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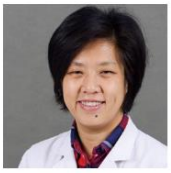

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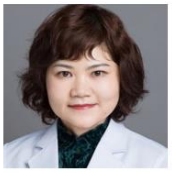

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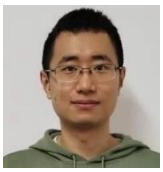

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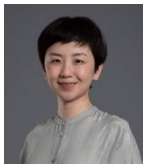

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Foreword

A Note from the Editorial Board

Welcome to this year's annual magazine from the Global Scientific Collaboration team.

uInnovation is a scientific magazine published by United Imaging Healthcare that has been successfully distributed for over past three years. It aims to serve as a platform for sharing ground-breaking advancements, emerging trends, and future possibilities in the vast expanse that is oncology.

uInnovation is currently in its fourth edition. This year's edition will inform, engage, and inspire you about the latest developments and applications of United Imaging Healthcare. This journal includes quick read sections for those in a rush, and appealing images to promote visual understanding.

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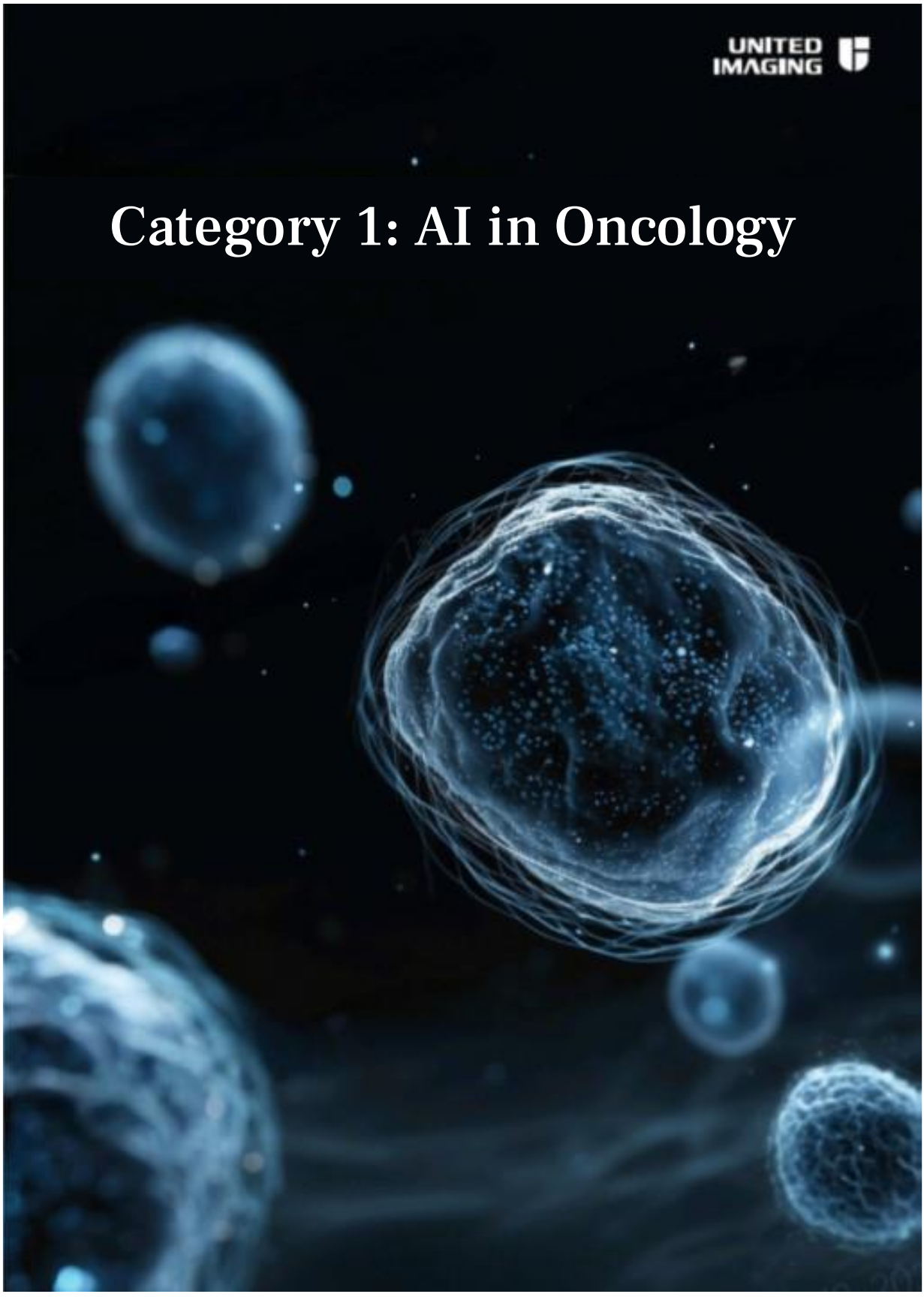
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Category 1: AI in Oncology

The Transformative Role of AI in Lung Cancer Screening

Samuel Reefath
MGM Healthcare, Chennai, INDIA

"*Screening in the AI era is more patient-centered than ever before. And this, in the end, is what matters most: earlier diagnoses, safer care, and better chances at life*."

Artificial Intelligence (AI) has shifted from being a futuristic idea to becoming a daily reality in radiology. Few areas showcase its impact as vividly as lung cancer screening. Over the past decade, I have seen the field evolve from painstaking manual review of chest CTs to AI-augmented workflows that are faster, sharper, and more consistent. For a disease where early detection is everything, this evolution is not just technological—it is lifesaving.

Cardiovascular related deaths are dominated by vascular diseases of the heart (coronary and microvasculature), and the large great vessels. Diagnostic cardiac catheterization was introduced by André Cournand and Dickinson Richards in the 1940s, followed by selective coronary angiography by Mason Sones in the 1960s. With the advent of catheter-based interventions, pioneered by Andreas Gruentzig in the 1970s. In the last 50 years, there has been tremendous progress in the refinement and expansion of these techniques. Today, percutaneous coronary intervention (PCI) access is through the femoral and the radial arteries. Coincidently, never ending development of interventional technologies have emerged from discrete single coronary artery (CA) lesions procedures to left main CA interventions, and more recently to multivessel coronary disease cases with risks too high for surgical solutions.

Has AI changed my practice?

The short answer is yes, and in a profound way. AI has altered the very rhythm of my day. What once involved long hours of scrolling through hundreds of CT slices to hunt for subtle nodules is now supported by AI algorithms that flag suspicious lesions, calculate volumes, and track growth across time. Instead of being consumed by the mechanics of detection, I can devote more attention to interpretation, context, and communication with patients and colleagues.

What AI tools I use currently

In my current practice, AI is woven into several steps of the lung cancer screening process:

- Nodule detection and volumetry software highlights even very small lesions and quantifies their growth across time.

- Deep learning-based reconstruction algorithms (DLR, including Delta reconstructions) enhance CT images while allowing us to reduce radiation exposure.

- Risk-stratification platforms combine imaging data with patient demographics and clinical risk factors to guide screening intervals.

These tools are not replacements for radiologists, but rather extensions of our skillset-helping us see more, measure more precisely, and decide more confidently.

Has AI made my practice better?

The gains are clear. Efficiency has improved, turnaround times have shortened, and my diagnostic confidence has increased. For example, when dealing with a patient who has multiple tiny nodules, manual tracking used to feel like assembling a jigsaw puzzle under pressure. Now, AI automatically compares current and prior scans, providing volumetric growth curves that allow me to focus on clinical judgment rather than raw measurement.

Perhaps more importantly, AI levels the playing field. It empowers junior radiologists to produce reports of consistent quality, aligning with international screening standards, and reducing inter-observer variability.

How has AI changed my interaction with colleagues?

AI has also reshaped conversations in the multidisciplinary tumor board. Instead of debating whether a nodule "looks a little bigger," we now discuss growth rates, malignancy risk scores, and structured AI-generated metrics. This has led to more precise planning with oncologists, particularly around

decisions of surveillance versus biopsy versus intervention. Among radiologists, too, AI has encouraged a culture of evidence-based dialogue rather than subjective hierarchy.

The pre-AI era: how was screening done?

Before AI, lung cancer screening was laborious and imperfect. Radiologists manually scrutinized hundreds of CT images, often revisiting the same dataset multiple times to ensure no subtle lesion had been missed. Nodule volume estimation was rudimentary, usually involving caliper measurements that were time-consuming and prone to variation. Reporting was slower, and despite best efforts, the risk of missed nodules remained high.

AI-based reconstructions: the new era

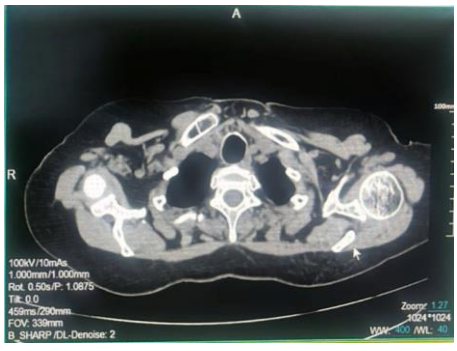
AI has brought a paradigm shift in CT reconstruction. Deep learning reconstruction (DLR) techniques now generate images that are cleaner, sharper, and less noisy—even at ultra–low radiation doses.

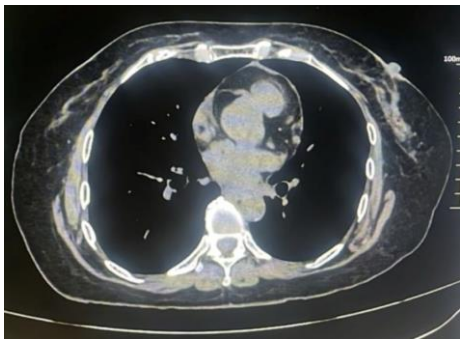
In our practice, we use ultra–low dose CT protocols with an effective dose of 0.18 mSv. To put this in perspective, that is equivalent to less than the radiation dose of two standard (assuming 0.1mSv effective dose for standard two-view) chest radiographs—while still providing full chest CT coverage. Importantly, these studies are performed without contrast yet retain the diagnostic clarity for nodule detection.

What makes this transformation even more remarkable is the ability to confidently detect nodules as small as 2.5 mm, with better characterization using advanced Delta reconstructions. Features such as the subtle solid component in a subsolid nodule, or early spiculation at the margins, are now easier to appreciate. The image quality is consistently good for assessment, even at ultra–low dose, allowing us to balance safety with precision.

Image quality improvements: examples from practice

The leap in image quality is not abstract; it plays out in everyday cases. Ground-glass nodules, once blurred at the edges, now appear with remarkable clarity, helping distinguish early adenocarcinomas from benign inflammatory opacities. Subsolid nodules with tiny solid components are more conspicuous, prompting timely intervention. Even delicate findings such as pleural tags or vascular convergence, which can signal early malignancy, are better appreciated with AI-enhanced reconstructions. These details directly influence patient management and outcomes.





Limitations of AI in lung cancer screening

That said, AI is not without limitations. False positives remain a significant challenge, sometimes leading to unnecessary follow-up imaging and patient anxiety. Integration into existing hospital systems can be uneven, and not all radiology teams are equally comfortable adopting AI.

Importantly, AI cannot yet replicate the nuanced judgment of a radiologist—whether a flagged nodule is relevant in the context of a patient's history still requires human insight.

The future of AI in screening

Looking ahead, AI's role will only deepen. I foresee systems evolving beyond detection to true longitudinal care orchestration: automatically tracking patients over years, integrating imaging with genetic and clinical data, and tailoring screening intervals to individual risk. Cloud-based AI solutions may democratize access, allowing smaller hospitals to deliver the same standard of lung cancer screening as large academic centers.

In the future, AI could even help identify pre-cancerous changes before nodules become visible—shifting screening from early detection to true prevention. But as powerful as these technologies become, radiologists will remain central: not just as image interpreters, but as communicators, guides, and decision-makers in the patient's cancer journey.

Author Biography

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Dr. Samuel Reefath is a consultant radiologist at MGM Healthcare, Chennai, with a special interest in chest imaging, oncologic radiology, and the clinical applications of artificial intelligence combining his clinical work with academic research as a PhD student at the Indian Institute of Technology Madras. He holds radiology credentials (including DMRD, DNB) and has experience in interventional imaging, contributing to MGM's advanced diagnostic and interventional radiology services.

Empowering Radiologists: An AI-aided system for Breast Cancer detection and diagnosis

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The Challenge

Breast cancer is one of the most common cancers diagnosed in women and a leading cause of mortality worldwide. Detecting breast cancer early is crucial for effective treatment and improving patient outcomes. However, the process of identifying suspicious lesions in mammograms is time-consuming. Importantly, the rising volume of mammograms leads to longer waiting times. These challenges underscore the urgent need for reliable, consistent, and efficient solutions.

Integration of computer aided detection (CAD) systems with artificial intelligence (AI) based solutions offers a promising solution to address these challenges. Moreover, such tools will act as potential "second reader" for radiologists enhancing the work efficiency by streamlining the clinical workflow as well as diagnostic performance in terms of sensitivity and specificity can also be improved.

AI solution

We present the UIH Full-Field Digital Mammography (FFDM) application, an artificial intelligence (AI) powered deep learning-based application developed by United Imaging Intelligence® for the automatic detection and diagnosis of breast cancer. The FFDM application will act as a radiologist aide highlighting suspicious regions, lesion classification and provide accurate lesion measurements and location into a single streamline report.

These capabilities enhance diagnostic efficiency, reduce reporting time and provide real-time decision support. Ultimately, this platform supports timely clinical decision-making and contributes to improved patient outcomes.

Background on Mammography

Mammography is one of the most common tools used to detect breast cancer. It is a low dose and non-invasive X-ray imaging technique. Breast is compressed between two plates and low-dose X-rays. Different breast tissues such as glandular, fatty, dense glandular tissues have different attenuation values. The X-ray passes through these tissues densities and is detected by a digital detector, and a high-resolution breast image is captured.

Full-field digital mammography (FFDM, 2D) and digital breast tomosynthesis (DBT, 3D) improve cancer detection by generating clearer, layered images of the breast. Conventionally, the mammograms are acquired in two views, first the craniocaudal (CC)view, the mammography unit is in a vertical position such that the X-ray beam is perpendicular to the floor, these do not contain any pectoral parenchyma of the breast. Second, the mediolateral (MLO) view that are acquired typically with mammography unit tilted between 40-60 degrees to match slope of pectoral muscles. For each exam four mammograms are acquired i.e. 2 left breasts (CC, MLO) and 2 right breasts (CC, MLO).

UIH AI Auto-Detect & Diagnose

The application analyzes mammographic images and identifies the suspicious lesion including masses, calcifications, architectural distortions, and asymmetries. The FFDM application classifies the lesions according to BI-RADS criteria. The FFDM uses multi-style and multi-view contrastive learning framework to learn the varying breast tissues, shapes, sizes and mammogram views. In the multi-view setting, the craniocaudal (CC) and mediolateral oblique (MLO) views of the same breast are treated as positive pairs, promoting view-invariant representation learning. These strategies are jointly optimized to produce robust, domain-agnostic embeddings. By leveraging deep learning algorithms trained on large-scale annotated datasets, FFDM provides radiologists with real-time decision support, highlighting potential areas of concern and generating probability-based assessments of malignancy. This not only enhances the accuracy and consistency of breast cancer detection but also optimizes workflow efficiency and supports early diagnosis, ultimately contributing to improved patient outcomes.

Table 1: BI-RADS classification and Interpretation

BI-RADS	Assessment	Interpretation
BI-RADS 0	Incomplete	Needs additional Imaging
BI-RADS 1	Negative	No abnormal findings. Continue Screening mammograms
BI-RADS 2	Benign	non-cancerous findings like cysts or fibroadenomas.
BI-RADS 3	Probably Benign	<2% chance of malignancy, short interval follow-up recommended.
BI-RADS 4	Abnormal suspicious -4A Low suspicion -4B Moderate suspicion -4C High suspicion	Biopsy should be considered
BI-RADS 5	Highly suggestive Malignant	Biopsy recommended
BI-RADS 6	Known biopsy proven	Awaiting treatment, surgical excision

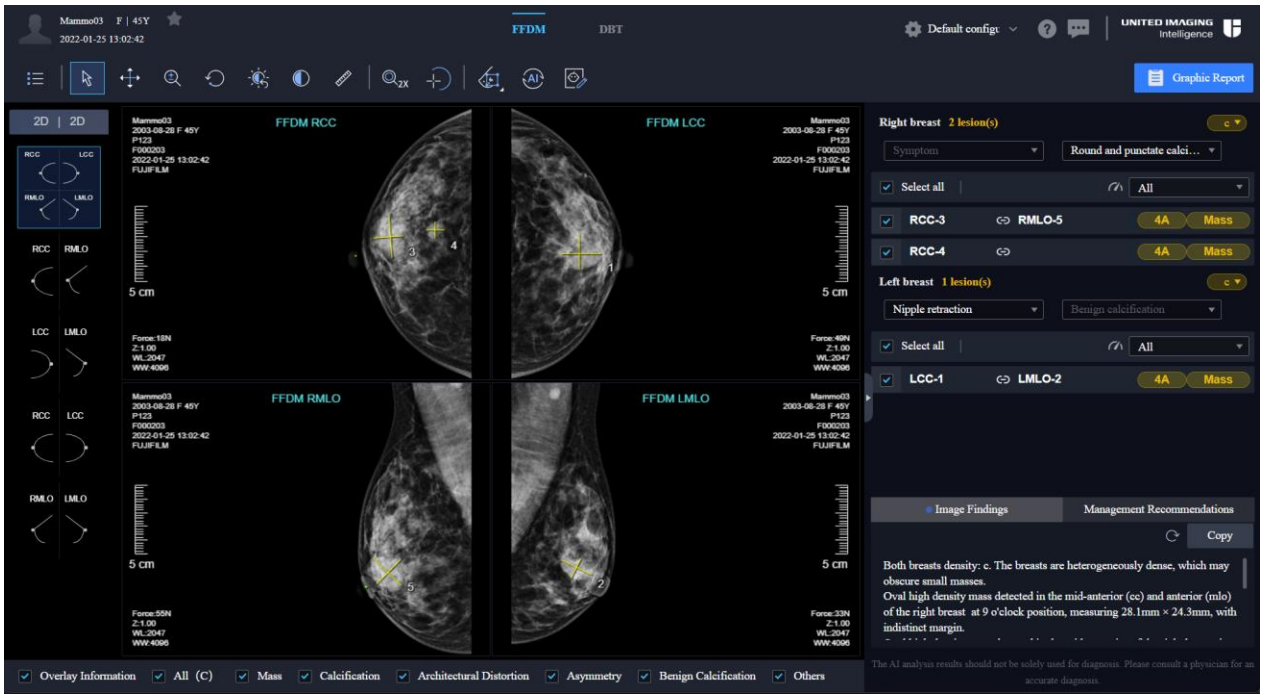


Figure 1: UIH FFDM Application Interface[#]

[#]UIH FFDM is a CE-marked but not a FDA cleared application. This product is not available for sale in the U.S. for clinical uses

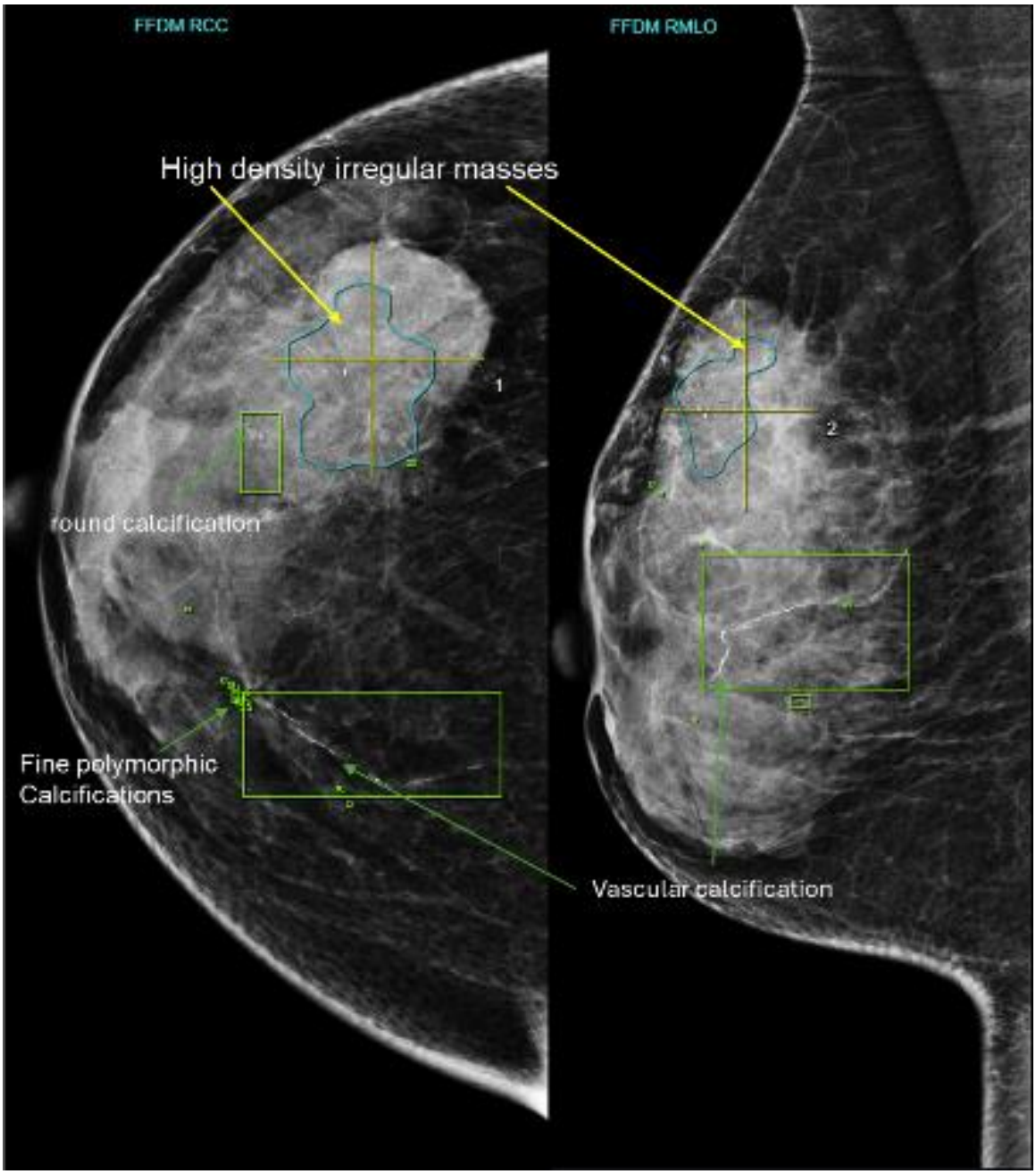


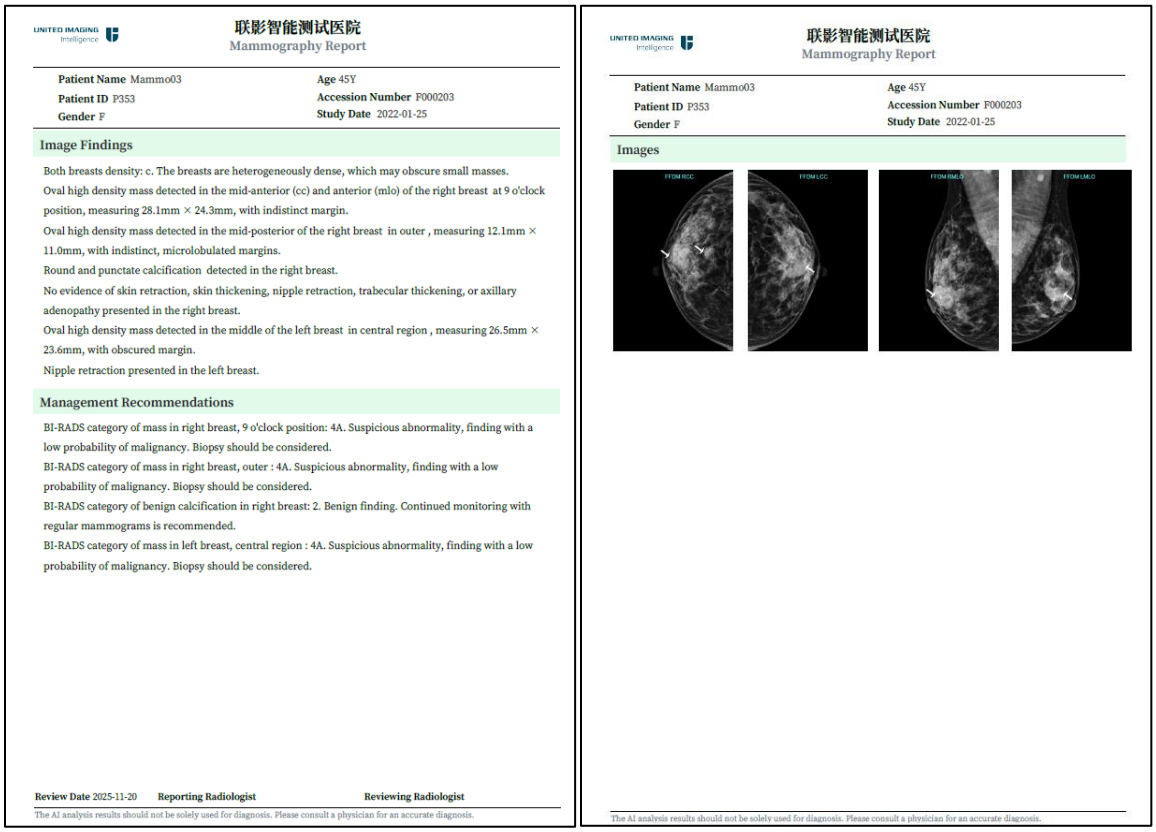
Figure 2: Masses and calcifications detected by UIH FFDM application and its findings. The breasts are heterogeneously dense, which may obscure small masses. Irregular high-density mass detected in the mid-posterior (cc) and middle (MLO) of the right breast in upper outer quadrant (cc 10-40/45; mlo 1-31/47), measuring 39.0mm × 28.7mm (16/47), with indistinct margin and grouped distribution of fine pleomorphic calcification can be seen in green bounding boxes. Rim or sphere calcification, round and punctate calcification, vascular calcification detected in the right breast. No evidence of skin retraction, skin thickening, nipple retraction, trabecular thickening, or axillary adenopathy presented in the right breast.

FFDM AI – Radiologist's Aide

The FFDM application provides quantitative measures such as tumor size, its shape and tissue density distribution. The AI powered system classifies the localized suspected region of interest according to BI-RADS categories, differentiating between benign, probably benign, and suspicious or malignant findings. The application highlights the potential areas of suspension and produces comprehensive reports for radiologists including morphological information (i.e. size, shape, tissue density and location) and a structured, probability-based report that summarizes lesion characteristics, risk assessment, and BI-RADS scoring.

UIH FFDM application provides a complete decision support tool for radiologists that not only enhances diagnostic accuracies but also streamlines the workflow efficiency. The integration of automatic detection, diagnosis and standard categorization into a single workflow supports timely treatment for patients as early detection is key to reducing the mortality rates.

The UIH FFDM AI application demonstrates significant potential as a radiologist aid, acting as a double-reading tool that highlights suspicious regions, characterizes BI-RADS classifications, and provides accurate lesion measurements and locations within a single streamlined report. These capabilities enhance diagnostic efficiency, reduce intra-observer variability, shorten reporting time, and deliver real-time decision support. The generated report also facilitates follow-up and supports treatment planning. Ultimately, this AI-powered platform strengthens radiologists' capabilities, supports timely clinical decision-making, and contributes to improved patient outcomes.



联影智能测试医院
Mammography Report

Patient Name Mammo03 **Age** 45Y
Patient ID P353 **Accession Number** F000203
Gender F **Study Date** 2022-01-25

Image Findings

Both breasts density: c. The breasts are heterogeneously dense, which may obscure small masses.
Oval high density mass detected in the mid-anterior (cc) and anterior (mlo) of the right breast at 9 o'clock position, measuring 28.1mm × 24.3mm, with indistinct margin.
Oval high density mass detected in the mid-posterior of the right breast in outer , measuring 12.1mm × 11.0mm, with indistinct, microlobulated margins.
Round and punctate calcification detected in the right breast.
No evidence of skin retraction, skin thickening, nipple retraction, trabecular thickening, or axillary adenopathy presented in the right breast.
Oval high density mass detected in the middle of the left breast in central region , measuring 26.5mm × 23.6mm, with obscured margin.
Nipple retraction presented in the left breast.

Management Recommendations

BI-RADS category of mass in right breast, 9 o'clock position: 4A. Suspicious abnormality, finding with a low probability of malignancy. Biopsy should be considered.
BI-RADS category of mass in right breast, outer : 4A. Suspicious abnormality, finding with a low probability of malignancy. Biopsy should be considered.
BI-RADS category of benign calcification in right breast: 2. Benign finding. Continued monitoring with regular mammograms is recommended.
BI-RADS category of mass in left breast, central region : 4A. Suspicious abnormality, finding with a low probability of malignancy. Biopsy should be considered.

Review Date 2025-11-20 **Reporting Radiologist** **Reviewing Radiologist**

The AI analysis results should not be solely used for diagnosis. Please consult a physician for an accurate diagnosis.

联影智能测试医院
Mammography Report

Patient Name Mammo03 **Age** 45Y
Patient ID P353 **Accession Number** F000203
Gender F **Study Date** 2022-01-25

Images

The AI analysis results should not be solely used for diagnosis. Please consult a physician for an accurate diagnosis.

Figure 3: Sample Report generated by UIH FFDM

Author Biography

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Dr. Kardinah (dr. K. Kardinah), Sp.Rad (K), is a senior diagnostic radiologist at **Dharmais Cancer Hospital** in Jakarta, where she has served as Chair of the Medical Committee. She has been a driving force in bringing nuclear medicine to Dharmais, including establishing PET/CT capabilities, and has emphasized rigorous quality control and radiation safety. She is also deeply involved in breast cancer early detection, spearheading training programs for medical staff in breast examination and ultrasound screening, as documented in peer-reviewed research. In addition to her clinical and administrative roles, Dr. Kardinah participates in national research and policy development, contributing to strategies for cancer control in Indonesia.

Clinical Significance of Coronary Artery Calcium Score in Predicting Single Low-Dose CT for Combined Lung Cancer Screening and Coronary Artery Calcium Scoring with Artificial Intelligence Iterative Reconstruction

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[a]Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, UNITED STATES
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The Challenge

Coronary artery disease (CAD) and lung cancer share several common risk factors. Patients eligible for screening one condition are hence often candidates for screening for the other condition too.

Currently, lung cancer screening is performed using low dose CT scans to detect lung nodules, while ECG-gated normal dose CT scans are used to assess coronary artery calcium (CAC) to evaluate CAD risk. As a result, patients undergo two separate scans targeting the overlapping anatomical regions.

Dual scanning has a number of disadvantages: it exposes patients to duplicate radiation. It also increases healthcare costs and contributes to inefficiencies in clinical workflows due to redundant imaging procedures. It is natural to explore whether the two screenings could be consolidated into a single scan.

The Technology

Artificial Intelligence Iterative Reconstruction (AIIR) may provide the necessary answer here. AIIR was evaluated for its ability to mitigate the image noise and artifacts inherent in low-dose CT lung cancer screening, and to determine if it could provide reliable calcium scoring results under these conditions.

Note on image reconstruction: AIIR is a next-generation reconstruction algorithm that combines the strengths of artificial intelligence with model-based image reconstruction. Its workflow (Figure 1) consists of two core components. Firstly, a data-fidelity term incorporates multiple models, including a system optics model, a detector model, and a quantum statistical model, to ensure an accurate characterization of the system for each specific scan. In each iteration, estimated images are forward-projected, compared with the acquired projection data, and updated via forward and backward projection, allowing raw projection data to enhance image reconstruction while preserving anatomical and pathological details. The second component, a deep-learning denoising engine, is trained on millions of high-quality/low-dose image pairs covering diverse clinical scenarios, including different body regions, scan protocols, dose levels, and pathologies. This extensive training dataset enhances the model's generalizability and robustness.

AIIR enhances the images from the low dose lung cancer screening CT to clearly depict the coronary arteries, allowing for an accurate CAC score measurement. The CAC scores are computed by an application in the uCT workstation (uInnovation-CT, R001, United Imaging Healthcare).

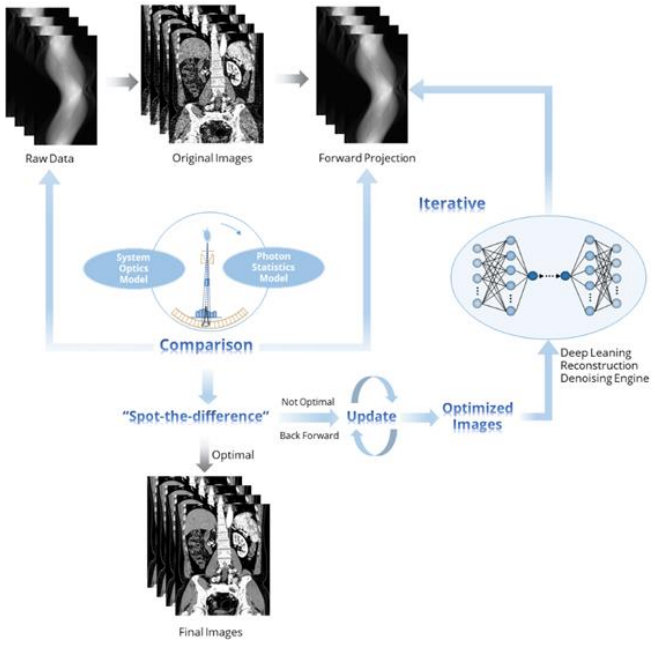

Figure 1. AIIR Reconstruction Workflow

Findings

Patient scans were compared in two categories: those with CAC scores of zero and those with non-zero. CAC score of zero means no calcified plaques or calcifications.

Figure 2 shows one example of a 72-year-old male with calcium detection in the right coronary artery. The calcium burden can be clearly detected in the low dose non-gated lung cancer screening (B) compared to the full-dose calcium scoring scan.

Scans with CAC score =0 on the gated full-dose scan also had a score of 0 on the AIIR non-gated CT, demonstrating 100% agreement in identifying patients without calcification.

For scans with non-zero CAC scores, low to moderate levels of calcification can be expected. Among the 18 patients with non-zero CAC scores on the full dose scan, category-level agreement varied:

I. 11 patients with a CAC score between 1 and 100, 10 remained in the same category on the lung cancer screening scan, while one was reclassified into the 101–400 category.

II. Among the four patients with scores between 101 and 400, three remained in the same category, and one was reclassified into the >400 category.

III. All three patients with CAC scores >400 on the full dose CAC scan were consistently categorized in the same group using the lung cancer screening scan.

These findings show that AIIR-enhanced low dose CT scans show excellent agreement in detecting the absence of CAC, and slight variability exists in score categorization among patients with low to moderate levels of calcification, particularly in borderline cases.

So What?

The application of AIIR to reconstruct images from low dose lung cancer screening CT scans for the purpose of CAC scoring demonstrates clear clinical utility. Comparative analysis indicates no statistically significant differences between the conventional dual-scan method and the proposed single-scan lung cancer screening protocol with AIIR reconstruction.

This integrated approach offers multiple advantages, including reduced radiation exposure, decreased imaging time, and lower overall patient costs. Additionally, it streamlines radiology department workflows by eliminating the need for separate CT acquisitions, improving operational efficiency and increasing daily patient throughput.

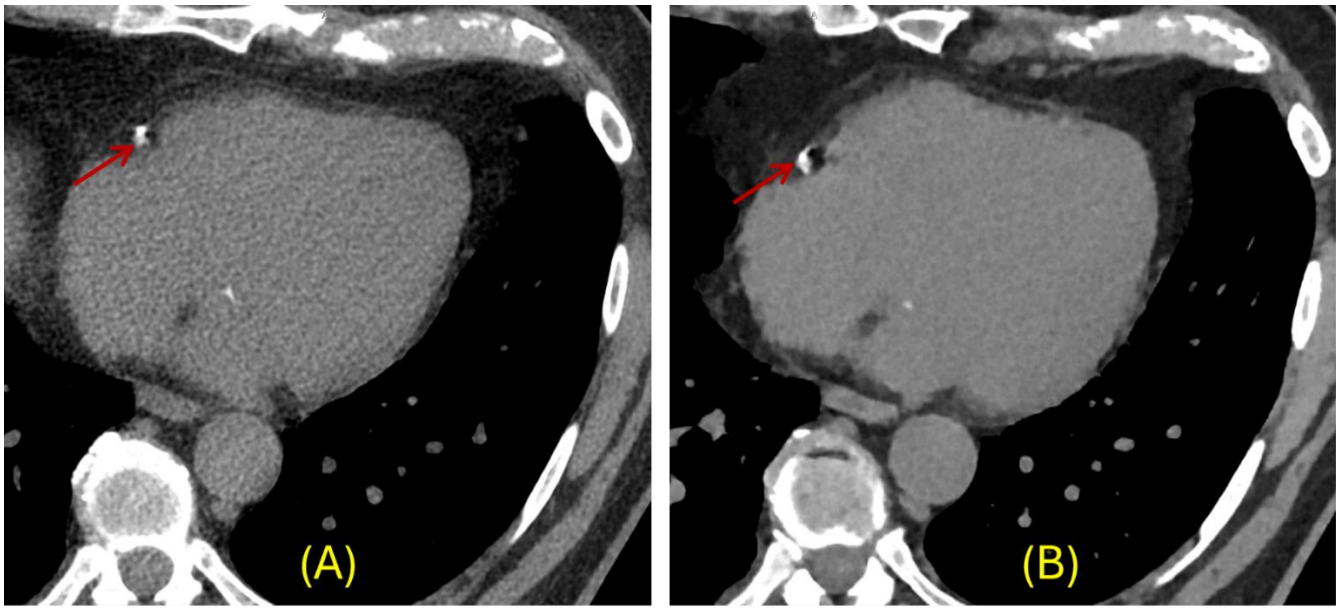

Figure 2. A 72-year-old male with calcium detection in the right coronary artery. (A) Image from a dedicated gated calcium scoring scan with a slice thickness of 2 mm × 2 mm. (B) Image from a non-gated lung cancer screening scan reconstructed using AI-based iterative reconstruction (AIIR) with a slice thickness of 1 mm × 1 mm.

Author Biography

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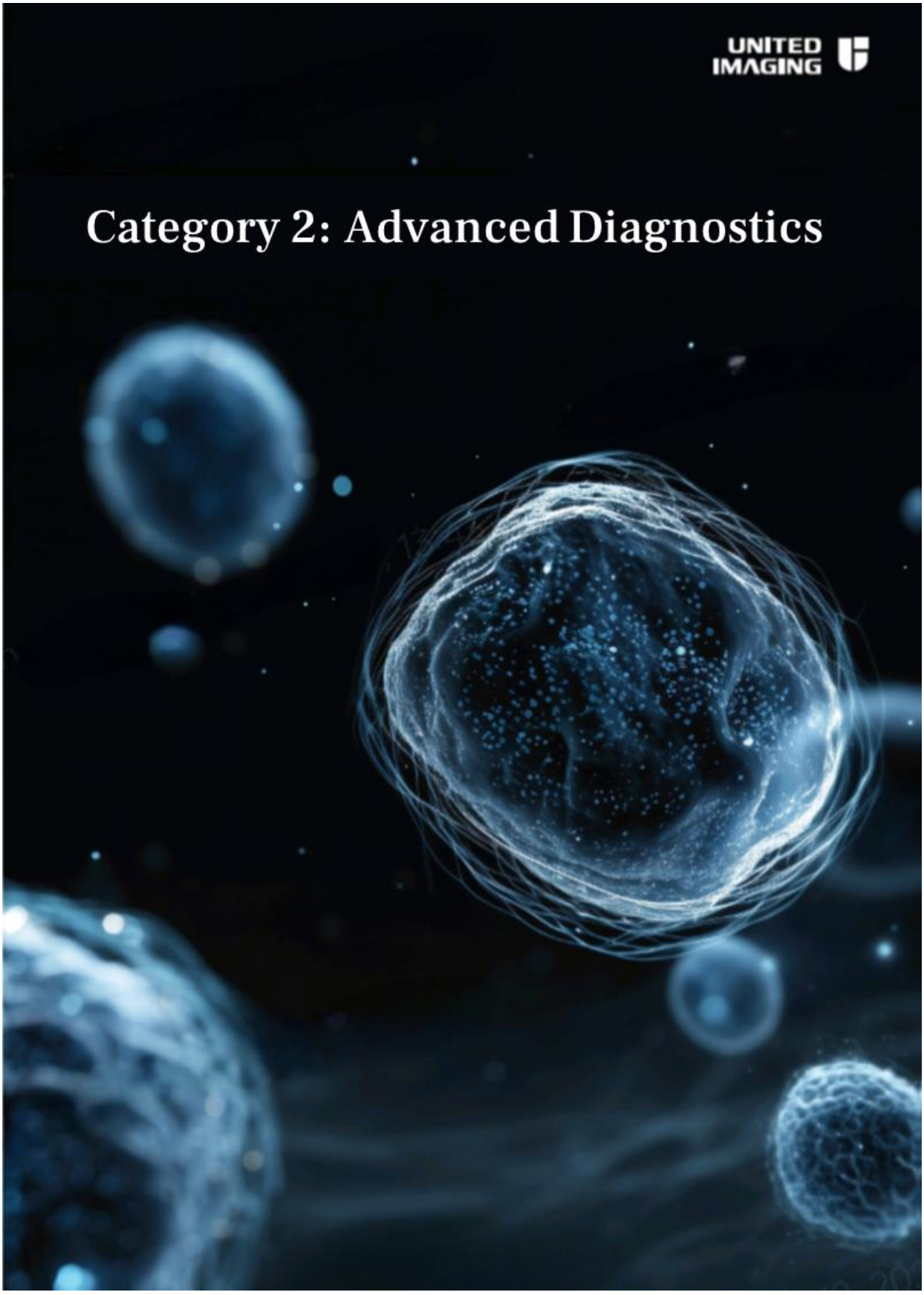
Dr. Omer Aras is a physician-scientist with formal training in both clinical radiology/nuclear radiology and molecular imaging research. His clinical interests lie in oncologic imaging, with a focus on genitourinary and bone marrow cancer. His primary research interest involves developing novel and innovative molecular imaging approaches for cancer diagnostics and combining and utilizing the biology, nanotechnology, chemistry with advanced non-invasive imaging methods (predominantly PET/optical imaging) to create novel imaging agents that allow much earlier detection and improve therapy monitoring of cancer. As a result of translational work, much of it completed under his own initiative, he has published a number of peer-reviewed papers in biomedical journals and been invited to present his work at national and international venues.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Category 2: Advanced Diagnostics

Brain Tumors at 5.0T MRI: Current and Future Research and How it Informs Patient Treatment

A United Imaging article by: Paul Polak & Interview with Haibo Xu

UIH: We are delighted today to be talking to Haibo Xu, MD, PhD, from the Department of Radiology, Zhongnan Hospital of Wuhan University. Dr. Xu's group has recently published a scientific journal paper which examines the use of ultra-high field MRI, specifically United Imaging's Jupiter 5.0T, in the area of brain tumors.

The paper we will be discussing is: "The feasibility of half-dose contrast-enhanced scanning of brain tumors at 5.0T: a preliminary study" [1] published in BMC Medical Imaging. Welcome Dr. Xu!

HX: Thank you! We are happy to discuss our work and what improvements they can make in terms of patient diagnosis and prognosis for brain tumors.

UIH: First, what were your motivations when initiating the research. So tell me a little about "The feasibility of half-dose contrast-enhanced scanning of brain tumors at 5.0T: a preliminary study."

HX: Certainly. For this paper, we wanted to investigate whether we had at least comparable image quality when using a half-dose of contrast at 5.0T, compared to using full dose at 3.0T. While contrast enhancement has become routine in MRI exams, its use does carry some risks, particularly for patients with renal problems. In addition, there is long-term concern for patients who have repeated contrast injections, as there is a risk of accumulation of Gadolinium in brain tissue.

We examined patients with brain tumors – patients with meningiomas, metastases, and glioblastomas – who underwent MRI exams at both field strengths and compared images using qualitative and quantitative measures. We used uMR Jupiter for the 5.0T, and a uMR 790 for the 3.0T images, and the protocols included 3D T1-weighted gradient echo sequences. The regions we were interested in were lesion, or tumor, and healthy appearing white and grey matter.

UIH: What were the major findings?

HX: We found that the images at half-dose at 5.0T were not only comparable to those at 3.0T, but actually superior. We found significant increases in both signal-to-noise and contrast-to-noise at the higher field strength, in some cases more than a 50% increase. While we did expect an increase in signal at 5.0T – approximately 1.7 times more, all things being equal – we also acquired at a higher resolution on the Jupiter. So even with the increased resolution available, there were still highly significant increases in the contrast and signal in the images as shown in Figure 1.

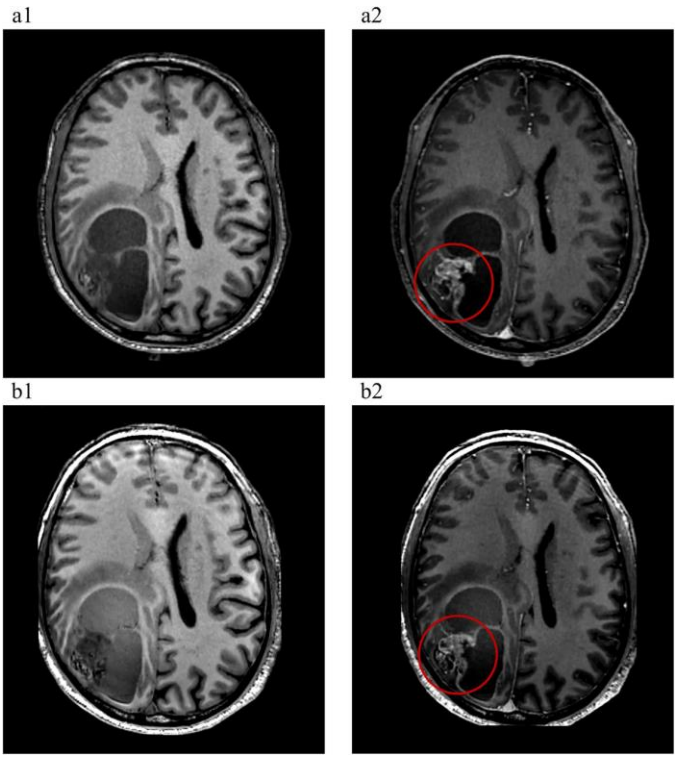

Fig. 1 Brain metastases (lung origin), 64-year-old male. (a1) T1w MRI without contrast enhancement at 3.0T and (b1) T1w MRI without contrast enhancement at 5.0T. (a2) Full-dose enhanced T1w MRI at 3.0T and (b2) half-dose enhanced T1w MRI at 5.0T. As depicted within the red circle, the augmentation of the lesion parenchyma exhibits a slightly greater intensity at 3.0T compared to 5.0T. However, in terms of delineating the intricacies of the lesion, 5.0T surpasses 3.0T due to its employment of a thinner scanning layer thickness and higher resolution, taken from [1]

UIH: What about the qualitative measures? Were they scored by clinical experts?

HX: Yes, Drs. Yu and Jiang – who have 16 years of experience as neuroradiologists between them – scored the images. They used a 10-point Likert scale, and rated the images based on tumor delineation, contrast enhancement, image homogeneity, grey and white matter differentiation, and the presence of artifacts. We found that the tumor structure and borders were significantly enhanced at 5.0T, with the overall sequence quality also significantly better at the higher field strength, although we did not find significant differences in terms of homogeneity or artifacts.

UIH: Those results sound very promising – how would you interpret them, and what are your thoughts about where this research goes next?

HX: The core message of this work is the superiority of imaging at ultra-high field. The increased resolution is very useful in delineating tumor borders, which can inform patient of treatment options, including both radiotherapy and chemotherapy and an example of such case is presented in our article (1) shown below as Figure 2.

The increased resolution, when paired with the increase in image quality and signal after contrast injection, make the case for Jupiter. In addition, from a clinical standpoint Gadolinium contrast enhanced scans are still, and for the foreseeable future, very much part of standard care.

Although this was executed as a pilot study in 12 patients, the fact that we can acquire these superior images at a lower risk to the patient by decreasing the amount of contrast we inject is a very exciting result. In the future, I believe it is worth investigating whether we can further reduce the amount of contrast we inject, which might be particularly important for patients with renal impairment. In addition, we are interested in investigating whether these results translate to tumors in other parts of the body, particularly the abdomen.

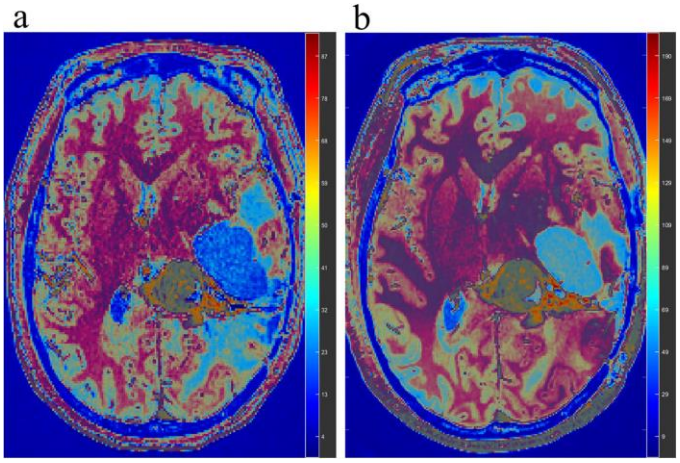

Figure 1. Representative image of a glioma patient (49 years old, female, Patient 10) at 3.0T (a) and 5.0T (b). The 5.0 T images showed a greater SNR than the 3.0 T images, especially for the tumour lesions, adapted from [1].

UIH: Finally, what would you say to your patients about the importance of this work?

HX: I would say that the increased image quality offered on Jupiter allows sharper details to be available to the doctor. This in turn gives the patients better information, which can allow them to make better decisions with their doctor.

UIH: Thank you.

References:

1. Jiang, Z., Sun, W., Xu, D. *et al.* The feasibility of half-dose contrast-enhanced scanning of brain tumours at 5.0T: a preliminary study. *BMC Med Imaging* **24**, 88 (2024). https://doi.org/10.1186/s12880-024-01270-z

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Total-Body PET/CT in Theranostics: Advancing Molecular Imaging in Precision Oncology

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Abstract

Total-body PET/CT is emerging as a transformative technology in theranostics—the integration of diagnostic imaging with targeted radionuclide therapy. By employing long axial fields-of-view (FOV) PET/CT and increased sensitivity, these scanners are reshaping oncology imaging and patient management. This article introduces theranostics and total-body PET/CT, reviews recent advances, and discusses their clinical impact through real-world experience. The unprecedented sensitivity and speed of total-body imaging enhance lesion detection, therapy planning, and treatment monitoring, while enabling more precise and personalized cancer care. Key challenges, including cost and data management, are addressed alongside future directions in dosimetry and novel radiopharmaceutical development.

" *Whole-body PET/CT technology isn't just about pixels or counts; it's about giving patients a fighting chance where cancer has nowhere to hide*."

Theranostics

Over the past two decades, this "see what you treat" strategy has been firmly established as a pillar of precision oncology (1). Foundational clinical work in neuroendocrine tumors (NETs) demonstrated the feasibility and efficacy of peptide receptor radionuclide therapy (PRRT), and early experience with prostate-specific membrane antigen (PSMA)–directed radioligand therapy broadened the scope of theranostics in prostate cancer (2,3). The advent of PSMA PET imaging provided the crucial diagnostic backbone, enabling reliable target visualization, patient selection, and therapy monitoring (4). Together, these foundational efforts laid the basis for routine adoption of PET-guided therapy selection and monitoring in oncology (5,6).

Building on this foundation, landmark phase 3 trials have confirmed the clinical value of theranostics. In NET, the NETTER-1 trial showed that [177Lu] Lu-DOTA-TATE (177Lu-Dotatate) significantly improved progression-free survival (PFS), leading to regulatory approval, and the recent NETTER-2 trial demonstrated benefit in higher-grade gastroenteropancreatic NETs (7,8). In prostate cancer, the pivotal VISION trial showed that [177Lu]Lu-PSMA-617 (177Lu-PSMA-617) improved overall survival (OS) in patients with advanced castration-resistant disease, while the PSMAfore trial moved PSMA radioligand therapy earlier into the taxane-naive metastatic castration-resistant prostate cancer (mCRPC) setting with radiographic PFS benefit (9,10). Looking ahead, the multicenter WARMTH Act study underscored the promise of 225Ac-PSMA as an alpha-emitter option after progressing on 177Lu-PSMA (11). Across these studies, PET serves as a gatekeeper for target expression and as a tool for serial response assessment, cementing its role in theranostics workflows.

Total-Body PET/CT

The concept of an extended axial FOV PET arose to the need to maximize sensitivity and enabling comprehensive kinetic imaging across distributed diseases. In 2018, Cherry and colleagues reported the first prototype and early human studies, demonstrating that with total-body PET/CT entire body could be scanned in one bed position and it could improve the detection of avid tracer uptake while shortening acquisition time (12). Traditional PET/CT systems cover ~20–30 cm per bed, requiring multiple passes for whole-body coverage. In contrast, total-body PET/CT systems extend to ~1–2 meters, enabling true head-to-toe imaging in a single acquisition (Fig. 1). Depending on AFOV length, detector technology, and reconstruction, effective sensitivity gains on the order of ~10–40× have been reported, permitting high-quality scans in minutes (12).

One immediate benefit is enhanced lesion detectability. Long axial FOV PET improves the detection of small lesions and low-contrast lesions compared with conventional scanners (13). The ability to lower administered activity while maintaining non-inferior diagnostic performance has been validated in selected settings, supporting dose reduction and

patient-centric protocols (14). Furthermore, advanced imaging protocols on total-body PET/CT—dynamic acquisition and delayed imaging –improving contrast-to-noise and quantitative accuracy beyond static imaging alone (15).

These advantages are now being demonstrated in prospective clinical settings. Early studies have shown that total-body PET can achieve diagnostic-quality images in a fraction of the time traditionally required, underscoring the potential for dramatically faster workflows and greater patient comfort (16). Simultaneously, total-body PET/CT systems facilitate first-in-human evaluations of novel radiopharmaceuticals by tracking whole-body distribution and pharmacokinetics in unprecedented detail (17). Together, these applications refine established protocols that illustrate and accelerate the development and translation of new theranostic agents—bridging discovery and clinical care with speed, sensitivity, and scalability.

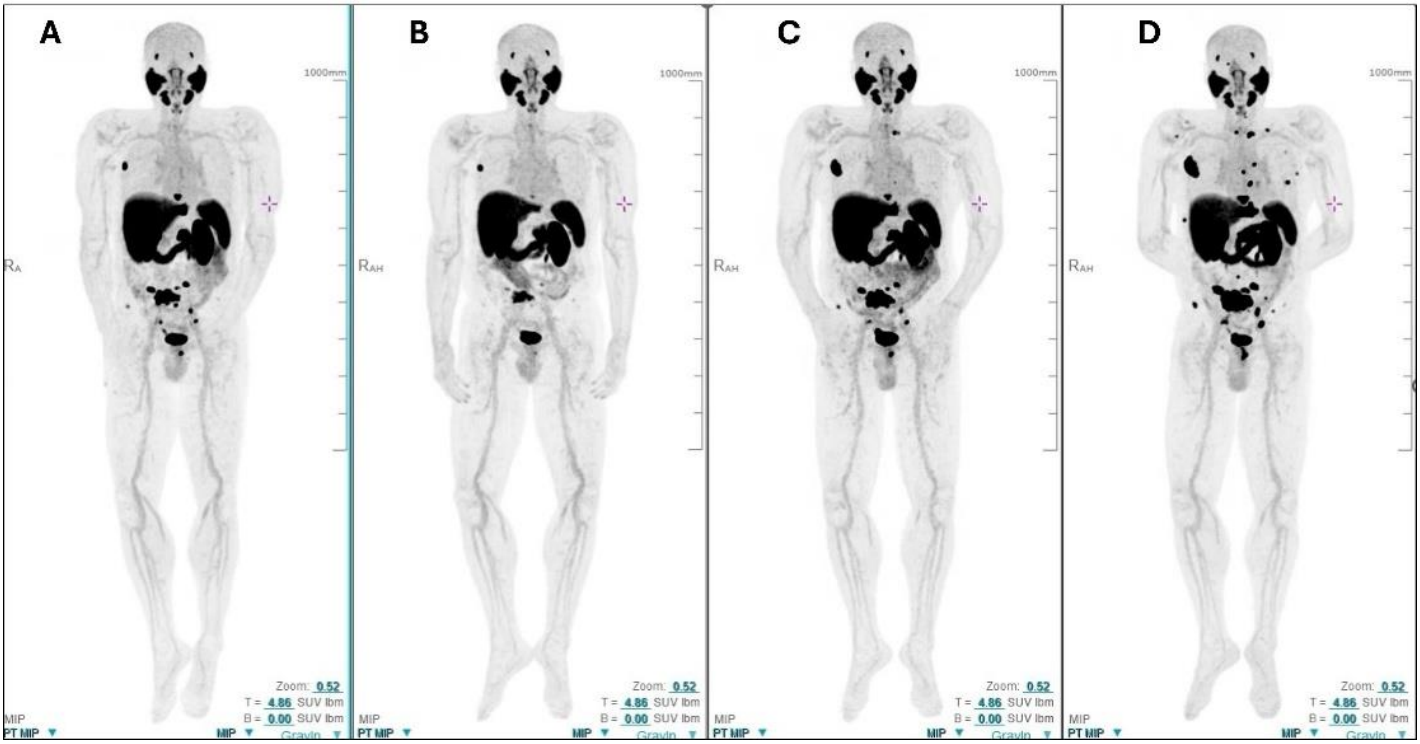

Fig. 1 A 65-year-old man with Gleason 4+5 metastatic prostate cancer previously treated with nine cycles of 177Lu-PSMA radioligand therapy at an outside center. He initially demonstrated a good response, followed by continued disease progression documented on serial ^{68}Ga-PSMA-11 total-body PET/CT (A–D, sequential MIP images).

In theranostics, sensitive detection, serial monitoring, and pharmacokinetics /dosimetry are crucial—these advances are transformative. Total-body PET/CT enhances patient care through earlier detection and individualized monitoring, and also opens pathways for innovation in tracer development, dosimetry, and adaptive therapy strategies.

Scaling Theranostics with Total-Body PET/CT: Impact, Challenges, and Future Potential

Speed, sensitivity, and quantitation

Total-body PET/CT has reshaped theranostic practice by bringing speed, sensitivity, and quantitation into daily practice. Exams that once required 30–40 minutes can often be completed within 5 minutes, mitigating patient burden, motion artifacts, and scheduling bottlenecks, thereby enabling a significantly higher patient throughput.

Higher sensitivity captures subtle disease—tiny nodes, early marrow/bone lesions, or faint visceral deposits—that directly influence eligibility and treatment planning. Total-body dynamic acquisitions add another dimension: pharmacokinetics and dosimetry may be measured in a

single visit, shifting the paradigm from “image and infer” to “measure and personalize”. In routine operations, where full research dosimetry is not yet standard or reimbursed, protocolized quantitative PET and safety labs care are increasingly evaluated in trials and select clinical pathways.

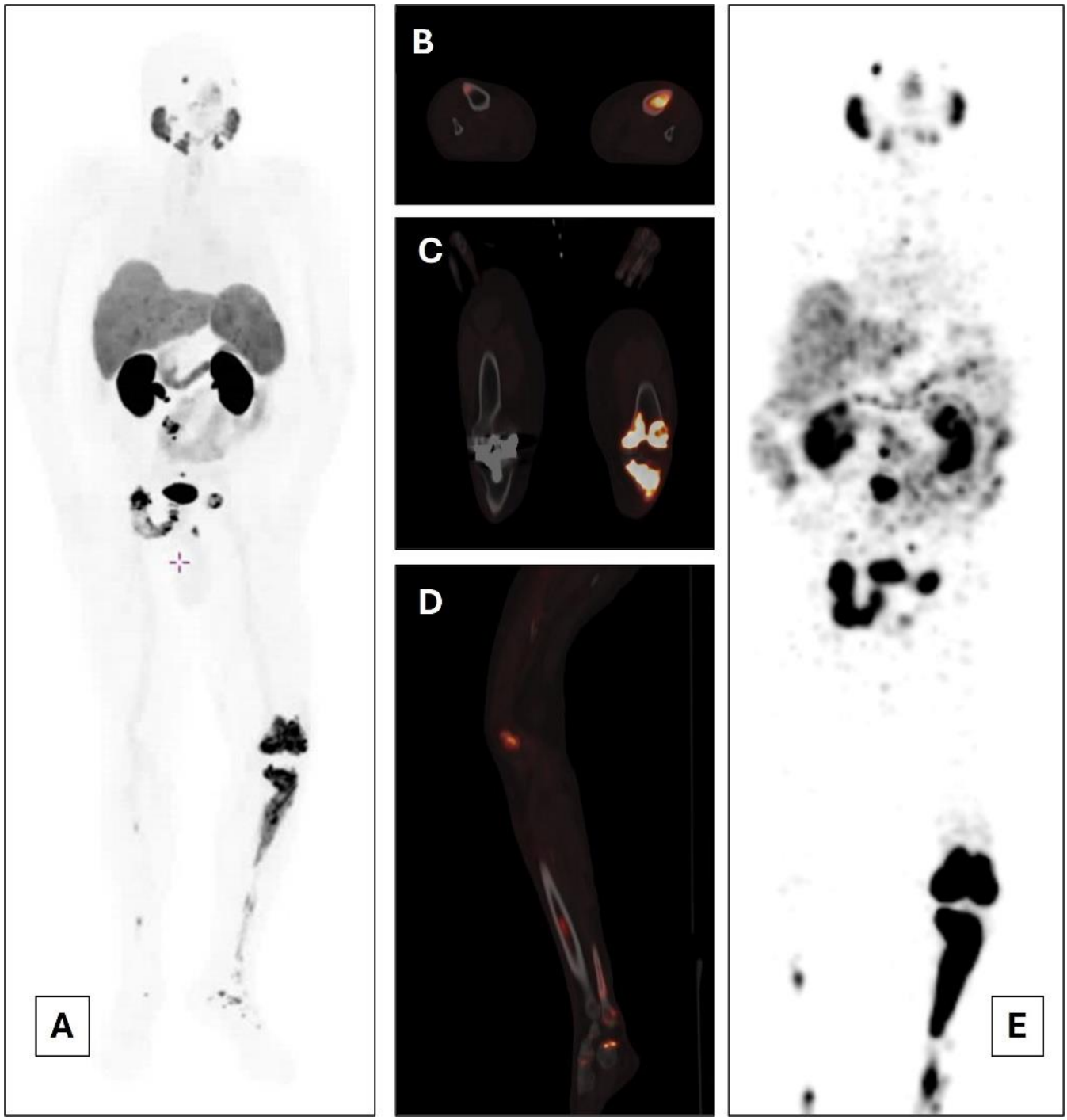

Fig. 2 An 81-year-old man with stage IVB (cTXN0M1b, Gleason 4+4=8, Grade Group 4) prostate adenocarcinoma (pre-treatment PSA 56 ng/mL). He received androgen deprivation therapy followed by apalutamide, pelvic external beam radiation, and 5 cycles of docetaxel chemotherapy (nadir PSA 1.9 ng/mL), complicated by congestive heart failure and peripheral neuropathy. (A–D) Pre-therapy ^{68}Ga-PSMA-11 PET/CT demonstrates extensive PSMA-avid osseous metastases, predominantly in the left femur, tibia, and tarsal bones, as well as additional lesions in the right lower limb and pelvis.

A scalable care model

At BAMF Health, these capabilities are embedded in an end-to-end pathway: standardized referral and triage, on-site GMP radio-pharmacy support, target-specific PET for eligibility, multidisciplinary review, therapy delivery, and post-therapy molecular response assessment. High-throughput imaging supports high-throughput, data-informed care. Robust molecular responders may be de-escalated or paused to limit exposure, and treatment continuation is guided by standardized imaging and clinical criteria. Throughout, standardized acquisition, reconstruction, and calibration and quality assurance (QA) maintain quantitative rigor as volumes grow.

PET/CT plus PET/MR

Co-location with PET/MR adds complementary strengths. PET/CT offers speed, sensitivity, and throughput; PET/MR provides superior soft-tissue contrast, diffusion metrics, and motion-robust sequences. Hybrid strategies include rapid total-body PET/CT for eligibility and quantity followed by targeted PET/MR for problem regions, and PET/MR for organ-specific monitoring when minimizing radiation is desirable. Together, the modalities support precise target confirmation, confident lesion detection, and cleaner longitudinal response curves.

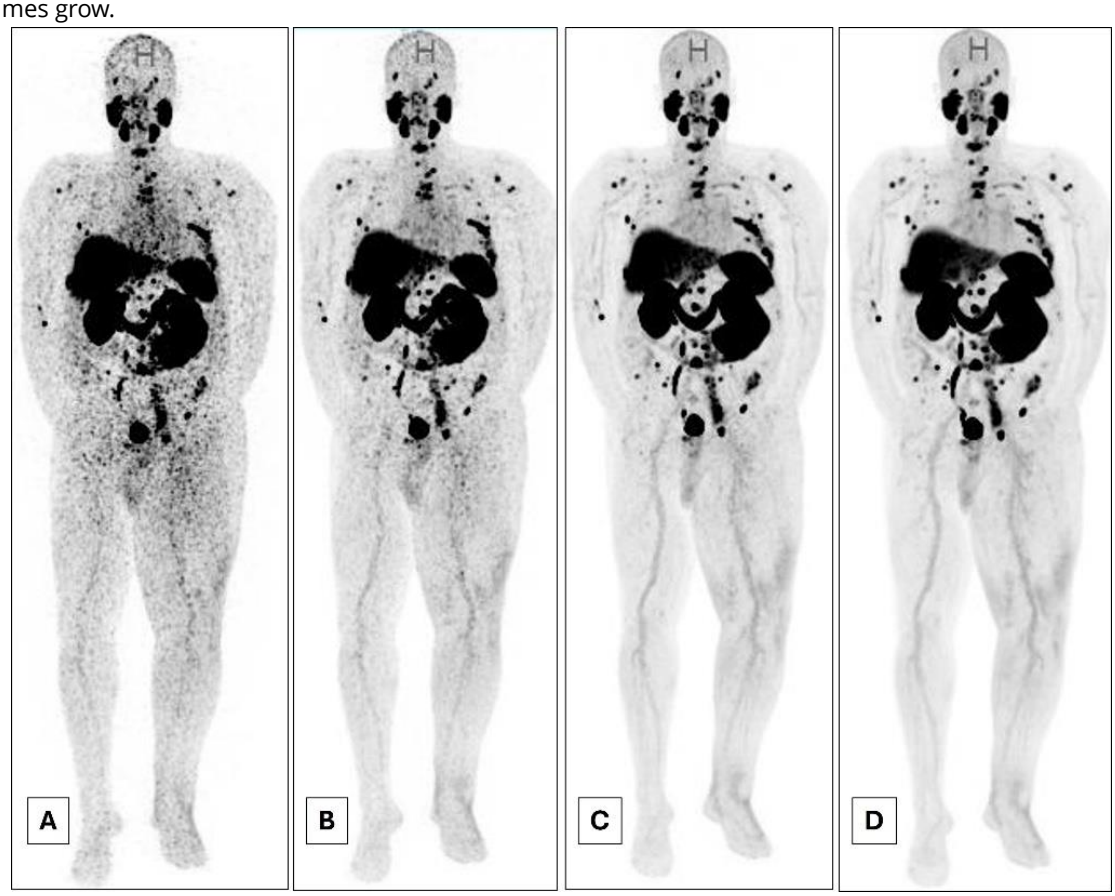

Fig. 3 A patient with Gleason 4+3=7 prostate adenocarcinoma after androgen deprivation therapy, novel androgen-axis therapy, and docetaxel. ^{68}Ga-PSMA-11 PET/CT demonstrates widespread PSMA-positive lymph node and osseous metastases. The patient was deemed eligible for177Lu-PSMA radioligand therapy. (A–D) MIP images with varying acquisition times: (A) 10 seconds, (B) 30 seconds, (C) 2 minutes, (D) 5 minutes. Even the 30-second acquisition clearly delineates the PSMA-positive disease burden.

Refining therapy response

Total-body PET/CT enables more consistent quantification of whole-body tumor burden by combining complete coverage with high sensitivity. With complete body coverage and superior sensitivity, cumulative uptake metrics can be quantified more reliably, enabling consistent tracking of global tumor burden. In NETs, reductions in somatostatin receptor-positive tumor volume (SSTR-TV) have been shown

to align with clinical improvement after PRRT. In prostate cancer, accurate quantification on PSMA PET enables whole-body tumor burden measurement and offers prognostic insights that can help guide decision-making. Beyond static measures, dynamic and longitudinal imaging provides access to biomarkers that may predict treatment efficacy early in the course of therapy. Faster, lower-dose acquisitions also open the door to more frequent monitoring, enabling nimble, evidence-driven adjustments.

Remaining challenges

Capital expenditure and facility build-out limit the access of LAFOV systems. Dynamic acquisitions generate vast data volumes, demanding robust PACS/VNA infrastructure and GPU-enabled analytics. Multicenter harmonization requires phantom experiment, cross-calibration, and locked or standardized reconstructions to preserve SUV fidelity. Workforce readiness—from physicians and physicists to technologists and nursing—must keep pace via standardized training. Supply-chain fragility for isotopes and reimbursement gaps for dosimetry and dynamic studies also constrain scalability. Finally, interpretation requires discipline, as physiological uptake variants are more conspicuous on highly sensitive images.

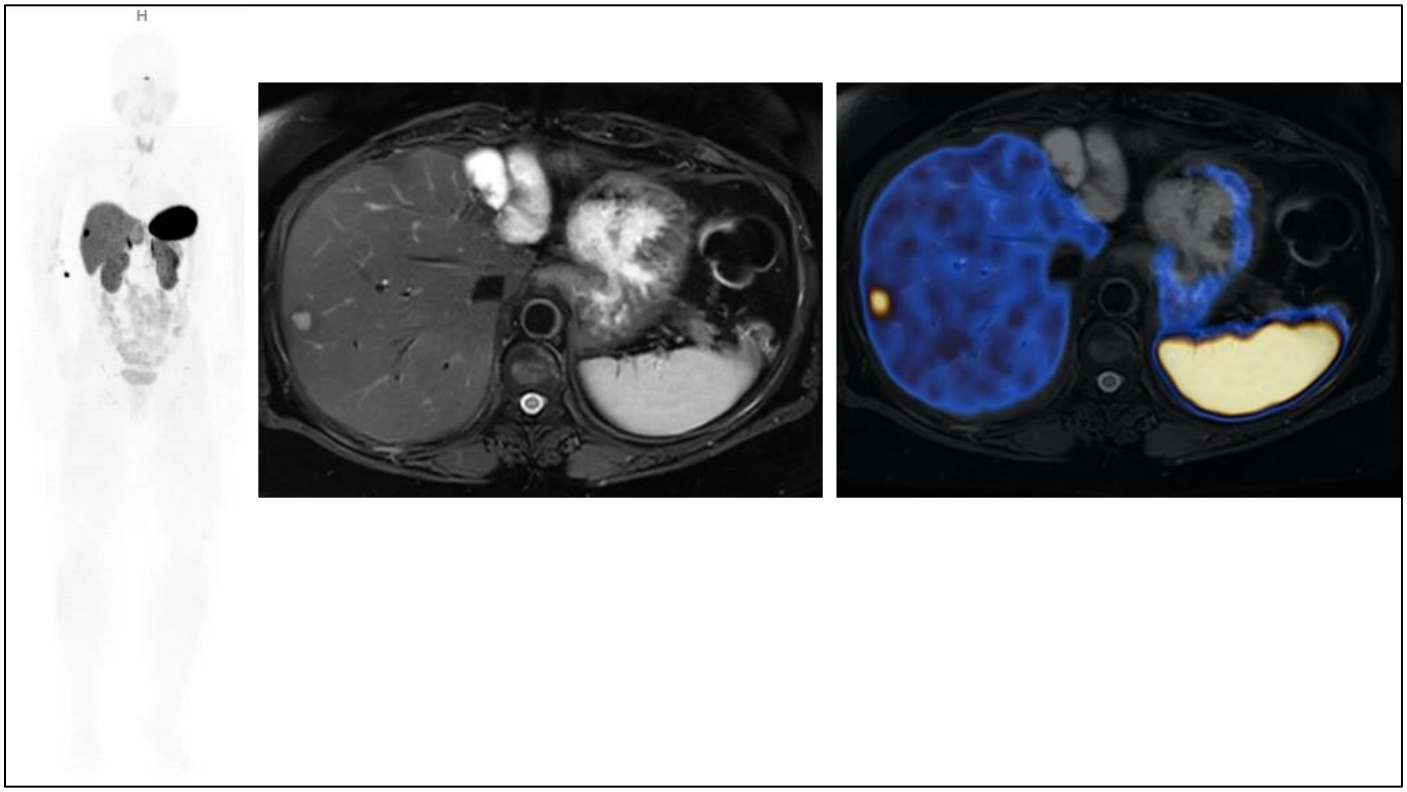

Fig. 4 ^{68}Ga-DOTATATE total-body PET/CT (A, MIP) in a patient with resected, well-differentiated ileal neuroendocrine tumor (NET) revealed a solitary liver lesion in segment VIII. Subsequent PET/MR performed with the same injection confirmed the lesion as a somatostatin receptor–positive metastasis (B, MRI; C, fused PET/MR).

The near future

Looking ahead, several trajectories are within reach. Routine prospective dosimetry with short multi-time-point scans is likely to become standard for PRRT and PSMA radiopharmaceutical therapies, improving dose–response correlations. Pre-therapeutic dosimetry using longer-lived positron emitters (e.g., 64Cu- or 89Zr-labeled analogues/antibodies) allows imaging over extended periods to model tumor and organ kinetics before therapy. This provides a pathway toward true individualized therapy planning in precision oncology.

AI-assisted quantitation could reduce reporting time and

inter-reader variability by automating lesion detection, whole-body tumor burden metrics, and kinetic mapping. Fast acquisitions further support the concept of a "one-stop" therapy day: eligibility PET in the morning, therapy midday, and a short post-therapy verification scan in the afternoon.

Expanding tracer portfolios, including FAP, GRPR, CXCR4, HER2, and antibody-based agents—can be evaluated rapidly in early-phase studies, accelerating drug development and translation. Finally, networked theranostics built on harmonized imaging standards will allow patients to be imaged and treated closer to home. In this vision, high-sensitivity long axial FOV PET/CT systems serve as the enabling technology, linking advanced quantitation with scalable, patient-centered care.

Why does this matter?

For patients, these advances translate into shorter and less stressful scans, earlier detection of actionable disease, and faster therapy adjustments when treatments underperform. For health systems, throughput and quantitation expand capacity while raising the bar for precision. And for innovators, total-body PET/CT provides the measurement engine that turns theranostics from promise into reproducible, scalable care—the very model BAMF is designed to deliver.

References

1. Baum RP, Kulkarni HR. (2012) THERANOSTICS: From Molecular Imaging Using Ga-68 Labeled Tracers and PET/CT to Personalized Radionuclide Therapy - The Bad Berka Experience. Theranostics.
2. Kwekkeboom DJ, et al (2008) Treatment with the radiolabeled somatostatin analog [177 Lu-DOTA 0,Tyr3]octreotate: toxicity, efficacy, and survival. J Clin Oncol.
3. Kulkarni HR, et al (2016). PSMA-Based Radioligand Therapy for Metastatic Castration-Resistant Prostate Cancer: The Bad Berka Experience Since 2013. J Nucl Med.
4. Afshar-Oromieh A, et al (2013). PET imaging with a [68Ga] gallium-labelled PSMA ligand for the diagnosis of prostate cancer: biodistribution in humans and first evaluation of tumour lesions. Eur J Nucl Med Mol Imaging.
5. Kulkarni HR, Baum RP. Patient selection for personalized peptide receptor radionuclide therapy using Ga-68 somatostatin receptor PET/CT. PET Clin. 2014
6. Kulkarni HR, Baum RP. Theranostics with Ga-68 somatostatin receptor PET/CT: monitoring response to peptide receptor radionuclide therapy. PET Clin. 2014 Jan;9(1):91-7.
7. Strosberg J, El-Haddad G, et al (2017) NETTER-1 Trial Investigators. Phase 3 Trial of 177Lu-Dotatate for Midgut Neuroendocrine Tumors. N Engl J Med.
8. Singh S, et al (2024); all the NETTER-2 Trial Investigators. [177Lu]Lu-DOTA-TATE plus long-acting octreotide versus high dose long-acting octreotide for the treatment of newly diagnosed, advanced grade 2-3, well-differentiated, gastroenteropancreatic neuroendocrine tumours (NETTER-2): an open-label, randomised, phase 3 study. Lancet.
9. Sartor O, et al (2021); VISION Investigators. Lutetium-177-PSMA-617 for Metastatic Castration-Resistant Prostate Cancer. N Engl J Med.
10. Fizazi K, Chi KN, et al (2025); PSMAfore Investigators. Final overall survival and safety analyses of the phase III PSMAfore trial of [177Lu]Lu-PSMA-617 versus change of androgen receptor pathway inhibitor in taxane-naive patients with metastatic castration-resistant prostate cancer. Ann Oncol.
11. Sathekge MM, et al (2024) Actinium-225-PSMA radioligand therapy of metastatic castration-resistant prostate cancer (WARMTH Act): a multicentre, retrospective study. Lancet Oncol.
12. Cherry SR, et al (2018). Total-Body PET: Maximizing Sensitivity to Create New Opportunities for Clinical Research and Patient Care. J Nucl Med.
13. Viswanath V, et al (2020) Numerical observer study of lesion detectability for a long axial field-of-view whole-body PET imager using the PennPET Explorer. Phys Med Biol.
14. Sachpekidis C, et al (2023) Application of the long axial field-of-view PET/CT with low-dose [18F]FDG in melanoma. Eur J Nucl Med Mol Imaging.
15. Wu Y, et al (2024) The role of dynamic, static, and delayed total-body PET imaging in the detection and differential diagnosis of oncological lesions. Cancer Imaging.
16. Kulkarni HR, et al (2023) J Nucl Med 2023;64 (supplement 1): P1408 https://jnm.snmjournals.org/content/64/supplement_1/P1408
17. Kulkarni HR, et al (2024) First-in-Human Total-Body PET/CT Imaging Using 89Zr-Labeled MUC5AC Antibody in a Patient with Pancreatic Adenocarcinoma. J Nucl Med.

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Intravoxel Incoherent Motion MRI for clinical assessment of Prostate and Liver Lesions

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The Diagnostic Gap

Accurate differentiation between malignant and benign lesions in the prostate and liver remains a persistent clinical challenge using conventional imaging methods. Current techniques either lack the sensitivity needed to detect early microstructural changes or depend on contrast agents, which are not suitable for all patients due to safety concerns and increased cost. Such diagnostic uncertainty often leads to delays in diagnosis, repeated imaging, or unnecessary biopsies, thereby increasing patient anxiety and adding to the burden on healthcare systems.

Contrast-enhanced imaging may be contraindicated in certain patient populations (e.g., renal impairment). Imaging workflows often require multiple sequences, leading to inefficiency creating a shortage of non-invasive, cost-effective methods that can offer high diagnostic accuracy.

Clinical challenges

Current diagnostic workflows lack sensitivity to detect microstructural and perfusion-related changes.

Why is sensitivity to microstructural changes important?

i. Microstructural alterations (e.g., changes in cell density, size, and organization) often occur early in disease before gross anatomical changes are visible.
ii. In prostate cancer, increased cellular density and reduced extracellular space preceded detectable tumor growth.
iii. In liver disease, fibrosis, cirrhosis, or malignant transformation alters tissue architecture at a microscopic level.

Why are perfusion-related changes important?

i. Perfusion reflects blood flow characteristics, including capillary density and vascular permeability, are closely tied to tumor angiogenesis and tissue viability.
ii. In prostate cancer, malignant lesions typically demonstrate altered microvascular perfusion compared to benign prostatic hyperplasia (BPH) or normal tissue.
iii. In liver lesions, perfusion characteristics help distinguish hepatocellular carcinoma (HCC), metastases, and benign entities such as hemangiomas or focal nodular hyperplasia (FNH).

Proposed solution: IVIM MRI

To address these diagnostic limitations, Intravoxel Incoherent Motion (IVIM) MRI can be employed. IVIM is a contrast-free technique that separates true molecular diffusion from microvascular perfusion.
IVIM provides three quantitative parameters:

- True diffusion coefficient (D): Reflects tissue cellularity
- Pseudo-diffusion coefficient (D*): Sensitive to microvascular blood flow
- Perfusion fraction (f): Estimates the proportion of perfusion-related signal

Why cannot standard diffusion imaging achieve the same?

Conventional diffusion-weighted imaging (DWI) models the MR signal as a single exponential decay and assumes that all signal changes are purely diffusion-driven. IVIM instead accounts for both molecular diffusion and microvascular perfusion within the same voxel. From a physiological perspective, this distinction is critical: malignant tissues often exhibit restricted diffusion due to increased cellularity, while simultaneously demonstrating altered perfusion caused by tumor angiogenesis and abnormal microvasculature. By separately quantifying these components, IVIM provides a more comprehensive characterization of tissue microenvironment than conventional DWI. Furthermore, IVIM addresses a major limitation of conventional DWI by

separating perfusion-related effects from true diffusion, thereby minimizing the risk of misinterpreting signal changes. This dual assessment adds diagnostic value by enhancing sensitivity to early pathophysiological changes, improving lesion characterization, and offering a non-invasive biomarker for differentiating benign from malignant prostate and liver lesions.

Parameter	Physiological Meaning	Prostate Lesions	Liver Lesions	Clinical Relevance / Key Insight
True Diffusion Coefficient (D)	Reflects tissue cellularity and extracellular space	↓Reduced D in malignancy *Reason*: high cellular density and reduced extracellular space	↓Reduced D in malignant lesions; also low in fibrosis or steatohepatitis due to extracellular matrix deposition	Sensitive to tumor cellularity, but less specific in liver where fibrosis can mimic malignancy
Pseudo-Diffusion Coefficient (D*)	Reflects microvascular flow and capillary architecture	↑Increased D* in malignancy *Reason*: neo- angiogenesis and abnormal micro- vessels	↑Elevated D* in HCC; variable in fibrosis (may decrease due to reduced sinusoidal perfusion)	Highlights perfusion heterogeneity; helpful to distinguish fibrotic vs vascular tumor tissue
Perfusion Fraction (f)	Fraction of signal influenced by microvascular perfusion	Reduced f in malignancy *Reason*: inefficient and disorganized tumor circulation	↓Reduced f in malignancy or fibrosis due to sinusoidal capillary loss	Decreases in both prostate and liver malignancy; reflects impaired microcirculation or loss of normal perfusion network

Methodology and workflow implementation

IVIM MRI is acquired using multi b-value diffusion-weighted sequences, incorporating both very low b-values (e.g., < 200 s/mm²) that are sensitive to perfusion effects and higher b-values that primarily capture molecular diffusion. For accurate modelling, acquisition requires at least one b = 0 image along with four or more non-zero b-values. The IVIM signal attenuation is then expressed by a bi-exponential model:

$$S^b/_{S^0} = (1-f) \times \exp(-bD) + f \times \exp\left[-b \times (D + D^*)\right]$$

where S^b is the signal at a given b-value, S^0 is the signal at b = 0; D is the true molecular diffusion coefficient, D* is the pseudo-diffusion coefficient associated with microvascular perfusion, and f represents the perfusion fraction. Post-processing generally involves nonlinear curve fitting or segmented fitting approaches to derive these quantitative maps, which can then be used for lesion characterization.

In a study with 60 subjects (30 prostate and 30 liver cases) included from two centers, prostate data were acquired at Radiopath Diagnostics, Ranchi, using a 1.5T MR scanner (uMR 580, United Imaging Healthcare Co., Ltd. Shanghai, China), while liver data were obtained at Nova Diagnostics, Astana, Kazakhstan, on the same scanner model. All datasets were processed using United Imaging Healthcare' post-processing platform (MR Diffusion Analysis tool), which is designed to facilitate streamlined integration of IVIM into clinical practice.

The workflow supports the following features:

- Seamless PACS data import
- Automated parameter extraction (D, D*, f)
- One-click lesion ROI propagation across slices
- ROI-based analysis and lesion characterization
- Direct export of quantitative parameter maps for clinical reporting

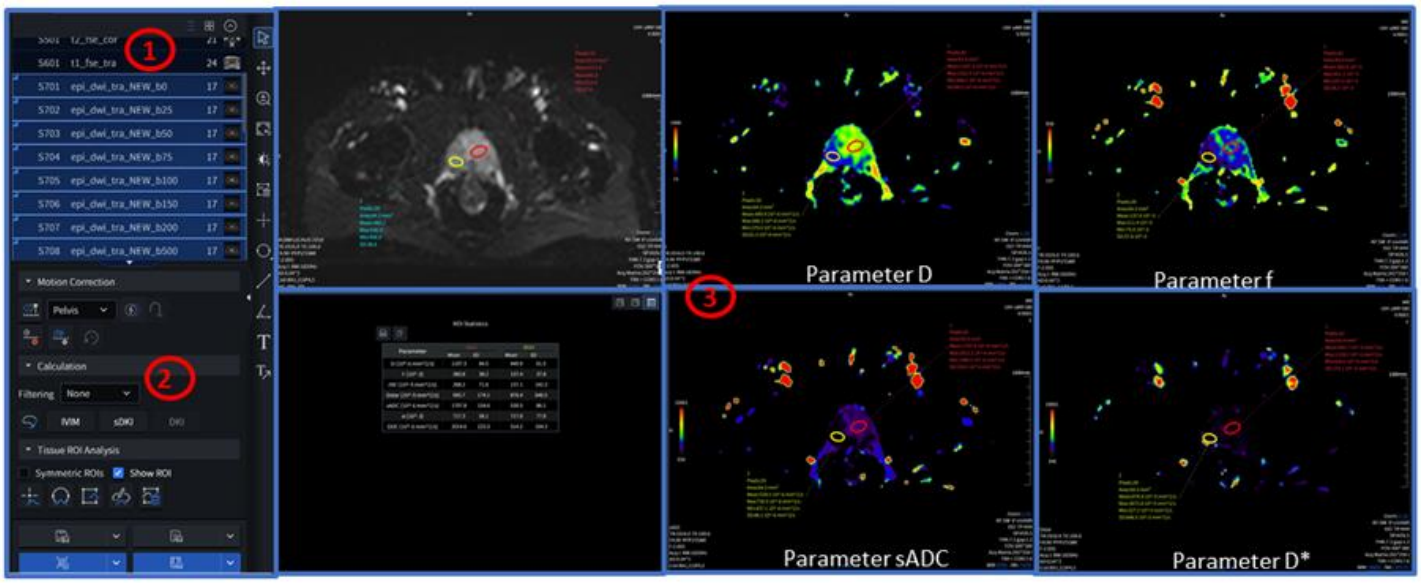

Figure 1: Representative IVIM MRI analysis in a 59-year-old male with a prostate lesion, demonstrating quantitative differences between healthy and malignant tissue regions. The images show manually placed ROIs in healthy peripheral zone (yellow) and lesion (red). Region 1 is study list where exam series can be selected. Region 2 is the control panel optional motion correction, filtering, model fitting, and calculation of parameters. Region 3 is where one can place ROIs, view pseudo-color maps, check statistics and export/push to PACS[#].

[#]The United Imaging Healthcare MR Diffusion Analysis post-processing platform is a non-FDA cleared, and non-CE marked application. This product is not available for the sale in the U.S. for clinical uses.

Key finding:

In the prostate cohort, malignant lesions demonstrated significantly reduced diffusion metrics compared with benign tissues.

- The parameter D was substantially lower in malignant tissues (Mean=0.85; SD=0.23) compared with healthy (Mean=1.20; SD=0.19) and BPH tissues (1.00 ± 0.14, $p < 0.05$).
- The IVIM parameter f of malignant tissues (Mean=0.24; SD=0.06) was also significantly reduced compared with healthy (Mean=0.31; SD=0.07) and BPH tissues (Mean=0.26; SD=0.07).
- In contrast, the pseudo-diffusion coefficient (D*) was significantly higher in malignant tissues (Mean=10.09; SD=4.90) compared with healthy (Mean=8.37; SD=5.41) and BPH tissues (Mean=9.40; SD=5.41).

In the liver dataset, malignant lesions showed marked alterations in perfusion-related parameters.

- The mean f was moderately reduced in malignant lesions (Mean=15.80; SD=3.20) compared with healthy liver tissue (Mean=21.50; SD=4.00, $p < 0.05$).
- The most striking difference was observed in pseudo-diffusion metrics, with malignant lesions demonstrating significantly higher D* values (Mean=4.12; SD=0.45) than healthy lesions (Mean=2.85; SD=0.37, $p < 0.01$), reflecting greater perfusion heterogeneity and microvascular irregularity.
- The parameter D was also substantially lower in malignant tissues (Mean=0.78; SD=0.20) compared with healthy liver tissue (Mean=1.12; SD=0.48, $p < 0.05$).

Takeaway at a glance

IVIM MRI offers a non-invasive, contrast-free, and quantitative method to differentiate benign from malignant lesions in the prostate and liver. By capturing subtle microstructural and perfusion characteristics often overlooked in conventional imaging, it enables more confident and informed clinical decision-making.

Clinical implications

Incorporation of IVIM into routine workflows could lead to:

- Improved diagnostic confidence
- Reduction in unnecessary contrast administration
- Streamlined imaging protocols
- Enhanced patient management and outcomes

As healthcare systems seek efficient, non-invasive diagnostic tools, IVIM stands out as a promising modality ready for broader clinical adoption.

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Dr. Zhanar Sagatbekovna Abdrakhmanova is an Associate Professor and Deputy Director of the Scientific Research Institute of Radiology named after Z. H. Khamzabayev, at Astana Medical University in Kazakhstan. She also serves as the chief radiologist at Nova Diagnostic in Astana. With deep expertise in magnetic resonance imaging (MRI) and functional MRI, her research spans diagnostic methods for temporomandibular joint disorders and congenital heart disease, including studies on the common arterial trunk. In addition, Dr. Abdrakhmanova has published on the challenges of radiological diagnosis in complex cases such as hemophiliac arthropathy. Her leadership in radiology has been recognized for advancing both clinical practice and medical education in Kazakhstan, particularly through integrating high-end imaging technology and mentoring the next generation of radiologists.

Clinical Utility of Diuretic FDG PET/MR in the Evaluation and Locoregional Staging of Urinary Bladder Cancer

Pawan G. Shinkar[a] and Palak Wadhwa
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Background

Carcinoma of the urinary bladder remains a formidable clinical challenge due to its heterogeneous presentation. Some patients may present with hematuria, while others experience nonspecific symptoms such as urinary frequency, urgency, or pelvic pain. A subset of patients may remain asymptomatic, with the disease detected only during routine check-ups.

Accurate staging and detection of local recurrence or metastatic spread are often difficult because of the high background tracer uptake in the bladder. Positron emission tomography (PET) imaging, particularly when combined with magnetic resonance imaging (MRI), has emerged as an important tool in the management of muscle-invasive and recurrent bladder cancer. However, the inherent limitation of FDG PET lies in the marked urinary excretion of 18F-fluorodeoxyglucose (FDG), which traditionally hampers its diagnostic utility.

To overcome this challenge, forced diuresis—achieved through administration of furosemide along with oral hydration—can be incorporated into PET protocols. This reduces urinary tracer activity, thereby improving the visualization of bladder wall lesions as well as perivesical and pelvic lymph nodes. There is growing interest in the role of diuretic-assisted PET/MR in this context.

This article discusses the technique, diagnostic performance, and staging implications of diuretic-assisted PET/MR in urinary bladder carcinoma and compares different modalities in pre and post-diuretic scenarios.

Imaging Challenges in Urinary Bladder Carcinoma

CT, MRI, and dynamic contrast-enhanced MRI provide valuable anatomical information; however, none achieve complete accuracy in staging, reflecting the limitations of morphology-based imaging.

Primary bladder lesions are particularly difficult to evaluate due to the physiology of tracer excretion. FDG, the most commonly used oncologic PET tracer, is excreted through the kidneys and accumulates in the urinary tract. This intense background activity can obscure primary lesions and adjacent lymph node or perivesical involvement. As a result, early detection and precise staging—critical for treatment planning in muscle-invasive bladder cancer—are frequently hampered by FDG-laden urine.

On conventional CT, nodal staging is based on size and morphology, but this is insufficient to distinguish reactive hyperplasia from true metastatic disease. In contrast, PET and MRI provide functional information, such as hypermetabolic activity on PET and diffusion restriction on MRI. Yet, the urinary accumulation of FDG continues to limit interpretation, resulting in potential misdiagnosis and false negatives.

These limitations provide the rationale for incorporating functional imaging strategies alongside forced diuresis to enhance diagnostic accuracy.

Forced Diuresis in PET Imaging

Concept of Forced Diuresis

Forced diuresis involves administering a potent diuretic, most commonly furosemide, together with oral hydration, followed by a delay in image acquisition. This promotes urinary washout of FDG, thereby reducing intravesical activity and enhancing the tumor-to-background contrast. The approach simplifies the detection of hypermetabolic bladder wall lesions and adjacent lymphatic spread.

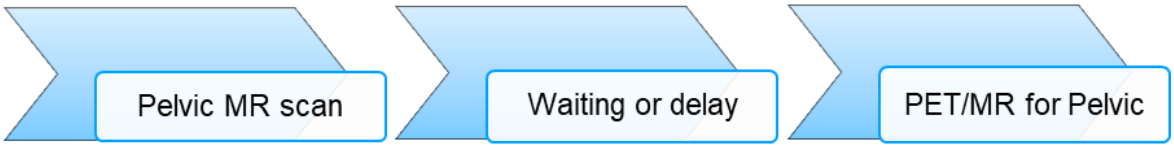
Implementation in PET/MR Protocol

The sequence of steps in the clinical protocol was as follows:

Step	Procedure
Baseline scan	Baseline PET/MR scan ~60 min post-FDG injection
Administration of Diuretic	Administer ~20 mg IV furosemide + ≥500 mL oral hydration

Waiting time	Encourage multiple voids over ~30–60 min
Delayed scan	Acquire delayed pelvic PET/MR scan (90–120 min post-injection)
Post processing	Measure SUVmax, MTV, TLG; review in multidisciplinary setting

Patients fasted prior to FDG administration, and blood glucose levels were confirmed to be within acceptable limits. Following FDG injection, intravenous hydration and furosemide were administered approximately 60–90 minutes later. After an additional delay of 60–90 minutes (resulting in a total imaging time of about 150–180 minutes post-injection), repeat scans were obtained. This delay was critical for reducing bladder tracer activity to near-background levels and minimizing false-positive findings from urinary contamination.



The whole-body PET/MR was performed in 4 beds with 5min per bed. The pre-diuretic pelvic MR scan included GRE Quick (1min 40sec) for MRAC fat suppression, T2 FS arms for reduced motion artifacts (6 to 7mins), T2 SSFSE during breath-holding (3min), and diffusion weighted imaging (about 8min). The delayed PET/MR pelvic scan protocol included MRAC (3min), Axial T2 FSE (3.25min), STIR axial (3.25 min), Diffusion weighted imaging (4min), 3D T1 VIBE (18sec), and 3D T2 Axial MX (2.25 min).

PET/MR provides high soft tissue contrast with MRI, complementing PET's metabolic information. Without measures to reduce bladder activity, however, PET/MR suffers the same pitfalls as PET/CT. Forced diuresis significantly improves image clarity by minimizing urinary tracer interference and is therefore a valuable adjunct to PET/MR in urothelial imaging.

Preliminary findings from Diuretic PET/MR Studies

In a pilot study of patients with bladder masses, diuretic PET/MR was incorporated to address urinary FDG interference. The aim was to assess the utility of delayed imaging for evaluation of bladder lesions and pelvic nodal metastases.

MRI identified the bladder lesion in all patients. PET, after diuretic administration, confirmed hypermetabolic uptake in the same regions, supporting tumor detection. PET/MR improved detection of pelvic nodal involvement, aiding surgical planning for pelvic lymph node dissection.

Noticeable feature of Diuretic PET/MR	**Advantage**
Reduced FDG Interference	Significant lowering of bladder FDG
Soft tissue delineation on MRI	Superior distinguishing of residual tumour from post-treatment fibrosis
Multiparametric assessment	Improvement in tumour characterization, treatment response evaluation, and recurrence detection
Radiation exposure	Reduced cumulative dose particularly for patients requiring serial imaging

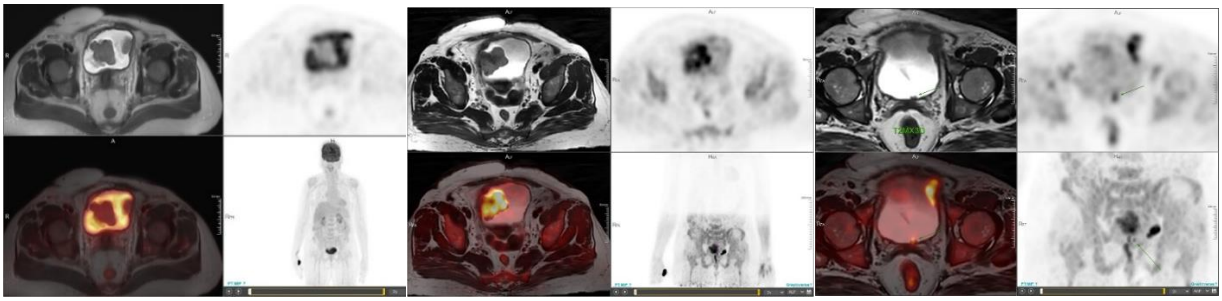
Conclusion

This study highlights two applications of diuretic-assisted PET/MR in bladder cancer: (1) preoperative staging of muscle-invasive disease with improved lesion and nodal assessment, and (2) restaging in suspected recurrence.

Diuretic-assisted FDG PET/MR offers a promising advancement in the evaluation and locoregional staging of urinary bladder carcinoma. By overcoming the long-standing challenge of urinary tracer interference, this technique significantly enhances the detection of bladder wall lesions and improves confidence in pelvic nodal assessment. The integration of PET's metabolic information with MRI's superior soft-tissue characterization provides a comprehensive, multiparametric evaluation in a single imaging session.

Beyond staging, diuretic PET/MR holds considerable value in restaging and surveillance, where distinguishing between recurrence and post-treatment changes is often challenging on conventional imaging.

While early studies demonstrate encouraging results, larger prospective, multicenter trials are warranted to validate its diagnostic accuracy, establish standardized protocols, and define its role in clinical decision-making. With further refinement and broader adoption, diuretic PET/MR has the potential to become an integral component of personalized management strategies for urinary bladder cancer.



A B C

Figure 1: Comparison of pre and post-diuretic PET/MR demonstrating significant improvement in the detection of the primary tumour involving the bladder wall. Top row in all show Axial T2-weighted images while bottom show fused PET/MR images. A: T2w showing partially distended urinary bladder with two polypoid lesions along lateral walls of the bladder. Fused image shows urinary radioactivity occupying the bladder cavity obscuring bladder lesion FDG uptake B: Post-Diuretic fused image and 3DMIP images reveal intense tracer uptake in the multiple bladder lesions C: Post-Diuretic fused images and 3DMIP images (green arrow) reveal small tracer avid sessile lesion along left side of trigone of urinary bladder medial to vesicoureteric junction.

Author Biography

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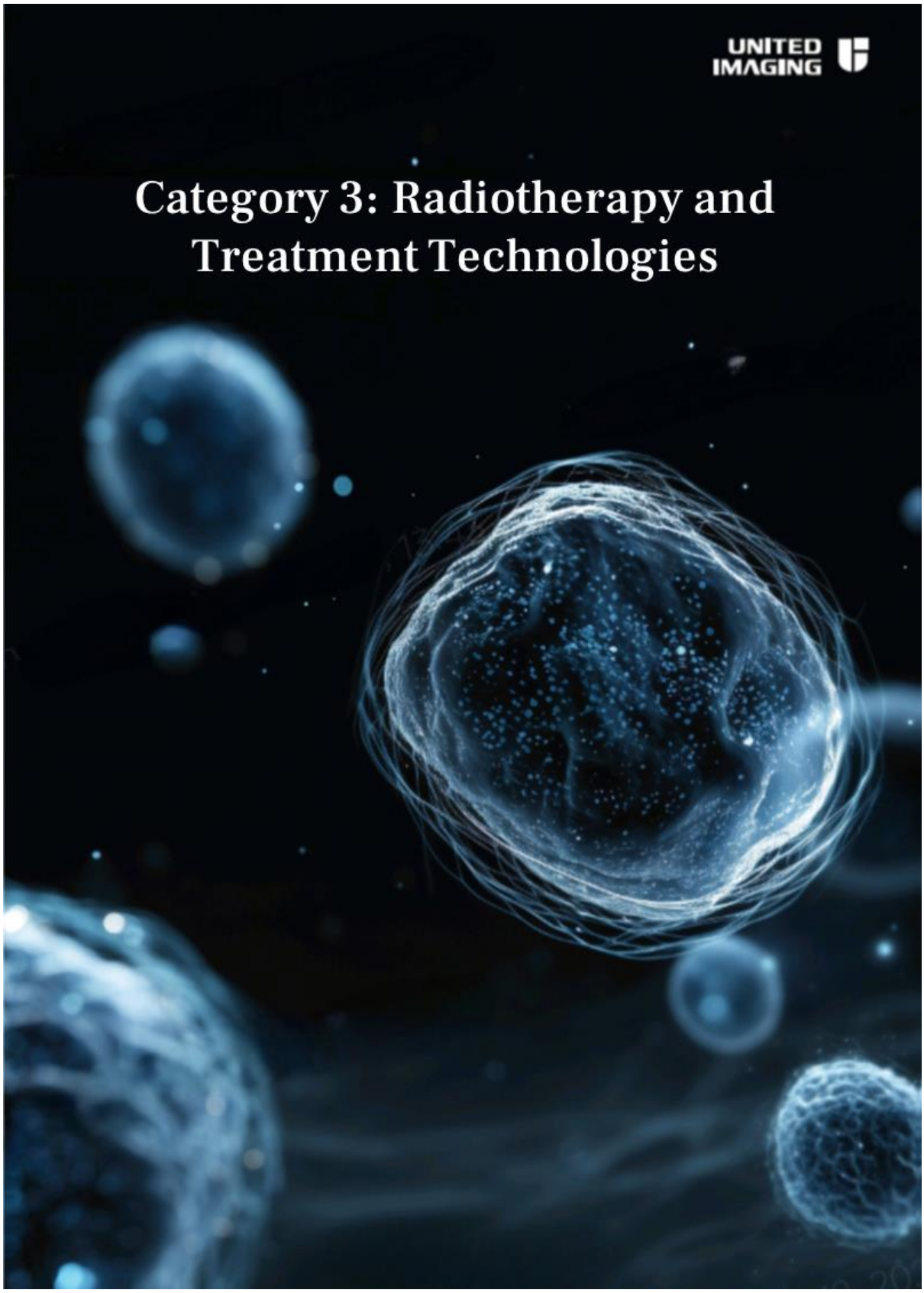
Dr. Pawan G. Shinkar is a seasoned radiologist at Omega Hospital, Banjara Hills, Hyderabad, with over 17 years of experience in diagnostic and interventional imaging. He earned his MBBS from the Maharashtra University of Health Sciences in Nashik (2008), followed by a DNB in Radio-Diagnosis from Lokmanya Tilak Municipal Medical College, Mumbai (2010), and a DMRE diploma from I-Care Eye Hospital (2013). Dr. Shinkar specializes in a broad spectrum of radiological services, including contrast radiography, vascular imaging, interventional diagnostics, uterine artery embolization, and neuroradiology. He is also a member of the Indian Radiological & Imaging Association and has published work in the Indian Journal of Nuclear Medicine.


UNITED
IMAGING
Category 3: Radiotherapy and
Treatment Technologies

Clinical application of CT-Linac with Artificial Intelligence for Online Adaptive Radiotherapy in Head & Neck and Pelvic Cancers

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*Shared Authorship

The Challenge

"*Clinics struggle with inefficient workflows. Traditional offline replanning takes days. What's missing is a fast, accurate, daily adaptive solution that fits into busy clinics without overwhelming staff or extending treatment time*"

Delivering precise radiation to tumors is complicated by the fact that a patient's anatomy changes daily — organs shift, tumors shrink, and weight fluctuates. This is especially problematic in cancers like nasopharyngeal and cervical cancer, where targets sit close to sensitive organs. When the original treatment plan no longer matches the patient's current anatomy, tumors may be underdosed, or healthy tissues overdosed leading to poor control or unnecessary side effects like hearing loss, xerostomia, or bowel toxicity.

The Solution

The uRT-Linac 506c — a diagnostic-quality fan-beam CT (FBCT) scanner fully integrated with a linear accelerator, developed by United Imaging Healthcare (UIH) offering these features:

Precision Imaging by FBCT: Same quality as CT Sim, can be used for contouring and dose calculation directly.

All-in-One Platform: Simulation, daily imaging, contouring, planning, and delivery happen on one machine — no patient transfer, no image mismatch.

AI Auto-Segmentation: Uses deep learning to contour targets and 35+ organs in nearly one minute, editable by clinicians.

AI Auto-Planning: Generates deliverable VMAT plans using prior plan knowledge and clinical goals less than 3.5 minutes (nasopharyngeal cancer) and less than 2.5 minutes (cervical cancer).

Real-Time QA: In-vivo EPID dose monitoring with gamma analysis during beam-on.

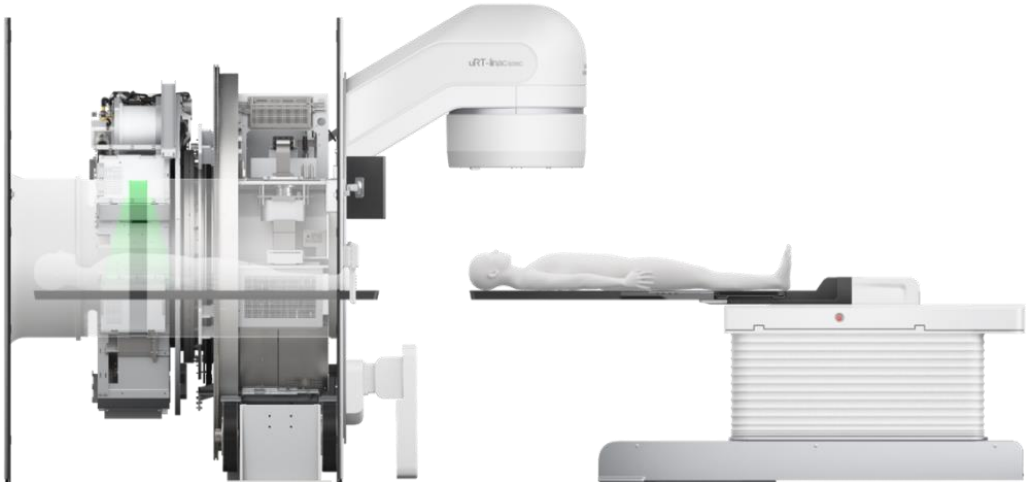


Figure 1. The integrated uRT-Linac 506c from United Imaging Healthcare [#].

[#] No 510k application for uRT-Linac 506c has been filed with the FDA. This product is not available for sale in the U.S. for clinical uses and also may not be available for sales in other countries.

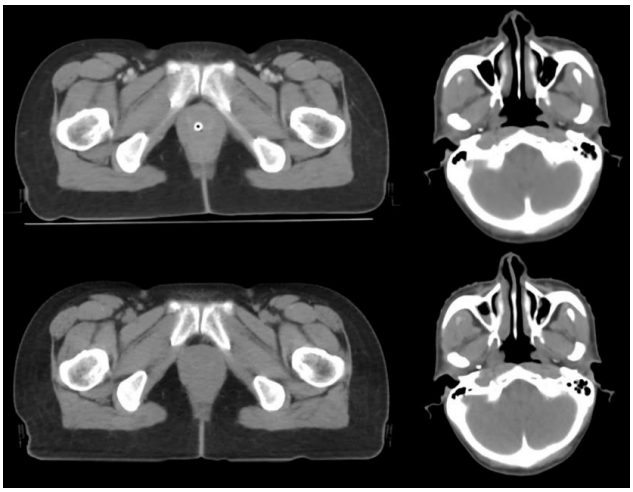


Figure 2. The comparison of simulation CT and FBCT by CT-Linac of a representative patient. The top row is simulation CT and the bottom row is FBCT.

Workflow Summary

The online adaptive radiotherapy (oART) workflow using CT-Linac consists of the following steps:

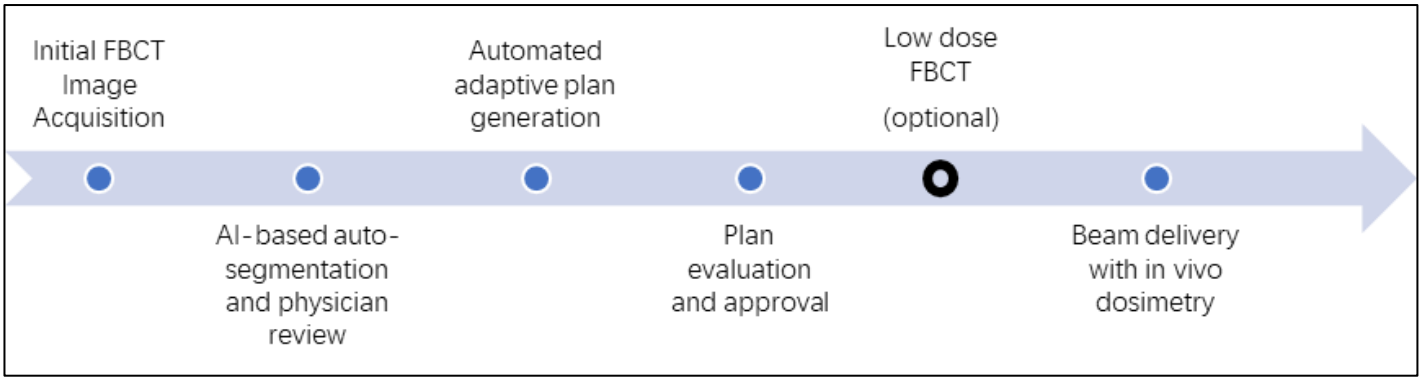
This turns oART from a research-only setting into a clinically feasible daily routine.

Here are the average RT times for two different types of cancer:

i. For Nasopharyngeal carcinoma, the following are the average time fraction:
   - FBCT Scan & Registration: ~3.3 min (16% of time)
   - AI Contouring + Review: ~8.2 min (39% of time)
   - AI Planning + Approve: ~5.0 min (24% of time)
   - Beam Delivery + EPID in Vivo: ~4.4 min (21% of time)

ii. For cervical cancer, the following are the average time fraction:
   - FBCT Scan & Registration: ~2.3 min (10% of time)
   - AI Contouring + Review: ~10.1 min (44% of time)
   - AI Planning + Approve: ~5.0 min (22% of time)
   - Low-dose verification FBCT: ~3 min (13% of time)
   - Beam Delivery + EPID in Vivo: ~2.4 min (11% of time)

This streamlined workflow demonstrates that CT-Linac–based oART can be efficiently integrated into routine clinical practice with acceptable time and dosimetry accuracy.



Did that Work?

FBCT–guided oART demonstrates clear dosimetric advantages in definitive cervical cancer treatment by ensuring consistent, high-quality target coverage while significantly reducing radiation exposure to critical organs at risk—thereby translating anatomical adaptability into tangible improvements in plan accuracy and safety.

Representative data from Nasopharyngeal carcinoma:

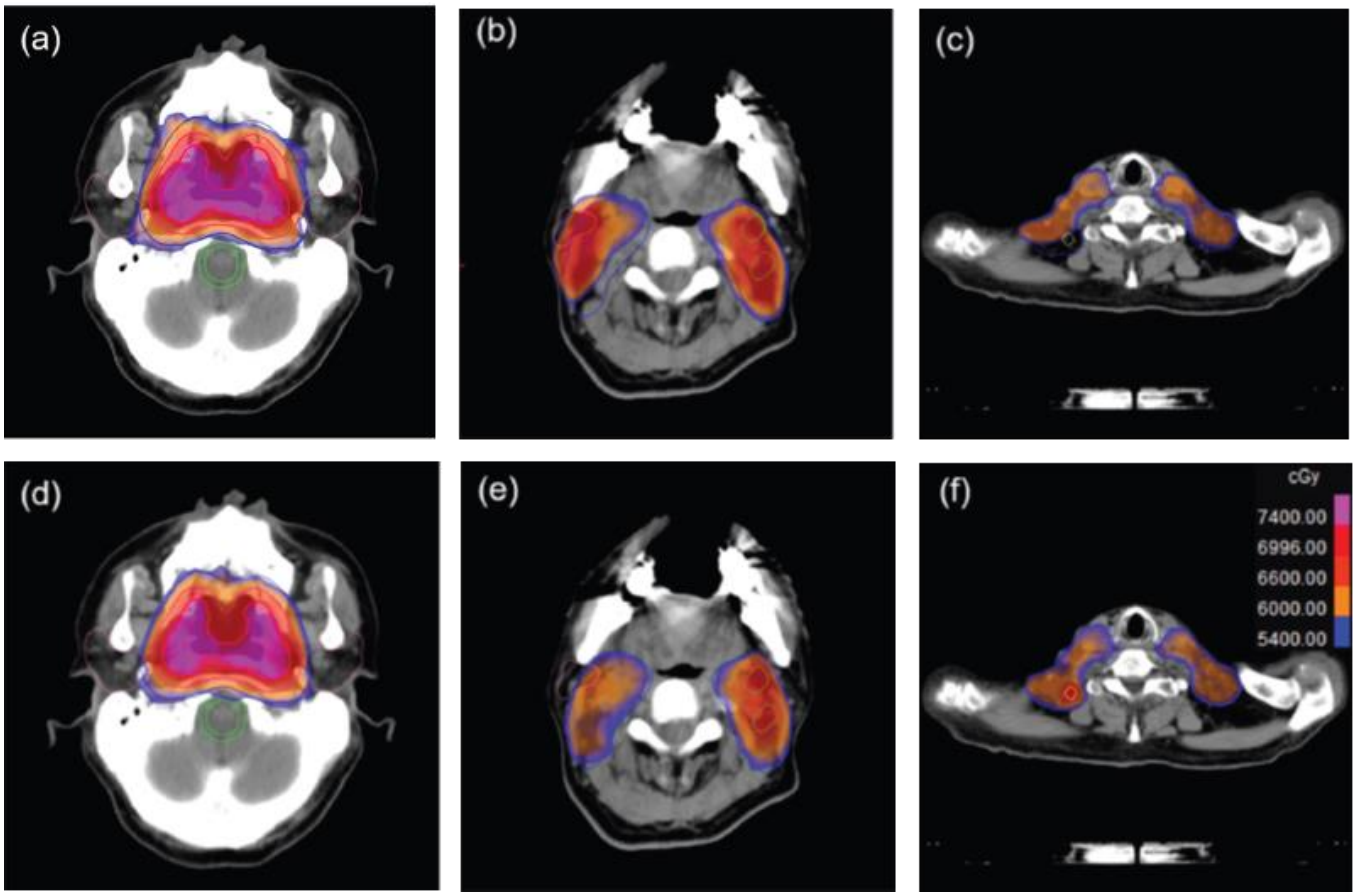


Figure 3. Dose distribution comparison between (a-c) scheduled plans and (d-f) ART plans. (adopted from [1])

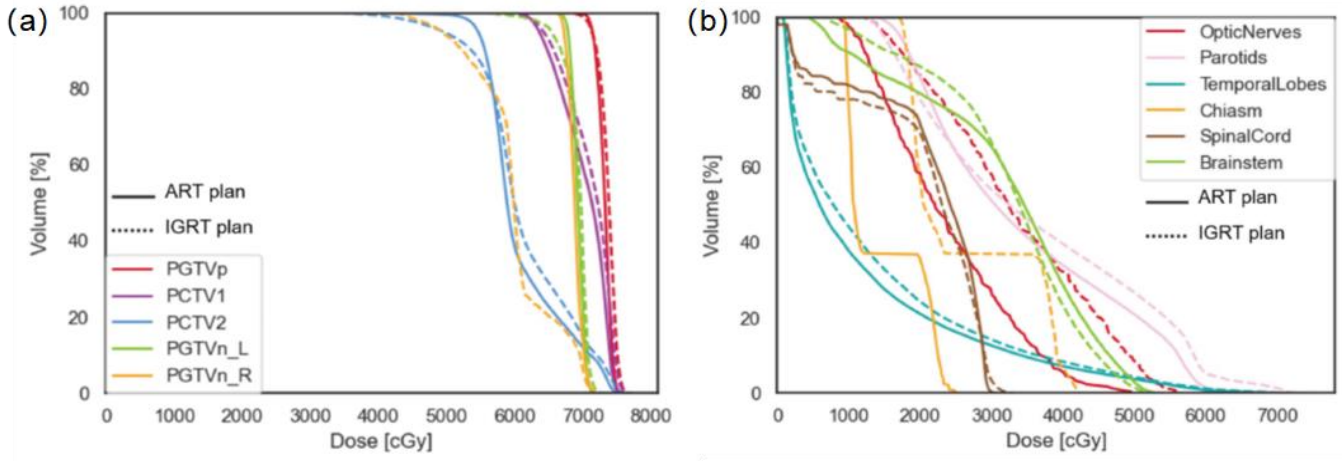


Figure 4. Dose and Volume Histogram (DVH) of targets(a) and OARs(b) of scheduled plans (dotted line) and ART plans (solid line). (adopted from [1])

The cumulative DVH plot of targets and OARs are shown in Figure 4, respectively. The solid line represents the ART plan, and the dotted line represents the scheduled plan.

ART plan is better than the scheduled plan - the dose to critical organs is reduced in ART. For example, in chiasm, there is 43% lower dose in ART plan.

Representative data from a Cervical cancer case:

Dose volume histogram comparison are shown for a cervical cancer patient. Adaptive planning consistently improved target coverage (PTV D95 met prescription) while reducing dose to rectum, bladder, and small bowel in Figure 5. Real-time EPID monitoring confirmed >99% gamma passing rate, validating delivery accuracy. Even with tumor movement and bladder fullness, adaptive plans-maintained precision — something static plans failed to do.

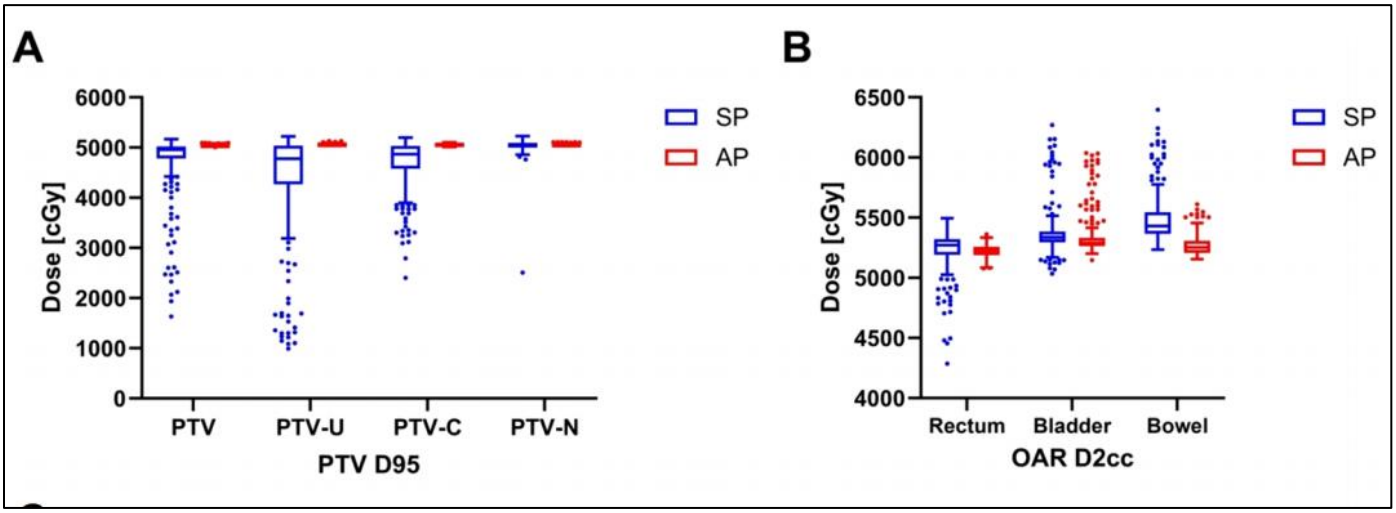


Figure 5. The differences in dosimetric parameters of targets and OARs between ART plans(red) and scheduled plans(blue) : (A) Targets (B) OARs. (adopted from [2])

The solid line represents the ART plan, and the dotted line represents the scheduled plan. So, it shows that ART plan is better than Scheduled plan because of improved distribution to both targets and organs at risk (OARs). First, the dose is reduced in ART plans for critical OARs. For example, in the small intestine, there is a 2.17 Gy lower D2cc (dose to the most irradiated 2 cm^3) for the ART plan, and in the rectum, the D2cc is 0.10 Gy lower, demonstrating superior organ sparing.

So What?

Patients win: fewer side effects, better tumor targeting, preserved organ function (like ovaries or hearing). Clinics win: no workflow disruption, no extra machines, no long waits.

The future? Daily adaptation becomes standard — not for select cases, but for all patients who need precision.

UIH's platform sets a new benchmark: adaptive radiotherapy that's fast, smart, and ready for prime time.

The impact? Higher cure rates, better quality of life, and a scalable model for global implementation — even in resource-limited settings.

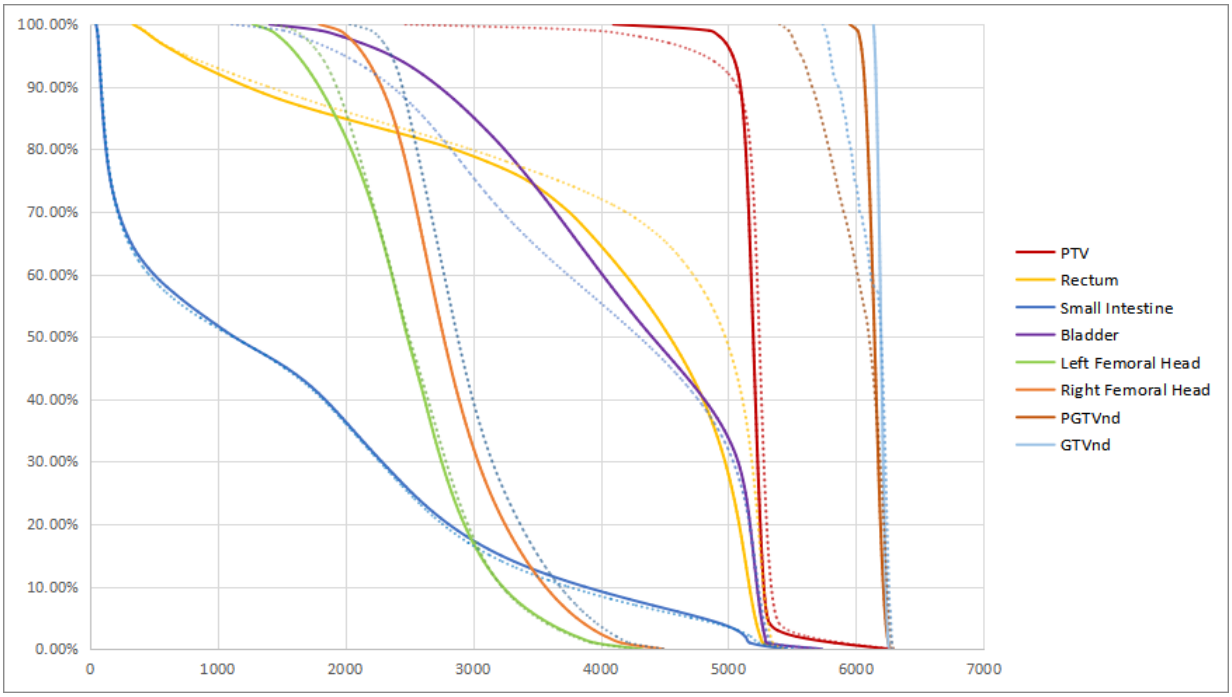


Figure 6. The DVH of the scheduled plans(dotted line) and ART plans(solid line) for a representative patient (adopted from [2]) **.**

Author Statement

Until now, adaptive radiotherapy was too slow, too complex, or too inaccurate for routine use. Our integrated CT-Linac with AI automation makes daily adaptation not just possible — but practical for busy departments treating complex head and neck or pelvic cancers.

References:

[1] Yang, Y-X, Li L et al. (2024). Initial Experience of CT-Based Online Adaptive Radiotherapy for Nasopharyngeal Carcinoma With a Novel Integrated Platform: A Case Report. Cureus.

[2] Sun, Gong et al (2025). Evaluating the Implementation of fan-beam CT-guided online adaptive re-planning in definitive cervical cancer radiotherapy. Frontiers in Oncology.

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All-in-One Radiotherapy：An AI-driven journey from simulation to treatment

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The Challenge

For decades, radiotherapy workflow has been a multi-step and resource-intensive process. What the patient faces is a fragmented journey: a visit for a CT Simulation, then days, or even weeks, of anxious waiting while radiation oncologists and physicists design complex treatment plans through steps including contouring, planning, evaluation and quality assurance. Only after this lengthy delay can the first treatment be delivered.

This waiting duration is agonizing for patients and their families, who are desperate to begin fighting the disease. Clinically, the delay is also problematic. A patient's anatomy can change, tumors can progress, and the plan created based images acquired a week ago may no longer be perfectly optimized for the day of treatment. The current workflow also poses economic burden for patients who travel long distances to the hospital.

The Technology

Many technical advances have been introduced to improve the efficiency of individual tasks during the radiotherapy workflow, such as auto segmentation and auto planning. In 2018, the world's first integrated CT-guided linear accelerator, uRT-Linac 506c was released, which provided the platform for the fully streamlined automation of the entire radiotherapy workflow. A unique approach called "All-in-One" radiotherapy workflow was co-developed by researchers from Fudan University Shanghai Cancer Center (FUSCC) and UIH. This approach redesigns the entire process around a single, seamless session using two core technological advancements:

- *Integrated Diagnostic-Quality CT:* The system is built on a hybrid machine that combines a diagnostic-quality CT scanner with a state-of-the-art linear accelerator (LINAC). This allows for both high-fidelity imaging and precise treatment delivery to happen on the same couch, eliminating the need for patient transport and re-positioning.
- *An Intelligent AI Engine:* This is another cornerstone of this workflow. An AI copilot is seamlessly integrated into the workflow, as soon as the CT scan is complete, AI copilot performs two critical tasks in minutes:
  - Auto segmentation: It instantly and accurately outlines the tumor and all nearby healthy organs (known as organs-at-risk).
  - Auto planning: It generates a high-quality, clinically optimal radiation plan tailored to the patient's specific anatomy.

The workflow is entirely automated, incorporating embedded QA solutions to ensure safety and precision at every stage. Users have the flexibility to choose from EPID transit QA and independent dose calculation QA to further validate the process. Strategically placed human checkpoints—including contour review, plan evaluation, IGRT verification, and QA approval—are seamlessly integrated into the workflow. This design allows for streamlined, single-visit completion, with the patient remaining on the treatment couch throughout the entire process. This approach minimizes delays, enhances efficiency, and ensures a high standard of care. The streamlined workflow improves efficiency of RTx preparation, minimizing patient waiting and hospital visit costs.

Did that work?

Yes, the results have been transformative. The "All-in-One" workflow was first pioneered at Fudan University Shanghai Cancer Center (FUSCC) on rectal cancer patients, proving the concept was feasible and could reduce the entire process to just 23 minutes.

Figure 1. Concept of the All-in-One solution

Figure 2. The World's First Integrated CT-Linac#.

#No 510k application for uRT-Linac 506c has been filed with the FDA. This product is not available for sale in the U.S. for clinical uses and also may not be available for sales in other countries.

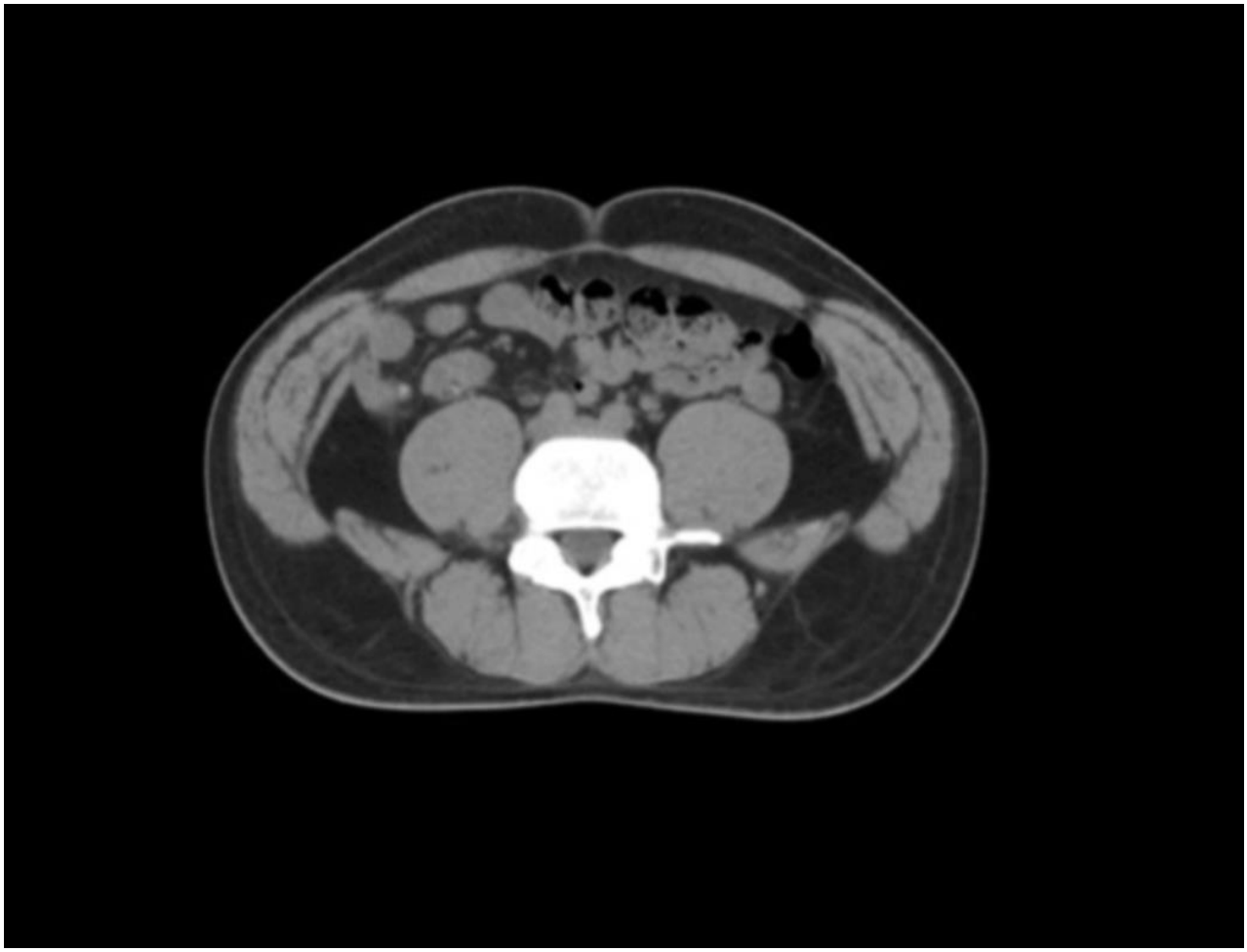

Figure 3. Fan-Beam CT Provides Diagnostic-Level Image Quality.

An example is CT image shown in Figure 3, the quality of this CT rivals that of a CT Simulator scan. This is made possible by the design of the integrated, on-board fan-beam CT (Figure 2). The superior soft tissue contrast, free from air cavity artifacts, provide clinicians with high confidence in target contouring and direct dose calculation, capabilities often limited by the poor contrast of conventional CBCT. An integrated EPID is provided to perform online transit dose verification, the γ passing rate result, shown in Figure 4, indicates that the All-in-one technique is not only safe, but also by minimizing the delay between the CT simulation and the first treatment, the system ensures that the treatment plan accurately reflects the patient's current anatomy, reducing the impact of systematic changes like tumor growth or weight fluctuation.

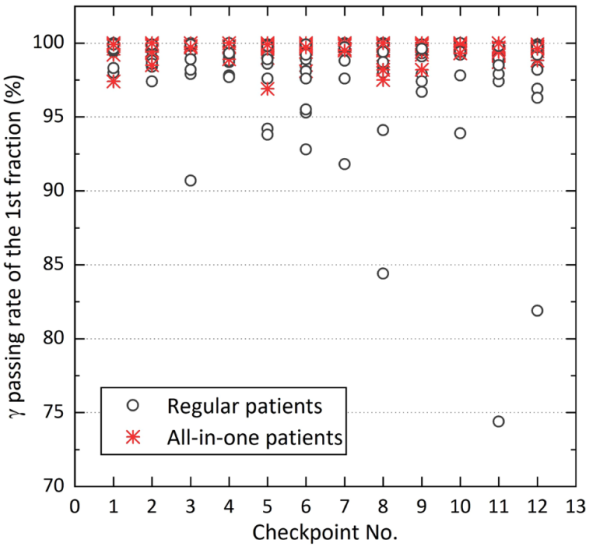

Figure 4.γ-passing rate of in vivo QA for the All-in-One patients (red star) and regular patients (black circle) during the first treatment. [1]

Building on this, Sun Yat-sen University Cancer Center (SYSUCC) has expanded the horizon of this technology significantly by demonstrating its feasibility on patients with nasopharyngeal carcinoma (NPC), one of the most complex cancers to treat due to its proximity to the brain and optic nerves. In a prospective study involving 120 patients, they found the AI-powered workflow to be a resounding success. The median time from the initial scan to the completion of the first treatment was only 23.2 minutes [2].

Most importantly, the quality of care was exceptional. The AI-generated plans were of high quality, an impressive 92% of plans met clinical requirements after a single optimization, a significant acceleration compared to the 4 to 6 rounds typically needed for manual plans. The clinical outcomes were outstanding, with 99.1% of patients achieving a complete tumor response at their 12-week follow-up along with a favorable acute toxicity profile. This large-scale validation proves the technology is not only incredibly fast but also safe and clinically powerful, even for the most challenging cases.

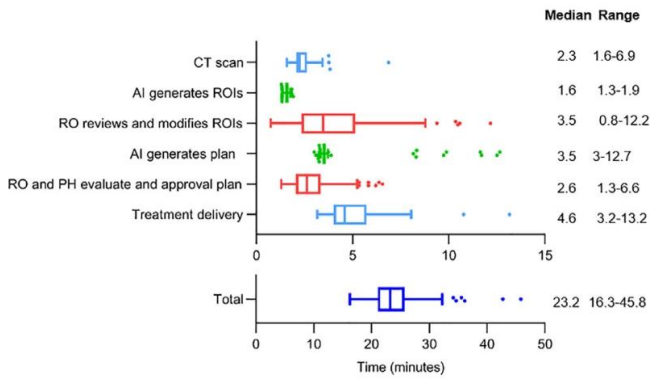

Figure 5. Overview of the MSI Workflow Time Spent. The workflow is color-coded: green steps represent AI-executed processes, red steps indicate manually performed tasks, and blue steps correspond to other processes. [2]

Author's statement:

For too long, the radiotherapy process has been fragmented, forcing patients to endure a lengthy and anxious wait between simulation and treatment. Our work demonstrates that by integrating smart hardware and AI, we can collapse this timeline from days into minutes. This isn't just about efficiency; it's about providing immediate, high-quality care, reducing patient uncertainty, and creating a more humane and responsive treatment experience from day one.

So What?

The validation of the All-in-One workflow by two domestic leading cancer centers marks a pivotal moment in radiation oncology. For patients, the benefit is immediate and profound: less waiting, less anxiety, and the start of treatment without delay. For hospitals, it represents a dramatic increase in efficiency, allowing them to treat more patients and focus expert resources on the most complex cases. In addition, the All-in-One workflow facilitates time-sensitive clinical trials where prompt radiotherapy treatment initiation is critical. Furthermore, it enables novel paradigms like Pulsar therapy, which can induce dramatic anatomical changes that overwhelm online adaptive radiotherapy. By providing rapid, integrated re-planning capabilities, the AIO platform offers a viable solution for managing these significant intra-treatment variations and advancing such innovative therapeutic strategies.

References:

[1] Yu L, Zhao J, Xia F, et al. (2023) Technical note: First implementation of a one-stop solution of radiotherapy with full-workflow automation based on CT-Linac combination. Medical Physics.

[2] Yang YX, Yang X, Jiang XB, et al. (2025) Artificial Intelligence-Empowered Multistep Integrated Radiation Therapy Workflow for Nasopharyngeal Carcinoma. International Journal of Radiation Oncology*Biology*Physics.

Authors Biography

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Dr. Zhen Zhang is a Professor and the Chair of the Department of Radiation Oncology at Fudan University Shanghai Cancer Center, where she specializes in gastrointestinal (GI) cancers. She completed her MD at Shanghai Medical University (now part of Fudan) and later earned a PhD in Oncology from Fudan University (2004–2007). Dr. Zhang also trained internationally, having been a clinical observer in the Radiation Oncology Department at MD Anderson Cancer Center in Texas. Her research has focused on chemoradiation strategies for rectal cancer, biomarkers (like COX-2) to predict radio sensitivity, and the use of advanced imaging in head-and-neck and abdominal radiotherapy.

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Interview with Prof. Akram Al-Ibraheem: Navigating Challenges and Opportunities in FAPI Imaging and Theranostics

Akram Al-Ibraheem
King Hussein Cancer Center, JORDAN

Interviewer: Professor Akram, thank you for joining us. You recently gave a webinar on the expanding role of theranostic medicine. Could you begin by telling us what you focused on in your talk?

Prof. Akram: Thank you, and I would like to thank United Imaging Healthcare for inviting me. My talk centered on Fibroblast Activation Protein Inhibitors—what we call FAPI. Specifically, I discussed the pitfalls, challenges, and opportunities when integrating FAPI PET/CT into clinical practice, and its enormous potential in theranostics. FAPI imaging is one of the most exciting innovations in nuclear medicine in recent years, but like any breakthrough, it comes with its own hurdles. Understanding these challenges is critical if we want to fully harness FAPI's potential—not just in cancer imaging, but also in therapy and even beyond oncology

Interviewer: For readers unfamiliar with FAPI, could you explain what makes it so promising?

Prof. Akram: Absolutely. For decades, FDG PET/CT was the workhorse of molecular imaging. But FDG has limitations, particularly in tumors with low glucose metabolism or where background uptake is high. FAPI is a game changer. It targets fibroblast activation protein, which is abundantly expressed in the tumor stroma—essentially the microenvironment that supports cancer growth. Unlike most normal tissues, these cancer-associated fibroblasts are activated and highly visible with FAPI tracers. This selective uptake results in excellent tumor-to-background contrast.

What makes FAPI truly exciting is that it is not only a powerful imaging agent but also a theranostic probe. Labelled appropriately, it can combine precise imaging with targeted therapy. That's why many call it a "molecule of the century."

Interviewer: You mentioned pitfalls. What are the major challenges in interpreting FAPI PET/CT scans?

Prof. Akram: One of the biggest challenges is non-malignant uptake. FAPI can accumulate in sites of inflammation, infection, or benign conditions. For example, uptake may be seen in uterine fibroids, arthritis, or post-surgical changes. In our experience at King Hussein Cancer Center (KHCC), we reported more than 220 such pitfalls across 48 patients. These findings can lead to false positives if not carefully interpreted.

However, these pitfalls are not just limitations, they represent opportunities. For instance, uptake in inflammatory or fibrotic diseases could allow us to extend FAPI imaging into non-oncologic applications, such as arthritis, liver fibrosis, or even cardiac remodeling after injury.

Interviewer: That's fascinating. How does FAPI compare to FDG in terms of performance?

Prof. Akram: Several studies have shown that FAPI provides superior lesion contrast with very low background activity compared to FDG. For example, FDG shows intense uptake in the brain and liver, which can obscure lesions. With FAPI, those tissues show minimal uptake, making it easier to detect tumors in challenging regions like the pancreas and abdomen.

That said, FAPI is not meant to replace FDG entirely, it is complementary. In some cancers where FDG performs poorly, FAPI could become the first-line imaging agent.

Interviewer: Could you share insights from your own institution's experience with FAPI?

Prof. Akram: Certainly. At KHCC, we introduced FAPI PET/CT in late 2022 with a state-of-the-art digital PET/CT scanner from United Imaging Healthcare. We recently published our first experience with 48 patients, covering a range of malignancies, especially gastrointestinal cancers. We found that biliary tumors had the highest uptake with excellent tumor-to-background ratios. Importantly, FAPI imaging impacted management decisions in about one-third of cases.

At the same time, we encountered numerous pitfalls—such as uptake in musculoskeletal or inflammation-related update — underscoring the importance of cautious interpretation.

Interviewer: You mentioned FAPI's potential beyond

oncology. Could you elaborate?

Prof. Akram: Yes. FAPI's role in non-oncologic diseases is gaining momentum. Active fibroblasts are not unique to cancer; they also appear in chronic inflammation and fibrosis. We've seen promising results in liver fibrosis, pulmonary fibrosis, and inflammatory arthritis. In fact, there are already more than 40 clinical trials exploring FAPI's role in non-oncologic applications. This could open the door to monitoring disease progression, guiding treatment, and evaluating response in conditions far beyond cancer.

Interviewer: And what about FAPI as a theranostic agent?

Prof. Akram: That is perhaps the most exciting frontier. When labelled with therapeutic radionuclides, such as Lutetium-177 or Actinium-225, FAPI can deliver targeted radiation directly to tumors. Early studies report disease control rates ranging from 65% to 95% in heavily pretreated patients, with acceptable safety profiles.

Of course, challenges remain—particularly rapid tracer washout, which can limit therapeutic efficacy. Researchers are working on strategies like albumin binders or multimeric constructs to improve tumor retention. Large-scale Phase II and III trials are still needed, but the progress so far is remarkable.

Interviewer: Finally, where do you see FAPI imaging and theranostics in the near future?

Prof. Akram: I believe FAPI will soon complement, and in some cases even surpass FDG PET/CT in selected tumors such as gastric cancer, sarcomas, and pancreatic cancer. Its theranostic applications are equally promising—offering targeted treatment options for patients with limited alternatives. Beyond oncology, I see FAPI playing a major role in fibrotic and inflammatory diseases.

In short, FAPI is not just another tracer—it is redefining what we can achieve in nuclear medicine. But as with any innovation, physicians must remain vigilant, understand the pitfalls, and interpret results in the right clinical context.

Interviewer: Thank you, Professor Akram, for these valuable insights into the future of FAPI imaging and theranostics.

Prof. Akram: Thank you. It's been a pleasure.

Expert's Biography

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Prof Dr. Akram Al-Ibraheem is President of Jordanian Society of Nuclear Medicine, JOSNM (2016-2022), Vice-President of the Asia Oceania Federation of Nuclear Medicine and Biology (AOFNMB) and past-President of Arab Society of Nuclear Medicine, ARSNM (2014-2019). Since 2012, he has served as an expert for the international Atomic Energy Agency. He has been the course director for many regional and international workshops in Amman, Jordan as joint projects by the IAEA and King Hussein Cancer Center (KHCC). Dr. Al-Ibraheem introduced state-of-the art nuclear medicine services to KHCC and Jordan such as DOTATOC and PSMA PET/CT imaging as well as peptide receptors radionuclide therapy (PRRT) and PSMA-ligand radionuclide therapy (PLRT). He is a faculty and board examiner of the Asian Nuclear Medicine Board and the Jordanian Board of Nuclear Medicine. He is the Director of Nuclear Medicine Residency and Nuclear Oncology Fellowship Programs at KHCC which receives many fellows from the region. Dr. Al-Ibraheem has authored and published many articles in international peer-reviewed journals focusing on molecular imaging and the role of PET/CT in cancer management and he is an editorial board member of several international journals. He is the principal investigator for several ongoing clinical trials and multi-centric research projects.

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