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Case Report

Conventional and spectral- CT for renal cell carcinoma thermal ablation: A case report ☆

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ABSTRACT

Dual-energy or spectral computed tomography (CT) information may be obtained by either sending X-ray beams of different energy spectra through the patient or by discriminating the energy of the X-rays that reach the detector. The spectral signal is then used to generate multiple results: conventional, virtual monoenergetic (MonoE), effective atomic number, electron density, and other material specific (e.g., iodine, calcium, or uric acid). This report demonstrates the potential benefits of spectral CT imaging during percutaneous tumor ablation procedures, specifically regarding visualization of inconspicuous tumors, accurate probe placement, and assessment of treatment efficacy.

Introduction

Radiologists encounter every day different technical challenges inherent to conventional CT percutaneous thermal ablation procedures due to issues like metal artifacts, accurate probe placement, inconspicuous tumors, thermo protection of structures near the ablation zone, and assessment of treatment efficacy [1]. These limitations impede real-time guidance, functional assessment, and precise probe placement in procedures such as thermal ablation [2].

The purpose of this case report is to highlight the benefits of spectral CT for percutaneous thermal ablation procedures.

We demonstrate the use of low virtual monoenergetic images (VMI) for lesion visualization, high VMI for metal artifact reduction during probe placement, and iodine quantification to confirm treatment efficacy. This patient received 2 clinically indicated thermal ablation procedures in 11 months to treat renal cell carcinoma; the first procedure was cryoablation performed on conventional angio-CT (Big Bore on rails, Philips Healthcare) and the second procedure was microwave thermal ablation performed on a first-of-kind spectral

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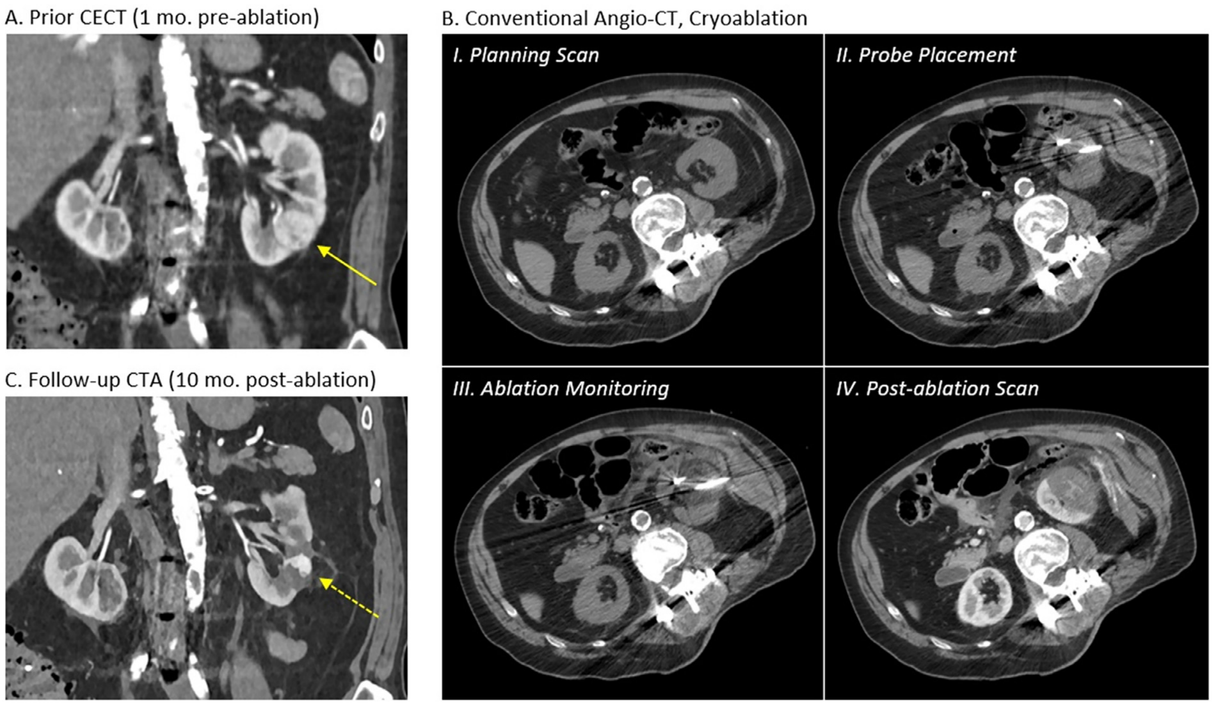

Fig. 1 – Cryoablation with conventional CT guidance. (A) Corticomedullary phase contrast-enhanced CT (CECT) obtained before initial treatment shows enhancing tumor mass (solid arrow). (B) Cryoablation phases include planning, probe placement, ablation monitoring, and post-ablation scan. (C) Coronally reconstructed image from CT angiogram (CTA) obtained 11 months following ablation shows intensely enhancing nodule centrally in the ablation zone (arrow), shown to represent vascular tumor at subsequent conventional angiography.

angio-CT (Spectral CT 7500 on rails, Philips Healthcare). This pair of procedures on conventional and spectral angio-CT highlights the potential added value of spectral information for interventional radiology. The recently developed spectral angio-CT makes use of a dual-layer spectral detector that differentiates low- and high-energy X-rays and enables new visualization modes relating to material decomposition and tissue characterization (i.e., mono-energetic, iodine density, bone removal, z-effective, electron density). Through this case report, we hope to highlight the potential benefits of spectral angio-CT for visualizing tumor masses, verifying probe placement, and assessing tumor vascularity before and after thermal ablation treatment.

Case presentation

A 65-year-old male patient underwent 2 clinically indicated thermal ablation procedures in 11 months to treat renal cell carcinoma; the first procedure was performed on conventional angio-CT (Big Bore on rails, Philips) the second on a first-of-kind spectral angio-CT (Spectral CT 7500 on rails, Philips). Initial treatment was performed using cryoablation, retreatment was performed after 11 months using microwave ablation due to the failure of cryoablation despite apparent technical success.

The patient presented with local recurrence 11 months after cryoablation of a left-sided renal cell carcinoma (Fig. 1). Retreatment was performed using microwave ablation due to the failure of initial cryoablation and the central location of the recurrent tumor. The ablation was performed under CT guidance on a Spectral CT suite (Philips, Best, Netherlands). Initial non-contrast CT imaging failed to delineate the recurrent mass. Therefore, a contrast-enhanced CT was performed using 60 mL of Omnipaque 300 (GE Healthcare, Waukesha, WI), which demonstrated the intensely enhancing recurrent mass within the left renal ablation zone. The low MonoE (50 keV) image showed improved lesion conspicuity relative to the conventional CT image (Fig. 2). Subsequently, a single microwave antenna (Emprint, Medtronic, Minneapolis, MN) was placed into the mass with care taken to avoid placing the tip of the antenna in the collecting system. A 17-gauge introducer needle was advanced along the anterior margin of the mass and 50 mL of fluid was injected to displace the adjacent colon. A limited CT was then obtained to assess antenna placement before ablation. On the conventional CT images, metal artifacts from the probe and metallic spinal hardware hindered visualization of the probe tip. The high MonoE (160 keV) images reduced metal artifacts and improved probe visualization, increasing operator confidence in tumor coverage and the safety of surrounding structures (Fig. 3).

With the microwave antenna in place, a 17-gauge introducer needle was advanced into the mass and 2 18-gauge core biopsies were obtained. The tumor was then ablated for 5 minutes at 75 Watts. The antenna was removed and postprocedural CT was obtained, again using 60 mL of contrast. Conventional CT images demonstrated no significant perinephric

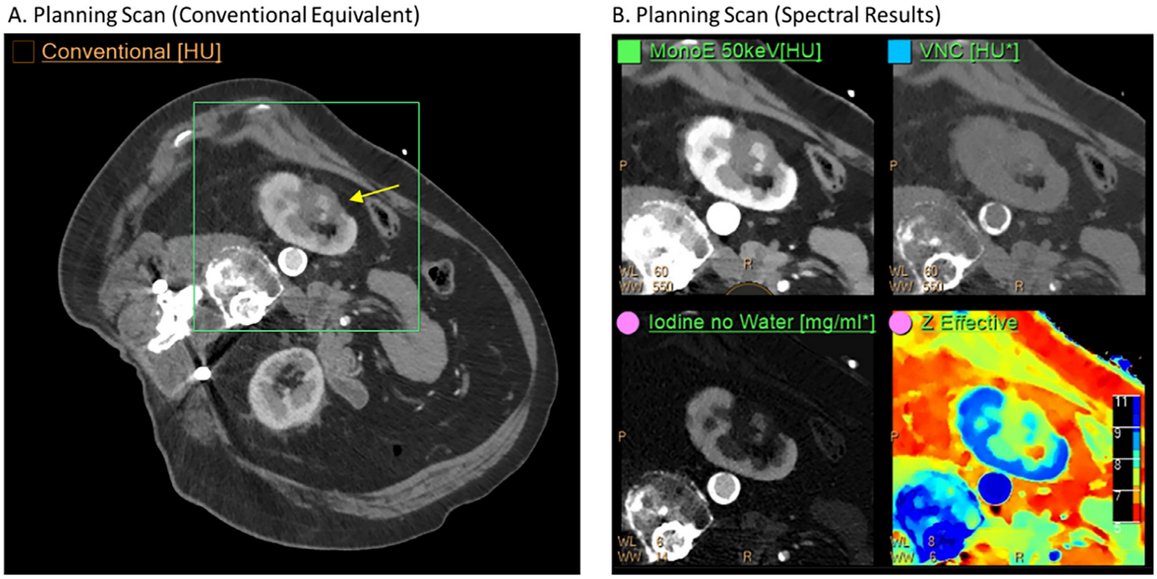

Fig. 2 – Corticomedullary phase contrast-enhanced spectral CT for procedure planning. (A) Conventional equivalent CT image with enhancing tumor mass (solid arrow). (B) Low monoenergetic (MonoE, 50 keV) results in improved lesion conspicuity relative to conventional CT images.

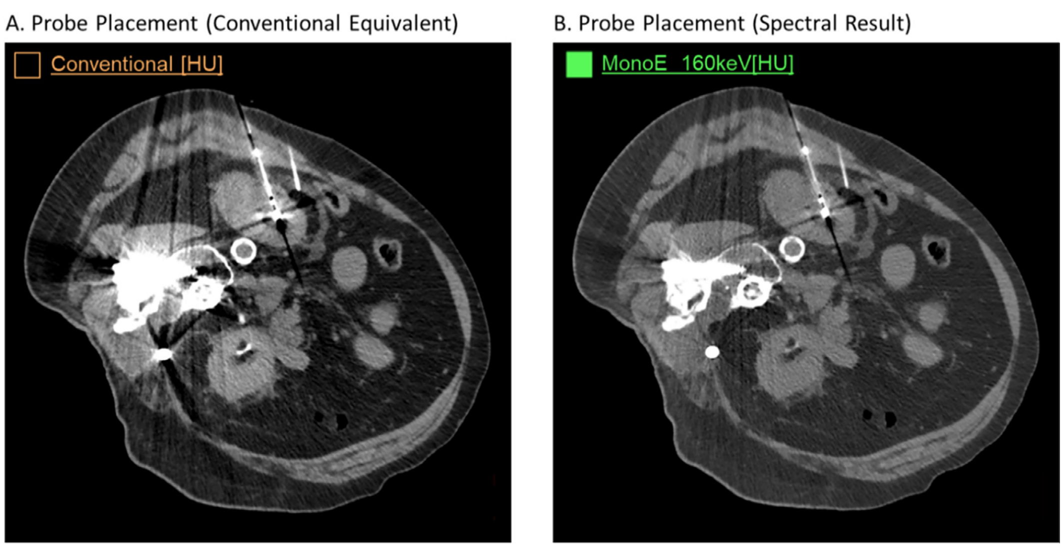

Fig. 3 – Non-contrast probe placement scan with spectral CT. (A) Conventional equivalent images contained severe metal artifacts. (B) The 160 keV MonoE had reduced artifacts from the antenna and metal in the spine.

hemorrhage. Contrast-enhanced images demonstrated complete coverage of the targeted tumor, with the iodine-only images confirming a lack of contrast enhancement within the ablation zone (Fig. 4).

1. *Cryoablation with Conventional CT Guidance*

Percutaneous cryoablation of the left renal mass under general anesthesia was performed with ultrasound and conventional CT guidance. An initial CT planning scan was acquired to localize the lesion of interest and plan needle placement. Five cryoprobes were placed under ultrasound guidance and their placement was confirmed with subsequent CT imaging. CT was used to monitor the cryoablation treatment to confirm tumor was fully encompassed within a lethal temperature zone and critical structures were avoided (i.e., ureter, bowel, and adrenal gland). Postablation scans showed no evidence of contrast enhancement within the original tumor volume, indicating that the ablation procedure was successful (Fig. 1B).

At 11 months following ablation, a CT angiogram showed an intensely enhancing and enlarging nodule within the prior ablation zone (Fig. 1C). Vascular enhancement was initially thought to be a pseudoaneurysm; however, subsequent angiography revealed tumor mass recurrence.

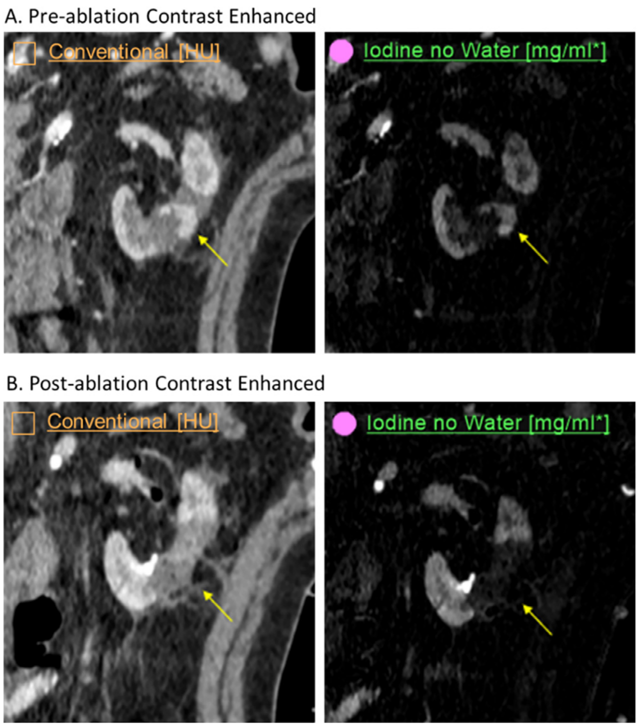

Fig. 4 – Pre- and post-ablation scans nephrographic phase contrast-enhanced, coronal plane. (A) Pre-ablation images indicate neovascularization of tumor mass leading to the enhanced lesion as seen in conventional and iodine-no-water images. (B) Postablation images indicate no enhancement within the ablation zone.

2. Microwave Ablation with Spectral CT Guidance

At 11 months following the initial cryoablation, the patient was admitted for a second thermal ablation procedure to treat a recurrence of tumor mass. For the second procedure, the microwave ablation was guided with spectral CT, as opposed to conventional CT.

The initial planning scan using noncontrast CT imaging failed to delineate the enhancing mass seen on the previous CT exam and angiogram. Consequently, 60 mL of intravenous contrast was administered, and subsequent images showed the enhancing recurrent mass within the left renal ablation zone. Several, spectral results were inspected to better visualize the recurrent mass, including low monoenergetic (MonoE), virtual non-contrast (VNC), Iodine no Water, and Z Effective images. The low monoE (50 keV) image showed improved lesion conspicuity relative to the conventional CT image (Fig. 2).

Subsequently, a microwave antenna was placed into the tumor mass with care taken to avoid placing the tip of the probe in the collecting system. A 17-gauge introducer needle was advanced along the anterior margin of the mass and 50 mL of fluid was injected to displace the adjacent colon. For the conventional image, metal artifacts from the probe and prior spine surgery compromised the visualization of the precise probe location. The high MonoE (160 keV) reduced the impact of metal artifacts resulting in improved visualization of the probe placement (Fig. 3).

Two 18-gauge core biopsies were obtained, and the tumor was ablated for 5 minutes at 75 W. The microwave antenna was removed without complication. Contrast-enhanced imaging immediately following ablation was performed to assess treatment. Conventional images indicated the enhancing tumor mass was effectively treated. Iodine no water images provided subjectively greater confirmation with the absence of iodine uptake in the ablation zone (Fig. 4).

A chest X-ray did not reveal any evidence of metastatic disease in the chest. Laboratory testing was within normal limits with normal renal function. A follow-up CT scan or MRI was recommended in 3 months.

Discussion

Interventional oncology teams experience different challenges during thermal ablation procedures. The use of spectral CT imaging during percutaneous renal mass ablation can facilitate procedural planning, probe placement, and assessment of treatment efficacy. This case report highlights three promising potential applications of spectral CT to overcome routine challenges for interventional oncology teams: (I) low MonoE for lesion localization and procedure planning, (II) high MonoE for accurate placement of interventional applicators, and (III) Iodine no Water for assessing treatment efficacy.

(I) In this case, the neovascularization of the tumor mass has increased iodine uptake compared to the surrounding tissue. This case indicates spectral CT with low MonoE can be used to improve lesion conspicuity relative to conventional CT for enhancing lesions. One promising direction is to use low MonoE to reduce the amount of contrast agents administered during interventional procedures. The patient in this case reported compromised renal function from bilateral renal artery stenosis and chronic kidney disease. This advantage has previously been demonstrated with diagnostic spectral CT in which low MonoE images enabled a reduction in administered contrast dose [1].

(II) Metal artifact is an inherent challenge during CT-guided interventions, particularly when more than one ablation device is necessary, or—as in this case—when there is additional artifact from hydro displacement needles and preexisting spinal hardware. In these instances, spectral CT with high MonoE can be used to reduce metal artifacts relative to conventional CT, thereby increasing confidence in probe placement and limiting the number of probe manipulations that might otherwise be necessary to optimize positioning. Previously groups have used spectral CT with high MonoE to reduce metal artifacts during diagnostic imaging [2].

(III) Contrast-enhanced CT imaging before and after ablation can be an important tool to determine treatment success. Confirming the absence of enhancement using iodine-only images can improve confidence in treatment success while limiting the dose of contrast administered to the patient.

Before ablations, most tumors show higher iodine content associated with increased vascularity and perfusion compared to other benign masses. After ablations, the absence of iodine uptake in the ablation zone would be indicative of successful treatment of the index tumor. This case indicates Iodine no Water images from spectral CT can be used to quantify the iodine content within the tumor mass before and after ablation to aid in confirmation of treatment success. In future studies, we plan to study the use of spectral CT Iodine no Water images to visualize malignant masses and quantify postablation iodine uptake within the ablation zone.

Conclusion

Overall, the use of spectral CT imaging during renal ablation can provide favorable adjunctive imaging information to improve procedural performance and potential treatment outcomes. This case report provides a preliminary indication of the benefits of a first-of-kind spectral -CT scanner for procedure planning, probe placement, and assessing treatment efficacy. Further research is necessary to confirm the benefit of spectral information for interventional CT applications.

Contributions

Each author has contributed equally.

Patient consent

We obtained written, informed consent for publication from the patient.

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