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Are there any relations among transplant centre volume, surgical technique and anatomy for donor graft selection? Ten-year multicentric Italian experience on mini-invasive living donor nephrectomy

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ABSTRACT

Background. Selection of the right or left living donor kidney for transplantation is influenced by many variables. In the present multi centric study including 21 Italian transplant centres, we evaluated whether centre volume or surgical technique may influence the selection process.

Methods. Intra- and perioperative donor data, donor kidney function, and recipient and graft survival were collected among 693 mini-invasive living donor nephrectomies performed from 2002 to 2014. Centre volume (LOW, 1–50 cases; HIGH, >50 cases) and surgical technique (FULL-LAP, full laparoscopic and robotic; HA-LAP, hand-assisted laparoscopy; MINI-OPEN, mini-lumbotomy) were correlated with selection of right or left donor kidney and with donor and recipient outcome.

Results. HIGH-volume centres retrieved a higher rate of donor right kidneys (29.3% versus 17.6%, $P < 0.01$) with single artery (83.1% versus 76.4%, $P < 0.05$) compared with LOW-volume centres. Surgical technique correlated significantly with rate of donor right kidney and presence of multiple arteries: MINI-OPEN (53% and 13%) versus HA-LAP (29% and 22%) versus FULL-LAP (11% and 23%), $P < 0.001$ and $P < 0.05$, respectively. All donors had an uneventful outcome; donor bleeding was more frequent in LOW-volume centres (4% versus 0.9%, $P < 0.05$).

Conclusions. Centre volume and surgical technique influenced donor kidney side selection. Donor nephrectomy in LOW-volume centres was associated with higher risk of donor bleeding.

Keywords: delayed graft function, donor outcome, living donor transplant, mini-invasive surgical approach, volume transplant centre

INTRODUCTION

Living donor kidney transplantation is considered the ideal therapy for patients on chronic renal failure and can concur to overcome organ shortage [1, 2].

Living donor nephrectomy is a safe and well-tolerated procedure that allows for a quick return of donors to their normal activities. However, although minimal, there still is a potential risk of mortality and a slightly increased long-term risk of end-stage renal disease (ESRD) [3–6]. Ensuring donor safety and providing outstanding recipient outcome in terms of patient survival and graft function are definitely the main goals of this type of surgery.

Nowadays, minimally invasive donor nephrectomy (MDN) is deemed the standard of care for living donors [7]. MDN is carried out with many variations according to a centre's tradition, volume and surgeon's expertise [7, 8]. It is unclear whether the type of surgical procedure in use or the centre volume might affect the decision of which kidney will be recovered for transplantation, either left or right, and even more whether or not there might be any effect on donor and transplant outcomes.

The aim of the present study was to compare the rate of right donor kidney selection among low- and high-volume centres and among different types of surgical techniques in the context of an observational multicentric study including the majority of Italian transplant centres that use MDN for living kidney donation.

MATERIALS AND METHODS

A retrospective multicentre observational analysis on the use of MDN was conducted on 21 Italian kidney transplant centres between January 2002 and September 2014. The present sub-analysis was conducted on the impact of different surgical techniques on the choice of the donor kidney for retrieval. All participating centres followed the principles of the European Renal Best Practice Guidelines for donor selection [2].

Endpoints

We hypothesized a relation among centre volume, surgical technique and choice of the donor kidney to be retrieved. Our primary endpoint was to find a statistical correlation among the rate of right kidney selection for donation, centre volume and surgical technique. Secondary endpoints were donor post-operative outcome, mean hospital stay, donor graft function, recipient graft function and post-operative complications.

Data collection

MDN data were collected prospectively and entered into a dedicated database. Variables such as centre volume, donor's characteristics, surgical techniques, perioperative donor and recipient parameters and outcomes were recorded and analysed with previous informed consent. The study was conducted in accordance with the Declaration of Helsinki and followed the Good Clinical Practice Guidelines of the International Conference on Harmonization. The study was approved by the local hospital's Ethics committee.

Surgical technique

MDN was performed by the participating centres using one of the following surgical techniques:

- transperitoneal laparoscopic nephrectomy with the organ recovered through either a port incision extension or a Pfannenstiel incision [9, 10];
- transperitoneal robotic-assisted laparoscopic nephrectomy [11–13];
- transperitoneal hand-assisted laparoscopic nephrectomy [14, 15];
- retroperitoneal mini-open donor nephrectomy, performed through a 10–12 cm lumbotomy incision [16, 17].

Donors were allocated to three different cohorts according to the type of surgical technique: FULL-LAP (full laparoscopy or robotic), HA-LAP (hand-assisted laparoscopy) and MINI-OPEN (mini-incision open lumbotomy, <13 cm in length). Robotic nephrectomy was analysed together with full laparoscopic nephrectomy, because the two techniques are both based on a pure laparoscopic approach and therefore differ from HA-LAP and MINI-OPEN.

Transplant centres were also classified according to the total volume of donor nephrectomies [18–20]: LOW volume (1–50 procedures) and HIGH volume (>50 procedures).

Statistical analysis

Univariate analysis was performed using Student's *t*-test for continuous variables and Fisher's exact test for categorical variables. For two-tailed calculations, differences were considered significant for $P < 0.05$.

RESULTS

Study design and population

Of the 21 contacted centres, 17 (80.9%) responded and sent their self-reported data; these centres overall performed 693 MDN that were finally included in the study. According to MDN volume, 14 centres were classified as LOW and 3 centres as HIGH. On the basis of surgical approach 13 centres used the FULL-LAP, 7 centres the HA-LAP and 5 centres the MINI-OPEN (some centres used more than one surgical technique). A total of 376 MDN were performed in LOW-volume centres and 317 in HIGH-volume centres; 424 MDN were carried out using FULL-LAP, 124 HA-LAP and 145 MINI-OPEN technique. Pure laparoscopic nephrectomy was the most common procedure (53%), followed by mini-open (21%), hand-assisted (18%) and robotic (8%) (Figure 1). Most of the HA-LAP were performed in LOW-volume centres (83.1% versus 16.9%, $P < 0.001$), while MINI-OPEN were mainly performed in HIGH-volume centres (72.4% versus 27.6%, $P < 0.001$), as reported in Table 1.

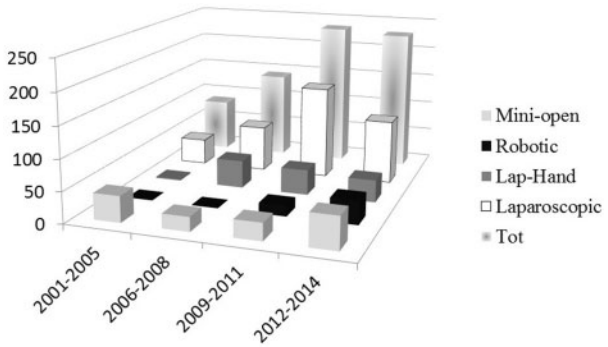

FIGURE 1: Trend of surgical technique preferences along different time periods.

Table 1. Type of surgical technique according to centre volume[a]

Surgical techniques	Centre volume		P
	LOW (%)	HIGH (%)	
FULL-LAP	233 (55)	191 (45)	<0.001
HA-LAP	103 (83.1)	21 (16.9)	
MINI-OPEN	40 (27.6)	105 (72.4)	

[a]Includes all donor nephrectomies.

Concerning donor features, median donor age was 52 years, and 20% of donors were older than 60 years. Median body mass index (BMI) was 25; BMI was >30 in only 7% of donors. Overall, median operative time was 4 h. The renal vessels were secured using endovascular staplers in 80% of cases, and with Hem-o-lok clips, prolene suture or a combination of techniques in the remaining cases. Use of Hem-o-lok clips was abandoned after 2011 based on FDA recommendations as it was considered not safe for the donor.

Intraoperative bleeding occurred in 11 (0.016%) cases, requiring blood transfusions in 10 and open conversion in 2 cases. No perioperative deaths were reported. Mean donor preoperative creatinine was 0.8 ± 0.2 mg/dL and 1.1 ± 0.2 mg/dL at discharge.

Donor BMI was lower in MINI-OPEN (median BMI 24) versus FULL-LAP and HA-LAP (median BMI 25, $P < 0.001$, as reported in Table 2).

Rate of right donor nephrectomy among different centre volumes and surgical techniques

The rate of right kidney selection for nephrectomy was significantly different among the study groups. Right nephrectomy was performed less frequently in LOW-volume centres compared with HIGH-volume centres (17.6% versus 29.3%, respectively; $P < 0.01$) and more frequently in MINI-OPEN (53%) versus FULL-LAP and HA-LAP (11% and 29%, respectively, $P < 0.001$, Table 2).

The choice of kidneys with multiple arteries was also affected by centre volume and surgical technique: 23.6% in LOW-versus 16.9% in HIGH-volume centres ($P < 0.01$) and 22.7% using FULL-LAP versus 21.7% HA-LAP versus 13% in MINI-OPEN ($P < 0.05$).

There was no correlation between choice of kidneys with multiple veins and centre volume and surgical techniques (Table 2).

Donor right kidney with single artery versus left kidney with multiple arteries

The rate of right donor kidney with single artery (RKSA) and left kidney with multiple arteries (LKMA) was significantly different according to centre volume and surgical technique (Table 3). HIGH-volume centres retrieved more frequently RKSA compared with LKMA (68% versus 41%, $P < 0.001$) and the rate of the use of LKMA compared with RKSA was higher in FULL-LAP (70%) versus HA-LAP (39%) and versus MINI-OPEN (13%) ($P < 0.001$).

Intra-operative and post-operative donor and recipient variables were not related to RKSA and LKMA apart from donor operation time.

Donor and recipient outcome

The bleeding complication rate was 4% in LOW versus 0.9% in HIGH ($P < 0.01$), while depending on surgical technique, bleeding rate was slightly higher in HA-LAP (7%) versus FULL-LAP (2%) and MINI-OPEN (0%) ($P < 0.01$). All techniques allowed for the same hospital stay, with the average length being 6 days for all the three groups. However, it was different

Table 2. Effect of donor characteristics, centre volume and surgical technique on right graft selection for donor nephrectomy

	Right nephrectomy (%)	P	Multiple arteries (%)	P	Multiple vein (%)	P	Median donor age	P	Median BMI	P
Centre volume										
LOW	**66 (17.6)**	**<0.01**	**23.6**	**<0.05**	5	N.S.	52	N.S.	25	N.S.
HIGH	**93 (29.3)**		**16.9**		7.7		50		25	
Technique										
FULL-LAP	**46 (10.8)**	**<0.001**	**22.7**	**<0.05**	7	N.S.	51	N.S.	**25**	**<0.01**
HA-LAP	**36 (29)**		**21.7**		5.8		53		**25**	
MINI-OPEN	**77 (53)**		**13**		4.3		52		**24**	

The bold values have statistical significance.

according to centre volume: 7 days in LOW compared with 5 days in HIGH ($P < 0.01$).

Recipient post-operative complications tended to be lower in HIGH versus LOW but without reaching any statistically significant correlation: delayed graft function [DGF, 3.5% versus 4.5%, P = not significant (N.S.)], urinary leak (0.6% versus 2.8%, P = N.S.) and vascular thrombosis (0.9% versus 2.8%, P = N.S.).

Recipient delayed graft function was more common in HA-LAP (8.5%) compared with FULL-LAP (2.9%) and MINI-OPEN (3.5%) ($P < 0.05$). The same difference was reported for urinary leak rate, 4.2% in HA-LAP versus 1.6% in FULL-LAP, nil in MINI-OPEN ($P < 0.05$) and for vascular thrombosis, which did not differ significantly among groups, although more thrombotic events were observed in HA-LAP (4.2%) versus FULL-LAP and MINI-OPEN (1.3% and 1.4%, respectively) (P = N.S.).

Median donor warm and cold ischaemia time was differently distributed according to centre volume (HIGH 2 and 70 min versus LOW 3 and 90 min, respectively, $P < 0.05$) and according to the techniques (HA-LAP 3 and 30 min versus FULL-LAP 3 and 60 min versus MINI-OPEN 2 and 150 min, respectively, $P < 0.001$). DGF incidence was significantly associated with increased warm ischaemia time (No-DGF median warm ischaemia time 3 min versus DGF warm ischaemia time 5 min, $P < 0.005$), while cold ischaemia time did not show any statistical correlation with DGF.

DISCUSSION

The use of mini-invasive techniques for living donor nephrectomy is increasing in Italy as in the rest of the world, allowing for a potential expansion of the donor pool in the near future [15]. The present data from a national multicentric survey confirms a relation among centre volume, surgical approach and selection of the side of the kidney to be procured.

In terms of surgical technique, high-volume centres seem to prefer pure laparoscopic, robotic and mini-open donor nephrectomy when compared with low-volume centres, where surgeons seem to feel more at ease with the use of hand-assistance in the context of a laparoscopic approach.

According to the number of procedures, centres with less experience (LOW-volume centres) were less confident in procuring right kidneys and preferred left kidneys despite the presence of multiple arteries (Tables 2 and 3), their rate of right kidney procurement was lower and the rate of kidneys with multiple arteries was higher than in HIGH-volume centres. This different selection process and the lower experience may explain the relatively higher rate of bleeding reported in the donor procedures.

In HIGH-volume centres, donor surgeons were more likely to procure kidneys with less complex vascular anatomy, because they were equally confident with retrieval of either right or left kidneys; this resulted in a progressive decline in left-sided nephrectomies. On the other hand, the rate of right nephrectomy was strongly related to the surgical technique: 53% for MINI-OPEN, 29% for HA-LAP and 10.9% for FULL-LAP. These results demonstrate that in the present series MINI-OPEN allows for a relatively more flexible selection of right and left regardless of vascular anatomy.

The nil rate of donor bleeding of this technique may be explained by the better selection of the donor arterial anatomy, but also because it was mainly used by high-volume centres (Table 1).

There seem to be many advantages in using mini-invasive techniques for donor nephrectomy, particularly, the present analysis showed that the laparoscopic approach allows for more frequent retrieval of kidneys with multiple arteries and kidneys from obese donors, thus further expanding the donor pool, while still respecting safety, as confirmed by the very low incidence of complications. Interestingly, pure laparoscopic donor nephrectomy and its robotic alternative were associated with a more frequent choice of the left kidney when compared with other approaches. In particular, the rate of left kidney with multiple arteries was very high compared with right kidneys with single artery (70%) and also compared with the other techniques (MINI-OPEN 13% and HA-LAP 39%) (Table 3).

Conversely, hand-assistance seemed to make transplant surgeons feel more confident in recovering right kidneys, compared with their colleagues who use pure laparoscopy. Apparently, this approach resulted in a small increase in the incidence of DGF and urinary leaks, although donor and recipient outcome were not affected. These results need cautious interpretation, because the HA-LAP was used mainly by low-volume centres, which tended to have higher post-operative complications, even if the differences did not reach statistical significance.

DGF was statistically related to donor warm ischaemia time, which was lower in HIGH-volume centre and in centres using the MINI-OPEN technique.

Table 3. Donor RKSA versus LKMA

	RKSA— 129 cases (%)	LKMA— 111 cases (%)	P
LOW-volume	**52 (41)**	**74 (59)**	**<0.001**
HIGH-volume	**77 (68)**	**37 (32)**	
FULL-LAP	**26 (30)**	**84 (70)**	**<0.001**
HA-LAP	**26 (61)**	**17 (39)**	
MINI-OPEN	**67 (87)**	**10 (13)**	
Donor			
Bleeding	0	2 (1.8)	N.S.
Other complications	3 (2.3)	3 (2.7)	N.S.
Operation time (median) (min)	**178**	**238**	**<0.001**
Recipient			
DGF	5 (3.9)	4 (3.6)	N.S.
Vascular thrombosis	3 (2.3)	2 (1.8)	N.S.
Urinary leak	2 (1.5)	4 (3.6)	N.S.
Creatinine at discharge (median) (mg/dL)	1.5	1.5	N.S.

The bold values have statistical significance.

Low-volume centres tended to prefer a hand-assisted laparoscopic approach, perhaps because of its shorter learning curve versus pure laparoscopy, as well as because it might simplify and expedite right nephrectomy [21]. The rate of right kidney retrieval was in fact higher in HA-LAP versus FULL-LAP (29% versus 10.8%, $P < 0.001$).

The participating centres that routinely performed mini-open donor nephrectomy recovered a greater percentage of right kidneys along with kidneys with a lower number of arteries. This approach was used more commonly in donors with lower BMI, possibly because obese donors can be technically more challenging.

Definitive conclusions about donor and recipient outcomes in relation to the different surgical approaches are not possible due to variation of surgical techniques and centre volume (Table 1) of our cohort. A hand-assisted laparoscopic approach, which is supposed to ease the procedure and improve donor safety [22], was associated with a slightly increased risk of bleeding in the donor and a comparably higher rate of complications in the recipient. However, this technique was predominantly adopted by low-volume centres, therefore, a learning-curve effect might explain this finding, which is not confirmed by most of the studies in the literature [23, 24].

Conversely, the MINI-OPEN technique was associated with a lower risk of bleeding with equivalent length of hospital stay compared with pure laparoscopy; this technique was carried out mostly by high-volume centres and the good results could be reasonably explained by the longer experience of the local surgeons with open nephrectomy.

Laparoscopy is often considered instrumental to improve perioperative donor's outcome in terms of better pain control, shorter hospital stay, faster return to work and physical activity [7], our results showed that it also leads to a more frequent choice of the left kidney for retrieval.

The upcoming data regarding increasing long-term risk of ESRD in kidney donors compared with selected healthy non-donors reinforce the assumption that in order to improve donor safety, the kidney that performs better should always stay with the donor [3–6]. Thus, the use of an 'ideal' minimally invasive procedure and its related technical considerations should not affect the choice of the kidney to be retrieved, unless the functional evaluation has showed a comparable performance of both kidneys.

There are few data in the literature regarding the amount of post-operative analgesia needed in the setting of mini-open versus open nephrectomy [16, 17] or about its theoretical advantages in terms of reduced operative and warm ischaemia time. We did not investigate this aspect in our analysis.

In conclusion, our data show that in HIGH-volume centres surgeons are more prone to retrieve more frequently right kidneys with single artery compared with LOW-volume centres. The risk of donor bleeding is higher in LOW-volume centres and lower if the MINI-OPEN approach is used, although this technique is used mainly in HIGH-volume centres, where the surgeon's longer experience may account for better results. In these centres, for the same reason, procurement of right kidneys with standard arterial anatomy is more frequent, while where laparoscopy was the standard approach, left kidneys were preferred, regardless of arterial anatomy.

This fact should encourage further investigations due to the potential clinical donor and recipient impact of choosing a RKSA versus a LKMA.

We strongly believe that in order to ensure donor safety and optimize graft function and survival the choice between a minimally invasive open approach and a laparoscopic one should be based on local surgeon's expertise [25, 26].

CONFLICT OF INTEREST STATEMENT

The authors of this manuscript have no conflicts of interest to disclose and declare that the results presented in this article have not been published previously.

AUTHORS' CONTRIBUTIONS

M.Ravaioli: performed the research design, planned the study, analysed the data and wrote the manuscript. E.C., G.S., L.D.C., G.P., M.C., A.A., G.B., P.D., C.B., C.S., M.A., U.B., F.C., M.F., S.G., M.S., A.D.P. and J.R. contributed to the interpretation of the results and revised the manuscript. L.F., M.I., M.P.S., A.Giacomoni, C.D.B., M.Rostand, L.B., A.B., A.C., S.V.I., A.Giussani, D.C.P., E.T., G.L.A., B.B., A.S., Collected data and revised the Manuscript. V.D.P. collected and analysed data and revised the manuscript.

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