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REVIEW

Evolution of robotic assisted nephrectomy over time and comparison with laparoscopic assisted nephrectomy: a comprehensive literature review

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This article belongs to the Special Issue: Robot-assisted surgery vs. laparoscopy surgery; which is better?

Abstract

Objectives: Radical nephrectomy (RN) is the mainstay surgical treatment for localized kidney tumors not amenable to partial resection. A huge development in the surgical approach has been recorded with the first laparoscopic assisted radical nephrectomy (LARN) reported in 1991 and a little more than a decade later, the utilization of robotic assisted radical nephrectomy (RARN) has become popular worldwide. We aimed to compare the outcome of RARN *vs*. LARN regarding safety, feasibility and efficiency.
Methods: A systematic review was conducted using PubMed, Cochrane, PMC PubMed central and Google Scholar using relevant search terms including nephrectomy, radical, robotic and laparoscopic. All papers published and available till January 2025 were included in our study.
Results: Across the included studies, operative time varied significantly between RARN and LARN. While early studies reported longer durations for RARN, more recent analyses have demonstrated narrowing differences, with some reporting comparable operative times. Variability was attributed to factors such as robotic docking time, higher BMI, and more complex cases in RARN cohorts. Estimated blood loss (EBL) was consistently lower in the RARN group, with studies reporting significantly reduced mean EBL. Length of hospital stay (LHS) was comparable or shorter with RARN in most studies, with some reports of successful same-day discharges. Postoperative pain management showed a trend toward reduced analgesia requirements in RARN, suggesting improved patient comfort. Complication rates were low and comparable in both groups, with some studies indicating a slight advantage for RARN in intraoperative and postoperative outcomes. Warm ischemia time (WIT), relevant in donor nephrectomy, was marginally longer with RARN but not clinically significant. Additionally, RARN demonstrated significant ergonomic benefits for the surgeon, reducing musculoskeletal strain and fatigue. However, the overall procedural cost for RARN remained higher, driven primarily by equipment and maintenance expenses.
Conclusion: Robotic Assisted Radical Nephrectomy has multiple advantages and can be even safer than the laparoscopic approach on comparing the perioperative outcomes. With wider usage and availability around the world, the cost-effectiveness of RARN will also improve.
Keywords: Nephrectomy, radical nephrectomy, robotic assisted nephrectomy, minimally invasive nephrectomy, renal cancer

Introduction

Renal cancer is the fourteenth most common cancer worldwide affecting around 434,840 in 2022 [1], wherein Clear Cell Renal Cell Carcinoma (ccRCC) represents 70% of the adult renal cancer. Renal Cell Carcinoma (RCC) is the sixteenth most common cause of cancer death [1]. The risk factors include male gender (1.7:1, M: F), older age, high blood pressure and most importantly tobacco smoking. Depending on the physical, physiological and clinical presentation, management approaches to RCC greatly vary. It can range from conservative options such as watchful waiting (WW) and active surveillance (AS), to surgical and radiological options such as, partial and radical nephrectomy as well as thermal ablation [2]. While WW is mainly applied to elderly/unfit/frail patients with

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adverse perioperative outcomes with poor oncological outcomes, AS with serial imaging is another method used mainly for small suspected RCC < 4 cm in comparatively fitter patients.
Radical Nephrectomy (RN) is the gold standard surgical option for treatment of > T2 tumors, where tumor is surgically amenable. Depending on surgeon, hospital, patient choice and tumor factors, RN can also be offered to T1 patients [2].
The pace of uptake of robotic radical nephrectomy has been relatively slower compared to other procedures such as robotic radical prostatectomy, robotic partial nephrectomy or robotic pyeloplasty. This is likely due to the less overt advantages that the robotic approach offers compared to pure laparoscopy, for radical nephrectomy. The first reported case of robotic assisted laparoscopic nephrectomy was in 2001 by Guillonneau *et al*. [3] performed on a non-functioning kidney. Since then, robotic nephrectomy has gained more popularity and demonstrated positive results, both in patient and surgeon factors. This has been due to the technical advancements such as finer manipulations, three-dimensional (3D) views, greater range of movement and improving surgeon ergonomics. The use of RARN has increased from 1.5% in 2003 to 27% in 2015 [4]. In this comprehensive literature review, we aim to compare the outcomes of RARN versus LARN and attempt to evaluate its progress since the first reported case in 2001 to now in 2025.

Materials and methods

Search strategy

Our review database included PubMed, PMC PubMed Central, Cochrane, and Google Scholar. The search terms included: "Nephrectomy", "Radical Nephrectomy", "Robotic Assisted Nephrectomy", "Laparoscopic Nephrectomy", "Renal Cell Carcinoma", "Renal Cancer".

Inclusion and exclusion criteria

The following inclusion criteria were used: 1) Studies published in English Language only; 2) Studies performed in adults; 3) Evaluation of at least one perioperative outcome such as Operating time (OT), estimated blood loss (EBL), length of hospital stay (LHS), warm ischemic time (WIT) and complications; 4) Robotic donor nephrectomies (RDN) *vs* laparoscopic donor nephrectomy (LDN).
The exclusion criteria were as follows: 1) Reviews; 2) Pediatrics studies; 3) Studies on partial nephrectomy only; 4) Studies in languages other than English.
We have included all studies since 2006 - January 2025.

Data collection

We performed an extensive web search of studies using the above-mentioned terms. The initial result includes 639 papers. Abstract and manuscripts were screened, and a total 23 reviews were selected based on the inclusion criteria using the PRISMA chart (Figure 1). Data analysis was done using the Microsoft Excel sheet. The summary

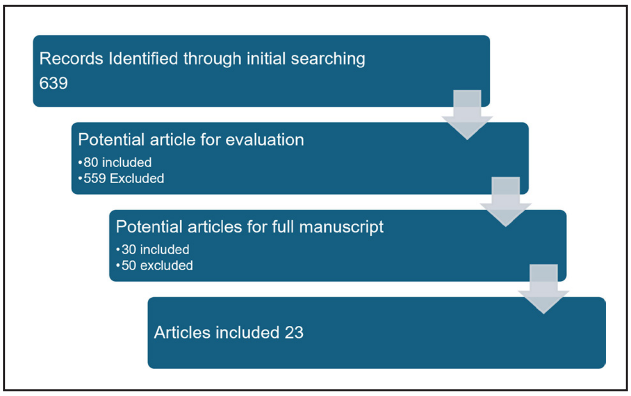

Figure 1. PRISMA chart.

of all the studies included are in (Table 1). A summary of findings between robotic and laparoscopic as per the studies included is found in (Table 2).

Results

Operation time

Patient safety and length of hospital stay are two important aspects considered when developing any new technique/ intervention. Operative time is defined as the total duration of a surgical procedure, encompassing the period from the initial incision to the final closure [27]. Nazemi *et al*. [5] in their early study in 2006 found that RARN required longer operative time (345 min in RARN arm *vs* 237.5 min in LARN arm). This study was in the nascent phases of RARN as robotic nephrectomy had only been introduced at their institute in 2001 and the study was concluded in 2004. All the 57 recorded surgeries were performed by the same surgeon. RARN showed comparable outcomes to LARN and these have been discussed in more details in relevant sections in this article.
Helmers *et al*. [6] and Yang *et al*. [7] found comparable operative times in both cohorts with no statistically significant difference in the two groups. Both these studies, reported more than 10 years after Nazemi *et al*. [5], demonstrate an improvement in operative times from ~300 min to ~150 min in the RARN arm.
Similarly, Anele *et al*. [8] in 2019 demonstrated an average operating time of 185 min in RARN arm *vs* 126 min in the LARN arm, which was statistically significant, however they also noted that the RARN arm involved more lymph node dissection (LND) and was used in patients with a higher body mass index, which might have contributed to the increased time. It was also of note in this study that the post-operative histopathology in RARN study showed a higher incidence of advanced disease (T3-4) (52.5% *vs* 24.2%) thereby indicating that the RARN cohort might have been more surgically complicated.
Takagi *et al*. [9] in their retrospective study on the learning curves for RARN *vs* LARN found that the surgeons needed 26 RARN procedures to achieve proficiency *vs* 23 LARN procedures for the laparoscopic surgery, and both these improvements in proficiency were statistically sig-

Table 1. Summary of all the studies included.

Author	Year	Journal	Country	Level of evidence	RARN/ LARN
Coco *et al.* [4]	2025	Journal of Kidney Cancer and VHL	Italy	2	
Nazemi *et al.* [5]	2006	Clinical Urology	USA	3	6/33
Helmers *et al.* [6]	2016	Canadian Journal of Urology	USA	3	76/243
Yang *et al.* [7]	2017	SpringerLink	USA	3	22/73
Anele *et al.* [8]	2019	SpringerLink	International	3	404/537
Takagi *et al.* [9]	2021	International journal of surgery		3	103/1792
Hemal and Kumar [10]	2009	SpringerLink	India	3	15/15
Asimakopoulos *et al.* [11]	2014	BMC	Italy	2	
Sands *et al.* [12]	2021	Journal of Endourology	USA	3	95/99
Hu *et al.* [13]	2015	BioMed Research International	Taiwan	3	18/18
Crocerossa *et al.* [14]	2020	Elsevier/ European Urology	Italy	2	
Grimaud *et al.* [15]	2020	Journal of Endourology	USA	3	842/2326
Windisch *et al.* [16]	2022	Springer/ PMC	Switzerland	3	72/104
Ragavan *et al.* [17]	2020	Turkish Journal of urology	India	3	
Boger *et al.* [18]	2010	JSLS	USA	3	13/46
Hinojosa-Gonzalez *et al.* [19]	2022	Annals	Mexico	2	606/570
Li *et al.* [20]	2017	JAMA Network	USA	3	5180/18573
Palese *et al.* [21]	2024	Journal of Endourology	USA	3	32/144
Harper *et al.* [22]	2008	Official journal of transplantation society	UK		
Cooper *et al.* [23]	2025	Journal of robotic surgery	UK	2	
Dalsgaard *et al.* [24]	2020	Annals of surgery	Denmark	3	
Perez-Salazar *et al.* [25]	2024	MDPI	Spain		
Greshmann *et al.* [26]	2020	European Urology Focus	USA	3	

nificant. They also noted, that more experienced surgeons had a smaller number of cases needed to achieve proficiency (Table 2).

Estimated blood loss (EBL)

Multiple studies and analyses have evaluated the intra-operative estimated blood loss (EBL) between RARN and LARN. The estimation of intra-operative blood loss as well as post-operative blood transfusion have a huge impact on morbidity and mortality related to any surgical intervention while also being a key indicator of perioperative safety.

In a retrospective study in 2015 in Taiwan, Hu *et al.* [10] found significantly smaller blood loss in the RARN arm (mean = 68.89 mL) *vs* the Laparoscopic hand assisted arm (mean = 358.33 mL).

Overall, the EBL with RARN was either equivalent [5, 7] or more commonly, reported as reduced compared to LARN [6, 9]. This was likely related to the superior 3D visualization and finer manipulation available when using the robot which offers superiority in performing vascular dissection and hemostasis. The third 'retraction' arm afforded by the robotic technique allows for improved traction that enables better visualization of vascular structures and focused coagulation prior to dissection. It also allows for better exposure and visualization of bleeders for quick and focused control.

Length of hospital stay (LHS)

Length of hospital stay forms an important factor in the economic landscape of elective surgeries in healthcare. Therefore, a reduction in LHS with stable or improving patient safety profile is important in acceptance and diffusion of new surgical techniques.

When looking at the trend of peri-operative outcomes with evolution of robotic nephrectomy, LHS has shown significant reduction. All the reported studies have shown comparable outcomes [7, 9-12] or a significantly shorter length of stay in RARN arm when compared to LARN [13]. Studies such as Hu *et al.* [10] in 2015, Crocerossa *et al.* [14] and Grimaud *et al.* [15] in 2021 and Windisch *et al.* [16] in 2022 all demonstrate a significantly shorter LHS in RARN arm as compared to LARN arm.

In 2021 Ragavan *et al.* [17] reported the first day-case robotic nephrectomies. They included simple nephrectomies (n = 7), radical nephrectomies (n = 15) along with radi-

Table 2. A summary of findings between robotic and laparoscopic nephrectomies as per the studies included.

Study		OT (min)	EBL (mL)	LOS (days)	Intra/post op	Complications	Comment
Coco *et al*. [4]	RARN	5432	Less 85	Shorter 1.3	Larger tumour		Higher cost but reduced readmission
	LARN	N/A	N/A	N/A	N/A		
Nazemi *et al*. [5]	RARN	345	125	3	19 mg	1%	
	LARN	237	125	4	30 mg	2%	
Helmers *et al*. [6]	RARN	139	50	2	More LND	Less by 2.8%	Cost $16000
	LARN	136	100	2	N/A	N/A	Cost $14000
Yang *et al*. [7]	RARN	Initially longer then equal	Similar	Similar	Longer WIT		Similar complication rate and Donor LHS and change in eGFR
	LARN		Similar	Similar			
Anele *et al*. [8]	RARN	185	N/A	3	More LND and higher BMI	Similar	
	LARN	126	N/A	5	N/A	Similar	
Takagi *et al*. [9]	RARN	180	40	3	N/A	N/A	
	LARN	179	200	4	N/A	N/A	
Hemal and Kumar. [10]	RARN	Longer	=	=	=	=	
	LARN		=	=	=	=	
Asimakopoulos *et al*. [11]	RARN	127-345	100-273	1.2-4.3	N/A		Higher cost
	LARN	N/A	N/A	N/A	N/A		
Sands *et al*. [12]	RARN	Longer 32	+ 145	Similar	N/A		Higher cost
	LARN	N/A	N/A	Similar	N/A		Higher comorbidities
Hu *et al*. [13]	RARN	255	68.8	6.7			More analgesia
	LARN	250	358	9.6			
Crocerossa *et al*. [14]	RARN	37	Lower	Shorter by 0.8			Higher $4700
	LARN						
Grimaud *et al*. [15]	RARN		N/A	Shorter by 1.73			
	LARN		N/A	N/A	Higher to covert to open		
Windisch *et al*. [16]	RARN	287	N/A	Shorter LHS	WIT 2.21		
	LARN	160	N/A	N/A	2.13		

Table 2 continued.

Study		OT (min)	EBL (mL)	LOS (days)	Intra/post op	Complications	Comment
Boger *et al.* [18]	RARN	168	100	2	30 mg	5	Cost $6869
	LARN	171	100	2	33 mg	3	Cost $5500
Hinojosa-Gonzalez *et al.* [19]	RARN	Longer 16 min	+ 10 mL	Shorter by 0.23	Longer WIM +1.14	Similar	Less use of analgesia
	LARN			N/A	N/A	Similar	
Li *et al.* [20]							No significant difference in all measurement
Palese *et al.* [21]	RARN	194	N/A	N/A	= WIT	=	
	LARN	190	N/A	N/A	=	=	
Gershman *et al.* [26]	RARN			Higher by 1.29	Lower intra and post op complication		Higher cost
	LARN						
Ambani *et al.* [28]	RARN	298	380	N/A		Similar	More LND
	LARN	251	233	N/A		Similar	
Klingler *et al.* [29]	RARN	321	150	3	28 mg		
	LARN	N/A	N/A	N/A	N/A		
Petros *et al.* [30]	RARN	172	67	1.1		5%	94% discharged day 1 post op
	LARN						

cal nephrectomy with para-aortic lymphadenectomy (n = 5), and adrenalectomy (n = 5)] in the upper-tract surgery. Their results with 0% readmission rates and no major post-operative complications (Clavien-Dindo grade>I) demonstrate a very positive trend in the direction of robotic surgery.

Pain Management

Post-operative pain management after RARN and LARN can have significant impact on LHS and patient morbidity. Most published papers showed minimal use of analgesia post-surgery in both approaches. Boger *et al*. [18] in 2010 showed the average use of opioids in form of oral morphine solution was 30 mg in RARN as compared to 33 mg in LARN. This compared to the earlier study conducted by Nazemi *et al*. [5] in 2006 found a larger difference in morphine usage; with 19 mg post RARN *vs* 30 mg post LARN, when they initially transitioned from open to robotic surgery.

The lesser use of analgesia between the two approaches was again attributed to finer movement and manipulation offered by robotic instrument stability which caused less tissue damage. The lesser use of analgesia could also be attributed to the advanced training and increased experience of the robotic surgeons.

Complication rate

Complication rates are a central consideration in evaluating the safety of minimally invasive techniques for any surgical intervention. It is reported using the Clavien–Dindo scale [31]. Multiple studies have assessed whether RARN confers a higher or lower risk of intraoperative and postoperative complications compared to LARN.

In his study, Nazemi *et al*. [5], the complication rates were 1% for RARN and 2% for LARN, demonstrating more superior perioperative outcome when using the robotic approach. The authors concluded that both approaches were equally safe, and the choice of surgical modality should be based on surgeon experience and institutional resources rather than concerns over safety.

In their systematic review Hinojosa-Gonzalez *et al*. [19] for donor nephrectomies, found a lower overall complication rate in robotic group (n = 397) *vs* laparoscopic group(n = 542), even though not significantly significant (p = 0.95). Both approaches were associated with low rates of intraoperative complications and conversions to open surgery, with minor complications such as ileus, wound issues, and urinary tract infections comprising the majority of adverse events.

In the meta- analysis conducted by Li J *et al*. [20], the authors concluded that intraoperative complications were lower in RARN, but postoperative ones were higher in comparison to LARN, intraoperative complications (OR, 1.13; 95% Cl, 0.61, 2.12; p = 0.62), postoperative complications (OR, 1.07; 95% Cl, 0.68, 1.67; p = 0.62).

In a retrospective single-center study by Windisch *et al*. [16], RDN had a smaller complication rate at 1.4% as compared to LDN at 1.9%. Similarly, a prospective analysis by Palese *et al*. [21] reported a difference in complication rates between the two techniques, reinforcing the notion that RDN is a safer alternative to LDN when performed in high volume centers by experienced surgeons.

Warm ischemic time (WIT)

WIT is a vital factor in donor nephrectomy; it is defined as the interval between arterial clamping and cold perfusion of the kidney. A shorter WIT is usually clinically associated with improved immediate graft function, although small variations are accepted (< 10 min) and may not significantly impact long-term outcomes [22]. Comparative analyses between RDN and LDN have shown a consistent, albeit small, increase in WIT associated with the robotic approach.

Hinojosa-Gonzalez *et al*. [19] performed a systematic review and meta-analysis including twelve studies and it showed that RDN was associated with a statistically significant increase in WIT compared to LDN, with a mean difference of 1.14 min(95% CI: 0.65–1.63 minutes, p < 0.0001). Despite this finding, the clinical effect on the graft function was negligible, and no significant differences in delayed graft function were observed.

A retrospective comparison between RDN and Laparoscopic Hand-Assisted DN (HADN) conducted by Windisch *et al*. [16], reporting no significant difference in WIT (RDN: 221 seconds *vs* LDN: 213 seconds; p = 0.446). Although operative times were longer in RDN, the approach was associated with a shorter LHS and reduced postoperative analgesia requirements.

Notably, a prospective study by Palese *et al*. [20] found no significant difference in WIT between RDN and LDN (mean WIT for both: 4.75 ± 1.54 min), underscoring that with optimized technique and experience, robotic approaches can match laparoscopic efficiency.

Oncological outcomes

The cancer specific survival (CSS) post-surgery for clear cell RCC is 80% as per EAU guidelines [2]. Hemal *et al*. [10] in their short term follow up of 8-9 months did not find any significant difference in the oncological outcome when comparing RARN with LARN. This was the only study we found that directly compared the robotic and laparoscopic nephrectomy arms in terms of the oncological survival.

Sands *et al*. [12] and Grimaud *et al*. [15], compared the surgical margin as part of their study, and found no difference in post-op surgical margin. However, more long-term data is currently needed to concretely conclude any advantage in oncological outcomes when comparing the two arms.

Surgeon ergonomics

Surgeon ergonomics is a critical yet often underappreciated aspect of surgical performance. RARN offers significant ergonomic advantages over LARN. In robotic surgery, the surgeon operates from a seated, console-based platform with ergonomic hand controls and high-definition 3D visualization, which reduces musculoskeletal strain and cognitive load. According to the International

Ergonomic Association, ergonomics can be defined as the understanding of the interactions amongst human and other elements of a system, and the optimisation of the environment to best fit a human work's requirements [23]. Major muscle groups used in laparoscopic surgery were identified and assessed including shoulder abductors and adductors, arm flexors and extensors, elbow flexors and extensors in addition to the wrist and hand fine movement, all these muscle groups were less activated in the robotic group when compared to the laparoscopic surgeons [24]. These ergonomic benefits are not only essential for surgeon comfort but also translate into improved surgical precision, reduced operative time in experienced hands, and improved and increased surgeon career longevity.

The existing literature directly comparing RARN *vs* LARN falls short of considering the surgeon ergonomics in their outcomes. This might be difficult to analyze for longer term benefit just yet, however in their 2024 study, Pérez-Salazar *et al*. [25] conducted simulator and experimental model surgical procedure and found robotic surgery to provide better ergonomic comfort to surgeons as compared to laparoscopic surgery.

Cost

Several studies have evaluated the economic implications of RARN compared to LARN, demonstrating increased overall cost with the robotic approach. Higher cost of maintenance and disposable instruments are the main two contributors to this. Gershmann *et al*. [26] has identified an average increase of about $1400 in the operation cost when using the robot. This was however associated with improved perioperative outcomes. More studies comparing the cost-effectiveness of RARN *vs* LARN can help global medicine in the future.

Discussion

The first laparoscopic nephrectomy was successfully performed in 1990 by Ralph Clayman [28] after observing the general surgeons and laboratory experiments. The LHS for this patient was only 6 days with an operative time of 7 hours. Within 5 years of the first LARN, Winfield *et al*. [29] reported a short case series of partial nephrectomy.

The typical laparoscopic nephrectomies require that the surgeon and the assistant remain standing throughout the surgery. The assistant is required to hold the camera steady and occasionally assist with the instruments. The classical LARN are done via 3-4 port sites.

Around the same time the first robotic surgery was being performed, this was developed using the National Aeronautics and Space Administration (NASA) inspired technology [32]. At Stanford Research Institute they used the combination of three-dimensional (3-D) environment with robotic telemanipulation. In 1985, neurosurgical biopsies were taken using Programmable Universal Machine for Assembly 200 [32]. The first documented urological utilization of this technique was in 1991 by Davies *et al*. [33] for prostatectomies. Within a decade the first reported case series of RARN [3] reported increased operative times, but comparable outcomes.

The main advantages of RARN include the 3-dimensional visualization of intra-abdominal viscera along with magnification and increased instrument maneuverability, which in turn reduce the intra-operative and post-operative morbidity. It also gives the added advantage of ergonomic benefit for the surgeon as the head, foot and hand console can be adjusted to the surgeon's physique and the assistant can also adjust the bed height, based on their physique.

We found that RARN has multiple advantages when compared to the well-established LARN approach. These advantages are mainly attributed to the advanced technology offered by the robotic system such as 3D visualization, the finer movement and less tissue trauma. Although it is thought to have longer operative time initially [5, 7] the increased experience of the surgeons performing this approach as well as its widespread usage allows to shorten this to almost equivalent time required for the LARN. Notably, the robotic approach involved more frequent lymph node dissection (LND) and greater median node count [25], compared to LARN in these studies that compared operation time.

In multivariable analyses Gershmann *et al*. [26] found RARN remained independently associated with a lower risk of intraoperative (odds ratio [OR] 0.50; $p = 0.001$) and postoperative complications (OR 0.72; $p < 0.001$). Klingler *et al*. [30] demonstrated a median tumor size of 66 cm^3 (29-120) when using the Da Vinci system in RARN. Multiple different robots are available and currently being used across the world such as Da Vinci and Da Vinci Xi [34]; along with Hugo™ [35] with ongoing progress in technology.

Some of the evolving changes in the new robots are the transition from a head console to a screen with hand and finger controls in Hugo™ [35] and the introduction of joystick handler for control in Versius™ [36].

Petros *et al*. [37] have concluded that RN allows for consistent outcomes regardless of procedure complexity. Which reinforces the advantage of the robotic approach in more challenging cases. We did not find a significant drop in blood loss using either RARN or LARN, although some studies suggested a reduction in EBL when using the robotic approach [9, 13].

Both approaches are considered minimally invasive with the RARN associated with fewer intra and post-operative complications on the Clavien–Dindo scale, shorter LHS and improved surgeon ergonomics. It has already demonstrated that it has long term advantages and potential for continued development with improving elements in the robot systems. Therefore, in our study we find robotic nephrectomy a suitable and promising progression from laparoscopic nephrectomy in terms of minimally invasive surgery. With wider usage of this technology, the cost effectiveness will also improve and this in turn can create more space for further patient and surgeon factor analysis in the field of robotic surgery.

Conclusions

Since its introduction, robotic surgery has shown immense promise and potential. This literature review, reflecting at the timeline of robotic surgery from 2006 till now helps highlight the safety profile and the ongoing improvement in patient safety with robotic surgery. With progress to day case robotic surgery and robotic nephrectomies, it would be helpful to see long-term outcomes for patients and surgeons. We recommend more research incorporating long term outcomes for both patients and surgeons, with greater emphasis on patient-centered measures such as postoperative pain, return to normal activities along with quality of life and surgeon outcomes and longevity.

Declarations

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References

1. Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, *et al*. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*, 2024, 74(3): 229-263. [Crossref]
2. (2025). "Renal Cell Carcinoma." from https://uroweb.org/guidelines/renal-cell-carcinoma/chapter/disease-management.
3. Guillonneau B, Jayet C, Tewari A, & Vallancien G. Robot assisted laparoscopic nephrectomy. *J Urol*, 2001, 166(1): 200-201.
4. Coco D, Leanza S, Viola MG, & Coco D. Systematic review of robotic nephrectomy for kidney cancer. *J Kidney Cancer VHL*, 2025, 12(1): 29-35. [Crossref]
5. Nazemi T, Galich A, Sterrett S, Klingler D, Smith L, & Balaji KC. Radical nephrectomy performed by open, laparoscopy with or without hand-assistance or robotic methods by the same surgeon produces comparable perioperative results. *Int Braz J Urol*, 2006, 32(1): 15-22. [Crossref]
6. Helmers MR, Ball MW, Gorin MA, Pierorazio PM, & Allaf ME. Robotic versus laparoscopic radical nephrectomy: comparative analysis and cost considerations. *Can J Urol*, 2016, 23(5): 8435-8440.
7. Yang A, Barman N, Chin E, Herron D, Arvelakis A, LaPointe Rudow D, *et al*. Robotic-assisted *vs.* laparoscopic donor nephrectomy: a retrospective comparison of perioperative course and postoperative outcome after 1 year. *J Robot Surg*, 2018, 12(2): 343-350. [Crossref]
8. Anele UA, Marchioni M, Yang B, Simone G, Uzzo RG, Lau C, *et al*. Robotic versus laparoscopic radical nephrectomy: a large multi-institutional analysis (ROSULA Collaborative Group). *World J Urol*, 2019, 37(11): 2439-2450. [Crossref]
9. Takagi K, Kimenai H, Terkivatan T, Tran KTC, Ijzermans JNM, & Minnee RC. Learning curves of minimally invasive donor nephrectomy in a high-volume center: a cohort study of 1895 consecutive living donors. *Int J Surg*, 2021, 86: 7-12. [Crossref]
10. Hemal AK, & Kumar A. A prospective comparison of laparoscopic and robotic radical nephrectomy for T1-2N0M0 renal cell carcinoma. *World J Urol*, 2009, 27(1): 89-94. [Crossref]
11. Asimakopoulos AD, Miano R, Annino F, Micali S, Spera E, Iorio B, *et al*. Robotic radical nephrectomy for renal cell carcinoma: a systematic review. *BMC Urol*, 2014, 14: 75. [Crossref]
12. Sands KG, Figenshau RS, Vetter J, Paradis A, Pierce A, Kim EH, *et al*. Contemporary pure laparoscopic *vs* robot-assisted laparoscopic radical nephrectomy: is the transition worth it? *J Endourol*, 2021, 35(10): 1526-1532. [Crossref]
13. Hu CY, Yang CK, Huang CY, Ou YC, Hung SF, Chung SD, *et al*. Robot-assisted laparoscopic nephroureterectomy versus hand-assisted laparoscopic nephroureterectomy for upper urinary tract urothelial carcinoma: a matched comparison study. *Biomed Res Int*, 2015, 2015: 918486. [Crossref]
14. Crocerossa F, Carbonara U, Cantiello F, Marchioni M, Ditonno P, Mir MC, *et al*. Robot-assisted radical nephrectomy: a systematic review and meta-analysis of comparative studies. *Eur Urol*, 2021, 80(4): 428-439. [Crossref]
15. Grimaud LW, Chen FV, Chang J, Ziogas A, Sfakianos JP, Badani KK, *et al*. Comparison of perioperative outcomes for radical nephrectomy based on surgical approach for masses greater than 10 cm. *J Endourol*, 2021, 35(12): 1785-1792. [Crossref]
16. Windisch OL, Matter M, Pascual M, Sun P, Benamran D, Bühler L, *et al*. Robotic versus hand-assisted laparoscopic living donor nephrectomy: comparison of two minimally invasive techniques in kidney transplantation. *J Robot Surg*, 2022, 16(6): 1471-1481. [Crossref]
17. Ragavan N, Bafna S, Thangarasu M, Prakash S, Paul R, Chirravur P, *et al*. Day-case robot-assisted laparoscopic surgery: feasibility and safety. *Turk J Urol*, 2021, 47(1): 30-34. [Crossref]
18. Boger M, Lucas SM, Popp SC, Gardner TA, & Sundaram CP. Comparison of robot-assisted nephrectomy with laparoscopic and hand-assisted laparoscopic nephrectomy. *Jsls*, 2010, 14(3): 374-380. [Crossref]
19. Hinojosa-Gonzalez DE, Roblesgil-Medrano A, Tellez-Giron VC, Torres-Martinez M, Galindo-Garza CA, Estrada-Mendizabal RJ, et al. Robotic-assisted versus laparoscopic living donor nephrectomy for renal transplantation: a systematic review and meta-analysis. *Ann R Coll Surg Engl*, 2023, 105(1): 7-13. [Crossref]
20. Li J, Peng L, Cao D, Cheng B, Gou H, Li Y, *et al*. Comparison of perioperative outcomes of robot-assisted *vs*. Laparoscopic radical nephrectomy: a systematic review and meta-analysis. *Front Oncol*, 2020, 10: 551052. [Crossref]
21. Palese MA, Chin CP, Garden EB, Eilender B, Levy M, Ravivarapu KT, *et al*. Comparison of single-port robotic donor nephrectomy and laparoscopic donor nephrectomy.

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J Endourol, 2024, 38(2): 136-141. [Crossref]
22. Harper SJ, Hosgood SA, Waller HL, Yang B, Kay MD, Goncalves I, *et al*. The effect of warm ischemic time on renal function and injury in the isolated hemoperfused kidney. *Transplantation*, 2008, 86(3): 445-451. [Crossref]
23. Cooper H, Lau HM, & Mohan H. A systematic review of ergonomic and muscular strain in surgeons comparing robotic to laparoscopic approaches. *J Robot Surg*, 2025, 19(1): 252. [Crossref]
24. Dalsgaard T, Jensen MD, Hartwell D, Mosgaard BJ, Jørgensen A, & Jensen BR. Robotic surgery is less physically demanding than laparoscopic surgery: paired cross sectional study. *Ann Surg*, 2020, 271(1): 106-113. [Crossref]
25. Pérez-Salazar MJ, Caballero D, Sánchez-Margallo JA, & Sánchez-Margallo FM. Comparative study of ergonomics in conventional and robotic-assisted laparoscopic surgery. *Sensors*, 2024, 24(12): 3840.
26. Gershman B, Bukavina L, Chen Z, Konety B, Schumache F, Li L, *et al*. The association of robot-assisted versus pure laparoscopic radical nephrectomy with perioperative outcomes and hospital costs. *European Urology Focus*, 2020, 6(2): 305-312. [Crossref]
27. (2025). "Significance of operative time." from www.wisdomlib.org/concept/operative-time.
28. Cwach K, & Kavoussi L. Past, present, and future of laparoscopic renal surgery. *Investig Clin Urol*, 2016, 57(Suppl 2): S110-s113. [Crossref]
29. Winfield HN, Donovan JF, Lund GO, Kreder KJ, Stanley KE, Brown BP, *et al*. Laparoscopic partial nephrectomy: initial experience and comparison to the open surgical approach. *J Urol*, 1995, 153(5): 1409-1414. [Crossref]
30. Klingler DW, Hemstreet GP, & Balaji KC. Feasibility of robotic radical nephrectomy--initial results of single-institution pilot study. *Urology*, 2005, 65(6): 1086-1089. [Crossref]
31. Dindo D, Demartines N, & Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*, 2004, 240(2): 205-213. [Crossref]
32. Morrell ALG, Morrell-Junior AC, Morrell AG, Mendes JMF, Tustumi F, LG DE-O-E-S, *et al*. The history of robotic surgery and its evolution: when illusion becomes reality. *Rev Col Bras Cir*, 2021, 48: e20202798. [Crossref]
33. Davies BL, Hibberd RD, Ng WS, Timoney AG, & Wickham JE. The development of a surgeon robot for prostatectomies. *Proc Inst Mech Eng H*, 1991, 205(1): 35-38. [Crossref]
34. (2025). "Intuitive's da Vinci 5 surgical system." from https://www.intuitive.com/en-gb.
35. (2025). "Hugo™ robotic-assisted surgery (RAS) system." from https://www.medtronic.com/covidien/en-gb/robotic-assisted-surgery/hugo-ras-system.html.
36. Koukourikis P, & Rha KH. Robotic surgical systems in urology: what is currently available? *Investig Clin Urol*, 2021, 62(1): 14-22. [Crossref]
37. Petros FG, Angell JE, & Abaza R. Outcomes of robotic nephrectomy including highest-complexity cases: largest series to date and literature review. *Urology*, 2015, 85(6): 1352-1359. [Crossref]

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