

R E V I E W

Percutaneous Radiofrequency Ablation (RFA) in renal cancer. How to manage challenging masses. A narrative review

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Abstract. *Background and aim:* In the last decades, the refinements in the imaging techniques led to an increased number of detected renal tumors. If radical and partial nephrectomy remain the gold standard for the treatment of renal cancer, Radio-Frequency Ablation (RFA) has emerged as a therapeutic option for renal masses. Even if this technique is minimally-invasive, it requires a proper preoperative anatomic study and in some cases RFA treatment is technically challenging. To date, there is no standardization for studying challenging cases before treatment and to plan a safe and effective procedure when intervening organs are in the trajectory of the needle. In this study we searched the literature focusing on the challenging cases and strategy applied to manage the treatment safely and effectively. *Materials and methods:* MedLine and Embase via Ovid database were searched, using the following key words: Percutaneous RFA, radiofrequency, renal ablation, kidney ablation, renal thermoablation, kidney thermoablation, hydrodissection, heat sink. The difficulties found in the literature while performing the ablation procedure were grouped and a categorization of the strategies applied to perform a safe and effective procedure was proposed, in the aim to standardize the approach for treatment of challenging cases. Literature was analyzed according with selection criteria agreed by the Authors. *Results:* The literature review showed four groups of lesions requiring an experienced approach. Group 1: Lesions close to the bowel. Group 2: Lesions close to the urinary tract. Group 3: Lesions close to intervening organs. Group 4: Lesions close to large vessels (*heat-sink* phenomenon). *Conclusion:* When planning a RFA treatment, a standardized approach to challenging masses is possible. This review make the treatment of these masses more systematic and safe. (www.actabiomedica.it)

Key words: radiofrequency, RFA, renal cancer, thermoablation

Introduction

Due to the increased detection of tumors by ultrasound (US) and computed tomography (CT), the number of incidentally diagnosed Renal Cell Carcinomas (RCCs) has increased (1-4). These tumors are usually smaller and of lower stage (5).

For many years, radical nephrectomy has been considered the best therapeutic approach for patients with RCC confined to the kidney. Today, partial

nephrectomy (PN) with the preservation of renal parenchyma is considered the gold standard for the treatment of small and localized RCCs. This technique has become more and more widespread over the last 10 years as it has proved to give similar oncologic results to radical nephrectomy in 5-year follow-up (6,7).

However, even if there is a low risk of mortality for young patients who undergo surgical resection, it is still responsible for morbidities (8,9).

The detection of an increasing number of RCC, and in some cases the old age of patients and their comorbidities, as well as previous renal failure, multiple RCC, hereditary RCC have led to the development of minimally invasive ablative techniques as an alternative to surgery in order to preserve renal function as much as possible.

For these reasons, in the last decades, percutaneous Radiofrequency Ablation (RFA) of renal tumors has been proposed as a therapeutic option.

Nevertheless, percutaneous treatment may be challenging due to the proximity of the surrounding organs, such as ureter, bowel, liver, and in some cases the lung. Moreover, the proximity of large vessels may decrease the effectiveness of the treatment, due to the so called *heat sink* phenomenon. Even if some techniques have been proposed in the last years to make the procedure safe and effective even if the bowel or a large vessel are close to the targeted lesion, a systematic approach to challenging procedure is still far away.

This review aims to highlight which masses should be considered “challenging” to treat and to increase the awareness of treating a mass that may require a higher level of expertise in order to make the procedure safe and effective. In addition, we reviewed the literature focusing on the technical aspects of the treatment of challenging masses, aiming to make more systematic the approach to these masses.

Background of RFA for Renal Masses

RCC is the commonest cancer of the kidney, accounting for 2-3% of all cancers, with a higher incidence in Western countries (10,11). Over the last two decades, the incidence of RCC has increased by about 2%, probably due to increased detection rate by US, CT, MRI and renal biopsy (12-16) and the increased risk related to cigarette smoking and obesity (17,18). Reportedly, the accuracy of the imaging techniques has improved also for many other urologic tumors and is may be integrated with confirmation biopsy selected cases (19,20).

For many decades, radical nephrectomy was considered the gold standard treatment for RCC and for a long time it was actually the only curative option.

However, the refinements in surgical techniques together with improvements in imaging modalities,

led to the development of nephron-sparing surgery, such as open, laparoscopic and robotic PN (8,21).

The advantages of laparoscopic and robot-assisted approach are well known and consist of shorter hospital stay, reduced morbidity, smaller wound, decreased analgesic requirement, reduced intraoperative blood loss and rapid recovery of patient's strength.

As for other minimally-invasive techniques for treating other genitourinary cancers (22), there is common agreement in the literature that radical surgery and nephron-sparing surgery are equivalent in terms of both oncologic and functional outcome (23,24).

Despite the number of studies reporting excellent results of the nephron-sparing techniques, investigations into ablative methods have expanded considerably, such as cryoablation and radiofrequency ablation (RFA).

In 1997, Zlotta et al reported the first clinical use of RFA for the treatment of localized renal masses (25). The American Association of Urology (AUA) supports consideration for RFA, stating this technique as a viable option for T1a stage renal malignancies smaller than 4 cm in size (26).

The European Association of Urology shares consideration for RFA, reporting the recommendation to offer RFA to elderly and/or comorbid patients with small renal masses (≤ 4 cm) (27).

In more details, Clark TW et al report the standard for percutaneous thermal ablation of renal carcinoma (28), showing that potential conditions of patient for RFA are those who are considered poor surgical candidates, due to impaired renal function, solitary kidney or comorbidities, as well as those with a high risk of RCC recurrence as a consequence of genetic syndromes, including Von Hippel-Lindau and Birt-Hogg-Dubé (29).

Even if the majority of studies on RFA are retrospective, with a small number of patients and in some cases with a short follow-up, almost all reported that the procedure is safe and effective (28-30,31) and found no differences in Recurrence Free Survival (RFS) and Cancer Specific Survival (CSS) between surgery and RFA (13,32-34).

Patients demographics of the cohorts reported in the literature show that the majority of lesions treated with RFA are exophytic. Olweny et al. argue that the

decision to treat a patient with RFA or cryoablation (CRA) rather than PN is often made upon “clinical judgement” (35). In retrospective observational studies where RFA is compared to PN, indeed, it is clear that the more a lesion is easy to be reached, the more the patients is likely to be indicated to RFA. This makes it arguable that lesions technically challenging to treat are easily considered unfit for RFA.

As a matter of facts, renal masses centrally located in the kidney, close to the pelvis or the calices require much more experience than small exophytic lesions and their treatment may expose to a number of clinically relevant complications, such as urinary fistula, bleeding, hematoma and infections. However, in our review of the literature we found that, in experienced hands, the treatment of renal masses close to the urinary tract did not show a significantly higher complication rate than the treatment of other masses.

Another circumstance that may make the percutaneous RFA challenging is the presence of large vessels close to the renal mass. As it is reported in the literature, tumors close to large vessels will suffer a *heat sink*, as regional vascular flow reduces the extent of the heat-induced damage (3).

Last but not least, percutaneous access to the renal mass may be complicated by the liver or the lung in the trajectory of the needle. In such cases, a modified patient decubitus and/or a modified percutaneous access may make the procedure feasible and effective avoiding to damage the intervening organs and tissues.

In conclusion, RFA of renal tumors seems to be safe and effective with a few tricks in most technically challenging cases, such as lesions located close to urinary tract, large vessels and bowel or lesions difficult to reach due to intervening organs.

Materials and Methods

Literature search and selection. We reviewed the literature focusing on the technical aspects of RFA for renal masses. The literature search was restricted to those cases requiring additional technical expertise in order to avoid complications and perform the treatment effectively and safely.

MedLine and Embase via Ovid database were searched, using the following key words: Percutaneous RFA, radiofrequency, renal ablation, kidney ablation, renal thermoablation, kidney thermoablation, hydrodissection, heat sink.

Selection criteria were: English language, articles published between 2001 and 2020, case series or case reports that included the treatment of masses presenting as technically difficult to treat and requiring the application of a dedicated approach, such as specific techniques; note of caution during treatment; unconventional radiologic study prior to or during the treatment; prolonged treatment due to the anatomic feature of the mass. All studies that did not meet the inclusion criteria were excluded.

All the articles were grouped into different groups by typology of difficulties encountered at the time of the procedure. We did not define any category before the literature search, as this would preclude the possibility to report groups of “challenging” procedure not expected before starting to search the literature. The design of the study was intended to report, analyze and discuss all the difficulties reported on the percutaneous ablation of renal masses. At the end of the process of literature search and selection and the analysis of the articles, the categories were defined by similarity of the difficulties reported by the Authors.

Results

Our review of the literature found 4 groups of potential “challenges”. Group 1: lesions close to the bowel; Group 2: lesions close to the urinary tract (pelvis, calices, ureter); Group 3: lesions difficult to reach due to intervening organs (liver, lung and genito-femoral nerve); Group 4: lesions close to large vessels.

Discussion

Group 1: Lesions Close to The Bowel

The proximity of the bowel to the renal mass may increase the complexity of the ablation procedure. Inadvertent thermal damage to the bowel may have

detrimental effects, such as perforation, fistulas or abscesses (36).

In the first reports of RFA procedure, a distance between bowel and renal tumor ≤ 3 cm was considered a contraindication. Nevertheless, early attempts to increase the distance between bowel and kidney are reported in the literature consisting in changing patient position (37).

As of today, adjusting patient position is considered a non-invasive method to prevent complications. Even if this technique is still recommended, whenever possible, because it is easy and costless and may help increase the distance from the bowel due to gravity (38), specialized bowel displacement techniques enable to make the ablation procedure safe and effective.

The most common invasive method to displace the bowel is hydrodissection (39,40). This technique consists in infusing sterile water or 5% dextrose solution into the tissue between the kidney and the bowel under CT guidance (Figure 1, S1-S3) (40,41).

The evaluation of prior cross-sectional imaging is fundamental, but the operator has to be aware of the change of position of the bowel from supine decubitus, in which CT is performed, to prone or lateral one, in which the patient is positioned during radiofrequency ablation (39).

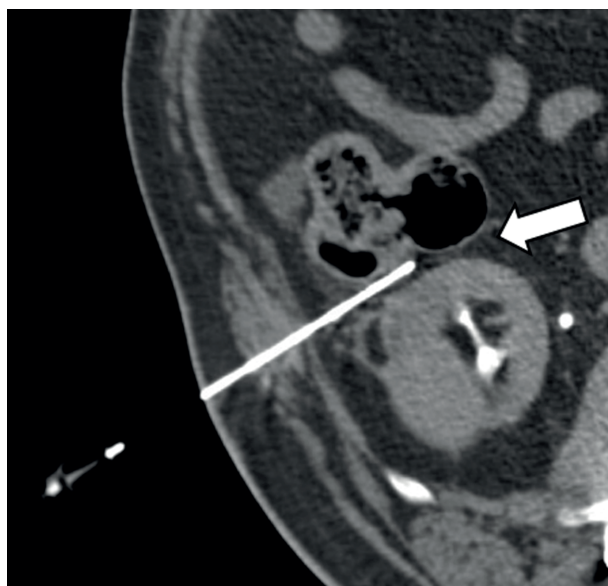


Figure 1. Hydrodissection needle placed between the colon and the kidney (arrow).

The precise knowledge of local anatomy is of the utmost importance, as the effectiveness of the dissection depends on the exact plane in which the needle tip is inserted (42). In order to achieve a real time monitoring of the dissected area, the injection of non-ionic contrast medium may be considered (43). At this regard, CIRSE Guidelines recommend a contrast/fluid dilution ratio of 1:50 (44). Hydrodissection, including the use of contrast medium, is reported not to affect the oncological outcome of the radiofrequency ablation, according with Khan F, et al. (45).

Although the rationale of hydrodissection is to increase the distance between organs, this technique also helps reduce the heat sink effect, thanks to the displacement of vessels from the ablation area (44).

Technical failure of hydrodissection in separating organs is not frequent, and it may occur in case of adhesions, generally related to previous surgery or when the injected fluid disperses from the site of injection (39).

Another technique that can be used for bowel displacement is probe traction and/or torqueing. The probe may be employed as a lever against the skin entry site or may be rotated to move vulnerable organs away from the ablation area (44,46,47). Straight probes can be used as a lever only, while probes with expandable electrodes can be used for torqueing, as they are fixed inside the lesion. Probe traction and torqueing are described not only for kidney, but also for lung and liver.

Reportedly, however, the efficacy of this technique is limited. Ginat DT, et al. reported that this technique allow only 8mm displacement in renal tumor RFA, but in other series only a 3-4mm displacement was obtained (39). Probe traction/torqueing is less effective in patients with little perirenal fatty tissue, as in this case there is limited excursion (48).

However, it is intuitive that this displacement technique carries the risk of potentially injuring the renal pedicle when performed forcefully, although major complications are not reported in the literature to our knowledge (39).

We reported probe traction/torqueing following hydrodissection, because it can be considered a complementary displacement technique, able to increase the efficacy of other methods.

Group 2: Lesions Close to The Urinary Tract

A damage to the ureter during the ablation procedure may have detrimental effects, like stricture formation and loss or renal function (48,49). The incidence of ureter complication is reported to be 1-2% (50,51). For this reason, all renal tumors close to the ureter, as well the pelvis and the calices, must be considered at risk when planning RFA treatment (Figure 2, S4, S5).

Unfortunately, patient position does not affect the position of the urinary tract. This led to the development of specific techniques to protect the urinary tract.

Among these, one of the most used is the pyeloperfusion. According with CIRSE Guidelines, pyeloperfusion is recommended in medial/inferior renal tumors < 1.5cm from the ureter or the uretero-pelvic junction (44).

Originally reported as a technique able to preserve renal parenchyma by achieving hypothermia during surgical procedures (52), pyeloperfusion showed to be of help in protecting the ureter during RFA (53,54). This technique consists in the placement of an externalized 5- to 7-French ureteral stent and irrigation during the procedure (44). The ureteral stent is generally removed at the end of the procedure, but is may be left in place for a few days or exchanged for and

internal ureteral catheter (double-J) for a few weeks in case of challenging procedure of suspect of ureteric damage (40).

The safety of pyeloperfusion and its efficacy in reducing potential complications related to the RFA procedure have been reported by many authors (54-56).

Theoretically, cooled irrigation may result in a heat-sink effect, thus reducing the effectiveness of thermal ablation. In favor of pyeloperfusion, however, it is well known the study of Margulis, showing that pyeloperfusion did not reduce the ablation volume in *in vivo* models [57].

Also, data reported in the literature suggest that pyeloperfusion does not affect the oncological outcome of the RFA procedure (56,58).

Group 3: Lesions Close to Intervening Organs

Lesions located in the upper pole of the kidney may be close to the lung or to the liver (Figure 3, S6, S7). Park BK et al. argues that the injury to these organs comes from inappropriate manipulation of the probe (59). The obliquity of the trajectory of the probe

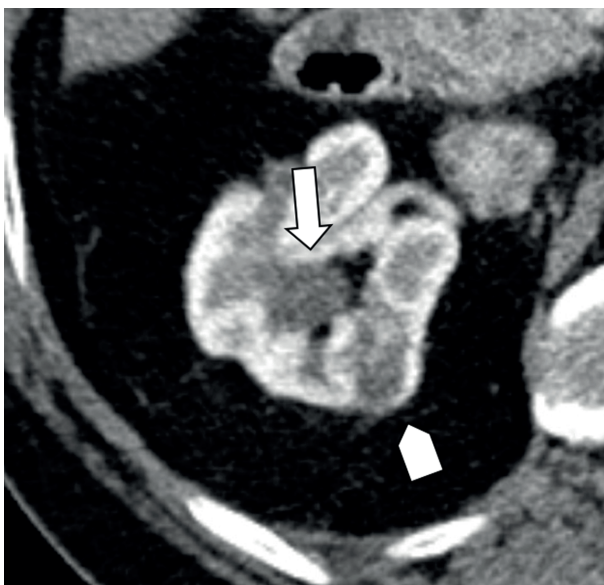


Figure 2. RCC (arrow head) close to the renal pelvis (arrow).

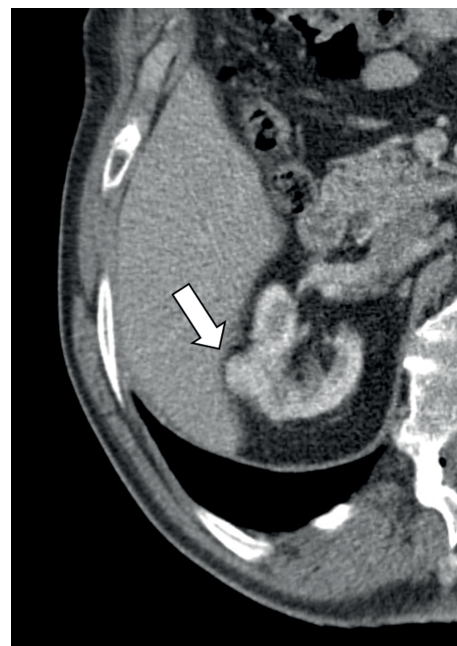


Figure 3. Axial plane image shows the RCC (arrow) close to the liver and on the same level of the right lower lobe of the lung.

is fundamental to avoid damage to these organs, as a vertical direction is reported to be one of the most frequent causes of pneumothorax (48), a complication with an incidence of 2% in the literature (51).

A mass located in the anterior part of the right kidney may require a transhepatic approach, that in selected cases has to be considered as one of the possible options, as it might be safer than passing the needle through a large portion of renal parenchyma (60).

Conversely, pneumothorax may be intentionally created, in order to perform an effective puncture of the lesion. In these cases, the RFA procedure should not be delayed and should be completed in the shorter time possible. A severe pneumothorax may require drainage, whereas a mild pneumothorax can be treated conservatively with bed rest and oxygen therapy (59,61).

Noteworthy, the the genitor-femoral nerve runs along the psoas muscle. A damage to this nerve is reported in 2-6% in the literature and no effective treatment is reported to our best knowledge (44). The course of the genitor-femoral nerve should be considered when planning a RFA procedure. In case of masses ≤ 5 mm distant from the psoas muscle, the above mentioned techniques of hydrodissection and probe traction are highly recommended (62,63).

Group 4: Lesions Close to Large Vessels (Heat-Sink Phenomenon)

Another circumstance that may make the percutaneous RFA challenging is the presence of large vessels close to the renal mass (Figure 4, S8). As it is reported in the literature, tumors close to large vessels will suffer a *heat sink*, as regional vascular flow reduces the extent of the heat-induced damage (3).

As the larger vessels of the kidney are in hilum, RFA showed limitations for the treatment of centrally located masses in terms of oncologic outcome in mid-to long follow-up.

In order to increase the distance between large vessels and the ablation area and to improve the oncologic results of RFA, some of the techniques described above for other challenging circumstances can be used.

First of all, the probe can be used as a lever, using the site of skin entry as a fulcrum. Probe traction/torqueing is actually the most simple technique to

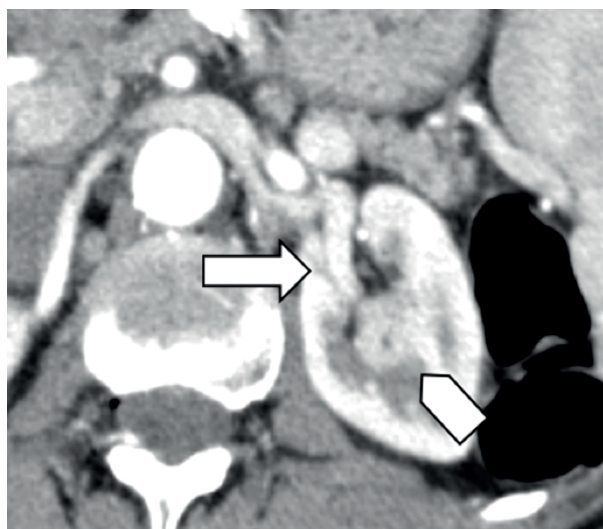


Figure 4. Hilar endophytic RCC (arrow head) close to the left renal vein (arrow).

avoid the heat-sink phenomenon, thus assuring the effectiveness of the procedure (44,64).

Another technique that can be used to reduce the effects of the heat-sink phenomenon is the hydrodissection, which can displace large vessels from the ablation area (64).

Cryoablation is supposed to provide better results compared to RFA for centrally located renal masses, which is probably due to the superiority of multiple probes to decrease the effects of the heat-sink phenomenon. For this reason, in the aim to reduce the failure of RFA treatment, cryoablation and RFA would be weighed when planning the treatment of masses close to large vessels (60).

Conclusion

RFA is a minimally invasive treatment, but may result in major complications, that require further treatment. The risk of complications is much higher when the renal mass is difficult to reach due to intervening organs, or when it is close to the bowel. Similarly, the proximity of ureter may increase the risk of major complications. Finally, the heat-sink phenomenon is a cause of failure of the RFA treatment, reportedly.

Unfortunately, no algorithm or flowchart is known to minimize the risk of damaging surrounding

organs and tissues in these challenging circumstances and the safety of the procedure is still in the hands of the surgeon, whose experience is crucial.

Our review highlights the characteristics of potentially challenging masses and outlines which technique is the most appropriate to make a safe and effective procedure. This review makes the approach to renal masses more systematic when planning a RFA treatment.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

References

- Ng CS, Wood CG, Silverman PM et al. Renal cell carcinoma: diagnosis, staging, and surveillance. *AJR Am J Roentgenol* 2008;191:1220–1232 doi:10.2214/AJR.07.3568
- Gervais DA, McGovern FJ, Arellano RS et al. Radiofrequency ablation of renal cell carcinoma. 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
- Zagoria RJ, Hawkins AD, Clark PE et al. Percutaneous CT-guided radiofrequency ablation of renal neoplasms: factors influencing success. *AJR Am J Roentgenol* 2004;183:201–207 doi: 10.2214/ajr.183.1.1830201
- Chow WH, Devesa SS, Warren JL, Fraumeni JF Jr. Rising incidence of renal cell cancer in the United States. *JAMA* 1999;281:1628–1631
- Kato M, Suzuki T, Suzuki Y, et al. Natural history of small renal carcinoma: evaluation of growth rate, histological grade, cell proliferation and apoptosis. *J Urol* 2004; 172: 863–6
- Lee JH, You CH, Min GE, et al. Comparison of the surgical outcome and functional outcome between radical and nephron-sparing surgery for renal cell carcinoma. *Korean J Urol* 2007;48:671–676
- Van Poppel H, Da Pozzo L, Albrecht W, et al. A prospective, randomized EORTC phase 3 study comparing the oncologic outcome of elective nephron-sparing surgery and radical nephrectomy for low-stage renal cell carcinoma. *EurUrol* 2011;59:543–552 doi:10.1016/j.eururo.2010.12.013
- Fergany AF, Hafez KS, Novick AC. Long-term results of nephron-sparing surgery for localized renal cell carcinoma: 10-year follow up. *J Urol* 2000;163:442–445
- Uzzo RG, Novick AC. Nephron-sparing surgery for renal tumors: indications, techniques and outcomes. *J Urol* 2001; 166:6–18.
- Ferlay J, Steliarova-Foucher E, Lortet-Tieulent J, et al. Cancer incidence and mortality patterns in Europe: estimates for 40 countries in 2012. *Eur J Cancer* 2013;49:1374–1403
- Jemal A, Tiwari RC, Murray T, et al. Cancer statistics, 2004. *CA Cancer J Clin* 2004;54:8–29
- Tsui KH, Shvarts O, Smith RB, et al. Renal cell carcinoma: prognostical significance of incidentally detected tumors. *J Urol* 2000;163:426–430
- Patard JJ, Rodriguez A, Rioux-Leclercq N, et al. Prognostic significance of the mode of detection in renal tumors. *BJU Int*; 2002;90:358–363
- Zagoria RJ. Imaging of small renal masses: a medical success story. *Am J Roentgenol* 2000; 175: 945–55
- Gentili F, Bronico I, Maestroni U, et al. Small renal masses (<4cm): differentiation of oncocytoma from Clear Cell Carcinoma using ratio of lesion-to-cortex attenuation and Aorta-Lesion Attenuation Difference (ALAD) on contrast-enhanced CT. *Radiol Med* 2020; 125: 1280–87
- Pagnini F, Cervi E, Maestroni U, et al. Imaging guided percutaneous renal biopsy: do it or not. *Acta biomed* 2020; 13: 81–8
- Hollingsworth JM, Miller DC, Daignault S, et al. Rising incidence of small renal cancer: a need to reassess treatment effect. *J Natl Cancer Inst* 2006; 98:1331–4
- Pantuck AJ, Zisman A, Beldegrun AS. The changing natural history of renal cell carcinoma. *J Urol* 2001; 166: 1611–23
- Ziglioli F, Maestroni U, Manna C, et al. Multiparametric Mri in the management of prostate cancer: an update. A narrative review. *Gland Surg* 2020; 9: 2321–30
- D'Amuri VF, Maestroni U, Pagnini F, et al. Magnetic resonance imaging of adrenal gland: state of the art. *Gland Surg* 2019; 8: S223–32
- Herr HW. Partial nephrectomy for unilateral renal carcinoma and a normal contralateral kidney: 10-year follow-up. *J Urol* 1999;161:33–35
- Ziglioli F, Baciarello M, Maspero G, et al. Oncologic outcome, side effects and comorbidity of high-intensity focused ultrasound (HIFU) for localized prostate cancer. A review. *Ann Med Surg* 2020; 56: 110–5
- Gill IS, Kavoussi LR, Lane BR, et al. Comparison of 1,800 laparoscopic and open partial nephrectomies for single renal tumors. *J Urol* 2007;178:41–46
- Park H, Byun SS, Kim HH, et al. Comparison of laparoscopic and open partial nephrectomies in T1a renal cell carcinoma: a Korean multi center experience. *Korean J Urol* 2010;51:467–471
- Zlotta AR, Wildschutz T, Raviv G, et al. Radiofrequency interstitial tumor ablation (RITA) is a possible new modality for treatment of renal cancer: ex vivo and in vivo experience. *J Endourol* 2007;11:251–258
- Campbell SC, Novick AC, Beldegrun A, et al. Guidelines for management of the clinical T1 renal mass. *J Urol* 2009; 182:1271–1279
- Ljunberg B, Bensalah K, Canfield S, et al. EAU Guidelines on renal cell carcinoma: 2014 updates. *EurUrol* 2015; 67:913–924
- Clark TW, Millward SF, Gervais DA, et al. Reporting standards for percutaneous thermal ablation of renal cell carcinoma. *J Vasc Interv Radiol* 2009;20 (7 Suppl):S409–416
- Van Poppel H, Becker F, Cadeddu JA, et al. Treatment of localised renal cell carcinoma. *EurUrol* 2011;60:662–672

30. Russo U, Maestroni U, Papapietro RV, et al. Imaging after radiofrequency ablation of renal tumors. *Future Oncol* 2018;14:2915-22
31. De Filippo M, Ziglioli F, Russo U, et al. Radio-frequency ablation of renal cancer T1a with externally cooled multitined expandable electrodes. *Radiol Med* 2020; 125: 790-7 doi: 10.1007/s11547-020-01175-1
32. Takaki H, Yamakado K, Soda N, et al. Midterm results of radiofrequency ablation versus nephrectomy for T1a renal cell carcinoma. *Jpn J Radiol* 2010;28:460-468
33. Johnson BA, Sorokin I, Cadeddu JA. Ten-year outcomes of renal tumor radiofrequency ablation. *J Urol* 2019;201:251-8
34. Filippidis D, Mauri G, Marra P, et al. Percutaneous ablation techniques for renal cell carcinoma: current status and future trends. *Int J Hyperthermia* 2019;36:21-30
35. Olweny EO, Park SK, Tan YK, et al. Radiofrequency ablation versus partial nephrectomy in patients with solitary clinical T1a renal cell carcinoma: comparable oncologic outcomes at a minimum of 5 years of follow-up. *Eur Urol* 2012;61: 1156-1161.
36. Atwell TD, Carter RE, Schmit GD, et al. Complications following 573 percutaneous renal radiofrequency and cryoablation procedures. *J Vasc Interv Radiol* 2012; 23: 48-54
37. Gervais DA, McGovern FJ, Arellano RS, et al. 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* 2005; 185: 64-71
38. Park BK, Kim CK. Complications of image-guided radiofrequency ablation of renal cell carcinoma: causes, imaging features and prevention methods. *Eur Radiol* 2009; 19: 2180-90
39. Ginat DT, Saad WE. Bowel displacement and protection techniques during percutaneous renal tumor thermal ablation. *Tech Vasc Interv Radiol* 2010; 13: 66-74
40. Mauri G, Nicosia L, Varano GM, et al. Tips and tricks for a safe and effective image-guided percutaneous renal tumor ablation. *Insight Imaging* 2017; 8: 357-63
41. Tsoumakidou G, Buy X, Garnon J, et al. Percutaneous thermal ablation: hot to protect the surrounding organs. *Tech Vasc Interv Radiol* 2011; 14:170-6
42. Bhagavatula SK, Chick JF, Chauhan NR, et al. Artificial ascites and pneumoperitoneum to facilitate ablation of liver tumors: a pictorial essay. *Abdom Radiol* 2017; 42: 620-30
43. De Benedictis CM, Beland MD, Dupuy DE, et al. Utility of iodinated contrast medium in hydrodissection fluid when performing renal tumor ablation. *J Vasc Interv Radiol* 2010; 21: 745-7
44. Garnon J, Koch G, Caudrelier J, et al. Percutaneous image-guided cryoablation of challenging mediastinal lesions using large volume hydrodissection: technical considerations and outcomes. *Cardiovasc Interv Radiol* 2016; 39: 1636-43.
45. Khan F, Rhim H, Lee MW, et al. Long-term outcome after percutaneous renal cryoablation performed with adjunctive techniques. *Clin Imaging* 2017; 12: 62-7
46. Kambadakone A, Baliyan V, Kordbacheh H, et al. Imaging guided percutaneous interventions in hepatic dome lesions: tip and tricks. *World J Hepatol* 2017; 9:840-9
47. Ginat DT, Saad W, Davies M, et al. Bowel displacement for CT-guided tumor radiofrequency ablation: techniques and anatomic considerations. *J Endourol* 2009; 23: 1259-64
48. Park BK, Kim CK. Using an electrode as a lever to increase the distance between renal cell carcinoma and bowel during CT-guided radiofrequency ablation. *Eur Radiol* 2008; 18: 743-6
49. Chen SH, Mouraviev V, Raj GV, et al. Ureteropelvic junction obliteration resulting in nephrectomy after radiofrequency ablation of small renal cell carcinoma. *Urology* 2007; 69: 982.e3-5.
50. Gervais DA, McGovern FJ, Arellano RS, et al. Radiofrequency ablation of renal cell carcinoma: part 1. Indications, results, and role in patients management over a 6-years period and ablation of 100 tumors. *Am J Roentgenol* 2005; 185: 64-71
51. Zagoria RJ, Traver MA, Werle DM, et al. Oncologic efficacy of CT-guided percutaneous radiofrequency ablation of renal cell carcinomas. *AJR* 2005; 189: 429-36.
52. Landman J, Rehman J, Sundaram CP, et al. Renal Hypothermia achieved by retrograde intracavitary saline perfusion. *J Endourol* 2002; 16: 445-449
53. Schultze D, Morris CS, Bhav AD, et al. Radiofrequency ablation of renal transitional cell carcinoma with protective cold saline cold saline infusion. *J Vasc Interv Radiol* 2003; 14: 489-92
54. Wah Tm, Koenig P, Irving HC, et al. Radiofrequency ablation of a central renal tumor: protection of the collecting system with a retrograde cold dextrose pyeloperfusion technique. *J Vasc Interv Radiol* 2005; 16:1551-5
55. Cantwell CP, Wah TM, Geravais DA, et al. Protecting the ureter during radiofrequency ablation of renal cell cancer: a pilot study of retrograde pyeloperfusion with cooled dextrose 5% in water. *J Vasc Interv Radiol* 2008; 19: 1034-40
56. Eswara JR, Geravais DA, Mueller PR, et al. Renal radiofrequency ablation with pyeloperfusion. *Int J Urol* 2018; 22: 131-2
57. Margulis V, Matsumoto ED, Taylor G, et al. Retrograde renal cooling during radiofrequency ablation to protect from renal collecting system injury. *J Urol* 2005; 174: 350-2
58. Dai Y, Covarrubias D, Uppot R, et al. Image-guided percutaneous radiofrequency ablation of central renal cell carcinoma: assessment of clinical efficacy and safety in 31 tumors. *J Vasc Interv Radiol* 2017; 28: 1643-50
59. Park BK, Kim CK. Prognostic factors influencing the development of an iatrogenic pneumothorax for computed tomography-guided radiofrequency ablation of upper renal tumor. *Acta Radiol* 2008; 49: 1200-6
60. Schmit GD, Kurup AN, Weisbrod AJ, et al. ABLATE: A renal ablation planning algorithm. *AJR* 2014; 202: 894-903
61. Ahrar K, Matin S, Wallace MJ, et al. Percutaneous trans-thoracic radiofrequency ablation of renal tumors using an iatrogenic pneumothorax. *AJR* 2005; 185: 86-8
62. Lee SJ, Choyke LT, Locklin JK, et al. Use of hydrodissection to prevent nerve and muscular damage during

radiofrequency ablation of kidney tumors. *J Vasc Interv Radiol* 2006; 17: 1967-9

63. Boss A, Clasen S, Kuczyk M et al. Thermal damage of the genitofemoral nerve due to radiofrequency ablation of renal cell carcinoma: a potentially avoidable complication. *AJR* 2005; 185: 1627-31
64. Garnon J, Cazzato RL, Caudrelier J, et al. Adjunctive thermoprotection during percutaneous thermal ablation procedures: review of current techniques. *Cardiovasc Interv Radiol* 2019; 42: 344-357

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Appendix - Supplementary Material

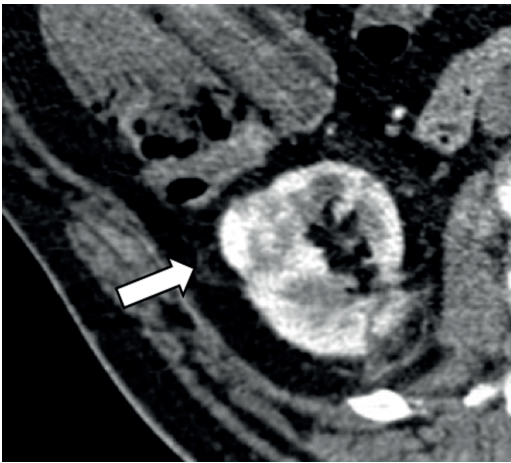


Figure S1. RCC (arrow) close to ascending colon.

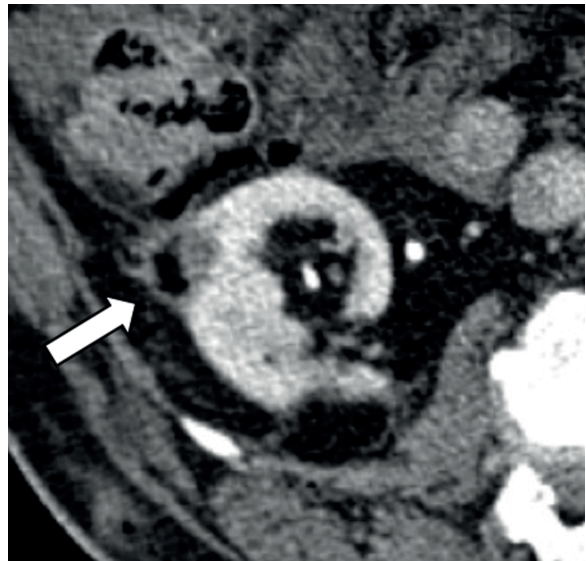


Figure S3. Axial plane image shows the absence of contrast enhancement in the treated area, demonstrating successful ablation.

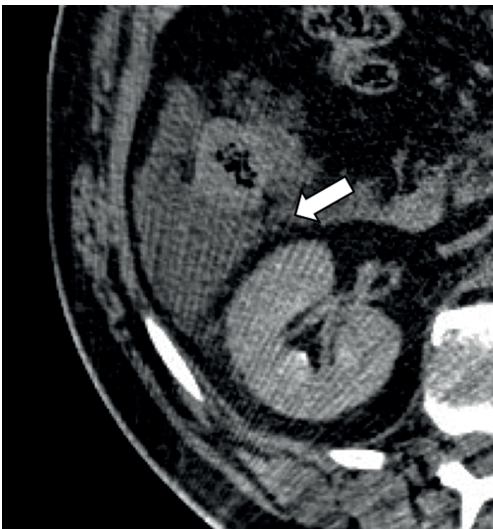


Figure S2. The distance between the two organs (arrow) is significantly increased thanks to the injection of 100 cc of glucose solution.

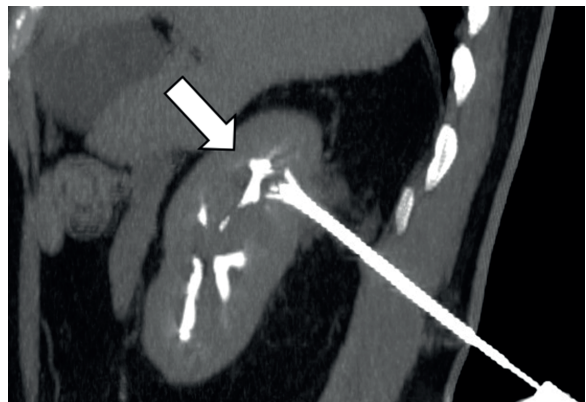


Figure S4. Sagittal image shows RFA probe in place, close to the the upper calyx (arrow) of the kidney.

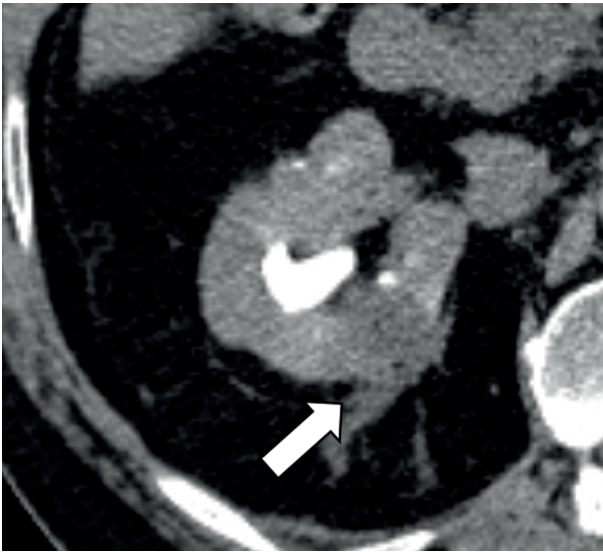


Figure S5. Axial pane image shows low density area (arrow) corresponding to the treated zone.

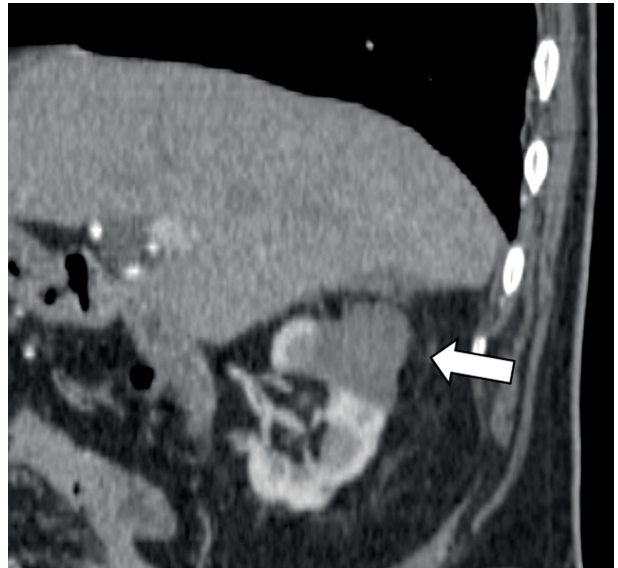


Figure S7. Absence of contrast enhancement in the treated area, showing successful ablation.

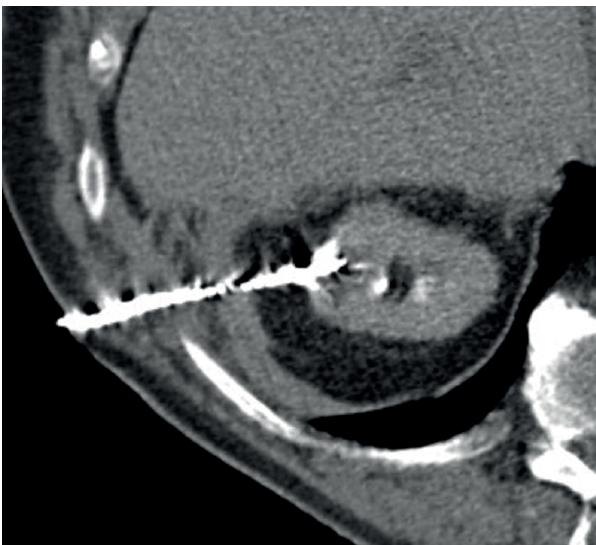


Figure S6. Lateral caudo-cranial approach allows a good probe positioning (coronal and axial plane).

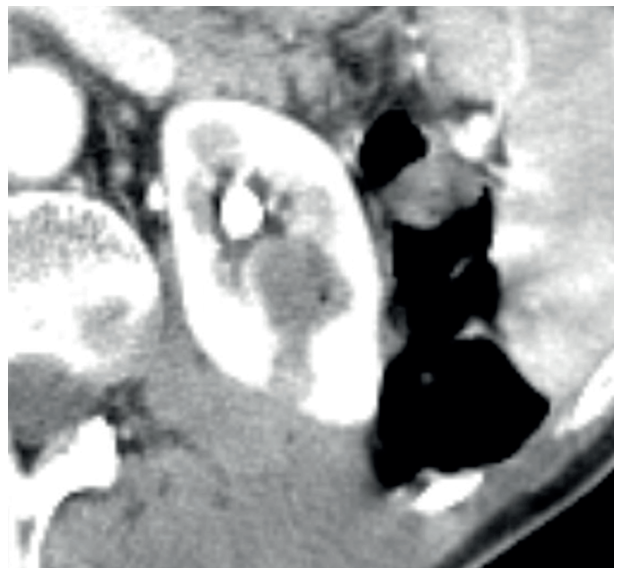


Figure S8. Absence of contrast enhancement in the treated area, showing successful ablation.