Real-Time Monitoring of Ablation Zone Adequacy Using Intraprocedural CT in Thermal Ablation

Milin Patel BHSc[1], Daniel Crawford MD[2], Sadeer Alzubaidi MD[2], Alex Wallace MD[2], Merve Ozen MD[2], Indravadan J. Patel MD[2]

1. Faculty of Medicine, University of Ottawa, Canada
2. Division of Vascular and Interventional Radiology, Mayo Clinic, Phoenix, AZ, USA

SYMPOSIUM ON CLINICAL INTERVENTIONAL ONCOLOGY

Introduction

- Complete tumor ablation with adequate margins is **essential** for the **treatment of oncological tumors** in image-guided thermal ablation procedures.
- However, this remains **challenging** when performing thermal ablation for **poorly visualized** lesions.
- This learning exhibit aims to demonstrate the utility of **intraprocedural CT for real-time assessment** of ablation zone coverage, guiding probe repositioning and additional ablation to ensure optimal treatment.

Utility of Intraprocedural CT

- Integrating intraprocedural CT imaging for margin assessment has shown **improved local tumor control**
- Real-time CT–CT image fusion during liver ablations reported a 2-year local tumor **progression-free survival** of 97% vs 74% for **hepatocellular carcinoma**, and 82% vs 56% for **colorectal liver** metastases (1)
- 96% primary technical efficacy rate with intraprocedural CT, compared to 70% without intraprocedural imaging in **renal tumor ablation** (2)
- ~4% of tumors treated with intraprocedural CT showed residual disease on follow-up, versus ~30% incidence of incomplete ablation when relying solely on next-day scans (2)
- Intraprocedural contrast-enhanced CT can directly measure the **minimal ablative margin** (MAM) around a tumor, which is highly predictive of outcome

Clinical Workflow

1. Pre-Procedural Planning
   - Identify target lesion location and surrounding structures
   - Plan initial probe trajectory and ablation zone
2. Initial Probe Placement
   - Advance probe under image guidance
   - Confirm position with non-contrast CT
3. Initial Ablation
   - Undergo ablation cycle and allow for thermal zone to stabilize
4. Intraprocedural CT Imaging
   - Acquire non-contrast CT to visualize ablation zone
   - Use contrast-enhanced CT to assess residual perfused tumor
5. Adequate zone coverage?
   - Yes → proceed
   - No → reposition probe or add additional probe
6. Final CT
   - Perform final CT scan and document complete ablation zone

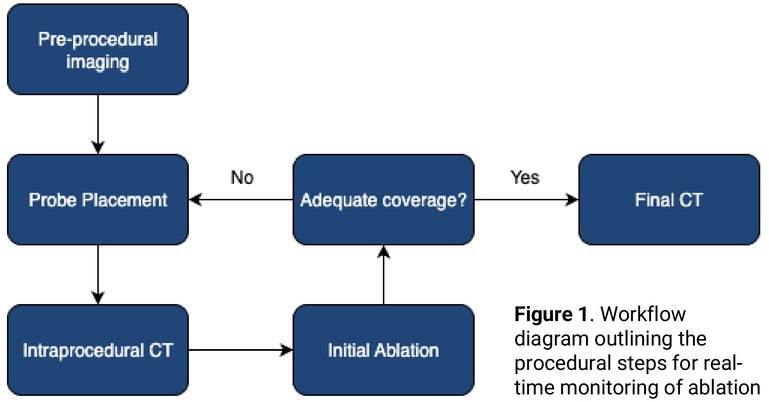


Figure 1. Workflow diagram outlining the procedural steps for real-time monitoring of ablation zone adequacy using intraprocedural CT.

Insights from Literature

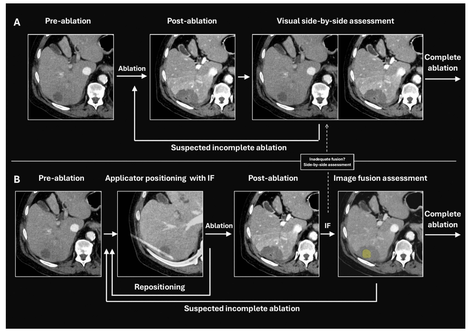
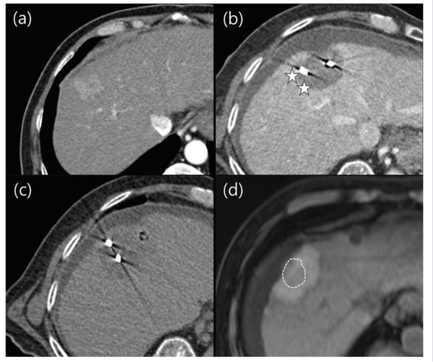


Figure 2 (above). Verdonschot et al. demonstrate clinical workflow for percutaneous thermal ablation:
(A) Before October 2019, where side-by-side image comparison was used to assess ablation
(B) After October 2019, where image fusion was used to verify positioning before ablation and assess treatment (1).

Figure 3 (below). Joo et al. Microwave ablation of HCC with intra-procedural CT showing insufficient margin, corrected by probe repositioning and repeat ablation. Post-procedural MRI confirms adequate >5 mm margin with artificial ascites protection (3).



Conclusion

- Incorporating intraprocedural CT imaging enhances procedural precision and improves oncologic outcomes by enabling immediate assessment and correction of incomplete ablation zones.
- This exhibit provides a practical framework for implementing real-time imaging workflows in thermal ablation practice.

References

1. Verdonschot KHM, Jenniskens SFM, van den Boezem PB, Tjwa ETTL, de Wilt JHW, Fütterer JJ, Stommel MWJ, Overduin CG. CT-guided Thermal Ablation of Liver Tumors Using Intraprocedural CT-CT Fusion for Applicator Position and Ablation Completeness Assessment: a Single-Center Comparative Analysis. Cardiovasc Intervent Radiol. 2025 Jul 10. doi: 10.1007/s00270-025-04111-w. Epub ahead of print. PMID: 40640410.
2. Grewal A, Khera SS, McGahan JP, Wilson M, Loehfelm TW, Dall'Era MA, Evans CP. Utility of Intraprocedural Contrast-Enhanced CT in Ablation of Renal Masses. AJR Am J Roentgenol. 2020 Jan;214(1):122-128. doi: 10.2214/AJR.19.21584. Epub 2019 Sep 18. PMID: 31532258; PMCID: PMC7552890.
3. Joo I, Morrow KW, Raman SS, McWilliams JP, Sayre JW, Lu DS. CT-monitored minimal ablative margin control in single-session microwave ablation of liver tumors: an effective strategy for local tumor control. Eur Radiol. 2022 Sep;32(9):6327-6335. doi: 10.1007/s00330-022-08723-5. Epub 2022 Apr 7. Erratum in: Eur Radiol. 2022 Sep;32(9):6554-6555. doi: 10.1007/s00330-022-08797-1. PMID: 35389047; PMCID: PMC9381632.