The AI-Assisted Journey in Interventional Oncology

Artificial intelligence is transforming interventional radiology, particularly in cancer treatment. This presentation explores how AI serves as a "co-pilot" throughout the patient journey - from diagnosis and procedure planning to real-time guidance and follow-up care.

Through the story of Dr. Qarara treating a patient with liver cancer, we'll examine current AI applications in interventional oncology and glimpse into the future of this rapidly evolving field.

by Iyad Sultan

Setting the Stage: Radiology's AI Revolution

Natural Fit

Radiology's image-heavy nature makes it ideal for AI applications, with diagnostic radiology seeing early adoption and success.

Proven Success

AI excels at processing images, detecting lesions, suggesting diagnoses, and enhancing image quality in diagnostic settings.

New Frontier

Interventional radiology represents the next evolution, bringing AI from diagnostics into procedure-oriented medicine.

Understanding Interventional Oncology

Definition

Interventional oncology (IO) is a subspecialty of interventional radiology focused on minimally invasive, image-guided cancer treatments.

Key Treatments

Primary IO procedures include tumor ablation (destroying tumors with heat, cold, or electricity) and embolization (cutting off tumor blood supply).

Imaging Centrality

Imaging guides every step of IO - from diagnosis and treatment planning to procedure navigation and outcome assessment.

Meet Our Patient: Mr. Abbas

1 Initial Discovery

Routine scan reveals a 2.5 cm hepatocellular carcinoma (HCC) in the right liver lobe.

2 Treatment Decision

Percutaneous tumor ablation selected as optimal treatment due to tumor size and location.

3 AI Assistance

Dr. Qarara will utilize AI tools throughout the treatment journey for optimal care.

AI in Cancer Detection

Automated Lesion Detection

AI flags suspicious areas that might be missed during routine scans.

Precise Measurement

AI accurately segments tumors, measuring size and volume for treatment planning.

3D Visualization

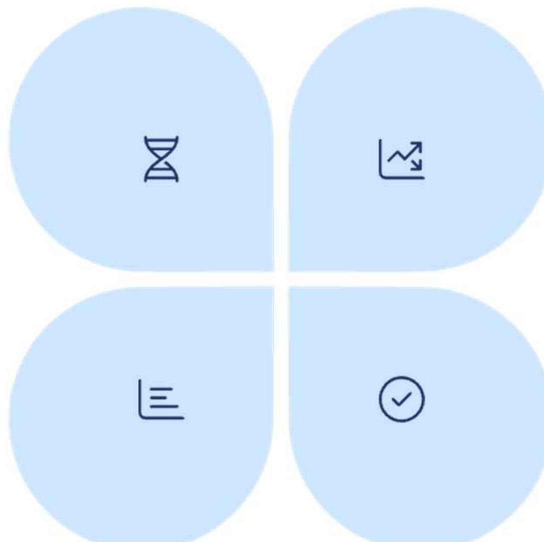
AI creates detailed 3D models showing tumor proximity to critical structures.

In studies, AI platforms have achieved Dice scores of approximately 0.88 in segmenting HCCs on CT scans, matching the performance of expert radiologists in finding and delineating liver tumors.

AI in Tumor Characterization

Radiomics Analysis

AI extracts thousands of quantitative features from images that are invisible to the human eye.



Pattern Recognition

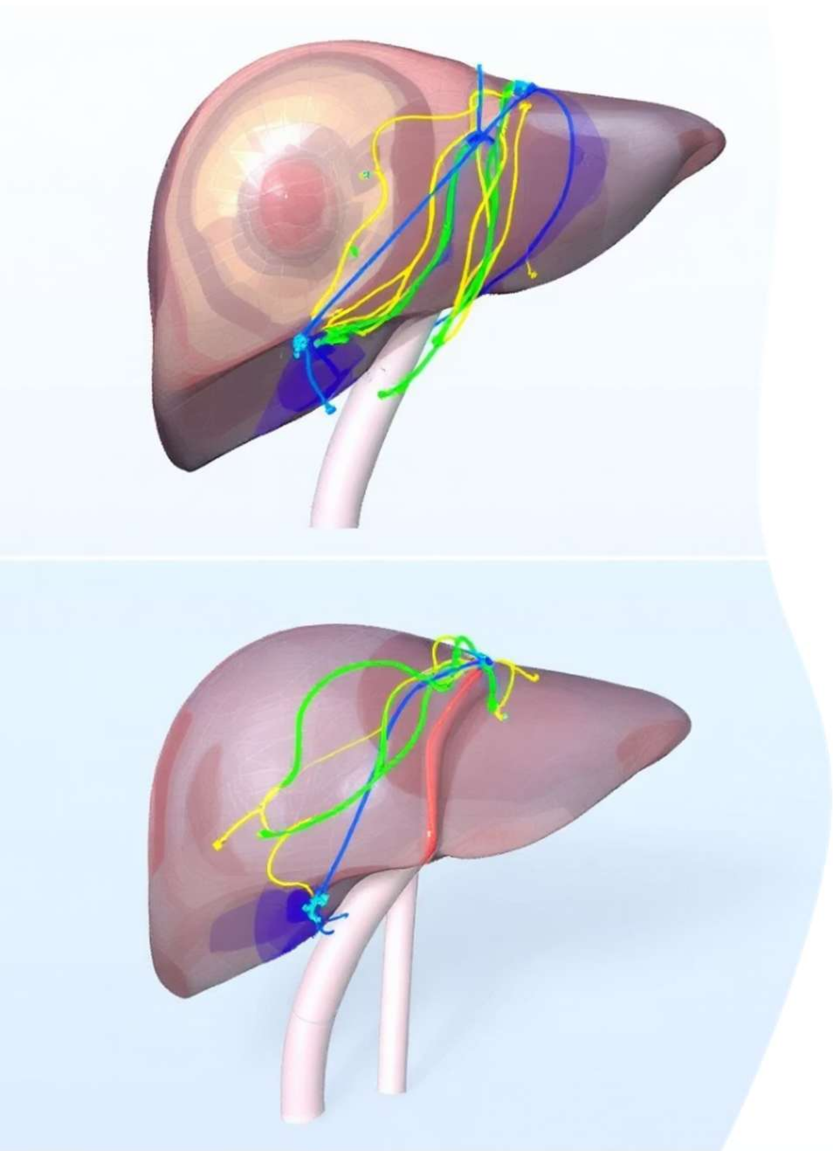
AI compares tumor features with thousands of past cases to identify patterns.

Aggressiveness Assessment

AI evaluates tumor features to predict biological behavior and treatment response.

Differential Diagnosis

AI provides probability scores for malignancy vs. benign lesions.



AI in Procedure Planning: Targeting

Automatic Segmentation

AI identifies and outlines the tumor, vessels, bile ducts, and other critical structures in 3D space.

Trajectory Planning

AI suggests optimal needle paths that avoid critical structures while providing direct access to the tumor.

Safety Verification

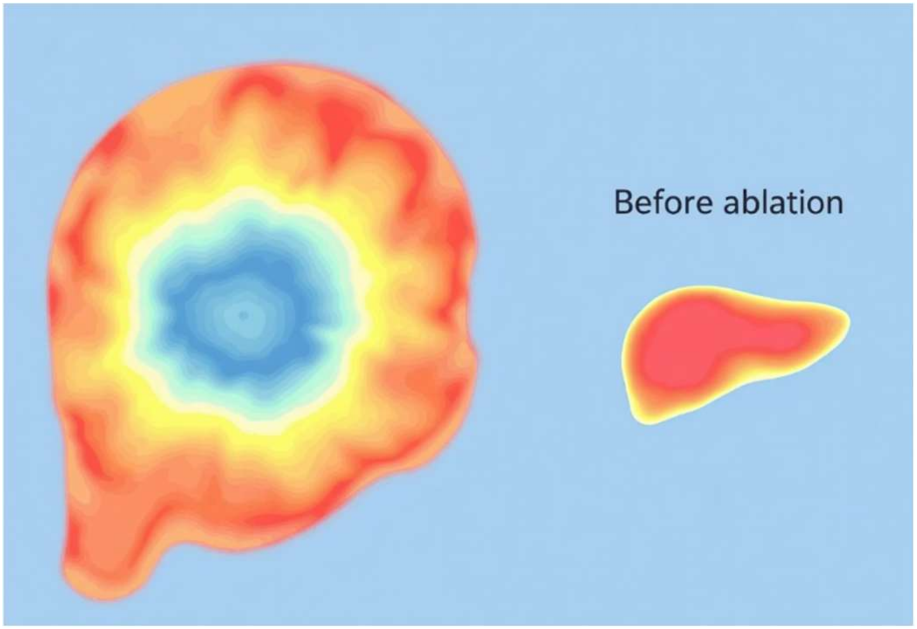
AI confirms that planned paths avoid risky areas and maintain safe margins from vital structures.

AI in Procedure Planning: Simulation

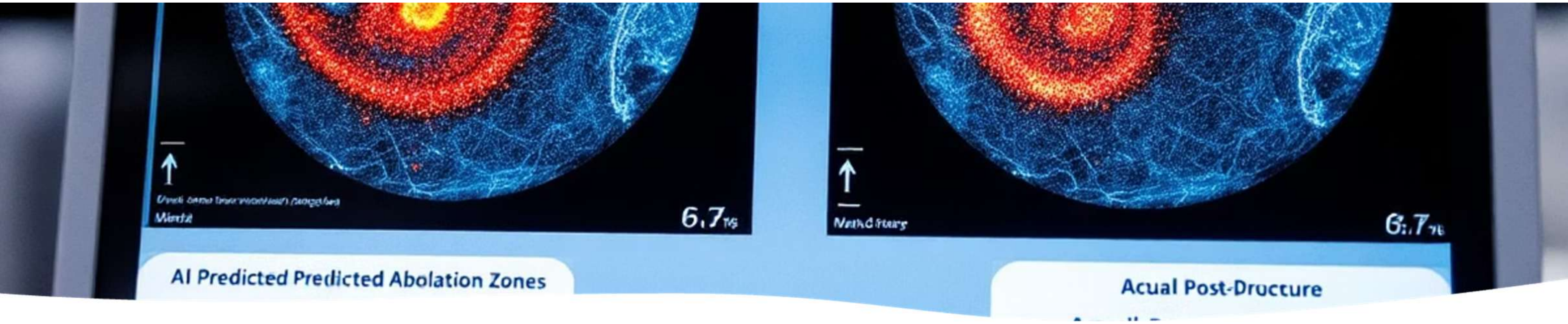
Digital Trial Run

Before the actual procedure, AI simulates the ablation process, predicting the size and shape of the ablation zone based on energy settings and duration.

The simulation accounts for the "heat-sink" effect of nearby blood vessels, which can reduce ablation effectiveness by cooling the surrounding tissue.



In Mr. Abbas's case, the simulation revealed that a single ablation might leave tumor tissue viable near a blood vessel, prompting Dr. Qarara to plan for overlapping ablations.



Ablation Zone Prediction: AI vs. Standard Charts

10.7%

Accuracy Improvement

Deep learning models predict ablation zones with significantly better accuracy (Dice score 0.62 vs 0.56) than device manufacturer charts.

0.79

Dice Score for Cryoablation

AI models for cryoablation can predict ice formation with high fidelity, even reflecting how ice shapes conform to organ boundaries.

100s

Training Cases

AI models learn from hundreds of previous ablations, incorporating real-world variables that standard charts cannot account for.

AI Applications in Other IO Procedures

Radioembolization

AI simulates microsphere distribution and predicts post-treatment Yttrium-90 PET imaging from pre-treatment SPECT, improving dose estimation to tumors.

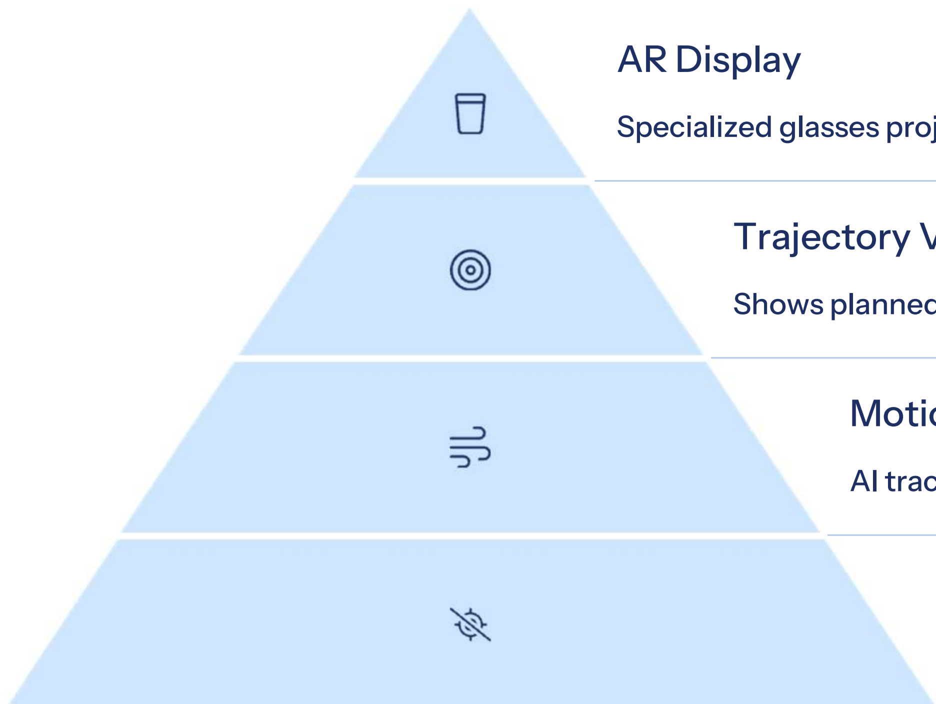
Chemoembolization

AI helps select optimal feeding vessels and predicts drug delivery patterns for more effective tumor targeting.

Virtual Reality

AI enables VR rehearsal of complex cases, allowing interventionalists to practice procedures before performing them on patients.

Real-Time Guidance: Augmented Reality



AR Display

Specialized glasses project holographic overlays onto the patient

Trajectory Visualization

Shows planned needle path through the body to the tumor

Motion Compensation

AI tracks patient breathing and adjusts overlays in real-time

Instrument Tracking

Monitors needle position relative to planned path

Studies have shown that AR-guided procedures can reduce radiation exposure and improve targeting accuracy. In one in-vivo study, an AR system successfully guided tumor ablations by overlaying virtual needle trajectories onto fluoroscopy views.

Real-Time Guidance: Enhanced Imaging

Deep Learning Reconstruction

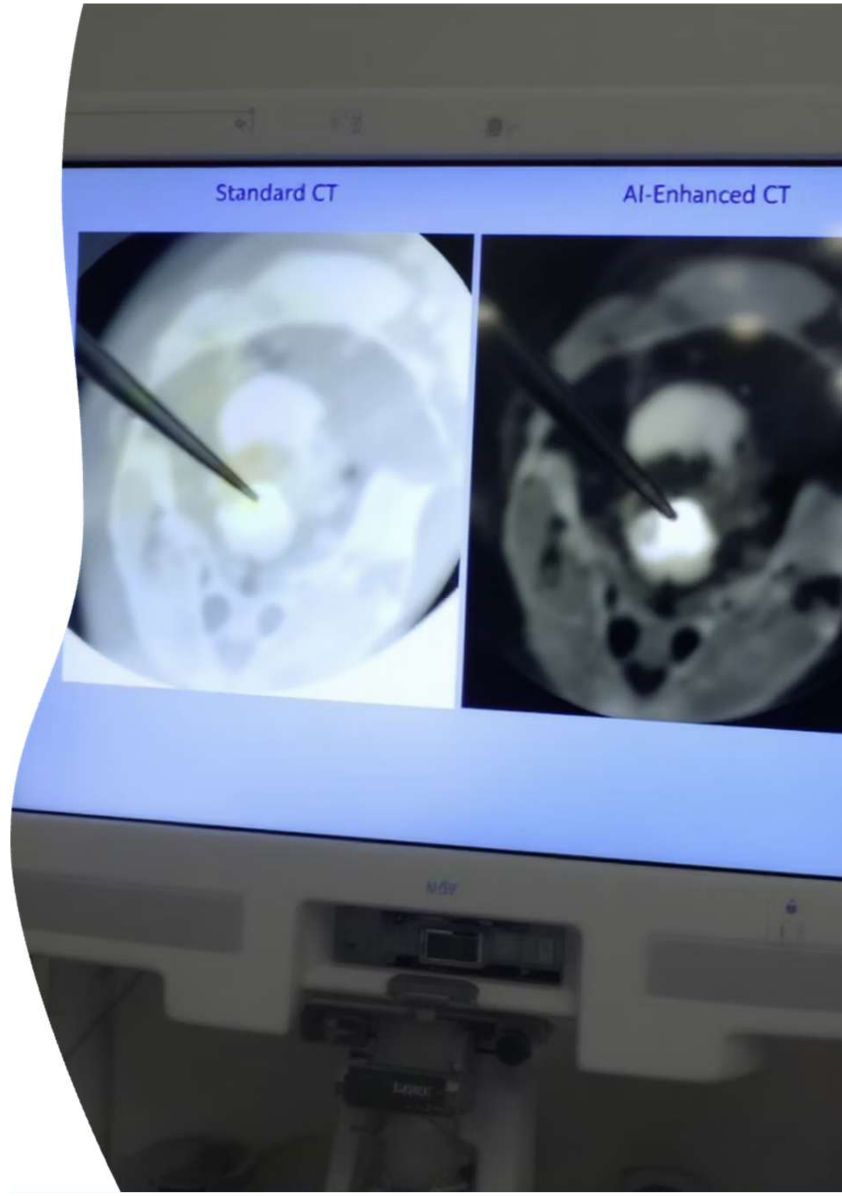
AI algorithms process CT images in real-time to enhance clarity while reducing radiation dose, making small details like vessels and tumor edges more visible.

Artifact Reduction

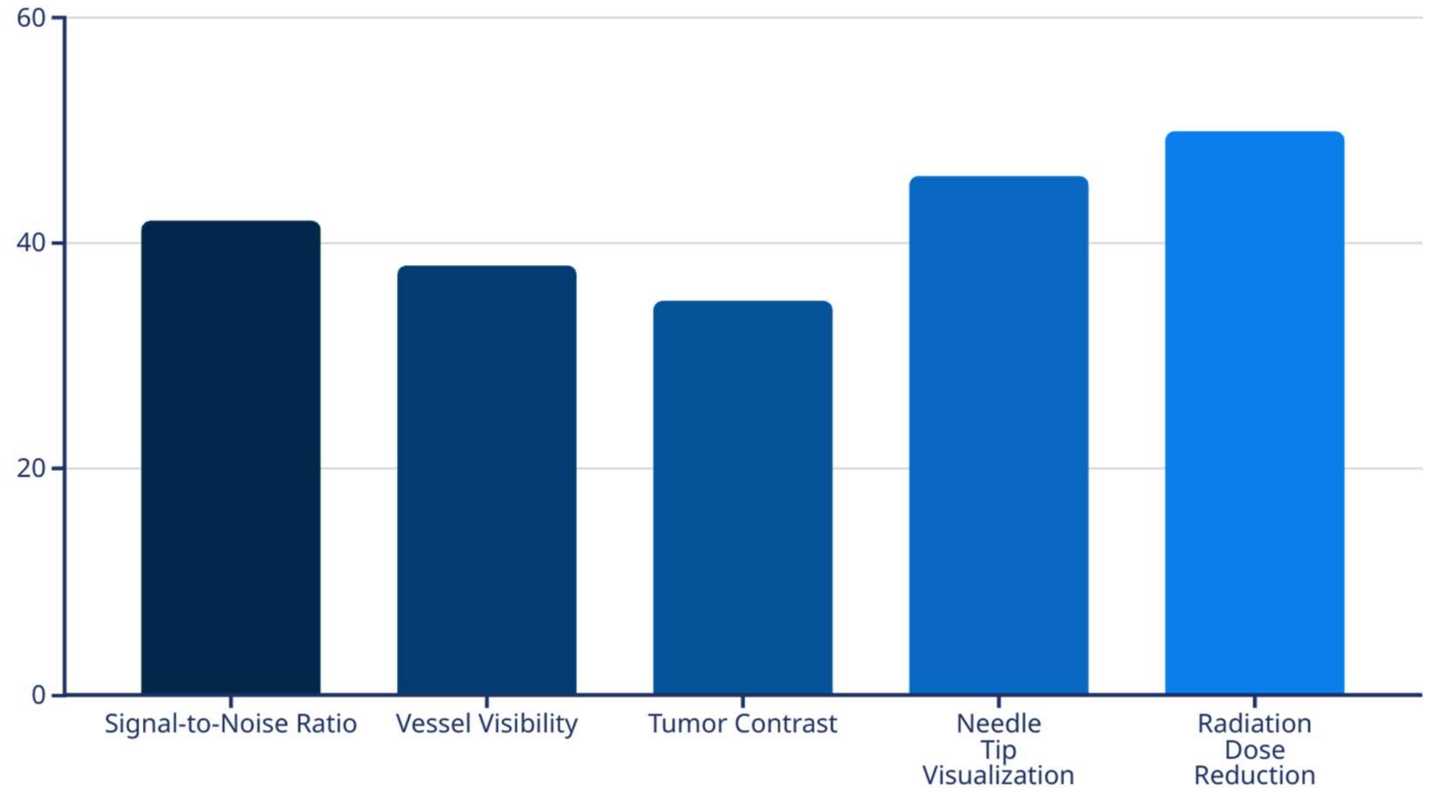
Specialized AI reduces metal streak artifacts from needles and probes, improving visualization of the instrument tip and surrounding anatomy.

Motion Correction

AI compensates for patient movement and breathing, stabilizing images for more accurate needle placement and tumor targeting.

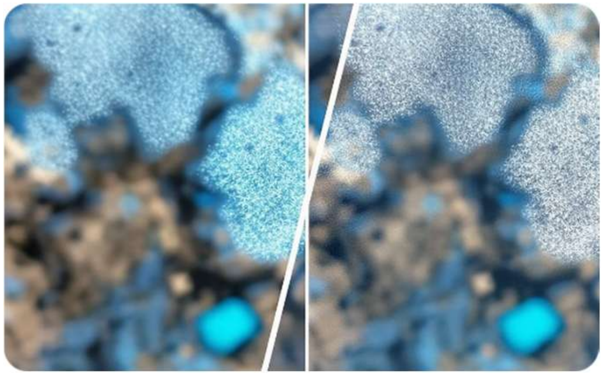


CT Quality Improvement with AI



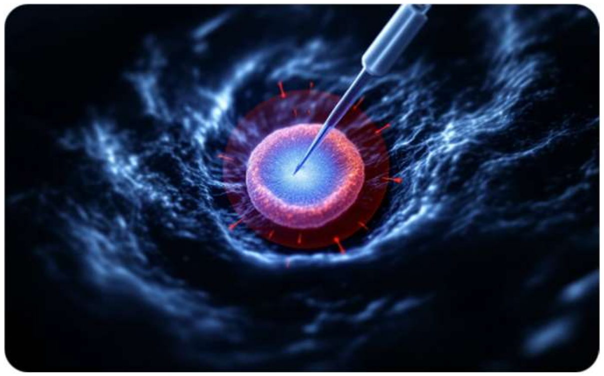
Studies show that deep learning reconstruction (DLR) in CT-guided procedures significantly improves image quality metrics while allowing for approximately 50% radiation dose reduction. This benefits both patients and medical staff by reducing radiation exposure without compromising visualization.

AI for Instrument Tracking and Visualization



Artifact Reduction

AI algorithms trained on thousands of images can virtually "erase" the bright streaks caused by metal instruments, improving visibility of the needle tip and surrounding anatomy.



Enhanced Ultrasound Guidance

AI improves needle visibility in ultrasound by enhancing contrast and automatically highlighting the instrument path relative to the target.

Fluoroscopy Enhancement

AI can automatically position X-ray equipment for optimal views and enhance vessel visibility during catheter-based procedures.

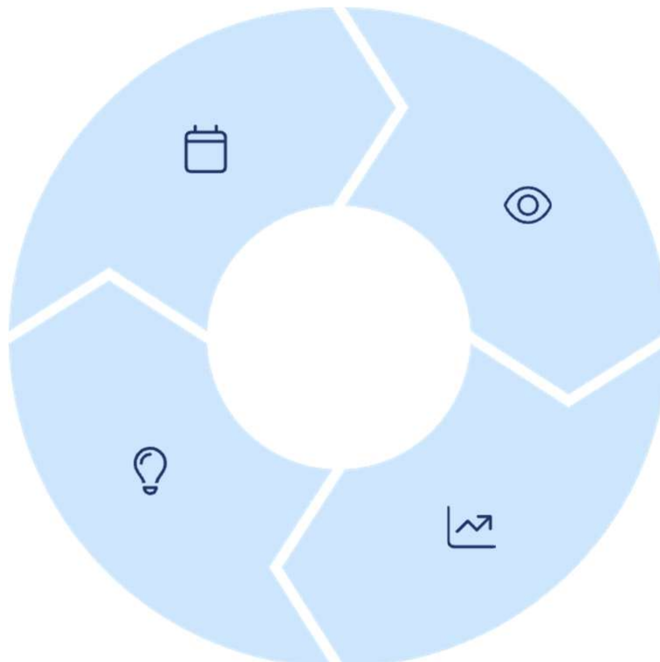
Post-Procedure Monitoring with AI

Follow-up Scheduling

AI risk assessment helps determine optimal follow-up intervals based on patient-specific factors.

Treatment Recommendations

Based on follow-up findings, AI can suggest whether additional intervention is needed.



Recurrence Detection

AI algorithms trained on thousands of post-ablation scans can distinguish normal post-treatment changes from suspicious new growth.

Response Assessment

AI evaluates treatment effectiveness by measuring changes in tumor size, enhancement, and texture over time.

Studies have shown remarkable accuracy in AI-based recurrence detection, with one radiomics-based approach achieving 92.7% accuracy (AUC 0.97) and another deep learning model reaching 97.6% accuracy (AUC 0.99) in identifying early HCC recurrence.