

**Supplementary Table 1 Details of the extracted radiomics features**

<b>Feature Category</b>	<b>Feature List</b>
shape features	(1) Elongation; (2) flatness; (3) least axis length; (4) major axis length; (5) maximum 2D diameter column; (6) maximum 2D diameter row; (7) maximum 2D diameter slice; (8) maximum 3D diameter; (9) mesh volume; (10) minor axis length; (11) sphericity; (12) surface area; (13) surface volume ratio; (14) voxel volume
first-order features	(1) 10 Percentile; (2) 90 Percentile; (3) Energy; (4) Entropy; (5) Interquartile range; (6) Kurtosis; (7) Maximum; (8) Mean absolute deviation; (9) Mean; (10) Median; (11) Minimum; (12) Range; (13) Robust mean absolute deviation; (14) Root mean squared; (15) Skewness; (16) Total energy; (17) Uniformity; (18) Variance
Gray Level Cooccurrence Matrix, GLCM	(1) Auto-correlation; (2) Cluster Prominence; (3) Cluster Shade; (4) Cluster Tendency; (5) Contrast; (6) Correlation; (7) Difference Average; (8) Difference Entropy; (9) Difference Variance; (10) Id; (11) Idm; (12) Idmn; (13) Idn; (14) Imc 1; (15) Imc 2; (16) Inverse Variance; (17) Joint Average; (18) Joint Energy; (19) Joint Entropy;

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(20) MCC; (21) Maximum Probability;  
(22) Sum Average; (23) Sum Entropy;  
(24) Sum Squares;

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Gray Level Dependence Matrix, GLDM

(1) Dependence Entropy;  
(2) Dependence Non-Uniformity;  
(3) Dependence Non-Uniformity Normalized;  
(4) Dependence Variance;  
(5) Gray Level Non-Uniformity;  
(6) Gray Level Variance;  
(7) High Gray Level Emphasis;  
(8) Large Dependence Emphasis;  
(9) Large Dependence High Gray Level Emphasis;  
(10) Large Dependence Low Gray Level Emphasis;  
(11) Low Gray Level Emphasis;  
(12) Small Dependence Emphasis;  
(13) Small Dependence High Gray Level Emphasis;  
(14) Small Dependence Low Gray Level Emphasis;

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(1) Gray Level Non-Uniformity;  
(2) Gray Level Non-Uniformity Normalized;  
(3) Gray Level Variance;  
(4) High Gray Level Run Emphasis;  
(5) Long Run Emphasis;  
(6) Long Run High Gray Level Emphasis;  
(7) Long Run Low Gray Level Emphasis;  
(8) Low Gray Level Run Emphasis;

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Matrix, GLRLM	(9) Run Entropy; (10) Run Length Non-Uniformity; (11) Run Length Non-Uniformity Normalized; (12) Run Percentage; (13) Run Variance; (14) Short Run Emphasis; (15) Short Run High Gray Level Emphasis; (16) Short Run Low Gray Level Emphasis;
	(1) Gray Level Non-Uniformity; (2) Gray Level Non-Uniformity Normalized; (3) Gray Level Variance; (4) High Gray Level Zone Emphasis; (5) Large Area Emphasis; (6) Large Area High Gray Level Emphasis; (7) Large Area Low Gray Level Emphasis;
Gray Level Size Zone Matrix, GLSZM	(8) Low Gray Level Zone Emphasis; (9) Size Zone Non-Uniformity; (10) Size Zone Non-Uniformity Normalized; (11) Small Area Emphasis; (12) Small Area High Gray Level Emphasis; (13) Small Area Low Gray Level Emphasis; (14) Zone Entropy; (15) Zone Percentage; (16) Zone Variance;
Neighbouring Gray Tone Difference Matrix, NGTDM	(1) Busyness; (2) Coarseness; (3) Complexity; (4) Contrast; (5) Strength
square-based first-order and texture features	(1) first-order; (2) glcm; (3) gldm; (4) glrlm; (5) glszm; (6) ngtdm
squareroot-based first-order and texture features	(1) first-order; (2) glcm; (3) gldm; (4) glrlm; (5) glszm; (6) ngtdm

logarithm-based first-order and texture features	(1) first-order; (2) glcm; (3) gldm; (4) glrlm; (5) glszm; (6) ngtdm
exponential-based first-order and texture features	(1) first-order; (2) glcm; (3) gldm; (4) glrlm; (5) glszm; (6) ngtdm
gradient-based first-order and texture features	(1) first-order; (2) glcm; (3) gldm; (4) glrlm; (5) glszm; (6) ngtdm
Wavelet-based first-order and texture features	(1) LLH; (2) LHL; (3) LHH; (4) HLL; (5) HLH; (6) HHL; (7) HHH; (8) LLL
Log-based first-order and texture features	(1) log-sigma-3-mm-3D; (2) log-sigma-5-mm-3D
Diagnostics( $ROI_{\text{tumor}}$ )	(1) original_Mean; (2) original_Minimum; (3) original_Maximum; (4) original_VoxelNum; (5) original_VolumeNum; (6) interpolated_Mean; (7) interpolated_Minimum; (8) interpolated_Maximum; (9) interpolated_VoxelNum; (10) interpolated_VolumeNum; (11) interpolated_Mean; (12) interpolated_Minimum; (13) interpolated_Maximum;
Diagnostics( $ROI_{\text{peri}}$ )	(1) original_Mean; (2) original_Minimum; (3) original_Maximum; (4) original_VoxelNum; (5) original_VolumeNum;

The 14 shape features were extracted from the original image. The 18 first-order features and 75 textural features were extracted from the 15 filtered images. In addition, 13 diagnostics features were extracted from each  $ROI_{\text{tumor}}$ ,

and five were extracted from each ROI<sup>peri</sup>. Therefore, the total radiomics features from each ROI<sup>tumor</sup> could be calculated as  $14+(18+75) \times 16+13=1515$ . The total radiomics features from each ROI<sup>peri</sup> could be calculated as  $14+(18+75) \times 16+5=1507$ . ROI<sup>tumor</sup>, regions of interest of tumor; ROI<sup>peri</sup>, regions of interest of 5-mm-wide peritumoral area.

**Supplementary Table 2 Univariate analyses of clinicoradiological factors for predicting M2 status in the training and validation datasets**

Variables	Training dataset (n = 189)			Validation dataset (n =81)			
	M0/M1	M2	<i>P</i> value	effect size	M0/M1	M2	<i>P</i> value
Gender			0.787				0.03
Female	16 (11)	5 (12)			5 (8)	6 (29)	
Male	131 (89)	37 (88)			55 (92)	15 (71)	
Age (years)			1				1
≤50	37 (25)	11 (26)			10 (17)	3 (14)	
>50	110 (75)	31 (74)			50 (83)	18 (86)	
Alcohol			0.714				0.331
No	128 (87)	35 (83)			47 (78)	19 (90)	
Yes	19 (13)	7 (17)			13 (22)	2 (10)	
Liver cirrhosis			0.667				0.542
No	25 (17)	9 (21)			12 (20)	6 (29)	
Yes	122 (83)	33 (79)			48 (80)	15 (71)	

Antiviral therapy			0.857				0.089
No	90 (61)	27 (64)			31 (52)	16 (76)	
Yes	57 (39)	15 (36)			29 (48)	5 (24)	
Ascites			0.543				0.42
No	81 (55)	26 (62)			28 (47)	7 (33)	
Yes	66 (45)	16 (38)			32 (53)	14 (67)	
Neutrophil (10 <sup>9</sup> /L)	2.7 (2.16, 3.58)	3.84 (3.02, 4.81)	< 0.001	0.562	3.03 (2.2, 3.51)	2.92 (2.56, 3.58)	0.961
Lymphocyte (10 <sup>9</sup> /L)	1.39 (1.1, 1.78)	1.35 (0.93, 1.62)	0.277		1.55 ± 0.57	1.3 ± 0.47	0.053
Platelets (10 <sup>9</sup> /L)	145 (111, 178)	179 (119.75, 228)	0.015	0.754	153 (113, 198.25)	169 (109, 217)	0.422
Monocyte (10 <sup>9</sup> /L)	0.39 (0.3, 0.51)	0.49 (0.38, 0.62)	0.004	0.708	0.44 (0.38, 0.58)	0.38 (0.32, 0.47)	0.07
NLR	1.78 (1.43, 2.73)	2.97 (2.09, 4.04)	< 0.001	0.568	1.72 (1.4, 2.48)	2.23 (1.73, 3.31)	0.086
PLR	98.8 (79.13, 132.99)	122.56 (86.77, 218.2)	0.017	0.757	98.55 (72.41, 132.37)	121.99 (103.95, 163.04)	0.025
LMR	3.5 (2.75, 4.7)	2.83 (1.77, 3.61)	0.001	0.674	3.45 ± 1.31	3.36 ± 1.28	0.796
Alanine aminotransferase			0.732				0.253

(U/L)						
≤40	94 (64)	25 (60)		39 (65)	10 (48)	
>40	53 (36)	17 (40)		21 (35)	11 (52)	
Aspartate aminotransferase			<			
(U/L)			0.001	0.297		0.139
≤35	84 (57)	9 (21)		36 (60)	8 (38)	
>35	63 (43)	33 (79)		24 (40)	13 (62)	
γ-Glutamyltransferase(U/L)			0.112			0.186
≤45	68 (46)	13 (31)		26 (43)	5 (24)	
>45	79 (54)	29 (69)		34 (57)	16 (76)	
Total bilirubin (μmol/L)			0.041	0.166		0.273
≤23	127 (86)	30 (71)		50 (83)	20 (95)	
>23	20 (14)	12 (29)		10 (17)	1 (5)	
Albumin (g/L)			1			0.42
≥40	77 (52)	22 (52)		42 (70)	12 (57)	
<40	70 (48)	20 (48)		18 (30)	9 (43)	
Prealbumin (g/L)			0.004	0.222		0.65



≥180	104 (71)	19 (45)		45 (75)	14 (67)	
<180	43 (29)	23 (55)		15 (25)	7 (33)	
Alkaline phosphatase (U/L)			0.016	0.190		0.282
≤135	122 (83)	27 (64)		53 (88)	16 (76)	
>135	25 (17)	15 (36)		7 (12)	5 (24)	
Prothrombin time (s)			0.714			0.07
≤14	128 (87)	35 (83)		57 (95)	17 (81)	
>14	19 (13)	7 (17)		3 (5)	4 (19)	
International normalized ratio	1.04 (0.98, 1.1)	1.07 (1.02, 1.09)	0.237	1.04 (0.99, 1.11)	1.03 (0.96, 1.11)	0.457
HBV DNA load (IU/mL)			1			0.687
<10000	124 (84)	36 (86)		44 (73)	17 (81)	
≥10000	23 (16)	6 (14)		16 (27)	4 (19)	
α-Fetoprotein (ug/L)			< 0.001	0.257		0.045
≤7	69 (47)	7 (17)		25 (42)	3 (14)	
>7	78 (53)	35 (83)		35 (58)	18 (86)	

Tumor diameter (cm)	4.5 (3, 7.25)	6.9 (4, 10)	< 0.001	0.666	4 (2.95, 6.12)	8 (6, 14)	< 0.001
Tumor number			0.731				0.163
Solitary	138 (94)	39 (93)			59 (98)	19 (90)	
Multiple	9 (6)	3 (7)			1 (2)	2 (10)	
CNLC			0.034	0.181			< 0.001
I a	81 (55)	14 (33)			38 (63)	4 (19)	
I b	59 (40)	25 (60)			21 (35)	15 (71)	
II a	7 (5)	3 (7)			1 (2)	2 (10)	
Child-Pugh			1				0.046
A	120 (82)	34 (81)			56 (93)	16 (76)	
B	27 (18)	8 (19)			4 (7)	5 (24)	
Lobe involved			0.024	0.182			< 0.001
Solitary	131 (89)	31 (74)			57 (95)	11 (52)	
Multiple	16 (11)	11 (26)			3 (5)	10 (48)	

Tumor margin			0.003	0.231			0.499
Smooth	64 (44)	7 (17)			27 (45)	7 (33)	
Non-smooth	83 (56)	35 (83)			33 (55)	14 (67)	
Tumor growth pattern			0.389				0.088
Intrahepatic growth	127 (86)	39 (93)			53 (88)	15 (71)	
Extrahepatic growth	20 (14)	3 (7)			7 (12)	6 (29)	
Enhancement pattern			0.6				0.316
Atypical	44 (30)	15 (36)			22 (37)	11 (52)	
Typical	103 (70)	27 (64)			38 (63)	10 (48)	
Peritumoral enhancement	arterial		0.083				1
Absent	135 (92)	34 (81)			52 (87)	18 (86)	
Present	12 (8)	8 (19)			8 (13)	3 (14)	
Internal arteries			0.003	0.231			< 0.001
Absent	68 (46)	8 (19)			37 (62)	2 (10)	
Present	79 (54)	34 (81)			23 (38)	19 (90)	

Intratumor necrosis			0.028	0.173		<
						0.001
Absent	61 (41)	9 (21)			29 (48)	1 (5)
Present	86 (59)	33 (79)			31 (52)	20 (95)
Enhancing capsule			0.01	0.201		0.006
Absent	81 (55)	13 (31)			28 (47)	2 (10)
Present	66 (45)	29 (69)			32 (53)	19 (90)
Peritumoral hypointensity ring			0.223			0.338
Absent	28 (19)	4 (10)			12 (20)	2 (10)
Present	119 (81)	38 (90)			48 (80)	19 (90)

Continuous variables were expressed as means  $\pm$  SD or medians with IQRs; categorical variables were expressed as numbers (percentages). NLR, neutrophil-to-lymphocyte ratio; PLR, platelets-to-lymphocyte ratio; LMR, lymphocyte-to-monocyte ratio; CNLC stage, China liver cancer stage; HBV, hepatitis B virus, M2, microvascular invasion = M2, M0, microvascular invasion = M0, M1, microvascular invasion = M1. Both antiviral therapy status and HBV DNA load were collected from patients on admission.

**Supplementary Table 3 Selected radiomics features related to MVI**

	<b>Radiomics features</b>	<b>Coefficient</b>
	Intercept	0.51782643
	wavelet.LHH_glcm_Imc2	-0.11978285
	wavelet.HHL_glcm_Imc2	-0.27754581
ROI <sup>tumor-AP</sup>	wavelet.HHH_glszm_Small Area Low Gray Level	-0.09933836
	Emphasis	0.03032820
	log.sigma.3.mm.3D_firstorder_Kurtosis	0.27099080
	original_firstorder_Maximum	0.20953277
	gradient_glszm_Size Zone Non-Uniformity	0.18264253
	gradient_glszm_Zone Variance	
	Intercept	0.499979757
	wavelet.LHL_glcm_Correlation	0.002443342
	wavelet.HHH_glszm_Zone Variance	0.015573344
	log.sigma.3.mm.3D_gldm_Dependence Variance	-0.058247619
ROI <sup>peri-AP</sup>	log.sigma.5.mm.3D_glcm_Idn	0.048106442
	log.sigma.5.mm.3D_glcm_Imc1	0.008912621
	log.sigma.5.mm.3D_glszm_Zone Entropy	0.098247979
	exponential_firstorder_Minimum	-0.206933413
	gradient_glszm_Size Zone Non-Uniformity	0.326363950
	Intercept	0.54427360
	wavelet.LHH_glszm_Size Zone Non-Uniformity	-0.07855375
	Normalized	-0.01782517
	wavelet.HLL_glcm_Imc2	-0.31061923
	wavelet.HHL_glcm_Imc2	-0.04781864
	wavelet.HHH_ngtdm_Strength	0.22878844
ROI <sup>tumor-DP</sup>	log.sigma.3.mm.3D_ngtdm_Strength	0.08018179
	log.sigma.5.mm.3D_glcm_Inverse Variance	-0.18835580

	log.sigma.5.mm.3D_glcm_Maximum Probability	0.04551612
	log.sigma.5.mm.3D_glszm_Small Area Emphasis	0.11786183
	original_firstorder_Maximum	0.13366009
	exponential_glrlm_Run Length Non-Uniformity	-0.13467064
	gradient_firstorder_Minimum	0.30342170
	gradient_glszm_Size Zone Non-Uniformity	0.34107837
	gradient_glszm_Zone Variance	
	Intercept	0.50221669
	logarithm_firstorder_Total Energy	0.36400995
ROI <sup>peri</sup>	exponential_glszm_Zone Percentage	-0.11691233
-DP	gradient_glrlm_Gray Level Non-Uniformity	0.09884673
	gradient_glszm_Gray Level Non-Uniformity	0.06819224
	Intercept	0.492511790
	wavelet.LLH_glcm_Idn	0.097231349
	wavelet.HHL_ngtdm_Contrast	-0.009270814
	wavelet.HHH_ngtdm_Contrast	-0.027201288
ROI <sup>tumor-PP</sup>	wavelet.HHH_ngtdm_Strength	-0.035522800
	log.sigma.3.mm.3D_glszm_Small Area Emphasis	0.158083152
	log.sigma.3.mm.3D_glszm_Zone Entropy	0.022682332
	gradient_glszm_Size Zone Non-Uniformity	0.264673160
	gradient_glszm_Zone Variance	0.084273498
	Intercept	0.4796724
	wavelet.LLH_firstorder_Maximum	0.1145282
ROI <sup>peri-PP</sup>	logarithm_firstorder_Total Energy	0.1529799
	gradient_glrlm_Gray Level Non-Uniformity	0.1650265

ROI<sup>tumor-AP</sup> represents the feature subset based on the regions of interest of tumor from arterial phase CECT images, and ROI<sup>peri-AP</sup> represents the feature subset based on the regions of interest of 5-mm-wide peritumoral area from

arterial phase CECT images. The remaining feature subsets and radiomics scores are named following a consistent pattern. PP, Portal-venous Phase; DP, Delayed Phase, MVI, microvascular invasion.

**Supplementary Table 4 The differentiation performance of MVI status based on selected radiomics features in the training and validation datasets**

CECT phases	Region	Selected features	Training dataset (n=189)	Validation dataset (n=81)
			AUC(95%CI)	AUC(95%CI)
AP	ROI <sup>tumor</sup>	7	77.2( 70.1-84.2)	59.4(46.9-71.9)
	ROI <sup>peri</sup>	8	81.9(75.9-87.9)	63.6(51.2-76.0)
DP	ROI <sup>tumor</sup>	13	87.0(81.9-92.2)	69.6(57.9-81.3)
	ROI <sup>peri</sup>	4	73.0(65.8-80.2)	61.4(48.7-74.1)
PP	ROI <sup>tumor</sup>	8	76.3(68.9-83.6)	72.0(60.3-83.8)
	ROI <sup>peri</sup>	3	69.0(61.4-76.7)	68.0(56.1-79.8)

MVI, microvascular invasion; CECT, contrast-enhanced CT; ROI<sup>tumor</sup>, region of interest of tumor; ROI<sup>peri</sup>, region of interest of 5-mm-wide peritumoral area; AP, arterial-phase; DP, delayed phase; PP, Portal-venous Phase; AUC, area under curve.



**Supplementary Table 5 Pairwise comparison for the predictive performance of different radscores in the training and validation datasets**

Pairwise comparison				<i>P</i> value (training dataset)	<i>P</i> value (training dataset)
radscore	(ROI <sup>tumor-DP</sup> )	vs	radscore		
	(ROI <sup>tumor-AP</sup> )			0.007	0.198
radscore	(ROI <sup>tumor-DP</sup> )	vs	radscore		
	(ROI <sup>peri-AP</sup> )			0.075	0.355
radscore	(ROI <sup>tumor-DP</sup> )	vs	radscore		
	(ROI <sup>peri-DP</sup> )			0.001	0.345
radscore	(ROI <sup>tumor-DP</sup> )	vs	radscore		
	(ROI <sup>tumor-PP</sup> )			0.003	0.666
radscore	(ROI <sup>tumor-DP</sup> )	vs	radscore		
	(ROI <sup>peri-PP</sup> )			<0.001	0.788

$ROI_{\text{tumor-AP}}$  represents the feature subset based on the regions of interest of tumor from arterial phase CECT images, and  $ROI_{\text{peri-AP}}$  represents the feature subset based on the regions of interest of 5-mm-wide peritumoral area from arterial phase CECT images. The remaining feature subsets and radiomics scores are named following a consistent pattern. PP, Portal-venous Phase; DP, Delayed Phase.

**Supplementary Table 6 Selected radiomics features associated with M2**

	<b>Radiomics features</b>	<b>Coefficient</b>
ROI <sup>tumor-AP</sup>	Intercept	-1.277017796
	log.sigma.3.mm.3D_firstorder_Kurtosis	0.186032227
	log.sigma.3.mm.3D_glszm_Small Area Emphasis	0.006589257
	log.sigma.5.mm.3D_gldm_Dependence Variance	0.006714370
	square_firstorder_Minimum	-0.117349090
	square_glszm_Zone Variance	0.084065738
ROI <sup>peri-AP</sup>	Intercept	-1.346224078
	wavelet.LLH_glcm_MCC	0.244821003
	wavelet.LHL_glszm_Large Area High Gray Level Emphasis	0.166407220
	wavelet.HLL_ngtdm_Strength	0.003064523
	log.sigma.5.mm.3D_glcm_Imc1	-0.047593946
	log.sigma.5.mm.3D_glrlm_Run Variance	-0.179552421
	square_glrlm_Gray Level Non-Uniformity Normalized	0.303022306
	square_glszm_Large Area High Gray Level Emphasis	-0.191810732
	squareroot_ngtdm_Contrast	-0.045330202
	exponential_gldm_Small Dependence Low Gray Level Emphasis	0.115780066
gradient_glszm_Size Zone Non-Uniformity		
ROI <sup>tumor-DP</sup>	Intercept	-1.272366240
	wavelet.LLH_glcm_Correlation	0.021857579
	wavelet.LLH_glcm_Idn	0.098104076
	log.sigma.3.mm.3D_glszm_Small Area Emphasis	0.005284062
	log.sigma.5.mm.3D_glszm_Zone Entropy	0.012192247
	square_glszm_Zone Variance	0.153281191
	exponential_glcm_Imc2	-0.079776562

	gradient_glszm_Zone Variance	0.025395012
	Intercept	-1.30118718
	square_glszm_Large Area High Gray Level Emphasis	0.03630443
ROI <sup>peri-</sup>	logarithm_firstorder_Total Energy	0.17329560
DP	gradient_glrlm_Gray Level Non-Uniformity	0.29403530
	Intercept	-1.27596122
	wavelet.LLH_glcm_Idn	0.07047329
ROI <sup>tumor-PP</sup>	wavelet.LHH_gldm_Large Dependence High Gray Level Emphasis	0.10205585
	log.sigma.3.mm.3D_glszm_Small Area Emphasis	0.17674073
	gradient_glszm_Zone Variance	
	Intercept	-1.30970036
	square_glszm_Large Area High Gray Level Emphasis	0.11837420
ROI <sup>peri-PP</sup>	logarithm_firstorder_Total Energy	0.10449451
	exponential_glszm_Gray Level Non-Uniformity	0.06536564
	gradient_glrlm_Gray Level Non-Uniformity	0.30825041

ROI<sup>tumor-AP</sup> represents the feature subset based on the regions of interest of tumor from arterial phase CECT images, and ROI<sup>peri-AP</sup> represents the feature subset based on the regions of interest of 5-mm-wide peritumoral area from arterial phase CECT images. The remaining feature subsets and radiomics scores are named following a consistent pattern. PP, Portal-venous Phase; DP, Delayed Phase, M2, microvascular invasion = M2.