NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of radiofrequency assisted liver resection

Some patient with liver tumours can benefit from liver resection surgery. Radiofrequency energy can be applied as part of the operation, to help minimise bleeding from the surgery

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 August 2006.

Procedure name

- Radiofrequency assisted liver resection.

Specialty society

- Association of upper Gastrointestinal surgeons of Great Britain and Ireland.

Description

Indications

Primary or secondary hepatobiliary cancer. Liver metastasis may occur as part of the disease process of many primary cancers and is particularly common in colorectal cancer. Primary liver cancer includes, most commonly, hepatocellular carcinoma (HCC) and cholangiocarcinoma.

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Current treatment and alternatives

Treatment strategies for liver cancer patients depend on the location of the tumour, the number of tumours and their size, and the origin. Overall primary liver cancer has poor prognosis, and treatment intent is usually palliative. Some patients may benefit from liver transplantation, and fewer from liver resection surgery.

Metastatic disease of the liver, particularly from colorectal cancer primaries, if operable, can have a better prognosis.

Liver tumours can be removed by open or laparoscopic resection. Haemostatic control is one of the major difficulties with this procedure and various methods have been employed such as the Pringle manoeuvre (continuous or intermittent), vascular clamping, inflow occlusion, and total hepatic vascular exclusion. However, vascular control can lead to iatrogenic damage to the liver.

What the procedure involves

Radiofrequency (RF) assisted liver resection aims to transect the liver with minimal blood loss. The procedure is usually undertaken under general anaesthesia and under computed tomography or ultrasound guidance as part of the liver resection surgery. Following a subcostal incision the capsule of the liver is scored, and then a line of dissection is marked at a safe distance from the tumour to be removed. Ablation of liver parenchyma is then achieved using a radiofrequency probe (a number of devices have been employed), using repeat applications until a sufficient depth of coagulation has been achieved. The liver is then resected along this line of necrosed tissue using a scalpel, scissors, electrocautery, or forceps.

Efficacy

Data on RF assisted liver resection were available from one randomised and one non-randomised controlled trial, and from four case series. Outcomes that were reported mainly relate to operative parameters, and few data are available regarding clinical efficacy.

A randomised controlled trial comparing radiofrequency assisted liver resection with a clamp crushing method found that there was no significant difference in total blood loss during the procedure, with the mean loss being 665 ml and 733 ml respectively ($p = 0.450$)[1]. The mean transection time was 79 minutes with radiofrequency-assisted resection and 80 minutes with clamp crushing, and there was no statistically significant difference in mean length of hospital stay, which was 16 days and 18 days respectively ($p = 0.941$).

In a nonrandomised controlled trial and four case series, mean operative blood loss during radiofrequency-assisted liver resection was 30 ml (in two studies)[2,3], 46 ml[4], 100 ml[5] and 120 ml[6]. Across these same studies the mean

operative time was between 90 minutes[6] and 220 minutes[4], although operative techniques differed between studies.

A case series of 15 patients undergoing RF assisted liver resection, followed up for a mean period of 7 months (range 2 to 20 months), reported that there was no local recurrence of liver tumours either on imaging or clinical examination[2].

In four studies, length of hospital stay following radiofrequency-assisted liver resection was reported to be 2[6], 6.5[5] or 8 days (two studies)[2,3].

Safety

All studies included in the overview reported some safety outcomes, but the follow up period was rarely beyond the point of discharge.

In a randomised controlled trial of patients undergoing radiofrequency-assisted liver resection there were three incidents of major biliary leakage and two other incidents of major morbidity among 40 patients; in the same number of patients having clamp crushing resection there were two major biliary leaks, and no other major morbidity[1]. There were no operative deaths in either group.

Bile leaks were observed in 2% (4/170) of patients in one case series of patients undergoing RF assisted liver resection. One patient suffered a pulmonary embolus at 2 weeks' follow up, but there were no postoperative haemorrhages and no reoperations were required[5].

In another case series a biliary leak from a hepatico-jejunostomy occurred in 2% (1/42) of patients soon after surgery, requiring intensive care unit admission and a blood transfusion[3]. In the same case series a subphrenic abscess developed in 2% (1/42) of patients, and one patient developed a chest infection.

In a third case series, significant intraoperative bleeding occurred in one of eight patients being treated by RF assisted liver resection, which required pressure and repeat RF coagulation[4]. One patient developed an abscess at the resection site, and one suffered worsening of heart failure symptoms.

Two studies reported no portative morbidity or mortality[2,6].

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to radiofrequency-assisted liver resection. Searches were conducted via the following databases, covering the period from their commencement to 24 July 2006: Medline, PreMedline, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches. (See appendix C for details of search strategy.)

The following selection criteria (Table 1) were applied to the abstracts identified by the literature search. If these criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded if no clinical outcomes were reported, or if 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 liver tumours whether primary or secondary.
Intervention/test	RF assisted liver resection by a range of interventions.
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 one randomised controlled trial[1], one non-randomised controlled trial[6], and four case series[2,3,4,5].

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed in appendix A.

Existing reviews on this procedure

There were no published reviews identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B details the recommendations made in each piece of guidance listed below.

Interventional procedures

- Laparoscopic liver resection. *NICE interventional procedure guidance* no. 135 (2005) Available from www.nice.org.uk/IPG135

- Radiofrequency ablation for the treatment of colorectal metastases of the liver. *NICE interventional procedure guidance* no. 92 (2004) Available from www.nice.org.uk/IPG092

Technology appraisals

None.

Clinical guidelines

None.

Public health

None.

Table 2 Summary of key efficacy and safety findings on radiofrequency assisted liver resection

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Arita J (2005)[1] **Randomised controlled trial** Japan Study period: Oct 2003 to Apr 2004 **n = 80 (40 RF assisted, 40 clamp crushing method)** Population: age= 67 years, male = 88%, metastatic liver tumour = 26, hepatocellular carcinoma = 46, other = 8, mean tumour size = 28 mm Indications: patients with hepatobiliary malignancy. Inclusion criteria included: age 20 to 79, acceptable clotting profile and ability to perform inflow occlusion at the hepatic hilum at laparotomy Technique: intermittent inflow occlusion used in all patients, observed biliary leakage controlled with fine suturing, and fibrin glue applied to cut surfaces in all patients RF assisted surgery by dissecting sealer at 90W with saline cooling along a transecting plane, parenchyma then divided by scissors of forceps. Or clamp crushing after cauterising the liver capsule, with the live parenchyma fractured by forceps **Follow-up: not stated** Conflicts of interest: study supported by a grant from a foundation	**Surgical parameters** RF assist (n = 40) / Clamp (n = 40) / p = Total blood loss: 665 ml (30 to 2840) / 733 ml (40 to 2550) / 0.450 Blood loss during parenchymal division: 373 ml (20 to 1930) / 535 ml (30 to 1762) / 0.252 Transection time: 79 min (18 to 162) / 80 min (17 to 202) / 0.740 Patients requiring blood transfusion: 2 / 0 / 0.494 Length of stay: 16 days (6 to 65) / 18 days (9 to 30) / 0.941 Mean and (range) values There were no significant differences between groups in any of the efficacy outcomes Multivariate analysis showed that type of transaction was not an independent predictor of blood loss (OR 1.17, 95% CI 0.39 to 3.53, p = 0.777). However, major surgical resection (OR 6.60, 95% CI 1.66 to 32.28, p = 0.011), multiple resections (OR 4.83, 95% CI 1.39 to 19.01, p = 0.017), and concomitant thoracotomy (OR 3.46, 95% CI 1.08 to 12.48, p = 0.045) were predictive of greater blood loss.	**Postoperative complications** RF assist (n = 40) / Clamp (n = 40) / p = Operative deaths: 0 / 0 / N/R Day 3 serum aspirate aminotrans-ferase: 98 units/litre (22 to 784) / 73 units/ml (27 to 452) / 0.091 Day 3 serum total bilirubin: 0.9 mg/dl (0.4 to 2.0) / 0.7 mg/dl (0.3 to 3.8) / 0.171 Biliary leakage (major): 3 / 2 / N/R Biliary leakage (minor): 2 / 2 / N/R Other morbidity (major): 2 / 0 / N/R Other morbidity (minor): 2 / 3 / N/R Mean and (range) values There were no significant differences between groups in any of the safety outcomes	Consecutive patients undergoing hepatic resection at one centre. Randomisation by computer generation allocation with stratification by age, indocyanine green retention rate, and type of resection (major or minor). Clinical and demographic characteristics were not significantly different between groups at baseline. Power calculation to determine sample size required to demonstrate a presumed 200 ml blood loss reduction. No patients were lost to follow up. Multivariate analysis to estimate the effect of the transaction method on blood loss, controlled for nine confounding factors. The clamp crushing method was used selectively in the RF-assisted resection group to prevent tumour rupture and injury to vessels being preserved. There was a median blood loss reduction of 160 ml using RF-assisted resection. A larger sample size may have identified a clinically significant benefit.

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Croce E (2003)[6] **Non-randomised controlled trial** Italy Study period: Jan 1993 to May 2002 **n = 7 (3 RF assisted, 4 argon laser coagulator)** Population: age = not stated, male = 43%, metastatic liver tumour from colorectal primary = 2, benign tumour = 5 Indications: patients with liver tumours (benign or liver metastases) undergoing liver resection Technique: laparoscopic RF-assisted surgery by combined coagulation and resection device. Liver tumour is marked and tissue coagulated by RF energy and then dissected by an incorporated blade. Or argon beam coagulation Resections included segmentectomies, wedge resections and bisegmentectomies **Follow-up = 15 days** Conflicts of interest: not stated	**Surgical parameters** Mean blood loss was 120 ml (range 80 to 200) and mean operative time was 90 mins (range 80 to 200) Hospital stay was 2 days and patients resumed normal physical activity and returned to work at 15 days No repeat surgery necessary	**Complications** There were no perioperative or postoperative complications among the three patients treated with RF assisted resection Postoperative pain at site of mini-laparotomy treated by analgesics	Largely descriptive paper defining operative technique. Method of case selection not described. Tumour size not reported. No comparative analysis of the two treatment procedures described. Authors state that there is a steep learning curve for laparoscopic surgery.

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Geller D A (2005)[5] **Case series** USA Study period: Apr 2001 to May 2004 **n = 170** Population: age = 62 years; male = 55%; primary cancer colorectal = 70, hepatocellular = 13, other = 87; cirrhosis present = 10, Child Pugh grade A = 100% Indications: patients with primary or secondary liver tumours Technique: in cases where lobectomy being performed hepatic vein divided by vascular stapler. Under US guidance liver capsule scored by electrocautery, RF ablation of the liver tissue along the line of transection using a probe at between 90-100 W. The hepatic parenchyma then divided by electrocautery or scissors, large blood vessels are secured by clips, suture, or vascular staplers. Resections included cystectomy, wedge resection, lobectomy and segmentectomy **Follow-up: N/S (until discharge)** Conflicts of interest: primary author is a consultant to device manufacturer	**Surgical parameters** Blood transfusions were required in 4% (6/170) of patients Mean blood loss was 100 ml (range 25 to 500) Mean hospital stay was 6.5 days	**Complications** There were no intraoperative or postoperative deaths. There were no cases of postoperative haemorrhage, and no reoperations were required Bile leaks were observed in 2% (4/170) of patients No abdominal or hepatic abscess occurred A few patients with ileus required transient replacement of nasogasric tube A pulmonary embolus occurred in one patient (1/170) at 2 weeks postoperatively.	Retrospective study. Liver blood inflow occlusion used in some cases. No details provided of case accrual method or case selection criteria. Authors state that there is a learning curve for operators to optimise surgical efficacy, and that surgeons are comfortable after 5 or 6 procedures. No clinical efficacy outcomes are reported.

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Navarra G (2004)[3] **Case series** UK Study period: Jan 2001 to Jul 2004 **n = 42** Population: age = 58 years; male = 62%; primary cancer colorectal = 20, carcinoid = 4, hepatocellular = 3, gallbladder = 3, other = 12 Indications: patients with primary or secondary liver tumours, with CT or MRI scan to exclude unresectable extrahepatic disease Technique: under general anaesthetic and intraoperative ultrasound scanning a right subcostal incision was made. A line marking the periphery of the tumour was made at 1 cm, coagulative dissection along this line with a RF probe with multiple applications. Liver parenchyma was then divided by scalpel. Resections ranged from multiple metastasectomies to hemi-hepatectomies. Thirteen major resections performed **Follow-up: assumed to be to discharge** Conflicts of interest: not stated	**Surgical parameters** All procedures were completed as planned The mean resection time was 50 min (range 30 to 110), the median blood loss was 30 ml (range 15 to 992), Median length of stay was 8 days (range 5 to 86). Haemoglobin values fell from 13.7 g/dl at baseline, to 11.8 g/dl postoperatively. **Liver function** There was a significant decrease in liver function at 25 hours follow up compared with baseline scores, but these normalised at 1 week follow up	**Complications** No patients required intraoperative blood transfusions One patient (2%) had a biliary leak from hepatico-jejunostomy soon after surgery, requiring admission to ICU and blood transfusion One patient (2%) developed a subphrenic abscess requiring percutaneous drainage. One patient (2%) developed a chest infection Postoperative complication rate was 7.1%	No details given of method of case accrual or selection. Operator experience not stated. Only operative and immediately postoperative outcomes are reported. A significant variation in degree of resection undertaken. Authors state that careful use can result in a virtual bloodless resection without vascular occlusion. Authors state that other energy modalities and different applications may be more suitable and reduce the operative time.

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Weber J-C (2002)[2] **Case series** UK Study period: Jan 2000 to Jun 2001 **n = 15** Population: age = 59 years; male = 67%; primary cancer colorectal = 7, other primary site = 8 Indications: patients secondary liver tumours, with CT or MRI scan to exclude unresectable extrahepatic disease Technique: under general anaesthetic and intraoperative ultrasound scanning a right subcostal incision was made. A line marking the periphery of the tumour was made at 1 cm, coagulative dissection along this line with a RF probe with multiple applications. Liver parenchyma was then divided by scalpel. Resections ranged from multiple metastasectomies to hemi-hepatectomies. One major resection performed **Follow-up = 7 months** Conflicts of interest: not stated	**Surgical parameters** All procedures were completed as planned The median resection time was 40 minutes (range 30 to 80) and median overall operative time 205 min (range 95 to 300), the mean blood loss was 30ml (± 10 ml), Median length of stay was 8 days (range 5 to 9) **Local control** There were no detected liver recurrences up to final follow up (range 2 to 20 months) on either imaging or by clinical examination	**Complications** No patient required blood transfusion during or after surgery There was no operative mortality or morbidity	Potentially some of the same patients as reported in Navarra (2004) because some overlap between treatment periods. Authors comment that shorter surgery also reduces anaesthetic time. No details provided of method of patient accrual or patient selection criteria. A range of resection severities are included. Operator experience not stated. These may be initial cases treated.

Abbreviations used: RF, radiofrequency; US, ultrasound; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; OR, odds ratio; 95%CI, 95% confidence interval.

Study details	Key efficacy findings	Key safety findings	Comments
Stella M (2003)[4] **Case series** Italy Study period: Jun 2002 to Nov 2002 **n = 8** Population: age = 65 years; male = 50%; primary cancer colorectal = 5, hepatocellular carcinoma = 3; mean tumour size = 20.7 mm Indications: patients with primary or secondary liver tumours Technique: under general anaesthetic and intraoperative ultrasound scanning a right subcostal incision was made. A line marking the periphery of the tumour was made at 1 cm, coagulative dissection along this line with a RF probe with multiple applications. Liver parenchyma was then divided by scalpel. Two bisegmentectomies, three segmentectomies, and 12 wedge resections were performed **Follow-up = 7 months** Conflicts of interest: not stated	**Surgical parameters** A mean of 68 applications of RF energy were required per resection The median overall operative time 220 min (range 170 to 420), the mean blood loss was 46ml (range 5 to 150 ml) No additional intervention was required to achieve haemostasis The Pringle manoeuvre was not used in any patient **Liver function** Haemoglobin values fell from 12.8 g/dl at baseline to 11.3 g/dl postoperatively All patients had postoperative increase in transaminase and bilirubin levels, but these normalised within 10 days follow up	**Complications** No patient required blood transfusion during or after surgery Significant intraoperative bleeding occurred in 1 of 8 patients which was controlled by pressure and repeat RF applications One of 8 patients developed an abscess at the site of resection One of 8 patients suffered worsening of heart failure post operatively	One patient was treated by intraoperative RF-assisted ablation alone for one unresectable tumour. No details provided of method of patient accrual or patient selection criteria. Operator experience not stated. These may be initial cases treated. A total of 12 tumours resected in 8 patients. No independent evaluation of outcome. No long term clinical outcomes are reported.

Validity and generalisability of the studies

- There is significant variation in interventions among studies, and a number of different devices were used.
- Some studies include patients with hepatocellular tumours, some colorectal metastases, and some a mixture of patients.
- The severity of resection undertaken varies both within and between studies.
- Very little follow up past 1 year, and few studies report on recurrence rates.
- Most studies report on blood loss as the main efficacy outcome.

Specialist advisers' opinions

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

Mr M Rees, Mr D Sherlock, Dr S Battacharya

- One adviser considered this procedure to be established, one that it is a modification of standard resection methods, and one that it is a novel procedure.
- The potential benefits of the procedure are that it irradiates tumours with minimal blood loss, and reduced operating time.
- Advisers report that there has been a case of Budd Chiari syndrome following thrombosis of all hepatic veins. Also bile leakage from cut liver surface, secondary haemorrhage, and diathermy skin burns have been reported.
- Additional theoretical adverse events may include intraoperative spillage of tumour cells and difficulty in assessing clearance margins.
- Some reports of 40% tumour recurrence.
- The procedure should be undertaken within a multidisciplinary team setting in hepatobiliary units.
- Operators need knowledge of liver surgery and experience of the equipment used.
- Audit criteria for this procedure should include measurement of blood loss, operative time, and length of stay, disease free survival and regular computed tomography of the liver, and liver function tests, as well as reporting of adverse outcomes of secondary haemorrhage, bile leak, infections, and diathermy burns.
- An ultrasonic aspiration assistance device is also available.
- If considered by NICE to be safe and effective one adviser thought that this would be taken up by fewer than 10 specialist UK centres, and two that it would be used in a minority of UK hospitals but at least 10.

Issues for consideration by IPAC

- This procedure is a combination of radiofrequency ablation and sharp resection. It was considered that the safety profile of the procedure may differ enough from other resection techniques to justify guidance being produced.

References

1 Arita J, Hasegawa K, Kokudo N et al. (2005) Randomized clinical trial of the effect of a saline-linked radiofrequency coagulator on blood loss during hepatic resection. *British Journal of Surgery* 92: 954–9.

2 Weber JC, Navarra G, Jiao LR et al. (2002) New technique for liver resection using heat coagulative necrosis. *Annals of Surgery* 236: 560–3.

3 Navarra G, Lorenzini C, Curro G et al. (2004) Early results after radiofrequency-assisted liver resection. *Tumori* 90: 32–5.

4 Stella M, Percivale A, Pasqualini M et al. (2003) Radiofrequency-assisted liver resection. *Journal of Gastrointestinal Surgery* 7: 797–801.

5 Geller DA, Tsung A, Maheshwari V et al. (2005) Hepatic resection in 170 patients using saline-cooled radiofrequency coagulation. *HPB* 7: 208–13.

6 Croce E, Olmi S, Bertolini A et al. (2003) Laparoscopic liver resection with radiofrequency. *Hepato-Gastroenterology* 50: 2088–92.

Appendix A: Additional papers on radiofrequency assisted liver resection not included in summary table 2

The following table outlines studies that were considered potentially relevant to the overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

Article title	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in Table 2
Haghighi KS, Wang F, King J et al. (2005) In-line radiofrequency ablation to minimize blood loss in hepatic parenchymal transection. *American Journal of Surgery* 190(1):43–7	Case series n = 8 Follow-up = 12 days	Mean blood loss was 6.5 ml/cm^2 of liver surface resected	Have larger series included in table 2
Jiao LR, Navarra G, Weber JC et al. (2005) Radiofrequency assisted liver resection--a novel technique. *Hepato-Gastroenterology* 52(66):1685–7	Case report n = 1 Follow-up = 6 days	Resection took 45 min with 30 ml blood loss. Patients was discharged on the 6th postoperative day with no complications	Have larger series included in table 2
Miyazawa M, Torii T, Toshimitsu Y et al. (2006) A new laparoscopic-assisted hepatectomy (LAH) utilizing radiofrequency ablation and high-frequency electrocautery. *Journal of Surgical Oncology* 93(1):68–71	Case report n = 2 Follow-up = to 12 months	Compared with laparoscopic hepatectomy this procedure seems safer, more effective, and is quicker	Have larger series included in table 2

Appendix B: Related published NICE guidance for radiofrequency assisted liver resection

Guidance programme	Recommendation
Interventional procedures	**Laparoscopic liver resection. *NICE interventional procedure guidance* no. 135** 1.1 Current evidence on the safety and efficacy of laparoscopic liver resection appears adequate to support the use of this procedure, provided that the normal arrangements are in place for consent, audit and clinical governance. 1.2 Patient selection for laparoscopic liver resection should be carried out by a multidisciplinary team. Surgeons undertaking laparoscopic liver resection should have specialist training and expertise both in laparoscopic techniques and in the specific issues relating to liver surgery. **Radiofrequency ablation for the treatment of colorectal metastases of the liver. *NICE interventional procedure guidance* no. 92** 1.1 Current evidence on the safety of radiofrequency ablation of colorectal metastases in the liver appears adequate. However, the evidence of its effect on survival is not yet adequate to support the use of this procedure without special arrangements for consent and for audit or research. 1.2 Clinicians wishing to undertake radiofrequency ablation of colorectal metastases in the liver should take the following actions. • Ensure that patients offered it understand the uncertainty about the procedure's efficacy and provide them with clear written information. Use of the Institute's *Information for the Public* is recommended • Audit and review clinical outcomes of all patients having radiofrequency ablation for the treatment of colorectal metastases in the liver. 1.3 Publication of research studies with outcome measures which include survival will be useful in reducing the current uncertainty about the efficacy of the procedure. The Institute may

	review the procedure upon publication of further evidence.
Technology appraisals	None applicable
Clinical guidelines	None applicable
Public health	None applicable

Appendix C: Literature search for radiofrequency assisted liver resection

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in other databases.

IP: 345 Radiofrequency-assisted liver resection		
Database	**Date searched**	**Version searched**
Cochrane Library	06/07/06	2006, Issue 3
CRD databases (DARE & HTA)	24/07/06	2006, Issue 3
Embase	25/07/06	1980 to 2006 Week 29
Medline	25/07/06	1966 to July Week 2 2006
Premedline	25/07/06	July 24, 2006
CINAHL	25/07/06	1982 to July Week 3 2006
British Library Inside Conferences	25/07/06	-
NRR	24/07/06	2006, Issue 3
Controlled Trials Registry	24/07/06	-

1	(radio-frequ$ or radiofrequ$ or radio frequ$).tw.
2	bloodless.tw.
3	Blood Loss, Surgical/pc
4	((transfusion adj free) or transfusion-free).tw.
5	(coagulat$ adj3 necrosis).tw.
6	or/1-5
7	((liver or hepat$) adj3 (neoplasm$ or cancer$ or carcinoma$ or adenocarcinom$ or tumour$ or tumor$ or malignan$ or trauma)).tw.
8	exp Liver Neoplasms/
9	or/7-8
10	((liver or hepat$) adj3 (resect$ or transection)).tw.
11	(hepatectom$ or ((liver or hepat$) adj3 (segmentectom$ or sectionectomy))).tw.
12	Hepatectomy/
13	or/10-12
14	6 and 9 and 13
15	animals/
16	humans/
17	15 not (15 and 16)
18	14 not 17
19	limit 18 to english language
20	limit 19 to yr="2000 - 2006"