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ORIGINAL ARTICLE

Recipient and donor risk factors for surgical complications following kidney transplantation

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Abstract

Objective. The aim of this study was to evaluate recipient and donor risk factors that are related to surgical complications after renal transplantation. *Material and methods.* In total, 419 kidney transplantations were analysed with regard to the influence of recipient and donor risk factors on the main postoperative surgical complications. *Results.* The mean follow-up for the entire group was 72.8 months (± 54.2 SD). Vascular complications were independently associated with donor age; and urological complications with recipient age >65 years and cyclosporine rather than tacrolimus therapy. Wound complications were independently associated with recipient age, preoperative dialysis time, recipient body mass index (BMI) and cyclosporine rather than tacrolimus therapy. Collections were independently associated with retransplantation, type 2 diabetes mellitus and wound complications. Overall surgical complications were associated with donor age and delayed graft function. In terms of severity, grade I complications were independently associated with recipient age and surgical revision, grade II with recipient age >50 years, grade III with recipient BMI, and grade IV with donor age. *Conclusions.* Recipient characteristics are the primary determinants of wound, urological and minor (Clavien grades I, II and III) complications; however, graft or donor characteristics are the primary risk factors for vascular, overall and major (Clavien grade IV) surgical complications.

Key Words: *kidney transplantation, risk factors, surgical complications*

Introduction

Kidney transplantation results in the best quality of life and survival for most patients with end-stage kidney disease [1,2]. Nevertheless, the benefits provided by the surgical procedure are not free of side-effects. Reported surgical complication rates following kidney transplantation range from 1% to 25%; the rate depends on the series and on the type of complications reported by the study [3–6].

The surgical complications that follow transplantation are serious because they occur in patients who have been weakened by chronic renal failure and who have a single kidney. These complications may lead to graft loss [5]. For this reason, early diagnosis and treatment are essential.

Although most surgical complications result mainly from technical errors, the recipient and donor characteristics also have a decisive influence. Previous studies have described the various recipient and donor risk factors that are related to specific types of surgical complications [7–11]. However, few studies have assessed the full effect of these risk factors on the different subtypes of surgical complications (parietal, urological and vascular) that are observed in the context of renal transplantation, and the available information is controversial. In addition, few studies have evaluated the effects of modern immunosuppressive drugs [mycophenolate mofetil (MMF), calcineurin inhibitors and mammalian target of rapamycin (mTOR) inhibitors] on the development of surgical complications [12,13].

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The purpose of this study was to evaluate all of the possible recipient and donor risk factors that are related to surgical complications after renal transplantation. The association of these risk factors with the development of postoperative complications was analysed, focusing on surgical events, and specific and global subtypes of complications were studied. Finally, the study investigators sought to correlate donor and recipient risk factors with the severity of the surgical complications, using a validated classification method.

Material and methods

Patients and data assessment

An analytical observational retrospective study was conducted of 419 consecutive adult kidney transplantations performed between 1994 and 2010. The influence of all possible risk factors on the incidence of surgical complications after renal transplantation was studied.

Acute rejection was confirmed through biopsies and by an improvement in renal function after administering corticosteroids. Delayed onset of kidney function was defined by a patient's need for dialysis within the first postoperative week. Glomerular filtration rates (GFRs) were calculated with the four-variable Modification of Diet in Renal Disease (MDRD) formula.

The clinical variables shown in Table I were obtained from hospital records respecting the confidentiality of any data obtained, using non-identifiable patient information.

The kidney transplantations were performed by the same four surgeons throughout the study period, using a previously described surgical technique [14].

The study was evaluated and approved by the clinical ethics committee of the hospital.

Surgical complications

The wound complications included wound infections and wound eventrations. Collections consisted of lymphoceles and perirenal haematomas. The urological complications included hydronephrosis with deterioration in renal function, urinary fistulae, ureterovesical junction stenosis, vesicoureteral reflux and graft lithiasis. The vascular complications consisted of postoperative haemorrhage, renal vein thrombosis, renal artery thrombosis and renal artery stenosis. All of the surgical complications were recorded and classified using the modified Clavien classification system (Table II) [15,16].

Table I. Demographic and clinical characteristics of the study group[a].

Recipient age (years)	49.9 ± 13.9
Donor age (years)	48.1 ± 18.3
Recipient BMI (kg/m^2)	25 ± 4
Donor BMI (kg/m^2)	25.4 ± 3.9
Donor ICU stay (d)	2.6 ± 3.1
Residual diuresis (ml)	842 ± 719
Preoperative dialysis time (months)	31.7 ± 44.2
HLA matches	2.2 ± 0.9
Cold ischaemia time (h)	14.5 ± 7.3
Males	256 (61.1)
Smokers	73 (17.4)
Recipient arterial hypertension	332 (79.2)
Recipient dyslipidaemia	123 (29.4)
X-ray vascular calcifications[b]	84 (20)
Ventricular hypertrophy[c]	134 (32)
Acute rejection episodes	180 (43)
Delayed graft function	89 (21.2)
Functioning grafts	328 (78.3)
Dialysis type:	
Predialysis	23 (5.5)
CAPD	72 (17.2)
Haemodialysis	307 (73.3)
CAPD + haemodialysis	17 (4.1)
Immunosuppression therapies	
Cyclosporine + MMF	120 (28.6)
Cyclosporine + azathioprine	71 (16.9)
Tacrolimus + MMF	181 (43.2)
Cyclosporine + sirolimus	12 (2.9)
Cyclosporine + everolimus	10 (2.4)
Other therapies	24 (5.7)
Original renal disease	
Polycystic kidney disease	81 (19.3)
Glomerulonephritis	98 (23.4)
Diabetic nephropathy	33 (7.9)
Obstructive uropathy	18 (4.3)
Autoimmune disease	12 (2.9)
Chronic pyelonephritis	35 (8.4)
Nephroangiosclerosis	43 (10.3)
Tubulointerstitial nephritis	26 (6.2)
Idiopathic	53 (12.6)
Other	20 (4.7)
Postoperative complications	
Overall surgical complications[d]	147 (35.1)
Vascular complications	38 (9.1)

Table I. (*Continued*).

Wound complications	49 (11.7)
Urological complications	55 (13.1)
Early complications	52 (12.4)
Late complications	97 (23.2)
Collections	52 (12.4)
Wound eventrations	41 (9.8)
Wound infection	21 (5)
Lymphoceles	35 (8.4)
Postoperative haemorrhage	23 (5.5)
Perirenal haematoma	21 (5)
Vesicoureteral reflux	1 (0.2)
Hydronephrosis[e]	36 (8.6)
Urinary fistula	19 (4.5)
Ureterovesical junction stenosis	15 (3.6)
Graft lithiasis	4 (1)
Postoperative haemorrhage	23 (5.5)
Renal vein thrombosis	13 (3.1)
Renal artery stenosis	3 (0.7)
Renal artery thrombosis	2 (0.5)

[a]Data are shown as mean ± SD or number (%) of patients. Mean follow-up (all patients combined) was 73 ± 54 months. [b]Determined by radiography; [c]determined by echocardiography; [d]147 (35.1) transplant recipients had 234 surgical complications; [e]hydronephrosis causing functional impairment.
BMI = body mass index; ICU = intensive care unit; HLA = human leucocyte antigen; CAPD = continuous ambulatory peritoneal dialysis; MMF = mycophenolate mofetil.

Immunosuppression

The recipients adhered to their immunosuppressive regimens for at least 1 year after transplantation. These therapies evolved over the study period. The more recent therapies involved tacrolimus and MMF, whereas the older approaches included cyclosporine and azathioprine. In addition, all of the patients received 5 mg/kg methylprednisolone intraoperatively. This dose was increased to 20 mg/day during the first month after the surgery. After this period, the dose was decreased in an effort to wean the patient off corticosteroids. The different immunosuppressive regimens are listed in Table I.

Statistical analyses

The data analysis was performed using statistical software (SPSS, version 15.0; SPSS, Chicago, IL, USA). Comparisons were made using the *t* test for continuous variables and the chi-squared test for categorical variables. The risk of developing surgical complications was calculated using univariate and multivariate binary logistic regression analysis. Continuous data are reported as the mean ± SD and categorical data as number (%). Statistically significant differences were considered to have a p value ≤ 0.05.

Results

The study group consisted of 419 renal allografts, mainly obtained from cadaveric donors (97.1%). The mean follow-up for the entire group was 72.8 ± 54.2 months. Surgical complications occurred in 147 of the 419 transplantations (35.1%). Most of the complications were treated with an invasive procedure involving surgery, endoscopy or radiology (Clavien grade III) (Table II). The specific surgical complication rates and other clinical characteristics are listed in Table I.

The transplant recipients in the group that had surgical complications were significantly older and had a higher frequency of delayed graft function and type 2 diabetes mellitus than the transplant recipients who did not have complications. The donors for the individuals in the surgical complications group were also significantly older and were more likely to have type 2 diabetes mellitus (Table III).

Donor and recipient risk factors related to "specific" surgical complications

The analysis of specific surgical complications revealed that lymphocele was independently associated with a recipient body mass index (BMI) greater than 25, as well as retransplantation and treatment with mTOR inhibitor rather than tacrolimus. The multivariate analysis also showed that the independent prognostic factors for wound eventration were recipient age, recipient BMI and cyclosporine rather than tacrolimus treatment.

Furthermore, hydronephrosis was independently associated with donor age; haematoma, with recipient age greater than 50 years; postoperative haemorrhage, with donor age and preoperative dialysis time; and wound infection, with recipient age and transplantation revision (Table IV).

Donor and recipient risk factors related to "types and severity" of surgical complications

The analysis of types of surgical complications showed that vascular complications were independently associated with donor age; urological complications, with recipient age greater than 65 years and cyclosporine rather than tacrolimus therapy. Wound complications were independently associated with recipient age, preoperative dialysis time, recipient BMI, and cyclosporine rather than tacrolimus therapy. Collections were

Table II. Classification of surgical complications in 419 consecutive recipients of kidney transplants[a].

Grade	Effects of complication	Observed complications	No. (%) of patients with complications
I	Alteration of the ideal postoperative course	Surgical wound infection	21 (5)
	No threat to patient's life		
	No reoperation; only bedside procedures necessary		
	No increase in hospital stay		
II	More medical treatment with drugs required (including transfusions and parenteral nutrition)	Perirenal haematoma	21 (5)
	No reoperation		
	Potentially life threatening		
	Limited residual disability		
III	Surgery, endoscopy or radiology required[b]	Wound eventration	109 (26)
		Lymphocele	
		Hydronephrosis	
		Vesicoureteral reflux	
		Graft lithiasis	
		Urinary fistula	
		Vesicoureteral junction stenosis	
IV	Life threatening	Renal vein thrombosis	35 (8.4)
	Residual long-term disability (including resection of the organ transplant or persistence of life-threatening condition)	Renal artery thrombosis	
		Renal artery stenosis	
		Postoperative bleeding	
V	Death	None	0 (0)

[a]Adapted and modified from Clavien et al. [15]. [b]Different subtypes according to the type of anaesthesia were not recorded.

independently associated with retransplantation, type 2 diabetes mellitus and wound complications and, finally, overall surgical complications with donor age and delayed graft function.

In terms of severity, grade I complications were independently associated with recipient age and transplantation revision; grade II, with recipient age greater than 50 years; grade III, with recipient BMI; and grade IV, with donor age (Table V).

Discussion

Surgical complication rates ranging from 1% to 25% have been reported [3–6]. This variability is due to the lack of an agreed classification system for these complications, which can lead to underestimating or overestimating the incidence of complications. The complication rate in this study (35.1%) was much higher than that in other reports. The higher rate is explained by the more comprehensive definition of complications used in this study. This definition included minor complications that are not recorded in many series and included both complications specific to transplants (such as renal vein thrombosis, urinary fistula, ureterovesical junction stenosis and renal artery stenosis) and those common to any surgical procedure (such as eventration of surgical wounds, wound infection, the need for repeat surgery and postoperative bleeding). When this factor is considered, the surgical complication rates are similar.

The present study provides a broader description of different surgical complications than has previously been available, with severity classified using the Clavien system (Tables IV and V). Previous studies have typically evaluated only one type of complication, such as wound, urological or vascular complications, or have reported data on overall surgical survival rates. However, no previous study has reported the severity of complications using a standardized classification system, such as the Clavien system. Furthermore, conflicting data have previously been reported about the donor or recipient characteristics that may predict the incidence of surgical complications.

Although some authors describe a relationship between vascular complications and recipient atheromatosis, delayed graft function and dialysis duration [17], this result has not been confirmed by others [18]. Traditionally, a higher incidence of vascular

Table III. Clinical factors, medical problems and treatment variables in donors and recipients of 419 kidney transplants[a].

Variables	Postoperative surgical complications		*p*
	No surgical complications group	Surgical complications group	
No. (%) of transplantations	272 (64.9)	147 (35.1)	
Donor			
Age (years)	46 ± 17.9	51.9 ± 18.5	≤0.003
BMI (kg/m^2)	25 ± 3	25.1 ± 3.7	NS
Serum creatinine (mg/dl)	1 ± 0.4	1.08 ± 0.4	NS
ICU stay (days)	2.8 ± 3.1	2.4 ± 3.2	NS
Medical problems			
Dyslipidaemia	24 (14.1)	9 (9.7)	NS
Arterial hypertension	56 (30.9)	36 (34.3)	NS
Type 2 diabetes mellitus	11 (6.4)	13 (13.8)	≤0.04
Recipient			
Age (years)	48.5 ± 13.4	52.7 ± 14.4	≤0.001
BMI (kg/m^2)	24.7 ± 3.9	25.4 ± 4.3	NS
Preoperative dialysis time (months)	29.2 ± 44	36.3 ± 43	NS
Cold ischaemia time (h)	14.6 ± 8.1	14.3 ± 5.5	NS
HLA matches	2.2 ± 1	2.3 ± 0.9	NS
Medical problems			
Delayed graft function	38 (14)	51 (34.7)	≤0.001
Acute rejection	122 (44.9)	58 (39.5)	NS
Arterial hypertension	222 (81.6)	110 (74.8)	NS
Dyslipidaemia	82 (30.1)	41 (27.9)	NS
Iliac vessel calcification[b]	51 (20.2)	33 (23.4)	NS
Type 1 diabetes mellitus	19 (7)	11 (7.5)	NS
Type 2 diabetes mellitus	6 (2.2)	10 (6.8)	≤0.02
Dialysis type			
Predialysis	19 (7)	4 (2.7)	
CAPD	43 (15.8)	29 (19.7)	
Haemodialysis	200 (73.5)	107 (72.8)	
CAPD + haemodialysis	10 (3.7)	7 (4.8)	NS

[a]Data are shown as mean ± SD or number (%) of patients. Mean follow-up (all patients combined) was 73 ± 54 months. [b]Determined by radiography.
BMI = body mass index; ICU = intensive care unit; HLA = human leukocyte antigen; CAPD = continuous ambulatory peritoneal dialysis; NS = not significant ($p > 0.05$).

complications has been reported for donors and recipients who have had vascular disease, including a higher frequency of arterial embolism and graft loss after manipulating the arteriosclerotic vessels [19], but vascular complications were independently associated with donor age in the present study. This finding suggests that vascular complications are related both to the recipient's "vascular status" and to graft quality, which is determined by donor age. In fact, iliac calcification in the recipient, as determined by radiography, was not associated with surgical complications in this study. Thus, poor quality graft and donor vessels have a decisive and more important influence on postoperative vascular complications than do recipient characteristics.

Furthermore, urological complications have also been widely analysed, with rates ranging from 2.5% to 27% in different series [4,20]. They are traditionally related to technical defects and to kidney rejection, but donor and recipient risk factors, such as recipient age or dialysis duration, are also involved [17]. In the present study cohort, urological complications were associated with recipient age greater than 65 years (odds ratio 2.4) and cyclosporine rather than tacrolimus therapy (odds ratio 1.9). To the authors' knowledge, there are no other studies that have suggested that tacrolimus has a better wound healing and tissue scarring profile than cyclosporine.

The most common post-transplantation surgical complications are wound complications. Diabetes,

Table IV. Recipient and donor risk factors related with specific surgical complications in 419 consecutive recipients of kidney transplants[a].

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p*	OR	95% CI	*p* ≤
Lymphocele						
Recipient BMI > 25 kg/m^2	2.5	1.08 to 5.7	≤0.03	4.8	1.4 to 16.5	≤0.001
Retransplantation	3.5	1.5 to 7.9	≤0.002	11.1	3.3 to 37.3	≤0.001
mTOR inhibitors vs tacrolimus	3.6	1.1 to 11.4	≤0.02	5.7	1.5 to 20.7	≤0.01
Renal failure caused by glomerulonephritis	2.7	1.3 to 5.5	≤0.006			
Wound eventration						
Recipient age (years)	1.04	1.02 to 1.07	≤0.002	1.04	1.004 to 1.08	≤0.03
Recipient BMI (kg/m^2)	1.2	1.1 to 1.3	≤0.001	1.1	1.04 to 1.2	≤0.01
MMF vs azathioprine	4.4	1.2 to 15.6	≤0.02			
Cyclosporine vs tacrolimus	3.7	1.6 to 8.6	≤0.002	3.8	1.6 to 9.1	≤0.002
mTOR inhibitors vs tacrolimus	4.6	1.5 to 13.6	≤0.006			
Hydronephrosis[b]						
Donor age (years)	1.02	1.001 to 1.04	≤0.048			
Haematoma						
Donor age (years)	1.03	1.004 to 1.06	≤0.02			
Recipient age > 50 years	3.4	1.2 to 9.5	≤0.01	3.4	1.2 to 9.5	≤0.02
Postoperative haemorrhage						
Donor age (years)	1.03	1.01 to 1.06	≤0.01	1.04	1.01 to 1.06	≤0.02
Recipient age > 50 years	3	1.2 to 7.8	≤0.02			
Preoperative dialysis time (months)	1.008	1.002 to 1.01	≤0.01	1.007	1.001 to 1.01	≤0.03
Wound infection						
Recipient age (years)	1.05	1.01 to 1.09	≤0.01	1.05	1.001 to 1.01	≤0.01
Donor age (years)	1.04	1.01 to 1.07	≤0.01			
Preoperative dialysis time (months)	1.007	1.001 to 1.01	≤0.03			
Transplantation revision	4	1.4 to 11	≤0.007	4	1.4 to 11.4	≤0.01
mTOR inhibitors vs tacrolimus	3.7	1.08 to 13.3	≤0.03			

[a]Surgical complications with limited casuistry (vesicoureteral reflux, urinary fistula, ureterovesical junction stenosis, graft lithiasis, renal artery stenosis, renal artery thrombosis, renal vein thrombosis) were not included in final "specific surgical complications" analysis. [b]Hydronephrosis causing functional impairment.
BMI = body mass index; mTOR = mammalian target of rapamycin; MMF = mycophenolate mofetil; OR = odds ratio; CI = confidence interval.

obesity, wound infections, rejection and immunosuppression are the promoting factors. In some cases, the decisive factor is patient obesity and chronic rejection [12,21], whereas others have focused on MMF and sirolimus as the major risk factors for this type of complication [17,22]. The present study confirms previous findings that wound complications are independently associated with recipient age, dialysis time, recipient BMI, and cyclosporine rather than tacrolimus therapy. In this case, recipient characteristics are the main predictors of wound complications.

The incidence of postoperative collections has not been clearly reported in the literature because collections are often diagnosed by ultrasound without having caused clinical signs or impaired graft function. The main causes of collections are deficient haemostasis during surgery, impaired haemostasis secondary to postoperative anticoagulation or to the coagulopathy of chronic renal failure, excess dissection of the iliac vessels (which damages the surrounding lymphatic vessels) and deficient sealing of the lymphatic vessels in the renal hilum during surgery [9,23]. In the present study, collections were also associated with donor and recipient risk factors, such as retransplantation, type 2 diabetes mellitus and wound complications.

The literature on overall surgical complications offers disparate results. In some reports, donor and recipient age have been described as the major risk factors for surgical complications after kidney transplantation [24–27]. By contrast, other studies have not found significant donor and recipient age effects [28–31]. Although some studies did not observe an effect of donor and recipient age on surgical complication rates, the present work confirms the importance of donor age and delayed graft function for the risk of surgical complications.

Table V. Recipient and donor risk factors related with types and severity of surgical complications in 419 consecutive recipients of kidney transplants[a].

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p*	OR	95% CI	*p*
Surgical complication type						
Vascular						
Donor age (years)	1.02	1.001 to 1.04	≤0.02			
Urological						
Recipient age > 65 years	2.2	1.2 to 4.4	≤0.02	2.4	1.2 to 4.9	≤0.01
Cyclosporine vs tacrolimus	1.8	1.02 to 3.4	≤0.040	1.9	1.08 to 3.6	≤0.03
Wound (all)						
Recipient age (years)	1.04	1.01 to 1.06	≤0.002	1.03	1.005 to 1.05	≤0.02
Donor age (years)	1.02	1.002 to 1.04	≤0.03			
Dialysis time (months)	1.01	1.001 to 1.05	≤0.04	1.01	1.003 to 1.02	≤0.01
Recipient BMI (kg/m^2)	1.15	1.07 to 1.2	≤0.001	1.16	1.06 to 1.3	≤0.001
Transplantation revision	2.3	1.02 to 5.1	≤0.04			
Delayed graft function	1.9	1.03 to 3.7	≤0.04			
Cyclosporine vs tacrolimus	2.2	1.06 to 4.6	≤0.03	2.5	1.2 to 5.5	≤0.02
mTOR inhibitors vs tacrolimus	4.7	1.7 to 12.4	≤0.002			
Collections[a]						
Retransplantation	2.3	1.1 to 4.8	≤0.02	3.1	1.2 to 8.1	≤0.02
Type 2 diabetes mellitus	3.4	1.1 to 10.3	≤0.02	2.7	1.2 to 6.4	≤0.02
Wound complication	2.3	1.1 to 4.9	≤0.03	3.7	1.03 to 14	≤0.04
Overall surgical complications						
Recipient age (years)	1.02	1.01 to 1.04	≤0.003			
Donor age (years)	1.02	1.01 to 1.03	≤0.002	1.03	1.01 to 1.4	≤0.002
Type 2 diabetes mellitus	3.7	1.1 to 11.4	≤0.02			
Donor type 2 diabetes mellitus	2.4	1.03 to 5.6	≤0.04			
Delayed graft function	3.2	2 to 5.3	≤0.001	3.1	1.9 to 5	≤0.001
mTOR inhibitors vs tacrolimus	4.1	1.7 to 9.7	≤0.001			
Severity of surgical complication[b]						
Grade I complication						
Recipient age (years)	1.05	1.01 to 1.09	≤0.01	1.05	1.001 to 1.01	≤0.01
Donor age (years)	1.04	1.01 to 1.07	≤0.01			
Preoperative dialysis time (months)	1.007	1.001 to 1.01	≤0.03			
Transplantation revision	4	1.4 to 11	≤0.007	4	1.4 to 11.4	≤0.01
mTOR inhibitors vs tacrolimus	3.7	1.08 to 13.3	≤0.03			
Grade II complication						
Recipient age > 50 years	3.4	1.2 to 9.5	≤0.01	3.4	1.2 to 9.5	≤0.02
Donor age (years)	1.03	1.004 to 1.06	≤0.02			
Grade III complication						
Recipient age (years)	1.02	1.001 to 1.03	≤0.04			
Donor age (years)	1.02	1.002 to 1.03	≤0.02			
Recipient BMI (kg/m^2)	1.1	1.01 to 1.15	≤0.02	1.07	1.02 to 1.1	≤0.01
Cyclosporine vs tacrolimus	1.9	1.1 to 3.4	≤0.02			
mTOR inhibitors vs tacrolimus	4.2	1.61 to 11.3	≤0.004			
Grade IV complication						
Recipient age (years)	1.01	1.001 to 1.04	≤0.04			

Table V. (*Continued*).

	Univariate analysis			Multivariate analysis		
	OR	95% CI	*p*	OR	95% CI	*p*
Donor age (years)	1.02	1.002 to 1.03	≤0.02	1.03	1.01 to 1.05	≤0.02
Cyclosporine vs tacrolimus	1.9	1.07 to 3.4	≤0.03			
mTOR inhibitors vs tacrolimus	4.2	1.6 to 11.3	≤0.004			

[a]Collections consisted of lymphoceles and perirenal haematomas. [b]Adapted and modified from Clavien et al. [15].
BMI = body mass index; mTOR = mammalian target of rapamycin; OR = odds ratio; CI = confidence interval.

In terms of severity, it is clear that minor complications (Clavien grades I, II and III) are associated with recipient risk factors (age, BMI and transplantation revision), whereas potentially life-threatening major events (Clavien grade IV) are mainly associated with donor factors (age).

The limitations of the present study include its retrospective design and lengthy study period (15 years). However, the large sample size (419 transplantations) helped to address the limitations of previous studies, which had smaller study populations, and allowed the characterization of the different surgical complication subtypes. Furthermore, most previous studies have used shorter follow-up periods than the present study; longer follow-up is crucial because some surgical complications, such as ureterovesical stenosis, hydronephrosis and wound complications, may develop more than a year after surgery.

In conclusion, surgical complications following kidney transplantation are serious; thus, early diagnosis and treatment is essential. In this sense, knowing the associated recipient and donor risk factors is crucial. The present results show that recipient characteristics, such as age, type of immunosuppressive therapy and BMI, may be the primary determinants of wound, urological and minor (Clavien grades I, II and III) complications; however, graft or donor characteristics may be the primary risk factors for vascular, overall and major (Clavien grade IV) surgical complications.

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