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Review

THE ROLE OF MINI-INVASIVE APPROACHES IN LIVING KIDNEY DONATION

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Summary

Today, living organ donation for transplantation has become a standardized practice, widely recognized for its incredible generosity and significant benefits to recipients in both the pediatric and adult fields. Living donor nephrectomy involves a singular surgical scenario where surgery is performed on a healthy individual with the primary objective of benefiting another patient.

It is well recognized that living donor kidney transplantation (LDKT) offers better outcomes in terms of recipient and organ survival, particularly if carried out pre-emptively, than deceased donor transplantation [1]. LDKT offers several significant benefits, including shorter waiting times for transplantation, higher quality kidney grafts and an elective surgical setting.

The percentage of living donations in the kidney transplant field has grown exponentially over the last 20 years in many countries.

The growth of this activity in recent decades has been driven, on one hand, by the development of ABO-incompatible transplant programs, kidney paired donation and HLA desensitization programs. On the other hand, a significant contribution can be found in the introduction of laparoscopic surgery in living donor nephrectomy, which has confirmed advantages over classic open surgery in terms of less postoperative pain, shorter hospital stay, faster recovery, and better cosmetic results.

We summarize here the various minimally invasive approaches in living kidney donation available today and their impact on the development of this procedure, with a particular focus on the Italian scenario

Key words: living donor nephrectomy, organ donation, kidney transplantation, mini-invasive surgery, laparoscopic, robotic

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INTRODUCTION

Today, living organ donation for transplantation has become a standardized practice, widely recognized for its incredible generosity and significant benefits to recipients in both the pediatric and adult fields. Living donor nephrectomy involves a singular surgical scenario where surgery is performed on a healthy individual with the primary objective of benefiting another patient.

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Technical aspects

The transperitoneal laparoscopic approach is considered the gold standard technique for living kidney donation, since the first report on laparoscopic living-donor nephrectomy in 1995 by Ratner [2, 3].

Over the years, the growing interest in this field has led to the development of new surgical approaches, spreading minimally invasive donor nephrectomy all over the world.

After the development of totally laparoscopic nephrectomy, hand-assisted-living donor nephrectomy (HALDN) was introduced in 1998 by Wolf et al. [4] to address concerns about long warm ischemia time associated with the totally laparoscopic procedure. This specific concern has been explored by two randomised controlled trials in 2006 [5] and 2008 [6], however, the authors did not find any significant differences between the two techniques, except for a small reduction in warm ischaemia time and operative time for the HALDN technique.

In 2002, Enrico Benedetti and his group in Chicago [7] introduced the application of the robotic system to donor nephrectomy, providing some potential advantages over laparoscopy: better ergonomics for the surgeon, the stability of the camera, and the optical 3-dimensional magnification. Moreover, it played a significant role in safely expanding the inclusion criteria to a large range of obese donors.

Recently, following the enthusiastic attempts of donor surgeons to further minimise morbidity and ameliorate cosmetic results, other laparoscopic techniques which include natural orifice transluminal endoscopic surgery (NOTES)-assisted and laparo-endoscopic single-site surgery (LESS) have been developed, with excellent results for both the donor and the graft.

In 2007, Raman et al. [8] pioneered the first single keyhole nephrectomy, utilizing novel articulating laparoscopic instrumentation (LESS-DN). This approach enabled intracorporeal triangulation and specimen extraction via the abdominal wall, addressing potential complications associated with NOTES, such as the risk of fistulization and sexual dysfunction.

In 2008, Gill et al. [9] demonstrated the feasibility of donor nephrectomy through an intra-umbilical incision, employing a novel single-access tri-lumen R-port. They termed this technique E-NOTES, emphasizing the use of the umbilicus, an embryonic (E) natural orifice, to avoid the need to open normal organs (vagina, stomach, rectum or urinary bladder) for graft extraction. This approach is categorized under NOTES rather than LESS.

In a recent retrospective series Musquera et al. [10], shared their 20 years of experience with transvaginal NOTES-assisted nephrectomy (offered to women with BMI < 30 kg/m^2 and an elastic vagina without pelvic varicosities) or LESS nephrectomy, provided to living donors with BMI < 27 kg/m^2, and compared it to the conventional laparoscopic approach. The authors noted a significantly higher warm ischemia time in the LESS and NOTES techniques, but no differences in donor and graft outcomes were observed compared to published results. Notably, to date no randomized controlled trials comparing laparoscopic and transvaginal NOTES-assisted living-donor nephrectomies are described in the literature.

Hakim's finger-assisted open donor nephrectomy [11] should also be mentioned. It is a mini open technique utilizing smaller incisions and the Hakim retractors with intrinsic light sources (specifically designed for this procedure). This approach has the potential to improve cosmetic outcome, reduce complications and pain, and promote faster recovery when compared with the traditional open approach. Furthermore, it does not significantly increase the operative duration and warm ischemia time as much as the total LDN approach.

Concerning the choice of right vs left kidney, both recipient surgeons and donor surgeons prefer the left kidney. The rationale underlying this preference is the greater length of the left renal vein, making implantation technically easier in most cases. On the other hand, some donor surgeons favor the right kidney due to the ease of retrieval, as there are no adrenal or gonadal veins draining into the right renal vein.

Moreover, in the past decades, many authors reported that right kidneys were not procured at the beginning of their experiences due to the presumed higher rate of vascular complications described. However, over time, several new reports have shown no significant differences between the two sides [12].

There have been studies in recent years comparing the risks and benefits of procuring either kidney; however, no single study has categorically shown a superiority of one side versus the other [13].

Currently, the ratio of right/left living-donor kidneys is similar in many transplant centres, and the right side no longer represents a contraindication for the laparoscopic approach, probably due to the surgeon's increased expertise [13].

Therefore, today the choice of kidney should primarily depend on anatomical and functional factors, reassuring both donor and recipient surgeons that retrieving and transplanting a right-sided kidney does not disadvantage either party. The ultimate decision on laterality should be made during MDT (Multidisciplinary Team) discussion.

Nonetheless, most meta-analyses today indicate that only 20-30% of LDNs are right-sided, and there are still high-volume centers that practically do not perform right-LDNs at all [14].

The assessment of a living donor is of key importance and requires a thourough understanding not only of the procedure but also of the potential future risks of living with a single kidney. The multidisciplinary approach to potential donor assessment is well-established worldwide, involving teams of nephrologists, transplant surgeons, anaesthesiologists, transplant coordinators, radiologists, and psychologists, as described in "Kidney disease: improving global outcomes guidelines" [1]. An angio-CT scan is performed to assess the kidney anatomy, urinary tract, and vascular features. All cases are presented to a multidisciplinary committee to confirm their viability. At the end of the evaluations, the cases are usually discussed once again in a multidisciplinary committee to ascertain their suitability. Additionally, as part of the pre-op work, donor advocate evaluates all candidates to ensure all ethical standards have been met.

Minimally invasive donor nephrectomy techniques (laparoscopy, transvaginal, LESS and robotic) are safe for both the donor and the graft, with low complication rates in well-selected donors operated by experienced surgeons. Several studies have shown that perioperative mortality related to LDN is extremely rare (0.01-0.1%) [15], and complication rates range from 8 to 18%. However, the potential for serious life-threatening complications is approximately 0.23% [16]. Schold et al. analyzed living live donor mortality of 0.17%, which was comparable to the mortality of patients undergoing a cholecystectomy (0.15%) and lower than appendectomy or nephrectomy (0.40 and 0.42%, respectively) [17].

Factors recognized to have an impact on complications by multivariate analysis are history of previous abdominopelvic surgery, paramedian incision, non-White race, male sex, and BMI. Additionally, donor age and number of arteries have been noted to significantly affect operating time.

The Minnesota Attributable Risk of Kidney Donation (MARKD) [18] study will compare the long-term risks for living donors from the University of Minnesota and Mayo Clinic, to the risks of contemporaneous, geographically similar, healthy matched controls from the Rochester Epidemiology Project. This study aims to provide essential data for long-term outcomes and to comprehensively assess living donors over extended periods, spanning beyond 50 years. The findings will be instrumental in informing potential living donors of risks and guiding the follow-up and care of current donors, enhancing the understanding of the safety of living kidney donation in the long run.

ITALIAN EXPERIENCE

In Italy, based on official data from the Italian Ministry of Health (www.trapianti.salute.gov.it), there were 369 living donors for transplantation out of a total of 1830 donors used in 2022, accounting for 20.1% of the total, with a steadily growing trend in the last decade. Specifically, living donor kidney transplants represented 335 out of a total of 2038 (16.4%), remaining consistent with the previous year, and showing an increase after the negative impact of the pandemic in 2020. In recent years, leading Italian transplant centers with a high volume of living kidney donor activities have standardized protocols to increase access to living donation, even for incompatible pairs. These protocols include desensitization methods for ABO-incompatible or cases with anti-HLA antibodies. Additionally, kidney exchange programs with local, national, and international chains have been explored and standardized [19]. These efforts aim to improve access to the best therapeutic option for patients with ESRD and potential donors, emphasizing the potential of the Italian transplant network, which is considered a model on an international level.

In 2017, we published a national survey on Italian living kidney donation activity [20]. The survey involved 17 Italian kidney transplant centres performing 693 mini-invasive donor nephrectomies, patients were classified into three different cohort based on the surgical technique used: full laparoscopy or robotic, hand-assisted laparoscopy, and mini-incision open lumbotomy. The study showed a relationship between transplant centre volume, surgical technique and donor graft anatomy. High-volume centres tended to prefer pure laparoscopic, robotic, and mini-open donor nephrectomy, while low-volume centres preferred left kidneys, even in cases with multiple arteries.

In 2023, two high-volume Italian center reported a comparison of 154 robotic versus 358 laparoscopic donor nephrectomy learning curves and survival outcome between 2010 and 2021 [3]. The study concluded that the robotic approach shows a faster learning curve compared with LDN and appears to improve multiple vessel handling. Both techniques have an excellent safety profile

with low morbidity rates. Of particular interest for the Italian scenario is that the data show a consistent experience with the newest surgical approach for living donor nephrectomies.

Recently, enrollment for the Italian trial [21] involving 5 transplant centres for the validation of a promising tool, the LAPDOCTOR (LAParoscopic DOnor nephrectomy scORe), has been completed. The scoring system is based on variables extrapolated from preoperative CT images and anthropometric characteristics of the donor [22]. It aims to identify challenging cases of living donor nephrectomies, potentially becoming a fundamental tool for surgeons to enhance surgical planning and achieve a more accurate stratification of operative risk. The final objective is to minimize morbidity and enhance outcomes.

CONCLUSIONS

Living donation is considered the optimal approach for kidney transplant, which in turn is the gold standard treatment of ESRD. Over the past decades, extensive literature has explored and substantiated these concepts through comparative data and randomized trials, forming a robust basis for international recommendations and guidelines. Simultaneously, technological advancements have continuously expanded the horizons of surgical techniques. Notably, minimally invasive approaches and personalized medicine have emerged as the present and future of living kidney donation for transplantation. The standardization of these techniques has facilitated the widespread development of living kidney donation programs. The surgeon's techniques and technical preferences serve as their stronghold, yet they are consistently guided by principles of safety and efficacy, thanks in part to continuous oversight by national and supranational bodies. The ultimate objective is to enhance recipient outcomes while safeguarding the well-being of living donors. Furthermore, the implementation of exchange programs aims to bolster the number of living donor transplants, fostering strong collaborations among the diverse professionals in the captivating world of transplantation.

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Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

Both the authors have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Ethical consideration

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