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The Need for Routine Native Nephrectomy in the Workup for Kidney Transplantation in Autosomal Dominant Polycystic Kidney Disease Patients

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Keywords
Autosomal dominant polycystic kidney disease · Polycystic kidney disease · Nephrectomy · Transplantation

Abstract
Introduction: There is no consensus if nor when a native nephrectomy should be performed in the workup for kidney transplantation in ADPKD patients. In our PKD Expertise Center, a restrictive approach is pursued in which nephrectomy is performed only in patients with severe complaints, i.e., in case of serious volume-related complaints, lack of space for the allograft, recurrent cyst infections, persistent cyst bleedings, or chronic refractory pain. We analyzed in a retrospective cohort study whether this approach is justified. ***Methods:*** All ADPKD patients who received kidney transplantation between January 2000 and January 2019 were reviewed. Patients were subdivided into three groups: no nephrectomy (no-Nx), nephrectomy performed before (pre-Tx), or after kidney transplantation (post-Tx). Simultaneous nephrectomy together with transplantation were not performed in our center. ***Results:*** 391 patients (54 ± 9 years, 55% male) were included. The majority of patients did not undergo a nephrectomy (n = 257, 65.7%). A nephrectomy was performed pre-Tx in 114 patients (29.2%). After Tx, nephrectomy was performed in only 30 patients (7.7%, median 4.4 years post-Tx). Surgery-related complication rates did not differ between both groups (38.3% pre-Tx vs. 27.0% post-Tx, p = 0.2), nor were there any differences in 10-year patient survival (74.4% pre-Tx vs. 80.7% post-Tx vs. 67.6% no-Nx, p = 0.4), as well as in 10-year death-censored graft survival (84.4% pre-Tx vs. 85.5% post-Tx vs. 90.0% no-Nx, p = 0.9). ***Conclusions:*** This study indicates that with a restrictive nephrectomy policy in the workup for kidney transplantation, only a part of ADPKD patients need a native nephrectomy.

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Introduction

Autosomal dominant polycystic kidney disease (ADPKD) is the most common inherited kidney disease. It is characterized by the formation of numerous renal cysts, resulting in progressive kidney growth and kidney function decline. Although the course of the disease is variable in ADPKD patients, the majority of patients need kidney replacement therapy. Approximately 50% of the patients are kidney replacement therapy-dependent by the age of 58 years [1–4], and (preemptive) kidney transplantation is the modality of first choice in these patients [5]. During the workup for kidney transplantation, in some ADPKD patients, one or both native kidneys are removed. At the moment, there is no consensus if or when nephrectomy should be performed [6–8].

In general, two different strategies are pursued. First, a (bilateral) nephrectomy can be performed routinely before kidney transplantation, to prevent complications associated with the native polycystic kidneys in the posttransplantation period when immunosuppressive agents are needed and the transplanted kidney is at stake [9–11]. However, preemptive bilateral nephrectomy may negatively impact quality of life because patients should restrict their fluid intake [5]. The other option is a restrictive approach, in which nephrectomy is only performed on indication, i.e., in case of serious volume-related complaints, lack of space for the allograft, recurrent cyst infections, persistent cyst bleedings, or chronic refractory pain [12]. The nephrectomy is performed before or after the transplantation. With this approach, patients are not overtreated and are not exposed to unnecessary risks. However, it might be that patients develop problems related to their afunctional polycystic kidneys in the posttransplantation period, when these patients are more at risk for complications because of the use of immunosuppressive agents, and when there is an additional risk for loss of the kidney transplant [11].

In our expertise center for polycystic kidney diseases, such a restrictive approach is pursued, but it is unknown whether this is justified. In this study, all transplanted ADPKD patients in our center were analyzed to answer this question. First, we therefore evaluated differences in patient characteristics between patients with a pretransplantation nephrectomy, a posttransplantation nephrectomy, and without nephrectomy. Second, complications rates were compared when the nephrectomy was performed pre- or posttransplantation. Lastly, graft and overall patient survival were analyzed in patients with a pretransplantation nephrectomy, a posttransplantation nephrectomy, and without nephrectomy.

Methods

Study Population

In this retrospective single-center cohort study, we included all patients over 18 years of age, with ADPKD and kidney transplantation in the University Medical Center Groningen, the Netherlands, between January 1, 2000 until January 1, 2019 ($n = 415$). The Ministry of Health, Welfare and Sport has designated our University Medical Center Groningen as an expert center in the field of polycystic kidney diseases. In case of the need for specialized ADPKD care, patients can be referred from all over the Netherlands to our tertiary care center. Exclusion criteria for the present analysis were a follow-up period ≤12 months ($n = 20$) and a previous kidney transplantation performed in another institute ($n = 4$). The study protocol was reviewed by the Institutional Review Board of the University Medical Center Groningen and deemed exempt of approval (METc 2017/422).

Data Collection

Eligible patients were identified from the Kidney Transplantation Database of the Dutch Organ Transplantation Registry (NOTR). The electronic medical records, including pathology reports, surgery reports, and discharge letters, were reviewed. Additional data were retrieved from the Dutch Pathology Registry (PALGA). Data were collected on incidence as well as indication for nephrectomy, timing, perioperative complications, and complications during follow-up. All complications were graded according to the Clavien-Dindo system. This classification consists of 5 grades from 1, defined as any deviation from the normal postoperative course, to 5, defined as death of a patient [13]. In addition, information regarding kidney transplantation procedure, graft function, and mortality was collected. Patients in the workup for kidney transplantation are seen by a multidisciplinary team that includes a transplant surgeon. In case this specialist judged, based on the supposed availability of enough space for the transplant kidney in the iliac fossa, that a nephrectomy was needed, a referral to a urologist followed, who performed the actual nephrectomy. Based on the incidence and timing of a nephrectomy, patients were subdivided into three groups. The pre-Tx group included patients who underwent a nephrectomy before kidney transplantation. The post-Tx group included patients who underwent a nephrectomy after kidney transplantation, whereas all other ADPKD patients are part of the no nephrectomy group (no-Nx). Patients with a nephrectomy performed twice, of which one before and one after kidney transplantation were allocated to the pre-Tx group. A diagnosis of ADPKD was based on the Ravine criteria [14]. After transplantation patients were treated according to the Kidney Disease Improving Global Outcomes guidelines. Most of the patients used a standard regimen with triple immunotherapy consisting of tacrolimus, mycophenolate mofetil, and prednisone.

Delayed graft function was defined as dependence of dialysis during the first week after transplantation. Graft failure was defined as a permanent need for dialysis after transplantation. Follow-up was until May 1, 2020 or death. All study data were collected and managed using Research Electronic Data Capture [15].

Statistical Analyses

Categorical data are expressed as number and percentage, whereas continuous data are expressed as mean ± SD when normally distributed or as median (interquartile range) when skewed.

Table 1. Patient characteristics

	All patients (*N* = 391)	Nx pre-transplantation (*N* = 114)	Nx post-transplantation (*N* = 20)	No-Nx (*N* = 257)	*p* value[1]	*p* value[2]	*p* value[3]
Age, years	54±9	54±8	53±7	54±10	0.8	0.5	0.6
Male, *n* (%)	216 (55.2)	71 (62.3)	17 (85.0)	128 (49.8)	0.07	0.03	0.002
BMI, kg/m^2	26.0±4.1	26.2±4.8	25.5±3.6	26.0±3.8	0.5	0.7	0.6
Age at first nephrectomy	–	50±10	57±6	–	0.004	–	–
Need for second nephrectomy, *n* (%)	–	21 (18.4)	7 (35.0)	–	0.6	–	–
Previous abdominal surgery, *n* (%)	132 (33.9)	46 (40.4)	5 (25.0)	81 (31.8)	0.2	0.1	0.6
Presence of liver cysts, *n* (%)	221 (57.7)	72 (66.7)	14 (70.0)	135 (52.9)	0.9	0.02	0.2
Dialysis dependent before transplantation, *n* (%)	287 (73.4)	109 (95.6)	11 (55.0)	167 (65.0)	<0.001	<0.001	0.5
Months of dialysis	32 [16–57]	33 [10–56]	54 [5–76]	32 [17–57]	0.5	0.6	0.6
Dialysis dependent before nephrectomy	85 (29.7)	74 (68.5)	NA		0.03		
Comorbidities at time of transplantation							
Cardiovascular disease, *n* (%)	96 (24.6)	32 (28.1)	6 (30.0)	58 (22.6)	0.9	0.3	0.4
Diabetes mellitus, *n* (%)	26 (6.6)	9 (7.9)	2 (10.0)	15 (5.8)	0.7	0.5	0.6
COPD, *n* (%)	19 (4.9)	6 (5.3)	2 (10.0)	11 (4.3)	0.3	0.8	0.2

Nx, nephrectomy; BMI, body mass index; NA, not applicable. [1] *p* value, comparison between Nx pretransplantation and Nx posttransplantation. [2] *p* value, comparison between Nx pretransplantation and no-Nx. [3] *p* value, comparison between Nx posttransplantation and no-Nx.

Information on demographics and follow-up were analyzed per included patient, whereas indications, surgical and pathological details, and complications were analyzed per nephrectomy performed. Differences in patient characteristics between both groups were calculated with a χ^2 test for categorical data, and for continuous data with Student's *t* test or a Mann-Whitney U test in case of nonnormally distributed data. A two-sided *p* value <0.05 was considered to indicate statistical significance. Statistical analyses were performed using SPSS 23.0 (IBM SPSS Statistics, Inc., Chicago, IL, USA).

Results

In this study, 391 patients were included, mean age at the moment of transplantation was 54 ± 9 years, and 55.2% of the patients were male (Table 1). Almost 50% of the patients received a kidney transplant from a living donor. Overall, 134 patients (34.3%) underwent nephrectomy, of which 114 patients (29.2%) before transplantation, whereas 20 patients (5.1%) had their first nephrectomy after transplantation. No combined procedures (simultaneous kidney transplantation and native nephrectomy) were performed in our center. In only 2 patients, bilateral nephrectomy was performed (in both prior to transplantation). Some patients that had a uninephrectomy subsequently also needed a nephrectomy at the contralateral side, 11 of these patients underwent both procedures before transplantation, in 10 patients the first side was performed before and contralateral side after transplantation, and 7 patients underwent both procedures after transplantation.

Age, BMI, and the presence of comorbidities did not differ significantly between the pre-Tx, post-Tx, and no-Nx groups. A larger proportion of male patients underwent a nephrectomy compared to women (40.7 vs. 26.3%, $p = 0.003$). The need for dialysis treatment before transplantation was significantly higher in the pre-Tx group ($p < 0.001$), only 5 patients were not dialysis dependent in this group, 73 patients (64.0%) were already on dialysis before nephrectomy, and 36 patients (31.6%) became dialysis dependent directly after nephrectomy. Patients were slightly younger at their first nephrectomy in the pre-Tx group compared to the post-Tx group (50 ± 10 years vs. 57 ± 6 years, $p = 0.004$). In case of a post-Tx nephrectomy, the median time of intervention after transplantation was 4.4 (2.1–6.3) years.

Nephrectomy Indication

In total, 133 unilateral nephrectomies and 2 bilateral nephrectomies were performed before kidney transplantation, and 37 unilateral nephrectomies were performed after transplantation. Most of the pre-Tx nephrectomies were performed because of a lack of space for a future kidney graft (49.6%), as shown in Table 2. Other common indications for a pretransplant nephrectomy were renal cyst infections (28.1%), (persistent) cyst hemorrhage (23.0%), and pain (20.0%). Post-Tx nephrectomies were done most often due to recurrent renal cyst infection

Table 2. Indications for nephrectomy

	Pretransplantation ($N = 114$, $n = 135$)	Posttransplantation ($N = 30$, $n = 37$)*	*p* value
Lack of space,** *n* (%)	67 (49.6)	–	<0.001
Renal cyst infection, *n* (%)	38 (28.1)	19 (51.4)	0.01
Urinary tract infection, *n* (%)	8 (5.9)	3 (8.1)	0.7
Cyst hemorrhage, *n* (%)	31 (23.0)	3 (8.1)	0.04
Pain, *n* (%)	27 (20.0)	9 (24.3)	0.6
Presence of GI symptoms, *n* (%)	8 (5.9)	7 (18.9)	0.02
Kidney stones, *n* (%)	1 (0.7)	–	0.9
Compression of graft, *n* (%)	–	1 (2.7)	0.2
Other, *n* (%)	2 (1.5)	2 (5.4)	0.2

Each procedure could have one or more indications. *N*, total number of patients; *n*, total number of procedures; GI symptoms, gastrointestinal symptoms (abdominal fullness, obstipation, or weight loss). * Ten patients had a nephrectomy both pre- and posttransplantation. ** Lack of space for the renal allograft by pretransplantation evaluation of a transplant surgeon.

Table 3. Perioperative data

	Pretransplantation ($N = 114$, $n = 135$)	Posttransplantation ($N = 30$, $n = 37$)*	*p* value
Time between transplantation and nephrectomy, months	20 [6–45]	52 [25–75]	<0.001
eGFR at time of Nx, mL/min/1.73 m^2	9 [6–13]	53 [39–62]	<0.001
Nx left/right, *n* (%)	62/71 (46.6/53.4)**	20/17 (54.1/45.9)	0.5
Surgical approach			
Open			
Transperitoneal, *n* (%)	58 (59.8)	20 (57.1)	0.1
Retroperitoneal, *n* (%)	26 (26.8)	14 (40.0)	
Laparoscopic, *n* (%)	13 (13.4)	1 (2.9)	
Time procedure, min	155 [127–212]	187 [157–229]	0.05
Need for blood transfusion, *n* (%)	10 (10.6)	1 (2.9)	0.3
Admission to ICU, *n* (%)	11 (10.7)	2 (5.6)	0.5
Hospitalization, days	10 [7–12]	6 [5–9]	<0.001
Volume removed kidney, mL	2034 [1332–3138]	1583 [1319–3049]	0.5

N, total number of patients; *n*, total number of procedures; Nx, nephrectomy; eGFR, estimated glomerular filtration rate; ICU, intensive care unit. * Ten patients had a nephrectomy both pre- and posttransplantation. ** Two procedures were performed bilateral.

(51.4%) or severe pain (24.3%). Renal cyst infection and cyst hemorrhage as nephrectomy indication were reported significantly more often in the pre-Tx group ($p = 0.01$ and $p = 0.04$, respectively), whereas volume-related gastrointestinal symptoms as indication for nephrectomy were noted more often in the post-Tx group ($p = 0.02$). No native kidney was removed because of trauma or hypertension. Incidentally, in 4 patients (pre-Tx 3 vs. post-Tx 1), a small renal cell carcinoma was found by pathological analysis, for which no additional treatment was needed.

Nephrectomy Procedure

Most of the native kidneys were removed with an open approach (89.4%), which did not differ between the pre-Tx and post-Tx groups ($p = 0.1$) (Table 3). Twelve different urologists performed the nephrectomy procedure. Of the 14 patients who underwent laparoscopic nephrectomy, no conversion to open nephrectomy was reported. Procedure time of the nephrectomy was slightly longer when performed post-Tx (3.1 h post-Tx vs. 2.6 h pre-Tx, $p = 0.05$). However, the median length of hospital admission was significantly shorter in these patients (6.0 days

Table 4. Complications after nephrectomy in first 90 days

	Pretransplantation ($N = 94$, $n = 115$)**	Posttransplantation ($N = 30$, $n = 37$)	*p* value
Any complication	44 (38.3)	10 (27.0)	0.2
Clavien-Dindo grade 2, *n* (%)			
Any	37 (32.2)	9 (24.3)	0.4
Supraventricular tachycardia	1 (0.9)	–	0.9
Hyperkalemia	2 (1.7)	–	0.9
Rebleeding	9 (7.8)	–	0.1
Hypotension	7 (6.1)	1 (2.7)	0.7
Fever	5 (4.3)	1 (2.7)	0.9
Pneumonia	2 (1.7)	1 (2.7)	0.5
Urinary tract infection	–	1 (2.7)	0.2
Wound infection	–	1 (2.7)	0.2
Sepsis	3 (2.6)	2 (5.4)	0.6
Adrenal insufficiency	2 (1.7)	–	0.9
Abdominal hernia	4 (3.5)	–	0.6
Incisional hernia	6 (5.2)	1 (2.7)	0.9
Rehospitalization after nephrectomy	6 (6.3)	3 (8.6)	0.7
Clavien-Dindo grade 3, *n* (%)			
Any	18 (15.7)	3 (8.1)	0.3
Bowel leakage	2 (1.7)	–	0.9
Ileus	5 (4.3)	–	0.3
Relaparotomy	4 (3.5)	2 (5.4)	0.6
Thromboembolic event***	10 (8.7)	1 (2.7)	0.3
Clavien-Dindo grade 4, *n* (%)			
Any	3 (2.6)	–	0.9
Upper digestive tract bleeding	1 (0.9)	–	0.9
Sepsis	1 (0.9)	–	0.8
Relaparotomy	1 (0.9)	–	0.9
Clavien-Dindo grade 5, *n* (%)			
Any	–	–	–
Death	–	–	–

Each nephrectomy could have one or more complications. *N*, total number of patients; *n*, total number of procedures. ** Of 20 procedures, no complications data were available. *** Defined as shunt occlusion, ischemic cerebrovascular disease, pulmonary embolism, or myocardial infarction within 3 months after nephrectomy.

post-Tx vs. 10.0 days pre-Tx, $p < 0.001$). There was no difference in the side of nephrectomy before or after transplantation ($p = 0.5$). The volume of the removed kidney did not differ between the pre-Tx and post-Tx groups ($p = 0.5$).

Nephrectomy Complications and Patient and Graft Survival

In the majority of patients, no perioperative complications were observed (64.5%) (Table 4). In case complications were observed, thromboembolic events (e.g., shunt occlusion), hemorrhages, hypotension, and incisional hernias were noted most frequently. Surgery-related complication rates did not differ between both groups (38.3% pre-Tx vs. 27.0% post-Tx, $p = 0.2$). Nine (5.9%) patients were rehospitalized after surgery and no nephrectomy-related death was observed. Several sensitivity analyses showed no significant differences in the complication rate between open or laparoscopic procedure nor between time period before 2010 and after 2010 ($p = 0.3$ and $p = 0.2$, respectively).

In addition, the incidence of delayed graft function, graft failure, and mortality was investigated. No differences were found in delayed graft function, graft failure, and mortality between the 3 groups (Table 5). Lastly, patient and graft survival analyses were performed (Fig. 1). There was no significant difference in 10-year patient survival (74.4% pre-Tx vs. 80.7% post-Tx vs. 67.6% no-Nx, *p*

Table 5. Follow-up data

	All patients (*N* = 391)	Nx pre-transplantation (*N* = 114)	Nx post-transplantation (*N* = 20)	No-Nx (*N* = 257)	*p* value[1]	*p* value[2]	*p* value[3]
Kidney transplantation							
Living donor, *n* (%)	189 (49.1)	49 (44.5)	13 (65.0)	127 (49.8)	0.1	0.3	0.2
Heart-beating deceased donor, *n* (%)	104 (27.0)	37 (33.6)	2 (10.0)	65 (25.5)	0.02	0.06	0.2
Nonheart-beating deceased donor, *n* (%)	92 (23.9)	24 (21.8)	5 (25.0)	63 (24.7)	0.9	0.8	0.9
Primary nonfunction of graft, *n* (%)	12 (3.1)	3 (2.7)	0 (0.0)	9 (3.5)	0.9	0.8	0.6
Delayed graft function, *n* (%)	76 (19.7)	25 (22.5)	4 (20.0)	47 (18.4)	0.9	0.4	0.8
Graft failure, *n* (%)	38 (9.7)	13 (11.4)	2 (10.0)	23 (8.9)	0.9	0.6	0.7
Follow-up, months	83 [49–139]	101 [60–155]	122 [81–154]	76 [43–125]	0.3	0.002	0.003
eGFR at follow-up, mL/min/1.73 m^2	48±20	49±21	47±18	48±21	0.8	0.8	0.9
Mortality, *n* (%)	106 (27.2)	36 (31.9)	4 (20.0)	66 (25.8)	0.3	0.3	0.6

Nx, nephrectomy; eGFR, estimated glomerular filtration rate. [1] *p* value, comparison between Nx pretransplantation and Nx posttransplantation. [2] *p* value, comparison between Nx pretransplantation and no-Nx. [3] *p* value, comparison between Nx posttransplantation and no-Nx.

= 0.4), as well as in 10-year death-censored graft survival (84.4% pre-Tx vs. 85.5% post-Tx vs. 90.0% no-Nx, p = 0.9). As sensitivity analyses, patient and graft survival analyses were also performed stratified for sex, and no significant difference was found in 10-year patient and graft survival between the groups.

Discussion

In this study, we analyzed whether a restrictive approach with respect to removing one or both native kidneys is justified in the workup of ADPKD patients that are planned for kidney transplantation. In our center, nephrectomy was performed in 29.2% of the patients before transplantation and only 30 patients (7.7%) needed a nephrectomy after transplantation. Pretransplantation nephrectomies were performed predominantly because of a lack of space or recurrent renal cyst infection, whereas posttransplantation this was done most often because of recurrent renal cyst infection or severe pain. Surgery-related complications did not differ between both groups, nor did patient and graft survival.

In literature, three workup approaches are reported how to deal with the native kidneys in ADPKD patients when a patient needs a transplantation [7, 16]. First, routine (bilateral) nephrectomy can be performed before kidney transplantation [8, 17]. The amount of patients that underwent routine nephrectomy differs between studies and is reported between 50% up to 100% of all patients [7, 18, 19]. Some studies suggest that both native kidneys should be removed before transplantation to lower the risk for cyst infection when the patient is transplanted and consequently uses immunosuppressive agents that may predispose to and complicate cyst infections [9, 20]. In line, the main indication to perform nephrectomy after transplantation in our study was cyst infection. However, this was necessary in only 4.9% of our total patient population. It should be mentioned that the risk to remove a kidney after transplantation due to a cyst infection is relatively low, and therefore, routine nephrectomy to avoid cyst infections may be unnecessary. Also other indications for nephrectomy posttransplantation were rare. In case all patients would have to undergo an elective pretransplantation nephrectomy, the majority of patients will therefore presumably be overtreated and exposed to a potential risk of perioperative complications.

Another argument to prefer pretransplantation nephrectomy in all ADPKD patients is the risk of kidney allograft damage due to hypotension or infection related to surgery when nephrectomy is to be performed posttransplantation on indication [7, 8, 21]. We therefore investigated patient and graft survival between the study groups and found no difference in patient and graft survival after 10 years between the pretransplantation, posttransplantation, and no nephrectomy groups. Our findings are in line with the findings of Chebib et al. [6], and they reported similar to our findings that nephrectomy does not negatively affect graft survival and is feasible when indicated. We therefore conclude that posttransplantation nephrectomy on indication is safe and that there is no need for preemptive nephrectomy in all ADPKD patients in the workup for transplantation to pre-

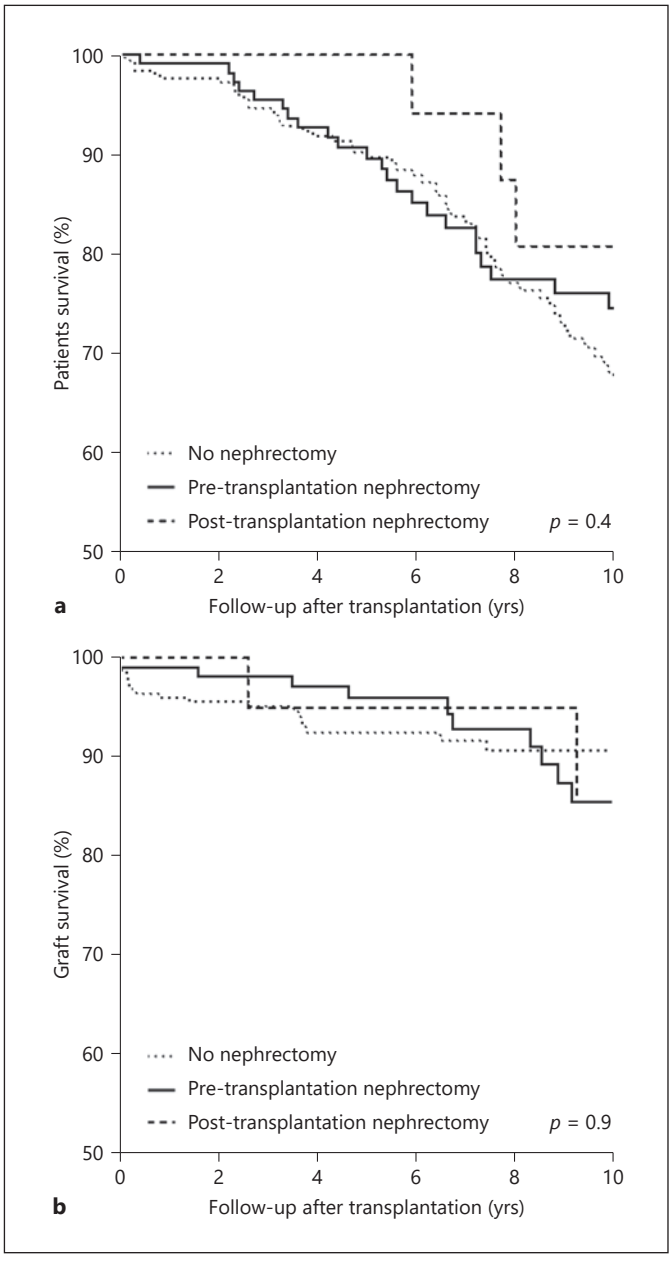

Fig. 1. Kaplan-Meier curves of patient (**a**) and death-censored graft survival (**b**) of ADPKD patients without nephrectomy, pretransplantation nephrectomy, and posttransplantation nephrectomy.

vent the risk of kidney allograft damage when nephrectomy is performed after transplantation.

Second, a combined nephrectomy and transplantation procedure can be performed to reduce the number of surgeries [16, 22–24]. Abrol et al. analyzed in 148 ADPKD patients whether a combined laparoscopic bilateral nephrectomy and kidney transplantation is safe compared to kidney transplantation alone. Patients who underwent a combined procedure had longer cold ischemia time, more often a need to be admitted to an intensive care unit, more need for blood transfusions, and a longer duration of hospital stay. After discharge, however, kidney function was comparable in both groups and no difference was found in delayed graft function nor in the incidence of other severe complications. Based on these results, this may be a promising approach. However, this is a single surgeon series, in which the surgeon has extensive experience in such a complicated, combined procedure, which is likely to have beneficially influenced the results that were obtained. In addition, all transplanted patients received a kidney from a living donor. In our center, the majority of patients receive a kidney allograft from a deceased brain-dead donor and this surgery is performed by various surgeons. The results of this study can therefore not easily be extrapolated to hold true for all ADPKD patients to undergo transplantation in our center, but may be promising for living donor procedures.

Third, a restrictive approach wherein nephrectomy is only performed for strict indications such as serious volume-related complaints, lack of space for the allograft, recurrent cyst infections, persistent cyst bleedings, or chronic refractory pain [7]. When such symptoms are present, nephrectomy is performed before transplantation, and in case the patient develops these symptoms after transplantation, a nephrectomy is performed afterward. In the literature, it is assumed that when such an approach is pursued, around 40–50% of the ADPKD patients undergo nephrectomy of one or both native kidneys [5, 20, 25]. In our study, only 30% of all ADPKD patients needed nephrectomy before transplantation. This low percentage confirms that we are restrictive in performing nephrectomies. In our center, the most common indications for pretransplantation nephrectomy were lack of space (49.6%) and recurrent cyst infection (28.1%). Despite this restrictive approach, only few patients (7.7%) needed a nephrectomy after transplantation. A possible explanation for the small number of posttransplantation nephrectomies is that size of the native ADPKD kidneys remains stable or even reduced after transplantation [26].

Using a restrictive approach with respect to the performing pretransplantation nephrectomy has several advantages. First, it has the benefit of maintaining the native kidneys in more patients, which preserves in these patients residual diuresis and kidney function, and thus may help to prevent the need for (more intense) dialysis [7] and thereby improve quality of life. Second, our study showed that pretransplantation nephrectomy led to lon-

ger hospital stay compared to posttransplantation nephrectomy. This probably can be explained by the fact that most patients who underwent pretransplantation nephrectomy became dialysis dependent thereafter, and that during admission, the start of dialysis had to be arranged. Third, Chebib et al. [6] observed more complications in patients who underwent nephrectomy pretransplantation compared to posttransplantation, especially regarding the need for blood transfusion. Also in our study, more patients needed a blood transfusion in the pretransplantation group compared to the posttransplantation group, although this difference did not reach statistical significance (10.6 vs. 2.9%, $p = 0.3$, respectively). It should be noted that a relatively high number of patients reported postoperative complications after nephrectomy (35.5%); however, other studies showed similar results regarding complication rates between 32% and 74.5% [6, 7, 16].

This study has limitations, of which the most important is the retrospective design. In addition, our study did not include an arm with simultaneous nephrectomy and transplantation as our center did not offer this approach. Around 50% of the patients received a renal allograft from a deceased donor. Most of these procedures took place in the evenings, nights, and/or weekends. Our center did not have the capacity to cover 24 h 7 days a week the possibility of a combined approach (simultaneous kidney transplantation by a transplant team and native nephrectomy by a urologist). However, currently, we are implementing such a combined approach in our center, especially for planned kidney transplant procedures with a living donor. After all, with the current data, we were able to answer the question whether a restrictive workup is justified. Furthermore, we do not report on patient-reported outcome measures, such as quality of life and nutritional status. The main strength of our study is the inclusion of a group of transplanted ADPKD patients that did not undergo nephrectomy. This allows a comparison between the three groups that is important to identify which patients need a nephrectomy and to compare the survival of patients with and without a nephrectomy.

Conclusion

Our study indicates that only a part of ADPKD patients needs a nephrectomy of one or both native kidneys in the workup for kidney transplantation. With a restrictive nephrectomy policy, only few patients need a nephrectomy after kidney transplantation for indications not to be foreseen before the transplantation. Routine nephrectomy may therefore be an overtreatment, especially when done to counteract the potential risk to develop a cyst infection after transplantation. Furthermore, complication rates of surgery, mortality, and death-censored graft loss are equal when comparing nephrectomy before and after kidney transplantation. Given these results, we suggest that routinely performing nephrectomies before kidney transplantation in ADPKD patients is not warranted and that a restrictive nephrectomy policy seems justified.

Statement of Ethics

All procedures in this study involving human participants were in accordance with the ethical standards of the Institutional Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study protocol was reviewed by the Institutional Review Board of the University Medical Center Groningen and deemed exempt of approval (METc 2017/422). As the present study was carried out retrospectively, the need to obtain written informed consent from the patients was waived by the Institutional Review Board. Personal identifiers of the patients were removed, and the data were analyzed anonymously.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Concept and design of this post hoc study were done by Niek F. Casteleijn, Anna M. Leliveld, and Ron T. Gansevoort. Acquisition of the data was performed by Niek F. Casteleijn, Paul Geertsema, Iris W. Koorevaar, Friso D.J. Inkelaar, Marnix R. Jansen, Steven J. Lohuis, Peter E. van de Streek, and Ron T. Gansevoort. Interpretation of the data and drafting of the manuscript were done by Niek F. Casteleijn, Paul Geertsema, Iris W. Koorevaar, Friso D.J. Inkelaar, Marnix R. Jansen, Steven J. Lohuis, Peter E. van de Streek, and Ron T. Gansevoort. Niek F. Casteleijn, Paul Geertsema, Iris W. Koorevaar, Friso D.J. Inkelaar, Marnix R. Jansen, Steven J. Lohuis, Esther Meijer, Robert A. Pol, Jan-Stephen Sanders, Peter E. van de Streek, Anna M. Leliveld, and Ron T. Gansevoort critically revised the manuscript for important intellectual content, agreed to publication, and can be held accountable for its content.

Data Availability Statement

The data that support the findings of this study are not publicly available because they contain information that could potentially compromise the privacy of the research participants and are however available from the corresponding author Niek F. Casteleijn upon reasonable request.

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