Machine Learning Models for Prediction of Hepatocellular Carcinoma Response to Transcatheter Arterial Chemoembolization

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Introduction
Hepatocellular carcinoma (HCC) is the most common primary hepatic malignancy worldwide (85-90% of primary liver cancers) and the fastest growing cause of cancer-related deaths in the United States.

Goal
Develop a fully automated machine learning algorithm that uses pretherapeutic quantitative image features and clinical factors as inputs and predicts HCC response to transcatheter arterial chemoembolization (TACE).

Methods
TACE outcome information on 113 HCCs in 105 patients receiving first-line treatment with TACE was obtained from a database. An automated segmentation program was developed using random forest classification methods to parse out each HCC. The Dice similarity coefficient was calculated to compare the automated segmentation accuracy with that of a manually validated process. The primary clinical endpoint was time to progression based on follow-up computed tomography radiological criteria (mRECIST). A 14 weeks cutoff was used to classify patients as TACE-susceptible (≥14weeks) or TACE-refractory (<14weeks). Response of HCC to TACE was predicted using a second random forest classifier with the inputs: 1) Barcelona Clinic Liver Cancer (BCLC) stage alone, 2) quantitative image features alone and 3) BCLC stage plus quantitative image features. A boruta feature selection algorithm was used for data reduction for the quantitative image features considered.

Results
The automated segmentation model had Dice similarity coefficient scores at baseline of 0.65 ± 0.048 and 0.64 ± 0.081 for viable and necrotic tissue, respectively. The model’s response prediction accuracy rate was 73.2% using a combination of BCLC stage and quantitative image features versus 62.9% using only BCLC stage. The no information (null model) accuracy rate was at 62%.

Shape image features of the necrotic and viable tissue on the arterial and delayed phases were the dominant predictors of response of HCC to TACE.

Conclusion
This preliminary study demonstrates the feasibility of improving the accuracy of predicting treatment response of HCC to TACE therapy using quantitative imaging feature obtained prior to therapy. The approach is likely to provide useful information for assisting in patient selection for TACE therapy.