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# Center size and surgical experience have an impact on donor selection but not on outcome of living kidney donation: results from the German national registry

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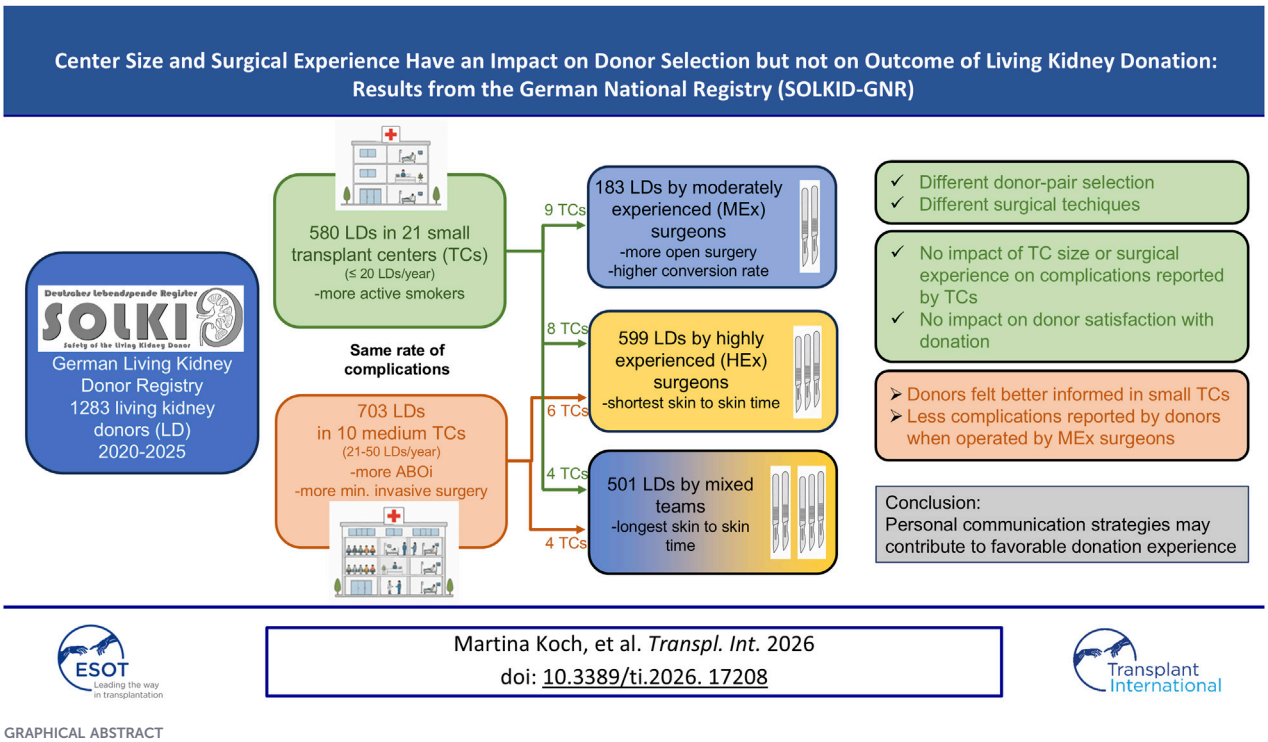
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Living kidney donation (LD) is a highly elective procedure that requires the highest safety standards. The aim of this analysis was to evaluate the impact of the annual number of LDs performed per transplant center (TC) and of the surgeons' individual experience on donor selection, perioperative outcomes, and donor satisfaction. We analyzed data from 1,283 donors included in the German Living Donor registry. TCs were categorized as small (S) or medium (M) performing ≤20 and >20 LD per year. Surgeons were classified as highly experienced with more than 100 LDs performed and as moderately experienced with less. S TCs performed less AB0i donations, accepted more actively smoking donors, but less with a history of malignancies. Complication rates did not differ depending on center size. Less experienced surgeons performed more open surgeries, had a higher conversion rate and longer skin-to-skin time. Whereas TC-reported complication rates did not differ, donors self-reported less complications if LD was performed by a less experienced surgeon. LD is safe in both S and M TCs. The lower donor-reported complication rate in LDs performed by less experienced surgeons may be partly explained by personalized communication strategies leading to a more positive donor experience in S TCs.

KEYWORDS
**high volume center, living kidney donation, minimum quantitiy, self-reported-outcomes, surgical complications**

## Introduction

Kidney transplantation (KT) is a life-saving procedure [1, 2], and transplantation with a graft from a living donor provides even better results compared to donation from a deceased donor. In contrast to the favorable results for the kidney recipient, a healthy donor experiences a significant loss of kidney function and undergoes an operation




associated with morbidity and even mortality [3–5]. Compared to other surgical procedures, living kidney donation (LD) is a relatively rare procedure with 451–638 operations performed annually in Germany between 2017 and 2024 [6]. As with several other operations, a minimum quantity for each transplant center (TC) is defined for KT in Germany as 25 per year. However, no minimum quantity is defined for LD. In 2023, 39 TCs were licensed by the German federal states performing 0–59 LDs per year [7]. This structure results in very small TCs with low numbers of LDs compared to, for example, the US [8]. In other European countries, especially those with smaller populations, TCs with less than 10 LDs per year are also common [9].

In TCs with limited caseloads, LD is often performed by a single surgeon. Conversely, in larger TCs, LD may be performed by a team comprising both experienced and less experienced surgeons.

We used the German living donor registry SOLKID-GNR to conduct a comprehensive analysis of the impact of center size and surgeons' experience on donor selection, perioperative complications, and outcomes. The investigation placed particular emphasis on donors' self-reported outcomes.

**Abbreviations:** AB0i, AB0 incompatible; BMFTR, Federal Ministry of Research, Technology and Space (Bundesministerium für Forschung, Technologie und Raumfahrt); CKD-EPI, chronic kidney disease epidemiology collaboration; eGFR, estimated glomerular filtration rate; HEx, highly experienced; KT, kidney transplantation; LD, living kidney donation; M, medium; MEx, moderately experienced; MIN, minimally invasive nephrectomy; ODN, open donor nephrectomy; ref, reference category; S, small; SOLKID-GNR, Safety of the Living Kidney Donor – German National Registry; TC, transplant center.

# Patients and methods

## Study-design

The design and structure of the registry have been published previously [10, 11] and are therefore only described briefly.

SOLKID-GNR is a prospective, voluntary registry of living kidney donors in Germany. Donors' self-reported outcomes are blinded to the treating physicians. SOLKID-GNR was registered in the German Clinical Trials Registry (DRKS: 00023532), and approval was granted from the ethics committee of the Medical Association of Westphalia-Lippe and the University of Muenster (2019-732-f-S) as well as the local ethics committees of the participating TCs. The registry was funded by the German Federal Ministry of Research, Technology and Space (grant no.: 01GY1906) and the medical faculty of the University of Muenster. Funding sources had no role in study design, data collection, analysis, or interpretation.

## Data collection

Donor questionnaires were collected within 4 weeks prior to donation, medical and demographic data within 1 year prior to donation. Medical information on surgical technique, side of donation, and surgical complications was collected within the first year after donation (10–14 months after donation = 1Y); donor questionnaires had to be completed 10–14 months after donation (1Y).

For this manuscript, donors were included if medical data prior to donation and after donation were available. Our analysis contains 1,283 donors enrolled from January 2020 to January 2025.

110 donors did not reach the 1Y time point yet, 18 LD were lost to follow up or withdrawal consent. Supplementary Figure S1 shows details on missing questionnaires.

## Inclusion criteria and informed consent

To be included, sufficient knowledge of the German, Turkish, or Russian language was necessary to answer donor questionnaires. Donors were informed by the responsible physician and gave their written consent to participate in the registry before registry-specific data collection.

## Data protection, collection, and quality

Personal identifying data was pseudonymized using the pseudonymization service Mainzelliste [12]. Registry data were collected and managed using REDCap electronic data capture tools hosted at the medical faculty of the University of Muenster [12, 13]. Data collection, pseudonymization, and storage were performed according to the European General Data Protection Regulation (EU-GDPR) guidelines.

Data was electronically collected from TCs as well as directly from donors.

Data were checked for plausibility by the registry's monitoring team promptly after entrance. Implausible data were compared with the source data during on-site monitoring or by the TC itself upon request by the data management via REDCap´s query management tool.

## Center size and surgeons' experience

Center size of the TC was evaluated using the number of living donor nephrectomies performed from 2021 to 2024, according to the Eurotransplant statistics library [14]. This is the time period during which most of the TCs enrolled patients in the registry. A TC was categorized as small (S) if a mean of 20 or less LDs per year were performed, and as medium (M) if > 20 LDs per year were performed. None of the participating TCs performed more than 50 LDs annually, therefore there is no category "large" in this analysis.

Surgeons' experience was defined as high (HEx) with more than 100 LDs personally performed, and as moderate (MEx) if the individual had performed less than 100 LDs. TCs were asked to provide the information if LD was mainly done by surgeons/urologists with a personal experience of less or more than 100 LDs or by both (mixed teams). TCs also had the opportunity to answer "I do not know/I do not want to answer", but no TC used this option.

## Statistical methods

Categorical variables are given as absolute and relative frequencies. Continuous variables are presented as mean and standard deviation for normally distributed variables or as median and 25% and 75% quartiles in the case of non-normal distributions.

Comparisons between groups of categorical variables were done using Fisher's exact test, between groups for continuous normally distributed variables using t-test or ANOVAs, and between groups for continuous non-normally distributed variables using the Wilcoxon-Mann-Whitney-test or the Kruskal-Wallis-test.

Logistic regressions were used to assess the influence of age (above vs. below 65 years), BMI (above vs. below 30), smoking (history of/recent vs. non-smoking), surgical technique, center size, and surgeons' experience for TC-reported complications, self-reported complications, and donor satisfaction. The model for self-reported complications also included TC-reported complications, and the model for donor satisfaction included both self-reported and TC-reported complications. Statistical analysis was done using SAS (version 9.4, SAS Institute in Cary, North Carolina, USA).

No imputation for missing values was performed. Number of existing values are presented for each variable.

# Results

## Center size and surgeons' experience

1,283 donors from 31 of 39 German TCs were included in the analysis. 21 TCs were categorized as S centers with 20 or less LDs per year. In these TCs, 580 LDs, 45.2% of the LDs included, were performed. 10 TCs were classified as M with 21–50 LDs per year, performing 703 (54.8%) of the LDs included (Table 1).

In 14 TCs, most or all LDs were performed by HEx surgeons with personal experience of more than 100 LDs. These were nearly half of all LDs in this cohort (n = 599, 46.7%). Eight of 21 S TCs and six of 10 M TCs reported that only HEx surgeons performed LD. Nine TCs stated that a MEx surgeon was responsible for LD. These were only S TCs and included 183 LDs (14.3%). Eight TCs had both HEx and MEx surgeons in their teams; this answer was given by 4 S and four M TCs. A total of 501 donors (39.1%) were operated in TCs with mixed teams (Table 1).

## Donor selection and evaluation

Neither size of the TC nor surgical experience had an impact on donor selection regarding age, gender, BMI, kidney function, or concomitant diseases hypertension, diabetes, or preexisting anticoagulation. The percentage of younger donors (<30 years) and elderly donors (>65 years) was not different in S and M TCs. Donors reporting an autoimmune disease (5.4%), chronic pain (4.0%), or mental disorders (5.7%) were rare and equally distributed across all TC sizes (data not shown).

Donor characteristics by center size are shown in Table 2. Larger TCs accepted significantly more blood group incompatible (AB0i) transplantations and donors with a history of malignancies, whereas smaller TCs tended to accept more active smokers.

While surgical experience had no impact on the selection of AB0i donations, more pre-emptive transplantations were performed by HEx surgeons (40.2%; 29.5% by MEx surgeons; 31.8% by mixed teams; p = 0.003). Donations with high immunological risk (i.e., recipient desensitization due to donor-specific antibodies) were less often performed by HEx surgeons (13.4% vs. 19.7% by MEx and 18.7% by mixed teams; p = 0.02).

Experienced surgeons were less likely to accept active smokers as donors (11.6% vs. 19.1% by MEx, 10.3% in mixed teams; p = 0.04).

TABLE 1 Distribution of center size and surgical experience levels.

| Surgical experience | S TC | M TC | Number of TCs (n of donors) |
|---|---|---|---|
| HEx surgeon | 8 | 6 | 14 (599) |
| MEx surgeon | 9 | 0 | 9 (183) |
| Mixed team | 4 | 4 | 8 (501) |
| Number of TCs (n of donors) | 21 (580) | 10 (703) | 31 (1,283) |

HEx, Highly experienced surgeons with >100 personally performed LDs; MEx, moderately experienced surgeons with less than 100 LDs performed. S TC, small transplant center with ≤20 LDs per year; M TC, medium transplant center with >20 LDs per year.

TABLE 2 Donor characteristics by center size (preoperative data).

| Donor characteristics | All n = 1,283 | S TC n = 580 | M TC n = 703 | P-value |
|---|---|---|---|---|
| AB0i [n; %] | 331; 25.9 | 130; 22.5 | 201; 28.6 | **0.02** |
| High immunological risk [n; %] | 209; 16.3 | 86; 14.9 | 123; 17.6 | 0.22 |
| Pre-emptive [n; %] | 453; 35.4 | 212; 36.7 | 241; 34.3 | 0.41 |
| Donor age [years; Mean ± SD (range)] | 54.5 ± 10.3; (20–83) | 54.7 ± 10.8; (20–80) | 54.3 ± 10.4; (26–83) | 0.47 |
| Female gender [n; %] | 808; 63.0 | 365; 63.0 | 443; 63.0 | 0.73 |
| BMI >30 kg/m$^2$ [n; %] | 181; 14.1 | 83; 14.3 | 98; 13.9 | 0.87 |
| eGFR CKD-EPI 2021 (mL/kg) before donation [Mean ± SD] (n = 1,215) | 94.5 ± 12.9 | 93.7 ± 13.0 | 95.1 ± 12.8 | 0.07 |
| Hypertension [n; %] (n = 1,278) | 361; 28.3 | 163; 28.3 | 198; 28.3 | 1.0 |
| Active smoking [n; %] | 155; 12.2 | 82; 14.2 | 73; 10.5 | **0.046** |
| Formerly smoking [n; %] | 566; 44.4 | 263; 45.5 | 303; 43.5 | |
| Self-reported history of malignancy [n; %] | 50; 3.9 | 15; 2.6 | 35; 5.1 | **0.03** |

STC, small transplant center with ≤20 LDs per year; M TC, medium transplant center with >20 LDs per year. High immunological risk = Transplantation with known donor-specific antibodies and/or plasma exchange/immunadsorption prior to transplantation. Representation: n = number (percentage); mean ± standard deviation (SD). Bold: statistically significant.

## Donor operations and outcome reported by TCs

Donor operations were categorized as open donor nephrectomy (ODN) including an open abdominal or open retroperitoneal approach and minimally invasive techniques (MIN) including laparoscopic and retroperitoneoscopic operations. In M TCs, more MIN nephrectomies were carried out ($p < 0.001$), but less procedures were roboter-assisted ($p < 0.001$; Table 3). The rate of conversion from MIN to open surgery was higher in S TCs compared to M TCs ($p < 0.001$). The skin-to-skin time was not significantly different in S and M TCs, and there was no difference regarding the side of donation. Slightly more left kidneys were donated in both S and M TCs (55%).

TC-reported complications within the first year after donation were designated as "all complications" if they were possibly related to the donation. This category includes all reported complications, e.g., surgical, psychological, or medical complications. The category "complications directly related to the operation" includes only complications that were likely related to the surgical procedure itself, e.g., wound infections, pain, haematoma. Neither surgery-related complications nor overall complications reported by the TCs within the first year were different according to center size (Table 3). Re-operations were rare and not different between TCs with small or medium caseload. Recipient outcomes, reported by the donors, were comparable.

Regarding the surgical experience, MEx surgeons performed significantly more open nephrectomies (35.0% vs. 15.7% by HEx surgeons; $p < 0.001$; Table 4), but used more robotics (22.7% vs. 11.3%; $p < 0.001$). The conversion rate was significantly higher with MEx surgeons (8.4% vs. 0.4%; $p < 0.001$), and the skin-to-skin time was significantly longer with 160 (129; 204) min vs. 150 (110; 199) min and longest in mixed teams with 169 (136; 210) min ($p < 0.001$). The side of donation was different according to surgical experience. HEx surgeons selected more left kidneys (59.7%) and MEx surgeons more right kidneys (54.1%; $p = 0.002$).

TC-reported complications (overall or surgery-related including re-operations) were not significantly different performed by HEx or MEx surgeons, or mixed teams (Table 4). There was no significant difference in recipient outcome reported by the donor, but a trend towards less recipients requiring dialysis after 1 year when operated by HEx surgeons.

A regression analysis of 806 cases revealed no impact of center size, surgical technique, surgical experience, older age, or obesity on overall complication rates reported by the TCs (Table 5). Non-smokers had a significantly lower risk to experience surgery-related complications ($p = 0.04$).

TABLE 3 Outcome and surgical data by center size.

| Outcomes | All (n = 1,283) | S TC | M TC | P-value |
|---|---|---|---|---|
| Minimally invasive nephrectomy [n; %] | 1,039; 81.0 | 440; 75.9 | 599; 85.2 | **<0.001** |
| Robotic-assisted [n; %] | 120; 11.6 | 84; 19.1 | 36; 6.0 | **<0.001** |
| Conversion of MIN to open surgery [n; %] | 19; 1.8 | 17; 3.9 | 2; 0.3 | **<0.001** |
| Side of donation: left [n; %] | 705; 55.0 | 319; 55.0 | 386; 55.0 | 1.00 |
| Skin-to-skin time [minutes; median (Q1; Q3)] | 160 (123; 205) | 176 (122; 209) | 159 (123; 201) | 0.17 |
| Re-operations [n; %] (n = 1,126) | 12; 1.1 | 6; 1.2 | 6; 1.0 | 0.78 |
| TC-reported complications (all) within the first year [n; %] (n = 809) | 81; 10.0 | 35; 9.8 | 46; 10.2 | 0.91 |
| TC-reported complications directly related to the operation within the first year [n; %] (n = 809) | 48; 5.9 | 19; 5.3 | 29; 6.4 | 0.55 |
| Donors' self-reported complications 1Y [n; %] (n = 863) | 94; 10.9 | 35; 9.2 | 59; 12.4 | 0.12 |
| Recipient alive 1Y [n; %] (n = 870) | 645; 98.8 | 283; 98.6 | 362; 98.9 | 0.74 |
| Recipient back on dialysis 1Y [n; %] (n = 857) | 55; 3.9 | 10; 3.5 | 15; 4.1 | 0.83 |

STC, small transplant center with ≤20 LDs, per year; M TC, medium transplant center with >20 LDs per year; MIN, minimally invasive nephrectomy. Representation: n = number (percentage); median (1st quartile; 3rd quartile); 1Y = 1 year after donation. Bold: statistically significant.

TABLE 4 Outcome and surgical data by surgeons' experience.

| Outcomes | All (n = 1,283) | HEx surgeons | MEx surgeons | Mixed team | P-value |
|---|---|---|---|---|---|
| Minimally-invasive nephrectomy [n; %] | 1,039; 80.1 | 505; 84.3 | 119; 65.0 | 415; 82.8 | **<0.001** |
| Robotic-assisted [n; %] | 120; 11.6 | 57; 11.3 | 27; 22.7 | 36; 8.7 | **<0.001** |
| Conversion of MIN to open surgery [n; %] | 19; 1.8 | 2; 0.4 | 10; 8.4 | 7; 1.7 | **<0.001** |
| Side of donation: left [n; %] | 705; 55.0 | 357; 59.7 | 84; 45.9 | 264; 52.7 | **0.002** |
| Skin to skin time [minutes; median (Q1; Q3)] | 160 (123; 205) | 150 (110; 199) | 160 (129; 204) | 169 (136; 210) | **<0.001** |
| Re-operations [n; %] (n = 1,126) | 12; 1.1 | 4; 0.7 | 3; 1.9 | 5; 1.2 | 0.41 |
| TC-reported complications (all) within the first year [n; %] (n = 809) | 81; 10.1 | 33; 8.7 | 8; 7.0 | 40; 12.7 | 0.12 |
| TC-reported complications directly related to the operation within the first year [n; %] (n = 809) | 48; 5.9 | 18; 4.7 | 5; 4.4 | 25; 7.9 | 0.17 |
| Donors' self-reported complications 1Y [n; %] (n = 863) | 94; 10.9 | 40; 9.9 | 8; 5.8 | 46; 14.4 | **0.02** |
| Recipient alive 1Y [n; %] (n = 870) | 645; 98.8 | 303; 99.3 | 103; 98.1 | 239; 98.4 | 0.44 |
| Recipient on dialysis 1Y [n; %] (N = 857) | 25; 3.9 | 6; 2.0 | 6; 5.8 | 13; 5.4 | **0.049** |

HEx, Highly experienced surgeons with >100 personally performed LDs; MEx, moderately experienced surgeons with less than 100 LDs performed. Representation: n = number (percentage); median (1st quartile; 3rd quartile); 1Y = 1 year after donation. Bold: statistically significant.

## Donors' self-reported satisfaction with the donation process

When asked about their experience prior to donation, more donors in M TCs stated that preparation for donation took too long (51.5% vs. 42.9%; p = 0.002; Table 6), and less donors in M TCs felt very well informed about the donation process (63.0% vs. 70.8%; p = 0.01). After 1 year, slightly more donors in S TCs still stated that they felt very well informed, but this was not statistically significant (61.9% vs. 56.7%, p = 0.60). At 1Y, donors reported no differences in either complication rates, satisfaction with the donation, or willingness to donate again (Table 6).

Comparing donors operated by HEx or MEx surgeons or mixed teams, significantly less donors operated by MEx surgeons reported complications related to the donation after 1 year (HEx surgeons: 9.9%, MEx surgeons: 5.8%, and mixed teams 14.4%; p = 0.02; Table 4).

In a regression analysis of self-reported complications, elderly donors (65 years and older) self-reported significantly less complications (p = 0.03), while center size, surgical experience, surgical technique, BMI, and smoking status had no impact (Table 7). The regression analysis included TC-reported complications as a potential influencing factor on donors' self-reported complications. No correlation was found between TC-reported complications and donor-reported complications,

TABLE 5 Regression analysis of TC-reported surgery-related complications.

| Logistic regression TC-reported complications | | | | |
|---|---|---|---|---|
| | Odds ratio | 95% confidence limits | | P-value |
| Center size | | | | 0.25 |
| S TCs vs. M TCs (ref) | 0.65 | 0.31 | 1.36 | |
| Surgical technique | | | | 0.99 |
| ODN vs. MIN (ref) | 1.01 | 0.45 | 2.24 | |
| Surgical experience | | | | 0.63 |
| MEx surgeons vs. HEx surgeons (ref) | 0.60 | 0.16 | 2.30 | |
| Mixed team vs. HEx surgeons (ref) | 1.16 | 0.63 | 2.15 | |
| Age >65 yes vs. no (ref) | 1.79 | 0.83 | 3.86 | 0.14 |
| BMI >30 yes vs. no (ref) | 1.22 | 0.55 | 2.71 | 0.62 |
| Smoking status never vs. active/former (ref) | 0.51 | 0.27 | 0.96 | **0.04** |

STC, small transplant center with ≤20 LDs, per year; M TC, medium transplant center with >20 LDs, per year; MIN, minimally invasive nephrectomy; ODN, open donor nephrectomy; HEx, highly experienced surgeons with >100 personally performed LDs; MEx, moderately experienced surgeons with less than 100 LDs performed. Bold: statistically significant.

TABLE 6 Donors' self-reported satisfaction with donation.

| Self-reported outcomes | All n = 1,265 | S TC n = 580 | M TC n = 703 | P-value |
|---|---|---|---|---|
| Preparation for donation took too long [n; %] | 597; 47.2 | 241; 42.9 | 356; 51.5 | **0.002** |
| How do you feel informed about the donation process (prior to donation) (n = 1,274) [n; %] | | | | |
| Very well informed | 848; 66.6 | 410; 70.8 | 438; 63.0 | **0.01** |
| Well informed | 386; 30.3 | 150; 25.9 | 236; 34.0 | |
| Moderately informed | 30; 2.4 | 13; 2.3 | 17; 2.5 | |
| Badly informed | 1; 0.1 | - | 1; 0.1 | |
| Very badly informed | 9; 0.7 | 6; 1.0 | 3; 0.4 | |
| How do you feel informed about the donation process (retrospectively 1Y) (n = 871) [n; %] | | | | |
| Very well informed | 514; 59.0 | 242; 61.9 | 272; 56.7 | 0.60 |
| Well informed | 306; 35.1 | 127; 32.5 | 179; 37.3% | |
| Moderately informed | 32; 3.7 | 13; 3.32 | 19; 4.0 | |
| Badly informed | 4; 0.5 | 2; 0.5 | 2; 0.4 | |
| Very badly informed | 15; 1.7 | 7; 1.8 | 8; 1.7 | |
| Very/rather satisfied with LD 1Y [n; %] (n = 866) | 800; 92.4 | 359; 92.5 | 441; 92.3 | 0.90 |
| Donate again definitely/rather yes 1Y [n; %] (n = 867) | 832; 96.0 | 373; 95.9 | 459; 96.0 | 1.0 |

STC, small transplant center with ≤20 LDs per year; M TC, medium transplant center with >20 LDs per year. Representation: n = number (percentage). Bold: statistically significant.

suggesting that there is only minimal overlap between the TC-reported complications and those reported by the donors.

## Discussion

There is some evidence that high volume TCs provide better results for recipients of a kidney graft and also for living kidney donors. Most of the data come from the US, where a TC with less than 50 LDs per year is categorized as small. A study by Patel et al. postulates that small centers with <50 LDs have worse results (<50, 50–100, >100 LDs per year) and shows that smoking, obesity, and hypertension have an impact on complications after LD [8]. A more recent US-study on KT by Sonnenberg et al. found no difference in three-year patient and graft survival in very large TCs (>196 KTs per year) compared to small centers (<66 KTs per year) [15]. It has to be taken into account that very small centers with less than 10 KTs per year were excluded in this study [15]. Another US study analyzed

TABLE 7 Regression analysis of self-reported complications.

| Logistic regression self-reported complications | | | | |
|---|---|---|---|---|
| | Odds ratio | 95% confidence limits | | P-value |
| Center size | | | | 0.54 |
| S TCs vs. M TCs (ref) | 0.85 | 0.50 | 1.44 | |
| Surgical technique | | | | 0.10 |
| ODN vs. MIN (ref) | 1.73 | 0.90 | 3.31 | |
| Surgical experience | | | | 0.18 |
| MEx surgeons vs. HEx surgeons (ref) | 0.48 | 0.20 | 1.13 | |
| Mixed team vs. HEx surgeons (ref) | 1.14 | 0.70 | 1.90 | |
| Age >65 yes vs. no (ref) | 0.35 | 0.14 | 0.90 | **0.03** |
| BMI >30 yes vs. no (ref) | 0.94 | 0.49 | 1.80 | 0.85 |
| Smoking status never vs. active/former (ref) | 0.72 | 0.45 | 1.14 | 0.16 |
| TC-reported complications yes vs. no (ref) | 1.04 | 0.52 | 2.09 | 0.91 |

STC, small transplant center with ≤20 LDs per year; M TC, medium transplant center with >20 LDs per year; MIN, minimally invasive nephrectomy; ODN, open donor nephrectomy; HEx, highly experienced surgeons with >100 personally performed LDs; MEx, moderately experienced surgeons with less than 100 LDs performed. Bold: statistically significant.

low volume centers (<32 KTs) vs. high volume centers (>72 KTs), which appears to be more comparable to the European situation [16]. After adjusting for multiple factors, the outcome in high volume centers was better. It is unclear whether the results of KT can be applied to living donor operations. A crucial difference between KT and LD is that KT can occur at any time of day or night. This means that a team of several surgeons/urologists must be responsible. In case of LD as a highly elective operation, a single specialized surgeon is sufficient to perform all donor operations in one center. We know from personal communication with the TCs that this is true for several S TCs in Germany.

In Germany, a minimal quantity of 25 annual KTs per center is mandatory, but there is no recommendation for LDs. Similarly, in some smaller European countries, several TCs perform less than 20 LDs per year. Only two centers in Germany perform more than 100 deceased-donor KTs, and only one center performs more than 50 LDs per year today [9].

In German quality control, a lower adjusted mortality after KT has been found in hospitals with more than 25 KTs per year [17]. For living donor nephrectomy, no difference has been demonstrated between smaller and larger transplant centers regarding surgical complications or graft function. There has always been the hypothesis that smaller TCs accept only donors with less risk. The present analysis confirms that AB0i transplantations are indeed less frequently performed in smaller TCs. This should not have an impact on donor complications, but might cause more complications in the recipients, which, however, was not investigated here. There was no difference in donor age, obesity, hypertension, or kidney function in TCs with different caseloads. The fact that more active smokers were accepted in S TCs entails a higher risk of perioperative complications rather than a lower one. Donors with self-reported history of malignancy were rare and not a homogeneous group. Therefore, this might not have a relevant impact on perioperative risks but on long term outcomes.

Interestingly, the experience of the surgeon/urologist performing the donation also had an impact on patient selection. HEx surgeons perform more pre-emptive transplantations, less immunologically high-risk donations, and they are less likely to accept active smokers for donation. We must note that usually it is not the surgeon/urologist alone who accepts the donor, but based on our data, more experienced surgeons seem to adhere to an even stricter donor selection policy.

In our cohort, the operation technique differs significantly with center size and surgical experience. Smaller TCs and less experienced surgeons performed less MIN operations but more robotic-assisted donations. This result is probably not due to the TC size, but to the fact that only in S TCs MEx surgeons were solely responsible for the LD. In larger TCs, surgeons were either highly experienced or worked in mixed teams. MEx surgeons, and therefore smaller TCs, not only performed fewer MIN, but also had a higher conversion rate and longer operating times. It is therefore surprising that neither the TC-reported surgery-related complications nor the overall complications were higher in small centers or MEx surgeons, and that donors even reported having fewer complications when less experienced surgeons performed their procedure. This is in opposition to published data that the surgeon's volume/experience has an impact on outcomes after KT [18], which does not necessarily mean that this also applies to donor operations.

Furthermore, older donors were less likely to self-report complications despite the fact that age had no impact on TC-reported complications. The findings of this study are of particular interest, as they suggest that the personal experience of complications may be influenced by communication and information. Well-informed donors are more likely to have realistic expectations regarding the post-operative course. We have shown before that self-reported complications have more impact on quality of life after donation than TC-reported complications [5]. It is possible that less experienced teams are less accustomed to standardized

procedures and therefore place particular emphasis on personalized communication with the donors. Combined with a lower caseload, this may enable them to devote more attention to donors' individual needs and maintain a closer contact. This different communication strategy might lead to a more positive experience regarding the donation, even in the event of complications. One indication of different communication strategies may be observed in the fact that in smaller TCs, a smaller proportion of donors state that evaluation took too long, and more donors felt very well informed about the donation process. It is a fact that the evaluation process in Germany is longer compared to the US [19], but is comparable to other western countries [20]. Overall, patient satisfaction was quite high in all TCs and independent of center size and self- or TC-reported complications.

Our study has some limitations. We were unable to compare our data with results in large TCs with more than 50 LDs per year. A recent review postulated a trend towards better outcomes in TCs with more than 50 LDs compared to TCs with less than 25 LDs [21], but such large TCs currently do not exist in Germany. There is only one TC with more than 50 LD per year, but this TC has two locations, reporting separately in our registry. Furthermore, there were several TCs with mixed teams, and we cannot attribute a specific LD to a particular surgeon in the registry. Additionally, the report of complications by the TCs might be influenced by the structure of the TC, and we can only speculate whether smaller or larger centers are more stringent with documentation of complications.

In conclusion, this is the first study to evaluate the impact of TC size on patient selection and outcome after living kidney donation in a country with a relevant number of small TCs compared to medium-sized TCs.

Less experienced surgeons in smaller TCs performed more open surgeries, had a higher conversion rate, and longer operation times, but this did not translate into a negative impact on TC- or donor-reported complications or satisfaction with the donation process. On the contrary, donors in smaller TCs felt better informed and self-reported less complications after donation when the operation was performed by less experienced surgeons.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Medical Association of Westphalia-Lippe and the University of Muenster (2019-732-f-S). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

Participated in research design: MK, BS, SK, CS. Participated in the writing of the paper: MK, EB, JW, SK. Participated in data analysis: EB, MK, JW, JG. Participated in the performance of the research: MK, JW, EB, SK, SR, PN, MS, JG, CS, BS. Registry Group Critical Review of the work: MK, JW, EB, SK, SR, PN, MS, JG, CS, BS, Registry Group. Final approval of the version to be published: all authors.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/ti.2026.17208/full#supplementary-material

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