

Table S1 Patient's other characteristics of all the enrolled patients

Variables	Validation cohort 1 (n=2,179)					Validation cohort 2 (N=1,550)				
	Stage 0 (n=322)	Stage I (n=745)	Stage II (n=793)	Stage III (n=231)	Stage IV (n=88)	Stage 0 (n=785)	Stage I (n=269)	Stage II (n=292)	Stage III (n=122)	Stage IV (n=82)
Gender, n (%)										
Male	287 (89.1)	679 (91.1)	711 (89.7)	210 (91.0)	82 (93.2)	685 (87.3)	227 (84.4)	263 (90.1)	113 (92.6)	74 (90.2)
Female	35 (10.9)	66 (8.9)	82 (10.3)	21 (9.0)	6 (6.8)	100 (12.7)	42 (15.6)	29 (9.9)	9 (7.4)	8 (9.8)
Age, years, n (%)										
≤50	159 (49.4)	440 (59.1)	374 (47.2)	110 (47.7)	45 (51.1)	398 (50.7)	136 (50.6)	160 (54.8)	70 (57.4)	40 (48.8)
>50	163 (50.6)	305 (40.9)	419 (52.8)	121 (52.3)	43 (48.9)	387 (49.3)	133 (49.4)	132 (49.2)	52 (42.6)	42 (51.2)
Biochemistries, n (%)										
Total bilirubin (mmol/L)										
≤18.8	228 (70.8)	543 (72.9)	448 (56.5)	130 (56.3)	25 (28.4)	603 (76.8)	197 (73.2)	179 (61.3)	69 (56.6)	26 (31.7)
>18.8	94 (29.2)	202 (27.1)	345 (43.5)	101 (43.7)	63 (71.6)	182 (23.2)	72 (26.8)	113 (38.7)	53 (43.4)	56 (68.3)
Albumin (g/L)										
≤34	10 (3.1)	47 (6.3)	154 (19.4)	35 (15.2)	49 (55.7)	76 (9.7)	22 (8.2)	36 (12.3)	20 (16.4)	44 (53.7)
>34	312 (96.9)	698 (93.7)	639 (80.6)	196 (84.8)	39 (44.3)	709 (90.3)	247 (91.8)	256 (87.7)	102 (83.6)	38 (46.3)
ALT (μL/L)										
≤44	185 (57.5)	348 (46.7)	350 (44.1)	108 (46.8)	40 (45.5)	505 (64.3)	164 (61.0)	124 (42.5)	58 (47.5)	38 (46.3)
>44	137 (42.5)	397 (53.3)	443 (55.9)	123 (53.2)	48 (54.5)	280 (35.7)	105 (39.0)	168 (57.5)	64 (52.5)	44 (53.7)
HbsAg										
Positive	284 (88.2)	670 (89.9)	668 (84.2)	208 (90.0)	78 (88.7)	682 (86.9)	245 (91.1)	262 (89.7)	109 (89.3)	72 (87.8)
Negative	38 (11.8)	75 (10.1)	125 (15.8)	23 (10.0)	10 (11.3)	103 (13.1)	24 (8.9)	30 (10.3)	13 (10.3)	10 (12.2)
Cirrhosis										
Yes	197 (61.2)	513 (68.9)	587 (74.0)	171 (74.0)	67 (76.1)	465 (59.2)	194 (72.1)	159 (54.5)	77 (63.1)	58 (70.7)
No	125 (38.8)	232 (31.1)	206 (26.0)	60 (26.0)	21 (23.9)	320 (40.8)	75 (27.9)	133 (45.5)	45 (36.9)	24 (29.3)
Tumor characteristics, n (%)										
AFP (ng/mL)										
≤400	173 (53.7)	274 (36.8)	306 (38.6)	79 (34.2)	20 (22.7)	382 (48.7)	110 (40.9)	95 (32.5)	44 (36.1)	20 (24.4)
>400	149 (46.3)	471 (63.2)	487 (61.4)	152 (65.8)	68 (87.3)	403 (51.3)	159 (59.1)	197 (67.5)	78 (63.9)	62 (75.6)
Tumor size (cm)										
≤5	149 (46.3)	138 (18.5)	119 (15.0)	17 (7.4)	6 (6.8)	287 (36.6)	62 (23.0)	25 (8.6)	9 (7.4)	6 (7.3)
>5	173 (53.7)	607 (81.5)	674 (85.0)	214 (92.6)	82 (93.2)	498 (63.4)	207 (77.0)	267 (91.4)	113 (92.6)	76 (92.7)
Tumor number										
Single	294 (91.3)	693 (93.0)	604 (76.2)	28 (12.1)	13 (24.8)	539 (68.7)	114 (42.4)	68 (23.3)	16 (13.1)	15 (18.3)
Multiple	28 (8.7)	52 (7.0)	189 (23.8)	203 (87.9)	75 (85.2)	246 (31.3)	155 (57.6)	224 (76.7)	106 (86.9)	67 (81.7)

Table S2 Median survival time of all the enrolled patients who underwent different treatments in training cohort and validation cohort

First treatment	Median survival time (95% CI)	
	Training cohort	Validation cohort
Resection	17.6 (15.7–19.6)	*35.8 (34.3–37.3)
TACE	3.7 (3.4–4.0)	4.0 (2.9–5.0)
MTD or Che	5.6 (5.4–5.9)	2.5 (1.1–3.9)
TACE-SUR	8.1 (7.3–9.0)	NA
RT-TACE	9.5 (6.8–12.3)	NA
TAI	NA	7.7 (6.3–9.1)
RF	NA	4.0 (0–10.4)
BSC	2.5 (1.7–3.3)	1.5 (1.3–1.7)

*, mean survival time. CI, confidence interval; MTD, multidisciplinary therapy; Che, systemic chemotherapy; SUR, surgery; RT, external radiotherapy; TAI, transhepatic arterial infusion; RF, radiofrequency ablation; BSC, best support care.

Table S3 Patient's variables of all the nodes by the conditional inference trees in training cohort

Tree nodes in two models	Variables in each node in the cohort 1	Training cohort (n=2,179)
Node1 and Node2	MVI; PS =0; Child-Pugh = A-B; resectability	322 (14.8)
Node4	PVTT; PS =1–2; Child-Pugh = A–B; resectable; extrahepatic spread =0	745 (34.2)
Node5	PVTT; PS =1–2; Child-Pugh = A–B; resectability; extrahepatic spread =0; MPV =0	551 (25.3)
Node6	PVTT; PS =1–2; Child-Pugh = A–B; resectable; extrahepatic spread =0; MPV =1	194 (8.9)
Node8	PVTT; PS =1–2; Child-Pugh = A–B; unresectable; extrahepatic spread =0	793 (36.4)
Node9	PVTT; PS =1–2; Child-Pugh = A–B; unresectable; extrahepatic spread =0; MPV =0	457 (21.0)
Node10	PVTT; PS =1–2; Child-Pugh = A–B; unresectable; extrahepatic spread =0; MPV =1	336 (15.4)
Node12	PVTT; PS =1–2; Child-Pugh = A–B; extrahepatic spread =1	231 (10.6)
Node13	PVTT; PS =1–2; Child-Pugh = A–B; extrahepatic spread =1; MPV =0	121 (5.6)
Node14	PVTT; PS =1–2; Child-Pugh = A–B; extrahepatic spread =1; MPV =1	110 (5.1)
Node15	Child-Pugh = C or PS =3–4; no matter other status	88 (4.0)

Table S4 The scaled Schoenfeld residual plots

	Relative coefficient				
	0	1	2	3	4
Child-Pugh	A–B				C
PVTT	No		Yes		
ECOG -PS	0		1-2		3-4
Extrahepatic Metastasis	No	Yes			
Tumor resectability	No	Yes			
MPV	No	Yes			

MPV, main portal vein.

Table S5 The 1-, 2- and 3-year overall and median survival outcomes of all the enrolled patients in the new staging system

	1-year		2-year		3-year		Median survival time (95% CI)	
	Training cohort	Validation cohort	Training cohort	Validation cohort	Training cohort	Validation cohort	Training cohort	Validation cohort
Stage								
0	86.3	78.1	69.7	67.5	61.9	61.4	57.1 (37.2-76.9)	*37.6 (35.9-39.2)
I	50.2	65.6	28.9	56.2	19.3	48.6	12.1 (11.0-13.2)	*30.4 (27.4-33.4)
II	26.8	29.6	8.7	12.8	2.9	12.8	5.7 (5.1-6.2)	6.4 (4.9-7.9)
III	10.6	12.5	NA				4.0 (3.3-4.6)	2.8 (1.3-4.4)
IV	0	1.2	NA				2.5 (1.7-3.3)	1.5 (1.3-1.7)
Sub-stage								
IA	55.5	67.3	33.2	59.3	23.1	50.9	13.9 (12.1-15.7)	*31.5 (28.4-34.7)
IB	35.1	55.4	16.9	33.3	8.3	33.3	6.0 (4.4-7.7)	15.0 (8.3-21.7)
IIA	29.7	34.8	11.8	17.8	3.8	17.8	6.4 (5.6-7.2)	6.4 (4.5-8.3)
IIB	20.8	22	4.7	5.6	1.7	NA	4.0 (3.0-4.9)	5.7 (3.2-8.3)
IIIA	10.4	16.1	NA				3.4 (2.1-4.6)	4.5 (2.6-6.4)
IIIB	0	6.7	NA				3.3 (2.6-4.0)	1.8 (1.2-2.4)

*, mean survival time. CI, confidence interval.