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Original Article

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Kidney Functions and Obstetric Outcome of Pregnancies After Kidney Transplantation

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ABSTRACT

Background: This study aims to assess the clinical course and pregnancy outcomes after kidney transplantation and investigate the function of kidney grafts.
Methods: This retrospective cohort analysis included 17 pregnancies in 14 patients with a history of kidney transplantation, who were followed up at a single tertiary hospital. Sociodemographic data, medical history, obstetric data, and laboratory parameters in each trimester, as well as before, within 24 hours, and 6 months after delivery, were collected.
Results: Among the 17 pregnancies, 1 patient had an abortion, 1 had dilatation and curettage, and 3 had 2 pregnancies during the study period. One woman had a twin pregnancy. The median serum creatinine concentration before conception was 0.8 (0.8-0.9) mg/dL. The median time interval between kidney transplantation and pregnancy was 78 months (interquartile range: 42-138 months). Serum creatinine levels were higher and estimated glomerular filtration rates were lower in the third trimester than in the pre-pregnancy, first, and second trimesters. The urinary protein-to-creatinine ratio was higher in the third trimester. None of the patients experienced graft rejection during pregnancy. Fourteen pregnancies resulted in live births; 8 patients had preeclampsia (53%); 11 neonates were born prematurely (73%); and 8 of the babies were small for gestational age (53%).
Conclusion: The short-term impact of pregnancy on allograft function appears to be acceptable despite a statistically significant increase in serum creatinine levels during the third trimester. However, close surveillance is mandatory in pregnancies after kidney transplantation, because it confers a greater risk of obstetric complications.
Keywords: Allograft function, kidney transplantation, preeclampsia, pregnancy

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INTRODUCTION

Kidney transplantation has been performed for the past 7 decades with the aim of improving the general quality of life and reducing mortality rates in individuals with kidney failure.[1] As a result, the number of women of reproductive age who have received a kidney transplant has grown considerably in recent years. However, this has brought many challenges due to the scarcity of the existing body of knowledge regarding the impact of pregnancy on allograft function and the potential effects of grafts on gestation.

Despite the fact that kidney transplant recipients generally experience higher birth rates and improved maternal outcomes than women with chronic kidney disease, their pregnancies are still considered to be at high risk because the frequency of preeclampsia, anemia, low birth weight, and premature birth is higher than normal

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population.[2] Furthermore, pregnancy can potentially lead to allograft dysfunction, such as new-onset proteinuria or elevated serum creatinine levels, which may persist even after delivery.[3]

Our aim was to investigate the function of kidney grafts before, during, and short term after pregnancy, as well as to evaluate the clinical course and outcomes of pregnancy in women who had undergone kidney transplantation. The quality of healthcare for this population can be improved by addressing the challenges faced by kidney transplant recipients during pregnancy, and both maternal and fetal outcomes can be optimized.

MATERIALS AND METHODS

Study Population

A retrospective analysis was conducted on pregnant women with a history of kidney transplantation who were followed up at Kocaeli University Hospital, a tertiary referral center. This study was approved by the Ethics Committee of Kocaeli University (GOKAEK-2024/02.43) and adhered to the ethical regulations and principles outlined in the Declaration of Helsinki. Informed consent was obtained from all patients. Pregnant women with a history of kidney transplantation who were followed up and delivered at the tertiary referral center between 2010 and 2024 were included in the study. Participants were required to have a functioning allograft at the time of conception, provide informed consent, and have complete medical records, including clinical, laboratory, and obstetric data. Patients with incomplete medical records, multiple organ transplants, or other significant comorbidities unrelated to transplantation that could affect pregnancy outcomes (e.g., advanced heart disease) were excluded.

Data Collection

Clinical and laboratory parameters were obtained from the medical records. The collected data included maternal age, parity, body mass index (BMI), time between transplantation and pregnancy, primary kidney disease, allograft type, number of transplantations, medications used for immunosuppression, duration of follow-up after delivery, presence of chronic hypertension, serum urea and creatinine levels, complete blood count, estimated glomerular filtration rate (eGFR), proteinuria, mode of delivery, presence of congenital anomalies, gestational age at birth, birth weight, and birth weight percentile. Obstetric complications, such as preterm rupture of membranes, preterm labor, polyhydramnios, oligohydramnios, gestational diabetes mellitus, preeclampsia, and anemia, were also noted.

Clinical Definitions

eGFR was defined as kidney function measured using a formula based on serum creatinine (mL/min/1.73 m^2) described by the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) in 2009.[4] The urinary protein/creatinine ratio (P/Cr) in midstream urine samples was used to detect proteinuria.[5] Serum urea and creatinine levels, eGFR, spot urine protein/creatinine ratio, 24-hour urine proteinuria, and complete blood count were evaluated before pregnancy, in each trimester, and 24 hours, and 6 months after delivery.

Preeclampsia was defined according to the criteria established by the American College of Obstetricians and Gynecologists as new-onset hypertension after the 20th week of pregnancy, with or without proteinuria, accompanied by end-organ dysfunction. The signs or symptoms of end-organ dysfunction include right upper quadrant or epigastric pain, thrombocytopenia (platelet count less than 100×10^9/L), abnormally elevated blood concentrations of liver enzymes (to twice the upper limit of normal concentration), severe persistent right upper quadrant or epigastric pain, serum creatinine concentration greater than 1.1 mg/dL or a doubling of the serum creatinine concentration, pulmonary edema, new-onset headache resistant to acetaminophen, and visual disturbances.[6]

Preterm birth was defined as delivery before the 37th week of pregnancy.[7] Small for gestational age (SGA) was defined as birth weight below the 10th percentile for the gestational age according to the Fetal Medicine Foundation neonatal population weight chart.[8]

The kidney allograft failure is accepted as a requirement for any form of kidney replacement therapy, and the kidney graft dysfunction is defined as an increase in serum creatinine of 15% from baseline.

Throughout pregnancy, monthly check-ups were performed by the nephrology team. These appointments included clinical assessments to monitor blood pressure and evaluate peripheral edema. Additionally, laboratory investigations were performed to measure serum creatinine, hemoglobin, proteinuria, urine culture, and serum levels of cyclosporine and tacrolimus. Obstetric follow-up visits were scheduled every 2 weeks during the first and second trimesters and every week during the third trimester.

Data Analysis

Data analysis was performed using SPSS version 25.0 (IBM SPSS Corp.; Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Continuous variables were presented as means and SD or medians with interquartile

MAIN POINTS

- The frequency of preeclampsia in kidney transplantation patients is higher than in the general population.
- Serum creatinine levels during the third trimester are elevated in pregnant women with kidney transplants.
- Preterm birth is common in pregnant women with kidney transplantation due to obstetric complications.

ranges based on their distribution. Normality of the data was assessed using the Shapiro–Wilk test. The Friedman test was used for repeated measures to analyze variations in parameter values during pregnancy. To determine which specific group comparisons were significantly different from each other, post hoc analysis was performed, and significance values were adjusted using the Bonferroni correction for multiple tests. The Mann–Whitney *U* test was used to compare groups with and without preeclampsia and groups with and without acute kidney injury in pregnancy. Statistical significance was set at $P < .05$.

RESULTS

A total of 17 pregnancies were identified in the 14 women who underwent kidney transplantation (Figure 1). Three patients had 2 pregnancies. One patient opted for termination of pregnancy at 6 weeks of gestation because of mycophenolate use. The second pregnancy occurred 6 months later. One patient had 2 deliveries after transplantation. One woman had a delivery and an abortion after kidney transplantation. The mean maternal age at pregnancy was 30.5 ± 5.2 years, and the BMI was 28.3 ± 4.0 kg/m^2 (Table 1). The median interval between kidney transplantation and pregnancy was 78 months (interquartile range: 42-138 months). Allografts were obtained from live donors in 12 cases (86%), while they were cadaveric in 2 cases (14%). Two patients had a history of multiple kidney transplantations prior to conception.

Primary kidney diseases are shown in Table 1. The maintenance immunosuppression consisted primarily of corticosteroids (13 patients), azathioprine (12 patients), tacrolimus (13 patients), and cyclosporine (1 patient). The therapeutic target serum levels of tacrolimus and cyclosporine were as C0: 5-8 ng/mL and C0: 50-150 ng/mL respectively.

Out of the 14 individuals in the study, 5 (36%) reported a prior diagnosis of long-term high blood pressure. The median serum creatinine concentration before conception was 0.8 (IQR 0.8-0.9) mg/dL. The median serum urea and creatinine concentrations, eGFR, protein/creatinine ratio, and aspartate transaminase, alanine transaminase, and lactate dehydrogenase levels before conception, in each trimester and postpartum period are presented in Table 2. The serum creatinine levels and eGFR during the follow-up of individual cases are shown in Figures 2 and 3, respectively. None of the patients experienced acute graft rejection during pregnancy or immediately after delivery. The serum creatinine levels before, during, and after pregnancy were significantly different ($P < .001$). Further examination through post hoc testing revealed that serum creatinine levels during the third trimester were significantly higher than those before pregnancy and during the first and second trimesters ($P = .006$, $P = .001$, and $P < .001$, respectively). Similarly, eGFR was found to differ before, during, and after pregnancy ($P < .001$); it was significantly lower in the third trimester than before pregnancy and in the first and second trimesters ($P = .010$, $P < .001$, and $P < .001$, respectively). Significant variations in the P/Cr ratio were observed across different stages: before, during, and after pregnancy ($P < .001$). The median P/Cr ratio in the third trimester was significantly elevated compared to the pre-pregnancy period (361 vs. 135, respectively, $P < .001$). The third trimester median P/Cr ratio was not statistically significant compared to that in the postpartum period (361 vs. 159, respectively, $P = .056$). The P/Cr ratio during the follow-up of the individual cases is shown in Figure 4.

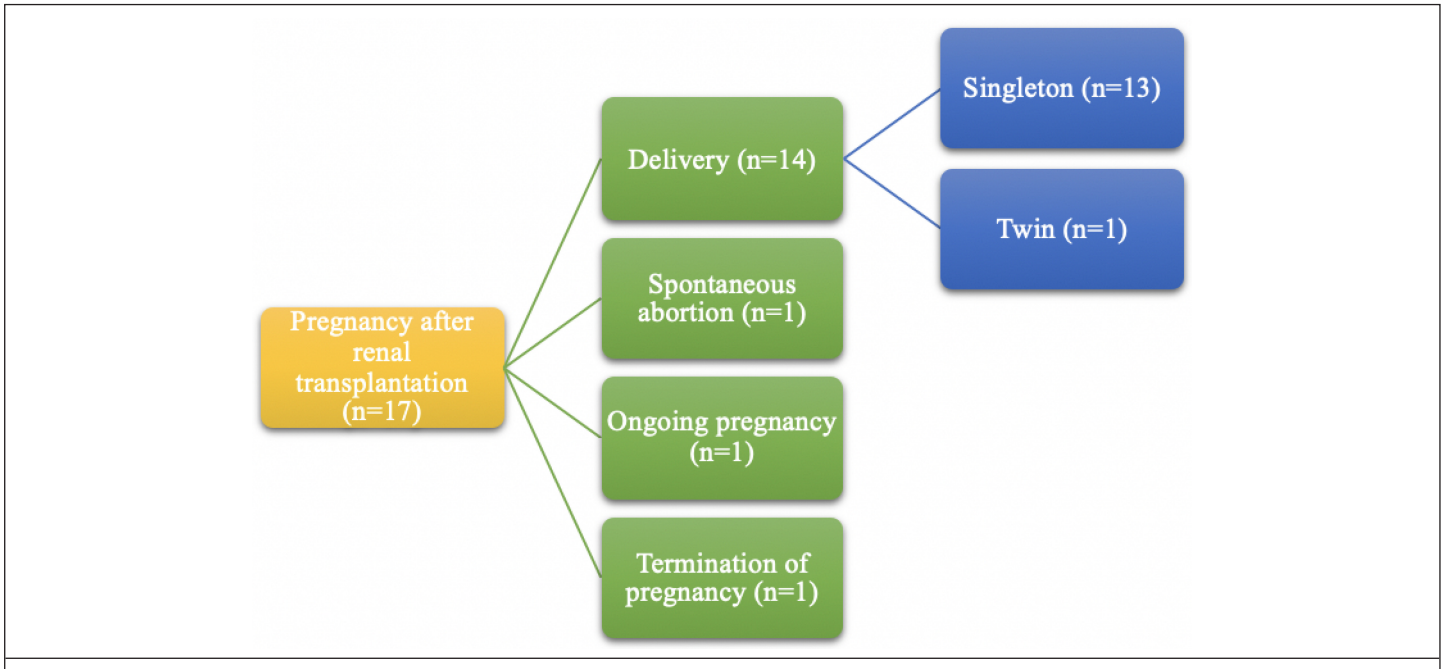


Figure 1. Pregnancy outcome of renal transplant recipients.

Table 1. Clinical Data of Pregnant Women with Kidney Transplantation

Age, years	30.5 ± 5.2
BMI, kg/m^2	28.3 ± 4.0 kg/m^2
Time interval between pregnancy and kidney transplantation, months	78 (42-138)
Chronic hypertension	5 (36%)
Donor type	
Live donor	12 (86%)
Cadaveric	2 (14%)
Primary kidney diseases	
Rapidly progressive glomerulonephritis (RPGN)	2 (14%)
Acute post-streptococcal glomerulonephritis (APSGN)	1 (7%)
Microscopic polyangiitis	1 (7%)
Focal segmental glomerulosclerosis (FSGS)	1 (7%)
Nephrolithiasis	2 (14%)
Nephronophthisis	1 (7%)
Unknown	6 (43%)

BMI: Body mass index, Data presented as number of patients and percentage (%), mean ± SD or median (interquartile range).

Table 3 shows blood pressure of patients in each trimester and postpartum period.

Out of 17 pregnancies examined, urinary tract infections were identified in 7 cases (41%). Six of these cases involved asymptomatic bacteriuria, while 1 presented with symptomatic infection. Urine culture results showed the presence of *Escherichia coli* in 4 instances, *Klebsiella pneumoniae* in 2, and *Enterococcus faecalis* in 1. Low serum hemoglobin levels were detected in 5 pregnancies (30%).

Of the 17 pregnancies, 16 were singleton pregnancies, while 1 was classified as a dichorionic diamniotic twin pregnancy. Assisted reproductive technologies yielded 3 pregnancies: 2 through in vitro fertilization and 1 via intrauterine insemination. The patients did not exhibit signs of pregestational or gestational diabetes mellitus. Fourteen pregnancies resulted in live birth. Table 4 shows obstetric complication rates in the cohort are as follows: among the pregnancies that reached 20 weeks of gestation, 8 (53%) were diagnosed with preeclampsia. There were 13 cesarean sections (93%) and 1 vaginal delivery (7%). Indications for cesarean delivery included several factors: preeclampsia was observed in 8 cases, acute fetal distress necessitated the procedure in 1 instance, a single patient had undergone a previous cesarean section, and 1 case involved a twin pregnancy with breech-cephalic presentation. The remaining 2 surgeries were elective. One spontaneous abortion occurred at 15 weeks of gestation. At the time of writing this

Table 2. Laboratory Parameters of Kidney Transplant Recipients Before, During and After Pregnancy

	Before Pregnancy	First Trimester	Second Trimester	Third Trimester	Postpartum 24-48 hours	Postpartum 6th Month	*P*
Hematocrit (%)	36.0 (35.0-38.5)	34.3 (32.1-38.0)	31.0 (27.4-31.3)	30.3 (28.0-32.2)	30.3 (27.8-35.0)	35.8 (32.4-38.0)	.002
Serum creatinine (mg/dl)	0.8 (0.8-0.9)	0.8 (0.7-1.0)	0.8 (0.7-1.1)	0.9 (0.8-1.6)	0.9 (0.8-1.4)	0.9 (0.8-1.4)	<.001
Serum urea (mg/dl)	27.0 (24.0-36.0)	26.1 (23.1-32.0)	26.5 (20.4-35.5)	32.0 (22.0-53.0)	30.5 (26.3-56.3)	32.1 (26.0-46.0)	.048
eGFR (mL/min/1.73 m^2)	90.0 (74.0-103.5)	100.0 (69.7-116.5)	88.0 (62.0-117.8)	85.0 (38.5-91.2)	76.0 (46.3- 96.1)	78.0 (48.1-97.0)	<.001
Protein/Creatinine ratio	135.0 (74.0-225.0)	169.5 (138.5- 400.2)	145.0 (140.0-270.0)	361.0 (196.5-599.5)	257.5 (125.5-850.0)	159.5 (102.7-342.2)	.003
Aspartate transaminase (U/L)	16.0 (15.0-18.0)	14.5 (11.0-17.5)	14.0 (11.2-17.5)	14.5 (10.5-18.5)	18.0 (17.0-36.0)	13.5 (11.0-18.7)	.285
Alanine transaminase (U/L)	12.0 (9.0-13.75)	9.5 (5.2-11.7)	8.5 (5.5-11.2)	8.0 (4.2-16.7)	15.0 (8.0-22.0)	12.0 (9.2-16.0)	.109
Lactate dehydrogenase (IU/L)	155.0 (126.7-186.5)	145.0 (136.0-157.0)	143.0 (127.5-162.0)	150.0 (136.5-194.5)	212.0 (152.2-306.0)	166.0 (139.2-204.2)	.016

Data are shown as median (interquartile range), statistical significance was set at <0.05.
eGFR, estimated glomerular filtration rate.

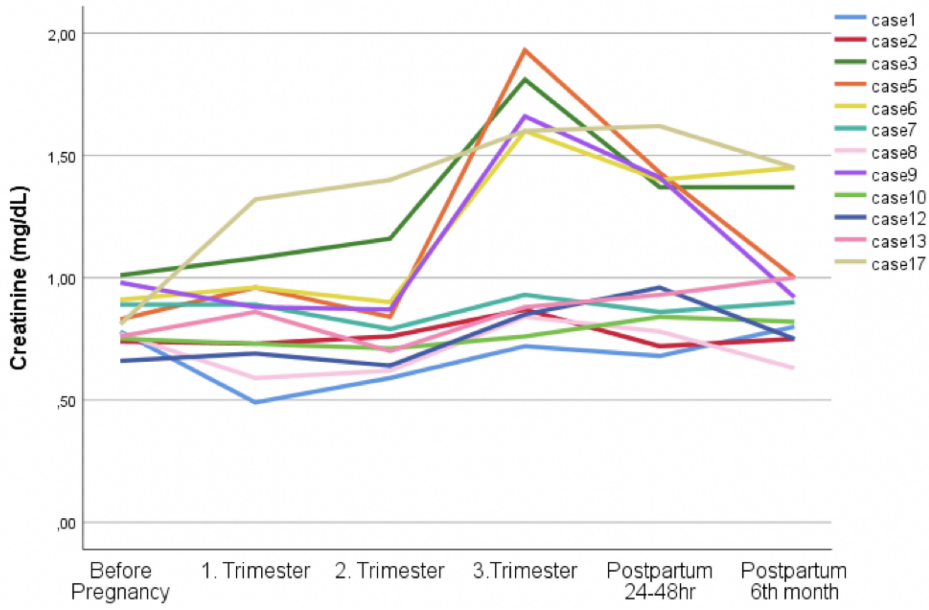


Figure 2. Creatinine levels of renal transplant recipients before pregnancy, first trimester, second trimester, third trimester, postpartum 24-48 hours and postpartum 6th month. Lines presented with different colors show pregnancies that reached the third trimester.

report, 1 patient had an ongoing and uneventful pregnancy in the third trimester. Eleven patients delivered prematurely, and the mean gestational age at delivery was 34.3 ± 3.1 weeks (range 26-38 weeks). The mean birth weight was 2378.2 ± 890.3 g. Of the 15 newborns, 7 (47%) were appropriate for gestational age, whereas 8 were SGA (53%). None of the infants had congenital anomalies, and only 1 had accompanying polyhydramnios.

Pre-pregnancy (P = .76), first trimester (P = .41), second trimester (P = .41), third trimester (P = .96), postpartum 24-48 hour (P = .14), and postpartum 6th month (P = .23) serum creatinine levels did not differ between patients with and without preeclampsia. Four patients in the preeclampsia group had chronic hypertension. The laboratory and clinical data of preeclampsia patients are presented in Table 5.

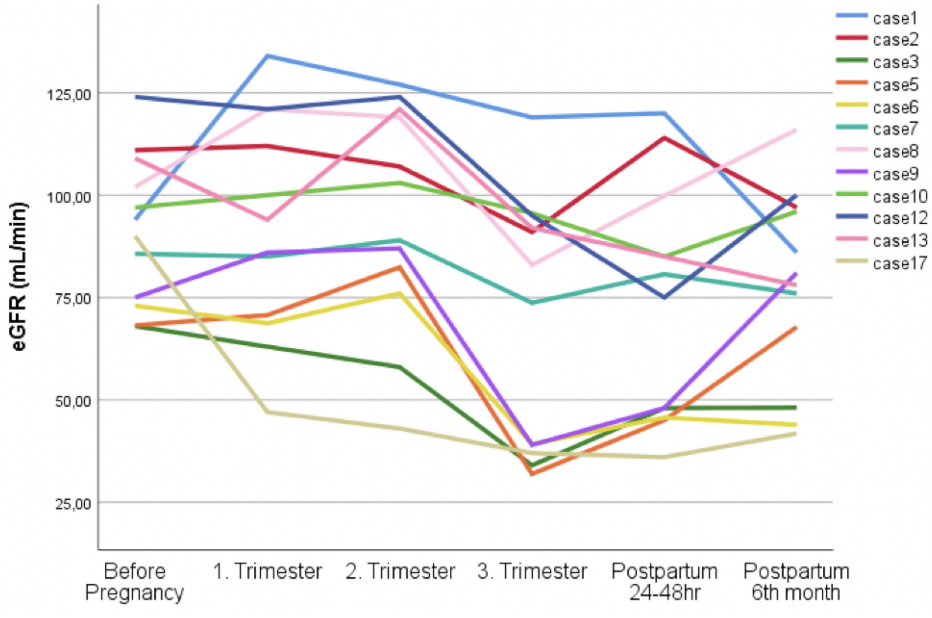


Figure 3. Estimated glomerular filtration rate (eGFR) levels of renal transplant recipients before pregnancy, first trimester, second trimester, third trimester, postpartum 24-48 hours and postpartum 6th month. Lines presented with different colors show pregnancies that reached the third trimester.

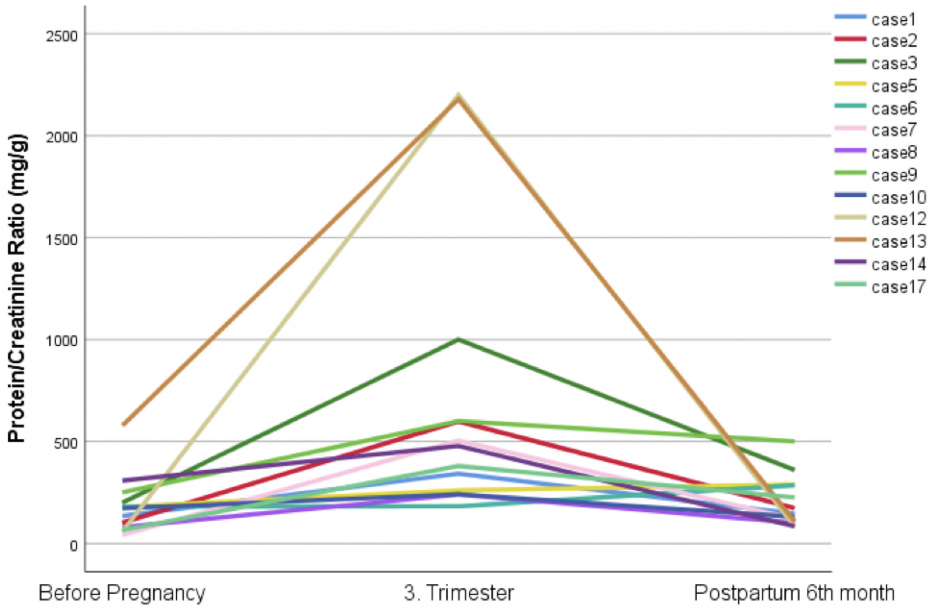


Figure 4. Protein/creatinine ratio of renal transplant recipients before pregnancy, third trimester, and postpartum 6th month. Lines presented with different colors show pregnancies that reached the third trimester.

Table 3. Blood Pressure of Kidney Transplant Recipients Before, During and After Pregnancy

	Before Pregnancy	First Trimester	Second Trimester	Third Trimester	Postpartum 24-48 hours	Postpartum 6th Month
Systolic blood pressure (mmHg)	110 (110-120)	110 (100-120)	110 (100-122.5)	120 (110-135)	125 (120-130)	115 (110-120)
Diastolic blood pressure (mmHg)	65 (60-70)	70 (62.5-70)	67.5 (60-70)	70 (65-80)	72.5 (66.2-80)	67.5 (60-70)

Data are shown as median (interquartile range).

Among the women who reached the third trimester, 4 patients had acute kidney graft dysfunction. Patients with acute kidney injury had a higher median creatinine level (0.95 mg/dL vs. 0.77 mg/dL, P = .008) and lower eGFR before pregnancy (70.6 vs. 95.5, P = .002). One woman in this group was diagnosed with preeclampsia. Table 6 displays the laboratory and clinical information for these patients, showing the values that correspond to the time when the highest creatinine levels were recorded during pregnancy.

DISCUSSION

The increasing success of modern surgical procedures and advancements in immunosuppressant drugs have led to a higher frequency of pregnancies among kidney transplant recipients. Although progress has been made, pregnancies following kidney transplantation still require careful management and monitoring. The research findings indicated that women who had undergone kidney transplantation still experienced a higher incidence of preeclampsia and preterm birth, although the overall outcomes were considered satisfactory.

"The European Best Practice Guidelines" recommend a minimum time interval of 2 years between conception and kidney transplantation, while the "Kidney Disease: Improving Global Outcomes" (KDIGO) guidelines suggest a waiting period of

Table 4. Obstetric Complications of Kidney Transplant Recipients

	N (%)
Low serum hemoglobin levels	5/17* (30%)
Urinary infection	7/17* (41%)
Polyhydramnios	1/15# (6%)
Acute fetal distress	1/15# (6%)
Premature rupture of membranes	1/15# (6%)
Preterm labor	2/15# (13%)
Preeclampsia	8 /15# (53%)
Preterm birth	11/15§ (73%)
Small for gestational age	8/15§ (53%)

Data presented as number of patients and percentage (%).
*Percentage calculated based on total pregnancy number.
#Percentage calculated based on pregnancies that reached 20 weeks of gestation, including the ongoing pregnancy.
§Percentage calculated based on deliveries that reached 20 weeks of gestation including twin pregnancy.

Table 5. Laboratory and Clinical Data of Preeclampsia Patients

	Urea* (mg/dL)	Cr* (mg/dL)	UA* (mg/dL)	LDH* (U/L)	AST* (U/L)	ALT* (U/L)	Plt* (x10^3/µL)	Na* (mEq/L)	K* (mEq/L)	Ca* (mg/dL)	Mg* (mg/dL)	Alb* (g/dL)	Prot* (g/L)	Prepreg Cr (mg/dL)	Tacrolimus levels*	Systolic BP (mm Hg)	Diastolic BP (mm Hg)	Chronic HT	UTI
Case 2	27.3	0.76	4.2	144	12	5	227	137	4.2	8.3	1.8	30.3	55.9	0.8	2,6	144	90	–	+
Case 3	71	1.81	8.8	157	19	24	154	138	4.6	9.4	1.6	35.6	62	1.02	8	150	100	+	–
Case 9	54	1.6	4.9	191	19	10	137	136	5	9.3	1.8	37.4	53	1.2	4.1	180	110	+	+
Case 11	75	2.24	7.2	252	50.7	64.1	106	132	4.5	8.6	2.4	31.3	48.6	1.7	4.8	140	90	+	–
Case 12	34	0.85	7.2	198	17	4	163	127	4.1	8.3	1.8	28	52.9	0.7	5.3	140	90	–	–
Case 13	40	0.88	6.6	131	14	9	182	136	5.7	8.9	1.5	36.9	67.4	0.8	3.4	165	100	–	+
Case 14	16.5	0.74	5.5	142	14	21	193	134	3.5	9.6	1.5	32.9	59	0.8	6.1	150	90	–	
Case 17	53	1.6	6.04	155	17	8	185	151	4.6	8.7	1.7	29.4	60	1.4	4.8	145	95	+	–

Alb, albumin; ALT, alanine transaminase; AST, aspartate transferase; BP, blood pressure; Ca, calcium; Cr, creatine; HT, hypertension; LDH, lactate dehydrogenase; Mg, magnesium; Plt, platelet; Prepreg Cr, pre pregnancy creatinine; Prot, total serum protein; UA, uric acid; UTI, urinary tract infection.
*Laboratory values of blood samples during preeclampsia.

Table 6. Laboratory and Clinical Data of Acute Kidney Injury Patients

	Urea* (mg/dL)	Cr* (mg/dL)	UA* (mg/dL)	LDH* (U/L)	AST* (U/L)	ALT* (U/L)	Plt* (x10^3/µL)	Na* (mEq/L)	K* (mEq/L)	Ca* (mg/dL)	Mg* (mg/dL)	Alb* (g/dL)	Prot* (g/L)	Prepreg Cr (mg/dL)	Tacrolimus levels*	PE	UTI
Case 3	71	1.81	8.8	157	19	24	154	138	4.6	9.4	1.6	35.6	62	1.02	5	-	-
Case 5	53	1.93	4.9	93	15	8	197	130	5.7	8.2	1.8	33	59	1.04	6.2	-	-
Case 6	34	1.66	5.8	148	20	22	163	136	3.8	8.3	1.79	34.2	55	0.9	1.9	-	-
Case 9	54	1.6	4.9	191	19	10	137	136	5	9.3	1.8	37.4	53	1.2	5.5	+	+

Alb, albumin; ALT, alanine transaminase; AST, aspartate transferase; Ca, calcium; Cr, creatine; LDH, lactate dehydrogenase; Mg, magnesium; PE, preeclampsia; Plt, platelet; Prepreg Cr, pre-pregnancy creatinine; Prot, total serum protein; UA, uric acid; UTI, urinary tract infection.
*Laboratory values of blood samples during acute kidney injury, values corresponding to the time at which peak creatinine levels were observed during pregnancy.

more than 1 year after kidney transplantation.[9,10] In the initial phase, conception seems to be hazardous due to the high drug levels and acute graft rejection risk. The time between kidney transplantation and conception in the research group exceeded 2 years. This extended interval was attributed to the study population's lower median age and higher frequency of live organ donations compared to previous reports in the literature.

Both the augmentation of renal blood flow and the reduction of oncotic pressure resulting from the expansion of plasma volume contribute to an improved eGFR in normal pregnancies.[11] Throughout normal pregnancy, serum creatinine levels decrease until approximately 24 weeks of gestation, which is followed by a subsequent rise that almost reaches the levels observed prior to pregnancy.[12] In women with kidney transplantation, as pregnancy advances, creatinine levels gradually increase in the second and third trimesters and eventually, decreases in the postpartum period.[13] In this study, there was no statistically significant increase in eGFR in the first trimester, but there was a significant decline in eGFR in the third trimester of pregnancy. Stavart et al[14] emphasized that there was a clear tendency for a decrease in eGFR after pregnancy when compared with baseline eGFR at the time of conception. In parallel, in a recent study, a significant median reduction of 9.3 ml/min/m^2 in eGFR was observed from the preconception period to 6 months postpartum.[15] This study found that eGFR values were lower after childbirth compared to pre-pregnancy levels, but this difference was not statistically significant. Studies have shown that patients with lower pre-pregnancy eGFR are at higher risk for adverse outcomes, including kidney allograft loss.[16] In this cohort, the majority of patients had well-preserved pre-pregnancy kidney function (eGFR >60 mL/min/1.73 m^2), which likely contributed to the favorable short-term graft survival observed.

According to the previous studies, an increase in serum creatinine levels over time was found to be a predictor of early graft loss.[17] Yadav et al[18] postulated that the lack of decline in serum creatinine levels in the earlier stages of pregnancy may indicate an unfavorable prognosis for both pregnancy and renal function. An earlier study showed that the levels of mean serum creatinine and creatinine clearance remained constant during the course of pregnancy and up to 1 year after childbirth.[19] On the contrary, Bramham et al[20] found that the median serum creatinine levels exhibited a decline during the first and second trimesters; however, during the third trimester, the levels increased. The same study also reported that serum creatinine levels do not decrease during pregnancy in approximately half of the kidney transplant recipients. A statistically significant elevation in serum creatinine levels was noted during the third trimester among the patients, with 4 individuals reaching thresholds indicative of acute allograft dysfunction. It is important to highlight that these patients exhibited elevated creatinine levels and reduced eGFR before pregnancy. The rise in creatinine levels during the third trimester of kidney transplant pregnancies can be multifactorial. Potential mechanisms include diminished kidney perfusion due to uterine compression, allograft stress induced by hyperfiltration, calcineurin inhibitor-related vasoconstriction, and preeclampsia. These factors, combined with the limited functional reserve of allografts, contribute to compromised kidney function. Notably, 1 patient who experienced acute kidney injury was diagnosed with preeclampsia in this study.

Research data indicates that during a normal pregnancy, the amount of albumin in urine tends to rise in the later phases of pregnancy, though it remains within the upper bounds of what is considered normal.[11] The amount of proteinuria in pregnant women who underwent kidney transplantation was found to increase up to threefold during the third trimester.[18] It is worth noting that this increase in proteinuria was temporary, as the levels returned to baseline at 3 months postpartum.[19] Hyperfiltration of kidney allografts may partially contribute to proteinuria in pregnant women who have undergone kidney transplantation. In this cohort, a significant increase in the P/Cr ratio was observed in the third trimester, consistent with the literature.

Globally, women after kidney transplantation have higher rates of live birth (73%-81%) and lower rates of miscarriage (15%) than those seen in the general population.[2,21,22] In accordance with these investigations, within this cohort, there was only 1 spontaneous abortion (6%) out of a total of 17 pregnancies. No instances of stillbirth were observed in this patients. However, post-transplantation pregnancies are associated with a higher incidence of obstetric complications.

A significant issue affecting this group is the occurrence of preeclampsia, which was observed in nearly half of the study participants. The definition of preeclampsia has broadened beyond the conventional diagnosis of high blood pressure and proteinuria to encompass maternal organ dysfunction.[6] Distinguishing between superimposed preeclampsia and pregnancy-related complications in patients who have undergone kidney transplantation poses a specific challenge. The reason for this is that a transplanted kidney typically exhibits reduced functionality, often coupled with pre-existing high blood pressure and some degree of pre-existing protein in the urine. Furthermore, the frequency of preeclampsia in kidney transplantation patients is higher than that in the general population, ranging from 16% to 42%.[23,24] The study's significantly higher preeclampsia rate may be attributed to the fact that high-risk patients are referred to the tertiary care facility. This creates a selection bias towards individuals who are more likely to experience complications. In a retrospective cohort study, chronic hypertension, previous preeclampsia, and elevated serum creatinine levels at the beginning of pregnancy were identified as prognostic factors for preeclampsia in women with kidney transplants.[25] Conversely, no difference could be found between creatinine levels in preeclamptic and non-preeclamptic women before, during, or after pregnancy. The lack of a difference in creatinine levels between

the preeclampsia and non-preeclampsia groups in this study may be attributed to several factors. The study's outcomes may have been affected by 2 key elements. The first is the small sample size, which could have hindered the detection of minor differences. The second is the relatively good kidney health of the participants at the study's outset, potentially reducing the chances of observing substantial kidney damage, even when preeclampsia developed. Furthermore, the patients were under close multidisciplinary monitoring, which likely mitigated the risk of renal deterioration through timely interventions, such as maintaining controlled blood pressure and scheduling delivery at an optimal time.

Studies have discovered that pregnancies in kidney transplant recipients with normal kidney function do not have a detrimental impact on the short- and long-term survival of both the patient and the transplanted organ, despite the potential for various complications.[3,26] The primary factor influencing the longevity of the allograft is kidney function prior to pregnancy.[27] Acute rejection during pregnancy was reported to be 8% in a recent meta-analysis, similar to that in patients without pregnancy.[28] None of the patients in this cohort experienced kidney allograft loss, either during or immediately after delivery. Furthermore, research has shown that although pregnancy has an impact on kidney histology and results in a reduction in eGFR, it does not seem to be associated with an increased risk of long-term allograft failure.[29]

In this study group, the rate of cesarean deliveries reached 93%, which is higher than the frequencies documented for kidney transplant recipients in earlier meta-analyses.[2,21] Emergency indications contribute significantly to the higher rates of cesarean deliveries observed in kidney transplant recipients. Literature reports figures as high as 94%.[24] Nevertheless, a large cohort study revealed that attempting vaginal delivery instead of scheduling a cesarean section is associated with improved outcomes for newborns of kidney transplant recipients without compromising the health of mothers.[30]

The frequency of fetal growth restriction is approximately 37% among pregnant women who have undergone kidney transplantation.[22] This is thought to be a consequence of pre-existing hypertension and kidney disease, immunosuppressive drug use, and an increased likelihood of preeclampsia. In this research, roughly 50% of the newborns were classified as SGA.

Preterm birth is common in patients with kidney transplants.[31] Prematurity often arises due to medical interventions aimed at inducing early delivery in patients with obstetric complications such as preeclampsia. In this study, the rate of preterm birth among the patients was 79%, with the majority of them having late preterm pregnancies. The high frequency of preeclampsia in this study may be the primary factor contributing to this outcome. The mean gestational age at delivery was 34.3 weeks, and the mean birth weight was 2378.2 ± 890.3 g in this study, aligning closely with the findings in the meta-analysis reported by Mustafa et al.[28] On the contrary, in the study conducted by Ayar et al,[32] it was observed that out of the 20 live births, 7 were classified as preterm, despite only 2 patients being diagnosed with preeclampsia.

The research had several constraints, including a restricted number of participants and the absence of a comparison group. Furthermore, the study only examined data over a brief period. Although the small sample size limits the generalizability of the findings, the advantage of consistent patient management in a single center, a multidisciplinary approach, and the use of standard clinical protocols add strength to the internal validity and reliability of this study. This study provides valuable insights into pregnancy in kidney transplantation patients, which might aid in counseling women following kidney transplantation.

In conclusion, although the short-term impact of pregnancy on allograft function appears acceptable, close surveillance is mandatory in pregnancies after kidney transplantation, because it confers a greater risk of obstetric complications.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

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