Development and Testing of a Clinical Tool to Predict and Optimize Liver Contrast-Enhanced CT Imaging

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Introduction

Iodinated contrast agent is **widely used** in CT imaging to enable and **improve clinical diagnosis** for low contrast tasks.

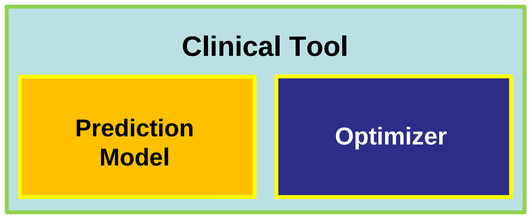
Iodine administration and scanning parameters can notably affect the **enhancement** within organs and vessels over time.

Iodine contrast has also been noted as **possible cause** of **contrast-induced acute kidney injury (CI-AKI)** and other allergic **reactions.**

Iodine administration and scanning parameters can be **optimized and personalized** to ensure **consistent and sufficient** level of enhancement in liver imaging.

Purpose: To develop, implement, and test a clinical contrast and scan parameter optimizer tool to support clinical decision making at the point of care.

Clinical tool framework and Prediction model



Clinical tool consists of (1) **previously-developed liver contrast enhancement** prediction model and (2) iodine administration and scan **parameter optimizer.**

The neural network prediction model was **trained on 1577 retrospective cases.**

The model can **predict liver parenchyma contrast** enhancement over time using **patient's information** (height, weight, age, sex, and BMI), **baseline liver HU** level, **scan parameters**, and **iodine administration** (bolus volume, injection rate, and concentration)

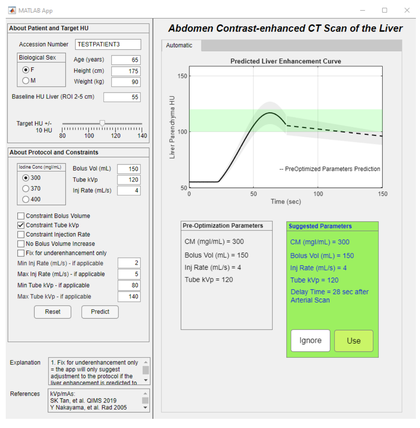
Optimizer Tool

Based on **pharmacokinetics** models and **clinical studies.**

Algorithm **calculates and distributes** the amount of adjustment needed of each parameters to **reach the target HU.**

Safety limits were incorporated in consultation with clinicians.

Parameter	Optimization Limits
Iodine Concentration	300 mgI/mL, 370 mgI/mL, 400 mgI/mL
Bolus Volume	50 mL to 200 mL
Injection Rate	2 mL/s to 5 mL/s
	< 60 kg: 80-140 kV
Tube Potential	60 to 135 kg: 100-140 kV
	> 135 kg: 120-140 kV

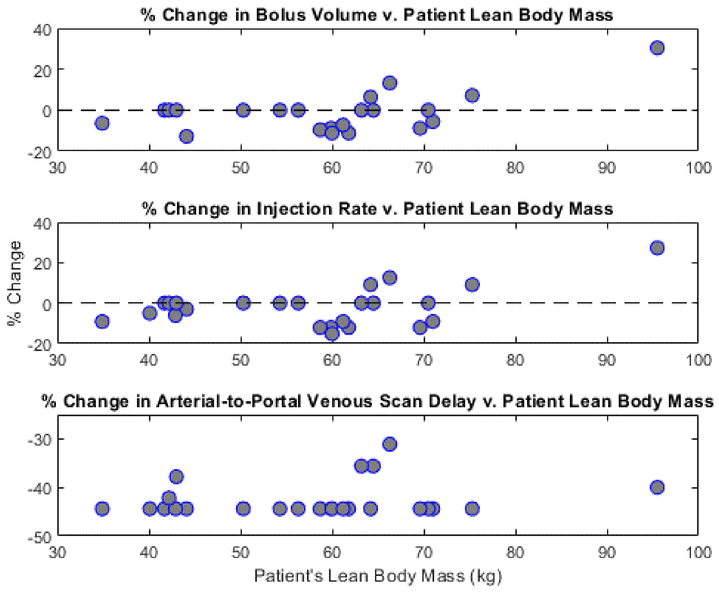


Prospective Clinical Test

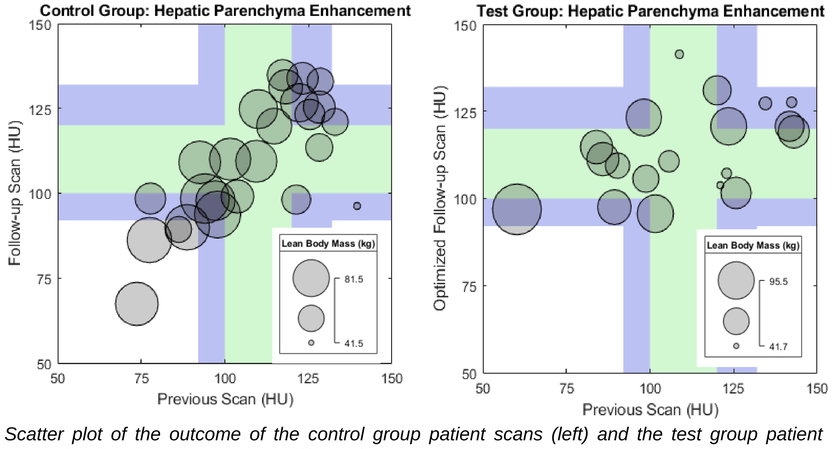
24 Patients with Renal Cell Carcinoma (RCC) protocol in January 2023. Standard protocol: 150 mL, 3 mL/s, 300 mgI/mL; or 125 mL, 3.3 mL/s, 370 mgI/mL. 19 of the 24 patients **had previous** RCC scans 2-12 months prior.

Control group to rule out coincidence in results: 25 **retrospective** patients with **similar median BMI** with two RCC scans, one in 2022, and one in February and March 2023.

If enhancement is **predicted to be improper**, a **suggested alternative** set of parameters is displayed. **15 patients received bolus volume and injection rate adjustments** and **all patients were scanned about 42.6% earlier** than the standard protocol.



Results



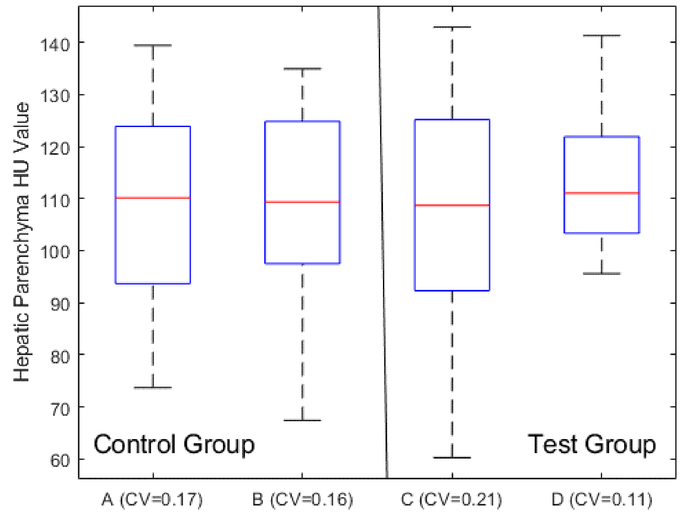
Scatter plot of the outcome of the control group patient scans (left) and the test group patient scans (right) between an earlier RCC-protocoled scan with a more recent follow-up scan of the same protocol for each patient. None of the scans received any optimization. The size of the bubble is linearly proportional to the lean body mass of the patient. The light gray shaded area represents the radiologist-preferred target range for hepatic parenchyma enhancement in this study (100 <HU<120), while the darker gray shaded region represents the target enhancement range according to (Y. Cheng et al. 2019) paper

Results and Statistical Comparison

The number of **under-enhanced test patients was halved**; **all previously over-enhanced test patients** received **enhancement reductions** when optimized.

Coefficients of Variation (CV) for the **test group** changes from 0.21 to 0.11 between the prior and study scans (median 111.3 HU and 108.7 HU, respectively). The **control group's** CV changes from 0.17 to 0.16 (median 110.1 HU and 109.3 HU, respectively)

Ansari Bradley test indicates **statistically significant change** in distribution in the **test group** (p=0.012), while the **control group** CV change **was statistically insignificant** (p=0.67).



Comparison of the hepatic parenchyma enhancement outcome at portal venous phase between the control group (left) and the test group (right). RCC-protocoled scans in control group A were conducted between September 2021 and January 2023, while scans in group B (of the same patients) were done in February and March 2023. The control group patients did not receive any optimization in either scan. RCC-protocoled scans in group C were acquired between June 2020 and November 2022, while scans in group D were acquired in January and February 2023. Scans in group D underwent optimization, while scans in group C (of the same patients as group D) did not receive optimization.

Conclusions

In this study we developed and tested a **patient-informed clinical framework** which **predicts** liver parenchyma contrast enhancement and **optimizes** contrast media administration and scan parameters.
Clinical test indicates **improved** hepatic parenchyma contrast enhancement **consistency**, and **decreased** number of **under-enhanced** patients.

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