Patient outcome after pulmonary radiofrequency ablation: a prospective analysis of results from a single centre

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Purpose

Thermal ablation has been used for a number of years in the treatment of both primary and secondary malignancies, mainly in the liver and lung. There is growing evidence to support its use, and the Royal College of Radiology predicts that it will have a more important role in the future. The technique is recognised by NICE (1) who acknowledge that further research is required to fully define its exact role. Because of the difficulty in performing true randomised controlled studies, much of the supportive data comes from prospective or retrospective observational studies based upon patient groups that are necessarily heterogeneous.

This single centre study aims to analyse factors affecting survival, recurrence and complication rates following RFA of pulmonary metastases, with a view to further supporting its use in selected patients with oligometastatic disease.

Methods and materials

90 tumours in 45 patients treated with radiofrequency ablation (RFA) between April 2009 and August 2013 during 83 separate procedures were analysed using a prospective database

All procedures were performed under deep conscious sedation (intravenous morphine and midazolam) using pulse oximetry and real time Bispectral Index (BIS) monitoring (Aspect Medical Systems, Inc. Norwood, MA, USA). Patients were positioned depending upon the location of the lesion. Local anaesthetic (20ml 1% lignocaine) was infiltrated to the pleura under CT guidance. Ablation was performed using either the Boston Scientific LeVeen needle (Natuck, MA, USA) or the Covidien Cool-tip system (Mansfield, MA, USA). Choice of equipment was based upon lesion size and location. Various manipulations including introduction of a pneumothorax, hydro-dissection with 5% dextrose solution and electrode angulation were used to achieve satisfactory access and a clear margin.

An ablation zone extending at least 5mm beyond the margin of the lesion, as assessed by the extent of ground glass shadowing on an immediate post treatment CT, was considered satisfactory. If ablation was felt to be unsatisfactory or incomplete the needle was repositioned and the lesion retreated.

A chest X-ray was performed at 4 hours post procedure. Follow up whole body CT imaging was performed at 1 month and then at 3 month intervals until three years and then 6 monthly until 5 years. All CT was performed using a GE Lightspeed 64-slice CT (GE systems, Milwaukee, USA) with dynamic IV contrast enhancement (100mls iodinated contrast (300mg/ml) delivered via a peripheral or central IV line at 3-5ml/sec).

Local recurrence or progression was felt likely when the ablation zone showed an increase in size on the 4 month CT or later, where there was typical enhancement related to the lesion or where there were other morphological changes suggesting regrowth.

The following data were recorded prospectively for each patient: histologically confirmed nature of the primary tumour, site and number of metastases, presence of metastases at other sites and if the patient received pre-treatment chemotherapy or other treatment e.g. prior liver or lung resection (table 1).

On a lesion-by-lesion basis the following data were recorded: site and size of the lesion, technical parameters of the ablation, length of the lesional tumour progression

free survival, overall survival and significant complications. These were defined as complications, which resulted in the patient requiring further treatment or prolonged inpatient stay as a direct result of the RFA. Small pneumothoraces noted on imaging following the procedure and which did not require intervention were not counted as significant.

Images for this section:

Figures and tables (to include)

VARIABLE	N (%)	MEAN SURVIVAL (WEEKS)	LOG RANK (P VALUE)
MAX TUMOUR SIZE			
0-15mm	26 (57.8%)	192	0.143
16-50mm	19 (42.2%)	168	
INITIAL NUMBER ABLATED			
≤ 1	33 (73.3%)	184	0.932
≥ 2	12 (26.7%)	180	
TOTAL NUMBER ABLATED			
≤ 2	34 (75.6%)	195	0.091
≥ 3	11 (24.4%)	150	
UNILATERAL/BILATERAL			
Unilateral	29 (64.4%)	189	0.468
Bilateral	16 (35.6%)	165	
TOTAL NUMBER PROCEDURES			
≤ 2	37 (82.2%)	191	0.28
≥ 3	8 (17.8%)	162	
ADDITIONAL METASTASES			
Yes	16 (35.6%)	158	0.163
No	29 (64.4%)	196	
PRE-RFA CHEMOTHERAPY			
Yes	16 (43.2%)	156	0.18
No	21 (56.7%)	186	
SITE OF PRIMARY			
Colorectal	30 (66.7%)	182	0.42
Other*	15(33.3%)	166	

Table (1) Patient characteristics and survival analysis
*breast (5), gallbladder (1), kidney (1), uterus (1), pelvic sarcoma (1), primary lung cancer (6)

Fig. 1

Results

Survival

Median survival was 105 weeks, with 1 year, 2 year and 3-year survival 95.5%, 89.9% and 77.7% respectively.

Patients who had a total number of tumour lesions # 3 ablated were found to have a mean survival of 150 weeks, compared to 195 weeks in those with a total number of lesions # 2. This almost reached statistical significance (p=0.091) (figures 1 and 2).

The following variables were not statistically significant (table 1): mean maximum tumour size; initial number of tumours ablated; whether the lesions were unilateral or bilateral; total number of RFA procedures performed; the presence of metastases at additional sites; pre-RFA chemotherapy; site of primary tumour.

Tumour Recurrence

17% of the lesions developed evidence of recurrence, with mean and median time to recurrence 32 and 30 (range 7 - 65) weeks respectively (Images 1a-c)

40% of recurrences occurred when the lesions were abutting segmental pulmonary arteries or larger vessels, including the thoracic aorta and superior vena cava.

Two of the patients who developed recurrence had suboptimal ablation. The first experienced an episode of bradycardia requiring atropine and had the procedure aborted; the second received inadequate analgesia and sedation so was unable to tolerate the ablation.

53% of the recurring lesions underwent repeat radiofrequency ablation. Only one demonstrated recurrence after second RFA, with a time to recurrence of 66 weeks. Thus, the secondary (after repeat ablations) effectiveness rate was 90.7% (78 of 86 lesions without tumour progression at the end of follow-up).

Complications

The significant complication rate was 12%.

Pneumothorax requiring insertion of a percutaneous chest drain occurred in a total of 6 ablation treatments.

There were 3 cases of pleural effusion requiring drainage, while one patient developed a post-procedure pneumonia.

One patient who underwent right lower lobe RFA developed a large false aneurysm in a right lower lobe artery (Image 2). This was treated by coil embolisation.

A further patient developed significant chest wall pain, probably due to intercostal nerve damage.

The thirty-day mortality rate following RFA was 0%.

Images for this section:

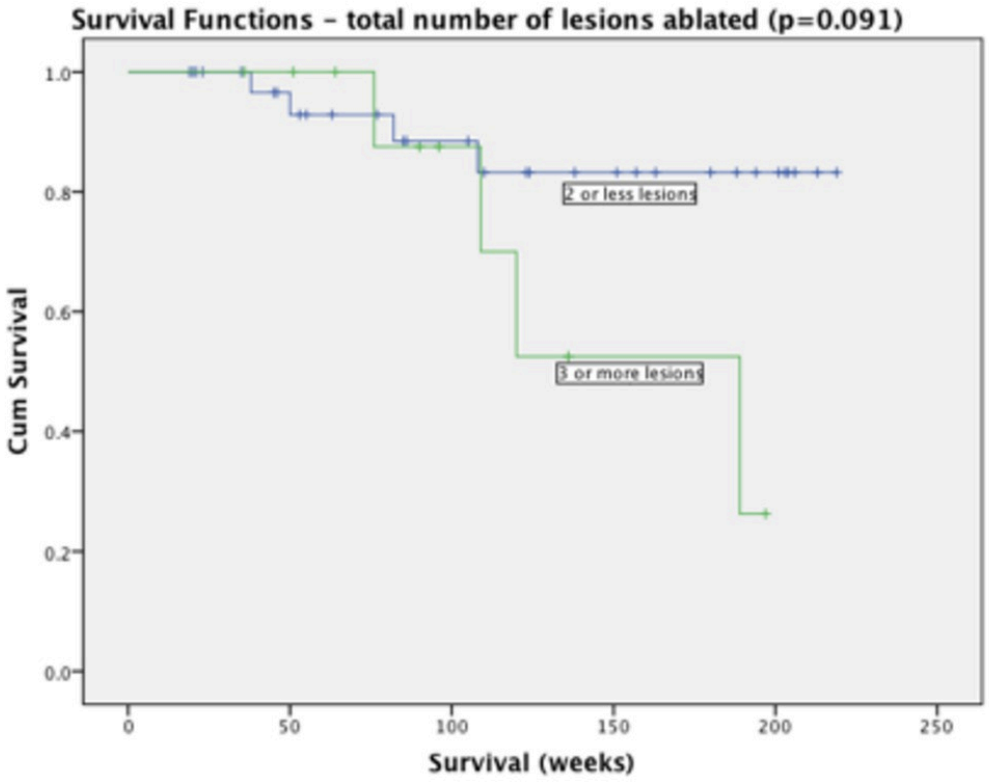

Fig 1. Kaplan Meier curve: Survival as a function of total number of lesions ablated. Survival difference in patients with 3 or more lesions almost reached statistical significance (p=0.091)

Fig. 2

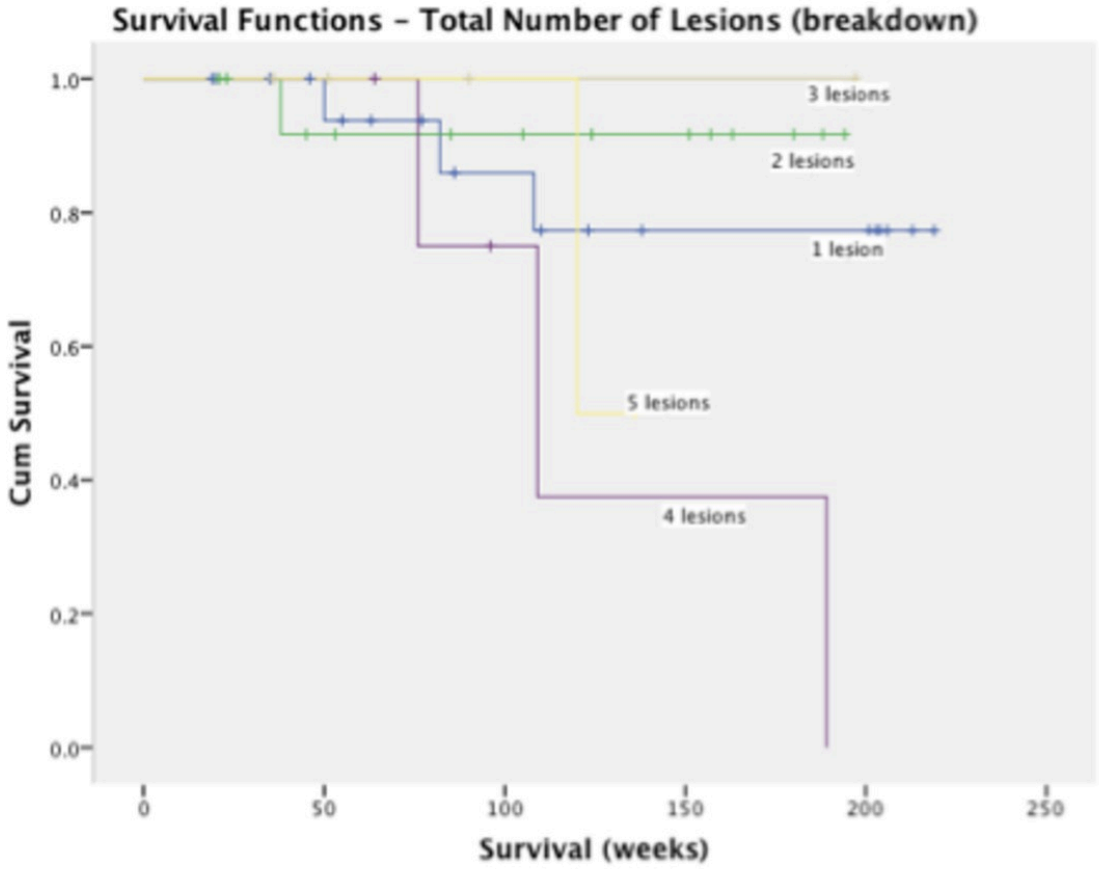

Figure 2. Kaplan Meier curve with total number of ablated lesions broken down

Fig. 3

Image (1): axial CT through the thorax. Satisfactory ablation zone (arrow) at 3 months post RFA of a solitary metastasis from a colorectal primary tumour (a) CT at 6 months (b) shows a small nodular recurrence at the ablation zone margin (arrow). CT performed 1 month after re-ablation shows a satisfactory cavitating ablation zone which encompasses the recurrence (c), arrow.

Fig. 5

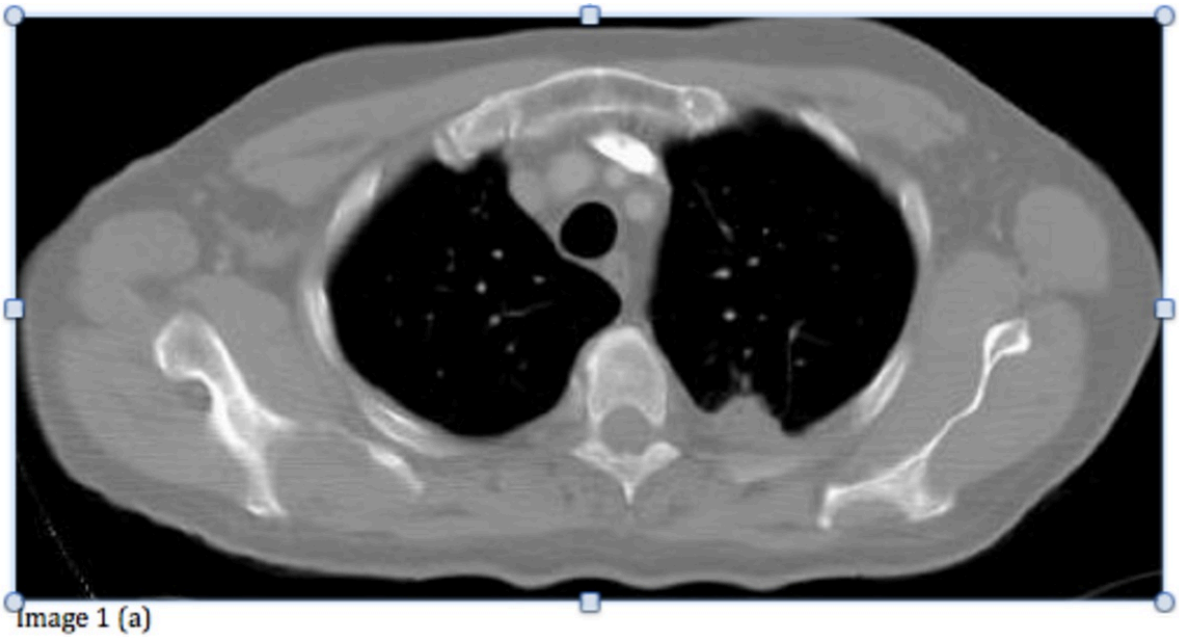

Image 1 (a)

Fig. 6

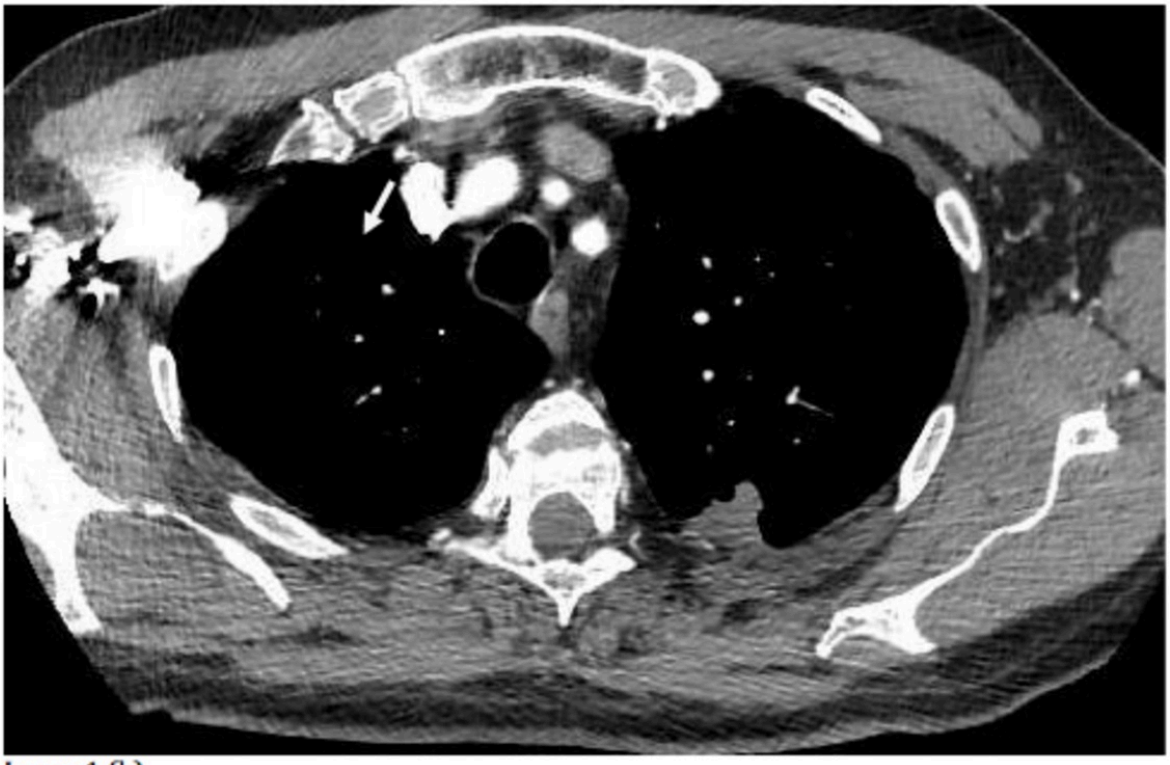

Image 1 (b)

Fig. 7

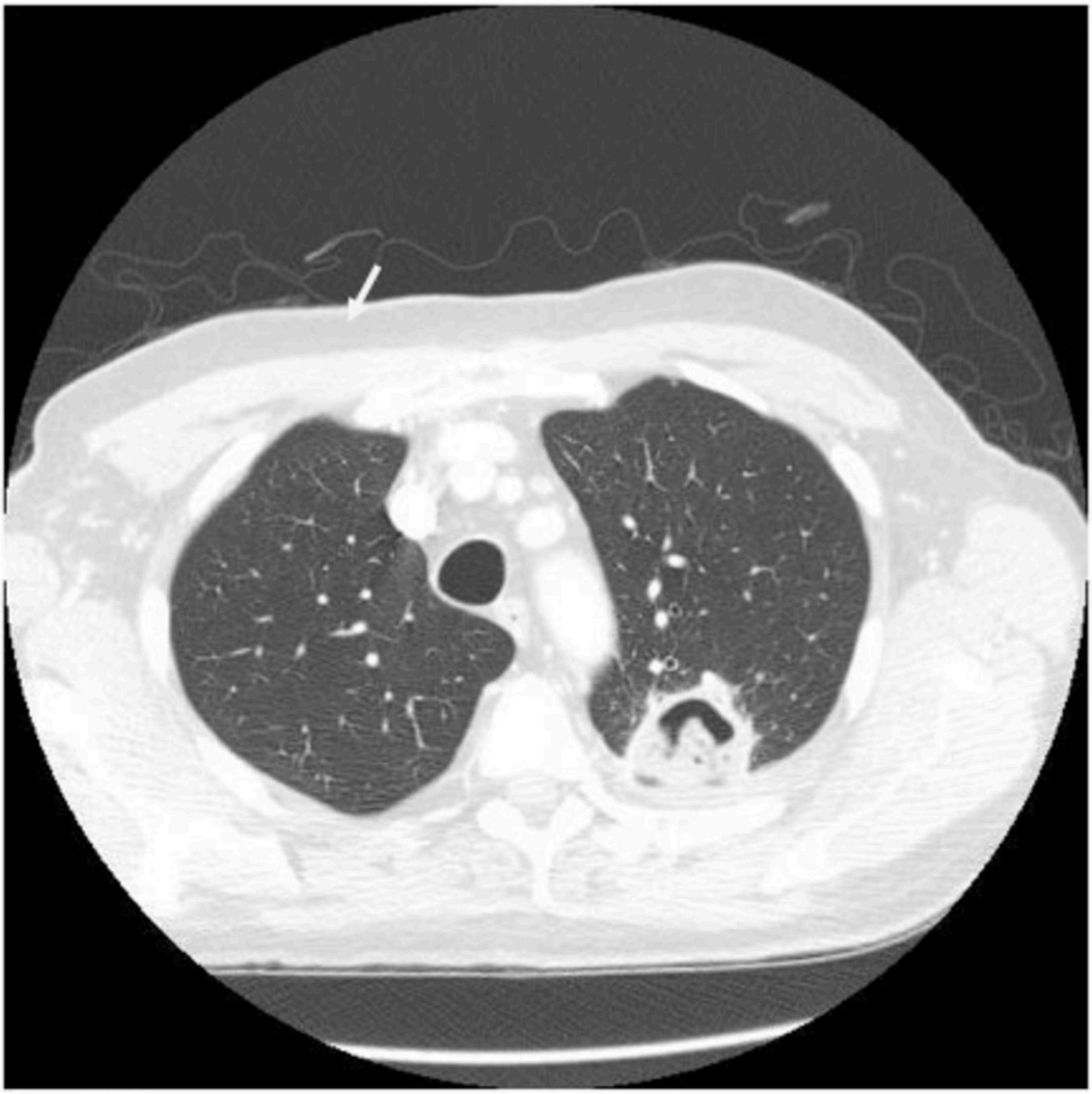

Image 1 (c)

Fig. 8

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Image (2): sagital reformat of a thoracic CT performed three days after RFA of a lower lobe metastasis. There is a pleural effusion together with a 4cm area of enhancement at the ablation site representing a large pseudoaneurysm.

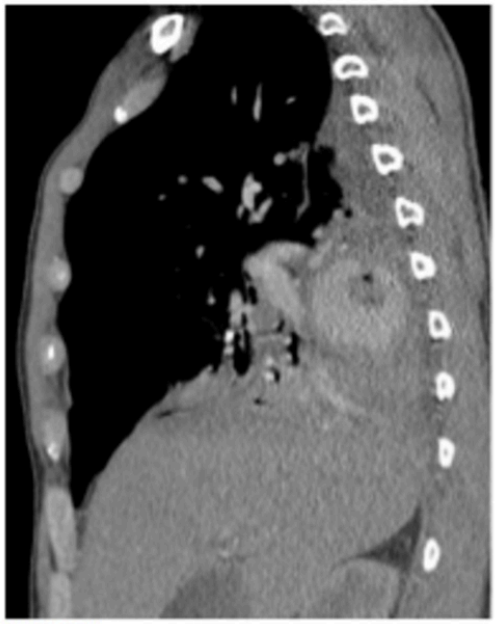

Image 2

Fig. 4

Conclusion

Pulmonary RFA is a safe and well-tolerated technique. Compared with surgical resection RFA is less invasive and may be performed under conscious sedation, either as a day case or with a single night in hospital, with negligible effect on the patient's lung function. When selecting patients for surgical metastatectomy performance status and poor lung function can preclude some patients from surgical treatment (2), whereas this is less likely to preclude patients from treatment with RFA.

The 3-year survival from our data was 77.7% for pulmonary metastases. This compares well with recently published data, which suggested that RFA could provide survival benefit. Gillams et al reported a 3-year survival of 57% in 122 patients (3). Other comparable studies reported a 46% 3 year survival in 55 patients (4), and 47% in 71 patients (5).

The main factors affecting survival were the total number of lesions treated, which came close to reaching statistical significance. Where the total number of lesions treated is 3 or more, then the overall survival is likely to be reduced.

We found no significant relationship between tumour size at the time of RFA and survival. This contrasts with published data, as other groups have found size to be a dominant factor affecting survival. Gillams et al (3) showed that lesions 2 cm or less demonstrated a trend toward better survival than tumours 2.1 cm to 4 cm in size. The majority of lesions treated at our centre were less than 15mm in diameter, and our local practice of treating lesions earlier, when smaller, may account for the apparent lack of a relationship between size and outcome shown in our results. The need for a clear ablation margin parallels that seen in surgical resections. The larger the tumour, the more difficult this is to obtain without multiple overlapping ablation zones. Complete ablation with this adequate margin becomes increasing difficult to ensure with increasing lesion size. For this reason most centres will accept a tumour size, beyond which ablation is likely to be incomplete. This is usually around 3-3.5cm in diameter.

Close proximity to segmental pulmonary or mediastinal vessels was the main risk factor for recurrence. Although not an absolute contra-indication to RFA, it is a significant contributor towards under-treatment.

Our 3-year survival of 77.7% compares favourably with surgical resection (6, 7, 8), suggesting that RFA is equivalent to resection in resectable disease.

The number of lesions ablated at the initial attempt does not appear to impact on survival. It is generally accepted from prior surgical series that surgical resection be limited to those candidates with 3 or fewer tumours (9, 10, 111) to prevent increased morbidity and mortality. This reinforces the usefulness of RFA as an alternative to surgery, as it can be used effectively in treating multiple lesions at the initial attempt while allowing easier re-treatment of recurring lesions.

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