

Perioperative Cost-Effectiveness of Partial Nephrectomy Techniques for Renal Cell Carcinoma in the United States

Vietbao H. Phan, PharmD¹; Mumbi E. Kimani, PhD¹; Inkyu Kim, PhD¹; Elizabeth Sottung, PharmD¹; Costas Lallas, MD, FACS²; Vittorio Maio, PharmD, MS, MSPH¹
1 - Jefferson College of Population Health, Thomas Jefferson University, Philadelphia, PA; 2 - Department of Urology, Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, USA

Background

- Robotic-assisted partial nephrectomy (RAPN) has emerged as the preferred minimally invasive approach for localized renal tumors, largely replacing laparoscopic partial nephrectomy (LPN).¹ While RAPN offers fewer perioperative complications, its higher hospital costs raise questions about comparative value relative to LPN and open partial nephrectomy (OPN).²
- This cost-effectiveness analysis provides a framework for evaluating whether the clinical benefits of newer surgical approaches justify their incremental costs.³

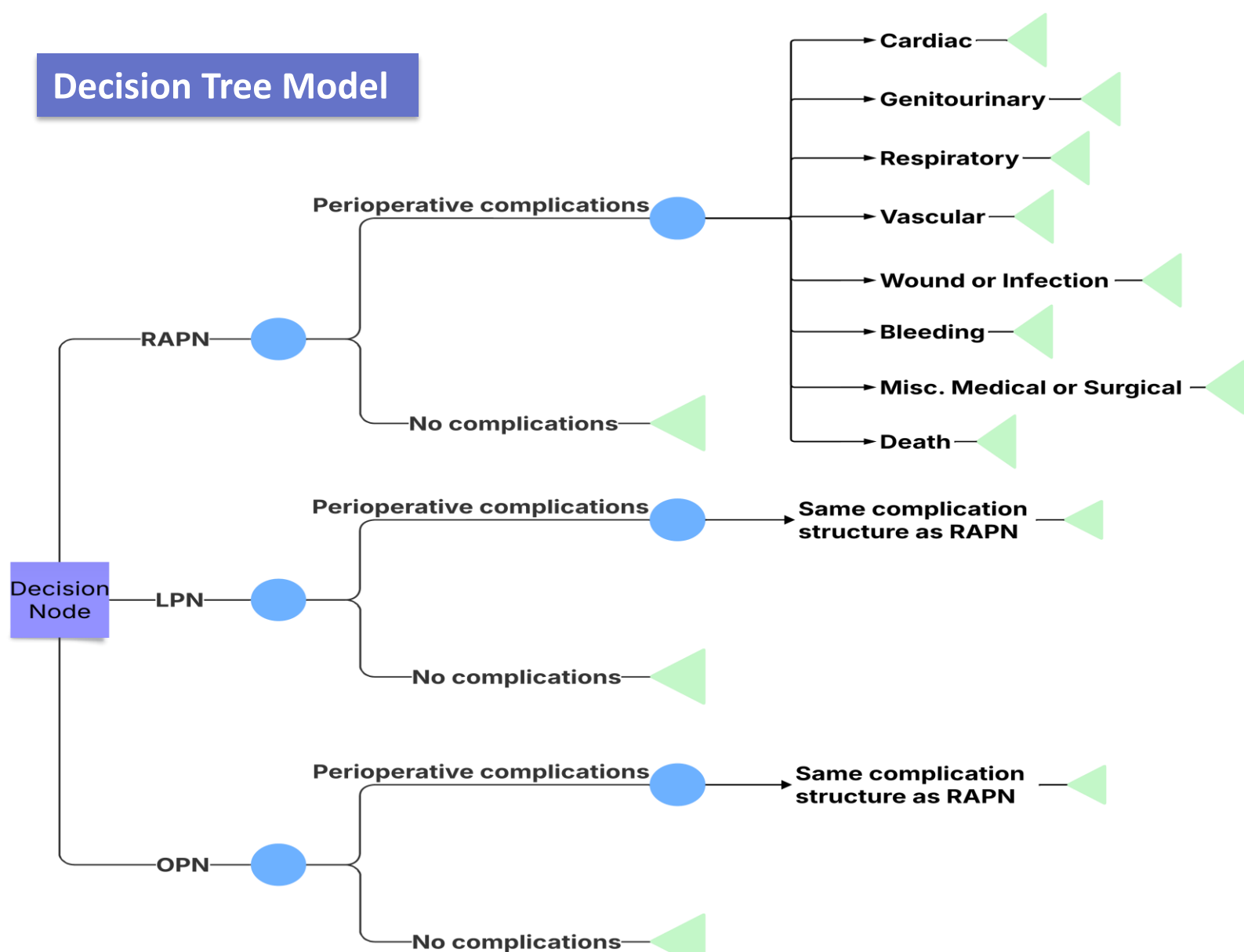
Objectives

To assess the perioperative cost-effectiveness of RAPN, LPN, and OPN for renal cell carcinoma from a U.S. hospital perspective, estimating perioperative incremental cost-effectiveness ratios (ICERs) per perioperative quality-adjusted life-year (QALY) gained as the primary endpoint, with cost per complication avoided as a supplementary clinically intuitive measure

Methods

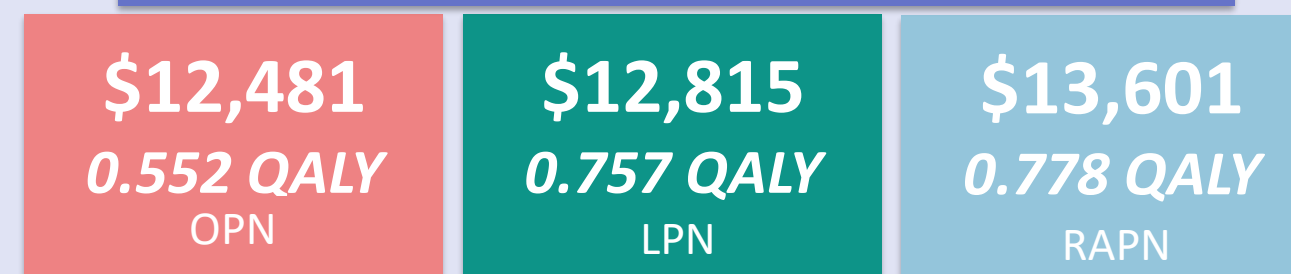
- **Model:** Decision tree model analyzed using published U.S. parameters
- **Inputs:** Inpatient perioperative complication rates, in-hospital mortality, inpatient costs, and short-term perioperative health state utilities
- **Outcomes:** Perioperative ICERs (\$/perioperative QALY) as the primary endpoint; cost per complication avoided as a supplementary endpoint aligned with the perioperative data horizon
- **Sensitivity analysis:** Probabilistic sensitivity analysis (PSA) with 1,000 Monte Carlo simulations; one-way sensitivity analysis using PSA-derived parameter ranges (2.5th–97.5th percentiles)
- **Perspective:** U.S. hospital (inpatient, perioperative episode)
- **Key assumption:** Equivalent post-discharge survival and health-related quality of life across surgical approaches; only perioperative differences are captured

Decision Tree Model



Results

Mean Inpatient Costs and Perioperative QALYs

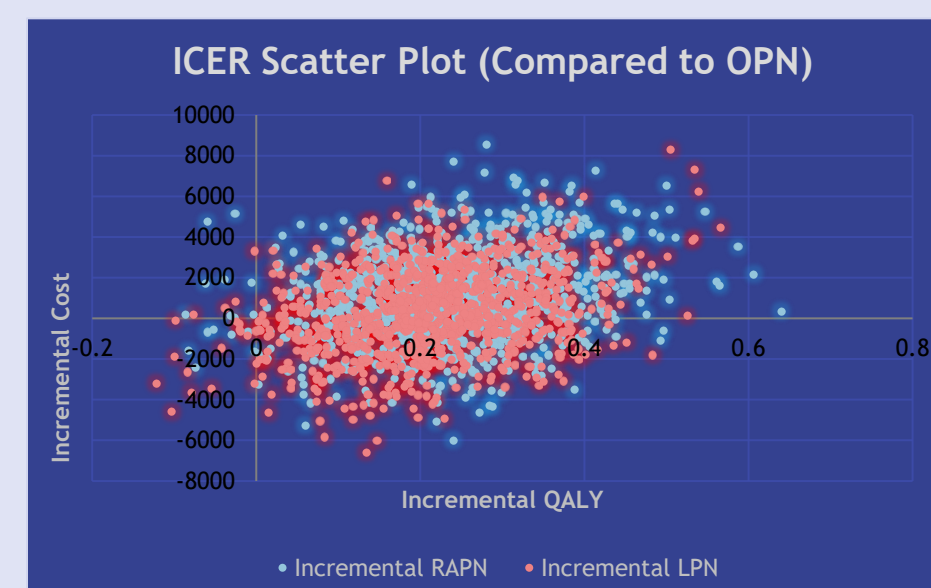
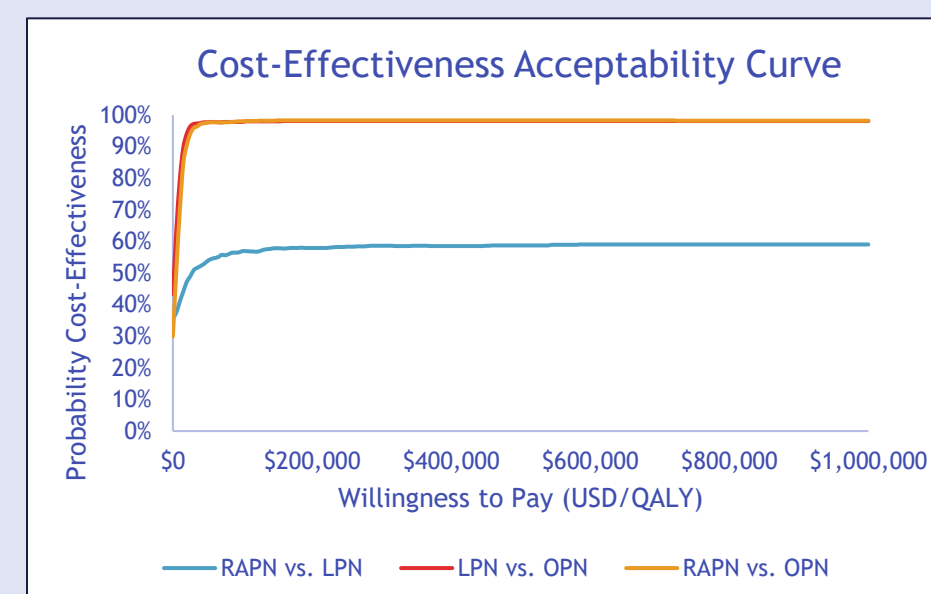


Parameter Table

Parameters	OPN			LPN			RAPN		
	Prob.	Utility	Cost	Prob.	Utility	Cost	Prob.	Utility	Cost
No perioperative complications	87.9%	0.7	\$15,364	92.4%	0.88	\$14,627	94%	0.88	\$15,187
Cardiac	0.7%	0.6508	\$22,693	0.4%	0.8308	\$20,328	0.4%	0.8308	\$20,328
Genitourinary	3.2%	0.6907	\$15,972	3.2%	0.8707	\$8,602	1.2%	0.8707	\$8,602
Respiratory	2.6%	0.6572	\$18,603	1.1%	0.8372	\$20,042	1.2%	0.8372	\$20,042
Vascular	0.3%	0.662	\$25,120	0.2%	0.842	\$16,832	0.1%	0.842	\$16,832
Wound or infection	1.5%	0.6	\$34,979	0.8%	0.78	\$49,375	0.8%	0.78	\$49,375
Bleeding	0.1%	0.6791	\$11,228	0.2%	0.8591	\$8,826	0.1%	0.8591	\$8,826
Misc. medical and surgical	5.5%	0.6654	\$13,708	3.1%	0.8454	\$33,039	3.1%	0.8454	\$33,039
Death	0.4%	0	\$102,899	0.8%	0	\$102,899	0.1%	0	\$102,899

Cost-Effectiveness Ratios (ICERs) and Probabilistic Sensitivity Analyses (PSA)

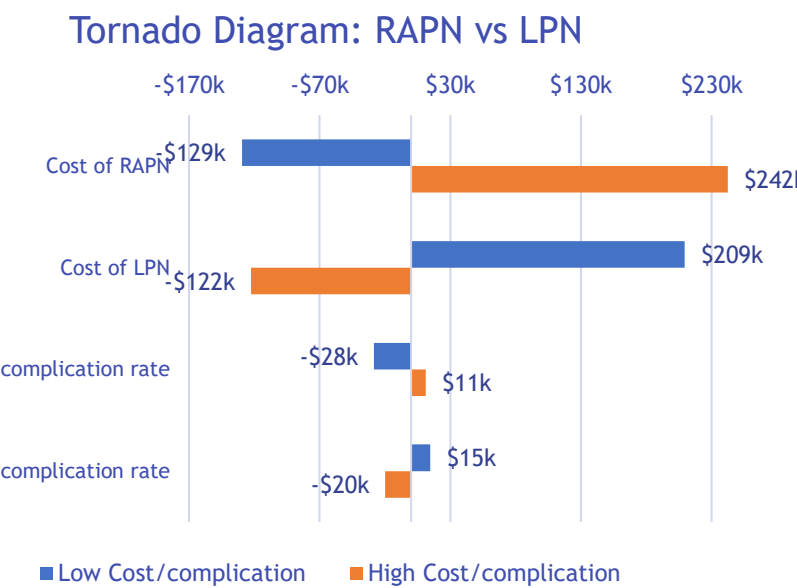
Comparison	Δ Cost	Δ QALYs	ICER (\$/QALY)	Interpretation
LPN vs. OPN	+\$334	+0.205	\$1,626	Highly cost-effective
RAPN vs. OPN	+\$1,120	+0.226	\$4,957	Highly cost-effective
RAPN vs. LPN	+\$786	+0.021	\$38,109	Modest QALY gain; higher cost



- At a \$50,000/QALY threshold, RAPN and LPN each have >95% probability of cost-effectiveness versus OPN
- RAPN vs. LPN reaches only ~55%, reflecting uncertainty in the narrow incremental QALY gain
- Both RAPN and LPN cluster in the northeast quadrant relative to OPN (higher cost, higher QALYs), with most simulations falling well below standard WTP thresholds
- The tighter LPN cluster reflects lower cost variability

Cost per Complication Avoided

Comparison	\$/Complication Avoided
LPN vs. OPN	\$7,418
RAPN vs. OPN	\$18,359
RAPN vs. LPN	\$49,130



Discussion

- Both RAPN and LPN demonstrate highly favorable perioperative ICERs versus OPN
- PSA confirmed >95% probability of cost-effectiveness for RAPN and LPN versus OPN, these reflect inpatient episode differences only
- The ICER of RAPN vs. LPN of \$38,109/QALY reflects the narrow incremental QALY gain (0.021), with PSA confirming only ~55% probability of cost-effectiveness at standard thresholds – suggesting decision-makers should interpret this comparison with caution
- In regard to cost per complication avoided, one-way sensitivity analysis identified OPN complication rate as the primary driver of uncertainty for RAPN vs. OPN, and cost uncertainty as the primary driver for LPN vs. OPN
- **Limitations:** Lack of tumor complexity data; proxy perioperative utility values; equal complication costs assumed across strategies; perioperative horizon only – long-term oncologic and renal function outcomes not captured
- Future research should incorporate tumor complexity index (e.g. RENAL nephrometry score)
- Longer-horizon modeling linking perioperative outcomes to lifetime oncologic and renal function trajectories would provide a more complete picture of comparative value across surgical approaches

References

- (1) Cheung H, Wang Y, Chang SL, Khandwala Y, Del Giudice F, Chung BI. Adoption of Robot-Assisted Partial Nephrectomies: A Population-Based Analysis of U.S. Surgeons from 2004 to 2013. *J Endourol.* 2017;31(9):886-892. doi:10.1089/end.2017.0174
- (2) Lucas SM, Mellon MJ, Erntsberger L, Sundaram CP. A comparison of robotic, laparoscopic and open partial nephrectomy. *JSLs.* 2012;16(4):581-587. doi:10.4293/108680812X13462882737177
- (3) Buse S, Hach CE, Klumpen P, et al. Cost-effectiveness analysis of robot-assisted vs. open partial nephrectomy. *Int J Med Robot.* 2018;14(4):e1920. doi:10.1002/rcs.1920



Scan this to explore sources used for parameters

Disclosure/Acknowledgement

- The authors have no conflicts of interest to declare
- This study used data from the Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample (NIS)