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Cost-Effectiveness of Robot-Assisted and Laparoscopic Radical Nephrectomy versus Open Radical Nephrectomy in the Treatment of Renal Cell Carcinoma

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INTRODUCTION

Renal Cell Carcinoma (RCC)

- RCC is common malignancy; in 2022, there were an estimated 434,840 incident cases and 155,953 deaths globally.
- More than 71,759 new cases each year in the US, 70% of cases with stage 1 RCC at diagnosis. [1, 2]

Open, Laparoscopic, and Robot Assisted Nephrectomy

- Radical nephrectomy (RN) remains the standard curative treatment for larger RCC tumors
- Minimally invasive surgical techniques, such as laparoscopic RN (LRN), are considered an alternative to open RN due to shorter recovery periods, less trauma and fewer postoperative complications.
- Robotic-assisted RN (RARN), introduced in 2005, has seen an uptake due to higher definition displays, finer manipulation, and broader scope in motion.

CEA on RN procedures warrant consideration because:

- LRN and RARN have similar perioperative complication but lower than ORN.
- RARN is associated with prolonged operating time and higher hospital costs than LRN and ORN.
- Economic evaluation may inform value-based surgical decision-making and provide evidence-based guidance for optimizing perioperative outcomes and resource allocation. [3]

OBJECTIVE

To evaluate the cost-effectiveness of RARN and LRN compared to ORN for treating RCC from a healthcare system perspective.

METHODS

Model Design

- This cost-effectiveness analysis employed a decision tree using Visual Basic Application (VBA) in Excel to compare RARN and LRN with ORN.
- It incorporated perioperative complications, including mortality, and inpatient costs.
- The model was parameterized using US-based published data.
- Probabilistic sensitivity analysis (PSA) was performed using 1,000 iterations of Monte Carlos simulations.

Cost Assessment

- Costs were analyzed from the US healthcare System's perspective, incorporating direct hospitalization costs such as room charges, surgical fees, and anesthesia.
- The calculation of direct surgical procedure costs was based on the National (Nationwide) Inpatient Sample (NIS) Database.

Outcome Measures and Analysis Parameters

- The primary health outcome measure was Quality-adjusted life years (QALYs), with particular focus on perioperative complications following RARN, LRN, and Open RN.
- The analysis considered outcomes during and immediately after RN, hence no discounting was necessary.
- A willingness-to-pay (WTP) threshold of USD50,000 per quality-adjusted life year (QALY) gained was assumed for the analysis.

RESULTS

Parameters and Model

- The constructed model is presented in Fig 1.
- Some input parameter are presented in Table 1.

Base Case Analysis

- RARN and LRN are both less costly and more effective than Open RN (Table 2).
  - ➢ **Both RARN and LRN are dominant strategies.**
- Reference case from payer's perspective offer similar results.

Probability Sensitivity Analysis

- ICER Scatter plot is presented in Fig 2.
- The Cost Effectiveness Accountability Curves (CEAC) are presented in Fig 3 and Fig 4.

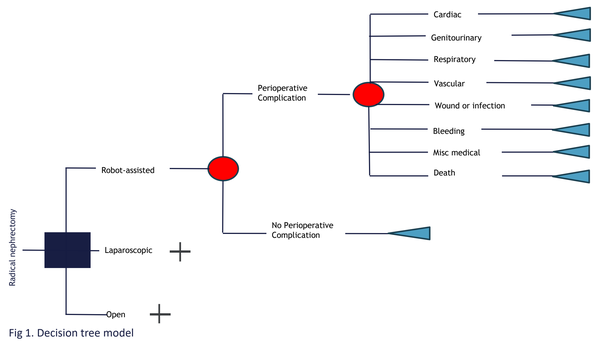

Fig 1. Decision tree model

Table 2.Results Base Case Analysis

Strategy	Cost, USD	Effectiveness, QALYs	Incremental Costs, USD	Incremental effectiveness, QALYs	ICER, USD per QALY gained
Open	16,730	0.4333			
Robot-Assisted	15,644	0.5161	1,087	0.0828	-13116
Laparoscopic	13,683	0.5262	-3,048	0.0929	-32796

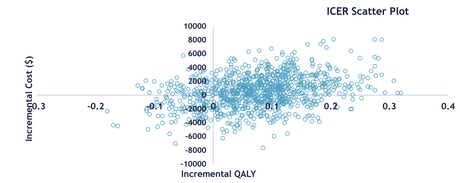

Fig 2. ICER Scatter plot

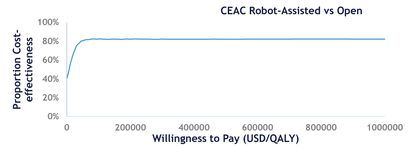

Fig 3. CEAC Robot-Assisted vs Open RN

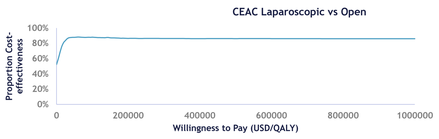

Fig 4. CEAC Laparoscopic vs Open RN

Table 1. Input Parameters

	Robot-Assisted	Laparoscopic	Open		
Probabilities (%)	**Parameters**			**Distribution**	**Reference**
Perioperative complications	0.08	0.071	0.158	Beta	4
No Perioperative complications	0.92	0.929	0.842	Beta	4
Cardiac	0.005	0.004	0.009	Beta	4
Genitourinary	0.017	0.015	0.033	Beta	4
Respiratory	0.015	0.01	0.035	Beta	4
Vascular	0.002	0.001	0.005	Beta	4
Wound or infection	0.014	0.011	0.039	Beta	4
Bleeding	0.002	0.002	0.039	Beta	4
Misc. medical and surgical	0.041	0.039	0.039	Beta	4
Death	0.2	0.3	0.3	Beta	4
Cost (USD)					
No Perioperative complications	17,051	14,174	18,095	Gamma	4
Cardiac	22,633	19,756	23,676	Gamma	5
Genitourinary	20,000	17,123	21,043	Gamma	5
Respiratory	22,682	19,805	23,726	Gamma	5
Vascular	23,339	19,805	23,726	Gamma	5
Wound or infection	23,339	20,462	24,383	Gamma	5
Bleeding	21,646	20,462	22,690	Gamma	5
Misc. medical and surgical	19,596	16,719	20,640	Gamma	5
Death	66,138	63,261	67,182	Gamma	6
Utilities					
Radical nephrectomy utility	0.73	0.73	0.73	Gamma	7
No Perioperative complications	0.61	0.61	0.61	Gamma	8
Cardiac	0.723	0.723	0.723	Gamma	8
Genitourinary	0.723	0.723	0.723	Gamma	8
Respiratory	0.723	0.723	0.723	Gamma	8
Vascular	0.686	0.686	0.686	Gamma	8
Wound or infection	0.64	0.64	0.64	Gamma	9
Bleeding	0.63	0.63	0.63	Gamma	10
Misc. medical and surgical	0.63	0.63	0.63	Gamma	7
Death	0	0	0		

CONCLUSIONS

Key Findings: The base case analysis demonstrates that both RARN and LRN are cost-effective compared to ORN in treating RCC, with LRN being notably more cost-effective than RARN.

Limitations: These results are limited by combining charges and marginal costs from diverse sources, using utility values from similar surgical complications rather than RN-specific complications, and focusing solely on in-hospital estimates without accounting for societal costs.

Future Research Directions: Future research is warranted to corroborate these findings and to explore whether LRN is more cost-effective than RARN.

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