

## Evaluation of the effect of kidney transplantation on cardiac activity in patients with chronic heart failure in the outcome of stage 5 chronic kidney disease

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### Abstract

The main cause of death in patients with terminal forms of chronic renal failure, on renal replacement therapy, are cardiovascular diseases. Cardiovascular diseases also account for 40 to 60% of all deaths after kidney transplantation.

**Objective:** in this study, we assessed the effect of kidney transplantation on the functional state of the heart in patients with stage 5 chronic kidney disease complicated by the development of chronic heart failure.

**Methods.** The study included 13 patients who had undergone kidney transplants. Inclusion criteria: patients over 18 years of age, the presence of informed consent, with the presence of chronic heart failure with a reduced left ventricular ejection fraction < 50%, a high level of final diastolic volume and a high calculated average pressure in the pulmonary artery.

**Results.** After transplantation, the lowest value of the ejection fraction was 49%, the highest value was 68%, the average value was 56.3%. The calculated average pressure in the pulmonary artery was the lowest value was 10 mmHg. the highest value was 38 mmHg. the average value was 19.69 mmHg. According to the results of the control ultrasound examination after transplantation, positive dynamics was noted in all 13 cases. The average calculated mean pressure in the pulmonary artery decreased from 39.46 mmHg to 19.69 mmHg. a decrease of 50.1%, the ejection fraction increased from 41.46% to 56.43%, an increase of 35.8%.

**Conclusion.** The research results highlight the significant improvement in both cardiac and pulmonary function in patients with chronic heart failure after kidney transplantation. However, in our study, some parameters, such as an increase in the ejection fraction and a decrease in the calculated average pressure in the pulmonary artery, turned out to be more pronounced, which may indicate the specifics of our patient population and treatment methods.

**Keywords:** chronic kidney disease, kidney transplantation, chronic heart failure, final diastolic volume, ejection fraction, arterial hypertension.

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## Introduction

Chronic kidney disease (CKD) is a persistent decline in kidney function that affects approximately 10% of the global population to some extent [1]. CKD significantly increases the risk of cardiovascular diseases due to fluid and electrolyte imbalances, leading to the development of hypertension and cardiovascular complications. Lipid metabolism disorders, calcium regulation disturbances, and chronic vascular wall inflammation caused by elevated blood creatinine and urea levels contribute to the development of atherosclerosis and cardiovascular diseases [2]. Thus, the primary cause of mortality in patients with end-stage renal disease (ESRD) undergoing renal replacement therapy is cardiovascular disease [3-5]. Additionally, cardiovascular diseases account for 40% to 60% of all deaths following kidney transplantation [5-6].

According to the European Dialysis and Transplant Association, the one-year survival rate for patients with ESRD on renal replacement therapy is 83.5%, the two-

year survival rate is 72.2%, and the five-year survival rate is 42.0%. In comparison, kidney transplant recipients have significantly higher survival rates: one-year survival at 96.8%, two-year survival at 94.9%, and five-year survival at 88.3% [7].

Kidney transplantation remains the only radical treatment for patients with ESRD [8]. The advantages of kidney transplantation over hemodialysis are evident, as it leads to an improved quality of life and higher survival rates. Kidney transplantation not only reduces the burden on the cardiovascular system but also significantly improves the functional state of the heart in patients with varying degrees of chronic heart failure [7].

In this study, we assessed the impact of kidney transplantation on the functional state of the heart in patients with stage 5 chronic kidney disease complicated by the development of chronic heart failure.

## Materials and methods

This study is a retrospective, quantitative analysis of data from patients who underwent kidney transplantation.

To assess heart function, the most accessible and informative method, transthoracic echocardiography (TTE), was used as an ultrasound-based cardiac assessment both before and after the transplantation procedure.

The evaluation also included complications associated with CKD and heart failure, such as arterial hypertension, respiratory failure, pleuritis, and pericarditis.

A total of 13 patients who had undergone kidney transplantation were included in the study. The inclusion criteria were: patients over 18 years old, informed consent,

and the presence of chronic heart failure with a reduced left ventricular ejection fraction (LVEF)  $\leq 50\%$ , high end-diastolic volume (EDV), and elevated estimated mean pulmonary artery pressure (mPAP). The exclusion criterion was the absence of informed consent.

This study was conducted in accordance with the principles of the Helsinki Declaration, and prior to its retrospective analysis, approval was obtained from the local bioethics committee of the "National Scientific Oncology Center".

All calculations were performed using Microsoft Excel, applying mean value calculations.

## Results

Between 2021 and 2023, a total of 160 kidney transplants were performed at our clinic from both living and deceased donors. Among these, 13 recipients with chronic heart failure and reduced left ventricular ejection fraction (LVEF)  $\leq 50\%$ , high end-diastolic volume (EDV), and elevated estimated mean pulmonary artery pressure (mPAP) were included in our study.

The average age of the recipients was 31.76 years, and the mean body mass index (BMI) was 19.36 kg/m<sup>2</sup>. One recipient had grade 2 obesity with a BMI of 32.79. Out of 13 patients, 12 were male and 1 was female. The causes of end-stage CKD were glomerular diseases in 12 patients and diabetic nephropathy in 1 patient. Pleural effusion was detected in 4 cases, and pericardial effusion was found in 6 cases. Before surgery, 8 patients were anuric, while 5 patients had a urine output of 100 to 500 mL of discolored urine per day. The average duration of hemodialysis before transplantation was 28.46 months.

Seven patients had type 1 respiratory failure, experiencing shortness of breath with minimal physical activity, while 5 patients had type 2 respiratory failure, experiencing shortness of breath with moderate physical activity. One patient had dyspnea at rest as a type 3 respiratory failure. Arterial hypertension was classified as a stage 3 hypertension in 10 patients, Stage 2 hypertension in 1 patient, and 2 recipients had stage 1 hypertension.

Echocardiography (ECHO) was performed 1 week to 1 month before kidney transplantation. Before transplantation, the lowest recorded LVEF was 29%, the highest was 48%, and the mean value was 41.46%. The

lowest recorded mPAP was 15 mmHg, the highest was 80 mmHg, and the mean was 39.46 mmHg. The lowest recorded EDV was 94 mL, the highest was 219 mL, and the mean was 144.23 mL.

All recipients underwent a standard, widely accepted kidney transplantation procedure using a living donor, with the transplant placed retroperitoneally in the right iliac fossa.

There were no cases of acute rejection or delayed graft function. The average postoperative hospital stay was 14 days. At discharge, all recipients had satisfactory kidney graft function.

Follow-up echocardiography was performed 1 to 3 months after discharge. Positive dynamics were observed in all 13 recipients.

After transplantation, the lowest recorded LVEF was 49%, the highest was 68%, and the mean was 56.3%. The lowest recorded mPAP was 10 mmHg, the highest was 38 mmHg, and the mean was 19.69 mmHg. The lowest recorded EDV was 80 mL, the highest was 161 mL, and the mean was 108.76 mL.

According to follow-up echocardiography, positive improvements were observed in all 13 cases. The average mPAP decreased from 39.46 mmHg to 19.69 mmHg, a reduction of 50.1%. LVEF increased from 41.46% to 56.3%, an improvement of 35.8%. EDV decreased from 144 mL to 108.76 mL, a reduction of 24.6%.

Table 1 - Clinical parameters of patients before and after transplantation

Clinical parameters	Before transplant	After transplant
Ejection fraction	41,46	56,43
estimated mean pulmonary artery pressure	39,46	19,69
end diastolic volume	144	108,76
Pericarditis	6	0
Pleurisy	4	0
Type 1 respiratory failure	7	2
Type 2 respiratory failure	5	0
Type 3 respiratory failure	1	0
Stage 3 hypertension	10	0
Stage 2 hypertension	1	1
Stage 1 hypertension	2	12

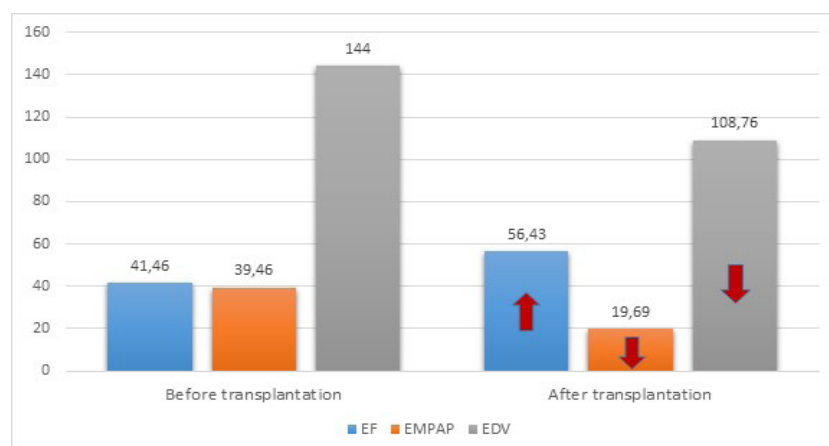


Figure 1 - Average value of EF (ejection fraction), EMPAP (estimated mean pulmonary artery pressure, EDV (end diastolic volume) before and after the kidney transplantation procedure

Type 1 respiratory failure was observed in 2 patients 3 months after transplantation, while the remaining 11 patients had no respiratory failure. Blood pressure normalization occurred in 7 patients without the use of

antihypertensive medications. In 3 patients, blood pressure improved with the use of antihypertensive drugs, reaching normal levels. Two patients had no arterial hypertension either before or after kidney transplantation.

## Discussion

The results of our study demonstrated a significant improvement in cardiovascular status in patients with chronic heart failure after kidney transplantation. The included recipients had pronounced manifestations of heart failure with reduced LVEF, high EDV, and elevated mPAP. It is important to note that this patient population is at high risk for complications associated both with end-stage renal failure and chronic heart failure.

One to three months after transplantation, all recipients showed positive dynamics in heart function indicators. The average increase in LVEF from 41.46% to 56.3% (a 35.8% improvement) indicates a significant improvement in left ventricular pumping function, likely related to the restoration of volume status following kidney transplantation. The reduction in mPAP from 39.46 mmHg to 19.69 mmHg (a 50.1% decrease) confirms the reduction of pulmonary artery pressure and improvement in hemodynamics. This suggests a positive effect of kidney transplantation on systemic circulation and pulmonary hypertension caused by renal failure.

Additionally, the significant reduction in EDV from 144.23 mL to 108.76 mL (a 24.6% decrease) indicates a reduction in left ventricular volume overload. This parameter may serve as an additional marker of improved

heart function and the general condition of patients after transplantation.

It is also important to highlight the positive changes in respiratory function. In most patients, respiratory failure either decreased or completely disappeared, indicating correction of metabolic disturbances and improved oxygenation following the normalization of renal function. Moreover, the normalization of blood pressure in most patients without the use of antihypertensive medications underscores systemic improvement.

These results confirm the effectiveness of kidney transplantation in patients with a combination of end-stage renal failure and chronic heart failure, which could have clinical significance for improving the prognosis of this patient group.

The instrumental methods used in our study were similar to those in other studies [9-12]. The obtained results are consistent with the data from other studies demonstrating an improvement in cardiovascular function after kidney transplantation in patients with chronic heart failure (CHF). In the study by Lentine et al. (2012), it was shown that kidney transplantation leads to significant improvement in heart function, including a reduction in

pulmonary hypertension and an increase in left ventricular ejection fraction (LVEF) [13]. However, in our study, the average increase in LVEF (by 35.8%) was higher than in some other studies, where improvement ranged from 15% to 25%. This could be due to the fact that our cohort included patients with more pronounced initial heart function abnormalities, which resulted in a more noticeable improvement after transplantation.

In the study of Kumar et al. (2024) discusses that the impact of kidney transplantation on pulmonary hypertension (PH) and highlights that, in some cases, kidney transplantation can lead to a reduction in mean pulmonary artery pressure (mPAP) [14]. In our study, we observed a more significant reduction - by 50.1%. The difference may be related to the methods of measuring mPAP, as well as differences in the patient cohort. Given the high baseline values of mPAP in our patients, transplantation may have had a more pronounced effect on reducing pulmonary artery pressure.

In the study Eun Jung Kim et al. (2019) analyzed the association between perioperative factors and changes in left ventricular diastolic function in patients with preserved ejection fraction following kidney transplantation. The study found that kidney transplantation was associated with improved diastolic function [15]. In our study, the reduction

in EDV was 24.6%, which is slightly higher compared to the 15-20% observed in other studies. This may indicate a more pronounced post-load correction of heart function in our patients after transplantation, which could also be explained by the specifics of their initial condition.

Several studies discuss that kidney transplantation can lead to better blood pressure control compared to dialysis, attributing this improvement to the restoration of endocrine functions and fluid balance by the transplanted kidney [16,17]. In our study, normalization of blood pressure without the use of antihypertensive medications was achieved in 7 out of 13 patients, which supports these findings. However, in 3 patients, antihypertensive medications were still used to control blood pressure, which is also consistent with other studies indicating that not all patients achieve complete blood pressure normalization after transplantation.

Thus, our results confirm and complement the data from other studies, highlighting significant improvements in both cardiac and pulmonary function in patients with CHF after kidney transplantation [17-19]. However, in our study, some parameters, such as the increase in LVEF and the reduction in mPAP, were more pronounced, which may indicate the specificity of our patient cohort and treatment methods.

## Conclusion

Many similar studies confirm the presence of positive dynamics in cardiovascular function, further emphasizing the invaluable role of kidney transplantation as a method that directly impacts the survival of patients with terminal stages of chronic kidney disease. We will continue to collect data from this patient group, incorporating additional criteria that may influence the process of improving cardiovascular function.

**Conflict of interest.** No.

**Acknowledgments.** No.

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## Созылмалы бүйрек ауруы 5 сатысында созылмалы жүрек жеткіліксіздігі бар науқастарда бүйрек трансплантациясының жүрек қызметіне әсерін бағалау

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## Түйіндеме

Созылмалы бүйрек жеткіліксіздігінің терминалды формалары бар, бүйректі алмастыратын терапиядағы пациенттер өлімінің негізгі себебі жүрек-қан тамырлары аурулары болып табылады. Сондай-ақ, жүрек-қан тамырлары аурулары бүйрек трансплантациясынан кейінгі барлық өлім-жітімнің 40-60% құрайды.

Зерттеудің мақсаты: Бұл зерттеуде біз созылмалы жүрек жеткіліксіздігінің дамуымен асқынған 5 сатыдағы созылмалы бүйрек ауруы бар науқастарда бүйрек трансплантациясының жүректің функционалды жағдайына қаншалықты әсерін бағаладық.

Әдістері. Зерттеуге бүйрек трансплантациясынан өткен 13 науқас қатысты. Қосу критерийлері: 18 жастан асқан пациенттер, сол жақ қарыншаның шығарылу фракциясы  $\leq 50\%$  төмендеген созылмалы жүрек жеткіліксіздігінің, соңғы диастолалық көлемнің жоғары деңгейінің және жоғары есептелген өкпе артериясындағы орташа қысымның болуымен ақпараттандырылған келісімнің болуы.

Нәтижесі. Шығарылу фракциясы трансплантациясынан кейін ең төменгі көрсеткіш 49% құрады, ең жоғары 68% орташа көрсеткіш 56,3% болды. Өкпе артериясындағы орташа қысымның ең төменгі мәні сынап бағанасы 10 мм. болды, ең жоғары мәні 38 мм. сынап бағанасы, орташа мәні 19,69 мм. сынап бағанасы болды. Трансплантациядан кейінгі бақылау ультрадыбыстық нәтижелері бойынша барлық 13 жағдайда оң динамика байқалды. Өкпе артериясындағы орташа қысымның орташа деңгейі 39,46 мм. сынап бағанасынан 19,69 мм. сынап бағанасына дейін төмендеді. Шығарылу фракциясы 46%-дан 56,43%-ға дейін 35,8%-ға ұлғайды.

Қорытынды. Біздің нәтижелеріміз бүйрек трансплантациясынан кейін созылмалы жүрек жеткіліксіздігі бар науқастарда жүрек және өкпе функциясының айтарлықтай жақсарғанын көрсетті. Дегенмен, біздің зерттеуімізде шығарылу фракциясының жоғарылауы және өкпе артериясындағы орташа қысымның төмендеуі сияқты кейбір параметрлер айқынырақ болды, бұл біздің пациенттер контингентінің және емдеу әдістерінің ерекшелігін көрсетуі мүмкін.

Түйін сөздер: созылмалы бүйрек ауруы, бүйрек трансплантациясы, созылмалы жүрек жеткіліксіздігі, соңғы диастолалық көлем, шығарылу фракциясы, артериялық гипертензия.

## Оценка влияния трансплантации почки на сердечную деятельность у пациентов с хронической сердечной недостаточностью в исходе хронической болезни почек 5 стадии

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### Резюме

Основной причиной смертности пациентов с терминальными формами хронической почечной недостаточности, на заместительной почечной терапии, являются сердечно-сосудистые заболевания. Также сердечно-сосудистые заболевания составляют от 40 до 60% всех случаев смерти после трансплантации почки.

В этом исследовании мы оценили на сколько влияет трансплантация почки на функциональное состояние сердца у пациентов с хронической болезнью почек 5 стадии осложнившейся развитием хронической сердечной недостаточностью.

Методы. В исследование были включены 13 пациентов которые перенесли трансплантацию почек. Критерии включения: пациенты старше 18 лет, наличие информированного согласия, с наличием хронической сердечной недостаточности со сниженной фракцией выброса левого желудочка  $\leq 50\%$ , высоким уровнем конечного диастолического объема и высоким расчетным средним давлением в легочной артерии.

Результаты. После трансплантации самое низкое значение фракция выброса составило 49% самое высокое значение 68% среднее значение составило 56,3%. Расчетное среднее давление в легочной артерии самое низкое значение составило 10 мм. рт. ст. самое высокое значение 38 мм. рт. ст. среднее значение составило 19,69 мм. рт. ст. По результатам контрольного ультразвукового исследования после трансплантации отмечена положительная динамика во всех 13 случаях. Средний уровень расчетного среднего давления в легочной артерии с 39.46 мм. рт. ст. снизилось до 19.69 мм. рт. ст. снижение на 50,1%, фракция выброса увеличилась с 41.46% до 56.43% увеличение на 35,8%, конечный диастолический объем со снижением со 144 мл. до 108.76 мл. снижение на 24,6%.

Выводы. Результаты исследования подчеркивают значительное улучшение как сердечной, так и легочной функции у пациентов с хронической сердечной недостаточностью после трансплантации почки. Однако в нашем исследовании некоторые параметры, такие как увеличение фракции выброса и снижение расчетного среднего давления в легочной артерии, оказались более выраженными, что может свидетельствовать о специфике нашего пациентского контингента и методов лечения.

Ключевые слова: хроническая болезнь почек, трансплантация почки, хроническая сердечная недостаточность, конечный диастолический объем, фракция выброса, артериальная гипертензия.