Long-Term Cost-Effectiveness of Robotic-Assisted vs Laparoscopic Surgery for Mid-Low Rectal Cancer in China

Microsimulation Based on the REAL Randomized Trial

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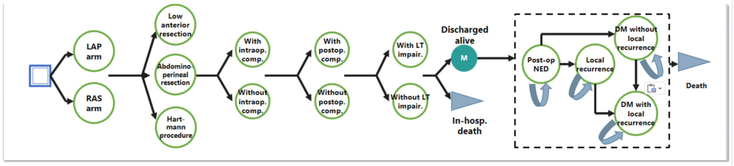
Background & Objective

The REAL trial (n=1,178) is a multicenter randomized trial across 11 tertiary hospitals in China comparing robotic-assisted surgery (RAS) with laparoscopy (LAP) for mid-low rectal cancer.

Key 3-year findings of REAL:
- **Local recurrence: 1.6% vs 4.0%**
- **Disease-free survival: 87.2% vs 83.4%**
- **Better urinary and male sexual function**

We aim to assess whether RAS provides long-term value for money in China .

Model Overview



Patient-level microsimulation with monthly cycles. A perioperative decision tree/conditional event chain feeds into a five-state long-term transition model: NED, local recurrence, distant metastasis without LR, distant metastasis with LR, and death. Costs, LYs, and QALYs accrue until death or the selected horizon.

Cycle length: 1 month | Discounting: 5% annually | Horizons: 1, 3, 5, 10, 20, 30 years, lifetime

Key Inputs & Cost Parameters

Parameter	Value	Source
Initial Admission		
LAP Arm	81,054 RMB	REAL Trial
RAS Arm	117,031 RMB	REAL Trial
Perioperative Events (Impact)		
Anastomotic Leak	+46,728 RMB	REAL Trial
Bowel Obstruction	+37,379 RMB	REAL Trial
Intra-abdominal Bleeding	+13,748 RMB	REAL Trial
Incision Complications	+7,004 RMB	REAL Trial
Conversion to Open Surgery	+6,163 RMB	REAL Trial
Deep-vein Thrombosis	+3,847 RMB	REAL Trial
Intraoperative Transfusion	+3,389 RMB	REAL Trial
Monthly State Costs		
NED / Follow-up	180 RMB	Chin 2022
Distant Metastasis Care	16,667 RMB	Shen 2020, Lindenberg 2022
Permanent Stoma Care	833 RMB	Carlsson 2023, Jones 2015
Utilities		
NED | LR | DM	0.82|0.71|0.54	Mulder et al. 2022, Jeong & Cairns 2016, Lee 2017,Miller 2000

Model Validation

Perioperative and 5-state disease pathways reflect clinical course. Internal validation supported the model within trial-observed period.

36-Month Calibration Targets

Endpoint	LAP (Obs/Cal)	RAS (Obs/Cal)
Local Recur.	0.039 / 0.039	0.015 / 0.015
DFS	0.834 / 0.834	0.872 / 0.872

60-Month Key Prediction vs REAL Trial

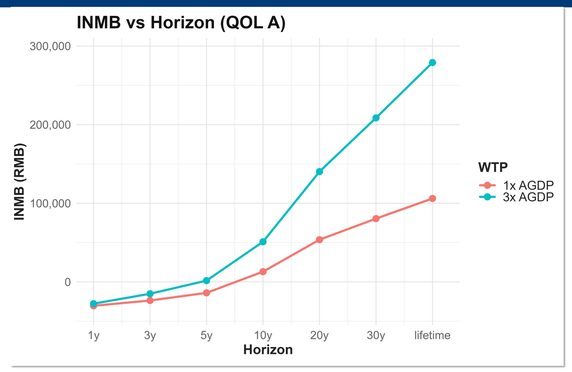
Endpoint & Arm	Pred 60m	Obs 60m
DFS (RAS)	84.29%	**84.42%**
LR (RAS)	2.04%	**2.16%**

Calibration, internal validation, and external comparisons (115/144 predicted values within 0.5–2.0 range) support credible extrapolation.

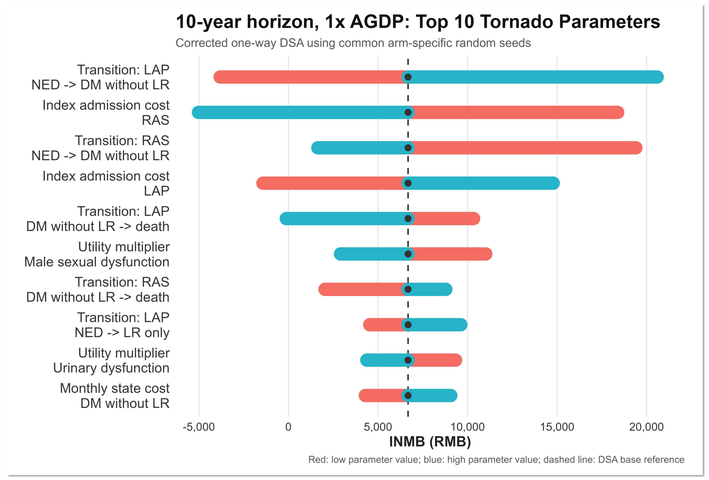
Base-Case Results

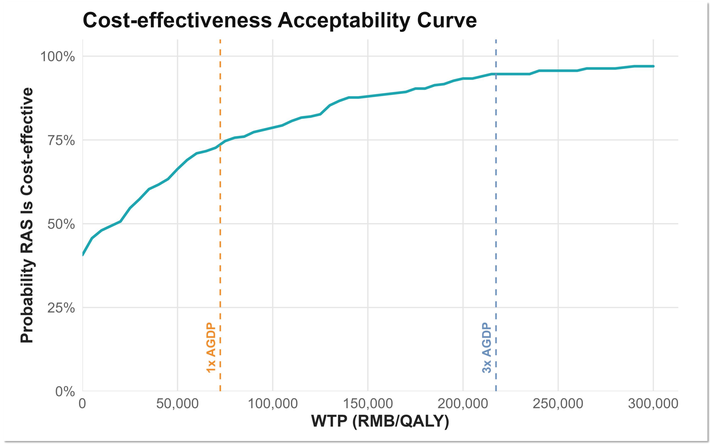
Hori-zon	RAS Cost (RMB)	LAP Cost (RMB)	△ Cost (RMB)	RAS QALY	LAP QALY	△ QALY	ICER	INMB @1x GDP (RMB)	INMB @3x GDP (RMB)
1y	137,068	105,298	+31,770	0.674	0.656	+0.019	+1,703,731	-30,419	-27,718
3y	175,805	147,838	+27,967	1.883	1.823	+0.059	+473,245	-23,686	-15,123
5y	206,169	184,420	+21,749	2.916	2.809	+0.107	+202,427	-13,966	+1,602
10y	254,905	248,852	+6,054	4.950	4.687	+0.263	+23,043	+12,979	+51,044
20y	314,732	325,075	-10,343	7.453	6.855	+0.598	Dominant	+53,650	+140,266
30y	348,124	364,539	-16,415	8.747	7.863	+0.884	Dominant	+80,478	+208,605
lifetime	375,702	395,307	-19,605	9.753	8.559	+1.194	Dominant	+106,076	+279,017

Economic Value Trajectory



Sensitivity & Uncertainty





Conclusions

RAS delivered clinically meaningful oncologic benefit (1.6% vs 4.0% LR at 3 years).In the microsimulation, cost-effectiveness improved materially as the timehorizon extended.

RAS may be cost-effective at 3x GDP by 5 years, may be cost-effectivess at 1x GDP by 10 years, and may be cost-saving from 20 years onward.

Overall, RAS may be cost-effectivess for rectal cancer surgery, especially in the long run.

Abbreviations: DFS = disease-free survival; DM = distant metastasis; GDP = gross domestic product; ICER = incremental cost-effectiveness ratio; INMB = incremental net monetary benefit; LAP = laparoscopic surgery; LR = local recurrence; NED = no evidence of disease; PSA = probabilistic sensitivity analysis; QALY = quality-adjusted life-year; RAS = robotic-assisted surgery; WTP = willingness to pay.