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Kidney Cancer

Treatment of Renal Tumors by Percutaneous Ultrasound-Guided Radiofrequency Ablation Using a Multitined Electrode: Effectiveness and Complications

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Abstract

Background: Radiofrequency ablation (RFA) is a minimally aggressive, therapeutic alternative for renal tumors. It can be an alternative to nephrectomy in patients with previous nephrectomy, bilateral tumors, von Hippel-Lindau disease, or small renal carcinomas and in those with contraindications for surgery.
Objective: To assess the effectiveness of the treatment of renal tumors by RFA in the short and medium term and to identify the possible complications and the factors that determine therapeutic success.
Design, setting, and participants: A retrospective review of patients with renal tumors treated with RFA between May 2005 and December 2008 was performed in a tertiary academic hospital. Patients were selected among those with previous nephrectomy, bilateral neoplasms, von Hippel-Lindau disease, surgical risk, comorbidity, advanced age, or patient's refusal to surgery. Tumors with evidence of extrarenal extension were excluded. Patients were followed up for 10–50 mo using computed tomography and magnetic resonance imaging.
Intervention: Ultrasound-guided RFA was performed on 65 tumors (range: 1.2–5.3 cm) of 58 patients using multitined electrodes.
Measurements: Incomplete ablation rate, therapeutic success rate, and complications rate.
Results and limitations: Therapeutic success was achieved in 59 of 65 tumors (91%): 53 in a single session, 5 in two sessions, and 1 in three sessions. A significant relationship was observed between size and growth pattern of the tumor and both therapeutic success and incomplete ablation rates. Therapeutic success in tumors >5 cm was 60%. Complications were detected in 10 patients (13%); 5% were considered major complications.

Limitations include the lack of pathologic studies to confirm a complete ablation and the lack of a control group to compare with the results of those who underwent nephrectomy.
Conclusions: RFA is safe and effective in renal tumors. Corticomedullary lesions and tumors >3 cm have greater possibility of incomplete ablation. In tumors >5 cm, RFA has a significant failure rate.

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1. Introduction

The detection of renal tumors has increased significantly in recent years, especially after the introduction of multi-detector computed tomography (CT). It is not infrequent that these lesions are detected casually in patients studied for unrelated causes, especially in elderly patients. Although treatment of choice in renal neoplasms is nephrectomy, many of them are benign lesions or small carcinomas that, followed expectantly, would have remained subclinical [1,2]. These patients, along with patients with nephrectomy, bilateral tumors, or von Hippel-Lindau disease and those not suitable for surgery, could benefit from a less aggressive therapeutic approach.

Radiofrequency ablation (RFA) is a minimally invasive procedure used in the treatment of renal tumors [3–23]. Although no reports have been published with 5-yr outcome data to allow comparison of RFA with surgical techniques, initial results suggest that RFA can be useful in the management and treatment of renal tumors [1,10,11,19].

The purpose of this study is to assess retrospectively the effectiveness of renal tumor treatment by a multitined RFA system guided by ultrasound in the short and medium term, and to identify the possible complications and the factors that determine therapeutic success.

2. Material and methods

Between May 2005 and December 2008, 77 RFAs were performed on renal tumors. Candidates for RFA were selected by our urology department among patients with renal tumors suspicious of carcinoma. In our hospital the standard treatment in these cases is nephrectomy. Reasons for using RFA included previous nephrectomy, bilateral neoplasms, von Hippel-Lindau syndrome, high surgical risk, comorbidity, advanced age, and patient's refusal of surgery. Tumors with evidence of extrarenal extension were excluded. All patients signed an informed consent form for the procedure. The study was approved by our institutional review board.

We utilize ultrasound guidance instead of CT whenever possible to perform image-guided techniques, always using a free-hand technique. In all cases the procedures could be performed using ultrasound (HD3500, HD5000, IU11, and IU22 platforms; Philips Medical Systems, Amsterdam, The Netherlands). An ultrasound-guided core biopsy using an 18G automatic needle (BioPince; InterV, Gainesville, FL, USA) was performed on all the lesions, obtaining at least two specimens per tumor. The specimens were immersed in cooled serum and immediately submitted to the pathology department for processing. Besides histologic and immunohistochemical analysis of the specimens, cytology of the centrifuged transport serum was performed.

Ablations were performed using a radiofrequency generator of 200 W (FR 3,000; Boston Scientific, Natick, MA, USA), connected to a multitined electrode (Leveen; Boston Scientific, Natick, MA, USA) with different ablation diameters. We selected an electrode and planned the procedure to create a thermal lesion with a 1-cm margin around the tumor (Fig. 1). In tumors located near the bowel, 5% dextrose solution was injected in the perirenal space to achieve 2 cm of separation between the tumor and the bowel (Fig. 2).

Ablation was performed under intravenous conscious sedation with propofol and fentanyl. Wattage was progressively increased until a rapid rise in impedance (roll-off) was obtained. A new ablation cycle was then performed. When roll-off was not achieved after 20 min, the tines were retracted to decrease the diameter by 1.5 cm, then the procedure was continued until roll-off. The tines then were redeployed and the procedure started again using the maximum wattage until roll-off. Retraction of the electrode was frequently needed in tumors >4 cm. When needed, overlapping ablations were performed to treat the entire volume of the tumor.

Patients were discharged home in 24 h. Follow-up was performed at 1 mo and, thereafter, every 3 mo for 2 yr, using alternately multidetector CT (Somatrom 4 Plus Volume Zoom or Somatom Sensation Open; Siemens, Erlangen, Germany) and 1.5-tesla magnetic resonance imaging (MRI; Magnetom Symphony Maestro Class; Siemens, Erlangen, Germany). The CT exams included nonenhanced, corticomedullary, and excretory series. MRI always included T1, T2, and fat-suppression series and a dynamic study after the administration of gadolinium. After 2 yr, a yearly CT follow-up was scheduled.

Presence of enhancement (>10 Hounsfield Units (HU) difference for CT or >15% of the signal for MRI) at 1-mo follow-up was considered incomplete ablation and in subsequent follow-ups was considered recurrence. Follow-up images were interpreted by consensus of two

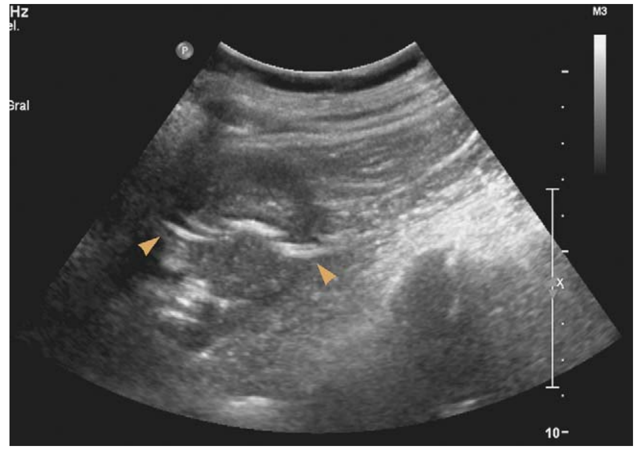

Fig. 1 – Sonographic verification of the placement of the tines in the tumor. Tines exceed the borders of the tumor on the two sides (tips of the arrow).

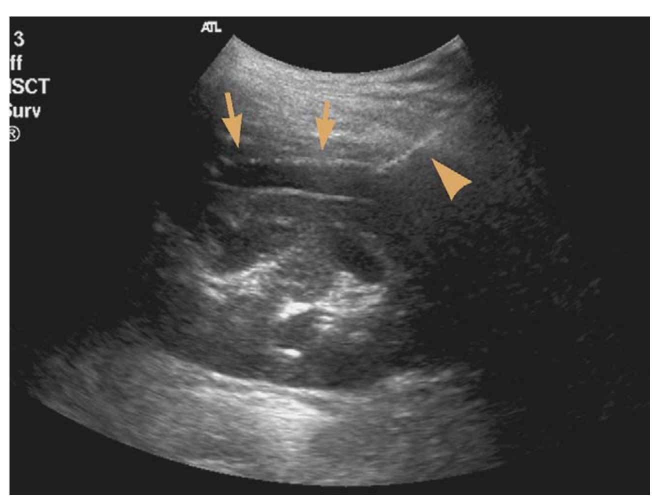

Fig. 2 – A needle (arrowhead) is used to perform an ultrasound-guided perirenal injection of a dextrose solution (arrows) to ensure a safety margin with nearby colon.

skilled radiologists. Patients with incomplete ablation or recurrence were considered candidates for a new RFA.

Demographics of the patients, characteristics and location of the tumors, and outcomes of treatment and follow-up were recorded. We considered tumors to be *cortical* if they were exclusively located in the cortical of the kidney and to be *corticomedullary* if they were contacting the renal sinus fat.

Statistical analysis was performed using SPSS v.15 software (SPSS Inc., Chicago, IL, USA). Student *t* test was used to assess differences between group means. *P* values obtained were based on bilateral analysis. Chi-square test and Fisher exact test were used to compare the qualitative variables. A *p* value of $\leq$0.05 was considered significant.

3. Results

We treated 65 lesions in 58 patients. Demographics of the patients and characteristics of the tumors are shown in Table 1. Twelve tumors were retreated, either for insufficient ablation (8 cases) or for recurrence (4 lesions), so the total number of RFA procedures was 77. The results of the biopsies of the lesions are shown in Table 2. The causes for using RFA are shown in Table 3. In 10 cases, a perirenal injection of a dextrose solution was performed. The volume injected was 50–200 cm^3.

Patients were followed up during 10–50 mo (mean: 26.5 $\pm$ 12). Six patients died during follow-up (2–27 mo after initial treatment): three from dissemination of a concomitant neoplasm, one from multiorgan failure, and one as a consequence of a cardiopathy. Another patient, who presented simultaneous carcinomas of bladder, prostate, and kidney (the latter could not be completely ablated), died from disseminated metastatic disease of undetermined origin.

Incomplete ablation was detected on 1-mo follow-up in 12 of 77 procedures. Late recurrences were observed in five treated tumors and occurred at 4, 7, and 13 (in three cases) mo. Complete ablation was finally obtained in 59 tumors (91%): 53 in one session, 5 in two sessions (Fig. 3), and 1 in three sessions. Of the six remaining tumors, three (in two patients) were surgically removed after being treated more than once. In all of them, pathology confirmed the diagnosis of the biopsy: clear cell carcinoma. Three patients rejected any treatment after an incomplete first ablation.

The mean diameter of the tumors in which the treatment was finally successful was 2.9 $\pm$ 0.92 cm, while the mean diameter of those that failed was 3.8 $\pm$ 1.06 cm. This difference was statistically significant ($p = 0.024$). Corticomedullary tumors were also significantly more frequently linked to treatment failure than cortical tumors ($p = 0.002$). Age and sex of the patients, polar or middle location, and anatomical side of the tumor did not show a significant relationship with the final success of the treatment.

Considering procedures, there was a statistically significant difference ($p < 0.001$) in the mean diameter of the tumors in incomplete ablations (3.9 $\pm$ 0.96 cm) and that of complete ablations (2.8 $\pm$ 0.83 cm). Incomplete ablations were significantly more frequent in corticomedullary tumors ($p = 0.002$). Age and sex of the patients, polar or middle location, and anatomical side of the tumor did not show a significant relationship with incomplete ablation. The distribution of the diameters, growth pattern, and locations of the tumors that required more than one RFA session and those in which the treatment failed appear in Table 4.

Complications occurred in 10 procedures (13%), four of which (5%) were major. No significant differences were found in the size or location of the tumors or in the age and sex of the patients between those who had complications and those who did not. Most of the complications were acute: six perirenal hematomas (one requiring hospitalization), one skin burn at the grounding pad site, and one respiratory failure after completing the procedure in a patient with chronic obstructive pulmonary disease. The latter recovered without consequences after cardiopulmonary resuscitation. Late complications occurred in two patients, who required hospitalization. Both presented with fever 1 wk after the ablation, and one had an aseptic fistula in the ablation tract (Fig. 4) that we attributed to an electrical burn in the tract.

Table 1 – Patient demographics and tumor characteristics

No. patients	58
Age, yr (mean)	43–84 (68 $\pm$ 10.9)
Sex	40 male, 18 female
No. tumors	65
Follow-up, mo (mean)	10–50 (26.5 $\pm$ 12)
Tumor diameter, cm (mean)	1.2–5.3 (3.08 $\pm$ 0.98)
Side	37 right, 28 left
Location, no. tumors (%)	
Lower	13 (20)
Upper	17 (26)
Middle	35 (54)
Growth pattern, no. tumors (%)	
Cortical	39 (60)
Corticomedullary	26 (40)

Table 2 – Result of the biopsy of the lesions treated with radiofrequency ablation

Lesion type	No. lesions (%)
Renal cell carcinomas	46 (70.7)
Oncocytomas	12 (18.5)
Metastatic melanoma	1 (1.5)
Angiomyolipoma	1 (1.5)
Nonconclusive	5 (7.7)

Table 3 – Reasons for radiofrequency ablation

Reason	No. patients (%)
Previous nephrectomy	9 (15.5)
Multiple renal tumors	3 (5.2)
Comorbidity or high surgical risk	30 (51.7)
Advanced age	14 (24.1)
Refusal of surgical treatment or personal preferences	12 (20.7)

Table 4 – Result of the ablation procedures related to the diameter, growth pattern, and localization of the tumors

	Ablation		Final success	
	Complete in one session, *n* (%)	Incomplete/recurrence, *n* (%)	Yes, *n* (%)	No, *n* (%)
Diameter, cm				
<3	28 (93)	2 (7)	29 (97)	1 (3)
3–3.9	18 (82)	4 (18)	19 (86)	3 (14)
4–4.9	6 (75)	2 (25)	8 (100)	0 (0)
≥5	1 (20)	4 (80)	3 (60)	2 (40)
Growth pattern				
Cortical	37 (95)	2 (5)	38 (97.5)	1 (2.5)
Corticomedullary	16 (61.5)	10 (38.5)	21 (81)	5 (19)
Localization				
Upper or lower pole	24 (80)	6 (20)	28 (93)	2 (7)
Middle	29 (83)	6 (17)	31 (89)	4 (11)
Total	53 (82)	12 (18)	59 (91)	6 (9)

4. Discussion

Our results confirm a therapeutic effectiveness of >90% for RFA of renal neoplasms, similar to that of other published series (Table 5), suggesting that RFA obtains local control in most renal tumors [3–21]. Also, RFA permits rescue surgery when initial RFA fails, as occurred in two of our patients. As previously described [10,17], size of the tumor was associated in our patients with incomplete ablations (Table 4); final success rates were lower for tumors >5 cm. This can be related to the limitations of the RFA system used, which permits a 5-cm maximum diameter of ablation. It has been shown that it is improbable that tumors >5.8 cm in diameter can be treated using RFA only [10]. Also, central localization of the tumors has been linked to RFA failure as occurred in our patients [10,17]. Perirenal fat acts probably as an oven, concentrating the heat; thus, the treatment is more effective in fat-surrounded areas whilst the presence of nearby thick vessels that dissipate the heat produced by the electrode can explain the reduced effectiveness of RFA in central tumors. Some authors have observed incomplete ablations in tumors removed after being treated with RFA using multitined electrodes similar to those we used [24,25]. Observed incomplete ablations in these studies have been attributed to an incorrect ablation technique or to a wrong diagnosis due to the use of inappropriate pathologic methods [26]. In our opinion it is very important to plan the procedure to achieve an ablation margin of 1 cm around the tumor, especially in the borders in contact with the renal parenchyma, where recurrences usually occur [1].

Although most of the solid renal tumors are carcinomas, an appreciable number of them, especially the small ones, are benign [27]. Percutaneous biopsy is not routinely practiced in solid renal tumors. However, in RFA, biopsy is the only opportunity to document the nature of the tumor. In our series, at least 19.5% did not correspond to carcinomas; a substantial number were oncocytomas. Also, we diagnosed a nonsurgical tumor and a renal metastasis,

Table 5 – Published series of percutaneous radiofrequency ablation of renal tumors

Authors	Tumors, *n*	Patients, *n*	Therapeutic success (%)	Guidance	Major and minor complications (%)	Follow-up, mo
Pavlovich et al (2002) [3]	24	21	79	US/CT	19	2
Ogan et al (2002) [4]	13	12	93	CT	8	1–13
Farrell et al (2003) [5]	35	20	100	US	20	1–23
Su et al (2003) [6]	35	29	100	CT	7	0–23
Roy-Choudhury et al. (2003) [7]	11	8	88	US/CT	0	10–26
Mayo-Smith et al (2003) [8]	32	32	87	US/CT	9	1–36
Lewin et al (2004) [9]	10	10	100	MRI	0	6–42
Gervais et al (2005) [10,11]	100	85	91	US/CT	11	3.5–72
Matsumoto et al (2005) [12]	63	63	98	CT	11	12–33
Ahrar et al (2005) [13]	30	29	96	CT	18	1–33
Weizer et al (2005) [14]	32	24	92	CT	21	1–28
Arzola et al (2006) [15]	27	23	90	CT	4	7–53
Sabharwal et al (2006) [16]	18	11	100	CT	0	1–24
Veltri et al (2006) [17]	44	31	89	US	18	1–54
Breen et al (2007) [18]	105	97	90	US/CT	4	1–76
Zagoria et al (2007) [19]	125	104	91	CT	8	1–76
Rouvière et al (2008) [20]	30	22	95	US/CT	9	3–84
Levinson et al (2008) [21]	56	46	90	CT	21	41–80
This series	65	58	91	US	13	10–50

US = ultrasound; CT = computed tomography; MRI = magnetic resonance imaging.

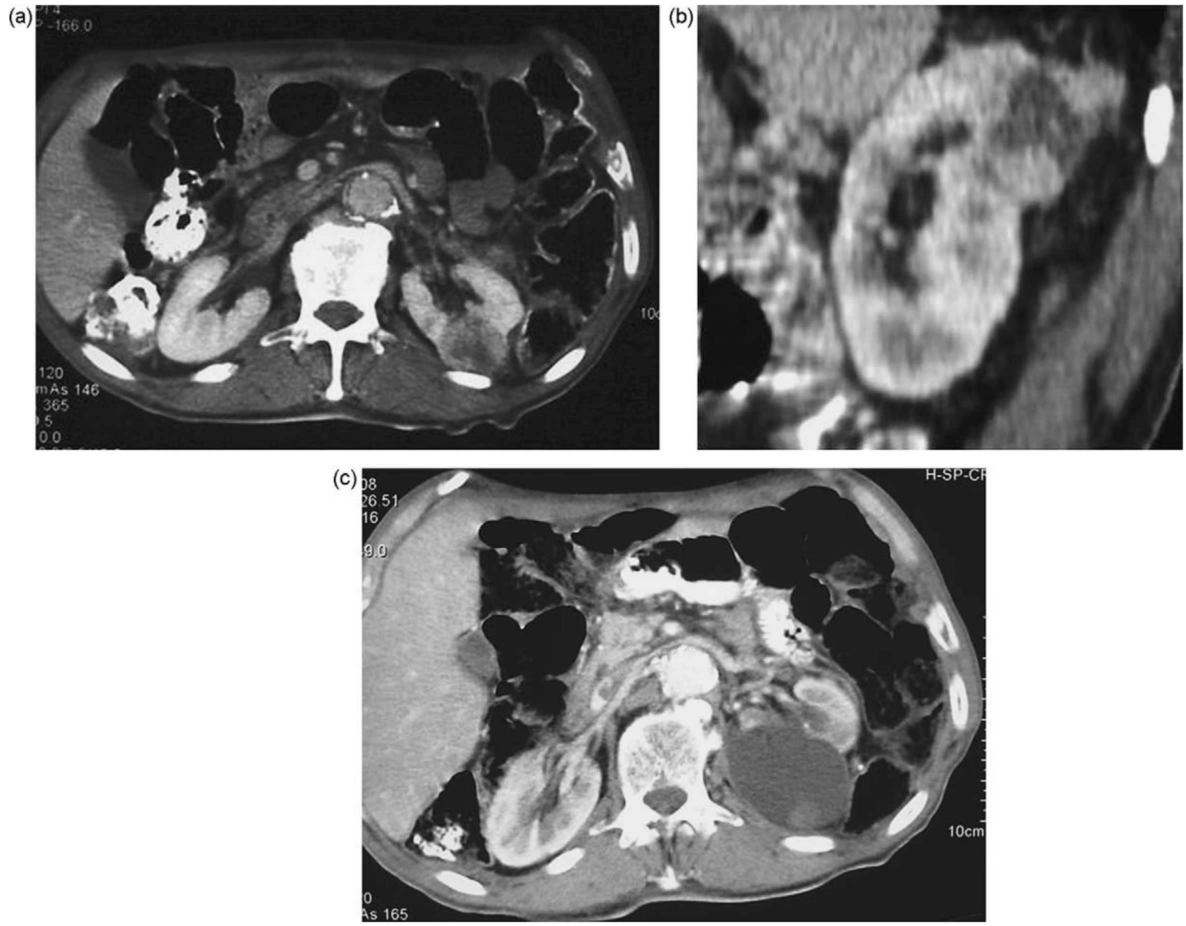

Fig. 3 – Male, age 79 with a renal cell carcinoma of 5.3 cm in the left kidney: (a) Tumor before treatment; (b) 7 month after treatment, a recurrence has occurred in the periphery of the treated area; (c) tumor 2 yr after a second ablation, no recurrence is observed.

which implied a change in the management of these patients. Biopsy was performed in our cases with ultrasound guidance and was diagnostic in 92.3% of tumors, a rate similar to that described in other series of percutaneous renal biopsies [28,29].

In published series, the preferred technique used to guide RFA was CT [3–23]. To our knowledge, our series is the largest published using ultrasound as a guidance method. The difficulty in visualizing some tumors or the need to control possible damage to adjacent structures has been indicated as the cause for the preference of CT for this procedure [18]. We did not find any case in which the lesion was not visible on ultrasound, or in which we could not control possible damage to adjacent structures. Ultrasound, moreover, allows wide versatility in accessing the lesion, which is not possible with other techniques. However, a CT or MRI prior to ablation is essential for planning of the procedure and, furthermore, it provides the base image for evaluating the lesion in the follow-up.

RFA has also fewer complications [30] than surgery. Complications described include hematuria, ureteral stenosis, urinoma, colorenal fistula, intestinal perforation, dissemination through the ablation tract, hematomas, infection, and transitory neuropathy [30]. In our cases, perirenal hematoma was the most frequent complication. In addition, we observed two complications not described before: a skin burn by the ground pads, already described in liver RFA, and respiratory failure in a patient with significant comorbidity. The average rate of major complications described in a recent meta-analysis (3.1%) [30] was similar to ours (5%).

For follow-up of the lesions, we alternated CT and MRI, trying to increase the sensitivity by taking advantage of the differences that each technique may have in the detection of recurrences. As most recurrences occur during the first 2 yr after RFA [3–23], we performed more frequent follow-ups during this time.

This study has various limitations. We do not have pathologic studies that confirm that the ablations were complete, and imaging techniques have limitations in identifying incomplete ablation and recurrence. Also, we do not have, as in other published series, 5-yr survival data. We also lack control groups with which to compare the results of nephrectomy or active surveillance.

Fig. 4 – Male, age 75, with 3.5-cm renal cell carcinoma in the left kidney: (a) 12 mo after the treatment, a fistula is observed between the ablation area and the skin; (b) at 18 mo posttreatment, the fistula had been resolved.

5. Conclusions

In conclusion, RFA is effective and safe in renal tumors. It is useful for patients who are not candidates for surgery. The results obtained also allow recommending it in patients in whom the surgery can have irreversible consequences, such as nephrectomized patients. We think that RFA is also a good option in accidentally discovered tumors $\leq$3.5 cm diameter. The possibility of this treatment and its results must be explained to patients in this situation so that they can make an educated choice about their treatment. Lesions >3 cm have greater risk of needing more than one treatment session. With lesions >5 cm, this possibility is close to 100% and the failure rate is high, so RFA should rarely be considered for these tumors.

Author contributions: Jose L. del Cura had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: del Cura, Zabala.
Acquisition of data: del Cura, Zabala, Iriarte, Unda.
Analysis and interpretation of data: del Cura, Iriarte.
Drafting of the manuscript: del Cura.
Critical revision of the manuscript for important intellectual content: Zabala, Iriarte, Unda.
Statistical analysis: del Cura.
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