test or the Fisher's exact test, as appropriate. A p value of ≤0.05 was considered as statistically significant. All statistical analyses were performed using the SPSS for Windows™ version 17.0 (SPSS Inc, Chicago, Ill, USA).

3. Results

During the period of the study, 1111 patients underwent resection of CRLM. The pre-and post-operative features of the cohort as a whole are summarised in Table 1. The patient population was predominantly male at 64.8%. The mean patient age was 64.8 years and 17% were ages 75 or older. A co-morbid condition was present in 47.2% of patients, the most common significant co-morbidity being a cardiac disorder, which was seen in 14% of patients, and 43.8% had an ASA score of ≥2. According to the current definition of extent of resection, a major resection (≥3 segments) was performed in 58.9% of cases. A post-operative complication was experienced by 23.0%, and impaired hepatic function was seen in 3.7% of patients undergoing resection for CRLM. Only a minority of patients (6.4%) required transfer to the ICU post-operatively for organ support purposes, with the mean stay for these patients being approximately 6 days. The mean hospital stay for the overall cohort was 9.5 days. The 30-, 60- and 90-day mortality rates were 1.1%, 1.4% and 1.4% respectively.

The outcomes in relation to the extent of resection performed are summarised in Table 2. Comaprison of the 3 scenarios, namely the traditional definition of minor and major (1–2 vs. ≥3 segments); duplets (1–2 vs. 3–4 vs. ≥5); or (1–4 vs. ≥5) revealed that the only classification able to distinguish outcome measures

Table 1
Demographic and pre-operative features of 1111 patients undergoing resection of CRLM.

	Number of patients (n = 1111)
Gender (male: female)	720: 391
Age (mean ± SD)	64.8 ± 10.7 years
Co-morbidities	524 (47.2%)
Diabetes	64 (5.8%)
Cardiac disorders	155 (14.0%)
Hypertension	75 (6.8%)
Respiratory disorders	44 (4.0%)
ASA grade	
1	624 (56.2%)
2	362 (32.5%)
3	125 (11.3%)
Number of segments excised	
1	240 (21.6%)
2	217 (19.5%)
3	115 (10.4%)
4	247 (22.2%)
5	196 (17.6%)
6	96 (8.6%)
Post-operative morbidity	256 (23.0%)
Hepatic impairment	42 (3.7%)
ICU stay	
Number of patients	71 (6.4%)
Number of days (mean ± SD)	5.7 ± 6.8 days
Post-operative stay (mean ± SD)	9.5 ± 7.9 days
Mortality	
30-day mortality	12 (1.1%)
60-day mortality	16 (1.4%)
90-day mortality	16 (1.4%)