

**Figure S1** Diameter and volume evaluation on MRI. (A,E) Oblique axial T2WI of the largest tumor section in patients aged 69 and 60 years. (B,F) ROI were oblique axial T2WI, avoiding visible necrotic tissue, blood vessels, rectal cancer intestinal wall, and rectal mucosa. The outlined red area shows the tumor area. (C,G)  $\text{Dia}_{\text{MRI}}$  was independently measured based on a single representative section's largest available tumor area. (D,H)  $\text{Vol}_{\text{MRI}}$  was calculated by multiplying the number of ROI pixels (N) by section thickness and voxel size. MRI, magnetic resonance imaging; T2WI, T2-weighted imaging; ROI, region of interest;  $\text{Dia}_{\text{MRI}}$ , MRI tumor diameter; MRI, magnetic resonance imaging;  $\text{Vol}_{\text{MRI}}$ , MRI tumor volume.

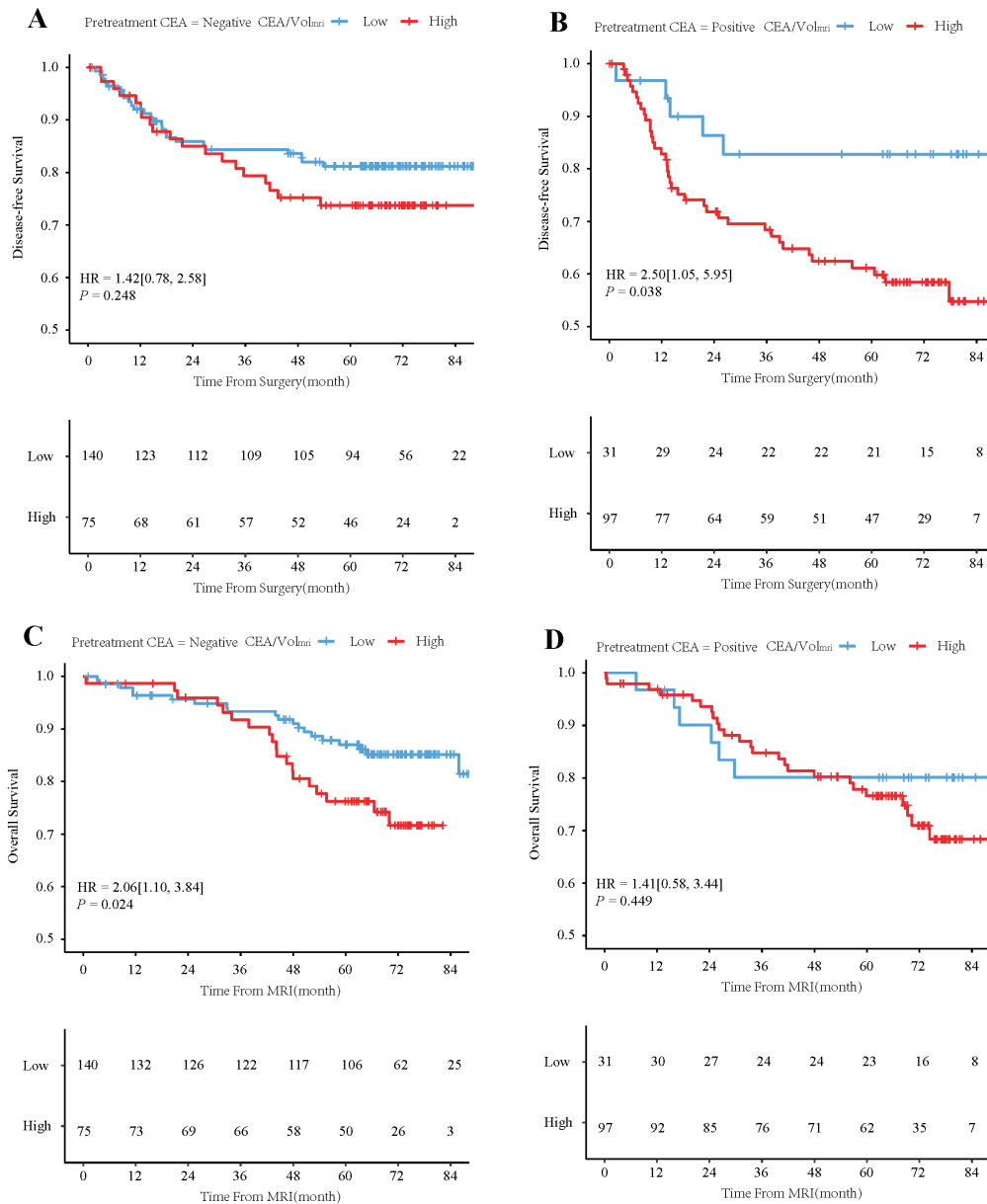
**Table S1** R packages and version

Packages	Version
caret	6.0-93
compareGroups	4.6.0
ggplot2	3.4.1
Hmisc	5.0-1
MASS	7.3-58.3
openxlsx	4.2.5.2
pROC	1.18.0
mice	3.15.0
rms	6.5-0
ROSE	0.0-4
OptimalCutpoints	1.1-5
showtext	0.9-5
survIDINRI	1.1-2
survival	3.5-3
survminer	0.4.9

**Table S2** Univariable Cox regression of DFS and OS

Parameter	DFS		OS	
	HR [95% CI]	P value	HR [95% CI]	P value
Age (>50 vs. ≤50 years)	1.63 [0.92, 2.88]	0.095	2.51 [1.20, 5.24]	0.014*
Sex (male vs. female)	0.99 [0.65, 1.51]	0.958	1.39 [0.85, 2.27]	0.185
Weight	0.99 [0.97, 1.01]	0.505	0.99 [0.97, 1.01]	0.498
BMI	0.99 [0.93, 1.06]	0.836	1.00 [0.93, 1.08]	0.943
Dia <sub>path</sub>	1.00 [0.98, 1.01]	0.701	1.00 [0.99, 1.01]	0.971
Dia <sub>MRI</sub>	1.01 [0.99, 1.03]	0.292	1.00 [0.98, 1.03]	0.732
Vol <sub>MRI</sub>	0.99 [0.98, 1.01]	0.416	1.00 [0.99, 1.02]	0.886
Pretreatment CEA (positive vs. negative)	1.88 [1.24, 2.86]	0.003*	1.43 [0.90, 2.26]	0.133
Location (middle vs. lower)	1.10 [0.61, 1.98]	0.741	1.28 [0.68, 2.42]	0.448
Location (upper vs. lower)	2.19 [1.21, 3.96]	0.009*	1.97 [1.01, 3.86]	0.047*
Differentiation (moderate vs. well)	2.59 [1.37, 4.88]	0.003*	1.32 [0.75, 2.31]	0.339
Differentiation (poor vs. well)	5.22 [2.02, 13.48]	0.001*	3.10 [1.21, 7.95]	0.018*
Clinical stage (II vs. I)	1.42 [0.61, 3.30]	0.416	1.28 [0.51, 3.19]	0.599
Clinical stage (III vs. I)	4.01 [1.83, 8.80]	0.001*	3.52 [1.50, 8.26]	0.004*
T stage (T3 vs. T1/2)	1.63 [0.90, 2.96]	0.105	1.70 [0.87, 3.33]	0.124
T stage (T4 vs. T1/2)	2.80 [1.06, 7.38]	0.037*	2.40 [0.75, 7.67]	0.138
N stage (N1 vs. N0)	3.09 [2.00, 4.8]	<0.001*	2.93 [1.82, 4.73]	<0.001*
LVI (positive vs. negative)	1.93 [1.05, 3.56]	0.034*	1.98 [1.01, 3.87]	0.045*
PNI (positive vs. negative)	2.23 [1.24, 4.03]	0.008*	2.42 [1.27, 4.61]	0.007*
Adjuvant therapy (yes vs. no)	1.12 [0.74, 1.71]	0.587	0.61 [0.37, 0.99]	0.044*
CEA/Dia <sub>path</sub> (high vs. low)	1.51 [0.99, 2.31]	0.056	1.29 [0.81, 2.05]	0.286
CEA/Dia <sub>MRI</sub> (high vs. low)	1.63 [1.07, 2.5]	0.024*	1.50 [0.94, 2.39]	0.090
CEA/Vol <sub>MRI</sub> (high vs. Low)	2.04 [1.31, 3.16]	0.001*	1.91 [1.18, 3.09]	0.008*

\*, P value was <0.05 and considered statistically significant. DFS, disease-free survival; OS, overall survival; HR, hazard ratio; CI, confidence interval; BMI, body mass index; Dia<sub>path</sub>, pathological tumor diameter; Dia<sub>MRI</sub>, MRI tumor diameter; MRI, magnetic resonance imaging; Vol<sub>MRI</sub>, MRI tumor volume; CEA, carcinoembryonic antigen; T stage, tumor stage; N stage, nodal stage; LVI, lymphovascular invasion; PNI, perineural invasion.



**Figure S2** The Kaplan-Meier Curve according to pretreatment CEA and CEA/Vol<sub>MRI</sub>. (A,B) The Kaplan-Meier DFS curves are shown for patients according to pretreatment CEA and CEA/Vol<sub>MRI</sub>. (C,D) The Kaplan-Meier OS curves are shown for patients according to pretreatment CEA and CEA/Vol<sub>MRI</sub>. P values were calculated using two-sided log-rank test. CEA, carcinoembryonic antigen; Vol<sub>MRI</sub>, MRI tumor volume; MRI, magnetic resonance imaging; HR, hazard ratio; DFS, disease-free survival; OS, overall survival.

**Table S3** Five-year recurrence rate and death rate in the high CEA/Vol<sub>MRI</sub> group and the low CEA/Vol<sub>MRI</sub> group

Parameter	DFS		OS	
	Low CEA/Vol <sub>MRI</sub>	High CEA/Vol <sub>MRI</sub>	Low CEA/Vol <sub>MRI</sub>	High CEA/Vol <sub>MRI</sub>
1-year	92.8% [89.0%, 96.8%]	87.4% [82.5%, 92.6%]	96.4% [93.7%, 99.3%]	97.7% [95.4%, 100.0%]
2-year	86.0% [80.8%, 91.5%]	77.7% [71.6%, 84.3%]	94.6% [91.2%, 98.1%]	94.6% [91.3%, 98.1%]
3-year	84.1% [78.7%, 89.9%]	73.2% [66.8%, 80.3%]	90.9% [86.6%, 95.4%]	87.8% [83.0%, 93.0%]
4-year	83.5% [77.9%, 89.4%]	68.1% [61.3%, 75.7%]	89.0% [84.3%, 93.9%]	80.3% [74.5%, 86.7%]
5-year	81.5% [75.7%, 87.7%]	66.7% [59.8%, 74.4%]	85.8% [80.5%, 91.3%]	76.4% [70.1%, 83.3%]

The data in parentheses were 95% confidence interval. CEA, carcinoembryonic antigen; Vol<sub>MRI</sub>, MRI tumor volume; MRI, magnetic resonance imaging; DFS, disease-free survival; OS, overall survival.

**Table S4** Step Cox regression of DFS and OS

Parameter	DFS		OS	
	HR [95% CI]	P value	HR [95% CI]	P value
Age (>50 vs. ≤50 years)	–	–	2.11 [0.99, 2.59]	0.053
Location (middle vs. low)	1.30 [0.72, 2.34]	0.386	–	–
Location (upper vs. low)	2.25 [1.24, 4.08]	0.008*	–	–
Differentiation (middle vs. well)	2.23 [1.17, 4.23]	0.015*	1.11 [0.62, 1.99]	0.725
Differentiation (poor vs. well)	4.36 [1.66, 11.48]	0.003*	3.18 [1.19, 8.49]	0.021*
N stage (N1 vs. N0)	2.78 [1.78, 4.33]	<0.001*	3.96 [2.31, 6.76]	<0.001*
PNI (positive vs. negative)	–	–	1.81 [0.93, 3.53]	0.079
Adjuvant therapy (yes vs. no)	–	–	0.35 [0.20, 0.59]	<0.001*
Pretreatment CEA (positive vs. negative)	1.66 [1.07, 2.59]	0.024*	–	–
CEA/Vol <sub>MRI</sub> (high vs. low)	1.62 [1.01, 2.60]	0.044*	1.57 [0.95, 2.59]	0.077

\*, P value was <0.05 and considered statistically significant. DFS, disease-free survival; OS, overall survival; HR, hazard ratio; CI, confidence interval; N stage, nodal stage; PNI, perineural invasion; CEA, carcinoembryonic antigen; Vol<sub>MRI</sub>, MRI tumor volume; MRI, magnetic resonance imaging.

**Table S5** The C-index and AUC of nomograms

Parameter	DFS		OS	
	Index [95% CI]	P value	Index [95% CI]	P value
C-index	0.72 [0.68, 0.79]	<0.001*	0.73 [0.68, 0.80]	<0.001*
1-year AUC	0.80 [0.72, 0.90]	<0.001*	0.68 [0.66, 0.91]	0.005*
2-year AUC	0.76 [0.69, 0.84]	<0.001*	0.76 [0.70, 0.90]	<0.001*
3-year AUC	0.75 [0.69, 0.83]	<0.001*	0.81 [0.75, 0.89]	<0.001*
4-year AUC	0.77 [0.72, 0.84]	<0.001*	0.79 [0.74, 0.87]	<0.001*
5-year AUC	0.76 [0.71, 0.83]	<0.001*	0.76 [0.71, 0.84]	<0.001*

\*, P value was <0.05 and considered statistically significant. C-index, concordance index; AUC, area under curve receiver operating characteristic; DFS, disease-free survival; CI, confidence interval; OS, overall survival.