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SINGLE-CENTER EXPERIENCE IN KIDNEY TRANSPLANTATION: OUTCOMES, CONCLUSIONS, AND PERSPECTIVES

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Kidney transplantation (KT) remains the best treatment for patients with chronic kidney disease (CKD) stage 4–5. It helps patients live longer, have better quality of life, and undergo improved medical and social rehabilitation. This paper examines the outcomes of KT performed between 2019 and 2023. **Materials and methods.** There were 1,106 KTs deceased donor KTs performed between January 1, 2029, and December 31, 2023. The recipients had a median age of 45 (37–54) years, with 664 (60%) males and 442 (40%) females. Donors were mainly males (n = 706, 63.8%), with the median donor age being 50 (43–57) years. Induction immunosuppressive therapy (IST) with monoclonal antibodies was administered to 859 (77.7%) recipients, with polyclonal antibodies to 122 recipients (11%), and induction without antibodies to 125 recipients (11.3%). Triple-drug baseline IST consisted of a combination of calcineurin inhibitors, antimetabolites and glucocorticoids. Tacrolimus was the most often utilized calcineurin inhibitor (n = 961, 86.9%), while cyclosporine was used less often (n = 145, 13.1%). Mycophenolic acid (n = 1041, 94.1%) was used as the second medication in most recipients, while everolimus (n = 54, 4.9%) and azathioprine (n = 11, 1%) were used less often. **Results.** Primary initial renal graft function was noted in 714 patients (64.6%) and delayed in 392 recipients (35.4%). Overall incidence of surgical complications was 11.6% (n = 130), and immunological complications 9.9% (n = 109). At hospital discharge, 768 recipients (69.4%) had satisfactory kidney allograft (KAG) function, while 276 recipients (25%) were discharged with graft dysfunction; median serum creatinine and blood urea levels were 158 (120–204) μmol/L and 11 (8–16) mmol/L, respectively. Twenty-six recipients (2.4%) were discharged to continue renal replacement therapy; 28 recipients (2.6%) underwent in-hospital graft nephrectomy. Twelve individuals passed away during the hospitalization phase. The cumulative uncensored in-hospital graft and recipient survival rates were 97.5% (n = 1078) and 98.9% (n = 1094), respectively. **Conclusion.** KT is an effective and safe transplant modality for stage 4–5 CKD. Our KT outcomes are consistent with those of reputable transplant centers around the globe.

Keywords: kidney transplantation, post-kidney transplant complications, immunological complications, acute kidney transplant rejection, kidney transplant survival, recipient survival.

INTRODUCTION

Chronic kidney disease (CKD) remains a significant financial burden worldwide and a major challenge for modern medicine. According to international data, kidney disease affects over 10% of the global population [1]. Approximately 850 million individuals worldwide are living with various stages of CKD, and about 3.9 million progressing to kidney failure [2]. A study by Vivekanand Jha et al. estimates that the average annual cost of treating CKD at stages IIIa, IIIb, IV, and V are approximately $3,060, $3,544, $5,332, and $8,736 per patient, respectively [3].

As of December 31, 2020, a total of 60,547 patients with stage 5 CKD in our country were on renal replacement therapy (RRT). Of these, 83.5% (n = 50,563) were undergoing dialysis-based treatment [4]. Non-transplant treatment options for this condition are limited, serving primarily as a "bridge to transplantation", which remains the most effective surgical intervention [5]. Kidney transplantation (KT) offers significantly improved quality and duration of life compared to dialysis-based RRT, offering superior outcomes in terms of medical and social rehabilitation. More than 100,000 kidney transplants are performed globally each year. In 2022 alone, 102,090 kidney transplant procedures were carried out [6], the majority

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involving deceased donors. Despite the reasonable expansion of donor eligibility criteria and advancements in organ preservation technologies, critical organ shortage persists, leading to a significant gap between the demand for and availability of transplant care [7–9].

One of the pressing challenges in clinical KT remains the prevention and management of delayed graft function (DGF), which leads to prolonged hospitalization and increased treatment costs. Currently, the incidence of DGF ranges widely from 20% to 62.2% [10–21]. Despite advances over the past two to three decades in protocols for the prevention, diagnosis, and treatment of immunological complications, these issues remain the leading cause of renal graft loss. Surgical complications, occurring in 16% to 46% of cases, also contribute significantly to increased morbidity and extended hospital stays [22–27]. Infectious complications continue to have a profound negative impact on both graft and recipient survival rates [28–36]. The development and implementation of modern, evidence-based protocols for patient management and the treatment of post-transplant complications are therefore crucial for improving outcomes.

Globally, it is common practice within the transplant community to publish KT outcomes from both individual transplant centers and national registries. Unfortunately, in the Russian literature, such comprehensive reports remain unreasonably scarce [37]. With this article, we aim to initiate and encourage the regular publication of transplant outcomes by other transplant centers in our country.

Objective: to analyze KT outcomes performed at the transplant center with the highest annual volume of deceased-donor KTs in the Russian Federation during the period 2019–2023.

MATERIALS AND METHODS

From January 1, 2019, to December 31, 2023, a total of 1,106 deceased-donor KTs were performed at the Kidney and Pancreas Transplant Department, Sklifosovsky Research Institute for Emergency Medicine. This Institute currently holds the highest annual volume of deceased-donor KTs in the Russian Federation. The annual distribution of transplant procedures performed during this five-year period is illustrated in Fig. 1.

Recipients

The study included 1,106 KT recipients, comprising 664 men (60%) and 442 women (40%). Recipient ages ranged from 18 to 75 years, with a median age of 45 years (interquartile range: 37–54). The age distribution based on WHO classification is shown in Fig. 2.

Body mass index (BMI) ranged from 14 to 39, with a median of 25 (IQR: 21–28). Among the patients, 83 (7.5%) were underweight, 469 (42.4%) had normal weight, 355 (32.1%) were overweight, 169 (15.3%) had obesity class I, and 30 (2.7%) had obesity class II.

Blood group distribution among recipients was as follows: 0(I) – 398 patients (36%), A(II) – 417 (37.7%), B(III) – 210 (19%), and AB(IV) – 81 (7.3%).

The underlying conditions leading to stage 4–5 CKD included: chronic glomerulonephritis in 461 patients (41.7%), polycystic kidney disease – 142 (12.8%), diabetes mellitus – 127 (11.5%), tubulointerstitial diseases – 101 (9.1%), hypertensive nephroangiosclerosis – 80 (7.2%), nephropathy of unknown origin – 59 (5.3%), congenital anomalies of the urinary system – 55 (5.0%), and other less common conditions – 81 patients (7.3%) (Fig. 3).

The majority of recipients (n = 1000; 90.4%) received RRT prior to transplantation. Of these, 772 patients (69.8%) underwent maintenance hemodialysis, and 228 (20.6%) were on out-patient peritoneal dialysis. The remaining 106 recipients (9.6%) were in the predialysis stage IV CKD at the time of transplantation.

Elevated levels of pre-existing anti-HLA antibodies were observed in 103 patients (9.3%). Among them, 75 had antibodies targeting HLA class I antigens, with mean fluorescence intensity (MFI) values ranging from

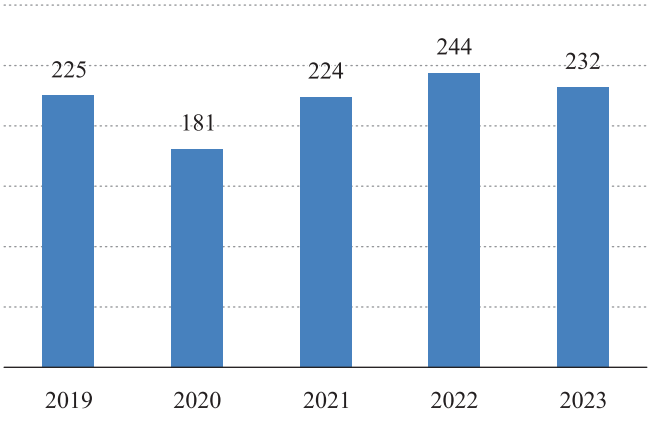

Fig. 1. Number of deceased donor kidney transplants by year for the period 2019–2023

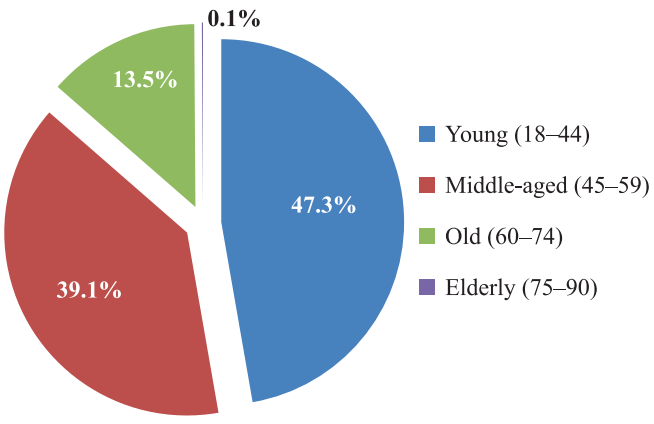

Fig. 2. Distribution of patients by age group according to the World Health Association classification for the period 2019–2023

505 to 14,444 (median 1567; IQR: 681.5–4188.5). Anti-HLA class II antibodies were present in 66 patients, with MFI ranging from 503 to 14,116 (median 1887; IQR: 788.8–7539). Both Anti-HLA class I and class II antibodies were detected in 43 patients (41.7%).

Kidney transplantation

Most recipients underwent primary KT (n = 990; 89.5%), while the remaining patients (n = 116; 10.5%) received repeat kidney transplants (second or third procedures). Cold ischemia time ranged from 7 to 27 hours, with a median of 15 hours (IQR: 12.5–17.5 hours).

Donor characteristics

The donor cohort was predominantly male (n = 706; 63.8%). Donor age ranged from 18 to 73 years, with a median age of 50 years (IQR: 43–57 years). According to the WHO age classification, 627 donors (56.7%) were middle-aged, 317 (28.7%) were young adults, and 160 (14.5%) were classified as elderly. Two donors (0.2%) had undocumented age.

The majority of donors (n = 861; 77.8%) were diagnosed with brain death after a stroke. The distribution of donor types is shown in Fig. 4.

Of the total donor pool, 671 donors (60.7%) met standard criteria, while 433 (39.2%) were classified as expanded criteria donors. Information was unavailable for two donors (0.2%). The median duration of donor hospitalization prior to organ retrieval was 2 days (IQR: 1–3.25 days).

Table 1 presents the immunological HLA compatibility and incompatibility characteristics of donor-recipient pairs.

Immunosuppressive therapy

All patients received induction and triple-drug baseline immunosuppressive therapy (IST). Induction IST with monoclonal antibodies was administered to 859 recipients (77.7%), while polyclonal antithymocyte globu-

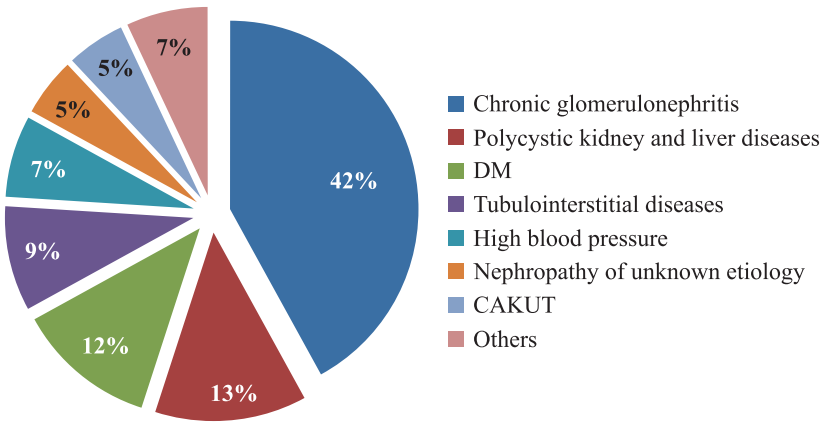

Fig. 3. Structure of the main diseases that led to chronic kidney disease stage 4–5 in patients of the study group. DM, diabetes mellitus; CAKUT, congenital anomalies of kidney and urinary tract

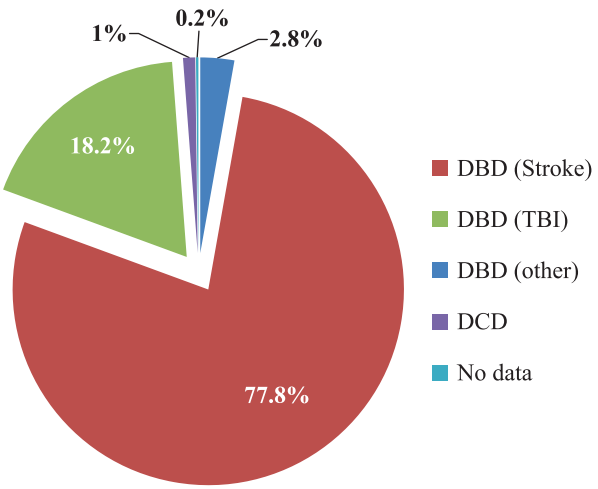

Fig. 4. Structure of donor types. DBD, donation after brain death; TBI, traumatic brain injury; DCD, donation after circulatory death

Table 1

Immunological HLA match/mismatch between donor and recipient

Indicator	Me	Q1–Q3
Number of HLA class I antigen mismatches (n, %)	2.00. 50.00	1.00–2.00. 25.00–50.00
Number of HLA class II antigen mismatches (n, %)	1.00. 50.00	1.00–2.00. 50.00–100.00
Total number of mismatches (n, %)	3.00. 50.00	2.00–4.00. 33.40–66.80
Number of class I antigen matches (n, %)	1.00. 25.00	0.00–1.00 0.00–25.00
Number of class II antigen matches (n, %)	1.00. 50.00	0.00–1.00. 0.00–50.00
Total number of matches (n, %)	1.00. 16.70	1.00–2.00. 16.70–33.40

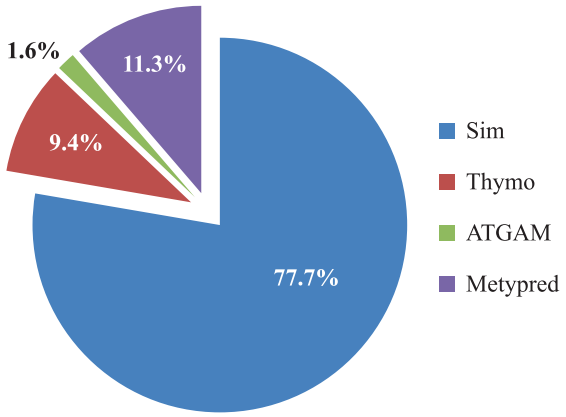

Fig. 5. Structure of induction immunosuppressive therapy. Sim, basiliximab (simulect); Thymo, polyclonal antithymocyte antibodies – human immunoglobulin (rabbit); ATGAM – polyclonal antithymocyte antibodies – human immunoglobulin (equine); Methypred, methylprednisolone

lin was used in 122 recipients (11%). In 125 recipients (11.3%), induction therapy was carried out without the use of antibodies (Fig. 5).

The triple-drug baseline IST regimen consisted of a combination of calcineurin inhibitors, antimetabolites, and glucocorticosteroids. Among calcineurin inhibitors, tacrolimus was predominantly used (n = 961, 86.9%), with cyclosporine being less commonly administered (n = 145, 13.1%).

As the antimetabolite component, mycophenolic acid was used in the majority of recipients (n = 1041, 94.1%). Everolimus was used in 54 patients (4.9%), and azathioprine in 11 patients (1%). No steroid-free IST regimens were used during this period.

Statistical data processing

Statistical analysis was performed using StatTech v. 4.0.6 (StatTech, Russia). The distribution of quantitative variables was assessed using the Shapiro–Wilk test (for sample sizes <50) or the Kolmogorov–Smirnov test (for sample sizes >50).

For variables with a normal distribution, results were presented as the arithmetic mean (M) and standard deviation (SD), along with 95% confidence intervals (95% CI). In cases where data did not follow a normal distribution, results were expressed as the median (Me) and interquartile range (Q1–Q3). Categorical variables were described using absolute counts and percentages (%).

Comparison of two groups by a quantitative variable with a non-normal distribution was performed using the Mann–Whitney U test. For comparisons among three or more groups, the Kruskal–Wallis test was applied, followed by Dunn's post hoc test with Holm's correction for multiple comparisons.

Analysis of categorical variables in 2×2 contingency tables was carried out using Pearson's chi-square test (when the expected frequencies were >10) or Fisher's exact test (when the expected frequencies were <10). For multi-field contingency tables, Pearson's chi-square test was used to compare proportions.

RESULTS

Renal graft function

Immediate graft function was observed in 714 recipients (64.6%), while delayed graft function (DGF) occurred in 392 patients (35.4%). The time to azotemia normalization ranged from 1 to 66 days, with a median of 8 days (IQR: 4–14 days). In DGF cases, the median number of extracorporeal detoxification procedures required was 4 (IQR: 2–8).

Surgical complications

The overall incidence of surgical complications was 11.6%, with 130 complications recorded in 128 patients. The distribution of surgical complications according to the Clavien–Dindo classification is presented in Table 2.

A classification of surgical complications is presented in Table 3.

Immunologic complications

The incidence of immunologic complications was 9.9%, with 109 episodes of acute rejection occurring in 107 patients. The onset of acute renal graft rejection ranged from 1 to 58 days post-transplant, with a median onset of 10 days (IQR: 6–17 days). The patients with rejection episodes received pulse corticosteroid (methyl-

Table 2

Structure of surgical complications according to the Clavien–Dindo Classification

Category of surgical complications	n, abs	%
I	4	3.1
II	6	4.6
IIIa	25	19.2
IIIb	70	53.8
IVa	21	16.2
IVb	4	3.1

Table 3

Types of surgical complications

Type of complication	n, abs	%
Occlusive arterial thrombosis	2	1.5
Non-occlusive venous thrombosis	17	13.1
Subcapsular renal transplant hematoma	22	16.9
Transplant renal artery kinking	1	0.8
Post-renal transplant lymphoceles	37	28.5
Urinary leakage	44	33.8
Ureteral stricture	4	3.1
Urethral stricture	1	0.8
Bleeding	2	1.5

prednisolone) therapy as follows: 31 patients received polyclonal antithymocyte antibody infusions, including 22 with rabbit antithymocyte globulin, 9 with equine antithymocyte globulin, 21 patients underwent plasmapheresis (1–6 sessions; mean: 3.48 ± 1.25 sessions), followed by intravenous immunoglobulin administration.

Outcomes

At the time of hospital discharge, 768 recipients (69.4%) demonstrated satisfactory kidney allograft (KAG) function, with serum creatinine levels below 200 μmol/L. An additional 276 recipients (25%) were discharged with KAG dysfunction, defined as serum creatinine levels exceeding 200 μmol/L, but without the need for RRT. The median serum creatinine among these two groups was 158 μmol/L (IQR: 120–204 μmol/L), and the median blood urea level was 11 mmol/L (IQR: 8–16 mmol/L).

Twenty-six recipients (2.4%) with adequately perfused grafts were transferred to the outpatient stage of care for RRT continuation. Twenty-eight recipients (2.6%) underwent graft nephrectomy during hospitalization for various clinical indications (see Table 4).

A total of 12 recipients (1.1%) died during the hospitalization period: 8 patients with a functioning renal graft and 4 patients following graft removal. The causes of death are presented in Table 5.

The cumulative uncensored graft survival rate during hospitalization was 97.5% (n = 1078), while the recipient survival rate for the same period was 98.9% (n = 1094).

Table 4

Causes of in-hospital renal graft loss

Reason for KAG nephrectomy	n, abs	%
Acute rejection crisis	12	42.9
Venous thrombosis	6	21.4
Sepsis	5	17.9
Donor pathology	1	3.6
Cortical necrosis	1	3.6
Bleeding from KAG	1	3.6
Bleeding from biopsy site	1	3.6
Necrosis of the lower pole of KAG	1	3.6

Table 5

Causes of in-hospital recipient mortality

Cause of death	n, abs.	%
Sepsis	5	41.7
Acute heart failure	3	25.0
COVID-19	2	16.7
Hypoxic brain injury	1	8.3
Acute stroke	1	8.3

DISCUSSION

According to registry data, the global incidence of CKD has been increasing steadily in recent years [38]. Dialysis-based RRTs are crucial for supporting patients with end-stage renal disease while they await KT, significantly extending their lifespan and improving their quality of life [5, 39]. However, there remains a critical gap between the demand for and the availability of kidney transplants, primarily due to a severe shortage of donor organs. Even with the expansion of criteria for graft suitability, this issue persists. Worldwide, the annual number of KTs performed exceeds 100,000, with the United States leading – a record of 25,487 KTs in 2021 [40]. In the Russian Federation, 1,562 KTs were carried out in 2022, with 1,334 from deceased donors and 228 from living-related donors [41]. Over the last decade, the Kidney and Pancreas Transplant Department, Sklifosovsky Research Institute for Emergency Medicine, has performed the highest number of deceased-donor KTs in the country.

Delayed graft function (DGF) remains one of the most common complications following kidney transplantation, negatively impacting early outcomes. It is associated with increased rejection rates, prolonged hospitalization, and consequently higher treatment costs [42–45]. A large study by Kim et al. found that DGF led to an average increase in costs of approximately $18,000 (10%) ($130,492 versus $112,598, $P < 0.0001$), 6 additional days of hospitalization (14.7 versus 8.7 days, $P < 0.0001$), and 2 extra days in the ICU (4.3 versus 2.1 days, $P < 0.0001$). Furthermore, multiple dialysis sessions were associated with an additional cost of $10,000 compared to patients who only required one session [46]. The reported incidence of DGF varies between 24% and 62% [21, 40, 47–50]. In our study, DGF incidence was 35.4%.

While not the primary cause of renal graft failure, surgical complications in kidney transplantation significantly increase patient morbidity and prolong hospitalization. The overall incidence of surgical complications following KT can range from 12% to 25%, with vascular complications occurring in 0.8% to 6% of cases [22, 24, 26]. The most common non-vascular surgical complications are urologic issues, affecting 2.5% to 30% of patients, and nephrotransplant bed lymphocele, which can range from 0.6% to 40% [22, 24]. In our center, the incidence of surgical complications was 11.6%. The incidence of acute graft rejection in the early postoperative period varies between 10% and 30% according to the available literature [51–53]. In our study, the incidence of immunological complications was 9.9%.

We evaluated in-hospital survival rates for both kidney transplants and recipients, which were 97.5% and 98.9%, respectively, aligning with the survival rates seen in leading transplant centers worldwide.

CONCLUSION

KT remains an effective and safe treatment option for stage 4–5 CKD patients. The outcomes achieved in our center – including the incidence of surgical and immunological complications, as well as in-hospital survival rates for both grafts and recipients – are comparable to those reported by leading international transplant centers.

The authors declare no conflict of interest.

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