JURNAL KOMPLIKASI ANESTESI
VOLUME 12 NOMOR 2, Maret 2025
PENELITIAN

# Correlation Between Ischemic Time with Kidney Graft Function in Living Donor Kidney Transplant at Sardjito Hospital

Yoki Chandra Juwono, Calcarina Fitriani Retno Wisudarti, Juni Kurniawaty
Department of Anesthesiology & Intensive Therapy Faculty of Medicine Public Health Nursing Universitas Gadjah Mada-Dr. Sardjito General Hospital Yogyakarta
*Coresponden author: Yoki Chandra Juwono, Department of Anesthesiology & Intensive Therapy Faculty of Medicine Public Health Nursing Universitas Gadjah Mada-Dr. Sardjito General Hospital Yogyakarta, Indonesia (yoki.chandra.yc@gmail.com)

How to cite: Juwono YC, et al,Correlation Between Ischemic Time with Kidney Graft Function in Living Donor Kidney Transplant at Sardjito Hospital. Jurnal Komplikasi Anestesi 12(2)-2025.

## ABSTRACT

Background: Kidney transplant function is expected to recover soon after transplantation, marked by decrease in serum creatinine and increase in urine output. Ischemic time is one of the factors that can affect kidney function. Creatinine Reduction Ratio day 2 (CRR2) can graft function
Objective: To know the correlation between ischemic time and early graft function in living donor kidney transplantation, measured by CRR.2.
Methods:This research used a retrospective cohort observational method. Data were collected from medical records of all kidney transplant patients at RSUP Dr. Sardjito from January 2017 to December 2024. The inclusion criteria are patients aged over 18 years, exclusion criteria are patients with hyperacute rejection, recipients lost of data, and those with extreme values. Normality tests using the Kolmogorov-Smirnov test, followed by Spearman correlation analysis. The cutoff for ischemic time was determined based on the highest sensitivity and specificity. The ischemic time and other variables that could affect CRR2 were analyzed bivariately. Variables with p-values < 0.25 are analyzed in multivariate analysis using logistic regression with backward method to identify variables influencing kidney transplant function.
Results: The total procedures was 91 samples, of which 82 patients met the inclusion criteria. One patient was excluded due to hyperacute rejection, six patients had no ischemic time data, and two patients were outliers. From the 82 samples, the average age was 38.65 ± 12.34 years, with 75.6% male and 24.4% female. The average BMI was 23.64 ± 4.72 kg/m². There is no significant correlation (r = -0.015, p = 0.891) between ischemic time with CRR2. Variables such as DM (p = 0.017, OR = 5.079) and KS2 (p = 0.01, OR = 2.249) had a significant relationship with kidney transplant function, while variables such as BMI (p = 0.148, OR = 0.886), Inotropics (p = 0.734, OR = 1.235), GFR2 (p = 0.404, OR = 1.019), and UOP 2 (p = 0.489, OR = 0.896) did not show a significant relationship with graft function.
Conclusion:
There is no significant relationship between ischemic time and early graft function in living donor kidney transplant surgery at Sardjito hospital.

**Keywords**: Living donor kidney transplant, Ischemic time, Creatinine Reduction Ratio day 2

## Introduction

Chronic Kidney Disease (CKD) is defined as abnormalities in kidney structure or function that persist for more than 3 months. CKD is a non-communicable disease whose incidence has increased over the past two decades, with more than 800 thousand patients diagnosed. According to data from the Indonesian Renal Registry in 2018, 133,142 people underwent hemodialysis as a result of CKD. The etiologies of CKD include hypertension (51%), diabetes mellitus (21%), cardiovascular diseases (7%), and other diseases such as viral infections, malignancies, and others.[1,2]

CKD is a progressive and irreversible kidney dysfunction that results in nephron damage, causing the body to fail in maintaining metabolism, fluid, and electrolyte balance, with the manifestation of uremia. Patients depend on Renal Replacement Therapy (hemodialysis, peritoneal dialysis, or kidney transplantation) to prevent life-threatening uremia (Roberta H, 2018). Kidney transplantation is currently the best available therapy for CKD patients. Kidney transplantation can reduce mortality and improve patients' quality of life.[3] The kidney transplantation procedure involves a flank incision, which can be performed laparoscopically or through open surgery. The allograft kidney is placed in the extraperitoneal space in the right or left iliac fossa. Vascular anastomosis is performed with the external iliac artery.[4]

Ischemic time is defined as the time between the donor renal artery cross-clamp and the recipient renal artery declamp. Ischemic time is divided into several terminologies, including the donor warm ischemic time, which represents the time between the donor renal artery cross-clamp and cold storage. This time is short and has minimal consequences on nephrectomy surgery for the donor. Meanwhile, the recipient warm ischemic time refers to the time when the donor kidney is removed from cold storage until reperfusion after declamping the recipient renal artery.[4] Tubular epithelium and endothelium are highly sensitive to ischemic conditions, and damage occurs in accordance with the duration of ischemia experienced. Hypoxic cells are unable to produce adequate adenosine triphosphate (ATP) (Ponticelli C, 2022). After reperfusion in the recipient's body, the ischemic-damaged transplanted kidney will receive reactive oxygen species (ROS) and inflammatory mediators, which cause further damage through oxidative stress and local inflammation. This condition is known as ischemic reperfusion injury (IRI).[5]

A retrospective cohort study conducted in 2015 with a sample size of 35,901 patients compared a group with ischemic times between 10 to <20 minutes to a group with ischemic times of ≥30 minutes. The study showed a significant difference ($p<0.0001$), where the group with ischemic times of ≥30 minutes was associated with higher mortality and kidney transplant failure rates.[6] Patients are expected to have good allograft kidney function soon after surgery. Early kidney function post-transplant surgery varies, from the immediate production of adequate urine, known as immediate graft function (IGF), to anuria, where there is no urine production after surgery. Adequate urine output (UOP) is a good indicator of allograft kidney function.[4] Delayed graft function (DGF) is defined as a transplant kidney that does not function immediately and requires dialysis within 72 hours after transplantation surgery. Several factors contribute to DGF, including donor factors (organ donors from deceased patients, donors with extended criteria such as those over 60 years old or over 50 with high blood pressure and serum creatinine levels > 0.5 or death due to stroke, ischemic time, organ quality, donor age, acute kidney injury conditions, high body mass index, organ transport distance, African American ethnicity), recipient factors (dialysis history before transplantation, prior transplant surgeries, Human Leukocyte Antigen mismatch, ABO incompatibility, high body mass index, African American ethnicity), and perioperative factors (hemodynamic instability, calcineurin inhibitors, nephrotoxic antibiotics, nephrotoxic analgesics).[5]

Acute tubular necrosis (ATN) is a kidney condition that arises after prolonged renal ischemia. ATN is the most common cause of delayed graft function (DGF). Ischemic causes include tubular damage in the donor, prolonged

cold or warm ischemic time, and ischemia-reperfusion injury.[4]

There are several biomarkers that can help clinicians to assess graft function. The first marker used to assess kidney function is urea. Currently, the gold standard for assessing kidney function is serum creatinine. A study by Nugroho conducted in 2019 on 28 patients undergoing kidney transplantation showed a significant decrease in serum creatinine (p = 0.008) from 7.9 ± 2.53 before surgery to 5.2 ± 4.4 after kidney transplantation. Another study conducted in 2021 assessed the serum creatinine reduction ratio on day 2 (CRR2), which is defined as the ratio of serum creatinine reduction between day 1 and day 2. This study, conducted on 44 patients who underwent kidney transplantation, showed that ischemic times of less than 40 minutes were associated with CRR2 > 30%, indicating immediate graft function (IGF) (p = 0.013).[7,8]

## Research Methodology

This study used a retrospective cohort method to asses correlation between ischemic time and graft function, as described by CRR2, in kidney transplant patients from living donors at Sardjito Hospital. The study was conducted after obtaining approval from the Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, as well as approval from the Education and Research Division (Diklit) of Sardjito Hospital Yogyakarta with the letter number DP. 04.03/D/XI 2/34695/2024.

The target population of this study was patients with end-stage chronic kidney disease who underwent kidney transplantation at Sardjito Hospital, and the accessible population was the target population who underwent kidney transplantation between 2017 and 2024. The study subjects were kidney transplant patients at Sardjito Hospital who met the inclusion and exclusion criteria. The inclusion criteria were: Age >18 years. The exclusion criteria included recipients with hyperacute rejection reactions, recipients with incomplete data (lacking ischemic time data and/or serum creatinine data, which were the main variables in the study), and extreme sample values (outliers). The total sample size studied was 82 patients.

Data were obtained from medical records at Sardjito Hospital. Continuous data were expressed as mean (SD), and categorical data were presented as frequency (n) and percentage. Normality testing was performed using the Kolmogorov-Smirnov test. A scatterplot was used to present the correlation between ischemic time and the independent variable, which was kidney transplant function, assessed by CRR2. Spearman correlation testing was used to examine the correlation between the two variables. Bivariate analysis of the correlation between ischemic time, as well as CRR2, which are nominal-scale variables, was analyzed using the chi-square test or Fisher's exact test. The correlation of secondary variables with serum creatinine and urine output (UOP) was analyzed using an unpaired t-test / Mann-Whitney test for continuous variables, and chi-square test or Fisher's exact test for categorical variables. Furthermore, for variables with a p-value <0.25 in the bivariate analysis, multivariate analysis was conducted using logistic regression because the dependent variable was nominal scale. All statistical analyses were performed using the SPSS software package (version 26.0) with a 95% confidence level.

## Results

Based on the results presented in Table 1, the demographic characteristics of kidney transplant patients show that the average age of patients was 38.65 ± 12.34 years. Regarding gender, the proportion of male patients was 75,6 %, while female patients accounted for 24,4 % of all recipients. The patients' BMI had an average value of 23.64 ± 4.72, indicating that there were no obese patients in this study population. The ischemic time variable had an average of 82,5 (47- 128) minutes, and the kidney transplant function variable, CRR2, had an average value of 30,14 (-46,09 - 79.48) with 41 patients having DGF (CRR2 < 30) and 41 patients having IGF (CRR2 > 30).

**Table 1. Patient Demographic**

| Characteristic | | n | % | Mean±SD atau Median (range) |
|---|---|---|---|---|
| Gender | Male | 62 | 75,6% | |
| | Female | 20 | 24,4% | |
| Age (years) | | | | 38.65 ± 12.34 |
| BMI (kg/m2) | | | | 23.64 ± 4.72 |
| GFR1 (mL/mnt) | | | | 23.85 (7.35-72.12) |
| GFR2 (mL/mnt) | | | | 33.59 (7.14-113.98) |
| KS1(mg/dL) | | | | 3.62 (1.14-10) |
| KS2(mg/dL) | | | | 2.54 (0.69-8.85) |
| UOP 1 (cc/kgbb/jam) | | | | 2.88 (0.09-18.73) |
| UOP 2 (cc/kgbb/jam) | | | | 1.76 (0.03-11.84) |
| Ischemic Time (Menit) | | | | 82.5 (47-128) |
| CRR2 (%) | | | | 30.14 (-46.09-79.48) |
| | <30 | 41 | 50,0% | |
| | >30 | 41 | 50,0% | |

BMI: Body Mass Index, GFR: Glomerular Filtration Rate, KS: Kreatinin Serum, UOP: Urine Output, CRR2: Creatinine Reduction Ratio day 2

**Table 2. Spearman Correlation Test**

| Characteristic | CRR2 |
|---|---|
| Waktu Iskemik (menit) | r= -0,015 |
| | P= 0,891 |

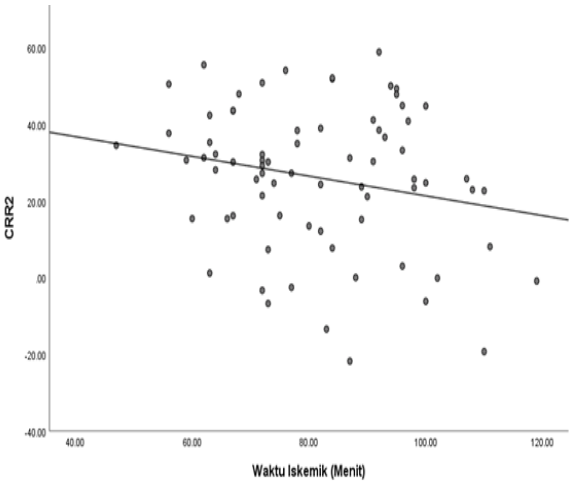


**Figure 1. Scatterplot Graphic between Ischemic time and CRR2**

To assess the correlation between the ischemic time and CRR2 variables, which are both numeric and have a abnormal distribution, Spearman's correlation test was used (Table 2). The p-value was 0.891 with an r value of -0.015, indicating no significant correlation between ischemic time and CRR2. In the scatterplot (Figure 1), the correlation between ischemic time (x-axis)

**Table 3. Sensitivity, Specificity, Youden Index**

| Waktu iskemik | Sensitivity | 1 - Specificity | Youden index |
|---|---|---|---|
| 62,5 | 0,951 | 0,854 | 0,098 |
| 63,5 | 0,927 | 0,805 | 0,122 |
| 65,0 | 0,902 | 0,780 | 0,122 |
| 66,5 | 0,878 | 0,780 | 0,098 |
| 67,5 | 0,854 | 0,707 | 0,146 |
| 69,5 | 0,854 | 0,683 | 0,171 |
| 71,5 | 0,829 | 0,683 | 0,146 |
| 72,5 | 0,732 | 0,610 | 0,122 |
| 73,5 | 0,683 | 0,585 | 0,098 |
| 74,5 | 0,659 | 0,585 | 0,073 |
| 75,5 | 0,634 | 0,585 | 0,049 |

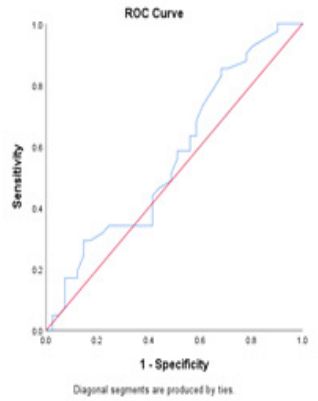


**Figure 2. ROC Curve to measure Ischemic Time Cut Off**

and CRR2 (y-axis) is shown. The graph displays a linear trend, meaning there is no significant correlation between ischemic time and CRR2. Based on the displayed ROC curve (Figure 2), the AUC value in the ROC analysis was 0,567, showing that the classification model used had a poor accuracy to distinguish between ischemic time and CRR2, with a p-value of 0,295 and a 95% CI of 0,44-0,69. The optimal cutoff point for ischemic time, analyzed using the Youden Index method (Table 3), was found to be 69,5 minutes. For the bivariate analysis evaluating the correlation between the two groups (CRR2 < 30

**Table 5. Multivariate Analysis**

| Characteristic | | CRR2<30 (n=41) | CRR2>30 (n=41) | p | RR | CI 95% |
|---|---|---|---|---|---|---|
| Ischemic time (Menit) | >69.5 minute | 35 (55.6%) | 28 (44.4%) | 0.067 | 1.76 | 0.87-3.54 |
| | <69.5 minute | 6 (31.6%) | 13 (68.4%) | | | |
| Age (years) | | 38.32 ± 13.29 | 38.97 ± 11.46 | 0.811 | | |
| BMI (kg/m²) | | 24.28 ± 4.74 | 22.99 ± 4.67 | 0.220 | | |
| Gender | male | 32 (51.6%) | 30 (48.4%) | 0.607 | 1.15 | 0.67-1.97 |
| | female | 9 (45%) | 11 (55%) | | | |
| DM | Yes | 14 (77.8%) | 4 (22.2%) | 0.008* | 1,84 | 1.26-2.69 |
| | No | 27 (42.2%) | 37 (57.8%) | | | |
| Hypertension | Yes | 39 (50%) | 39 (50%) | 1.000$ | 1.00 | 0.36-2.73 |
| | No | 2 (50%) | 2 (50%) | | | |
| Autoimmune | Yes | 7 (38.9%) | 11 (61.1%) | 0.286 | 0,73 | 0.39-1.36 |
| | No | 34 (53.1%) | 30 (46.9%) | | | |
| Reduced Heart Function | Yes | 10 (45.5%) | 12 (54.5%) | 0.618 | 0.88 | 0.52-1.48 |
| | No | 31 (51.7%) | 29 (48.3%) | | | |
| Inotrope | Yes | 17 (58.6%) | 12 (41.4%) | 0.248 | 1.29 | 0.85-1.98 |
| | No | 24 (45.3%) | 29 (54.7%) | | | |
| Vasopressor | Yes | 16 (51.6%) | 15 (48.4%) | 0.820 | 1.05 | 0.68-1.64 |
| | No | 25 (49%) | 26 (51%) | | | |
| GFR1(mL/mnt) | | 23.69 (8.1-72.11) | 24.13 (7.35-54.63) | 0.849 | | |
| GFR2 (mL/mnt) | | 27.44 (7.14-77.67) | 43.88 (18.06-113.97) | 0.001* | | |
| KS1(mg/dL) | | 3.63 (1.14-10) | 3,46 (1,3-9,6) | 0.422 | | |
| KS2 (mg/dL) | | 3.23 (0.87-8.85) | 1,97 (0.69-5.47) | 0,001* | | |
| UOP 1 (cc/kg/hour) | | 2.01 (0.08-18.72) | 3,66 (0,76-16.14) | 0.078 | | |
| UOP 2 (cc/kg/hour) | | 1.43 (0.02-6.7) | 2,16 (0,66-11.83) | 0.018* | | |

**Table 5. Multivariate Analysis**

| Characteristic | | p | OR | 95% C.I. Lower | Upper |
|---|---|---|---|---|---|
| Step 1[a] | Ischemic time (>69,5Menit) | ,135 | 2.780 | ,728 | 10.622 |
| | DM | ,013 | 7.139 | 1,515 | 33.626 |
| | Inotrope | ,734 | 1.235 | ,367 | 4.155 |
| | BMI | ,148 | ,886 | ,752 | 1.044 |
| | GFR2 | ,404 | 1.019 | ,975 | 1.065 |
| | SCr2 | ,007 | 3.211 | 1.378 | 7.482 |
| | UOP 2 | ,489 | ,896 | ,655 | 1.224 |
| | Constant | ,333 | ,146 | | |
| Step 2[a] | Ischemic time(>69,5Menit) | ,140 | 2,759 | ,716 | 10.625 |
| | DM | ,012 | 7,143 | 1,529 | 33.357 |
| | BMI | ,150 | ,889 | ,756 | 1.044 |
| | GFR2 | .421 | 1.018 | ,975 | 1.064 |
| | KS2 | ,006 | 3.246 | 1.397 | 7.540 |
| | UOP 2 | ,521 | ,903 | ,663 | 1.232 |
| | Constant | ,333 | ,145 | | |
| Step 3[a] | Ischemic time(>69,5Menit) | ,163 | 2.574 | ,681 | 9.726 |
| | DM | ,014 | 6.891 | 1,468 | 32.345 |
| | Characteristic | p | OR | 95% C.I. Lower | Upper |
| | BMI | ,182 | ,900 | ,770 | 1.051 |
| | GFR2 | ,517 | 1,014 | ,973 | 1.057 |
| | KS2 | ,006 | 3,234 | 1.400 | 7.471 |
| | Constant | ,249 | ,107 | | |
| Step 4[a] | Ischemic time (>69,5Menit) | ,167 | 2.508 | ,680 | 9.245 |
| | DM | ,017 | 6.246 | 1.380 | 28.269 |
| | BMI | ,231 | ,917 | ,795 | 1.057 |
| | KS2 | ,000 | 2.656 | 1.536 | 4.593 |
| | Constant | ,328 | ,204 | | |
| Step 5[a] | Ischemic time(>69,5Menit) | ,150 | 2.611 | ,706 | 9.657 |
| | DM | ,029 | 4.527 | 1.166 | 17.570 |
| | KS2 | ,001 | 2.329 | 1.431 | 3.791 |
| | Constant | ,000 | ,038 | | |
| Step 6[a] | DM | ,017 | 5,079 | 1,334 | 19,339 |
| | KS2 | ,001 | 2,249 | 1,402 | 3,608 |
| | Constant | ,000 | ,084 | | |

and CRR2 > 30), for the ischemic time variable, the group with ischemic times greater than 69.5 minutes consisted of 35 patients (55,6 %) with DGF, indicated by CRR2 < 30, and 28 patients (44,4%) with IGF, indicated by CRR2>30. For the group with ischemic times less than 69.5 minutes, 6 patients (31,6%) had CRR2 < 30, and 13 patients (72,2%) had CRR2>30. This correlation was not significant with a p-value < 0.067, RR = 1,75, and a 95% CI of 0,87-3,54.

The age variable showed no statistically significant difference between the two groups, with a p-value of 0.811. The mean age in the CRR2<30 group was 38.82 ± 13.29 years, while in the CRR2>30 group it was 38.97 ± 11.46 years. Similarly, BMI did not differ significantly between groups (p = 0.220), and sex was also not significantly associated with CRR2 classification (p = 0.607; RR = 1.15; 95% CI: 0.67–1.97). In contrast, Diabetes Mellitus (DM) showed a statistically significant association with CRR2 (p = 0.008). Among patients with DM, 14 (77.8%) had CRR2<30, while only 4 (22.2%) were in the group with CRR2>30. Among patients without DM, 27 (42.2%) had CRR2<30 and 37 (57.8%) had CRR2>30.

In this study, the variable hypertension was not significantly associated with CRR2 outcomes (p = 1.000; RR = 1.00; 95% CI: 0.36–2.73), with each group comprising 39 patients (50%). Among patients without hypertension, 2 (50%) were in the CRR2<30 group and 2 (50%) in the CRR2>30 group. Unlike hypertension, autoimmune comorbidities showed a borderline significant association with CRR2 outcomes (p = 0.092; RR = 0.58; 95% CI: 0.27–1.22). The autoimmune conditions considered included nephrotic syndrome, Henoch-Schönlein purpura, and psoriasis. Reduced ejection fraction was not significantly associated with CRR2 (p = 0.618; RR = 0.88; 95% CI: 0.52–1.48), nor was the use of inotropic agents (p = 0.241; RR = 1.29; 95% CI: 0.85–1.98). Similarly, vasopressor use showed no significant relationship with CRR2 outcomes (p = 0.820; RR = 1.02; 95% CI: 0.68–1.64). Both GFR2 (Glomerular Filtration Rate on Day 2) and SCr2 (Serum Creatinine on Day 2) showed statistically significant associations with CRR2, each with a p-value of 0.001.

Subsequently, variables with p-values <0.25 were included in a multivariate logistic regression analysis using the backward elimination method, with the aim of identifying significant predictors of kidney transplant function and controlling for potential confounding variables. The results of the backward multivariate logistic regression analysis (Table 5) show that the variables significantly affecting CRR2 were DM and SCr2.

## Discussion

Kidney transplantation is the most effective therapy for patients with chronic kidney disease (CKD), as it significantly reduces mortality and improves quality of life (Kaballo, 2018). Proper perioperative management contributes greatly to graft function and both short- and long-term graft survival. Various factors may affect kidney transplant outcomes, including ischemic time, which is recognized as an independent variable influencing renal function. CRR2 can be used as a predictor of early kidney transplant function.3,8 This study compared ischemic time and CRR2 as indicators of transplant kidney function, categorizing the outcomes into Delayed Graft Function (DGF, CRR2 ≤ 30) and Immediate Graft Function (CRR2 > 30%). Previous research has identified CRR2 as an independent predictor of transplant kidney function and an early detector of renal dysfunction.[7,8]

In terms of patient demographics, the mean recipient age in this study was 38.65 ± 12.34 years, which aligns with findings by Tennankore et al. (2015), who reported an average transplant age of 39 ± 16 years. This suggests that kidney transplantation commonly occurs between ages 35–50. In this study, age was not a significant factor in the bivariate analysis (p = 0.811). However, donor age has been recognized as a risk factor for impaired kidney transplant function. A meta-analysis by Yao in 2025 involving 28,936 patients (8,708 DGF cases) reported a significant association between donor age and DGF (p = 0.003, OR 1.02, 95% CI: 1.01–1.03), with high heterogeneity ($I^2$ = 84.6%, p < 0.0001).[10]

Recipient BMI was analyzed numerically in this study and showed no significant association

with CRR2, which is consistent with a 2025 meta-analysis by Yao involving 25,060 kidney transplant patients (both living and deceased donors), where 6,472 cases of DGF were recorded. Among deceased donors, recipient BMI was not significantly associated with DGF (p = 0.065, OR 1.23, 95% CI: 0.99–1.53), and the same was found for living donors (p = 0.303, OR 1.91, 95% CI: 0.85–1.66).[10]

In contrast, donor BMI significantly affected transplant function. In a meta-analysis by Yao (2025) involving 3,832 patients, donor BMI was a significant risk factor for DGF (p < 0.0001, OR 1.09), with low heterogeneity ($I^2$ = 25.2%, p = 0.263). Two of the three included studies involved deceased donors. According to WHO classifications, high donor BMI is associated with pathophysiological mechanisms such as vascular access difficulties, prolonged ischemic and anastomosis times, and a deficiency in anti-inflammatory factors that protect against ischemia-reperfusion injury. Obesity is also linked to comorbidities like hypertension and hyperlipidemia, which compromise donor quality and increase the risk of DGF. Jindal et al. also reported a positive correlation between recipient obesity and increased DGF risk.[10]

In this study, ischemic time was not significantly associated with transplant kidney function as assessed by CRR2, aligning with findings from Kinoshita (2021), who studied 272 Asian patients and found no significant association between ischemic time and CRR2 (p = 0.34, OR 1.17). However, a large meta-analysis by Yao (2025) including 153,008 patients showed that prolonged ischemic time significantly increased DGF risk (p < 0.0001, OR = 1.05, 95% CI: 1.03–1.07). Ischemic injury and inflammation likely underlie this association, particularly due to the sensitivity of tubular epithelium and endothelium to ischemia (Bellini MI, 2021).[10]
In this study, the optimal ischemic time cut-off was identified as 69.5 minutes, with a sensitivity of 0.854 and 1–specificity of 0.683. However, ischemic time does not appear to be a reliable early detection tool for predicting good transplant kidney function outcomes. This aligns with studies showing that ischemic durations between 60 and <120 minutes are associated with poor outcomes, including DGF and lower graft survival (Foley M, 2023). Tennankore et al. (2015), in a study of 131,677 patients, reported that prolonged ischemic time correlated with long-term CRR2 outcomes. Toufeeq (2019) also found that warm ischemia time over 60 minutes significantly increased DGF incidence, delayed creatinine clearance, and led to higher serum creatinine by day seven. Yao's meta-analysis (2025) confirmed that cold ischemic time is a risk factor for DGF, with DGF groups showing longer CIT than non-DGF (OR = 1.05, 95% CI: 1.03–1.03, Z = 5.36, p < 0.0001), particularly in deceased donor transplants.[10] Diabetes Mellitus (DM) showed a significant association with CRR2 (p = 0.017, OR = 5.079, 95% CI: 1.334–19.339). This supports findings by Yao (2025), who reported a significant association between DM and transplant kidney function (p < 0.0001, OR = 1.52, 95% CI: 1.40–1.64), with low heterogeneity ($I^2$ = 39.3%, p = 0.176). In diabetic patients, microvascular and macrovascular complications, combined with post-transplant steroid-induced hyperglycemia, may exacerbate risks. DM is a known risk factor for cardiovascular morbidity and mortality.[10]

HLA, encoded by the Major Histocompatibility Complex (MHC), plays a crucial role in kidney transplant immunology. Among HLA antigens, HLA-A, HLA-B, and HLA-DR are particularly important for transplant outcomes (Kang, 2023). New guidelines incorporate HLA mismatch grading to assess donor-recipient histocompatibility, based on 14 HLA molecules. Zhao et al. reported increased DGF incidence when HLA mismatch exceeded two factors. This study did not analyze HLA factors due to a lack of electronic medical records (EMR) data.[10] In this study, post-transplant serum creatinine (SCr2) was significantly associated with CRR2 (p = 0.001, OR = 2.249, 95% CI: 1.402–3.608). Good transplant kidney function is characterized by adequate urine output and a decrease in serum creatinine (Subramaniam K, 2017). Kim J (2019) found that serum creatinine and urine measurements on post-transplant day 2 were most reliable, likely due to elevated renin-angiotensin II levels for up to 48 hours post-surgery. Declining urine output

and rising serum creatinine are early indicators of graft dysfunction.[4,8,10] This study has limitations, this study did not differentiate between warm ischemic time and cold ischemic time, both of which may affect transplant kidney outcomes.

## Conclusion

There was no significant association between ischemic time and early kidney transplant function as measured by CRR2.

## Suggestions

Future research should distinguish and analyze both warm ischemic time and cold ischemic time independently.

## References

1. Kovesdy CP. Epidemiology of chronic kidney disease: An update 2022. Kidney Int Suppl. 2022;12(1): 7-11. Doi: 10.1016/j.kisu.2021.11.003
2. IRR. In: 11th Report of Indonesian Renal Registry. 2018;1-46. Available at: https://indonesianrenalregistry.org/
3. Kaballo MA, Canney M, O Kelly P, Williams Y, Seaghdha CM, Conlon PJ. A comparative analysis of survival of patients on dialysis and after kidney transplantation. Clin Kidney J. 11(3):389-93. Doi: 10.1093/ckj/sfx117
4. Subramaniam K, Sakai T. Anesthesia and perioperative care for organ transplantation. Springer New York. 2017. Availabale from: https://doi.org/10.1007/978-1-4939- 6377-5
5. Ponticelli C, Reggiani F, Moroni G. Delayed graft function in kidney transplant: Risk factors, consequenses and prevention strategies. J Pers Med. 2022;12(10):1-13 Doi: 10.3390/jpm12101557
6. Tennankore KK, Kim SJ, Alwayn IPJ, Kiberd BA. Prolonged warm ichemia tim is associatd with graft falure and mortality after kide transplantaton. Kidney Int. 2016;89(3): 648-58. Doi: 10.1016/j.kint.2015.09.002
7. Lusito, Nurani A, Partiningrum DL, Arwanto A, Lestariningsih, Chasani S. Relationship between Warm Ischemic Time and Resistive Index on Creatinine Reduction Ratio Day Two after Living Kidney Donor transplantation. J Midwifery and Health Science of Sultan Agung. 2022;1(1):3-16. Doi: https://doi.org/10.30659/jmhsa.v1i1.4
8. Kinoshita Y, Katano S, Nishida S, Shimizu T, Fujimura T, Kume H, et al. Creatinine reduction ratop on postoperative day 2 predicts long term outcomes after Living donor kidney transplantation. Int J Urol. 2022;29(2):114-120 Doi: 10.1111/iju.14726
9. Bellini MI, Tortorici F, Amabile MI, D'Andrea V. Assessing kidney graft viability and its cells metabolism during machine perfusion. Int J Mol Sci. 2021; 22(3): 1-16. Doi: 10.3390/ijms22031121
10. Yao Z, Kuang M, Li Z. Risk factors for delayed graft function in patient with kidney transplantation: A systematic review and meta analysis. BMJ Open. 15(3):1-15 Doi: https://doi.org/10.1136/bmjopen-2024-087128