

Revolutionizing Renal Tumor Ablation: CEUS-MRI Fusion for Sub-Centimeter Precision

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Purpose

- To review current techniques and outcomes of fusion-guided microwave ablation for sub-centimeter renal tumors, focusing on the role of contrast-enhanced ultrasound and MRI integration in improving lesion visualization and ablation accuracy.

Materials and Methods

- A comprehensive literature review was conducted focusing on fusion-guided microwave ablation techniques for sub-centimeter renal tumors.
- Sources included clinical studies and retrospective analyses examining the integration of contrast-enhanced ultrasound, MRI, and advanced navigation systems.

Results

- Percutaneous ablation is an established alternative to surgery for small renal tumors, particularly in patients with comorbidities or impaired renal function.
- However, sub-centimeter lesions can be challenging to visualize on conventional ultrasound, leading to incomplete ablation. Advanced imaging techniques have significantly enhanced the precision of percutaneous ablation for small renal tumors with limited ultrasound visibility.
- Multimodal fusion imaging, robotic navigation, and artificial intelligence (AI) applications collectively improve lesion localization and procedural accuracy.
- Lerardi et. al, using cone beam CT fused with cross-sectional imaging (i.e. CT or MRI), reported a technical success rate of 93%, with no complications or recurrences at 12-month follow-up. [1]
- Another study by Mauri et al involved over 90 renal lesions treated with real-time ultrasound–CT fusion imaging and demonstrated 100% targeting accuracy, a primary efficacy rate of 98.9%, and technical success in 95.9% of cases. [2]
- These findings underscore the value of next-generation imaging tools in improving treatment outcomes for patients with technically challenging renal tumors.

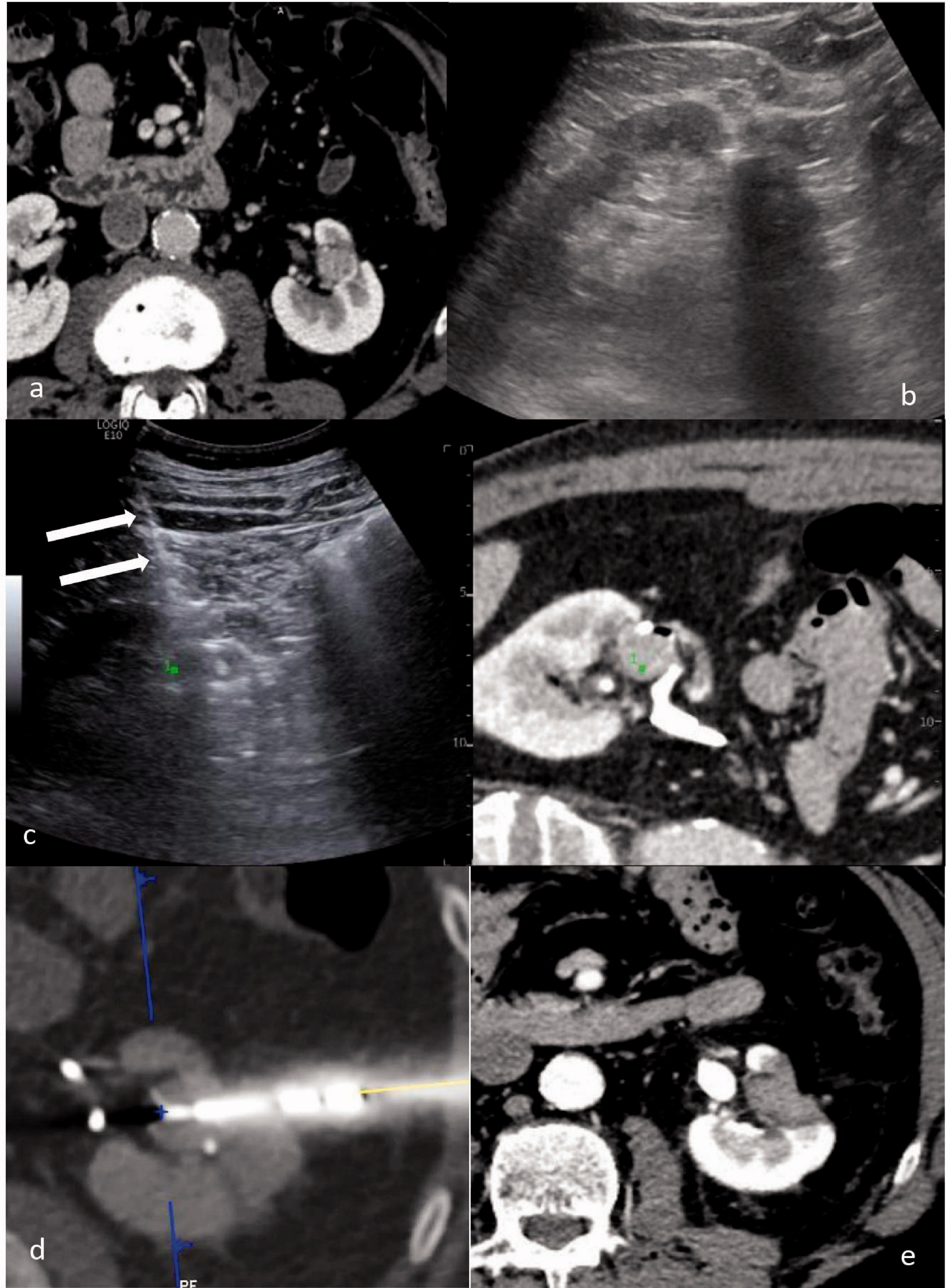


Figure 1: Adapted from Mauri et al. Imaging workflow in a 52-year-old patient with a 12 mm renal cell carcinoma (RCC) recurrence following robotic-assisted partial nephrectomy. (a) Contrast-enhanced CT demonstrating a 12 mm enhancing lesion in the left kidney. (b) Pre-treatment ultrasound failed to clearly visualize the tumor. (c) Fusion of CT and ultrasound images during the procedure enabled tumor localization, with a marker placed on CT (green) to guide ultrasound targeting and needle insertion (white arrows). (d) Immediate post-insertion CT confirmed accurate tumor targeting (blue marker). (e) Follow-up CT at 24 hours demonstrated complete ablation. [2]

Conclusions

- Fusion-guided microwave ablation, particularly when enhanced by multimodal fusion imaging, offers a promising solution for treating sub-centimeter renal tumors that are traditionally difficult to visualize and target.
- This educational review highlights the evolving role of multimodal imaging in elevating the standard of care for patients with small renal masses, especially those for whom surgery is not an option.
- Continued research and innovation will be essential in refining these techniques and expanding access to image-guided, minimally invasive treatments.

References

1. Lerardi AM, Carnevale A, Stellato E, et al. Cone Beam Computed Tomography Image Fusion with Cross Sectional Images for Percutaneous Renal Tumor Ablation: Preliminary Data. *Technol Cancer Res Treat*. 2023;22:15330338231154994. doi:[10.1177/15330338231154994](https://doi.org/10.1177/15330338231154994)
2. Mauri G, Monfardini L, Della Vigna P, et al. Real-Time US-CT fusion imaging for guidance of thermal ablation in of renal tumors invisible or poorly visible with US: results in 97 cases. *Int J Hyperthermia*. 2021;38(1):771-776. doi:[10.1080/02656736.2021.1923837](https://doi.org/10.1080/02656736.2021.1923837)