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Melanoma incidence in 17,252 organ transplant recipients in Poland between 2010 and 2022

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Introduction. Numerous studies indicate an increased incidence of skin malignancies among organ transplant recipients. Melanoma pose a significant threat to post-transplant recipients, leading to considerable mortality. This study explores the incidence of melanoma after 17,252 organ transplantations in Poland over the past 13 years.

Materials and methods. The data on the occurrence of melanoma in patients after renal, heart, or liver transplantation were obtained from the National Health Fund, encompassing individuals who underwent kidney, heart, or liver transplantation between 2010 and 2022. The analysis focused on skin melanoma (C43).

Results. The study examined skin melanoma in renal (12,250 cases), liver (3,584 cases), and heart (1,418 cases) transplant recipients over a period of thirteen years. Melanoma incidence slightly increased in renal recipients (1-year cumulative incidence 0.016% *vs.* 0.007%, $p = 0.024$; 5-year cumulative incidence 0.131% *vs.* 0.040% $p < 0.001$; the 10-year cumulative incidence 0.213% *vs.* 0,09, $p < 0.001$). In liver transplant recipients there is a non-significant difference 1-year after transplantation (cumulative incidence 0.03% *vs.* 0.01%, $p = 0.337$) but after 5 and 10 years the difference between the two groups remains statistically significant (5-year cumulative incidence 0.14% *vs.* 0.04%, $p < 0.014$; the 10-year cumulative incidence 0.14% *vs.* 0.09%, $p < 0.001$). In heart transplant recipients, a paradoxical reduction in incidence was observed compared to the general population (1-year cumulative incidence 0% *vs.* 0.01%, $p = 0.317$; 5-year cumulative incidence 0.07% *vs.* 0.04%, $p = 0.049$; the 10-year cumulative incidence 0.07% *vs.* 0.09, $p < 0.001$).

Conclusions. The incidence of melanoma increases in kidney transplant recipients over the first 10 years post-transplant, with a peak between 4 to 7 years. For heart and liver transplant recipients, melanoma cases occur within the initial 5 years post-transplant, and no new cases were recorded afterward. The long-term surviving kidney, heart, and liver transplant recipients show a steady rise in new cases over time. Our study, based on a thorough analysis of data from the National Health Fund, confirms the link between an elevated risk of melanoma in organ transplant recipients.

Key words: skin cancer, melanoma, transplant recipients, transplantation

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Introduction

In 2023, according to the National Health Fund, a total 1,910 organ transplants were performed in Poland, including 1,055 kidney transplants, 550 liver transplants, and 178 heart transplants, marking an unprecedented achievement in the country's medical history [1]. This notable increase surpassed previous numbers, such as 1,608 organ transplants in 2012 [2]. The global prevalence of organ transplants has been steadily rising, reaching hundreds of thousands annually.

Organ transplantation, hailed as the sole long-term curative treatment for end-stage renal, heart, or liver disease, introduces complex lifelong therapy for recipients. The lifelong immunosuppressive treatment necessary for adequate graft function makes recipients susceptible to various diseases, prominently increasing the risk of cancer. Melanoma, though comprising only 4% of cutaneous malignancies, contributes to 80% of skin cancer deaths in the general population, underscoring its significance among both transplant and non-transplant individuals [3].

The results of available studies show that transplant recipients face a 1,5- to 8-fold increased risk of melanoma compared to the general population, depending on the studied population [4–6], but the risk of developing melanoma consistently increases in all presented data over the time since transplantation.

Data from different European studies also show significant diversity in the risk of neoplasia despite a similar geographical latitude, indicating additional risk factors for the occurrence of cancer, such as genetic predispositions, the influence of applied treatment, or the frequency of human papillomavirus (HPV) infection [7, 8]. Unfortunately, despite numerous works, there is a lack of epidemiological studies based on a large number of patients, especially regarding the frequency of melanoma, which would help in a precise assessment of the real risk of skin cancer in the transplant recipient group.

This report explores the incidence of melanoma after organ transplantation in Poland over the past 13 years (2010–2022), providing insights into the challenges and risks encountered by transplant recipients. This is the largest analysis performed on that particular subject in Poland so far. The study is based on a National Health Fund dataset (public health insurance governmental agency), which provides the most accurate information on actual health incidents for all Polish citizens.

Materials and methods

The data on the occurrence of melanoma in patients after renal, heart, or liver transplantation were obtained from the National Health Fund. The dataset includes patients who underwent renal, heart, or liver transplantation between 2010 and 2022, and it was used to identify a cohort of patients with a diagnosis of melanoma based on any inpatient or outpatient claim associated with an International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) code for melanoma (C43.0–C43.9).

The information is presented through distinct sets of diagrams, illustrating melanoma (C43) in recipients of the most commonly transplanted organs in Poland – specifically, in renal transplant recipients, liver transplant recipients, and heart transplant recipients. Exclusion criteria included a history of previous organ transplantation and transplantation of more than one of the mentioned organs. Differences in the occurrence of melanoma skin cancer are presented in the diagrams. It is important to note that diagrams related to each specific patient group use a consistent percentage scale for uniform data presentation. To investigate the association between two categorical variables, analytical methods, including Fisher's exact test and the two-sample test for equality of proportions (applied without a continuity correction) were employed. An alpha level ($\alpha = 0.05$) was chosen as the criterion for determining statistical significance. Analyses were conducted using the R Statistical language (version 4.3.1; R Core Team, 2023) on Windows 10 Pro 64 (build 19045).

Based on data obtained from the National Health Fund, we calculated the cumulative incidence rate of melanoma, coded as C43, among organ transplant (Tx) recipients compared to a control population over a 1-, 5-, and 10-year follow-up period. The dataset for this time frame (between 2010 and 2020) was created using information acquired from the National Cancer Registry [9].

Results

The cumulative incidence rate of melanoma, coded as C43, among renal transplant (Tx) recipients compared to a control population over a 1-, 5-, and 10-year follow-up period provided an insightful perspective into the risk stratification associated with this malignancy post-transplantation.

Renal Tx recipients vs. *control population*

The analysis covered 12,250 renal transplant recipients (2010–2022), examining the risk of melanoma skin cancer. The histogram (fig. 1) displays the percentage of melanoma cases among living renal transplant recipients. A slight increase is observed in the fourth to seventh years (0.04% and 0.07%, respectively), followed by a decrease in subsequent years. No cases are reported after the tenth year.

Table I presented the cumulative incidence rates of melanoma (C43) in patients post renal Tx as opposed to a control population over 1-, 5-, and 10-year intervals, allowing for a comparative oncological risk assessment. The observed trend in table I suggests that renal transplant recipients exhibited a higher cumulative incidence of melanoma skin cancer over time when compared to the general population. This elevated risk could be attributed to the immunosuppressive regimens required to maintain graft function, which can reduce the efficacy of the immune system to detect and eliminate malignant

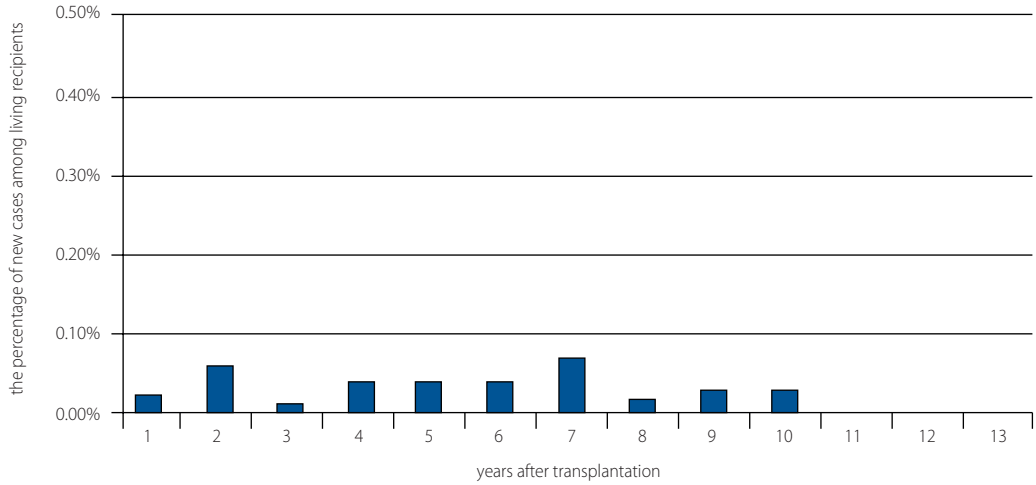

Figure 1. Melanoma in renal transplant recipients

Table I. Cumulative incidence rate of melanoma (C43) over time in patients with renal Tx and control population

Follow-up	Stratification by Tx		p value[b]
	yes[a] N_1 = 12,205	no[a] N_2 = 37.75 mln	
1 yr.	2 (0.02%)	2,660 (0.01%)	0.024
5 yr.	16 (0.13%)	15,092 (0.04%)	<0.001
10 yr.	26 (0.21%)	34,313 (0.09%)	<0.001

N – population size; n – incidence rate of melanoma; [a] – n (%); [b] – two-sample test for equality of proportions

cells. The significantly higher incidence rates in the renal transplant recipients highlighted the interplay between immunosuppression and carcinogenesis.

In the immediate 1-year follow-up, the incidence of melanoma in the renal transplant cohort was 0.016% (2 cases *per* 12,205 patients), which was statistically higher (p = 0.024) than the 0.007% (2,660 cases *per* 37.75 million) observed in the general population. The 5-year cumulative incidence notably increased in the transplant recipients to 0.131% (16 cases *per* 12,205 patients), with a further amplified contrast to the control population's 0.040% (1,592 cases *per* 37.75 million), a difference that was highly significant (p < 0.001). At 10-year, the incidence in the transplant group further escalated to 0.213% (26 cases *per* 12,205 patients), while the control population incidence was 0.091% (34,313 cases *per* 37.75 million), again with a statistically significant difference (p < 0.001).

Liver Tx recipients vs. *control population*

The analysis encompassed 3,584 liver transplant recipients, investigating the risk of melanoma skin cancer. The histogram (fig. 2) illustrates the percentage of melanoma cases among living liver transplant recipients at different intervals post-transplant. The data reveals fluctuations, reaching a peak of 0.12% in the third year, while the other years have either minimal or zero reported cases. Notably, no cases are documented

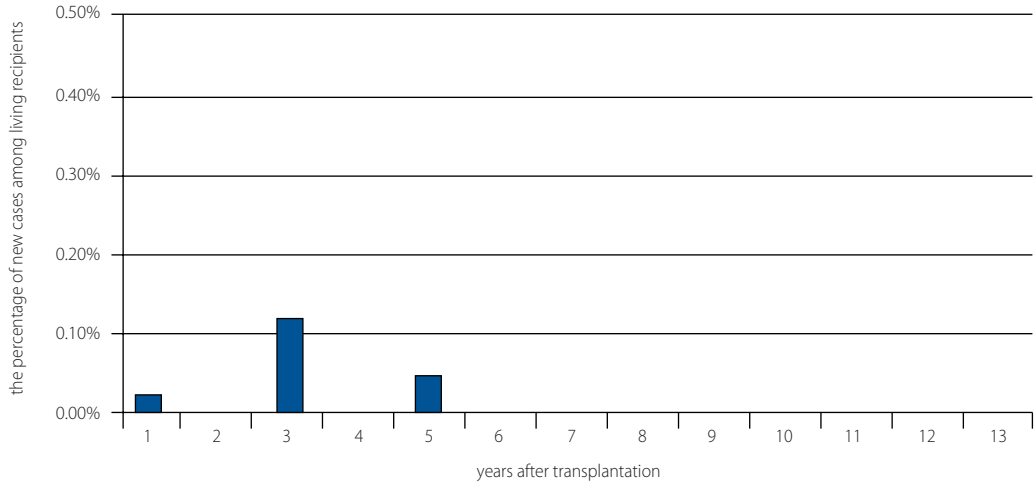

Figure 2. Melanoma in liver transplant recipients

Table II. Cumulative incidence rate of melanoma (C43) over time in patients with liver Tx and control population

Follow-up	Stratification by Tx		p value[b]
	yes[a], N_1 = 3,584	no[a], N_2 = 37.75 mln	
1 yr.	1 (0.03%)	2,660 (0.01%)	0.337[c]
5 yr.	5 (0.14%)	15,092 (0.04%)	0.014
10 yr.	5 (0.14%)	34,313 (0.09%)	<0.001

N – population size; n – incidence rate of melanoma; [a] – n (%); [b] – two-sample test for equality of proportions; [c] – Fisher's exact test

from the fourth to the thirteenth-year post-transplant. This data effectively portrays the patterns in melanoma incidence among liver transplant recipients over a thirteen-year period.

Table II presented the cumulative incidence rates of melanoma (C43) in patients post liver Tx as opposed to a control population over 1-, 5-, and 10-year intervals, allowing for a comparative oncological risk assessment.

In the 1-year follow-up, there was a single case of melanoma (0.028%) among the 12,205 liver Tx patients, compared to a 0.007% incidence (2,660 cases) within the control population of 37.75 million. The p value of 0.337 indicated no significant difference in the melanoma incidence rate between the liver Tx cohort and the general population at this interval. At the 5-year milestone, the cumulative incidence in liver Tx patients slightly increased to 0.140% (5 cases out of 12,205 patients), which was statistically higher than the control group's 0.040% incidence (1,592 cases out of 37.75 million), with a p-value of 0.014. By the 10-year follow-up, the incidence rate remained at 0.140% (5 cases *per* 12,205 patients) in the liver Tx group, which is intriguing as it did not increase from the 5-year mark. In contrast, the control group's incidence raised to 0.091% (34,313 cases *per* 37.75 million), with the difference between the two groups remaining statistically significant ($p < 0.001$).

Heart Tx recipients vs. *control population*

The assessment of non-melanoma skin cancer risk involved 1,418 heart transplant recipients. During the initial three years post-transplant, no new cases of melanoma were reported. However, in the fourth year post-transplant, a slight increase in the percentage of cases was observed, reaching 0.16%. From the fifth to the thirteenth year, no new cases were recorded. This histogram (fig. 3) depicts a minimal percentage of melanoma cases among the population of heart transplant recipients in the years following the procedure. Table III delineated the cumulative incidence rate of melanoma (C43) in heart Tx recipients compared with a control population over a 1-, 5-, and 10-year follow-up period.

At 1-year, there were no reported cases of melanoma (0%) among the 1,408 heart Tx recipients, in contrast to the control population's 0.007% incidence (2,660 cases out of 37.75 million). The $p = 0.317$ indicated no statistically significant difference between the groups, which could be due to the relatively short period post-transplantation, not allowing sufficient time for melanoma development or detection. By the 5-year follow-up, the cumulative incidence of melanoma in heart Tx patients was recorded at 0.071% (1 case out of 1,408 patients), which was statistically higher than the control group's incidence of 0.040% (1,592 cases out of 37.75 million), with a p-value of 0.049. The 10-year data revealed the incidence in the heart Tx cohort remained at 0.071% (1 case *per* 1,408 patients), without an increase from the 5-year incidence. This was in contrast to the control population's incidence, which rose to 0.091% (34,313 cases per 37.75 million), with the difference between the groups remaining statistically significant ($p = 0.001$), this time higher in the control group.

Discussion

Melanoma after organ transplantation results in substantial mortality [10, 11]. Several studies have examined the risk of skin melanoma after transplantation, demonstrating a broad

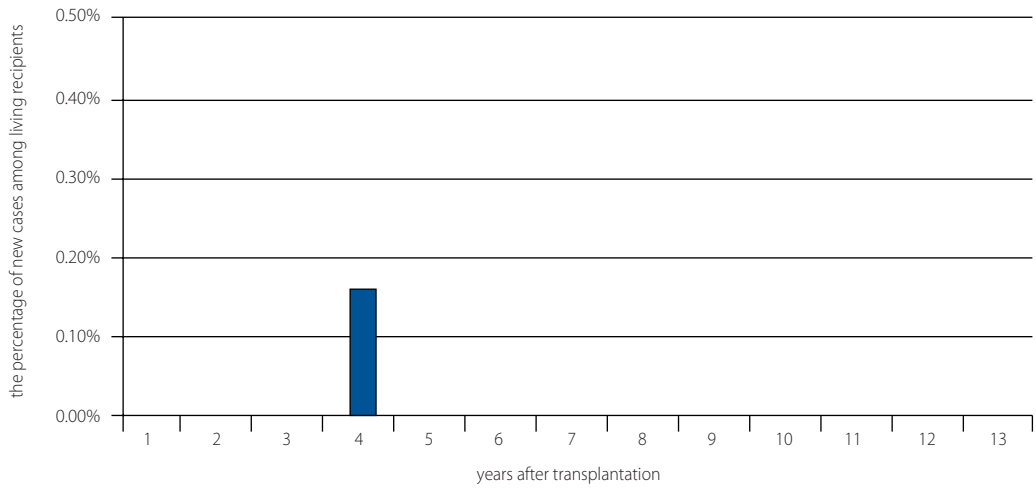

Figure 3. Melanoma in heart transplant recipients

Table III. Cumulative incidence rate of melanoma (C43) over time in patients with heart Tx and control population

Follow-up	Stratification by Tx		p value[b]
	yes[a], N_1 = 1408	no[a], N_2 = 37.75 mln	
1 yr.	0 (0%)	2,660 (0.01%)	0.317[c]
5 yr.	1 (0.07%)	15,092 (0.040%)	0.049
10 yr.	1 (0.07%)	34,313 (0.09%)	0.001

N – population size; n – incidence rate of melanoma; [a] – n (%); [b] – two-sample test for equality of proportions; [c] – Fisher's exact test

and diversified range of the presented increase in the risk of incidence. This raises many questions regarding the scale of this phenomenon in Poland. Studies available for the Polish population describe individual cases conducted on a small group of individuals, or pertain to past times when immunosuppressive treatment often differed from the currently used protocols [4, 12–15].

Our study aimed to reanalyze the potential connection between organ transplant recipients in Poland and the prevalence of melanoma. The authors conducted an analysis of data from the National Health Fund, revealing the occurrence of melanoma in the three most common groups on life-long immunosuppressive therapy:

- renal transplant recipients,
- liver transplant recipients, and
- heart transplant recipients.

Cases of melanoma were recorded only within the first 10 years after renal transplantation, and the cumulative risk of developing melanoma in this period was 0.21%, while the population incidence in this range of time, according to data from the National Cancer Registry, was 0.09%. This suggested a sustained and growing divergence in the risk profile for melanoma between the two groups, possibly attributable to chronic immunosuppressive therapy, which although facilitating survival may contribute to the accumulation of oncogenic mutations and the growth of malignant cells by limiting the body's natural antitumor immune responses.

Melanoma cases in liver transplant recipients were reported only in the first 5 years (cumulative risk 0.14%). This statistically significant difference suggests the potential impact of the post-transplant condition, including the immunosuppressive therapy necessary to prevent liver graft rejection, on the risk of developing melanoma. By the 10-year follow-up, the incidence rate remained at the same level, which is intriguing as it did not increase from the 5-year mark. The stable incidence rate in the liver Tx cohort over the 5 to 10-year period might suggest a plateau effect in the risk of melanoma post-transplant, indicating that the highest risk period may be within the first five years post-transplant. These findings suggest that liver Tx patients have an increased cumulative incidence of melanoma when compared to the general population, particularly evident beyond the 1-year post-transplant period, likely influenced by immunomodulatory effects of long-term immunosuppression, which may reduce immunosurveillance, and allow for the development and progression of melanoma.

Heart transplant recipients in Poland also received a melanoma diagnosis only within 5 years of organ transplantation, but not significantly (cumulative risk 0.07% *vs.* 0.04% in the control group). At 1-year, there were no reported cases of melanoma which could be due to the relatively short period post-transplantation, not allowing sufficient time for melanoma development or detection. The stabilization of melanoma incidence in the heart Tx group from 5 to 10 years might suggest that the period of highest vulnerability to melanoma in heart transplant recipients was within the first five years following transplantation. The analytical interpretation of this data suggests an epidemiological anomaly where the expected increased risk of melanoma in an immunocompromised cohort, such as heart Tx recipients, was not observed over the long term. Instead, a paradoxical reduction in incidence was noted when compared to the general population.

Our study has several important limitations. Firstly, the detailed data of our interest in the National Health Fund database are only available from 2010 on. Moreover, there is a potential for overdiagnosis (i.e. "overreporting" C43 by general practitioners at referral without proper histopathological diagnosis), which we attempted to mitigate by considering only hospital and clinical data concerning the diagnoses (i.e. we excluded ICD codes entered at primary care units). To further clarify the available dataset, we also compared the obtained number of patients with those in the PolTransplant database. Datasets largely overlap (between 2010 and 2020, 42,756 diagnoses of C43 were established based on National Health Fund data, and respectively, 37,585 based on the National Cancer Registry report [15]). Despite the above, the strength of our report lies in its scrupulous analysis of available data, strict inclusion criteria, and integrating them to create a clinically important consensus.

To the best of our knowledge, the study is the first analysis of such a large population of organ transplant recipients in our country and in Europe, with data sourced from one of the most reliable medical information repositories run by a public governmental agency concerning transplant recipients in Poland.

As the data elucidates, organ transplantation and the associated life-long changes for the patient (like immunosuppression) bring not only benefits, but is also associated with a greater risk of melanoma prevalence, however, it is not as high as previously believed. In our opinion it is obligatory to inform patients and educate them in self-examination techniques, while also encouraging them to undergo frequent follow-up visits for skin lesion control within the first few years post-transplant. Guidelines recommend that transplant recipients should

be screened for skin cancer at least twice a year from five years post-transplantation [16–18]. We hope that the presented results will allow for a real assessment of the risk of developing melanoma in our country, and contribute to standardizing screening practices in this group of patients, offering valuable insights for medical professionals and researchers.

Conclusions

The incidence of melanoma has been observed to increase among renal transplant recipients over the first 10 years post-transplant, with a peak in cases occurring between 4 and 7 years after transplantation. In heart and liver transplant recipients, cases of melanoma are reported within the first 5 years post-transplant, and no new cases have been recorded after this period. The 10-year cumulative melanoma incidence slightly increased in renal recipients (0.213% *vs*. 0.09, $p < 0.001$) and in liver transplant recipients (0.14% *vs*. 0.09%, $p < 0.001$) as opposed to the general population of Poland.

After a thorough analysis of data obtained from the National Health Fund in Poland, our study confirms that melanoma risk increased in the group of renal and liver recipients, but there is no association between melanoma occurrence and heart transplantation. The melanoma risk increase in renal, liver, and heart transplant recipients, although statistically significant, is lower than was believed before the study. The authors particularly emphasize the value of monitoring transplant recipients for skin melanoma, with special attention paid to patients living over 5 years with a transplanted organ.

Article information and declarations

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Ethics statement

No ethical issues or concerns were applicable to this research.

Author contributions

Aleksandra Kulbat – conceptualization, data curation, project administration, resources, software, validation, visualization, writing – original draft preparation, writing – review and editing.

Karolina Richter – visualization, writing – original draft preparation.

Marta Krzysztofik – writing – original draft preparation.

Krzysztof Batko – writing – original draft preparation, formal analysis, validation.

Aleksandra Karwańska – writing – original draft preparation.

Marta Kołodziej-Rzepa – writing – review and editing, supervision.

Tomasz Wojewoda – writing – review and editing, supervision.

Wojciech M. Wysocki – conceptualization, writing – funding acquisition, original draft preparation, writing – review and editing, supervision.

Conflict of interest

None declared

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