Artificial Intelligence Integration in Interventional Oncology: Enhancing Precision and Immunotherapy Synergy

Mustaqueem Pallumeera, BS,[1] Marcus Hong, BS,[1] and Mina S Makary, MD[2]
[1] The Ohio State University College of Medicine, Columbus, OH; [2] Department of Radiology, The Ohio State University College of Medicine, Columbus, OH.

Purpose

- Artificial intelligence (AI) is transforming interventional oncology (IO) by enabling non-invasive tumor profiling and improved personalization of image-guided therapies.
- As IO expands beyond conventional ablation and embolization, AI tools such as radiomics and machine learning (ML) are being integrated to improve treatment prediction and therapeutic outcomes, particularly in synergy with immunotherapy.

Materials and Methods

- The primary methodology employed in this educational exhibit involves a comprehensive evidence- and case-based PubMed literature review of published outcomes to date.

Results

- AI-driven radiomics can extract complex features from medical imaging, enabling prediction of tumor immunologic characteristics. In a prospective study of 17 hepatocellular carcinoma (HCC) lesions, contrast-enhanced MRI features were used to train ML models to predict ImmunoScore: a measure of CD3+, CD4+, and CD8+ T-cell infiltration.
- Feature selection and model development included linear regression and random forest algorithms, validated by leave-one-out cross-validation.[1]

Results

- Simultaneously, AI is informing strategies combining ablative techniques (e.g., radiofrequency ablation, microwave ablation, and irreversible electroporation) with immunotherapies for systemic benefit.[2]
- The MVP microvascular plug (Medtronic) aimed to overcome these downsides in both deliverability and occlusion.[3]
- The random forest model accurately classified tumors as immunologically “hot” or “cold” with an F1 score of 88.24 and an AUC of 85.83, showing the feasibility of imaging-derived immune prediction.[1]
- Locoregional therapies are increasingly combined with immunotherapy agents such as checkpoint inhibitors and oncolytic viruses to stimulate antitumor immunity.
- Ablation modalities, including high-frequency irreversible electroporation (H-FIRE), have shown the ability to produce non-thermal, immunogenic tumor destruction near sensitive structures.
- In vivo studies demonstrated that H-FIRE can achieve large ablation volumes (4.62 × 1.83 cm) using a single-needle probe, while triggering immune cell infiltration and avoiding cardiac synchronization 3

Conclusion

- AI integration in IO offers a pathway toward precision oncology by enabling non-invasive immune profiling, treatment personalization, and optimized combination therapy.
- ML-enhanced imaging biomarkers may reduce the need for invasive biopsies and guide patient selection for immunotherapy.
- As novel ablation modalities emerge, AI will be critical in real-time treatment planning and predicting response, establishing a new paradigm in personalized cancer intervention.2,4

References

Yang J, Shewarega A, Santana J, et al. Use of machine learning to predict the histopathological ImmunoScore in hepatocellular carcinoma on multiparametric MRI. *J Hepatol*. 2022;77(S1):S935.
Altun I, Demirlenk YM, Atar D, et al. Advances and challenges in interventional immuno-oncology locoregional therapies. *J Vasc Interv Radiol*. 2024;35(2):164–172. doi:10.1016/j.jvir.2023.10.009.
Aycock KN, Campelo SN, Salameh ZS, et al. Toward large ablations with single-needle high-frequency irreversible electroporation in vivo. *IEEE Trans Biomed Eng*. 2025;72(2):705–714. doi:10.1109/TBME.2024.3468159.
Breuer JA, Ahmed KH, Al-Khouja F, Macherla AR, Muthoka JM, Abi-Jaoudeh N. Interventional oncology: new techniques and new devices. *Br J Radiol*. 2022;95(1138):20211360. doi:10.1259/bjr.20211360.

Contact

mustaqueem.pallumeera@osumc.edu