

# NATIONAL INSTITUTE FOR CLINICAL EXCELLENCE

## INTERVENTIONAL PROCEDURES PROGRAMME

### Interventional procedures overview of percutaneous radiofrequency ablation of renal tumours

#### Introduction

This overview has been prepared to assist members of the Interventional Procedures Advisory Committee 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 June 2003.

#### Procedure name

- Percutaneous radiofrequency ablation of renal tumours.

#### Specialty societies

Specialist advice was sought from:

- *Royal College of Radiology.*
- *British Society of Interventional Radiology.*
- *British Association of Urological Surgeons.*

#### Description

##### Indications

Renal cancer is the eighth most common cancer in men, and the fourteenth most common in women in the UK. Each year, there are more than 3600 new cases of kidney cancer in men, and more than 2200 cases in women.

There are few symptoms in the early stages of renal cancer. The first symptom of cancer of the kidney is often blood in the urine. Pain, haematuria, and a flank mass constitute the classic symptom triad; however, this is only seen in approximately 10% of patients, usually those with advanced disease.

##### Current treatments and alternatives

The standard treatment for renal cancer has been partial or total nephrectomy. The past decade has seen a substantial increase in the detection of small and incidentally discovered renal tumours. This has been, in part, because of improved medical imaging techniques, and is also related to the increased incidence of renal cancer in the general population.

These smaller tumours (smaller than 4 cm) have better prognostic features and clinicians have begun treating some of these tumours with less invasive or nephron-sparing surgery, including laparoscopic partial nephrectomy, cryoablation, high-intensity ultrasound, and radiofrequency ablation.<sup>1</sup>

Radiofrequency ablation has been suggested as an option for patients who are poor surgical candidates or have multiple comorbid illnesses, a solitary kidney, renal insufficiency or unresectable tumours.<sup>2</sup> Radiofrequency ablation may also be a viable treatment option for patients in whom renal preservation is desired, such as those with von Hippel-Lindau disease, a hereditary form of renal cancer.

This overview assess the efficacy and safety of percutaneous radiofrequency ablation in patients with small renal tumours who are poor candidates for surgery or who refuse surgery.

### **What the procedure involves:**

The procedure is carried out either under sedation or under general anaesthesia, using either CT scanning or ultrasound as image guidance. Destruction of the tumour is achieved by heating cancer cells to temperatures exceeding 60°C.

Radiofrequency ablation works by inducing temperature changes by using high-frequency alternating current applied via an electrode or electrodeless placed within the tissue to generate ionic agitation.<sup>3</sup>

Ionic agitation is generated in the areas surrounding the electrode tip as the ions attempt to change directions and follow the alternating current, creating localised friction heat. The resulting frictional heating of tissue surrounding the electrode generates localised areas of coagulative necrosis and tissue destruction.

### **Efficacy:**

The evidence base for this procedure is small and based on case-series studies. In a UK study of eight patients with 11 masses, seven patients (87.5%) remained tumour-free at a mean follow up of 17 months. This supports the findings of a larger study of 29 patients, where 10 out of 12 patients with more than 12 months follow up showed no residual or recurrent tumour on CT imaging. In most of the studies it was unclear at what time point recurrence had been measured. While median length of follow-up had been reported, few studies gave enough information to determine individual data.

There is also some evidence to suggest that larger renal masses (in general greater than 3 cm) require more than one treatment session to achieve the same outcome as smaller masses.

The Specialist Advisors commented that long-term efficacy has yet to be established because only a small number of patients have been treated with this procedure. One Advisor commented that although the treatment can be repeated, the likelihood of failure increases as the size of the tumour increases.

### **Safety:**

Haematomas were the most commonly reported complication in the studies. In a study of 34 patients, three patients developed a haematoma, while in a study of 32 patients, two patients experienced haematomas. Other reported complications included urethric stricture and abdominal pain.

The Specialist Advisors listed the main adverse events as bleeding, infection and ureteric strictures, seeding of the needle track and injury to adjacent bowel were also listed but noted as uncommon.

## Literature review

### Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to percutaneous radiofrequency ablation of renal tumours. Searches were conducted via the following databases, covering the period from their commencement to June 2003: 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 (Table 1) 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

**Table 1 Inclusion criteria for identification of relevant studies**

Characteristic	Criteria
Publication type	Clinical studies included. Emphasis was placed on identifying good quality comparative 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 in appraising methodology.
Patient	Patients with renal cancer who are not candidates for surgery.
Intervention/test	Radiofrequency ablation.
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.

### Studies included in the overview

This overview is based on the evidence from seven studies.<sup>4-10</sup>

All seven studies are uncontrolled and report on a small number of patients. Six of these papers included patients with renal cancer who were poor candidates for surgery. In one paper patients had hereditary forms of renal cell carcinomas, that is von Hippel-Lindau disease (VHL) and hereditary papillary renal cancer.<sup>10</sup>

Appendix A includes a list of studies relevant to this topic but not included in the tables below.

**Table 1 Summary of key efficacy and safety findings**

Study details	Tumour size, technology	Key efficacy findings	Key safety findings	Comments
<p>Gervais, DA et al (2003)<sup>4</sup></p> <p>Uncontrolled study</p> <p>USA</p> <p>34 patients</p> <p>Poor surgical candidates (comorbid condition, life expectancy 1–10 years)</p> <p>24 men, 10 women</p> <p>Age range: 22–86 years; mean age 69 years.</p> <p>Follow up: 3-42.6 months (mean 13.2 months, median 9.9 months).</p>	<p>42 lesions</p> <p>140 ablations, during 54 visits</p> <p>Diagnosis confirmed by biopsy (41) MRI (1)</p> <p>Size: 1.1–8.9 cm; mean 3.2 cm</p> <p><b>Location:</b> Exophytic 29 Parenchymal 2 Central 4 Mixed 7</p> <p>Generator used varied. Target temperature was 105°C (for one type of generator)</p> <p>Ablations performed with CT (33)/US (8) guidance</p>	<p><b>Ablation (measured by CT/MRI)</b> 2 radiologists assessed the images</p> <p>36/42 tumours (86%) (this includes one and two visits)</p> <p>Exophytic 29/29 Parenchymal 2/2 Central 1/4 Mixed 4/7</p> <p>6 patients were not considered a technical success.</p> <p>At the time of writing 3 patients were still undergoing treatment.</p> <p>Results broken down by tumour size, location. In general patients with larger tumours (greater than 3 cm) required more than one visit.</p>	<p><b>Complications</b></p> <ul style="list-style-type: none"> <li>▪ 3 patients developed haematomas (2 major, 1 minor)</li> <li>▪ 1 patient urethral stricture</li> <li>▪ 4 patients died of other causes (2 had residual disease at time of death)</li> </ul>	<p>One clinician had extensive experience in procedure.</p> <p>Successful ablation was defined as absence of enhancement from the 1-, 3- and 6-month follow up. Patients then followed up at 6 monthly intervals.</p> <p>Unclear whether patients were consecutive.</p> <p>Patients originally excluded (patients with Von Hippel-Lindau disease (VHL) and metastatic disease) were included later in the study as experience with the procedure increased.</p> <p>20 patients alive 6 or more months after the achievement of technically successful RF ablation treatment.</p>
<p>Mayo-Smith et al (2003)<sup>5</sup></p> <p>Uncontrolled study retrospective</p> <p>USA</p> <p>1998–2002</p> <p>32 patients</p> <p>Poor candidates for surgery, refused surgery (age or co</p>	<p>32 tumours</p> <p>Diagnosis confirmed by biopsy (18), CT (14)</p> <p>Size: 1–5 cm (mean 2.6 cm)</p> <p><b>Location:</b> Exophytic 29 Mixed 3</p> <p>Internally cooled RF system Average number of RF treatments</p>	<p><b>Ablation (measured by CT)</b> 26/32 tumours (81%) showed no evidence of recurrence at follow-up after one treatment session.</p> <p>6/32 patients showed evidence of recurrence were given a second session.</p> <p>5/6 patients showed no evidence of recurrence after second session.</p>	<p><b>Complications</b></p> <ul style="list-style-type: none"> <li>▪ 2 patients has transient hypertension</li> <li>▪ 2 patients had haematomas</li> </ul> <p>Several patients had pain several weeks after the procedure</p>	<p>Patients were consecutive.</p> <p>Successful ablation was defined as absence enhancement.</p> <p>Noted that masses requiring a second treatment session were significantly larger (greater than 3.5 cm).</p> <p>Follow up after the ablation session was performed at 1-, 3- and 6-months – patients were</p>

Study details	Tumour size, technology	Key efficacy findings	Key safety findings	Comments
<p>morbid conditions)</p> <p>21 men, 11 women.</p> <p>Age range: 52–87 years (mean 76 years)</p> <p>Follow up: 1–36 months (mean 9 months)</p>	<p>per renal mass was 2.4.</p> <p>Average time was 9.2 minutes</p> <p>Average maximum temperature 78.1°C</p> <p>26 patients were treated in a single session</p> <p>Ablation performed with sonography or CT guidance</p>			<p>imaged at the 6-month follow up if there was no residual enhancement.</p> <p>No raw data given on follow-up.</p> <p>On average second session was 4 months after first session.</p>
<p>Su, L-M et al (2003)<sup>6</sup></p> <p>USA</p> <p>Uncontrolled</p> <p>September 2000–October 2002.</p> <p>29 patients</p> <p>Poor candidates for surgery (age, co morbidities).</p> <p>3 patients had VHL</p> <p>Age range: 25–90 years, VHL patients were younger</p> <p>Follow up: 0–23 months; mean 9 months</p>	<p>35 lesions</p> <p>Diagnosis by biopsy</p> <p>Size: 1–4 cm; mean 2.2 cm.</p> <p><b>Location:</b> Exophytic 28 Intraparenchymal 7</p> <p>Ablation with CT guidance</p> <p>Two RF generators were used (17 lesions, 18 lesions)</p> <p>Target temperature 100°C for 10 minutes</p>	<p><b>Ablation (measured by CT)</b> 33/35 (94%) renal lesions required only a single treatment session.</p> <p>11/13 lesions (85%) (12 patients) with more than 12 months follow-up have shown no evidence of residual growth or enhancement.</p> <p>Two patients found to have recurrence (at 3 months and 6 months) – authors state that patients were treated early in the series were likely represented insufficient ablation.</p>	<p><b>Complications</b></p> <ul style="list-style-type: none"> <li>▪ 1 patient abdominal pain (burn)</li> <li>▪ 1 patient died (not procedure related)</li> <li>▪ 8 patients haematomas.</li> </ul>	<p>Successful ablation was defined as absence enhancement.</p>
<p>Farrell et al (2003)<sup>7</sup></p> <p>USA</p>	<p>35 lesions 4 lesions in one patient with VHL</p> <p>Diagnosis confirmed by imaging</p>	<p><b>Ablation (measured by CT, MRI)</b> 20/20 patients (100%) no evidence of recurrence on follow-up</p>	<p><b>Complications</b></p> <ul style="list-style-type: none"> <li>• 3 patients developed ipsilateral pain or paresthesia(2 patients pain</li> </ul>	<p>Larger tumours had extended treatment session.</p> <p>Follow up was at 3 months after</p>

Study details	Tumour size, technology	Key efficacy findings	Key safety findings	Comments
<p>uncontrolled, retrospective May 2000–May 2002.</p> <p>20 patients</p> <p>Prior surgery, refused surgery, poor candidates for surgery, VHL</p> <p>15 men, 5 women.</p> <p>Age range: 27–80 years, mean 64 years.</p> <p>Follow up: 1–23 months (mean 9 months)</p>	<p>(33) and biopsy (2)</p> <p>Size: 0.9–3.6 cm (mean 1.7 cm)</p> <p><b>Location:</b> Exophytic 22 Intraparenchymal 13</p> <p>Two different RF generators were used (12 tumours, 23 tumours).</p> <p>Lesion treatment times ranged from 12–20 minutes</p> <p>Ablation performed with sonography (22) or CT (5) guidance</p>		<p>transient, 1 patient remaining pain at 9 months)</p> <ul style="list-style-type: none"> <li>1 patient perirenal fluid collection</li> </ul>	<p>ablation and then at 6-month intervals.</p> <p>Limited information on patients.</p> <p>Procedure described elsewhere.</p>
<p>Roy-Choudhury et al (2003) <sup>8</sup></p> <p>England, UK</p> <p>Uncontrolled. prospective</p> <p>November 1999–January 2002</p> <p>8 patients</p> <p>Poor candidates for surgery 1 patients VHL 14 sessions</p> <p>6 men, 2 women</p> <p>Age range: 60–88 years, mean 73.4 years</p> <p>Follow up: 10–26 months, mean 17.1 months</p>	<p>11 lesions</p> <p>14 sessions (12 minutes)</p> <p>Diagnosis based on biopsy (3) or CT (8)</p> <p>Size: 1.5–5.5 cm (mean 3.0 cm)</p> <p><b>Location:</b> Exophytic 9 Central 2</p> <p>Ablation performed with sonography or CT guidance.</p> <p>Water-cooled radiofrequency ablation system. Minimum target temperature 60°C.</p>	<p><b>Ablation (measured by CT)</b> 3 days: complete ablation 9/11 masses.</p> <p>7/8 patients (87.5%) no evidence of recurrence at follow-up.</p> <p>7/8 patients no significance rise in creatinine level.</p> <p>No patients needed more than two treatment sessions.</p>	<p><b>Complications</b> Authors note that no significant complications occurred.</p> <p>2 patients died (1 not related to procedure, 1 patient with VHL died from metastatic renal carcinoma).</p>	<p>Unclear whether patient selection was consecutive procedures.</p> <p>One operator performed all procedures.</p> <p>Unclear at what time point outcomes were measured.</p> <p>Larger tumours (greater than 3.7 cm) needed more than one session.</p>

Study details	Tumour size, technology	Key efficacy findings	Key safety findings	Comments
<p>De Baere et al (2001)<sup>9</sup></p> <p>France</p> <p>Case series</p> <p>5 patients</p> <p>Poor candidates for surgery</p> <p>Age range: 59–80 years</p> <p>Follow up: 6–18 months, median 9 months</p>	<p>5 tumours</p> <p>Diagnosis based on biopsy</p> <p>Size: 3–4 cm (mean 3.3 cm)</p> <p><b>Location:</b> Peripheral</p> <p>Ablation performed with sonography or CT guidance</p> <p>15 minute sessions</p>	<p><b>Ablation (measured by CT)</b> 5/5 patients (100%) no evidence of recurrence on follow-up</p> <p>Two deliveries were needed in one patient</p>	<p><b>Complications</b> Authors state that no complications were encountered related to the procedure or during follow-up.</p> <ul style="list-style-type: none"> <li>▪ 1 patient transient haematoma (less than 2 months)</li> <li>▪ 2 patients macroscopic haematuria</li> </ul>	<p>One operator performed all procedures.</p> <p>Two independent radiologists read the CT scans.</p> <p>Successful ablation was defined as absence enhancement (first CT scan was performed at 2 months).</p> <p>Unclear at what time point outcomes were measured.</p>
<p>Pavlovich et al (2002)<sup>10</sup></p> <p>USA</p> <p>Uncontrolled study</p> <p>21 patients</p> <p>All had hereditary forms of RCC</p> <ul style="list-style-type: none"> <li>• 19 patients VHL</li> <li>• 2 hereditary papillary renal cancer</li> </ul> <p>Mean age: 39 years</p> <p>Follow up: 2 months</p>	<p>24 tumours</p> <p>Size: median 2.5 cm</p> <p><b>Location:</b> Exophytic 13 Central ( 14 – unclear?)</p> <p>Ablation performed with ultrasound or CT guidance</p> <p>Two types of devices used</p> <p>Target probe temperature set to 100°C, tumours heated to 70°C 10-12 minutes</p>	<p><b>Ablation (measured by CT)</b> 19/24 tumours (79%) showed no signs of recurrence at 2 month follow-up</p> <p>5 cases optimal temperature was not reached.</p>	<p><b>Complications</b></p> <ul style="list-style-type: none"> <li>▪ 4 patients experienced pain and numbness</li> <li>▪ 1 patient haematoma</li> </ul> <p>Some patients experienced pain and nausea after the procedure.</p>	<p>Successful ablation was defined as absence enhancement (difference in HU of less than 12).</p> <p>Exophytic/smaller tumours were more successfully treated.</p> <p>Biopsy was not needed because of patient group.</p>

## Validity and generalisability of the studies

- One of the main limitations of the studies is the use of loss of CT lesion enhancement as a surrogate of successful tumour destruction.
- In only one study was it reported that these CT scans were read independently.
- Numbers of tumours, rather than patients were also reported in a number of studies. This is important given that patients with VHL were included and this disease is characterised by multiple tumours.
- Patient characteristics such as tumour location and tumour size varied among the studies. This is important when assessing the generalisability of results. The authors of one study noted that the success rate in their series may have been higher than other reports because of the absence of patients with centrally located tumours.<sup>7</sup>
- Inclusion and exclusion criteria also differed among the studies. This primarily relates to patients with metastatic disease and VHL. In one study inclusion criteria changed as the authors experience with the technique increased.<sup>4</sup>
- It should also be noted that in most studies patients were diagnosed by either biopsy or imaging.
- The generator used to deliver the radiofrequency energy also differed among the studies and within the same study.<sup>6</sup> This seemed to be related to the location and size of the tumour.
- In two of the studies the authors note that recurrence may have been due to insufficient ablation.<sup>6, 10</sup> Experience of the operator and target temperature are two factors that could be related to this finding.
- Further to this, experience of the operator is not commonly reported and the target temperature is not consistent among the studies.
- It was also unclear in most of the studies at what time point recurrence had been measured. While median length of follow-up had been reported, few studies gave enough information to determine individual data.

## Specialist advisors' opinions

- Very few centres in the UK have performed this procedure.
- Because the procedure is new, the safety and efficacy profile of the procedure is not firmly established.
- Pelvi-calyceal injury, haematuria, and thermal gut injury are all potential complications. However, they are rare in the worldwide experience to date.
- The procedure has potential for many patients with small volume, incidentally detected renal cancers. This is a group that is currently not well served by partial nephrectomy.
- Good imaging and interventional radiological skills are needed.

## Issues for consideration by IPAC

- To date the procedure has been used for patients who are considered poor candidates for surgery or who refuse surgery. However, there has been increasing interest in using radiofrequency ablation as a primary treatment.<sup>16</sup>

## References

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- 2 Wood BJ, Ramkaransingh JR, Fojo T, Walther MM, et al. Percutaneous tumor ablation with radiofrequency. *Cancer* 2002; 94(2):443–51.
- 3 Sutherland L, Middleton P, Simpson B. Radiofrequency ablation of liver tumours. *MSAC applications 1025*. 2003. Canberra.
- 4 Gervais DA, McGovern FJ, Arellano RS, McDougal WS, et al. Renal cell carcinoma: clinical experience and technical success with radio-frequency ablation of 42 tumors. *Radiology* 2003; 226(2):417–24.
- 5 Mayo-Smith WW, Dupuy DE, Parikh PM, Pezzullo JA, et al. Imaging-guided percutaneous radiofrequency ablation of solid renal masses: techniques and outcomes of 38 treatment sessions in 32 consecutive patients. *AJR* 2003;180(6):1503–8.
- 6 Su L, Jarrett TW, Chan DY, Kavoussi LR, et al. Percutaneous computed tomography-guided radiofrequency ablation of renal masses in high surgical risk patients: preliminary results. *Urology* 2003; 61(1):26–33.
- 7 Farrell MA, Charboneau WJ, DiMarco DS, Chow GK, et al. Imaging-guided radiofrequency ablation of solid renal tumors. *AJR* 2003;180(6):1509–13.
- 8 Roy-Choudhury SH, Cast JE, Cooksey G, Puri S, et al. Early experience with percutaneous radiofrequency ablation of small solid renal masses. *AJR* 2003; 180(4):1055–61.
- 9 De Baere T, Kuoch V, Smayra T, Dromain C, et al. Radio frequency ablation of renal cell carcinoma: Preliminary clinical experience. *Journal of Urology* 2002; 167(5):1961–4.
- 10 Pavlovich CP, Walther MM, Choyke PL, Pautler SE, et al. Percutaneous radio frequency ablation of small renal tumors: initial results. *Journal of Urology* 2002; 167(1):10–5.
- 11 Rendon RA, Kachura JR, Sweet JM, Gertner MR, et al. The uncertainty of radio frequency treatment of renal cell carcinoma: Findings at immediate and delayed nephrectomy. *Journal of Urology* 2002; 167(4 I):1587–92.
- 12 Walther MM, Shawker TH, Libutti SK, Lubensky I et al. A phase 2 study of radio frequency interstitial tissue ablation of localized renal tumors. *Journal of Urology* 2000; 163(5):1424–7.
- 13 Jacomides L, Ogan K, Watumull L, Cadeddu JA. Laparoscopic application of radio frequency energy enables in situ renal tumor ablation and partial nephrectomy. *Journal of Urology* 2003; 169(1):49–53.
- 14 Matlaga BR, Zagoria RJ, Woodruff RD, Torti FM, et al. Phase II trial of radio frequency ablation of renal cancer: evaluation of the kill zone. . *Journal of Urology* 2002; 168(6):2401–5.
- 15 Michaels MJ, Rhee HK, Mourtzinos AP, Summerhayes IC, et al. Incomplete renal tumor destruction using radio frequency interstitial ablation. *Journal of Urology* 2002; 168(6):2406–9.
- 16 Bonn D. Radiofrequency ablation: first-line treatment for renal cancer? *The Lancet Oncology* 2002; 3(1):3.

## Appendix A: Studies not included in the summary tables

Article	Number of patients	Follow-up/ comments	Direction of the conclusions
Ogan K, Jacomides L, Dolmatch BL, Rivera FJ, et al. Percutaneous radiofrequency ablation of renal tumors: technique, limitations, and morbidity. <i>Urology</i> 2002; 60(6):954–8.	12	Mean 4.9 months	
Gervais DA, McGovern FJ, Wood BJ, Goldberg SN, et al. Radio-frequency ablation of renal cell carcinoma: early clinical experience. <i>Radiology</i> 2000; 217(3):665–72.	8	Mean 10.3 months  Earlier paper of {16}	
Lewin, J.S., Nour, SG, Connell CF. <i>Follow-up findings of a phase II trial of interactive MR-guided radiofrequency thermal ablation of primary kidney tumours</i> (abstract). Proceedings of the 10 <sup>th</sup> Scientific Meeting of the International Society for Magnetic Resonance in Medicine; Honolulu, Hawaii, 18-24 <sup>th</sup> May 2002.	10	Mean 18.5 months  Abstract	
Michaels MJ, Rhee HK, Mourtzinis AP, Summerhayes IC, et al. Incomplete renal tumor destruction using radio frequency interstitial ablation. [comment]. <i>Journal of Urology</i> 2002; 168(6):2406–9.	15	RF before partial nephrectomy	
Rendon RA, Kachura JR, Sweet JM, Gertner MR, et al. The uncertainty of radio frequency treatment of renal cell carcinoma: Findings at immediate and delayed nephrectomy. <i>Journal of Urology</i> 2002; 167(4 1):1587–92.	10	RF at immediate and delayed nephrectomy	
Walther MM, Shawker TH, Libutti SK, Lubensky I, et al. A phase 2 study of radio frequency interstitial tissue ablation of localized renal tumors. <i>Journal of Urology</i> 2000; 163(5):1424–7.	4	RF before surgical removal	
Matlaga BR, Zagoria RJ, Woodruff RD, Torti FM, et al. Phase II trial of radio frequency ablation of renal cancer: evaluation of the kill zone. [comment]. <i>Journal of Urology</i> 2002; 168(6):2401–5.	10	RF before surgery nephrectomy	

## Ongoing studies

Trial	Study title	Study details	Status
NCIG00 1850	Magnetic resonance guided radiofrequency ablation in treating patients with primary kidney cancer, liver metastases or their solid tumours	Not stated	Currently recruiting patients

## Appendix B: Literature search for percutaneous radiofrequency ablation of renal cancer

The following search strategy was used to identify papers in Medline. A similar strategy was used to identify papers in EMBASE, Current Contents, PredMedline and all EMB databases.

For all other databases a simple search strategy using the key words in the title was employed.

#	Search history
1	radiofrequency.mp.
2	radio frequency.mp.
3	radio-frequency.mp.
4	exp Catheter Ablation/
5	or/1-4
6	renal cancer.mp. or exp Kidney Neoplasms/
7	*"Carcinoma, Renal Cell"/
8	renal masses.tw.
9	or/6-8
10	5 and 9
11	(radiofrequency ablation adj4 renal).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
12	10 or 11