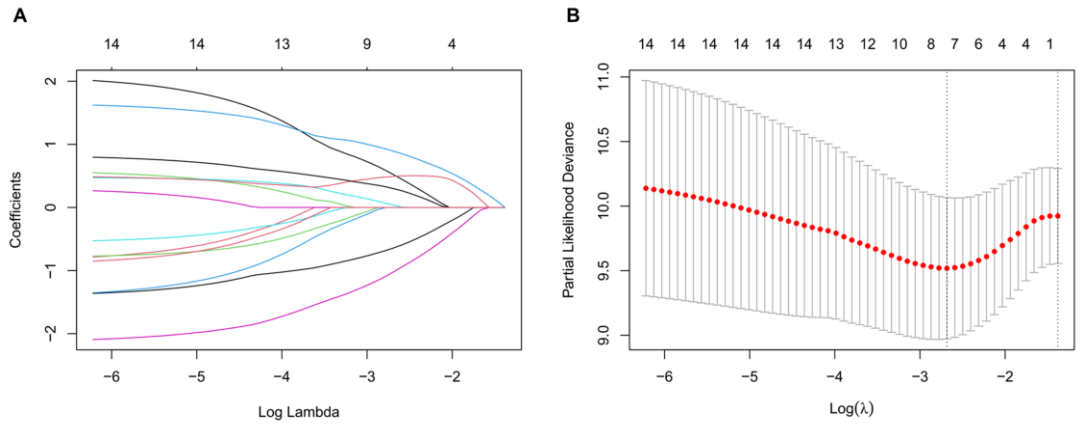
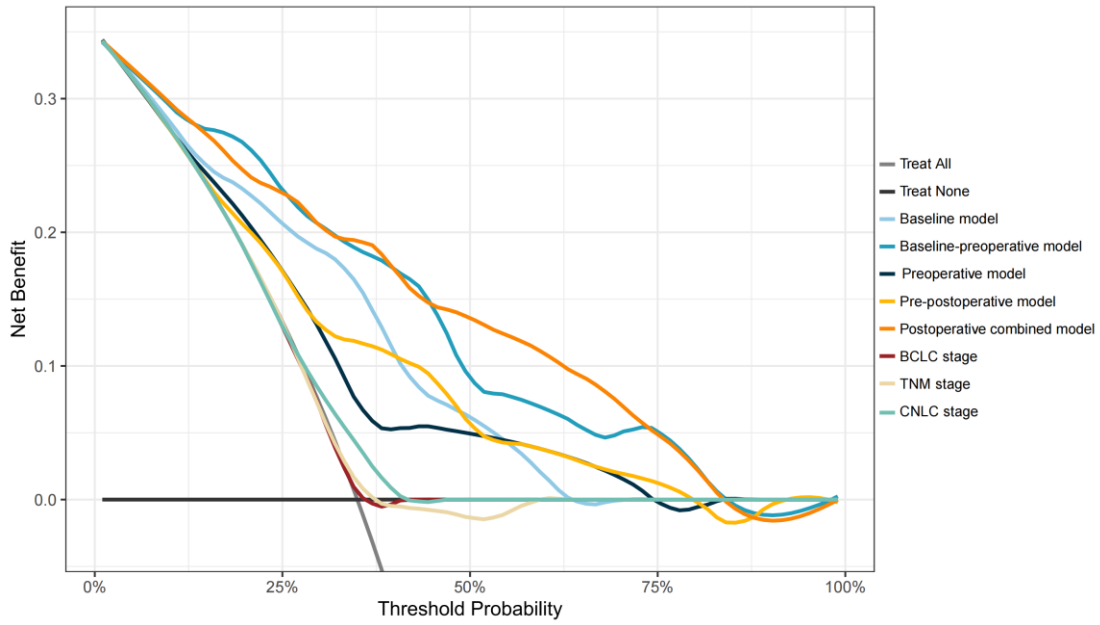
Supplemental Material

Supplementary A1 Dynamic contrast–enhanced MRI technique

For dynamic contrast-enhanced T1-weighted imaging, unenhanced, arterial phases (30s), portal venous phase (60s), delayed phase/transitional phase (180s), and hepatobiliary phase (20min, only for gadoxetic acid) were acquired before and after injection of gadodiamide (Omniscan 0.5 mmol/ml; GE Healthcare) at a dose of 0.2 mL/kg with a rate of 2 mL/s or gadoxetic acid (Primovist, Bayer Healthcare) at a dose of 0.1 mL/kg with a rate of 1 mL/s followed by a 20 mL 0.9% saline flush via an auto-injector.



Supplementary Figure 1 Variable selection by least absolute shrinkage and selection operator (LASSO) Cox regression analysis. A: A coefficient profile plot was produced against the log(lambda) sequence; B: Cross-validation diagram for tuning parameter selection based on the minimum criteria (left dotted line) and the 1-SE criteria (right dotted line).



Supplementary Figure 2 Decision curves of the prognostic models and major staging systems for 1-year early recurrence-free survival. BCLC, Barcelona Clinic Liver Cancer; TNM, tumor-node-metastasis; CNLC, China Liver Cancer.

Supplementary Table 1 Magnetic resonance imaging sequences and parameters

Sequence	TR (ms)	TE (ms)	FOV (mm)	ST/space (mm)	Matrix
GE Signa HDxt					
Dual-echo T1WI	4.6	2.5/1.3	400×320	5/0	256×224
T2WI/FS	10,000	91.9	360×360	6/1	320×320
DWI	8571	59.3	360×360	6/1	128×128
CE-T1WI	3.9	1.6	360×288	4.8/0	288×192
GE Discovery MR 750					
Dual-echo T1WI	3.9	2.2/1.2	360×288	5/0	256×224
T2WI/FS	6000	85.6	360×304	6/1	320×224
DWI	6316	58.8	380×304	6/1	128×160
CE-T1WI	3.1	1.3	360×288	5/0	256×192
GE SIGNA™ Pioneer					
Dual-echo T1WI	4.4	2.5/1.3	360×324	4/0	256×224
T2WI/FS	8,000	85	360×360	5/1	320×320
DWI	5500	56	380×380	5/1	140×160
CE-T1WI	4.4	1.4	360×324	4/0	256×224
Siemens MAGNETOM Prisma					
Dual-echo T1WI	4.2	2.7/1.3	380×325	3/0	320 x 256
T2WI/FS	4351	83	393×355	4/1	320 x 320
DWI	2560	63	393×355	4/1	152 x 152
CE-T1WI	3.34	1.3	380×325	3/0	384 x 307

Abbreviations: TR, repetition time; TE, echo time; FOV, field of view; ST, slice thickness; T1WI, T1-weighted imaging; T2WI, T2-weighted imaging; FS, fat

suppression; DWI, diffusion-weighted imaging; CE-T1WI, contrast-enhanced T1-weighted imaging.

Supplementary Table 2 Definitions of imaging features

Imaging Features	Definition
Tumor burden	
Tumor size	Largest outer-edge-to-outer-edge dimension of a tumor
Tumor number	Number of unequivocal HCC
Satellite tumors	Presence of separate unequivocal HCCs within 2 cm of the border of the dominant tumor
Tumor in vein	Presence of unequivocal enhancing soft tissue in vein
LI-RADS major features	
Nonrim APHE	Nonrim-like enhancement of the tumor in the arterial phase unequivocally greater in whole or in part than the liver
Nonperipheral washout	Nonperipheral visually assessed temporal reduction in the enhancement of the tumor in whole or in part relative to composite liver tissue in the portal venous phase or delayed phase
Enhancing capsule	Smooth, uniform, sharp border around most or all of a tumor, unequivocally thicker or more conspicuous than fibrotic tissue around background nodules, and visible as enhancing rim in portal venous phase, delayed phase, or transitional phase
LI-RADS ancillary features	
Mild-moderate T2 hyperintensity	Signal intensity of the tumor on T2WI higher than the liver, similar to or lower than a non-

	iron-overloaded spleen, and lower than simple fluid
Corona enhancement	Peritumoral enhancement in the late arterial phase or early portal venous phase. The enhancement is contiguous with and surrounds all or part of the tumor
Nonenhancing capsule	Subtype of capsule that does not show enhancement on any image
Nodule-in-nodule	Presence of smaller inner nodule within and having different imaging features than larger outer nodule.
Mosaic architecture	Presence of any combination of internal nodules, compartments, or septations, within a solid or mostly solid mass
Blood products in mass	Intralesional or perilesional hemorrhage in the absence of biopsy, trauma, or intervention
Fat in mass	Excess fat within a mass, in whole or in part, relative to the adjacent liver
LR-M features	
Rim APHE	Spatially defined subtype of arterial phase hyperenhancement in which arterial phase enhancement is most pronounced in tumor periphery
Peripheral washout	Presence of apparent washout most pronounced in the tumor periphery
Delayed central enhancement	Central area of progressive postarterial phase enhancement
Targetoid restriction	Concentric pattern on diffusion-weighted imaging characterized by restricted diffusion

	in tumor periphery with less restricted diffusion in tumor center
Other prognostic features	
Necrosis or severe ischemia	Presence of unequivocal intralesional necrosis or severe ischemia
Non-smooth tumor margin	The tumor margin is irregular and/or has areas of bulging, nodular projection, or infiltration into adjacent tissues at the tumor periphery in any imaging plane
APHE portion ≥50%	Presence of ≥50% tumor volume demonstrating arterial phase hyperenhancement
Intratumoral artery	Presence of discrete arteries within the tumor on arterial phase images
Complete capsule	Presence of non-disrupted "capsule" in all imaging planes
RECIST 1.1 categories	
CR	Disappearance of all target lesions
PR	At least a 30% decrease in the sum of diameters of target lesions, taking as reference the baseline sum of the diameters of target lesions
PD	At least a 20% increase in the sum of diameters of target lesions, taking as reference the smallest sum of the diameters of target lesions recorded since treatment started
SD	Neither PR nor PD
mRECIST categories	
CR	Disappearance of intratumoral arterial enhancement in all target lesions

PR	At least a 30% decrease in the sum of diameters of viable (enhancement in the arterial phase) target lesions, taking as reference the baseline sum of the diameters of target lesions
PD	At least a 20% increase in the sum of diameters of viable (enhancing) target lesions, taking as reference the smallest sum of the diameters of viable (enhancing) target lesions recorded since treatment started
SD	Neither PR nor PD

Supplementary Table 3 Univariable Cox regression analysis for early recurrence-free survival

Variables	Hazard ratio (95% CI)	*P* value
Baseline clinical variables		
Age	1.02 (0.99-1.05)	0.208
Sex (Male)	1.41 (0.43-4.61)	0.566
Cirrhosis	2.30 (0.82-6.50)	0.115
Hepatitis B	1.30 (0.60-2.85)	0.506
Hepatitis C	1.06 (0.25-4.40)	0.939
BCLC stage		0.877
A	Ref	Ref
B	0.61 (0.08-4.54)	0.632
C	1.05 (0.53-2.08)	0.878
AFP >400 ng/mL	1.25 (0.66-2.39)	0.494
PLT <100×10^9/L	0.71 (0.10-5.16)	0.732
ALT >40 U/L	1.60 (0.83-3.09)	0.164
AST >40 U/L	1.58 (0.82-3.04)	0.170
GGT >60 U/L	3.23 (1.59-6.58)	0.001
TBIL >21 μmol/L	0.96 (0.44-2.11)	0.922
Albumin <40 g/L	1.30 (0.46-3.67)	0.622
ALBI grade (2 vs 1)	1.31 (0.55-3.14)	0.545
Baseline imaging features		
Tumor size >5 cm	1.75 (0.77-3.98)	0.184
Tumor number (2-3 vs 1)	1.24 (0.44-3.50)	0.684
Satellite tumors	1.32 (0.47-3.74)	0.597
Tumor in vein	1.11 (0.56-2.21)	0.765
Nonrim APHE	0.64 (0.33-1.23)	0.179
Nonperipheral washout	0.99 (0.39-2.55)	0.985

Enhancing capsule	2.09 (0.50-8.73)	0.310
Mild-moderate T2 hyperintensity	NA	1.000
Corona enhancement	1.27 (0.65-2.49)	0.490
Nonenhancing capsule	0.50 (0.07-3.68)	0.498
Nodule-in-nodule	0.90 (0.35-2.31)	0.824
Mosaic architecture	1.09 (0.57-2.08)	0.788
Blood products in mass	1.19 (0.62-2.29)	0.596
Fat in mass	1.38 (0.72-2.64)	0.338
Rim APHE	1.53 (0.80-2.93)	0.200
Peripheral washout	1.52 (0.59-3.91)	0.383
Delayed central enhancement	0.44 (0.11-1.85)	0.264
Targetoid restriction	0.60 (0.21-1.70)	0.336
Necrosis or severe ischemia	0.93 (0.39-2.23)	0.868
Non-smooth tumor margin	0.98 (0.38-2.51)	0.965
APHE portion ≥50%	0.46 (0.23-0.91)	0.025
Intratumoral artery	1.21 (0.63-2.32)	0.577
Complete capsule	1.33 (0.68-2.62)	0.405
Tumor ADC ($\times 10^{-3}$ mm^2/s)	1.00 (1.00-1.00)	0.762
Tumor-to-liver ADC ratio	0.35 (0.05- 2.68)	0.314
Preoperative clinical variables		
TACE prior to RT	1.23 (0.38-4.01)	0.730
Concurrent systemic therapy	0.84 (0.44-1.60)	0.596
TACE after RT	1.49 (0.58-3.84)	0.405
Preoperative AFP >400 ng/mL	3.65 (1.66-8.03)	0.001
Preoperative PLT $<100\times10^9$/L	1.42 (0.70-2.88)	0.328
Preoperative ALT >40 U/L	0.61 (0.26-1.47)	0.273
Preoperative AST >40 U/L	0.65 (0.29-1.49)	0.308
Preoperative GGT >60 U/L	1.24 (0.63-2.43)	0.538
Preoperative TBIL >21 μmol/L	0.26 (0.04-1.90)	0.185

Preoperative Albumin <40 g/L	1.18 (0.61-2.31)	0.619
Preoperative ALBI grade 2 (2 vs 1)	0.81 (0.40-1.64)	0.555
Preoperative imaging features		
Early response by RECIST (CR+PR vs SD+PD)	0.69 (0.34-1.44)	0.326
Early response by mRECIST (CR+PR vs SD+PD)	0.66 (0.35-1.26)	0.209
Preoperative response by RECIST (CR+PR vs SD+PD)	0.90 (0.47-1.73)	0.762
Preoperative response by mRECIST (CR+PR vs SD+PD)	0.62 (0.32-1.20)	0.157
Preoperative CR by mRECIST	0.32 (0.11-0.89)	0.030
Tumor ADC ($\times 10^{-3}$ mm^2/s)	1.00 (1.00-1.00)	0.462
Tumor-to-liver ADC ratio	0.42 (0.12-1.46)	0.173
ΔADC%	0.71 (0.22-2.25)	0.557
Pathologic variables		
Major pathological response	0.72 (0.37-1.42)	0.347
Pathological complete response	0.43 (0.10-1.79)	0.245
Poor tumor differentiation	1.18 (0.62-2.25)	0.610
MVI	2.15 (1.10-4.18)	0.024
Satellite nodules	2.07 (0.86-4.97)	0.103
Invasion of liver surface	1.32 (0.67-2.59)	0.421

CI, confidence interval; BCLC, Barcelona Clinic Liver Cancer; AFP, alpha-fetoprotein; PLT, platelet Count; ALT, alanine aminotransferase; AST, aspartate aminotransferase; GGT, gamma-glutamyl transpeptidase; TBIL, total bilirubin; ALBI, albumin-bilirubin; APHE, arterial phase hyperenhancement; ADC, apparent diffusion coefficient; RT, radiotherapy; TACE, transarterial chemoembolization; RECIST, response evaluation criteria in solid tumor; mRECIST, modified response evaluation criteria in solid tumor; CR, complete

response; PR, partial response; SD, stable disease; PD, progressive disease; MVI, microvascular invasion.

Supplementary Table 4 Interobserver agreement of imaging features

Variables	Interobserver agreement*
Categorical variables	
Tumor size >5 cm	0.87 (0.72-0.97)
Tumor number (2-3 vs 1)	1.00 (1.00-1.00)
Satellite tumors	1.00 (1.00-1.00)
Tumor in vein	0.88 (0.74-0.97)
Nonrim APHE	0.74 (0.56-0.88)
Nonperipheral washout	0.68 (0.41-0.90)
Enhancing capsule	0.77 (0.49-0.95)
Mild-moderate T2 hyperintensity	0.79 (0.40-1.00)
Corona enhancement	0.66 (0.49-0.82)
Nonenhancing capsule	0.58 (0.20-0.95)
Nodule-in-nodule	0.66 (0.34-0.89)
Mosaic architecture	0.63 (0.47-0.80)
Blood products in mass	0.92 (0.84-1.00)
Fat in mass	0.82 (0.68-0.93)
Rim APHE	0.70 (0.53-0.85)
Peripheral washout	0.69 (0.31-0.93)
Delayed central enhancement	0.75 (0.46-0.95)
Targetoid restriction	0.84 (0.59-1.00)
Necrosis or severe ischemia	0.79 (0.54-0.97)
Non-smooth tumor margin	0.95 (0.82-1.00)
APHE portion ≥50%	0.83 (0.69-0.95)
Intratumoral artery	0.80 (0.67-0.92)
Complete capsule	0.73 (0.55-0.88)
Early response by RECIST (CR+PR vs SD+PD)	0.86 (0.73-0.97)
Early response by mRECIST (CR+PR vs SD+PD)	0.82 (0.68-0.93)

Preoperative response by RECIST (CR+PR vs SD+PD)	0.88 (0.75-0.98)
Preoperative response by mRECIST (CR+PR vs SD+PD)	0.80 (0.64-0.94)
Preoperative CR by mRECIST	0.73 (0.52-0.90)
Continuous variables	
Baseline tumor ADC	0.91 (0.87-0.94)
Baseline liver ADC	0.84 (0.81-0.92)
Preoperative tumor ADC	0.91 (0.86-0.94)
Preoperative liver ADC	0.87 (0.81-0.92)

* Interobserver agreement was measured using κ coefficient for categorical variables and intraclass correlation coefficient for continuous variables.