



## Long-term Outcomes of Kidney Transplant Recipients with Delayed Graft Function: A Single-center Experience

Gecikmiş Greft Fonksiyonu Gelişen Böbrek Nakli Alıcılarının Uzun Dönem Sonuçları: Tek Merkez Deneyimi

İb Selim Keçeoğlu<sup>1,2</sup>, İb Mesut Yavaş<sup>1</sup>, İb Ramazan Kozan<sup>1</sup>, İb Aydın Dalgıç<sup>1</sup>, İb Hakan Sözen<sup>1,2</sup>

<sup>1</sup>Department of General Surgery, Gazi University, Faculty of Medicine, Ankara, Türkiye

<sup>2</sup>Department of Organ Transplantation Center, Gazi University, Faculty of Medicine, Ankara, Türkiye

### ABSTRACT

**Objective:** Delayed graft function (DGF), defined as the need for dialysis within the first week after transplantation, is a common early complication after deceased donor kidney transplantation. Although it is associated with adverse short-term outcomes, its long-term impact remains uncertain. We evaluated long-term patient and graft outcomes among deceased donor kidney transplant recipients who developed DGF.

**Methods:** This retrospective study identified 92 adult recipients of first deceased donor kidney transplants, of whom 79 developed DGF and constituted the primary analytic cohort. DGF was defined as dialysis requirement within 7 days post-transplant. Rejection, infections, graft loss, mortality, and long-term survival were analyzed among the 79 recipients who developed DGF.

**Results:** DGF occurred in 79 of 92 recipients (85.9%). Median follow-up was 113 months. Among the 79 recipients with DGF, six acute rejection episodes were observed, including two antibody-mediated cases; all rejection episodes received treatment according to the type of rejection. Among the 79 recipients with DGF, five viral infections were documented (BK virus n = 3, cytomegalovirus n = 1, parvovirus n = 1). During follow-up, 22 graft losses and 13 deaths occurred. Patient survival at 1, 3, 5, and 10 years was 100%, 97%, 93%, and 89%, respectively. Death-censored graft survival rates were 100%, 97%, 93%, and 86%, respectively.

### Öz

**Amaç:** Transplantasyon sonrası ilk hafta içinde diyaliz gereksinimi olarak tanımlanan gecikmiş greft fonksiyonu (*delayed graft function*, DGF), kadavra vericiden böbrek nakli sonrasında sık görülen erken dönem komplikasyonlardan biridir. Kısa dönem olumsuz sonuçlarla ilişkili olmasına rağmen, uzun dönem etkisi belirsizliğini korumaktadır. Bu çalışmada, DGF gelişen kadavra vericiden böbrek nakli alıcılarında uzun dönem hasta ve greft sonuçlarının değerlendirilmesi amaçlandı.

**Yöntemler:** Bu retrospektif çalışmada, ilk kez kadavra vericiden böbrek nakli yapılan 92 erişkin alıcı değerlendirildi. Bunların 79'unda DGF gelişti ve bu hastalar temel analiz kohortunu oluşturdu. DGF, transplantasyon sonrası 7 gün içinde diyaliz gereksinimi olarak tanımlandı. DGF gelişen 79 alıcıda rejeksiyon, enfeksiyonlar, greft kaybı, mortalite ve uzun dönem sağkalım analiz edildi.

**Bulgular:** DGF, 92 alıcının 79'unda (%85,9) gelişti. Ortanca takip süresi 113 aydı. DGF gelişen 79 alıcıda, ikisi antikor aracılı olmak üzere toplam altı akut rejeksiyon atağı gözlemlendi; tüm rejeksiyon atakları, rejeksiyon tipine uygun olarak tedavi edildi. DGF gelişen 79 alıcı arasında beş viral enfeksiyon saptandı (BK virüsü, n = 3; sitomegalovirüs, n = 1; parvovirüs, n = 1). Takip süresince 22 greft kaybı ve 13 ölüm meydana geldi. Hasta sağkalımı 1., 3., 5. ve 10. yıllarda sırasıyla %100, %97, %93 ve %89 olarak bulundu. Ölüm sansürlü greft sağkalım oranları ise sırasıyla %100, %97, %93 ve %86 idi.

**Cite this article as:** Keçeoğlu S, Yavaş M, Kozan R, Dalgıç A, Sözen H. Long-term outcomes of kidney transplant recipients with delayed graft function: a single-center experience. Gazi Med J. 2026;37(4):533-537

**Address for Correspondence/Yazışma Adresi:** Selim Keçeoğlu, Department of General Surgery; Department of Organ Transplantation Center, Gazi University, Faculty of Medicine, Ankara, Türkiye  
**E-mail / E-posta:** selimkeceoglu@gmail.com  
**ORCID ID:** [orcid.org/0000-0002-9985-3972](http://orcid.org/0000-0002-9985-3972)

**Received/Geliş Tarihi:** 26.06.2026

**Accepted/Kabul Tarihi:** 08.09.2026

**Publication Date/Yayınlanma Tarihi:** 15.10.2026



©Copyright 2026 The Author(s). Published by Galenos Publishing House on behalf of Gazi University Faculty of Medicine. Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 (CC BY-NC-ND) International License.

©Telif Hakkı 2026 Yazar(lar). Gazi Üniversitesi Tıp Fakültesi adına Galenos Yayınevi tarafından yayımlanmaktadır. Creative Commons Atıf-GayriTicari-Türetilemez 4.0 (CC BY-NC-ND) Uluslararası Lisansı ile lisanslanmaktadır.

## ABSTRACT

**Conclusion:** In this cohort of deceased donor kidney transplant recipients who developed DGF, favorable long-term patient and graft outcomes were observed. These findings suggest that favorable long-term outcomes may be achieved among recipients who develop DGF when appropriate post-transplant management is provided. The occurrence of viral infections highlights the need for close monitoring and individualized immunosuppressive strategies.

**Keywords:** Delayed graft function, kidney transplantation, deceased donor kidney transplantation, graft survival, patient survival, acute rejection, long-term outcomes, immunosuppressive therapy

## Öz

**Sonuç:** DGF gelişen kadavra vericiden böbrek nakli alıcılarından oluşan bu kohortta, uzun dönem hasta ve greft sonuçlarının olumlu olduğu gözlemlendi. Bu bulgular, uygun nakil sonrası yönetim sağlandığında DGF gelişen alıcılarda olumlu uzun dönem sonuçlara ulaşılabilirliğini düşündürmektedir. Viral enfeksiyonların görülmesi, yakın izlemin ve bireyselleştirilmiş immünosüpresif tedavi stratejilerinin gerekliliğini ortaya koymaktadır.

**AnahtarSözcükler:** Gecikmiş greft fonksiyonu, böbrek transplantasyonu, kadavra vericiden böbrek nakli, greft sağkalımı, hasta sağkalımı, akut rejeksiyon, uzun dönem sonuçlar, immünosüpresif tedavi

## INTRODUCTION

Kidney transplantation is the preferred treatment for patients with end-stage kidney disease, offering improved patient survival, enhanced health-related quality of life, and reduced long-term healthcare expenditures compared with maintenance dialysis (1,2). Although substantial progress has been achieved in operative procedures, graft preservation methods, and immunosuppressive management, early post-transplant events remain an important determinant of clinical outcomes, especially among deceased donor kidney transplant recipients. Among these, delayed graft function (DGF) remains a common and clinically relevant complication (1).

The most widely accepted definition of DGF is the requirement for dialysis during the first post-transplant week. It is widely considered a manifestation of ischemia-reperfusion injury leading to acute tubular dysfunction and delayed recovery of graft function (3). The incidence of DGF varies according to multiple donor-related, recipient-related, and transplant-related factors, as well as preservation and ischemia times, but it is consistently higher in deceased donor transplantation, particularly in expanded-criteria and donation after circulatory death donors (1,4,5).

The impact of DGF extends beyond the initial post-transplant stage. DGF has been linked to extended hospital stays, greater healthcare resource consumption, an elevated risk of acute rejection, and suboptimal early graft function (6). Nevertheless, the long-term consequences of DGF remain a matter of ongoing debate. While some investigators have observed poorer graft survival among recipients who develop DGF, others have reported satisfactory long-term outcomes when modern immunosuppressive protocols and optimized post-transplant follow-up are applied (6,7). Emerging evidence also indicates that the severity and duration of DGF may be more relevant than its presence alone (8).

These inconsistencies likely reflect differences in donor quality, recipient risk profiles, ischemia exposure, and center-specific practices. Therefore, contemporary data with extended follow-up are needed to better define the long-term implications of DGF.

In this study, we evaluated long-term patient and graft outcomes among deceased donor kidney transplant recipients who developed DGF, with a focus on rejection, infectious complications, graft loss, and long-term survival.

## MATERIALS AND METHODS

### Study Design and Setting

This retrospective, single-center cohort study was conducted at the Gazi University Transplantation Center, Ankara, Türkiye. All consecutive deceased donor kidney transplantations performed between January 2006 and December 2019 were screened for eligibility. Clinical and demographic data were obtained from the institutional transplant registry, electronic medical records, and archived hospital charts.

### Study Population

A total of 92 deceased donor kidney transplant recipients were identified during the study period. Patients undergoing first deceased donor kidney transplantation with available follow-up data were eligible. Patients with re-transplantation, multi-visceral transplantation, or incomplete clinical data were excluded (Figure 1). DGF developed in 79 of the 92 recipients, whereas 13 recipients did not develop DGF. Because the primary objective was to evaluate long-term patient and graft outcomes among recipients who developed DGF, the primary outcome analysis was restricted to the 79 recipients with DGF.

### Surgical Technique

Kidney grafts were preferentially implanted in the right iliac fossa; the left iliac fossa or an intraabdominal approach was used when clinically indicated. Vascular reconstruction was performed using

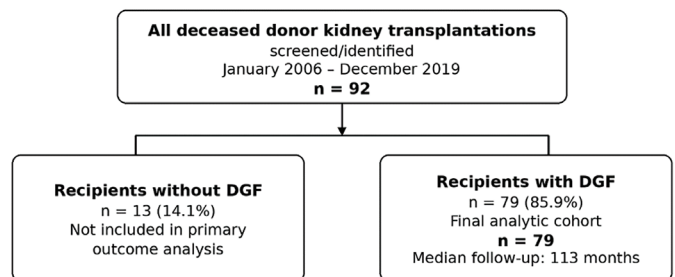


**Figure 1.** Flowchart of patient selection and formation of the primary analytic cohort.

DGF: Delayed graft function.

standard end-to-side anastomosis techniques, including Carrel patch implantation when appropriate. Ureterovesical anastomosis was carried out using a modified Lich-Gregoire technique. When indicated, the corner-saving modification described by Mehmet Haberal and colleagues was applied (9). Double-J ureteral stents were routinely used and removed postoperatively according to institutional practice. The surgical approach has been described previously (10).

### **Definition of DGF**

DGF was considered present when dialysis was required during the first post-transplant week (11). The decision to initiate dialysis was based on clinical and biochemical parameters, including hyperkalemia, metabolic acidosis, fluid overload, or insufficient early graft function. The same DGF definition and dialysis initiation criteria were applied consistently throughout the study period (2006-2019).

### **Immunosuppressive Protocol**

The institutional immunosuppressive approach has been described previously (10). Briefly, all recipients received a calcineurin inhibitor-based triple maintenance regimen consisting of tacrolimus or cyclosporine, mycophenolate mofetil, and corticosteroids. Induction therapy was administered according to immunological risk and institutional protocols. Interleukin-2 receptor antagonists were used in selected recipients, whereas antithymocyte globulin (ATG) was preferred in patients with high immunological risk or DGF. In recipients with DGF, calcineurin inhibitor initiation could be delayed, and ATG was continued until graft recovery, defined clinically by improving urine output and/or a substantial decline in serum creatinine. The immunosuppressive protocol remained unchanged throughout the study period (2006-2019).

### **Post-transplant Monitoring and Infection Prophylaxis**

Recipients were followed with scheduled outpatient visits, laboratory assessments, serum creatinine monitoring, therapeutic drug level measurements, and surveillance for infectious complications. Standard perioperative antibiotic prophylaxis was administered. Trimethoprim-sulfamethoxazole was used for *Pneumocystis jirovecii* prophylaxis, and cytomegalovirus (CMV) prophylaxis was provided according to donor-recipient serostatus and institutional protocols.

### **Study Outcomes**

The prespecified outcomes were patient survival, death-censored graft survival, acute rejection episodes, viral and opportunistic infections, and causes of graft loss. Graft loss was defined as permanent loss of graft function requiring return to dialysis or retransplantation. Acute rejection was diagnosed based on clinical and/or histopathological findings according to Banff criteria when biopsy material was available (12). T-cell-mediated rejection was treated with pulse corticosteroids, whereas antibody-mediated rejection was managed with plasmapheresis, intravenous immunoglobulin, and/or lymphocyte-depleting therapy.

### **Data Collection**

The following variables were recorded: recipient sex, donor age, cold ischemia time, number of human leukocyte antigen (HLA)

mismatches, duration of ATG therapy, DGF status, acute rejection, infections, graft loss, cause of graft failure, cause of death, and follow-up duration. Variables known to be associated with DGF and post-transplant outcomes were considered during dataset construction (1-3,5-8).

### **Ethical Approval**

This retrospective study was performed in accordance with the ethical principles of the Declaration of Helsinki and institutional requirements. The study protocol received approval from the Gazi University Ethics Commission before data extraction and analysis (approval no: 05.02.2026-E.1456672, date: 05.02.2026). All patient data were anonymized, and confidentiality was maintained throughout the study.

### **Statistical Analysis**

The primary analysis included the 79 recipients who developed DGF. All outcome analyses, including patient survival and death-censored graft survival, were performed in this primary analytic cohort. Descriptive statistics for continuous variables were reported as mean  $\pm$  standard deviation or median (minimum-maximum), as appropriate. Categorical data were described using absolute numbers and corresponding percentages. Survival outcomes, including patient survival and death-censored graft survival, were evaluated by Kaplan-Meier survival curves. Kaplan-Meier estimates were used to describe patient survival and death-censored graft survival at 1, 3, 5, and 10 years among the 79 recipients in the primary analytic cohort. Given the retrospective design and limited sample size, analyses were primarily descriptive, and findings were interpreted within the context of an observational study.

## **RESULTS**

### **Baseline Characteristics**

A total of 92 deceased donor kidney transplant recipients were identified during the study period. DGF occurred in 79 recipients (85.9%), whereas 13 recipients did not develop DGF. Among the 79 recipients with DGF, 40 were female and 39 were male. The mean donor age was  $41 \pm 19$  years, mean cold ischemia time was  $21 \pm 6.1$  hours, and mean number of HLA mismatches was  $3 \pm 2.1$ . The mean duration of rabbit ATG therapy was  $9.4 \pm 4$  days.

### **Follow-up Duration**

The primary analytic cohort was followed for a mean duration of  $98 \pm 59$  months (range, 6-173 months), with a median follow-up of 113 months.

### **Rejection Outcomes**

Among the 79 recipients with DGF, 6 acute rejection episodes (7.6%) were documented, including 2 antibody-mediated rejections. All rejection episodes received treatment according to the type of rejection.

### **Infectious Complications**

Among the 79 recipients with DGF, 5 viral infections were observed: BK virus (BKV) in 3, CMV in 1, and parvovirus in 1. During the follow-

up period, no instances of post-transplant lymphoproliferative disorder or newly developed malignancy were recorded.

### **Graft Loss**

Among the 79 recipients with DGF, 22 graft losses occurred during follow-up. The leading cause was chronic allograft nephropathy ( $n = 12$ ), followed by BKV nephropathy ( $n = 3$ ), hemolytic uremic syndrome ( $n = 2$ ), sepsis-related graft failure ( $n = 2$ ), infection originating from the native kidneys ( $n = 1$ ), CMV-associated injury ( $n=1$ ), and unexplained causes ( $n = 1$ ).

### **Patient Mortality**

Among the 79 recipients with DGF, 13 recipients (16.4%) died during follow-up. The most common cause of death was sepsis ( $n = 7$ ), followed by aortic dissection ( $n = 1$ ) and traffic accident ( $n = 1$ ). In the remaining cases, the cause of death could not be determined.

### **Long-term Survival Outcomes**

The estimated patient survival rates at 1, 3, 5, and 10 years were 100%, 97%, 93%, and 89%, respectively. Corresponding death-censored graft survival rates were 100%, 97%, 93%, and 86% at the same time points.

## **DISCUSSION**

In this single-center cohort of recipients who developed DGF, long-term patient and graft survival were favorable. These findings indicate that favorable long-term outcomes can be observed among recipients who develop DGF, although the absence of a formal non-DGF comparator analysis precludes determining whether DGF itself influences long-term outcomes (1,6). Our findings should be interpreted in the context of the high prevalence of DGF in this cohort. The exceptionally high DGF incidence observed in our cohort exceeds rates reported in most contemporary series (20-50%). This difference may be attributable to the exclusively deceased-donor population, prolonged cold ischemia times, and center-specific donor characteristics. Importantly, the same operational definition of DGF and clinical criteria for dialysis initiation were applied throughout the study period, making a change in diagnostic practice an unlikely explanation for the high observed incidence.

A likely contributing factor is the relatively young donor age in our cohort. Younger donor kidneys may better tolerate ischemia-reperfusion injury and recover function despite early dysfunction, which may have mitigated the long-term impact of DGF in this series (2,3).

DGF has been linked to higher early morbidity, including acute rejection and delayed recovery. In our cohort, rejection episodes were infrequent and controllable. The use of ATG-based induction in selected patients with DGF may have contributed to the low acute rejection rate observed in our cohort, potentially reflecting the relatively prolonged ATG exposure during delayed graft recovery (7,13).

Previous studies suggest that the duration and severity of DGF may be more relevant determinants of long-term outcomes than its mere presence. In our cohort, chronic allograft nephropathy accounted for the majority of graft losses, suggesting that long-term graft failure

may also reflect ongoing chronic allograft injury rather than the initial episode of DGF alone.

Viral infections, particularly BKV, were observed during follow-up. Recipients with DGF may be exposed to more intensive immunosuppression, which can increase susceptibility to opportunistic infections. This highlights the importance of close monitoring and timely adjustment of immunosuppressive therapy in this group (6,14).

The relationship between DGF and immunosuppression requires careful consideration. More intensive induction may reduce early rejection but can increase infection risk. In practice, this balance should be individualized according to patient risk.

Despite the exceptionally high prevalence of DGF in our cohort, long-term patient and graft outcomes remained favorable. Long-term follow-up revealed sustained patient survival, with estimated rates of 100% at 1 year, 97% at 3 years, 93% at 5 years, and 89% at 10 years. Death-censored graft survival remained comparably high, reaching 100%, 97%, 93%, and 86% at the respective time points. These outcomes indicate that favorable long-term patient and graft survival can be observed in recipients who develop DGF (2,6,7). The favorable survival observed in our cohort may reflect the combined effects of careful post-transplant monitoring, appropriate immunosuppressive management, and timely treatment of complications. Collectively, these findings support the concept that successful long-term outcomes can be achieved despite early graft dysfunction when recipients receive comprehensive post-transplant care. Prospective studies involving multiple transplant centers are necessary to validate the present findings and to clarify the recipient-, donor-, and transplant-related factors that may affect outcomes following DGF.

### **Study Limitations**

The findings of this study should be interpreted in light of certain limitations. Its retrospective nature, conduct at a single transplant center, and modest cohort size may limit the applicability of the results to broader transplant populations. In addition, the absence of a comparator group without DGF precluded assessment of the independent effect of DGF on outcomes; therefore, our findings should be interpreted as descriptive rather than causal. Some potentially relevant variables, including donor instability and preservation details, were not consistently available. Therefore, our findings should be considered hypothesis-generating rather than confirmatory.

## **CONCLUSION**

In conclusion, although DGF was highly prevalent in this deceased donor kidney transplant cohort, long-term patient and graft outcomes remained favorable. The occurrence of viral infectious complications highlights the importance of close monitoring and individualized immunosuppressive management. Therefore, careful post-transplant surveillance and tailored immunosuppressive strategies remain essential in recipients with DGF. These findings may help inform risk-adapted management approaches and support individualized care in this patient population.

## Ethics

**Ethics Committee Approval:** The study protocol received approval from the Gazi University Ethics Commission before data extraction and analysis (approval no: 05.02.2026-E.1456672, date: 05.02.2026).

**Informed Consent:** All patient data were anonymized, and confidentiality was maintained throughout the study.

## Footnotes

### Authorship Contributions

Concept: S.K., H.S., R.K., A.D., Design: S.K., R.K., H.S., M.Y., A.D., Data Collection or Processing: H.S., R.K., R.K., A.D., Analysis or Interpretation: S.K., H.S., R.K., M.Y., Literature Search: H.S., R.K., S.K., M.Y., Writing: H.S., S.K., R.K., M.Y.

**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study received no financial support.

## REFERENCES

- Ponticelli C, Reggiani F, Moroni G. Delayed graft function in kidney transplant: risk factors, consequences and prevention strategies. *J Pers Med*. 2022; 12: 1557.
- Yao Z, Kuang M, Li Z. Risk factors for delayed graft function in patients with kidney transplantation: a systematic review and meta-analysis. *BMJ Open*. 2025; 15: e087128.
- Schröppel B, Legendre C. Delayed kidney graft function: from mechanism to translation. *Kidney Int*. 2014; 86: 251-8.
- Nashan B, Abbud-Filho M, Citterio F. Prediction, prevention, and management of delayed graft function: where are we now? *Clin Transplant*. 2016; 30: 1198-208.
- Tingle SJ, Figueiredo RS, Moir JA, Goodfellow M, Talbot D, Wilson CH. Machine perfusion preservation versus static cold storage for deceased donor kidney transplantation. *Cochrane Database Syst Rev*. 2019; 3: CD011671. Update in: *Cochrane Database Syst Rev*. 2024; 7: CD011671.
- Li MT, Ramakrishnan A, Yu M, Daniel E, Sandra V, Sanichar N, et al. Effects of delayed graft function on transplant outcomes: a meta-analysis. *Transplant Direct*. 2023; 9: e1433.
- Jayaram D, Kommareddi M, Sung RS, Luan FL. Delayed graft function requiring more than one-time dialysis treatment is associated with inferior clinical outcomes. *Clin Transplant*. 2012; 26: E536-43.
- Helfer MS, Pompeo JC, Costa ORS, Vicari AR, Ribeiro AR, Manfro RC. Long-term effects of delayed graft function duration on function and survival of deceased donor kidney transplants. *J Bras Nefrol*. 2019; 41: 231-41.
- Haberal M, Emiroglu R, Karakayali H, Torgay A, Moray G, Arslan G, et al. A corner-saving ureteral reimplantation technique without stenting. *Transplant Proc*. 2006; 38: 548-51.
- Sözen H, Onaran M, Özen O, Dalgıç A. Urologic complications after renal transplant: a single-center experience. *Exp Clin Transplant*. 2017.
- Mallon DH, Summers DM, Bradley JA, Pettigrew GJ. Defining delayed graft function after renal transplantation: simplest is best. *Transplantation*. 2013; 96: 885-9.
- Roufosse C, Simmonds N, Clahsen-van Groningen M, Haas M, Henriksen KJ, Horsfield C, et al. A 2018 reference guide to the Banff classification of renal allograft pathology. *Transplantation*. 2018; 102: 1795-814. Erratum in: *Transplantation*. 2018; 102: e497. Erratum in: *Transplantation*. 2022; 106: e528.
- Wu WK, Famure O, Li Y, Kim SJ. Delayed graft function and the risk of acute rejection in the modern era of kidney transplantation. *Kidney Int*. 2015; 88: 851-8.
- Hirsch HH, Randhawa PS; AST Infectious Diseases Community of Practice. BK polyomavirus in solid organ transplantation-Guidelines from the American Society of Transplantation Infectious Diseases Community of Practice. *Clin Transplant*. 2019; 33: e13528.