NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedures overview of laparoscopic liver resection

Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee (IPAC) in making recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in January 2005.

Procedure name

- Laparoscopic liver resection.
- Laparoscopic hepatectomy.

Specialty societies

- British Society of Gastroenterology.
- Association of Laparoscopic Surgeons of Great Britain & Ireland.
- Pancreatic Society of Great Britain and Ireland.
- British Association of Surgical Oncology.
- British Transplant Society.

Description

Indications

The most common indication for laparoscopic liver resection is a solitary liver metastasis from a colorectal cancer, but it may also be used for hepatocellular carcinoma (HCC) and for benign liver tumours or cysts.

The early stages of primary and secondary liver cancer are often asymptomatic. As the tumour grows, symptoms may include jaundice, loss of appetite, weight loss, nausea and tiredness.

Benign liver tumours are usually small and do not cause any problems. If they grow large enough, they may cause symptoms such as pain, nausea and vomiting.

Current treatment and alternatives

Open surgical resection, to remove the affected part of the liver, is the standard treatment for patients with localised colorectal liver metastases and HCC. This procedure is performed through a large incision across the abdomen. A number of

alternative therapies have also been developed, including hepatic artery infusion chemotherapy, percutaneous ethanol injection, cryoablation, microwave coagulation therapy, laser-induced thermotherapy, and radiofrequency ablation.

Benign liver tumours are usually treated only if they are causing symptoms. The standard treatment is open surgical resection.

What the procedure involves

Laparoscopic liver resection is performed under a general anaesthetic. The abdomen is insufflated with carbon dioxide and a number of small incisions are made to provide access for the laparoscope and surgical instruments. Diathermy is used to mark the line of transection on the liver surface. The hepatic parenchyma is then transected and the main blood vessels and bile ducts are divided and closed with clips or staples. Hepatic haemorrhage may be reduced by clamping the hepatic pedicle (Pringle manoeuvre), either continuously for a period of time or intermittently throughout the procedure. The resected liver is enclosed in a bag and removed, through a small incision in the umbilical area. Haemostasis of the transection line may be obtained by several techniques including cautery, haemostatic swabs and fibrin glue.

Hand-assisted laparoscopic liver resection allows the surgeon to place one hand in the abdomen while maintaining the pneumoperitoneum required for laparoscopy. An additional small incision is made which is just large enough for the surgeon’s hand and an airtight ‘sleeve’ device is used to form a seal around the incision.

Efficacy

In five studies that compared laparoscopic liver resection with open resection in patients with malignant tumours, there were no statistically significant differences in the extent of the resection margins. One study of 55 patients reported that there was no difference in the overall patient survival rate or disease-free survival rate whereas another study of 27 patients reported that the overall 3-year survival was significantly higher for patients with laparoscopic resection than for patients with open resection (89% versus 55%, $p = 0.04$).

Four of the six non-randomised comparative studies reported that the postoperative hospital stay was significantly shorter after laparoscopic liver resection than after open liver resection. The mean hospital stay ranged from 4 to 15 days for laparoscopic resection compared with 8 to 22 days for open resection.

The Specialist Advisors stated that there were concerns that resection margins may be compromised.

Safety

All the studies reported the rate of conversion to laparotomy, which ranged from 0% (0/30) to 15% (2/13). Five of the seven studies reported that blood transfusion was necessary in 0% (0/18) to 13% (4/30) of patients. Other complications included liver failure, biliary leak, ascites, atelectasis of the left lower pulmonary lobe, pulmonary infection and biliary fistula.

The Specialist Advisors stated that uncontrollable haemorrhage, bile leakage, gas embolism, deep vein thrombosis and infection are the main potential adverse effects of the procedure.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to laparoscopic liver resection. Searches were conducted via the following databases, covering the period from their commencement to December 2004: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and Science Citation Index. Trial registries and the Internet were also searched. No language restriction was applied to the searches.

The following selection criteria were applied to the abstracts identified by the literature search. Where these criteria could not be determined from the abstracts the full paper was retrieved.

Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising methodology.
Patient	Patients with benign or malignant liver disease.
Intervention/test	Laparoscopic liver resection.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on six non-randomised comparative studies and one case series, summarised in Table 1. Two studies compare laparoscopic liver resection and open liver resection in patients with benign or malignant lesions.[1,4] One study compares laparoscopic and open liver resection in patients with HCC or metastatic tumours.[2] One study includes only patients with benign lesions,[6] one includes patients with colorectal liver metastases [3] and the remaining non-randomised comparative study includes only patients with HCC.[5]

The case series includes patients with benign liver tumours only.[7]

Other studies that were considered to be relevant to this overview but have not been summarised in Table 1 are listed in Appendix A.

Table 1 Summary of key efficacy and safety findings on laparoscopic liver resection

Study details	Key efficacy findings	Key safety findings	Comments
Morino M (2003)[1] Non-randomised comparative study Italy 1997–2001 60 patients • Laparoscopic group = 50% (30/60) • Open group = 50% (30/60) Mean age (years): • Laparoscopic group = 56 (range 25 to 78) • Open group = 58 (range 23 to 75) Malignant lesions: • Laparoscopic group = 47% (14/30) • Open group = 83% (25/30) Mean diameter of lesion: 42 mm Type of resection: 43% (26/60) bisegmentectomies, 40% (24/60) segmentectomies, 17% (10/60) wedge resections. Indications: benign (symptomatic, adenomas or suspected malignancies) or malignant lesions (metastases and HCC). Follow-up period not stated.	**Main outcome measures: operative time, hospital stay and resection margins in malignant tumours.** Mean operative time (minutes): • Laparoscopic = 148 • Open = 142 p = not significant Pringle manoeuvre necessary: • Laparoscopic = 13% (4/30) • Open = 53% (16/30) p < 0.05 Mean blood loss (ml): • Laparoscopic = 320 (range 50 to 1500) • Open = 479 (range 100 to 2100) p < 0.05 Resection margins greater than 1 cm for malignant tumours: • Laparoscopic = 57% (8/14) • Open = 56% (14/25) Mean postoperative hospital stay (days): • Laparoscopic = 6.4 (range 2 to 16) • Open = 8.7 (range 2 to 17) p < 0.05	**Complications** Conversion to laparotomy = 0% (0/30) Blood transfusion: • Laparoscopic = 13% (4/30) • Open = 6.6% (2/30) Postoperative ascites: • Laparoscopic = 6.6% (2/30) • Open = 3.3% (1/30) Pleural effusion: • Laparoscopic = 0% (0/30) • Open = 3.3% (1/30) There were no perioperative deaths.	No randomisation. Matched-pair analysis – control group patients were selected from a computer database of open liver resection patients operated from 1988 to 1996 by the same surgeon. Patients were matched for tumour location, type of resection, tumour size, the presence of underlying liver disease, sex, age, and American Society of Anaesthesiologists (ASA) status. No long-term follow-up. The authors state that their patients have not experienced any port site or cutaneous metastasis or abdominal carcinomatosis but no timeframe is stated.

Study details	Key efficacy findings	Key safety findings	Comments
Shimada M (2001)[2] Non-randomised comparative study Japan 1994–2000 55 patients • Laparoscopic group = 31% (17/55) • Open group = 69% (38/55) Mean age (years): • Laparoscopic group = 62 • Open group = 63 Mean diameter of lesion (cm): • Laparoscopic group = 2.6 • Open group = 2.5 Type of resection: left lateral segmentectomy or partial hepatectomy less than systematic subsegmentectomy. Indications: HCC or metastatic liver cancer. Inclusion criteria: solitary tumour, tumour diameter < 5 cm, tumour in lateral segment or in segment 4, 5 or 6. Mean follow-up period (days): • Laparoscopic group = 500 • Open group = 838	**Main outcome measures: operative time, resection margins, length of hospital stay and survival rates.** Median operative time (minutes): • Laparoscopic = 325 • Open = 280 p = 0.18 Median blood loss (ml): • Laparoscopic = 400 • Open = 800 p = 0.08 Mean surgical margin (mm): • Laparoscopic = 8 • Open = 7 p = 0.65 Positive surgical margin (tumour invasion within 5 mm of the surgical cut surface): • Laparoscopic = 41.2% • Open = 50.0% p = 0.54 Mean postoperative hospital stay (days): • Laparoscopic = 12 • Open = 22 p < 0.001 There were no differences in the patient survival rate and disease-free survival rate between the two groups (Kaplan-Meier). No recurrence was found in the stump of the remaining liver after laparoscopic procedure.	**Complications** Conversion to laparotomy = 0% (0/17) Liver failure: • Laparoscopic = 5.9% (1/17) • Open = 5.3% (2/38) Respiratory failure: • Laparoscopic = 0% (0/17) • Open = 5.3% (2/38) During follow-up, 23.5% (4/17) patients in laparoscopic group died and 41.8% (23/55) patients in the open group died.	No randomisation. Patients who underwent open hepatectomy during the same period were selected as controls. Patients in the control group were followed up for a longer period than the laparoscopic group. 17.6% of patients in laparoscopic group and 21.1% of patients in the open group received simultaneous splenectomy because of hypersplenism.

Study details	Key efficacy findings	Key safety findings	Comments
Mala T (2002)[3] Non-randomised comparative study Norway 1998–2001 27 patients (29 procedures) • Laparoscopic group = 48% (13/27) • Open group = 52% (14/27) Mean age (years): • Laparoscopic group = 68 (range 55 to 73) • Open group = 59 (range 24 to 74) Mean diameter of lesion (cm): • Laparoscopic group = 2.6 (range 1 to 6) • Open group = 3 (range 1.5 to 9) All patients had minor resections (nonanatomical wedge resections and left lobectomies). Indications: colorectal liver metastases. Median follow-up period (months): • Laparoscopic group = 8 (range 1 to 35) • Open group = 15.5 (range 3 to 40)	**Main outcome measures: operative time, resection margins and length of hospital stay.** Mean operative time (minutes): • Laparoscopic = 187 (range 80 to 334) • Open = 185 (range 100 to 335) p = not significant Inflow occlusion: • Laparoscopic = 0% (0/15) • Open = 21.4% (3/14) Mean blood loss (ml): • Laparoscopic = 600 (range 100 to 3300) • Open = 500 (range 100 to 3700) p = not significant More than one resection during the same procedure: • Laparoscopic = 33% (5/15) • Open = 14% (2/14) Resection margins greater than 1 cm: • Laparoscopic = 71% (15/21) • Open = 63% (10/16) p = 0.57 Resection margin involvement: • Laparoscopic = 4.8% (1/21) • Open = 11.8% (2/17) Mean postoperative hospital stay (days): • Laparoscopic = 4 (range 1 to 6) • Open = 8.5 (range 5 to 23) p < 0.001	**Complications** Conversion to laparotomy = 0% (0/15) Pneumonia: • Laparoscopic = 7.7% (1/13) • Open = 7.1% (1/14) Atelectasis of the left lower pulmonary lobe: • Laparoscopic = 7.7% (1/13) • Open = 0% (0/14) Reoperation due to bleeding: • Laparoscopic = 0% (0/13) • Open = 7.1% (1/14) Biliary leakage: • Laparoscopic = 0% (0/13) • Open = 14.3% (2/14) There were no perioperative deaths. During follow-up, two patients in laparoscopic group died 11 and 17 months postoperatively. Three patients in the open group died at 11, 18, and 40 months postoperatively.	No randomisation. All patients with minor resections during the study period were included; the choice of technique was left to the surgeon. Patients in the control group had a longer median follow-up period than the laparoscopic group. All patients had previous abdominal surgery with primary tumour removal at least 3 months before liver resection. Most patients, therefore, also had adhesions which complicated the procedures. Five patients also had cryoablation at the same time (three in laparoscopic group and two in control group).

Study details	Key efficacy findings	Key safety findings	Comments
Lesurtel M (2003)[4] Non-randomised comparative study France 1996–2000 38 patients • Laparoscopic group = 47% (18/38) • Open group = 53% (20/38) Mean age (years): • Laparoscopic group = 55 • Open group = 47 Malignant lesions: • Laparoscopic group = 33% (6/18) • Open group = 35% (7/20) All resections were left lateral lobectomies (bisegmentectomies). Indications: benign lesions (symptomatic, diagnosis of hepatic adenoma or cystadenoma, or an uncertain diagnosis on biopsy), hepatocellular carcinomas (HCC) in cirrhotic patients, metastases. Follow-up: 1 month.	**Main outcome measures: operative time, resection margins in malignant tumours and liver function tests.** Mean operative time (minutes): • Laparoscopic = 202 (range 150 to 360) • Open = 145 (range 90 to 180) p < 0.01 Mean clamping time in patients who had a Pringle manoeuvre (minutes): • Laparoscopic = 39 (range 23 to 62) • Open = 23 (range 15 to 45) p < 0.05 Mean blood loss (ml): • Laparoscopic = 236 (range 100 to 600) • Open = 429 (range 200 to 1000) p < 0.05 Resection margins greater than 1 cm for malignant tumours: • Laparoscopic = 83% (5/6) • Open = 100% (7/7) Mean postoperative hospital stay (days): • Laparoscopic = 8 (range 4 to 21) • Open = 10 (range 5 to 26) p = not significant Postoperative rise of serum aspartate aminotransferase (IU/L): • Laparoscopic = 176 • Open = 87 p < 0.05 There were no significant differences in the postoperative rise of serum alanine aminotransferase, decreases in thrombin activity or increases in serum bilirubin.	**Complications** Conversion to laparotomy = 11% (2/18) Blood transfusion: • Laparoscopic = 0% (0/18) • Open = 15% (3/20) Specific liver resection complications (haemorrhage of hepatic section, ascites, subphrenic collection): • Laparoscopic = 0% (0/18) • Open = 15% (3/20) General complications (incisional hernia in port site, pneumonia): • Laparoscopic = 11% (2/18) • Open = 0% (0/20) There were no deaths in either group.	No randomisation. Matched-pair analysis – control group patients were selected from a computer database of open liver resection patients operated from 1990 to 1998 in the same department. Patients were matched for histology, tumour size, and the presence of underlying liver disease. Laparoscopic approach was considered based on the size and location of the lesion and the preoperative diagnosis. Lesions were 5 cm or smaller in diameter but pedunculated lesions could be larger. The Pringle manoeuvre was used in cirrhotic patients or when minor bleeding occurred during transection. No long-term follow-up. May include some patients also reported in Laurent M (2003).

Study details	Key efficacy findings	Key safety findings	Comments
Laurent A (2003)[5] Non-randomised comparative study France 1998–2000 27 patients • Laparoscopic group = 48% (13/27) • Open group = 52% (14/27) Mean age (years): • Laparoscopic group = 62.6 • Open group = 65.9 Mean tumour size (mm): • Laparoscopic group = 33.5 • Open group = 34.3 Type of resection: left lateral lobectomy (bisegmentectomy of segments 2 and 3) segmentectomy, and atypical resection (resection of less than 1 segment). Indications: chronic liver disease and solitary subcapsular HCC lesion localised in the anterior or lateral segment of the liver. Follow-up period not stated.	**Main outcome measures: operative time, resection margins and liver function tests.** Mean operative time (minutes): • Laparoscopic = 267 (range 180 to 360) • Open = 182 (range 90 to 130) p = 0.006 Mean clamping time (minutes): • Laparoscopic = 68 (range 40 to 117) • Open = 25 (range 0 to 60) p = 0.006 Mean blood loss (ml): • Laparoscopic = 620 (range 100 to 1500) • Open = 720 (range 100 to 3000) p = 0.45 Resection margins less than 5 mm: • Laparoscopic = 15.4% (2/13) • Open = 14.3% (2/14) Mean postoperative hospital stay (days): • Laparoscopic = 15.3 • Open = 17.3 p = 0.83 Overall 3-year survival: • Laparoscopic = 89% • Open = 55% p = 0.04 Recurrence rate at 3 years: • Laparoscopic = 44% • Open = 46%	**Complications** Conversion to laparotomy = 15.4% (2/13) Postoperative mortality: • Laparoscopic = 0% (0/13) • Open = 14.3% (2/14) p = 0.2 Blood transfusion: • Laparoscopic = 7.7% (1/13) • Open = 28.6% (4/14) p = 0.49 Ascites: • Laparoscopic = 7.7% (1/13) • Open = 35.7% (5/14) p = 0.15 Liver failure: • Laparoscopic = 7.7% (1/13) • Open = 35.7% (5/14) p = 0.15 Pulmonary infection: • Laparoscopic = 15.4% (2/13) • Open = 7.1% (1/14) p = 0.46 Variceal bleeding: • Laparoscopic = 0% (0/13) • Open = 14.3% (2/14) p = 0.83	No randomisation. Patients with open liver resection between 1990 and 2000 were selected from a computer database and matched for severity of liver disease, tumour size, and type of liver resection. 12% (14/112) of patients fulfilled the selection criteria. Intention-to-treat analysis. May include some patients also reported in Lesurtel M (2003). No patient developed recurrence at the site of resection.

Study details	Key efficacy findings	Key safety findings	Comments
Farges O (2002)[6] Non-randomised comparative study France 42 patients: • Laparoscopic group = 50% (21/42) • Open group = 50% (21/42) Age range: • Laparoscopic group = 18 to 56 years Mean tumour size: • Laparoscopic group = 5 cm (range 2.5 to 11 cm) Type of resection: left lateral segmentectomy, bisegmentectomy, segmentectomy, and tumourectomy. Indications: benign tumours (either symptomatic or resection indicated as part of the diagnosis work-up). Follow-up period not stated.	**Main outcome measures: operative time and hospital stay.** Mean operative time (minutes): • Laparoscopic = 177 • Open = 156 p = not significant Mean blood loss (ml): • Laparoscopic = 218 • Open = 285 p = not significant Mean postoperative hospital stay (days): • Laparoscopic = 5.1 • Open = 6.5 p = 0.0002	**Complications** Conversion to laparotomy = 0% (0/21) Blood transfusion: • Laparoscopic = 4.8% (1/21) • Open = 0% (0/21) Biliary leak: • Laparoscopic = 4.8% (1/21) • Open = 0% (0/21) Haematoma: • Laparoscopic = 4.8% (1/21) • Open = 0% (0/21) Pleural effusion: • Laparoscopic = 0% (0/21) • Open = 4.8% (1/21) Ascites: • Laparoscopic = 0% (0/21) • Open = 4.8% (1/21)	No randomisation. Matched-pair analysis – control group patients were selected from an ongoing database of open liver resection patients during the past 5 years. Patients were blindly matched for age, sex, body mass index, tumour size and topography, and type of resection performed. No long-term follow-up. Patients did not have underlying chronic liver disease. The authors state that in retrospect a number of these patients did not require resection.

Study details	Key efficacy findings	Key safety findings	Comments
Descottes B (2003)[7] Case series Multi-centre (France, Belgium, Italy, Luxembourg) 1992–2000 87 patients Mean age: 41 years (range 17 to 75) Mean diameter of lesion: 6 cm Type of resection: right hepatic lobectomy (n = 1), left hepatic lobectomy (n = 2), left lateral segmentectomy (n = 20), bisegmentectomy S5 and S8 (n = 1), segmentectomy (n = 25), wedge resection (n = 38). Indications: benign liver tumours (focal nodular hyperplasia, liver cell adenoma, haemangioma, hamartoma, hydatid liver cysts, adult polycystic liver disease, liver cystadenoma). Mean follow-up: 13 months (range 2 to 72)	**Main outcome measures: length of hospital stay, disease-free survival.** Mean postoperative stay: 5 days (range 2 to 13) Portal triad clamping: 9% (8/87) Mean duration of total portal triad clamping: 59 minutes (range 20 to 120). Overall and disease-free survival was 100% for patients with solid benign liver tumours. The two patients with adult polycystic liver disease presented persistent asymptomatic liver cysts.	**Complications** • Conversion to laparotomy = 10% (9/87) (4 due to bleeding) • Blood transfusion = 6% (5/87) • Bleeding = 8% (7/87) • Pneumonia = 1% (1/87) • Urinary infection = 1% (1/87) • Residual cystic stones = 1% (1/87) There were no perioperative deaths.	Retrospective study. Standardised questionnaires were sent to 18 surgical centres in Europe, requesting information on patient's characteristics, clinical data, type of tumour, technical details of the operation, and early and late clinical outcome. The length of hospital stay was significantly affected by the extent of hepatectomy and the need for conversion to open laparotomy. Most of the patients included in this study had small, superficial, peripheral lesions located in the left lateral segments or in the anterior segments of the right part of the liver. The authors note that careful patient selection is necessary for this procedure.

Validity and generalisability of the studies

- The studies included heterogenous populations. Some studies included only patients with malignant tumours, some included only patients with benign tumours and some studies included a combination.
- One study specified that it only included patients with a tumour diameter less than 5 cm.[4]
- The extent of resection varied within and between studies.
- None of the studies had a mean follow up of more than 2 years for patients with laparoscopic liver resection. The longest reported mean follow-up period was 16 months.[2]
- None of the studies were randomised controlled studies.
- All of the studies had small patient numbers.

Specialist Advisors' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College.

- This procedure is definitely novel and of uncertain safety and efficacy.
- Open liver resection is the appropriate comparator.
- The key efficacy outcomes include length of hospital stay, recurrence rates of liver cancer, 5-year survival rates, tumour clearance, and operative time.
- Advanced skills in laparoscopy and hepatic resection are required and training is important.
- It is likely to be carried out in specialist centres only.
- Only a small proportion of patients referred for liver surgery would be suitable for laparoscopic liver resection.
- There are concerns that the procedure may be used inappropriately for some cases.

Issues for consideration by IPAC

None other than those described above.

References

1 Morino M, Morra I, Rosso E, et al. Laparoscopic vs open hepatic resection. *Surgical Endoscopy* 2003; 17: 1914–8.

2 Shimada M, Hashizumo M, Maehara S, et al. Laparoscopic hepatectomy for hepatocellular carcinoma. *Surgical Endoscopy* 2001; 15: 541–4.

3 Mala T, Edwin B, Gladhaug I, et al. A comparative study of the short-term outcome following open and laparoscopic liver resection of colorectal metastases. *Surgical Endoscopy* 2002; 16: 1059–63.

4 Lesurtel M, Cherqui D, Laurent A, et al. Laparoscopic versus open left lateral hepatic lobectomy: a case-control study. *Journal of the American College of Surgeons* 2003; 196: 236–42.

5 Laurent A, Cherqui D, Lesurtel M, et al. Laparoscopic liver resection for subcapsular hepatocellular carcinoma complicating chronic liver disease. *Archives of Surgery* 2003; 138: 763–9.

6 Farges O, Jagot P, Kirstetter P, et al. Prospective assessment of the safety and benefit of laparoscopic liver resections. *Journal of Hepato-Biliary-Pancreatic Surgery* 2002; 9: 242–8.

7 Descottes B, Glineur D, Lachachi F, et al. Laparoscopic liver resection of benign liver tumours. *Surgical Endoscopy* 2003; 17: 23–30.

Appendix A: Additional papers on laparoscopic liver resection not included in the summary tables

Article title	Number of patients/ follow-up	Comments	Direction of conclusions
Buell JF, Thomas MJ, Doty TC, et al. An initial experience and evolution of laparoscopic hepatic resectional surgery. *Surgery* 2004; 136; 804–11.	17 patients (21 resections).	Case series. Benign and malignant lesions.	Reoperation for haemorrhage = 12% (2/17) Biliary leakage = 6% (1/17) Death from hepatic failure = 6% (1/17)
Cherqui D, Husson E, Hammoud R, et al. Laparoscopic liver resections: a feasibility study in 30 patients. *Annals of Surgery* 2000; 232: 753–62.	30 patients.	Case series. Benign and malignant lesions.	7% (2/30) conversion rate. 0% mortality rate. Complication rate = 20% (6/30)
Gigot JF, Glineur D, Azagra JS, et al. Laparoscopic liver resection for malignant liver tumours. *Annals of Surgery* 2002; 236: 90–7.	37 patients.	Case series. Malignant lesions.	13.5% (5/37) conversion rate (higher for HCC than for metastases). Reoperation rate = 5% (2/37). Complication rate = 22% (8/37).
Huscher CG, Lirici MM, Chiodini S. Laparoscopic liver resections. *Seminars in Laparoscopic Surgery* 1998; 5: 204–10.	38 patients.	Case series. Malignant and benign lesions.	Postoperative mortality = 2.6% (1/38).
Kaneko H, Takagi S, Shiba T. Laparoscopic partial hepatectomy and left lateral segmentectomy: technique and results of a clinical series. *Surgery* 1996; 120: 475.	11 patients.	Case series. Malignant and benign lesions.	10% (1/11) conversion rate.
O'Rourke N, Fielding G. Laparoscopic right hepatectomy: surgical technique. *Journal of Gastrointestinal Surgery* 2004; 8: 213–6.	12 patients.	Case series.	17% (2/12) conversion rate. Blood transfusion = 33% (4/12). Bile leakage = 8% (1/12).
Rau HG, Buttler E, Meyer G, et al. Laparoscopic liver resection compared with conventional partial hepatectomy – a prospective analysis. *Hepato-Gastroenterology* 1998; 45: 2333–8.	34 patients.	Non-randomised comparative study.	6% (1/17) conversion rate. Significantly shorter hospital stay and operative time for laparoscopic resections.
Takagi S, Kaneko H, Ishii T, et al. Laparoscopic hepatectomy for extrahepatic growing tumor. *Surgical Endoscopy* 2002; 16: 1573–8.	19 patients.	Extra-hepatic growing (EG) tumours and intra-hepatic tumours.	Mean blood loss significantly less and mean operative time significantly shorter for EG tumours.
Tang CN, Li MK. Laparoscopic-assisted liver resection. *Journal of Hepato-Biliary-Pancreatic Surgery* 2002; 9: 105–10.	11 patients. Mean follow-up = 10 months.	Case series.	9% (1/11) conversion rate. Bile leakage = 9% (1/11). No significant long-term complications.

Appendix B: Literature search for laparoscopic liver resection

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in EMBASE, Current Contents, PreMedline and all EMB databases.
For all other databases a simple search strategy using the key words in the title was employed.

1	hepatectomy/ (12348)
2	hemihepatectom$.tw. (298)
3	(liver$ adj5 resection$).tw. (4909)
4	(wedge$ adj5 resection$).tw. (1774)
5	hepatectom$.tw. (8862)
6	segmentectom$.tw. (1006)
7	laparoscop$.tw. (35743)
8	laparoscopy/ (27791)
9	or/1-6 (19855)
10	7 or 8 (40520)
11	9 and 10 (541)
12	hemangioma/ (12167)
13	liver/ (288287)
14	liver$.tw. (383025)
15	13 or 14 (495433)
16	12 and 15 (1179)
17	exp liver neoplasms/ (78755)
18	(liver$ adj5 cancer$).tw. (10307)
19	(liver$ adj5 metastas$).tw. (12071)
20	Carcinoma, Hepatocellular/ (33151)
21	or/16-20 (85649)
22	11 and 21 (212)
23	limit 22 to human (207)