
MRI Habitat Patterns Flag MVI Risk and Prognosis in HCC



Hepatocellular carcinoma (HCC) continues to drive significant morbidity and mortality. Microvascular invasion (MVI) is a key marker of aggressive biology, yet confirmation usually arrives only after surgery. An MRI-based approach now captures how uneven the tumour and its immediate surroundings appear on routine sequences, turning those patterns into quantitative signals of risk. Using gadoxetate disodium-enhanced imaging alongside T2-weighted and precontrast T1-weighted scans, investigators created maps of intratumoural and peritumoural “habitats” and trained machine learning models. In multicentre cohorts of patients with solitary HCC up to 5 cm undergoing curative resection, the combined habitat approach identified MVI preoperatively and separated recurrence and survival outcomes, pointing to a practical route for risk stratification before the operation.

Habitat Mapping on Multiparametric MRI

The workflow began with careful segmentation of each lesion and a narrow rim of liver around it to capture peritumoural change. Images were harmonised for voxel size and intensity so that features would be comparable across scans. Within the tumour and the surrounding rim, the method partitioned tissue into multiple small habitats that shared similar image characteristics. Features describing intensity, texture and spatial organisation were then extracted from each habitat on T2-weighted, precontrast T1-weighted, arterial phase (AP) and hepatobiliary phase (HBP) images.

Must Read: [MRI Radiomics for Liver Tumour Differentiation](#)

Rather than relying on one summary from the whole tumour, the approach measured how much these features varied across habitats, producing a large panel of intratumoural heterogeneity (ITH) and peritumoural heterogeneity (PTH) metrics. In simple terms, higher values reflected more uneven patterns within the tumour or its immediate environment. Peritumoural bands at set distances from the margin were included to capture subtle transitions at the tumour–liver interface. This habitat-based lens preserved local differences that whole-tumour averages can dilute, offering a more sensitive readout of complex growth and infiltration.

Consistent MVI Prediction Across Centres

The analysis included several hundred patients from three institutions, all with pathologically confirmed solitary HCC, preoperative gadoxetate disodium-enhanced MRI and curative hepatectomy. One centre supplied data for internal training and testing, while two others provided an external test cohort. MVI was present in a meaningful share of cases across all cohorts. After reproducibility checks and feature selection, a focused tumour heterogeneity subset combined ITH and PTH signals for modelling.

Seven algorithms were assessed. A deep neural network built on the heterogeneity subset delivered the most reliable performance. It achieved high discrimination on internal data and maintained solid accuracy on external cases, with acceptable calibration across cohorts. In multivariable analysis, the model’s predicted probabilities remained the only independent classifier of MVI, and performance did not depend on MRI field strength. Models based on conventional radiomics without habitat encoding consistently underperformed, reinforcing the added value of capturing within-tumour and peritumoural variation rather than averaging it away.

Robustness was a central concern. Heterogeneity metrics showed strong reproducibility, and performance held up when habitat settings were varied within reasonable bounds. Statistical power analyses supported the reliability of the reported receiver operating characteristic results at the observed accuracy levels. Taken together, these findings indicate that habitat-aware heterogeneity is not only measurable and stable but also clinically meaningful for preoperative MVI risk assessment.

Prognostic Signals and What Drives the Model

Beyond detection, the model's outputs tracked outcomes. Pathologic MVI was linked with shorter recurrence-free survival (RFS) and overall survival (OS). Predicted MVI from the deep neural network mirrored these patterns, separating survival curves in line with pathological status. Hazard ratios for both OS and recurrence indicated materially higher risk in MVI-positive groups, whether defined by pathology or by model prediction, and differences reached statistical significance.

Interpretability analyses pointed to why the model behaved as it did. Features drawn from the peritumoural rim contributed most to predictions, with AP and HBP sequences carrying particular weight. Among the influential signals were measures reflecting how intensities are distributed and how textures vary in small zones near the tumour edge. This emphasis on the peritumoural region accords with clinical intuition that microvascular spread alters the interface between tumour and liver even before it is visible by eye. Visual examples showed that cases with MVI tended to exhibit more pronounced intra- and peritumoural heterogeneity, consistent with the numerical rankings of feature importance.

Encoding local habitats within and around HCC on multiparametric MRI yields stable heterogeneity metrics that support noninvasive MVI identification and risk stratification before surgery. A deep neural network trained on these signals generalised across centres, aligned with differences in RFS and OS and highlighted interpretable drivers rooted in the peritumoural arterial and hepatobiliary response. For solitary HCC up to 5 cm, this habitat-based approach offers a pragmatic path to preoperative decision support and targeted postoperative surveillance, reducing reliance on invasive confirmation while staying grounded in information already present on routine imaging.

Source: [Radiology: Imaging Cancer](#)

Image Credit: [iStock](#)

Published on : Sun, 9 Nov 2025