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The Analysis Study of Surgical Approaches and Outcome in Living Donor Nephrectomy: A Comprehensive Systematic Review

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ABSTRACT

Background: The shortage of deceased donor kidneys has led to a significant increase in the use of living donor kidneys for transplantation. Since the first successful living donor nephrectomy in the 1950s, surgical techniques have advanced considerably, evolving from open donor nephrectomy (ODN) to more refined minimally invasive procedures. This systematic review aims to compare the various surgical techniques for living donor nephrectomy and their outcomes. **Methods:** The study followed PRISMA 2020 guidelines, reviewing English-language publications from 2014 to 2024. Editorials, duplicate reviews from the same journal, and papers lacking a DOI were excluded. The literature search was conducted using PubMed, SagePub, SpringerLink, and Google Scholar. **Result:** A total of 2,172 articles were initially identified through online databases (PubMed, SagePub, SpringerLink, and Google Scholar). After three rounds of screening, eight relevant studies were selected for full-text analysis. **Conclusion:** LDN and other minimally invasive techniques, such as RDN and robot-assisted nephrectomy, offer advantages in recovery time and reduced complications. However, each method has unique strengths and considerations. The choice of approach should depend on donor anatomy, surgeon expertise, and institutional resources.

Keywords: nephrectomy, living donor, kidney donor

INTRODUCTION

The shortage of deceased donor kidneys has led to a significant increase in the use of living donor kidneys for transplantation. Since the first successful living donor nephrectomy in the 1950s, surgical techniques have advanced considerably, evolving from open donor nephrectomy (ODN) to more refined minimally invasive procedures. These include laparoscopic donor nephrectomy (LDN), hand-assisted laparoscopic donor nephrectomy (HALDN), retroperitoneoscopic LDN (RDN), and robot-assisted donor nephrectomy (RADN). These innovations aim to improve donor safety, reduce recovery time, and optimize outcomes for both donors and recipients.[1–3]

Over time, the field of living donor nephrectomy has seen significant changes, transitioning from the traditional ODN to minimally invasive methods. LDN, for example, is associated with shorter operating times, reduced blood loss, and quicker recovery when compared to RADN. Despite this, robot-assisted techniques, although more costly and time-consuming, offer increased precision during surgery.[4,5]

The safety of the donor is a crucial consideration in living donor nephrectomy, as the procedure involves healthy individuals undergoing a high-risk surgery. Minimizing complications and ensuring a swift recovery are of utmost importance. Studies have shown that minimally invasive techniques, such as LDN, generally lead to shorter hospital stays, less need for analgesics, and faster recovery compared to open surgery. These benefits reduce donor morbidity and improve their overall experience, which has made these approaches increasingly preferred by surgeons.

Despite numerous studies on various nephrectomy techniques, a comprehensive systematic review comparing all the available approaches is lacking. Most existing reviews focus on pairwise

comparisons of specific methods, addressing outcomes such as complications or recovery time, but do not provide an overarching comparison of all surgical options. In particular, there is limited analysis of long-term outcomes like graft survival and delayed graft function (DGF), which are critical to the success of kidney transplantation.[6,7]

While previous research has primarily focused on donor-related outcomes, the impact of different surgical approaches on recipient outcomes—such as graft survival and DGF—deserves equal attention. Some studies suggest that the surgical method may influence the rate of DGF and 1-year graft survival, but these relationships are not fully understood.[8] This systematic review aims to compare the various surgical techniques for living donor nephrectomy and their outcomes.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to compare the various surgical techniques for living donor nephrectomy and their outcomes based on literature from the past decade. The review aimed to provide insights to improve patient treatment strategies, with an emphasis on the significance of key findings in the reviewed studies. Inclusion criteria for the study included: 1) Papers published in English, and 2) Papers published between 2014 and 2024. Exclusion criteria were: 1) Editorials, 2) Papers without a DOI, 3) Previously published review articles, and 4) Duplicate entries in journals..

Search Strategy

The keywords used for this research are nephrectomy, living donor, kidney donor. The Boolean MeSH keywords inputted on databases for this research are:

("nephrectomy"[MeSH Terms] OR "nephrectomy"[All Fields] OR "nephrectomies"[All Fields]) AND ("living donors"[MeSH Terms] OR ("living"[All Fields] AND "donors"[All Fields]) OR "living donors"[All Fields] OR ("living"[All Fields] AND "donor"[All Fields]) OR "living donor"[All Fields]) AND (("kidney"[MeSH Terms] OR "kidney"[All Fields] OR "kidneys"[All Fields] OR "kidney s"[All Fields]) AND ("donor s"[All Fields] OR "tissue donors"[MeSH Terms] OR ("tissue"[All Fields] AND "donors"[All Fields]) OR "tissue donors"[All Fields] OR "donor"[All Fields] OR "donors"[All Fields])).

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	("nephrectomy"[MeSH Terms] OR "nephrectomy"[All Fields] OR "nephrectomies"[All Fields]) AND ("living donors"[MeSH Terms] OR ("living"[All Fields] AND "donors"[All Fields]) OR "living donors"[All Fields] OR ("living"[All Fields] AND "donor"[All Fields]) OR "living donor"[All Fields]) AND (("kidney"[MeSH Terms] OR "kidney"[All Fields] OR "kidneys"[All Fields] OR "kidney s"[All Fields]) AND ("donor s"[All Fields] OR "tissue donors"[MeSH Terms] OR ("tissue"[All Fields] AND "donors"[All Fields]) OR "tissue donors"[All Fields] OR "donor"[All Fields] OR "donors"[All Fields]))	466
Springer Link	((nephrectomy) AND (living donor)) AND (kidney donor)	402
Sagepub	((nephrectomy) AND (living donor)) AND (kidney donor)	500
Google Scholar	((nephrectomy) AND (living donor)) AND (kidney donor)	804

Table 2. JBI *Critical appraisal of Study*

Parameters	Serrano (2016)	Windisch (2022)	Zaytoun (2021)	Garcia-Ochoa (2019)	Achit (2020)	Burkhalter (2017)	Musquera (2022)	Khalil (2016)
1. Bias related to temporal precedence Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation Was there a control group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Bias related to confounding factors Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No.	No.	No.	No.	No.	No.	No.	No.
5. Bias related to assessment, detection, and measurement of the outcome Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	No.	No.	No.	No.	No.	No.	No.	No.
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6. Bias related to participant retention Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

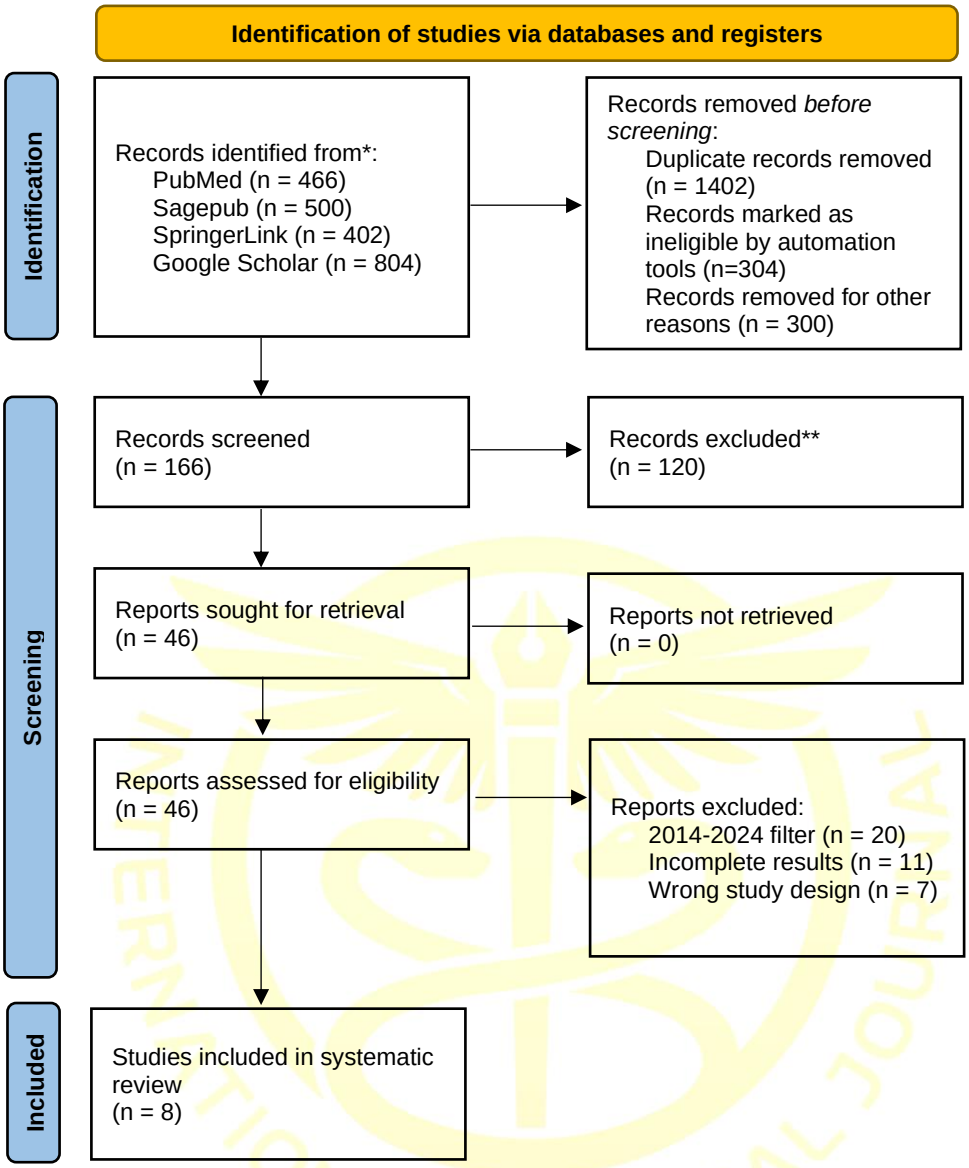

Figure 1. Article search flowchart

RESULT

The initial number of articles retrieved from online databases (PubMed, SagePub, SpringerLink, and Google Scholar) is 2,172 articles. After conducting three levels of screening, eight articles that directly relate to the current systematic review have been chosen for further assessment through full-text reading and analysis. Table 3 presents the selected literature included in this analysis.

Table 3. The literature included in this study

No.	Author	Origin	Method	Sample	Result
1.	Serrano, et al.[9] (2016)	USA	Retrospective cohort study	4286	In this study of 4,286 donor nephrectomies (DNs), 2,759 were open donor nephrectomies (ODNs), 1,190 were hand-assisted laparoscopic DNs (HA-LDNs), 203 were pure laparoscopic DNs (P-LDNs), and 97 were robot-assisted laparoscopic DNs (RADNs). Laparoscopic DNs were associated with older and heavier donors, and a higher likelihood of left kidney procurement. While laparoscopic techniques resulted in longer operative times, robot-assisted LDN required significantly more time than both HA-LDN and P-LDN. Laparoscopic procedures reduced the need for blood transfusions, intraoperative complications, and hospital stays, but led to higher rates of readmissions, both short-term and long-term. HA-LDN had a higher incidence of incisional hernia compared to other

					modalities. For recipients, LDN showed lower rates of graft failure at one year compared to ODN, but P-LDN with multiple arteries was linked to a higher risk of delayed graft function.
2.	Windisch, et al.[10] (2022)	Switzerland	Retrospective cohort study	176	This study included 176 patients, with 72 undergoing retroperitoneoscopic donor nephrectomy (RDN) and 104 undergoing hand-assisted laparoscopic donor nephrectomy (HLDN). Left-sided nephrectomy was more common in the RDN group (82% vs 52%, $p < 0.01$). The operative time was significantly longer in RDN (287 minutes vs 160 minutes, $p < 0.01$), while warm ischemia time was similar between the two groups (221 seconds vs 213 seconds, $p = 0.446$). The hospital stay was shorter for RDN (3.9 days vs 5.7 days, $p < 0.01$). A slight but persistent increase in creatinine ratio (7%) was observed in the RDN group compared to HLDN (1.56 vs 1.44 at one-month checkup, $p < 0.01$).
3.	Zaytoun, et al.[11] (2021)	Egypt	Retrospective cohort study	110	This study included patients with a mean age of 38 years, of whom 77% were male. Three cases (2.72%) required conversion to open donor nephrectomy (ODN), but

					no cases required intraoperative blood transfusions. The mean warm ischemia time (WIT) was 2.6 minutes. Two cases (1.8%) experienced major vascular injury (Clavien grade IIIb), leading to conversion to ODN. Postoperatively, one patient (0.9%) required a transfusion of one unit of packed red blood cells (Clavien grade II). The mean length of stay (LOS) was 2 days. The most common early postoperative complication was ileus (Clavien grade II) in 4 cases (3.6%), followed by incisional hernia (Clavien grade IIIb) in 2 cases (1.8%) and wound infection (Clavien grade I) in 2 cases (1.8%), which were treated conservatively.
4.	Garcia-Ochoa, et al.[12] (2019)	Canada	Retrospective cohort study	1421	In this study of 1,421 living kidney donor candidates, 1,042 individuals proceeded with donation, and 134 (13%, 95% CI: 11%-15%) experienced 142 perioperative complications, including 55 intraoperative and 87 postoperative. The most common intraoperative complication was organ injury, while ileus was the most frequent postoperative complication. No donor

					deaths occurred during the perioperative period. The majority of complications were minor (90% of 142 complications, 95% CI: 86%-96%), with only 12 donors (1%, 95% CI: 1%-2%) experiencing major complications. No significant differences in complication rates were found between donor groups or by surgeon characteristics, nor by high- versus low-volume centers. A survey of 43 of 48 eligible surgeons (90%) revealed no variation in complication rates based on these factors.
5.	Achit, et al.[13] (2020)	France	Retrospective cohort study	264	In this study of 264 kidney donors, the participants underwent open surgery (n = 65) or one of three laparoscopic techniques: standard laparoscopic nephrectomy (n = 65), hand-assisted laparoscopic nephrectomy (n = 65), and robot-assisted laparoscopic nephrectomy (n = 69). While the nephrectomy techniques varied significantly in cost and immediate postoperative outcomes, there were no differences in clinical outcomes at 90 days. Hand-assisted laparoscopy was the most cost-effective, with the lowest cost per quality-of-life recovery unit and shortest post-operative disability

					days (e2056/40.1%/2.3 days). Robot-assisted laparoscopy, despite having the highest cost (e3430/59.1%/2.6 days), provided the best post-operative outcomes.
6.	Burkhalter, et al.[14] (2017)	Switzerland	Retrospective cohort study	1649	In this study, no perioperative mortality was observed, and the overall complication rate was 13.5%. Major complications (Clavien ≥3) occurred in 2.1% of donors. Obesity was not associated with any complications. However, donor age over 70 years was linked to an increased risk of major complications (odds ratio [OR] 3.99) and genitourinary issues, such as urinary tract infections (OR 5.85) and urinary retention (OR 6.61). While there were more major complications in donors who underwent laparoscopic surgery compared to open surgery (p = 0.048), the overall complication rate was similar between the two groups (p = 0.094).
7.	Musquera, et al.[15] (2022)	Spain	Retrospective cohort study	714	This study involved 714 minimally invasive living donor nephrectomies (MILDNs), with 541 cases (75.88%) using the conventional laparoscopic approach, 116 (16.9%) using natural orifice transluminal endoscopic

					surgery (NOTES), 55 (7.7%) using laparoendoscopic single-site surgery (LESS), and one mini open (0.14%). Two-thirds of the donors were female, with a mean age of 52.87 years. Six donors (0.8%) had a small renal mass, which was removed before transplantation. The right kidney was removed in 17.8% of cases. Warm ischemia time was higher in the NOTES and LESS groups, and there were eight conversions to open surgery. The intraoperative and postoperative complication rates were 6.8% and 4.9%, respectively, with no donors developing renal disease during a mean follow-up of 3.68 years. The five-year recipient and graft survival rates were 98.8% and 96.8%, respectively.
8.	Khalil, et al.[16] (2016)	USA	Retrospective cohort study	58 599	This study analyzed 58,599 living donor transplants, with 86.1% of them being laparoscopic donor nephrectomies (LDN). There were no significant demographic differences between recipients or donors. Right donor nephrectomy (RDN) recipients had higher rates of delayed graft function, with a hazard ratio of 1.38 (95% CI 1.24–1.53; p <

					0.0001). While primary failure rates were similar, graft thrombosis was more common in the RDN group, with a hazard ratio of 1.48 (95% CI 1.18–1.86, p = 0.0004), and graft survival was significantly lower (p = 0.006). For donors, the conversion from laparoscopic to open surgery was higher in the RDN group (odds ratio 2.02, 95% CI 1.61–2.52; p < 0.00001). There was no significant difference in vascular complications or re-operations due to bleeding, though re-operations and readmissions were higher in the LDN group.

Serrano, et al.[9] (2016) showed that laparoscopic techniques decreased intraoperative complications and hospital length of stay but were associated with increased readmission rates and long-term complications.

Windisch, et al.[10] (2022) suggest that RDN is a safe and effective alternative to the standard HLDN technique, with similar warm ischemia times but longer operative times for RDN. RDN patients had a shorter hospital stay, though this may be influenced by differences in hospital discharge criteria.

Zaytoun, et al.[11] (2021) found that living donor nephrectomy (LDN) is a safe and effective technique with manageable intraoperative and postoperative complications. It offers advantages such as a short hospital stay, better cosmesis, and faster recovery. In experienced hands, it can successfully address vascular and

ureteral anomalies without compromising early graft function.

Garcia-Ochoa, et al.[12] (2019) confirms the safety of living kidney donation, with a low rate of major perioperative complications. No specific donor or surgeon characteristics were associated with an increased risk of complications.

Achit, et al.[13] (2020) showed that hand-assisted, standard, and robot-assisted laparoscopies are more cost-effective than open surgery, with hand-assisted laparoscopic surgery being the most cost-efficient. Robot-assisted surgery, while more resource-intensive, delivers the best clinical outcomes.

Burkhalter, et al.[14] (2017) found a low rate of both major and minor complications following living donor nephrectomy, regardless of surgical technique. Obesity did not increase the risk of complications, but elderly donors over 70 years had a higher risk for perioperative complications.

Musquera, et al.[15] (2022) concluded that MILDN techniques are safe for both donors and grafts, with low complication rates.

Khalil, et al.[16] (2016) showed that while there are statistical differences between left and right kidney donor nephrectomies in terms of recipient outcomes, these differences are minimal. The choice of donor kidney and laterality should be based on center and surgeon preference and experience.

DISCUSSION

Living donor nephrectomy (LDN) has become a cornerstone in the treatment of end-stage renal disease, providing a crucial alternative to deceased donor transplants. Over the years, the evolution of surgical techniques has improved donor safety and transplant outcomes, contributing to the growing preference for minimally invasive approaches. This systematic review synthesizes findings from several studies, providing a comprehensive overview of the different surgical approaches, their outcomes, and donor-related factors influencing complications.[17–19]

The study by Serrano et al. (2016) highlighted key differences between open donor nephrectomy

(ODN) and laparoscopic techniques, which include hand-assisted laparoscopic (HA-LDN), pure laparoscopic (P-LDN), and robot-assisted laparoscopic nephrectomies (RADNs).[20] The use of laparoscopic techniques was associated with reduced intraoperative complications and shorter hospital stays, while robot-assisted techniques, despite being more time-consuming, showed superior clinical outcomes in the immediate postoperative period. These findings emphasize the advantage of laparoscopic approaches in terms of donor recovery, although the higher readmission rates associated with laparoscopic methods may necessitate further investigation into long-term outcomes.[9]

In a similar vein, Windisch et al. (2022) explored retroperitoneoscopic donor nephrectomy (RDN) and hand-assisted laparoscopic donor nephrectomy (HLDN), finding that while RDN required longer operative times, it was associated with a shorter hospital stay compared to HLDN. This may be due to the less invasive nature of the retroperitoneal approach, which minimizes abdominal wall manipulation, potentially leading to quicker recovery. Despite the longer surgery time for RDN, both techniques demonstrated comparable warm ischemia times, indicating similar efficacy in kidney preservation. These results support RDN as a safe alternative to HLDN, particularly for centers where the retroperitoneal approach is well-established.[10]

Zaytoun et al. (2021) further emphasized the safety and efficacy of laparoscopic approaches, including managing complications like vascular injuries. This study demonstrated that even with more complex anatomical challenges, such as vascular and ureteral anomalies, LDN could be safely performed with minimal impact on early graft function. The short hospital stays and rapid recovery associated with LDN make it an appealing option for both donors and recipients, reinforcing the notion that minimally invasive techniques are beneficial in terms of donor morbidity and recovery.[11]

Garcia-Ochoa et al. (2019) observed a low incidence of major

perioperative complications, with only a small proportion of donors experiencing significant adverse events. The study also revealed no correlation between surgeon experience or center volume and complication rates, suggesting that living kidney donation can be safely performed in a variety of settings. This further strengthens the argument that LDN, regardless of the surgeon's experience level, is a safe procedure when performed under proper conditions.[12]

Cost-effectiveness is another critical factor in the choice of surgical technique, as demonstrated by Achit et al. (2020). Their study found that while robot-assisted laparoscopic nephrectomy offered the best clinical outcomes, it was the most resource-intensive approach. In contrast, HA-LDN proved to be the most cost-effective, with fewer postoperative disability days and a more favorable cost per quality-of-life recovery unit. This highlights the importance of considering not only clinical outcomes but also economic factors when selecting a surgical approach, especially in resource-constrained settings.[13]

Burkhalter et al. (2017) explored the role of donor characteristics in influencing complication rates, specifically focusing on obesity and age. While obesity did not appear to increase the risk of complications, older donors, particularly those over 70, had a significantly higher risk of major complications. These findings align with the general consensus that careful consideration of donor age is crucial in minimizing perioperative risks. This study underscores the importance of individualized donor selection to ensure the safety of both the donor and recipient.[14]

Musquera et al. (2022) added further evidence supporting the safety of minimally invasive living donor nephrectomy (MILDN). The study showed low complication rates, with a five-year graft survival rate of 96.8%. This finding aligns with previous studies highlighting the benefits of MILDN techniques in both donor and graft outcomes. While the increased warm ischemia time observed in the NOTES and LESS

groups warrants attention, the overall favorable outcomes suggest that these techniques can be considered safe, provided proper expertise is available.[15]

Khalil et al. (2016) examined the differences between left and right kidney donor nephrectomies, showing minimal statistical differences in recipient outcomes. However, the study highlighted the increased risk of delayed graft function in recipients of right donor kidneys, suggesting that the choice of kidney laterality should be based on the surgeon's experience and the preferences of the transplant center. This finding reinforces the flexibility in donor selection, where the choice of laterality is less critical than factors such as donor health and surgical expertise.[16]

The accumulated evidence from these studies consistently supports the safety and efficacy of laparoscopic and minimally invasive approaches to living donor nephrectomy. While certain complications, such as delayed graft function and the need for conversion to open surgery, remain a concern, the overall complication rates are low. Notably, the risk of complications is influenced by factors such as donor age and the presence of comorbidities, particularly obesity and vascular anomalies. Thus, donor selection remains a critical aspect of ensuring successful outcomes.[21,22]

CONSCLUSION

Ureteroscopy is a safe, effective, and cost-efficient treatment for ureteral calculi during pregnancy. Early intervention minimizes complications, and URS remains a successful option for managing obstructive uropathy. Future research should optimize protocols and assess long-term outcomes for improved care.

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