ORIGINAL ARTICLE

Thermal Ablation of Renal Tumors under Ultrasound Guidance and Conscious Sedation: A Retrospective Experience

Sergio Sartori[1], Paola Tombesi[1], Lara Bianchi[1], Francesca Di Vece[1], Antonella Sgarbi[2]

[1]Section of Interventional Ultrasound, St. Anna Hospital, via A. Moro 8, 44100 Ferrara, Italy, [2]Department of Anesthesiology, St Anna Hospital, via A. Moro 8, 44100 Ferrara, Italy

ABSTRACT

Purpose: Computed tomography (CT) guidance and general anesthesia have recently been recommended as the approach of choice for percutaneous ablation of small renal cell carcinoma (RCC), whereas ultrasound (US) guidance and conscious sedation have been tagged as inadequate. Aim of the study was to assess the safety and effectiveness of percutaneous thermal ablation of small RCC under ultrasound (US)-guidance and conscious sedation. **Methods:** The records of 74 patients with small RCC (≤5 cm), who underwent US-guided thermal ablation under conscious sedation were retrospectively reviewed. Conscious sedation was usually induced by means of intravenous bolus of midazolam 50–100 µg/kg plus continuous infusion of a 25 µg/mL solution of remifentanil at a rate of 0.05 µg/kg/min. Technical success, technical efficacy, local tumor progression (LTP), primary and secondary efficacy rates, complication rate, and 1-, 3-, and 5-year survival rates were analyzed. **Results:** No procedure needed to be converted to general anesthesia, and all tumors were treated according to the protocol, with a technical success of 100%. One patient died after surgical intervention for bowel perforation and other 2 patients experienced grade 3 complications. Mortality rate and major complication rate were 1.3% and 2.7%, respectively. One-month technical efficacy was 100%. LTP was observed in 4/74 patients, with a primary efficacy rate of 94.6%. Two of them underwent successful thermal ablation and secondary efficacy rate was, therefore, 97.3%. The median follow-up was 38 months (range 1–130 months). No patient died for tumor progression. 1-, 3-, and 5-year survival rates were 94%, 80.5%, and 60%, respectively. **Conclusion:** US guidance and conscious sedation remain valid alternatives to CT guidance and general anesthesia for the percutaneous ablation of small RCC.

Key words: Conscious sedation, renal cancer, thermal ablation, ultrasound

INTRODUCTION

Renal cell carcinoma (RCC) is increasingly diagnosed in T1a stage (≤4 cm), mainly due to incidental imaging findings.[1] Partial nephrectomy is the first option to treat T1a RCC, as it maintains oncologic outcomes comparable to total nephrectomy while better preserving renal function.[2] In the last years, percutaneous image-guided thermal ablation is gaining increasing interest as a valid option for patients with small renal cancer who are unsuitable for surgery, as they have has a lower complication rate and are more nephron sparing, while obtaining 90–100% of successful ablation.[3,4] The cardiovascular and interventional radiology society of Europe (CIRSE) guidelines recommend radiofrequency ablation (RFA) and cryoablation (CRA) as the ablation modalities of choice; moreover, they suggest that microwave ablation (MWA) may represent a promising technique, as it can produce larger ablation volumes than RFA and is only slightly influenced by the heat sink effect.[5,6] Furthermore, quite recently, laser ablation (LA) has been reported to be an effective and safe alternative to RFA, CRA, or MWA in patients with increased risk of bleeding.[7] Whatever

Address for correspondence:
Sergio Sartori, Section of Interventional Ultrasound, St. Anna Hospital, via A. Moro 8, 44100 Ferrara, Italy.

ablation technique was used, historically the approach under ultrasound (US) guidance and conscious sedation, with the patient in supine, lateral, or prone position according to the best acoustic window to reach the target, was mostly used worldwide.[8-10] In the last years such an approach has been questioned,[5] and recently computed tomography (CT) guidance and general anesthesia, with the patient in prone position, have strongly been recommended in the Annual Meeting of CIRSE as the standard approach for percutaneous ablation of RCC.[11]

In this retrospective study, we evaluated the safety and effectiveness of percutaneous thermal ablation of small RCC under US-guidance and conscious sedation.

METHODS

The data of 74 patients (43 males and 31 females, age range 51–87 years) with small RCC, who underwent US-guided thermal ablation under conscious sedation from April 2006 to December 2019, were retrospectively reviewed. Approval of the Ethics Committee of our hospital was obtained (protocol 2019/104) and patients' informed consent was waived. Inclusion criteria were: Refusal or contraindications to surgery because of comorbidity or advanced chronic renal failure; long-axis diameter of the tumor ≤5 cm; absence of distant metastases, lymph node involvement, or renal vein invasion; tumor location at least 5 mm from the major calyces or pelvis; and informed consent to undergo the procedure. Exclusion criteria were: Distance of the tumor <5 mm from the bowel and impossibility to displace bowel by at least 10 mm from the tumor; platelet count <50,000/µL; international normalized ratio >1.5; and final histopathologic diagnosis of a benign lesion. In 27 patients, the diagnosis was obtained by percutaneous biopsy, in 47 patients, the diagnosis was based on the imaging findings, and biopsy was performed before thermal ablation. Long-axis and short-axis diameters of the tumors ranged from 13 mm to 50 mm (median 25) and from 12 mm to 48 mm (median 22 mm), respectively. RFA was used to treat tumors with long-axis diameter up to 3 cm, MWA was used to treat lesions with long-axis diameter exceeding 3 cm. LA was used to treat tumors with long-axis diameter up to 3 cm that were judged at high risk of bleeding owing to their deep location, or antiplatelet therapy that could not be discontinued.[7]

Ablation procedures

All thermal ablations were carried out under US-guidance. The patients underwent preliminary US examination in supine, prone, and right or left lateral position to assess the best acoustic window to reach the target. Afterward, the lesions were examined by contrast-enhanced US (CEUS) to assess tumor vascularity using a 2.4 mL intravenous bolus of an 8 mL solution of sulfur hexafluoride microbubbles stabilized by a phospholipid shell as US contrast agent (SonoVue®, Bracco, Milan, Italy). The CEUS clips were stored to allow a comparison with post-ablation changes of vascularity. If the distance of the tumor was <10 mm from the bowel, hydrodissection was performed by instilling 5% dextrose solution to obtain an at least 10-mm safety margin between the bowel and the tumor; if hydrodissection was unsuccessful, ablation procedure was not carried out. Conscious sedation was induced by means of i.v. bolus of midazolam 50–100 µg/kg plus continuous infusion of a 25 µg/mL solution of remifentanil at a rate of 0.05 µg/kg/min. If necessary, an i.v. bolus of propofol 1% 0.5 mg/kg, followed by continuous infusion at a rate of 1–2 mg/kg/h, was also administered. Vital signs were continuously monitored throughout the ablation procedure.

RFA was performed using an internally-cooled system, a generator with a maximum power output of 200 W, and a 17-gauge needle electrode with a 2- or 3-cm exposed tip, according to the size of the tumor (Cool-tip RFA System, Valleylab, Boulder, CO, U.S.A). MWA was performed using an internally-cooled system with a miniaturized device on the tip of the MWA antenna as a remedy to back heating effects (AMICA MWA System, HS Hospital Service, Aprilia, Italy). MWA procedures were carried out using a generator with a frequency of 2450 MHz and maximum power output of 140 W, and 14- or 16-gauge antennas with energy delivery output between 70 and 100 W for 8–10 min, according to the size of the tumor. LA was performed using a semi-conductor diode system (EchoLaser, Elesta Srl, Florence, Italy) with a wavelength of 1064 nm and a multi-source device that enables to use up to four 300 µm fibers at once, that were inserted into the nodules through 21-G Chiba needles.[12,13] Two and three laser fibers were used for tumors with long-axis diameter up to 14 mm and larger than 14 mm, respectively, and 1800 J per fiber was delivered in 6 min according to the technique described elsewhere.[7]

After the end of the procedures, the patients underwent CEUS to assess the completeness of ablation. If an avascular zone with no enhancement completely covering the tumor was observed, ablation was judged complete [Figures 1a and b]. When some residual foci with vascular enhancement were depicted in the ablation zone, the treatment was completed under CEUS guidance [Figures 2a-c].

Follow-up

All patients were followed up until death or the time the data were censored (June 30, 2020). Contrast-enhanced CT or CEUS if the patients had reduced renal function were performed 30 days after thermal ablation. Afterward, contrast-enhanced CT or CEUS were carried out every 3 months for the first 2 years, then every 6 months.

Technical success, technical efficacy, primary and secondary efficacy rate, and local tumor progression (LTP) were recorded and defined according to the recommendations of the International Working Group on the Image-guided Tumor Ablation.[14] Complications were recorded and classified according to the CIRSE classification system for complications reporting.[15]

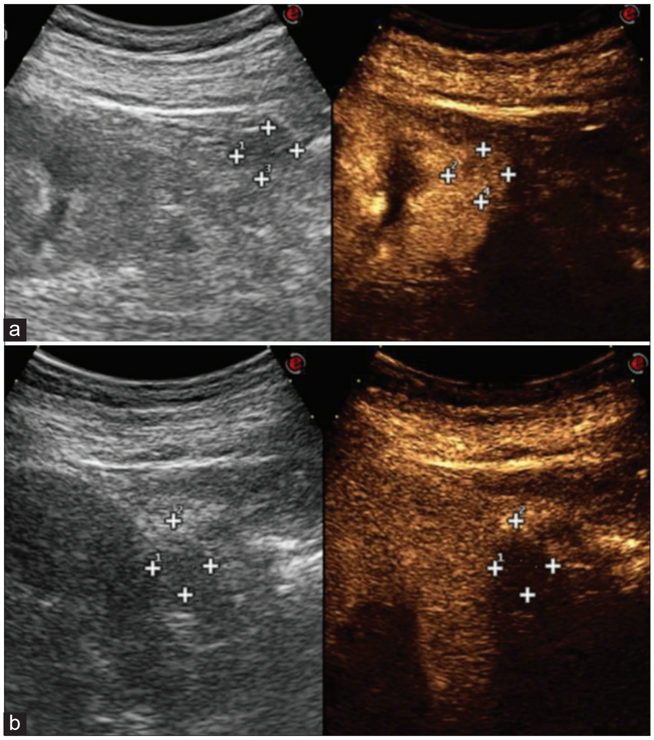

Figure 1: Complete tumor ablation. (a) CEUS scan showing an exophytic inhomogeneous enhancing nodule in the upper pole of the left kidney (cross-shaped markers); (b) post-ablation CEUS scan showing a non-enhancing zone completely covering the nodule (cross-shaped markers)

Statistical analysis

Overall survival (OS) for the entire population and OS for the patients treated with RFA, MWA, and LA were estimated using the Kaplan–Meier method and were calculated from the date of the ablation procedure to patients death or June 30, 2020. All analyses were performed using a statistical software program (STATA 13.0 for Windows; StataCorp., College Station, TX, U.S.A.).

RESULTS

Main characteristics of patients and tumors are reported in Table 1.

Forty-seven patients underwent RFA, 15 MWA, and 12 LA. In sixty-nine cases, the patients were treated in supine or lateral position, just in five cases (6.7%), they were placed in prone position. In nine patients, post-procedural CEUS depicted residual viable tumor tissue, and the treatment was completed by CEUS-guided RFA, MWA, or LA. No procedure needed to be converted to general anesthesia and all tumors were treated according to protocol and were completely covered by the ablation zone, with a technical success of 100%. One patient died after surgical intervention for bowel perforation following MWA of a 38 × 30 mm RCC in the left kidney, despite an apparently successful hydrodissection. Two patients experienced Grade 3 complications: A genitofemoral nerve injury and a skin burn in the site of the needle insertion, respectively. Both complications resolved after adequate

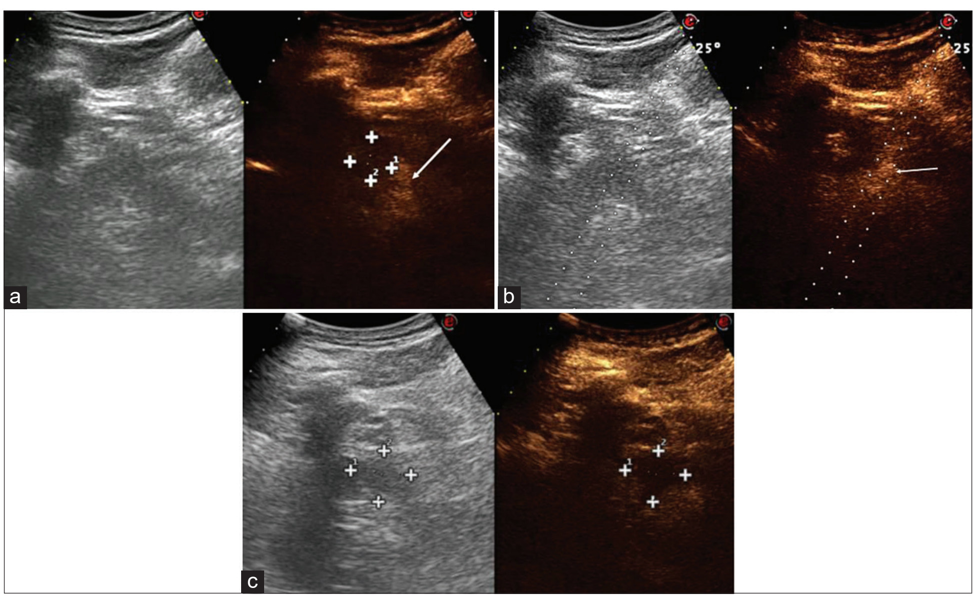

Figure 2: Incomplete tumor ablation and retreatment under CEUS guidance. (a) Post-ablation CEUS scan showing residual enhancing tissue (arrow) in the lateral margin of the ablation zone (cross-shaped markers); (b) the residual enhancing tissue (arrow) is targeted for retreatment under CEUS guidance (dotted lines); (c) post-retreatment CEUS showing a non-enhancing zone completely covering the residual viable tissue (cross-shaped markers)

Table 1: Patients and tumors characteristics

Age/sex	Kidney	Tumor size (long axis × short axis)	Ablation technique	Date of ablation	Major complications	LTP (treatment)	Date of death	Cause of death
78/F	Right	25×21 mm	RF	05/04/06	No	No	09/09/13	Heart failure
65/M	Left	22×18 mm	RF	11/13/06	No	No	10/28/14	Car accident
70/M	Right	23×20 mm	RF	07/09/07	No	No	02/14/18	Stroke
75/F	Right	29×25 mm	RF	11/09/07	No	No	04/18/12	Stroke
70/F	Right	24×20 mm	RF	12/03/07	No	No	07/23/14	Heart failure
74/M	Left	24×21 mm	RF	06/02/08	No	No	03/22/15	Pneumonia
72/M	Right	30×25 mm	RF	12/10/08	No	No	05/30/16	Lung cancer
70/F	Right	24×20 mm	RF	10/06/08	No	No	11/24/18	Cirrhosis
76/F	Right	26×22 mm	RF	03/15/09	No	No	04/12/15	Renal failure
79/M	Left	30×25 mm	RF	05/29/09	No	Yes (RF)	10/14/17	Colon cancer
68/F	Left	22×20 mm	RF	08/18/09	No	No	Alive	--
72/M	Left	30×26 mm	RF	06/06/10	No	No	06/23/14	Heart Attack
65/F	Right	25×20 mm	RF	12/03/10	No	No	Alive	--
72/F	Left	20×15 mm	RF	12/17/10	No	No	08/29/15	Stroke
62/M	Left	30×26 mm	RF	03/14/11	No	No	Alive	--
79/F	Right	19×17 mm	RF	09/21/11	No	No	12/18/18	Renal failure
73/M	Left	24×20 mm	RF	11/02/11	No	No	Alive	--
85/F	Left	30×26 mm	RF	05/08/13	No	No	11/23/17	Heart failure
77/M	Right	22×20 mm	Laser	07/08/13	No	No	09/12/17	Endocarditis
65/F	Right	26×21 mm	RF	08/21/13	No	No	Alive	--
58/M	Left	18×16 mm	Laser	08/21/13	No	No	Alive	--
68/M	Right	26×24 mm	RF	08/21/13	No	No	Alive	--
73/M	Left	16×14 mm	Laser	08/28/13	No	Yes (Laser)	07/16/17	Larynx cancer
51/M	Left	14×12 mm	Laser	09/12/13	No	No	Alive	--
69/F	Right	30×28 mm	RF	09/12/13	No	No	03/23/17	Pancreatitis
77/F	Right	15×12 mm	Laser	02/27/14	No	No	Alive	--
69/M	Right	28×24 mm	RF	02/27/14	No	Yes (RF)	Alive	--
80/F	Left	13×12 mm	Laser	05/15/14	No	No	Alive	--
82/F	Right	50×48 mm	MW	10/08/15	No	No	Alive	--
73/M	Left	27×22 mm	RF	10/08/15	No	No	Alive	--
83/F	Right	25×23 mm	RF	03/17/16	No	Yes (RF)	Alive	--
80/M	Left	20×17 mm	Laser	06/05/16	No	No	10/12/17	Broncopneumonia
87/F	Left	37×30 mm	MW	09/29/16	No	No	Alive	--
52/M	Left	18×15 mm	Laser	11/13/16	No	No	08/19/19	Colon cancer
85/M	Left	25×23 mm	RF	11/24/16	No	No	Alive	--
69/F	Right	23×20 mm	Laser	01/13/17	No	No	Alive	--
73/M	Right	22×18 mm	RF	02/23/17	No	No	08/20/18	Heart Attack
85/M	Left	50×46 mm	MW	03/19/17	No	No	01/24/19	Stroke
81/M	Right	24×22 mm	RF	04/06/17	No	No	Alive	--
81/F	Left	30×25 mm	RF	04/20/17	No	No	12/21/17	Stroke
81/F	Left	22×20 mm	RF	04/20/17	No	No	02/21/19	Stroke
84/M	Right	28×22 mm	RF	06/15/17	No	No	01/24/19	Broncopneumonia

(*Contd...*)

Table 1: (*Continued*)

Age/ sex	Kidney	Tumor size (long axis × short axis)	Ablation technique	Date of ablation	Major complications	LTP (treatment)	Date of death	Cause of death
81/F	Right	34×28 mm	MW	07/13/17	No	No	Alive	--
83/F	Right	29×24 mm	RF	08/24/17	No	No	Alive	--
74/M	Left	16×14 mm	Laser	09/21/19	No	No	Alive	--
81/F	Left	30×20 mm	RF	09/28/17	No	No	Alive	--
72/F	Left	18×15 mm	Laser	12/21/17	No	No	07/30/19	Sepsis
76/M	Right	24×20 mm	RF	12/21/17	No	No	Alive	--
66/M	Right	45×37 mm	MW	01/11/18	No	No	Alive	--
80/M	Left	35×32 mm	MW	03/01/18	No	No	Alive	--
82/M	Right	50×43 mm	MW	03/23/18	No	No	Alive	--
79/M	Left	40×30 mm	MW	06/28/18	No	No	Alive	--
81/F	Left	38×30 mm	MW	08/17/18	Colon perforation (Death)	No	09/29/18	Colon perforation
80/F	Right	16×12 mm	Laser	09/20/18	No	No	Alive	--
78/M	Left	24×20 mm	RF	09/20/18	No	No	Alive	--
70/M	Left	16×12 mm	RF	10/05/18	No	No	Alive	--
81/M	Right	28×22 mm	RF	12/21/18	No	No	Alive	--
82/M	Left	50×45 mm	MW	01/31/19	No	No	Alive	--
79/M	Right	40×32 mm	MW	02/14/19	Genitofemoral nerve injury	No	03/04/19	Heart attack
83/F	Right	39×32 mm	MW	02/27/19	No	No	Alive	--
83/M	Left	18×16 mm	RF	05/30/19	No	No	Alive	--
85/M	Right	18×15 mm	RF	06/04/19	No	No	Alive	--
71/M	Left	30×28 mm	RF	06/06/19	No	No	Alive	--
72/M	Left	16×12 mm	RF	06/20/19	No	No	Alive	--
80/F	Right	25×23 mm	RF	06//21/19	No	No	Alive	--
57/M	Right	16×13 mm	RF	06/21/19	No	No	Alive	--
81/M	Left	35×30 mm	MW	07/10/19	Skin burn	No	09/14/19	Endocarditis
80/M	Right	35×34 mm	MW	07/11/19	No	No	Alive	--
65/M	Left	45×35 mm	MW	07/19/19	No	No	Alive	--
69/F	Left	24×20 mm	RF	07/19/19	No	No	Alive	--
61/F	Right	19×14 mm	RF	08/01/19	No	No	Alive	--
67/M	Left	18×12 mm	RF	09/18/19	No	No	Alive	--
81/M	Left	14×12 mm	RF	11/21/19	No	No	Alive	--
76/F	Right	18×16 mm	RF	12/19/19	No	No	Alive	--

LTP: Local tumor progression

treatment with no post-procedure sequelae. No complication of conscious sedation was observed. On the whole, mortality rate and major complication rate were 1.3% and 2.7%, respectively.

CT or CEUS performed 1 month after the procedure showed successful ablation of 74/74 tumors and technical efficacy was 100%. LTP occurred 3–10 months after thermal ablation in 4/74 patients, and primary efficacy rate was 94.6%. Two of them underwent successful CEUS-guided RFA and LA, whereas 1 of them experienced tumor recurrence after retreatment with RFA and underwent surgery, and 1 patient was not retreated owing to the inability to displace the colon from the tumor recurrence. Secondary efficacy rate was, therefore, 97.3%.

The median follow-up was 38 months (range 1–130 months, mean 45.1 ± 36). Twenty-eight patients died 1–127 months after thermal ablation: One owing to complications following the ablation procedure and 27 for causes other than renal cancer. No patient died for disease progression. Forty-six patients were still alive 6–130 months after ablation, and 44 of them were disease free.

One-, 3-, and 5-year OS was 94%, 80.5%, and 60% for the entire population, respectively [Figure 3]. No difference in OS was observed among the subgroups of patients treated with RFA, MWA, and LA [Figure 4].

DISCUSSION

Surgical intervention is worldwide considered the first choice for the treatment of RCC. However, in the last years, percutaneous thermal ablation has evolved into a valid alternative for the treatment of T1a RCC, with oncological outcomes comparable to surgery and lower complication rate.[1,3,4,16] Moreover, the availability of an effective minimally invasive technique such as thermal ablation is turning the current opinion about the role of active surveillance that for a long time has been recommended for T1a tumors in patients unsuitable for surgery.[17,18] Quite recently, the CIRSE guidelines suggested that active surveillance should be reserved just for patients who are not suitable for ablation for age or comorbidities.[5]

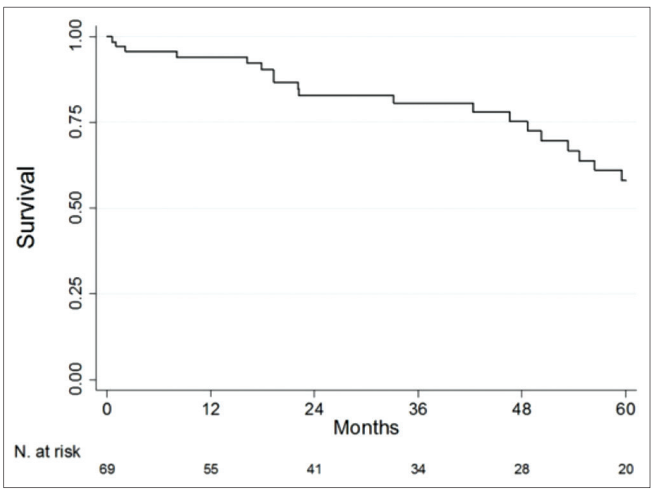

Figure 3: Survival curve for all patients from tumor ablation to death or June 30, 2020

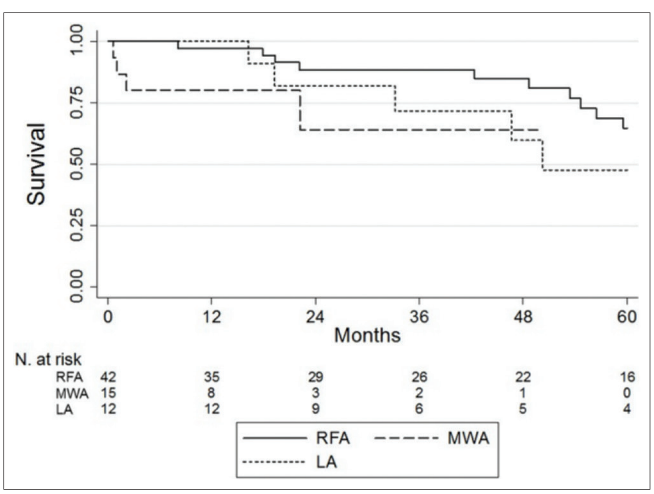

Figure 4: Overall survival curves for patients treated with RFA, MWA, and LA

The best imaging method to guide percutaneous ablation of RCC is widely being discussed. US remains the most used method of guidance, due to its availability, low cost, lack of radiation exposure, and the considerable advantage to enable the real-time monitoring of each step of the ablation procedure, as well as to place the patients in the most suitable position to reach the target.[1,9,10] Moreover, the use of US contrast medium after the end of the procedure allows to assess the completeness of the ablation and to guide the immediate retreatment if residual viable foci of tumor tissue are detected. Indeed, the post-procedural assessment of the completeness of ablation has been proven to increase primary technical efficacy,[19] and in our series, CEUS enabled to detect 9/74 (12.2%) residual viable tumor foci and to guide the retreatment, with a technical success and technical efficacy of 100%. In this regard, a prior study suggested that CEUS is as effective as CECT or MRI in the assessment of residual or recurrent tumors after RFA,[20] and quite recently this observation has been confirmed by other authors.[21] However, US can be limited by inherent patient characteristics, and sometimes the exact anatomical relationship with the surrounding organs (particularly the bowel loops) cannot be easily delineated.[5] Moreover, gas formation during the procedure can limit the adequate visualization of the ablation zone, making post-procedural assessment hard.[1] For these reasons, the recent CIRSE guidelines did not recommend US as the guidance modality of choice and suggested that CT or MRI guidance should be preferred.[5] However, there are no studies in the literature that compared both effectiveness and complication rates of US-guided, CT-guided, and MRI-guided thermal ablation, so the superiority of one imaging modality over the others has never been proved.[10,22]

Another debated issue is the ideal anesthesiologic regimen to perform the ablation procedure. General anesthesia undoubtedly ensures better pain control than conscious sedation and reduces patient anxiety or panic, but it is not free of risks such as myocardial infarction, stroke, and malignant hyperthermia.[23] On the other hand, conscious sedation is more painful but does not require intubation, and several relative contraindications to general anesthesia such as impairment of lung function do not preclude its use.[1] Although most percutaneous ablations of renal tumors are currently performed under conscious sedation, there is a widespread belief that general anesthesia can ensure a better outcome. However, data to support such a belief are weak. A study reported that general anesthesia can decrease the number of sessions required to achieve complete tumor ablation in early-stage hepatocellular carcinoma, but no difference was observed in 2-year OS and recurrence-free survival rate in comparison with conscious sedation.[23] Other authors reported excellent initial success rates of CT-guided RFA under general anesthesia, but no comparison with conscious sedation was done.[24] Finally, general anesthesia was reported to provide better intermediate outcomes than conscious sedation in RFA ablation of small RCC, but the results of the study are fairly questionable.[25] Indeed, in the conscious sedation group (just ten patients vs. 41 patients in the general anesthesia group) LTP occurred in 40% of cases that are a surprisingly high rate when compared with all studies published in literature on US-, CT-, or MRI-guided ablation of renal tumors.[1,3,4,7,8-10,16,19] Furthermore, excellent results were reported in a study comparing two types of conscious sedation in US-guided RFA of liver tumors.[26] Despite the lack of clear evidence of superiority of a type of anesthesia over the other one, as well as of an imaging technique of guidance over the others, the need for standardization of percutaneous thermal ablation of renal tumors has recently been advocated, and a prone CT-guided approach under general anesthesia has been recommended.[11] Conversely, US guidance and conscious sedation have been tagged as inadequate.[11] We think such statements reflect more the personal opinion and experience of some skilled interventional radiologists than the proven finish line of all skilled interventional radiologists. There are a lot of papers in literature reporting excellent results of ablation of RCC under US guidance and conscious sedation that are comparable to those obtained with CT or MRI guidance and general anesthesia.[1,3,7-10,20,22,27] According to these prior reports, our experience confirms that US-guided ablation under conscious sedation of RCC is as safe and effective as the other ablation approaches. US guidance enabled to detect and confidently target the tumors, and conscious sedation allowed to complete all the interventions, with no need to convert any procedure to general anesthesia and with a technical success of 100%. LTP after one or two ablation sessions was 5.4% and 2.7%, respectively, and was comparable to that reported in literature for CT-guided ablation under general anesthesia.[23,28,29] One cancer-related death occurred 1 month after thermal ablation because of complications of the procedure, whereas 73/74 patients (98.7%) are still alive or died for causes other than RCC. Likewise, also our major complication rate (2.7%) resulted in the range of that reported in literature for the other ablation approaches (1.6–6%).[1,5,30]

CONCLUSIONS

Although our study is retrospective, concerns just our experience with US-guided ablation of RCC under conscious sedation, and has no control group treated with other approaches, our results compare well with those reported in literature for CT-guidance and general anesthesia. According to many prior reports,[1,3,7-10,20,22,27] our experience suggests that US guidance and conscious sedation remain valid alternatives to CT guidance and general anesthesia in the percutaneous ablation of small RCC.

Each modality of guidance and anesthesia has advantages and disadvantages[1] that make them more or less suitable in each particular setting. We do not think there is an ideal approach for all the patients and all the tumors, but we believe the time is ripe for an individually tailored approach based on tumor and patient characteristics to select the optimal modalities of guidance and sedation in each single case.

REFERENCES

1. Filippiadis D, Mauri G, Marra P. Charalampopoulos G, Gennaro N, De Cobelli F. Percutaneous ablation techniques for renal cell carcinoma: Current status and future trends. Int J Hyperthermia 2019;36:21-30.
2. Finelli A, Ismaila N, Bro B, Durack J, Eggener S, Evans A, *et al*. Management of small renal masses: American society of clinical oncology clinical practice guideline. J Oncol Pract 2017;35:668-80.
3. Gervais DA, McGovern FJ, Arellano RS, McDougal WS, Mueller PR. Radiofrequency ablation of renal cell carcinoma: Part 1, Indications, results, and role in patient management over a 6-year period and ablation of 100 tumors. AJR Am J Roentgenol 2005;185:64-71.
4. Ma Y, Bedir S, Cadeddu JA, Gahan JC. Long-term outcomes in healthy adults after radiofrequency ablation of T1a renal tumours. BJU Int 2014;113:51-5.
5. Krokidis ME, Orsi F, Katsanos K, Helmberger T, Adam A. CIRSE guidelines on percutaneous ablation of small renal cell carcinoma. Cardiovasc Intervent Radiol 2017;40:177-91.
6. Di Vece F, Tombesi P, Ermili F, Maraldi C, Sartori S. Coagulation areas produced by cool-tip radiofrequency ablation and microwave ablation using a device to decrease back-heating effects: A prospective pilot study. Cardiovasc Intervent Radiol 2014;37:723-9.
7. Sartori S, Mauri G, Tombesi P, Di Vece F, Bianchi L, Pacella CM. Ultrasound-guided percutaneous laser ablation is safe and effective in the treatment of small renal tumors in patients at increased bleeding risk. Int J Hyperthermia 2018;35:19-25.
8. Mayo-Smith WW, Dupuy DE, Parikh PM, Pezzullo JA, Cronan JJ. Imaging-guided percutaneous radiofrequency ablation of solid renal masses: Techniques and outcomes of 38 treatment sessions in 32 consecutive patients. AJR Am J Roentgenol 2003;180:1503-8.
9. Veltri A, Calvo A, Tosetti I, Pagano E, Genovesio A, Virzì V, *et al*. Experiences in US-guided percutaneous radiofrequency ablation of 44 renal tumors in 31 patients: Analysis of predictors for complications and technical success. Cardiovasc Intervent Radiol 2006;29:811-8.
10. Veltri A, Garretto I, Pagano E, Tosetti I, Sacchetto P, Fava C. Percutaneous RF thermal ablation of renal tumors: Is US guidance really less favorable than other imaging guidance techniques? Cardiovasc Intervent Radiol 2009;32:76-85.
11. Breen DJ. Is Renal Tumor Ablation Ready for Prime Time? State-of-the-Art of Interventional Radiology Treatment.

Barcelona, Spain: Proceedings of the Annual Meeting of the Cardiovascular and Interventional Radiological Society of Europe; 2019.
12. Pacella CM, Bizzarri G, Magnolfi F, Cecconi P, Caspani B, Anelli V, *et al*. Laser thermal ablation in the treatment of small hepatocellular carcinoma: Results in 74 patients. Radiology 2001;221:712-20.
13. Di Costanzo GG, D'Adamo G, Tortora R, Zanfardino F, Mattera S, Francica G, *et al*. A novel needle guide system to perform percutaneous laser ablation of liver tumors using the multifiber technique. Acta Radiol 2013;54:876-81.
14. Ahmed M, Solbiati L, Brace CL, Breen DJ, Callstrom MR, Charboneau JW, *et al*. Image-guided tumor ablation: Standardization of terminology and reporting criteria--a 10-year update. J Vasc Interv Radiol 2014;25:1691-705.
15. Filippiadis DK, Binkert C, Pellerin O, Hoffmann RT, Krajina A, Pereira PL. CIRSE quality assurance document and standards for classification of complications: The CIRSE classification system. Cardiovasc Intervent Radiol 2017;40:1141-6.
16. Lourenco P, Bilbey N, Gong B, Bahrabadi A, Halkier B. Percutaneous ablation versus nephrectomy for small renal masses: Clinical outcomes in a single-center cohort. Cardiovasc Intervent Radiol 2018;41:1892-900.
17. Chawla SN, Crispen PL, Hanlon AL, Greenberg RE, Chen DY, Uzzo RG. The natural history of observed enhancing renal masses: Meta-analysis and review of the world literature. J Urol 2006;175:425-31.
18. Rais-Bahrami S, Guzzo TJ, Jarrett TW, Kavoussi LR, Allaf ME. Incidentally discovered renal masses: Oncological and perioperative outcomes in patients with delayed surgical intervention. BJU Int 2009;103:1355-8.
19. Grewal A, Khera SS, McGahan JP, Wilson M, Loehfelm TW, Dall'Era MA, *et al*. Utility of intraprocedural contrast-enhanced CT in ablation of renal masses. AJR Am J Roentgenol 2019;214:122-8.
20. Meloni MF, Bertolotto M, Alberzoni C, Lazzaroni S, Filice C, Livraghi T, *et al*. Follow-up after percutaneous radiofrequency ablation of renal cell carcinoma: Contrast-enhanced sonography versus contrast-enhanced CT or MR. AJR Am J Roentgenol 2008;191:1233-8.
21. Guo F, Hu B, Chen L, Li J. Clinical application of contrast-enhanced ultrasound after percutaneous renal tumor ablation. BJR 2019;92:20190183.
22. Park S, Cadeddu JA. Outcomes of radiofrequency ablation for kidney cancer. Cancer Control 2007;14:205-10.
23. Kuo YH, Chung KC, Hung CH, Lu SN, Wang JH. The impact of general anesthesia on radiofrequency ablation of hepatocellular carcinoma. Kaohsiung J Med Sci 2014;30:559-65.
24. Gupta A, Raman JD, Leveillee RJ, Wingo MS, Zeltser IS, Lotan Y, *et al*. General anesthesia and contrast-enhanced computed tomography to optimize renal percutaneous radiofrequency ablation: Multi-institutional intermediate-term results. J Endourol 2009;23:1099-105.
25. Kim HJ, Park BK, Chung IS. Comparison of general anesthesia and conscious sedation during computed tomography-guided radiofrequency ablation of T1a renal cell carcinoma. Can Radiol Assoc J 2018;69:24-9.
26. Joung KW, Choi SS, Jang DM, Kong YG, Lee HM, Shim JH, *et al*. Comparative effects of dexmedetomidine and propofol on us-guided radiofrequency ablation of hepatic neoplasm under monitored anesthesia care: A randomized controlled study. Medicine (Baltimore) 2015;94:e1349.
27. Gervais DA, Arellano RS, Mueller P. Percutaneous ablation of kidney tumors in nonsurgical candidates. Oncology (Williston Park) 2005;19:6-11.
28. Georgiades CS, Rodriguez R. Efficacy and safety of percutaneous cryoablation for stage 1A/B renal cell carcinoma: Results of a prospective, single-arm, 5-year study. Cardiovasc Interv Radiol 2014;37:1494-9.
29. Psutka SP, Feldman AS, McDougal WS, McGovern FJ, Mueller P, Gervais DA. Long-term oncologic outcomes after radiofrequency ablation for T1 renal cell carcinoma. Eur Urol 2013;63:486-92.
30. Kim KR, Thomas S. Complications of image-guided thermal ablation of liver and kidney neoplasms. Semin Intervent Radiol 2014;31:138-48.

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