Generative AI-Enabled Imaging Substitution for Equitable Preoperative Decision-Making in Rectal Cancer Care (Extended Abstract)

Chang Li[1,2], Xiang Zhao[3], Jia Meng[1], John Moraros[1], Shuihua Wang[1,*]

[1]Department of Biosciences and Bioinformatics & Suzhou Municipal Key Lab of AI4Health, School of Science, Xi'an Jiaotong-Liverpool University
[2]Department of Mathematical Sciences, School of Physical Sciences, University of Liverpool
[3]Qilu Hospital of Shandong University
Chang.Li18@student.xjtlu.edu, 202335815@sdu.edu, {Jia.Meng, John.Moraros, Shuihua.Wang}@xjtlu.edu

Abstract

This extended abstract presents a generative AI-enabled framework for rectal cancer that supports mesenteric fascia (MRF) invasion assessment under CT-only workflows, aiming to improve diagnostic equity, decision quality, and healthcare resource efficiency in real-world settings.

Introduction

Accurate assessment of mesenteric fascia (MRF) invasion is a critical imaging-based decision point in rectal cancer care, directly determining whether patients should receive neoadjuvant therapy and whether curative surgery is feasible (Ayuso et al. 2026). From a healthcare operations and management perspective, this decision is high-stakes, resource-intensive, and time-sensitive. Magnetic resonance imaging (MRI) is widely regarded as the gold standard for MRF evaluation due to its superior soft-tissue contrast (Horvat et al. 2019). However, in real-world clinical systems, access to MRI is constrained by uneven equipment distribution, clinical contraindications, scheduling delays, and patient financial burden (Frija et al. 2021). As a result, a substantial proportion of patients undergo preoperative assessment using computed tomography (CT) alone, leading to reduced diagnostic certainty, inequitable decision quality, and suboptimal allocation of downstream treatment resources.

This work addresses a critical gap between ideal clinical guidelines and operational reality by reframing imaging limitations as a decision-support and resource-access problem rather than a purely diagnostic one. We propose a generative AI–enabled imaging substitution framework that leverages routinely available CT scans to generate high-fidelity synthetic MRI (sMRI), enabling MRI-equivalent decision support within CT-only workflows. By augmenting existing CT-based pipelines rather than replacing them, the proposed approach aims to improve decision coverage and equity without increasing dependence on scarce imaging infrastructure.

Technically, the framework is built upon a 2.5D slice-to-slice conditional latent diffusion model (Rombach et al. 2022) trained on paired CT–MRI data collected from multiple hospitals. The model integrates a diffusion rectification and estimation adaptive training strategy and pseudo numerical methods for diffusion models to improve generation stability, efficiency, and deployment feasibility. Rather than treating image synthesis as an end, the sMRI serves as an intermediate representation to support automated MRF status assessment. A downstream MRF classification model is jointly developed, and explainable AI techniques are incorporated to provide structure-level visual explanations aligned with anatomical boundaries, enhancing transparency and clinical trust. Performance is further benchmarked against blinded radiologist readings, enabling a direct comparison between AI-assisted sMRI-based assessment and human expert interpretation under CT-only conditions.

From an AI in Business perspective, this study demonstrates how generative AI can be operationalized as a scalable decision-support infrastructure rather than a standalone diagnostic tool. By embedding explainability and workflow compatibility into the system design, the framework addresses key governance and adoption challenges associated with deploying generative AI in high-stakes healthcare environments. The results suggest that AI-driven imaging substitution can play a meaningful role in improving decision equity, reducing patient-level financial burden, and enhancing the efficiency of healthcare delivery systems.

Acknowledgments

This extended abstract is supported by Basic Research Program of Jiangsu, BK20241815 and Xi'an Jiaotong-Liverpool university research development fund RDF-23-02-004. All ethical and experimental procedures and protocols were approved by the Ethics Committee of Qilu Hospital of Shandong University and conducted with the Declaration of Helsinki (KYLL-202111-087-1). Relevant data have been deidentified.

References

Ayuso, J.-R.; Balyaniskova, S.; Beets-Tan, R. G.; Blazic, I.; Blomqvist, L.; Caruso, D.; Crimi, F.; Curvo-Semedo, L.; Dresen, R. C.; Gollub, M. J.; et al. 2026. MRI to guide clinical management of rectal cancer: updated consensus recommendations from the European Society of Gastrointestinal and Abdominal Radiology (ESGAR)-PART I primary staging. *European Radiology.*

Frija, G.; Blaˇzi´c, I.; Frush, D. P.; Hierath, M.; Kawooya, M.; Donoso-Bach, L.; and Brkljaˇci´c, B. 2021. How to improve access to medical imaging in low-and middle-income countries? *EClinicalMedicine*, 38.

Horvat, N.; Carlos Tavares Rocha, C.; Clemente Oliveira, B.; Petkovska, I.; and Gollub, M. J. 2019. MRI of rectal cancer: tumor staging, imaging techniques, and management. *Radiographics,* 39(2): 367–387.

Rombach, R.; Blattmann, A.; Lorenz, D.; Esser, P.; and Ommer, B. 2022. High-resolution image synthesis with latent diffusion models. In *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*, 10684–10695.