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## ABSTRACT

# SURVIVAL ANALYSIS ON THE HEART TRANSPLANT WAITING LIST: RESULTS OF A SINGLE-CENTER STUDY

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**Introduction.** Heart failure is one of the leading causes of mortality worldwide, and heart transplantation (HT) remains the only radical treatment for the terminal stage of this disease. However, the shortage of donor organs and prolonged waiting periods significantly limit the availability of HT, leading to high mortality rates among patients on the waiting list. The aim of this study was to analyze the survival of patients awaiting HT at the State Institution "Heart Institute of the Ministry of Health of Ukraine."

**Materials and Methods.** A retrospective analysis was conducted on 464 patients included in the HT waiting list from 2021 to 2024. Data were obtained from the Unified State Information System for Transplantation and medical records. Demographic parameters, urgency status, the use of mechanical circulatory support (MCS), and survival rates were assessed. Survival was estimated using the Kaplan-Meier method, and statistical analysis was performed using SPSS 26.0.

**Results.** The median age of the patients was 49 (38; 58) years, with men comprising 82.8% of the cohort. The median time spent on the waiting list was 271 (138; 547) days. HT was performed in 19.2% of cases, while mortality on the waiting list was 21.1%. Patients with a higher urgency status had significantly lower survival rates, with the highest mortality observed among those with Status I urgency (55.6%). Overall 1-year survival was 88.0%, and 2-year survival was 77.0%.

**Conclusions.** The findings indicate a positive trend in reducing waiting times, which may result from improvements in the transplant system in Ukraine. The development of mechanical circulatory support and further analysis of survival factors remain a priority.

**Keywords:** heart failure, heart transplantation, survival, waiting list, mechanical circulatory support, cardiac surgery.

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### АНАЛІЗ ВИЖИВАННЯ НА ЛИСТІ ОЧІКУВАННЯ ТРАНСПЛАНТАЦІЇ СЕРЦЯ: РЕЗУЛЬТАТИ ОДНОЦЕНТРОВОГО ДОСЛІДЖЕННЯ

**Вступ.** Серцева недостатність є однією з основних причин летальності у світі, а трансплантація серця (ТС) залишається єдиним радикальним методом лікування термінальної стадії цього захворювання. Проте дефіцит донорських органів та тривалий період очікування значно обмежують доступність ТС, що зумовлює високий рівень летальності серед пацієнтів у листі очікування. Метою дослідження був аналіз виживаності пацієнтів, які очікували ТС у ДНП «Інститут серця МОЗ України».

**Матеріали та методи.** Було проведено ретроспективний аналіз 464 пацієнтів, включених до листа очікування ТС у 2021-2024 рр. Дані отримано з Єдиної державної інформаційної системи трансплантації та медичної документації. Оцінювали демографічні показники, статус ургентності, використання механічної підтримки кровообігу (МПК) та виживаність. Виживаність визначали методом Каплана-Маєра, статистичний аналіз виконували у SPSS 26.0.

**Результати.** Середній вік пацієнтів становив 49 (38; 58) років, частка чоловіків – 82,8%. Медіана перебування у листі очікування – 271 (138;547) діб. ТС була проведена у 19,2% випадків, летальність на листі очікування становила 21,1%. Пацієнти з вищим статусом ургентності мали достовірно нижчу виживаність, причому найвищий рівень летальності спостерігався серед осіб з I статусом ургентності (55,6%). Загальна 1-річна виживаність становила 88,0%, 2-річна – 77,0%.

**Висновки.** Отримані дані свідчать про позитивну динаміку у скороченні термінів очікування, що може бути результатом покращення трансплантаційної системи в Україні. Пріоритетним залишається розвиток механічної підтримки кровообігу та подальший аналіз факторів виживаності.

***Ключові слова:*** *серцева недостатність, трансплантація серця, виживаність, лист очікування, механічна підтримка кровообігу, кардіохірургія*.

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## INTRODUCTION

Heart failure remains one of the most serious medical problems of our time and is among the most common causes of mortality in the world [1, 2, 18]. Progression of this disease leads to the development of a severe, refractory form that is not amenable to medical treatment and is associated with a 50% mortality rate within five years of diagnosis [3, 19].

Even though heart transplantation (HT) is the only radical treatment for patients with end-stage heart failure, its use is significantly limited by the shortage of donor organs and the increasing number of patients requiring transplantation. This, in turn, prolongs waiting time and increases the risk of mortality among those on the waiting list [4, 5]. Study of these aspects is crucial for optimizing the transplantation system and

developing effective strategies for managing patients during the waiting period.

Ukraine currently lacks large-scale national studies dedicated to analyzing the survival of patients awaiting heart transplantation. The lack of such data makes it difficult to assess the real risks for these patients and to develop effective mechanisms for managing the waiting list. In addition, the lack of centralized statistical research limits the ability to compare national indicators with international practice, which is an important step towards improving the transplantation system in Ukraine.

The introduction of the Unified State Transplantation Information System (USTIS) in accordance with the Resolution of the Cabinet of Ministers of Ukraine dated December 23, 2020 No. 1366 “On Approval of the Regulations on the Unified State Information System for Organ and Tissue Transplantation” has become an important step in improving the transplantation system of Ukraine, because centralized accounting of recipients and donors, as well as automated organ distribution, contribute to more transparent and effective management of the waiting list [6]. At the same time, an analysis of the survival of patients on this list is necessary to assess the effectiveness of the transplantation system and identify ways to improve it further. That is why the **objective** of this study was to analyze survival among patients awaiting heart transplantation at our center.

## MATERIALS AND METHODS

### *Ethical aspects*

The study was conducted in accordance with the Declaration of Helsinki and approved by the local Ethics Committee of the State Non-Profit Organization "Heart Institute of the Ministry of Health of Ukraine". Given the retrospective nature of the study, informed consent was not required to participate in the study.

### *Inclusion and exclusion criteria*

A retrospective analysis was conducted involving 464 patients who were on the waiting list for heart transplantation at the Heart Institute of the Ministry of Health of Ukraine from 2021 to 2024. Patients were included in the analysis at the time of their initial inclusion on the HT waiting list. Waiting list time was defined as the time from initial inclusion to removal from the list due to transplantation, death, or recovery. Patients were excluded from analysis at the time of transplantation or recovery.

### *Data collection*

Data were obtained from the Unified State Transplantation Information System and medical documentation of the State Non-Profit Organization "Heart Institute of the Ministry of Health of Ukraine". Demographics, underlying causes of heart failure (HF), patient urgency status, use of mechanical circulatory support (MCS), and survival were analyzed.

### *Statistical analysis*

Data were presented as medians (25th; 75th percentiles) for nonparametric variables and as frequencies (%) for categorical variables. Survival was assessed by the Kaplan-Meier method using the Log-rank test for comparison between groups. The $\chi^2$ test and Mann-Whitney U test were used to analyze the relationship between variables. A p-value $<0.05$ was considered statistically significant. All calculations were performed using SPSS 26.0 software.

## RESULTS

According to the Unified State Transplantation Information System, there were 464 patients on the waiting list of the State Non-Profit Organization "Heart Institute of the Ministry of Health of Ukraine” from 2021 to 2024, and at the time of the study, 245 people remained on the list. The median age of patients was 49 (38; 58) years, and the proportion of men was 384 (82.8%). Detailed characteristics of patients on the heart transplantation waiting list are given in Table 1.

The median duration of stay on the waiting list was 271 (138; 547) days. Of the total number of patients, 16 (3.45%) required mechanical circulatory support (MCS) while on the waiting list: 9 patients were supported by extracorporeal membrane oxygenation (ECMO), 4 patients – by a ventricular assist device, and 3 patients – by an intra-aortic balloon pump (Table 1).

It is worth noting that most often, patients were in heart transplantation urgency status 4 and 5 (292 (62.9%) and 73 (15.7%) patients, respectively). At the same time, heart transplantation urgency status 2 and 1 were less common (3 (0.65%) and 9 (1.93%) patients, respectively).

The number of heart transplants among patients on the heart transplant waiting list was 89 (19.2%) cases, with the average waiting time for a donor heart being 222 ± 45 days (Figure 1). Further detailed analysis of the waiting time for a donor heart showed a decreasing trend from 259 ± 43 days in 2021 to 187 ± 64 days in 2024 ($p = 0.154$).

The mortality rate on the waiting list was 98 (21.1%). The distribution of mortality depending on the urgency status on the HT list revealed a significant dependence between the level of mortality and the urgency status ($p = 0.039$) (Fig. 2).

Patients with urgency status 1 were characterized by the highest mortality rate on the waiting list – 55.6%, with a further decrease in the mortality rate to urgency status 5. At the same time, we obtained interesting results regarding patients with status 6, whose mortality on the waiting list was higher compared to status 5 and 4.

*Table 1* – **Characteristics of patients on the heart transplant waiting list**

| **Parameter** | **N = 464** |
|---|---|
| Age | 49 (38; 58) |
| Males | 384 (82.8%) |
| Causes of HF | |
| - Dilated cardiomyopathy | 309 (66.6%) |
| - Ischemic cardiomyopathy | 93 (20.0%) |
| - Hypertrophic cardiomyopathy | 2 (0.50%) |
| - HF of other origin | 60 (12.9%) |
| Duration of stay on the waiting list | 271 (138; 547) |
| Bridge to transplantation | |
| - Ventricular assist device | 4 (0.86%) |
| - Extracorporeal membrane oxygenation | 9 (1.93%) |
| - Intra-aortic balloon pump | 3 (0.65%) |
| Distribution by urgency status | |
| - 1 | 9 (1.93%) |
| - 2 | 3 (0.65%) |
| - 3 | 42 (10.12%) |
| - 4 | 45 (9.70%) |
| - 5 | 73 (15.7%) |
| - 6 | 292 (62.9%) |
| Share of transplants | 89 (19.2%) |
| Duration of stay on the waiting list before HT, days | 222 ± 45 |
| Mortality rate | 98 (21.1%) |

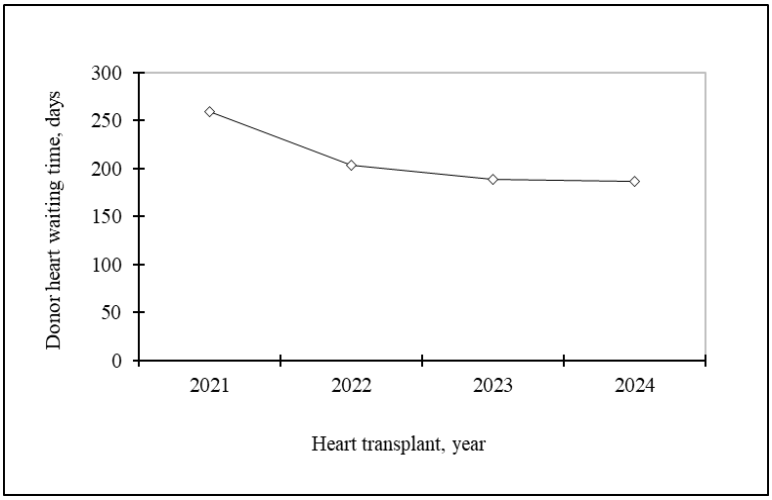


*Figure 1 – Donor heart waiting time*

Based on the Kaplan–Meier study, the 1-year and 2-year survival rates in patients on the waiting list were 88.0 ± 1.70% (95% CI 84.7; 91.5%) and 77.0 ± 2.80% (95% CI 71.8; 82.6%) (Fig. 3).

Further analysis did not reveal a significant difference in survival between genders (p=0.589 by Log-rank) (Fig. 4).

Thus, one-year survival among men was 88.0 ± 1.90% (95% CI 84.4; 91.8%) vs. 88.4 ± 3.90% (95% CI 81.0; 96.4%) (Fig. 4).

A similar pattern was also observed when analyzing the age-specific effect on the survival of patients on the waiting list. In particular, one-year survival on the waiting list among children was 85.6±7.80% (95% CI 76.1; 100%) vs. 90.0±1.60% (95% CI 86.9; 93.2%) in adults (p=0.465 by Log-rank) (Fig. 5).

At the same time, we found a significant difference in survival depending on the urgency status on the HT waiting list (p=0.001 by Log-rank) (Fig. 6).

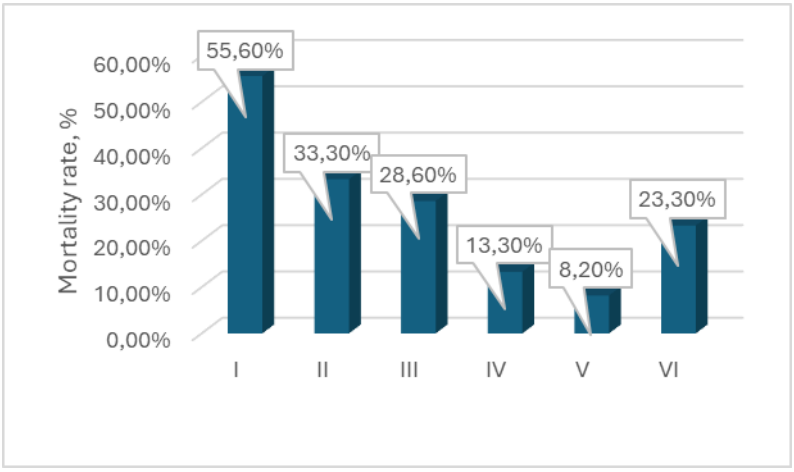


*Figure 2 – Distribution of mortality depending on the urgency status on the heart transplant waiting list*

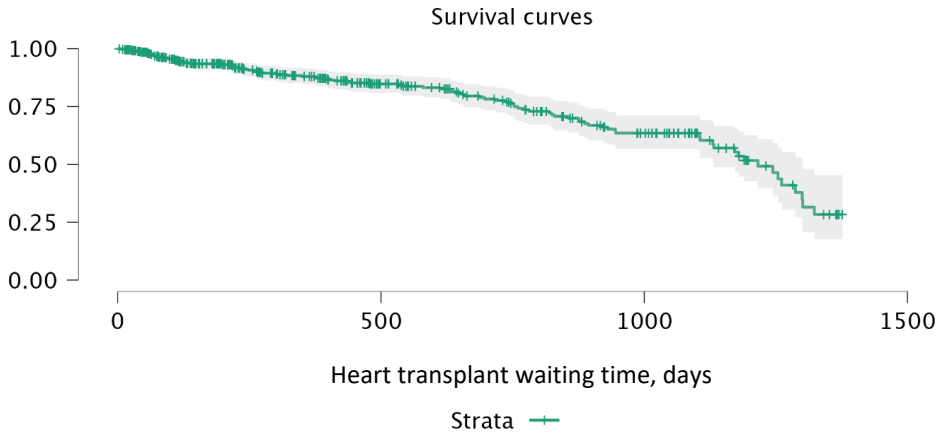


*Figure 3 – Survival of patients on the heart transplant waiting list*

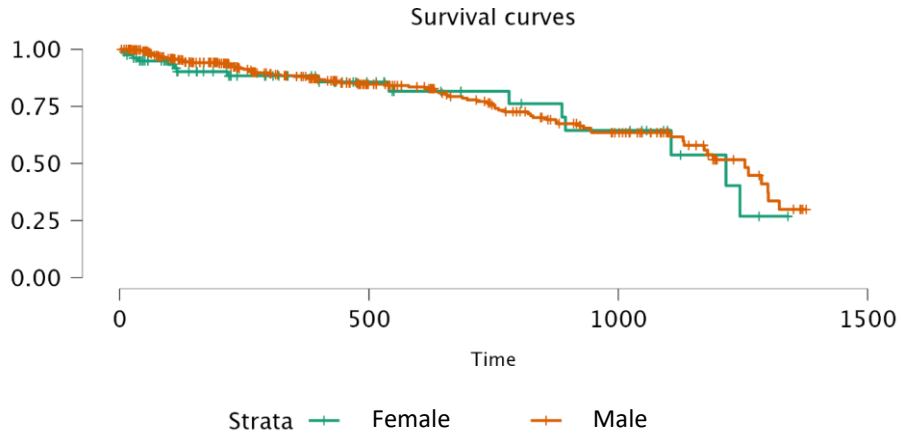


*Figure 4 – Gender-specific survival of patients on the heart transplant waiting list*

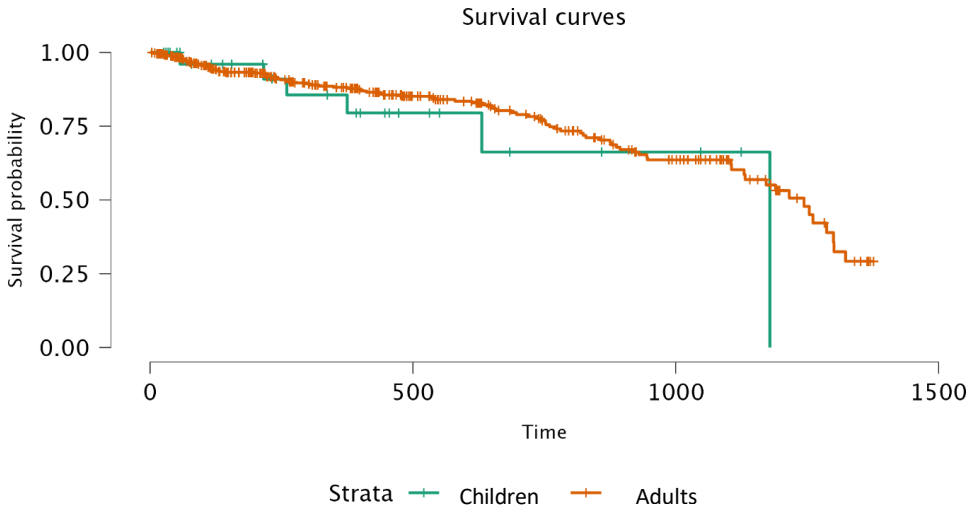


*Figure 5 – Age-specific survival of patients on the heart transplant waiting list*

Thus, one-year survival in patients with urgency status 1 on HT waiting list was 50.0 ± 20.4% (95% CI 22.5; 100%), with urgency status 2 – 50.0 ± 35.4% (95% CI 12.5; 100%), with urgency status 3 – 85.6 ± 6.90% (95% CI 73.1; 100%), with urgency status 4 – 93.5 ± 4.50% (95% CI 85.2; 100%), with urgency status 5 – 93.5 ± 3.90% (95% CI 85.6; 100%), and with urgency status 6 – 88.3 ± 2.00% (95% CI 84.5; 92.3%) (Fig. 6).

**DISCUSSION**

Despite advances in the treatment of heart failure, transplantation remains the only treatment option for patients with end-stage disease. Our study aimed to analyze survival among patients on the heart transplantation (HT) waiting list at our center. The results showed important aspects regarding mortality and predicting patient survival at this stage of treatment.

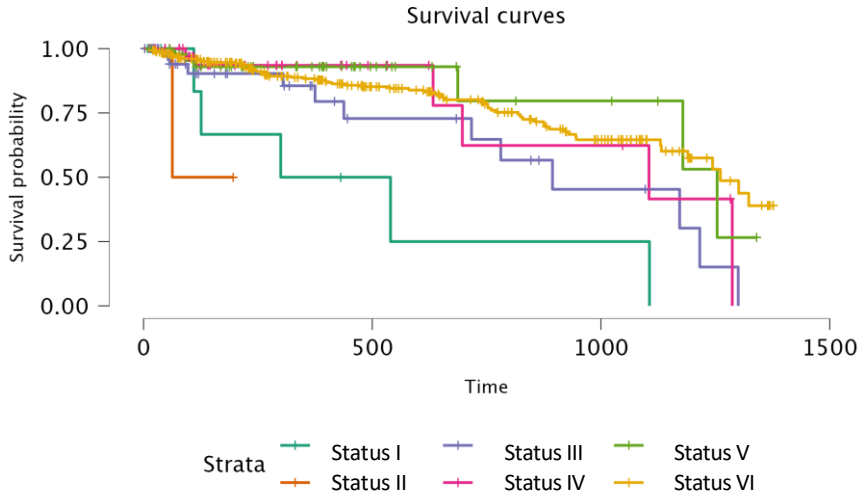


*Figure 6 – Survival of patients on the heart transplant waiting list depending on the urgency status*

Admission of a patient to the waiting list for heart transplantation means that he or she has a terminal stage of the disease and a high risk of mortality [7, 8]. According to our data, the mortality rate among patients on the waiting list was 21.1%.

Both European countries and the United States report shorter waiting times, but the number of patients on the waiting list is growing faster than the supply of donor organs [9]. Overall, we found that the average duration of stay on the heart transplant waiting list was 7.4 months. This indicator is consistent with data obtained in a study by Lund LH et al., who reported that the waiting time for a donor heart was 9.2 months [10].

In addition, we have identified a trend towards a decrease in the waiting time for a donor heart, which may indicate the active development and spread of the transplantation program in Ukraine. This is a positive signal that may be due to improved organizational processes, an increase in the number of donors, improved organ allocation criteria, and an increase in

the overall efficiency of the national transplantation system.

Analysis of the relationship between mortality and urgency status revealed a significant correlation between these parameters. Patients with the highest urgency status (1) had the highest mortality rate of 55.6%, which highlights the critical nature of their condition. These results are consistent with previously reported data indicating a higher mortality rate in patients with severe cardiac dysfunction requiring transplantation as soon as possible [11, 17].

An interesting finding was that patients with urgency status 6 had a higher mortality rate than patients with status 5 or 4, indicating more complex cases or the need for additional support methods such as ECMO or ventricular assist devices. This may also indicate the need to clarify the criteria for determining the urgency status in national practice.

Analysis of patient survival based on Kaplan–Meier curves demonstrated high rates of 1-year survival (88.0 ± 1.70%) and 2-year survival (77.0 ± 2.80%). The results obtained are consistent with other studies, according to which the 1-year and 5-year survival rates are 90% and 69%, respectively [12]. This confirms the critical role of timely transplantation and highlights the importance of continuous monitoring of patients on the waiting list for the timely identification of those requiring urgent intervention.

As for possible differences in outcomes among transplant centers, they have a multifactorial explanation. Thus, previous studies indicated differences in waiting times and mortality rates for patients on the waiting list and after transplantation [13, 14]. In addition, according to Grimm JC et al., there is a relationship between center size and survival on the HT waiting list [15, 16].

Our results showed no statistically significant gender- and age-related differences in survival between men and women, and between children and adults. This may indicate that the main factors in survival on the waiting list are not gender or age, but the severity of heart failure and the presence of associated complications.

Particular attention should be paid to significant results regarding urgency status. Patients with higher urgency status have significantly lower transplant-free survival, which highlights the need to develop effective strategies for improving access to transplants and mechanical circulatory support.

**CONCLUSIONS**

The survival rate of patients on the heart transplant waiting list remains high, but the mortality rate depends largely on the urgency status. The highest mortality rates were observed among patients with the highest level of urgency, which highlights the need for continuous monitoring and improvement of the criteria for assessing transplant urgency. The overall 1-year survival rate was 88.0%. The results obtained emphasize the importance of improving the donor organ distribution system and perioperative patient management to further reduce mortality and increase the effectiveness of heart transplantation.

## AUTHOR CONTRIBUTIONS

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N. Sikora – D
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## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest and no personal financial interest in performing the study and writing the paper.

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