Angiographic CBCT Radiomics as a Quantitative Imaging Biomarker of Tumor Perfusion in Patients Undergoing Y-90 TARE

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INTRODUCTION

- Y-90 Transarterial Radioembolization (TARE) is an established treatment for Hepatocellular carcinoma (HCC)
- Dose distribution in Y-90 is governed by the quality of vascular perfusion in and around the tumor volume
- There are little to no current quantifiers of perfusion quality on CBCTs
- Radiomics is a field of quantitative image analysis that offers spatial characterization of tumor heterogeneity
- Potential use of radiomics as a biomarker of perfusion could lead to improved quality of care and understanding of this type of treatment

AIM

The aim of this work was to assess the efficacy of radiomics features as measures of response and perfusion quality in Y-90 TARE cases

METHODS

- 60 HCC tumors from 60 glass Y-90 TARE treatments were retrospectively selected
- Gross tumor volumes (GTVs) were delineated on pre-treatment imaging and transferred to post-treatment SPECT/CT imaging
- Absorbed dose was calculated using the local deposition method and DVH methods were extracted
- 43 first- and second-order radiomics features were extracted from pre-treatment angiographic CBCT images
- Mann-Whitney U test performed to identify features with significant differences
- Random Forest was used to identify which features were most associated with response
- Cross-validated logistic regression (LR) was used to create dosimetry-only, radiomics-only, and combined models
- Patients were stratified according to top performing radiomics features to qualitatively compare perfusion quality

RESULTS

- 13 patients did not have adequate follow-up imaging
- Based on mRECIST criteria, 32 patients were responders (68%) and 15 were non-responders (32%)
- 5 dosimetry features and 11 radiomics features differed significantly between groups
- Gray-level Run Length Matrix (GLRLM) Run Length Variance (RLV) was consistently ranked as the top radiomics feature
- V200(cc) was consistently ranked as the top dosimetry feature
- V200(cc) alone had an AUC of 0.755 ± 0.029
- RLV alone had an AUC of 0.768 ± 0.020
- Combined model had an AUC of 0.753 ± 0.024
- An optimal probability threshold was identified for RLV by maximizing Youden's J index, allowing for a feature-level cutoff value
- 34 patients were above while 13 were below this cutoff
- Non-responders were much more likely to have RLV values below the threshold (9/15, 60%) compared to responders (6/32, 19%) ($p<0.001$)
- Qualitatively, patients with more apparent vasculature on CBCT scans tended to have RLV values above the cutoff
- Patients below the cutoff tended to have visibly dark necrotic regions within the tumor

RESULTS

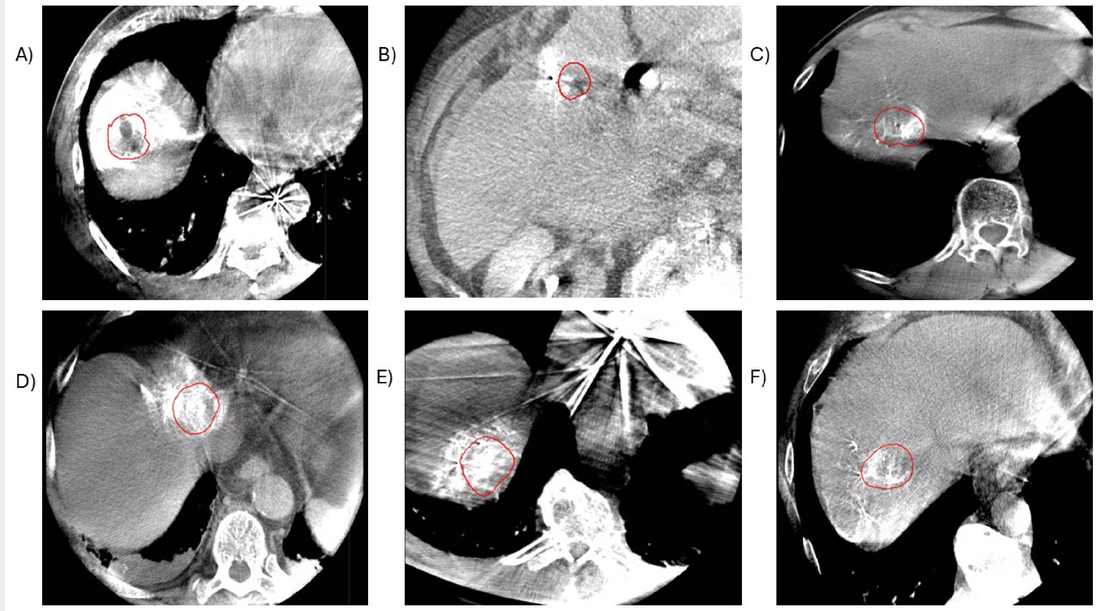

Figure 1: CBCT images for several patients with similar GTV volumes. The red line outlines the gross tumor volume (GTV) derived and transferred from the most recent diagnostic imaging. Patient A) had RLV above cutoff, GTV volume 15.79cc, and was a non-responder. Patient B) had RLV value below the cutoff, GTV volume 25.70cc, and was a responder. Patient C) had RLV value below the cutoff, GTV volume 26.65cc, and was a non-responder. Patient D) had RLV value above the cutoff, GTV volume 17.78cc, and was a responder. Patient E) had RLV value above the cutoff, GTV volume 17.71cc, and was a responder. Patient F) had RLV value above the cutoff, GTV volume 20.65cc, and was a responder.

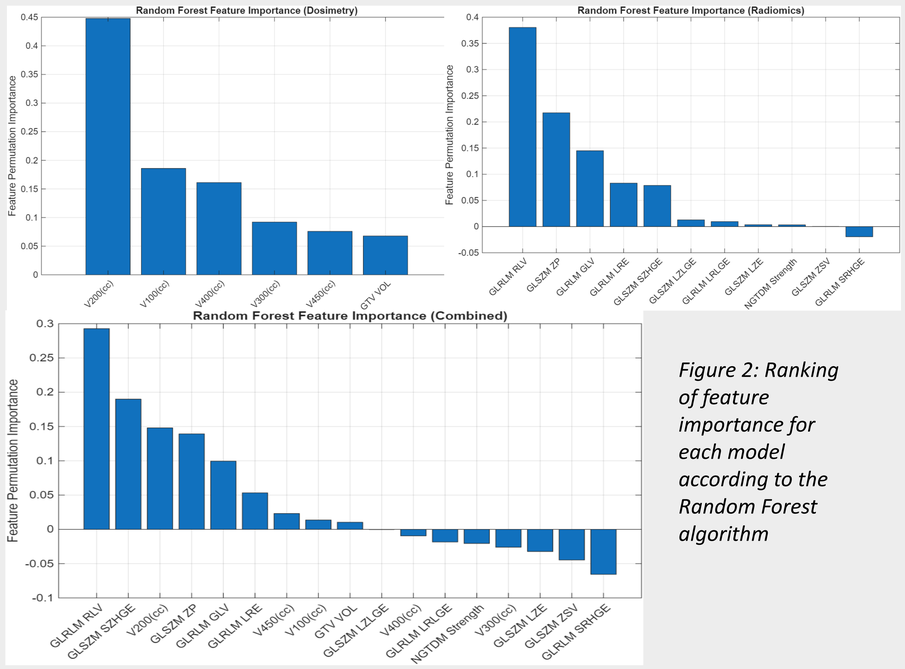

Figure 2: Ranking of feature importance for each model according to the Random Forest algorithm

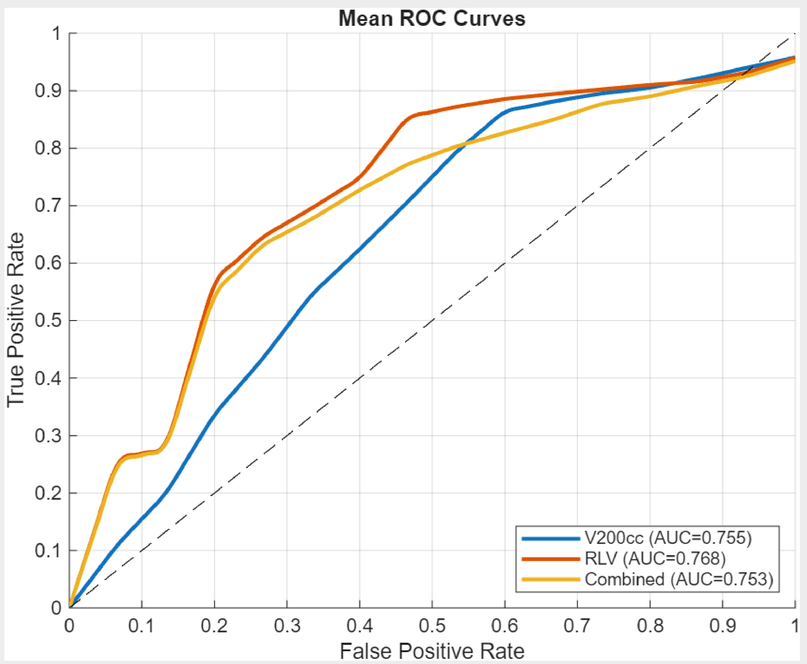

Figure 3: Mean AUC curves of each model

DISCUSSION

- The top radiomics feature, RLV, was able to modestly predict treatment response (better than top dosimetry feature)
- RLV was not correlated with any dosimetry features, hinting that it is encoding distinct information
- A cutoff value derived from the RLV value was able to significantly stratify responders and non-responders
- It is likely that RLV performs better because it contains spatial information that DVH information is lacking
- The biggest limitation of this work is reproducibility, as radiomics feature values are highly variable across institutions and patient cohorts

CONCLUSIONS

- Angiographic CBCT Radiomics can be used to predict response to Y-90 TARE treatment
- Radiomics can be used as a quantitative biomarker of tumor perfusion quality

REFERENCES

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