Tidsskriftet Tidsskrift for Den norske legeforening

Heart transplantation in Norway 1983–2023

ORIGINAL ARTICLE

ARNE K. ANDREASSEN

aandreas@ous-hf.no
Department of Cardiology
Oslo University Hospital, Rikshospitalet
Author contribution: concept, design, collection and analysis of data, literature search, drafting of manuscript and approval of submitted version
Arne K. Andreassen MD, PhD, specialist in cardiology, senior consultant and medical director for heart transplantation
The author has completed the ICMJE form and declares no conflicts of interest.

JOHANNES L. BJØRNSTAD

Department of Cardiothoracic Surgery
Oslo University Hospital, Rikshospitalet
and
Institute of Clinical Medicine
University of Oslo
Author contribution: design, collection and analysis of data, drafting of manuscript and approval of submitted version
Johannes L. Bjørnstad PhD, specialist in cardiothoracic surgery, senior consultant and associate professor
The author has completed the ICMJE form and declares no conflicts of interest.

EINAR GUDE

Department of Cardiology
Oslo University Hospital, Rikshospitalet
Author contribution: design, collection and analysis of data, drafting of manuscript and approval of submitted version

Einar Gude PhD, specialist in cardiology, senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

TOM N. HOEL

Department of Cardiothoracic Surgery
Oslo University Hospital, Rikshospitalet
Author contribution: design, data collection, drafting of manuscript and approval of submitted version
Tom N. Hoel MD, PhD, specialist in cardiothoracic surgery, senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

KASPAR BROCH

Department of Cardiology
Oslo University Hospital, Rikshospitalet
Author contribution: design, collection and analysis of data, drafting of manuscript and approval of submitted version
Kaspar Broch PhD, specialist in cardiology, senior consultant
The author has completed the ICMJE form and declares the following conflicts of interest: employer has received funding from AstraZeneca for participation in the DAPARHT study, from Amgen for the EVOLVD study, and from Novartis for the SCHEDULE study. He has received speaker fees from AstraZeneca, Bayer, Boehringer, Novo Nordisk, Novartis, Pfizer and Pharmacosmos, and has served on advisory boards for Bayer, Pharmacosmos and Novo Nordisk.

HÅVARD RAVNESTAD

Department of Cardiology
Oslo University Hospital, Rikshospitalet
Author contribution: design, collection and analysis of data, drafting of manuscript and approval of submitted version
Håvard Ravnestad, specialist in cardiology, senior consultant
The author has completed the ICMJE form and declares no conflicts of interest.

ODD R. GEIRAN

Department of Cardiothoracic Surgery
Oslo University Hospital, Rikshospitalet
Author contribution: concept, design, collection and analysis of data, drafting of manuscript and approval of submitted version
Odd R. Geiran MD, PhD, specialist in cardiothoracic surgery, professor emeritus

The author has completed the ICMJE form and declares no conflicts of interest.

ARNT E. FIANE

Department of Cardiothoracic SurgeryOslo University Hospital, Rikshospitalet
and
Institute of Clinical Medicine
University of Oslo
Author contribution: concept, design, collection and analysis of data, drafting of manuscript and approval of submitted version
Arnt E. Fiane MD, PhD, specialist in cardiothoracic surgery, senior consultant, head of department and professor
The author has completed the ICMJE form and declares no conflicts of interest.

Background

November 2023 marked 40 years since heart transplantation was introduced as a treatment option for advanced heart failure in Norway. International registry data show a median post-transplant survival of slightly more than 11 years, with most centres performing 10–19 transplants annually. The aim of this study was to provide an overview of outcomes following heart transplantation in Norway.

Material and method

The study is a retrospective observational analysis of heart transplant recipients at Oslo University Hospital, Rikshospitalet, in the period 6 November 1983 to 31 December 2023. The focus is on patient and donor characteristics, survival and complications.

Results

Between 6 November 1983 and 31 December 2005, a median of 24 (interquartile range: 21–27) heart transplants were performed annually, compared with 32 (29–35) between 1 January 2006 and 31 December 2023. Among 1078 first-time transplant recipients, median survival was 13.4 years (95 % confidence interval (CI): 12.7–14.4). Median survival was 11.0 years (95 % CI: 9.3–12.9) for patients transplanted between 6 November 1983 and 31 December 1993; 13.1 years (95 % CI: 11.7–15.4) for those transplanted between 1 January 1994 and 31 December 2003; and 14.8 years (95 % CI: 13.5–16.8) for patients transplanted between 1 January 2004 and 31 December 2013. This was despite increasing donor age and a high proportion of recipients requiring intensive care or receiving mechanical circulatory support immediately prior to transplantation. Survival was highest among patients without ischemic heart failure. Various types of cancer, along with

chronic/progressive graft failure (myocardial infarction, sudden death in the context of known graft vasculopathy/coronary disease/fibrosis), were the most common causes of death.

Interpretation

A steady improvement has been observed in survival following heart transplantation in Norway. Rikshospitalet's heart transplant activity is among the highest in the world, and its outcomes are comparable to the leading international centres.

Main findings

In the period 1983–2005, a median of 24 heart transplants were performed annually, compared to 32 in the period 2006–2023.

Median survival was 11.0, 13.1 and 14.8 years for patients transplanted in the periods 1983–93, 1994–2003 and 2004–13, respectively.

Median survival for the entire 40-year period was 13.4 years.

The leading causes of death were various types of cancer (23 %) and chronic/progressive graft failure (20 %).

After Christiaan Barnard performed the first human heart transplant in Cape Town in 1967, the following years were marked by poor outcomes. Organ rejection and complicating infections often limited survival times to just days or weeks, and several centres discontinued their transplantation programme. However, Norman Shumway's team at Stanford University in California continued their programme, and by 1982 had performed over 300 transplants. Following the introduction of morphological rejection diagnostics and cyclosporin A as an immunosuppressive agent in 1980, Shumway's team reported a two-year survival rate of 80 %.

The medical community at Rikshospitalet closely followed the results from Stanford and believed this was a treatment option that should be introduced in Norway. A project group concluded that the Stanford protocol should be adopted. The first heart transplant in the Nordic countries was thus performed at Rikshospitalet on 5–6 November 1983 (1). The recipient enjoyed a good quality of life and lived for another 33 years.

Today, heart transplantation is the preferred treatment option for selected patients with end-stage heart failure. In a previous edition of the Journal of the Norwegian Medical Association, we described our experiences with 522 transplanted patients up to 2005 (2). At that time, the average age at transplantation was 48.8 years, and coronary artery disease was the most common cause of heart failure. One-year survival was 85 %, and half of the patients were still alive after 11.8 years. The leading causes of death were graft failure due to coronary artery disease and cancer.

Changes in practice over the past 15–20 years include advances in perioperative care, increased use of various forms of mechanical circulatory support, broadened age criteria for donors and recipients, acceptance of donors previously considered unsuitable, and the introduction of new immunosuppressive medications. The aim of this study was to evaluate 40 years of heart transplantation. We also sought to examine whether newer practices have impacted on survival and causes of death in the period 2006–2023 compared to 1983–2005 (2).

Material and method

We conducted a retrospective observational study of all patients who underwent heart transplantation in Norway at Rikshospitalet between 6 November 1983 and 31 December 2023. Initial local evaluation of heart failure was completed at Rikshospitalet in all cases. All patients underwent orthotopic transplantation (i.e. the graft was implanted in the original anatomical position of the diseased organ).

Variables registered included age, gender, underlying condition, post-transplant survival and cause of death, all obtained from the Norwegian LVAD and Heart and Lung Transplant Registry. Data on deaths while on the waiting list were obtained from Scandiatransplant. Post-transplant deaths were assessed based on received reports and discharge summaries, including from local hospitals, primary care doctors and nursing homes, and were reviewed alongside clinical information in the medical records from the last visit, admission or contact with Rikshospitalet.

Statistical analyses

The results are presented as absolute numbers (with percentages in parentheses) and median values (with interquartile range as the measure of dispersion). Survival is reported as percentages (with 95 % confidence intervals in parentheses) or as median survival in years (with 95 % confidence intervals in parentheses). The Kaplan-Meier method was used to calculate survival from the first heart transplant in Norway, with the censoring date set at 15 December 2023. Groups were compared using the log-rank test, and a trend test was used for the time periods. Analyses were performed using RStudio (Posit Software, Boston, MA, USA). The 'survival' package was used for survival analyses. The 'cmprsk' package, based on the methods described by Fine and Gray (3), was used to present causes of death as competing events, with retransplantation also included as an event.

Ethics

The registry was approved by the data protection officer at Oslo University Hospital and by the Regional Committees for Medical and Health Research Ethics (REK) in South-Eastern Norway (reference: 886245).

Results

In the period 6 November 1983 to 31 December 2023, a total of 1105 heart transplants were performed on 1080 patients in Norway. Of these, 1078 were first-time transplant patients, while two patients had originally been transplanted abroad. Among the 1078 first-time recipients, 988 (92 %) were adults and 90 were children (<18 years). A total of 260 out of 1080 heart transplant patients (24 %) were women. The age at first transplantation was similar in the two time periods: 52 years (44–58) and 53 years (34–60) in the period 6 November 1983–31 December 2005, and after 1 January 2006, respectively. During the same periods, the median number of transplants performed per year was 24 (21–27) and 32 (29–35), respectively (Figure 1). In 2023, this corresponded to 5.8 heart transplants per million inhabitants in Norway. Twenty-seven patients underwent retransplantation, including two whose first transplant was performed abroad. Combined transplantation of heart and liver, heart and kidney, and heart and lung was performed in 2, 9 and 27 patients, respectively.

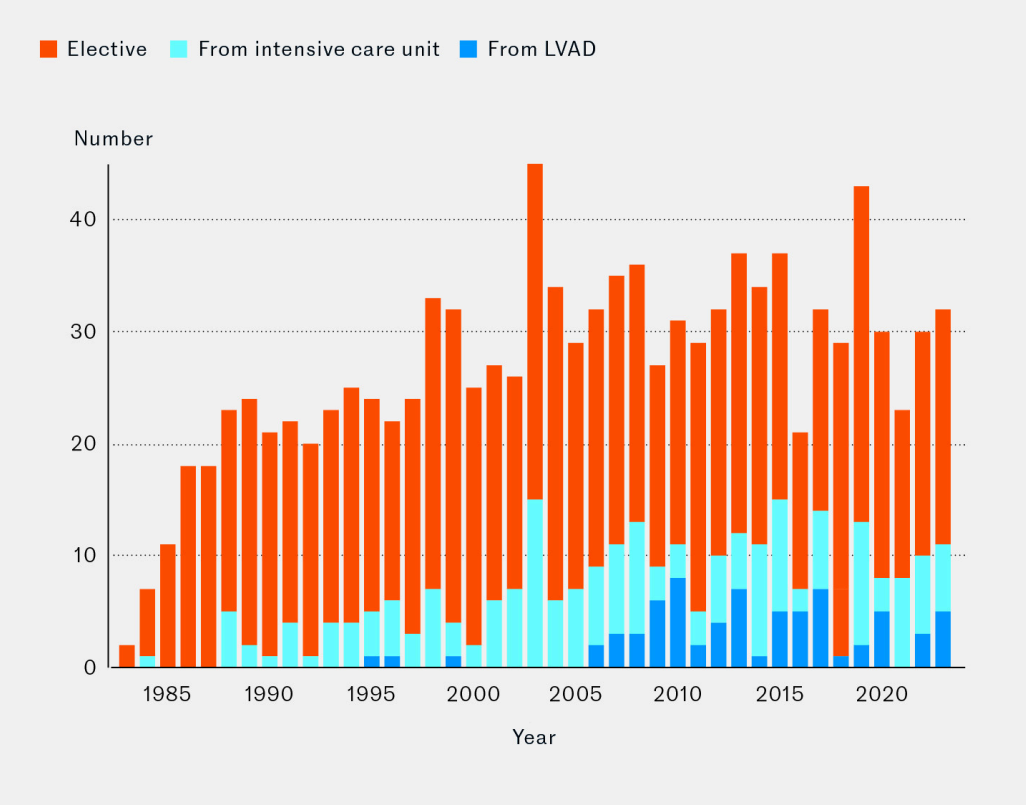
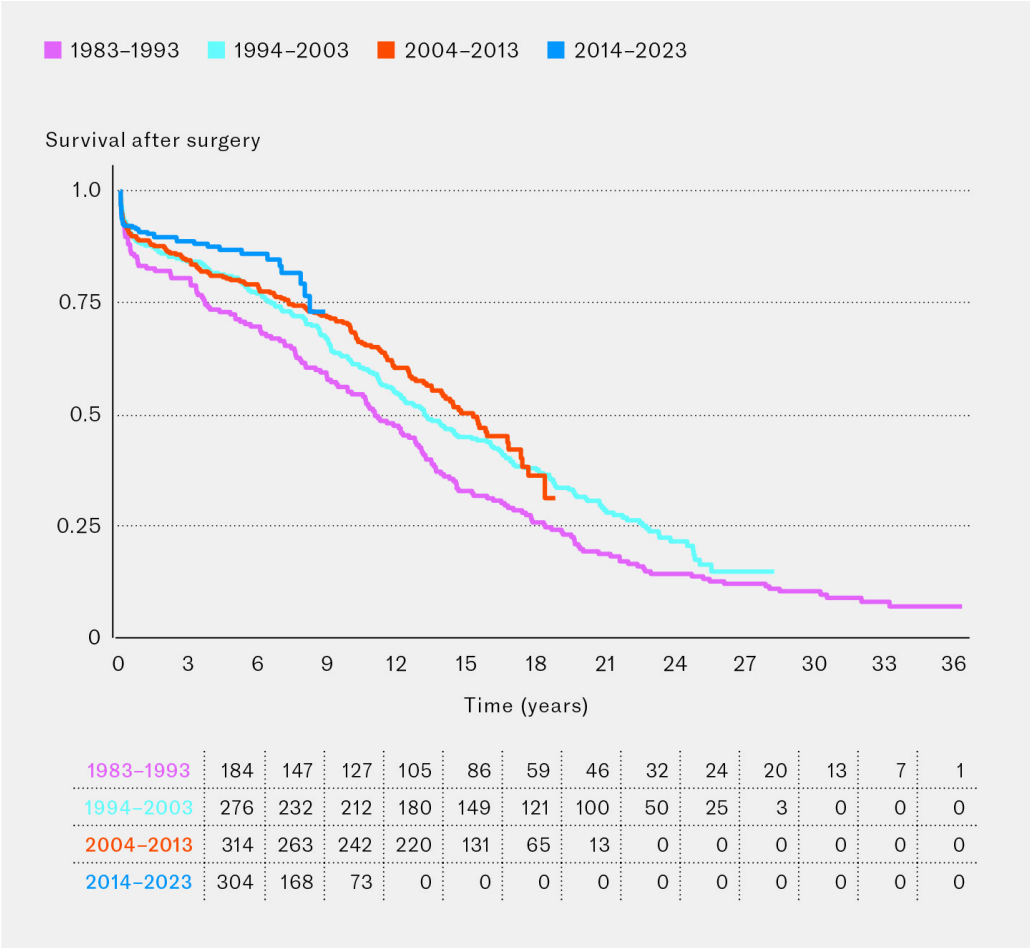


Figure 1 Number of heart transplants per year from 6 November 1983 to 31 December 2023. The bars also indicate whether the transplants were performed electively, directly from the intensive care unit, or from an implanted mechanical pump (LVAD).

The most common cause of heart failure in first-time heart transplant recipients was cardiomyopathy (447/1078; 41 %), while ischemic heart disease (415/1078; 38 %) represented the second largest group of underlying diagnoses (Table 1).

The proportion of recipients transplanted while receiving mechanical or pharmacological circulatory support (primarily including vasodilators, inotropic agents and antiarrhythmic medications) increased steadily after 2005 (Figure 1). Until 2005, a total of three patients with a left ventricular assist device (LVAD) had been transplanted. In 2023, five patients were transplanted from an LVAD, and the median annual usage from 2006 onward was 2 (range 0–5).

Median survival for the entire period was 13.4 years (95 % CI 12.7 to 14.4). One-year survival was 88 % (95 % CI 86 to 90), and five-year survival was 80 % (95 % CI 77 to 82). There was no gender gap in survival rates (p = 0.14, log-rank test). Survival over the 40-year period, distributed over four decades, is shown in Figure 2. There was significantly (p = 0.039, log-rank test for trend) better survival in the three most recent decades compared to the period 6 November 1983 to 31 December 1993. Median survival per decade was 11.0 years (95 % CI 9.3 to 12.9), 13.1 years (95 % CI 11.7 to 15.4) and 14.8 years (95 % CI 13.5 to 16.8) for the periods 6 November 1983–31 December 1993; 1 January 1994–31 December 2003; and 1 January 2004–31 December 2013, respectively. The observation period was too short to report median survival for 1 January 2014–31 December 2023.



1983–1993	184	147	127	105	86	59	46	32	24	20	13	7	1
1994–2003	276	232	212	180	149	121	100	50	25	3	0	0	0
2004–2013	314	263	242	220	131	65	13	0	0	0	0	0	0
2014–2023	304	168	73	0	0	0	0	0	0	0	0	0	0

Figure 2 Survival after heart transplantation in the period 6 November 1983 to 31 December 2023, distributed by decade. Survival had significantly improved in the three most recent decades compared to the period 1983–93 (p = 0.039, log-rank test with test for trend). Benjamini–Hochberg-adjusted log-rank p-values were 0.03, 0.003 and 0.003, respectively.

The improvement in survival was most pronounced after the first year, while early postoperative mortality remained at 5–10 %. Underlying diagnoses and comorbidities affected post-transplant prognosis, with significant differences in survival between patients with underlying cardiomyopathy, congenital heart disease/valvular disease/other, and ischemic heart disease (Figure 3). At the end of the observation period on 31 December 2023, 505 heart transplant recipients were still alive, while 575 had died. Various types of cancer (*n* = 132/575, 23 %) were the most common cause of death among patients who survived more than three months after transplantation, followed by cardiac causes (*n* = 113/575, 20 %) such as myocardial infarction and sudden death/unknown cause. Infection was also a notable cause of death (*n* = 64/575, 11 %). Acute rejection and primary graft failure (*n* = 64/575, 11 %) were the leading causes of death during the first three months postoperatively (Figure 4).

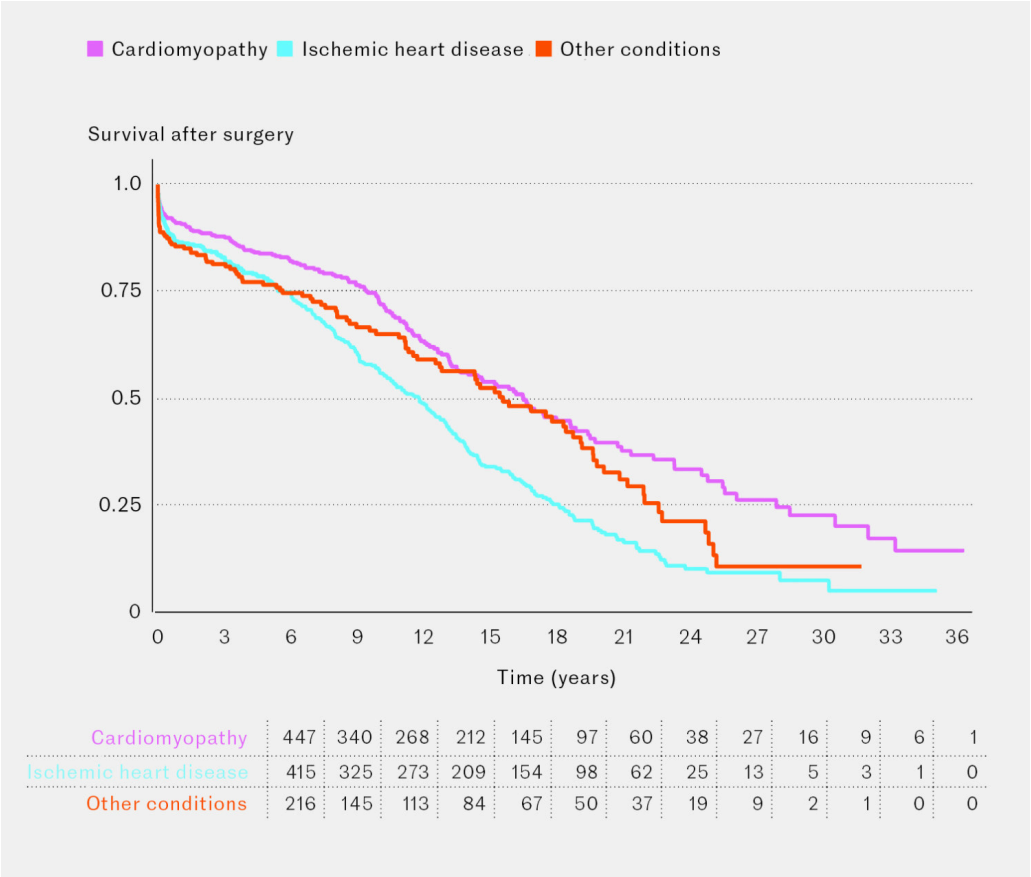


Figure 3 Survival after heart transplantation in the period 6 November 1983 to 31 December 2023, distributed by underlying condition. Underlying diagnoses impacted on post-transplant survival, with significant differences ($p < 0.001$, log-rank test) between patients transplanted due to cardiomyopathy, ischemic disease and congenital heart disease/valvular disease/other. Benjamini–Hochberg-adjusted log-rank p-values were < 0.001 for 'cardiomyopathy' versus 'ischemic heart disease'; 0.034 for 'cardiomyopathy' versus 'other'; and 0.013 for 'other' versus 'ischemic heart disease'.

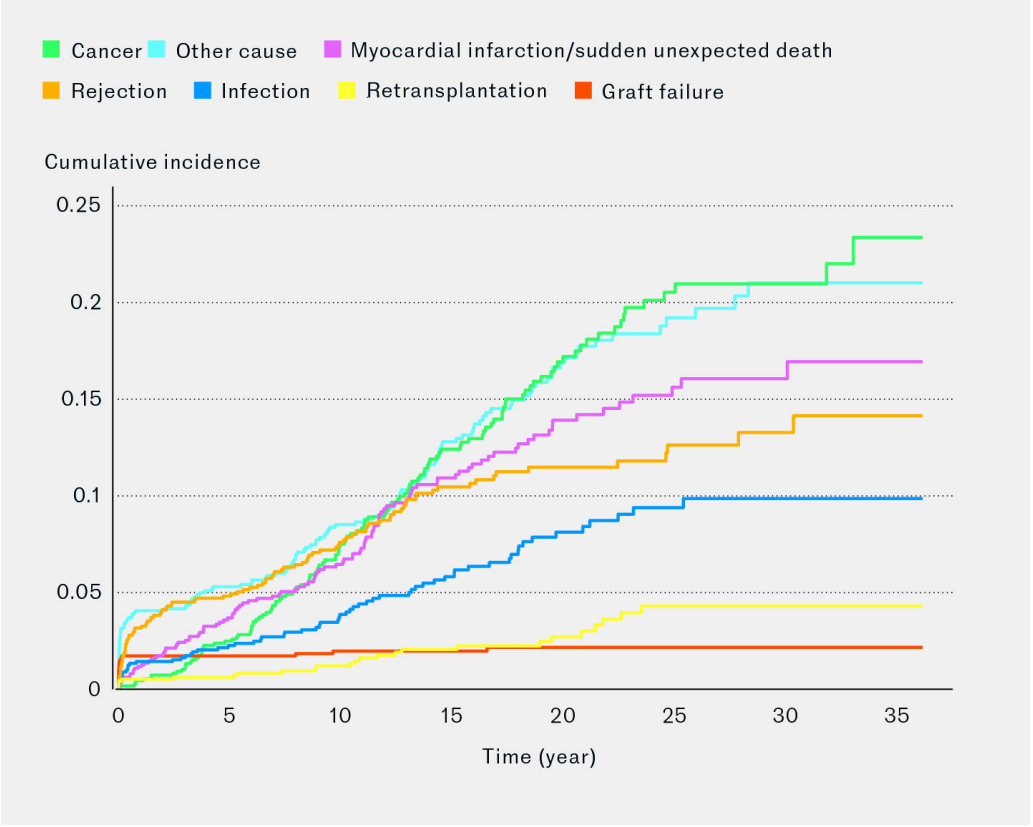


Figure 4 Cumulative incidence of causes of death or re-transplantation among heart transplant recipients during the period 6 November 1983 to 31 December 2023. This presentation illustrates the timing of when the various causes of death occur.

Donors in Norway were used in 931 of 1105 (84 %) transplants. A total of 164 of 1105 (15 %) grafts were obtained through the exchange agreement with Scandiatransplant, while 10 of 1105 (1 %) were from other European countries. The median age of donors was 33 years (range 21–44) up to 2005, and 39 years (range 25–51) in the period 2006–23. Blood types were: 47 % A, 7 % B, 1 % AB, and 45 % O; median height was 175 cm (range 170–182) and median weight 76 kg (range 67–85). The cause of donor death was brain haemorrhage or other cerebrovascular catastrophe in 456 of 1105 cases (41 %) and head trauma in 423 of 1105 cases (38 %). Other causes of death included other space-occupying brain lesions (e.g. oedema due to meningitis) and anoxia from other causes (e.g. drowning, strangulation, poisoning).

Data from Scandiatransplant show that of the 1219 patients on the transplant waiting list, 57 (5 %) died while waiting, and an additional 57 (5 %) were removed from the list because they were no longer eligible for transplantation.

Discussion

Survival after heart transplantation in Norway has increased over 40 years, from 11 years in the first decade to almost 15 years in the third decade. Median survival for the entire period was 13.4 years. The number of heart transplants per year has also risen, from a median of 24 in the period 6 November 1983 to 31 December 2005, to 32 between 1 January 2006 and 31 December 2023. Various types of cancer, together with chronic/progressive graft failure

(including myocardial infarction/coronary artery disease, sudden death with known development of sclerosis and fibrosis in the graft) are the main causes of death.

Among the 346 centres that report annually to the International Society of Heart and Lung Transplantation (ISHLT) registry, most perform 10–19 heart transplants per year. Rikshospitalet is among the top 10 % performing 30 or more heart transplants annually (4). Having a single national centre with a high level of activity may have contributed to the favourable survival rates following heart transplantation in Norway, compared with international registries. The most recent ISHLT registry report shows a median survival of 11.3 years for adults in the period 1992–2017 (4), compared with 13.4 years among recipients in Norway. Outcomes have improved over time despite an increase in donor age, likely due to advances in immunosuppression, surgical techniques, anaesthesia and general transplant medicine. The fact that median survival continues to increase despite rising donor age and broader acceptance of donors with comorbidities ('marginal donors') suggests, however, that donor-related factors are less impactful than recipient-related factors.

Since our 2007 report, cancer has ranked alongside chronic/progressive graft failure as one of the most common causes of death following heart transplantation (2). This is consistent with international findings. As recipient age has not increased significantly, the increased cancer incidence may be attributed to better transplant care, leading to fewer cases of organ rejection and longer survival, with prolonged exposure to immunosuppressive therapy. Cardiomyopathy has now overtaken ischaemic heart disease as the most common underlying diagnosis. A lower age-adjusted incidence of coronary artery disease in the population – with fewer major infarctions, likely due to quicker and more effective interventions followed by improved pharmacotherapy – may have contributed to this shift. The geographical distribution remains relatively even, as in 2007 (2), while the proportion of female recipients has increased from 19 % to 24 %. Internationally, the ISHLT registry data shows 25 % female recipients.

Among European centres, the median donor age increased from 31 years in the period 1998–2000 to 45 years in the period 2010–18. Over the same period, the increase in donor age in North America was more modest, rising from 28 to 31 years. This trend can be partly explained by the ageing population and the limited supply of organs, leading to the acceptance of older donors. In the United States, the wave of opioid-related deaths may help explain why the increase has been significantly less pronounced (5). While all organ donations in this study were performed in accordance with Norwegian criteria for brain death, controlled donation after circulatory death (cDCD) has been introduced internationally as a supplementary method. Use of this approach offers the potential to increase the total number of transplants by 15–20 % (6). Randomised studies in heart transplantation show that six-month survival and complication rates with organs donated via this newer method are no worse than with conventional donation (7). Similar outcomes have been reported from centres with five years of experience (8). If we are to expand our activity

and improve access to donor organs through circulatory death donation, the procedure must also be accepted for heart transplantation, and know-how and resources must be extended to all 28 donor hospitals in Norway.

Effective immunosuppression, including the discovery and introduction of calcineurin inhibitors, has been crucial for favourable outcomes after heart transplantation. However, these drugs have serious adverse effects that contribute to morbidity and can prevent further improvements in long-term survival. We have shown that renal function one year postoperatively is an independent predictor of survival and the development of graft sclerosis (9). Careful monitoring and dosing of tacrolimus/cyclosporine according to serum levels is essential to avoid nephrotoxic damage in patients, many of whom have renal impairment secondary to heart failure. In collaboration with other Nordic countries, we have introduced everolimus as an alternative treatment in patients with calcineurin inhibitor–induced renal failure (10). This treatment helps prevent progressive kidney damage, reduces early signs of graft sclerosis and lowers the incidence of cytomegalovirus infection. However, it is still not clear whether avoiding calcineurin inhibitors also decreases the risk of various types of cancer.

An evaluation of outcomes after heart transplantation should include more than just years of survival, and assessments of physical and mental quality of life have been central to our postoperative follow-up. Health-related quality of life improves significantly after surgery to levels comparable with the general population (11). Among a sample of 115 patients, improvement was still evident after 10–12 years of follow-up (11). However, in a survey of 147 patients more than five years post-transplant, depression (mainly mild to moderate) was found in 25 %, irrespective of lifestyle factors and somatic risk factors. At an average follow-up of six years, symptoms of depression were an independent predictor of death, highlighting a need for treatment (12). Compared with healthy controls, oxygen uptake one year after surgery was 60–80 % of the expected level (13). In a randomised study we conducted, supervised high-intensity interval training produced significantly greater and clinically relevant improvements in physical performance and muscle strength after nine months, compared with standard exercise (13). As self-reported physical health and maximal oxygen uptake are both strong predictors of survival among heart transplant recipients (14), patients are encouraged to remain physically active.

Retransplanted patients have experienced graft failure due to chronic rejection. Chronic rejection is an obliterative process that begins in the myocardial microvasculature and leads to diastolic dysfunction, followed by progressive systolic dysfunction. This low-grade form of rejection often manifests as vasculopathy, with angiographically visible deposits in the coronary arteries of the transplanted heart. It is the most common cause of late graft failure. Statins have been shown to reduce the incidence of graft sclerosis. In collaboration with our Scandinavian colleagues, we recently conducted a study in which we found that evolocumab, a PCSK9 inhibitor (proprotein convertase subtilisin/kexin type 9 inhibitor), despite significantly lowering circulating cholesterol levels, did not further reduce the extent of intimal thickening (15). These findings suggest that dyslipidaemia may be secondary to low-grade rejection and inflammation as the primary drivers of graft sclerosis.

Our results for retransplantation are in line with data from the ISHLT registry, where survival after second-time transplantation (data not shown) is almost the same as for first-time recipients (16). Outcomes are poorer in cases of early retransplantation due to primary graft failure or acute rejection, possibly due to acute immunological activation. Retransplantation is an ethical dilemma: some patients live longer thanks to a second donor organ, while others might die on the waiting list, never having had the opportunity for a first transplant. Internationally, several smaller centres therefore do not offer retransplantation.

A key strength of this study is the complete dataset covering all heart transplant recipients, with long follow-up and no loss to follow-up. Limitations include the retrospective nature of the analysis and a degree of uncertainty surrounding the causes of death.

The steadily improving survival rates following allograft heart transplantation (human-to-human grafts where the donor and recipient are genetically different) suggests that this procedure will remain an important treatment option for end-stage heart failure. The greatest challenges to further improvement lie in the chronic shortage of donor organs. There is a need to expand the supply of donors and ensure optimal utilisation of donated organs, improve and extend preservation of donor hearts after retrieval, develop safer pump technology to improve outcomes by serving as a temporary bridge to transplantation, and reduce long-term complications such as graft failure and cancer. Future alternatives may include artificial hearts and xenotransplantation (animal to human transplantation). The timeframe for when these might become viable alternatives to allotransplantation remains to be seen.

The article has been peer-reviewed.

REFERENCES

1. Frøysaker T, Lindberg H, Geiran O et al. Første hjertetransplantasjon i Norge. Tidsskr Nor Lægeforen 1984; 104: 946–8. [PubMed]

2. Simonsen S, Andreassen AK, Gullestad L et al. Overlevelse etter hjertetransplantasjon i Norge. Tidsskr Nor Lægeforen 2007; 127: 865–8. [PubMed]

3. Gray RJ. A Class of K-Sample Tests for Comparing the Cumulative Incidence of a Competing Risk. Ann Stat 1988; 16: 1141–54. [CrossRef]

4. International Society for Heart and Lung Transplantation. The International Thoracic Organ Transplant Registry of the International Society for Heart and Lung Transplantation: Thirty-fifth Adult Heart Transplantation Report-2018; Focus Theme: Multiorgan Transplantation. J Heart Lung Transplant 2018; 37: 1155–68. [PubMed][CrossRef]

5. Mehra MR, Jarcho JA, Cherikh W et al. The drug-intoxication epidemic and solid-organ transplantation. N Engl J Med 2018; 378: 1943–5. [PubMed]

[CrossRef]

6. Lindenskov PH, Dahlberg J. Når er en potensiell organdonor død? Tidsskr Nor Legeforen 2022; 142: 302–8.

7. Schroder JN, Patel CB, DeVore AD et al. Transplantation outcomes with donor hearts after circulatory death. N Engl J Med 2023; 388: 2121–31. [PubMed][CrossRef]

8. Messer S, Cernic S, Page A et al. A 5-year single-center early experience of heart transplantation from donation after circulatory-determined death donors. J Heart Lung Transplant 2020; 39: 1463–75. [PubMed][CrossRef]

9. Arora S, Andreassen AK. Simonsen S at al. Prognostic importance of renal function 1 year after heart transplantation for all-cause and cardiac mortality and development of cardiac allograft vasculopathy. Transplantation 2007; 84: 149–54. [PubMed][CrossRef]

10. SCHEDULE Investigators. Everolimus initiation and early calcineurin inhibitor withdrawal in heart transplant recipients: a randomized trial. Am J Transplant 2014; 14: 1828–38. [PubMed][CrossRef]

11. SCHEDULE investigators. The effect of everolimus versus calcineurin inhibitors on quality of life 10–12 years after heart transplantation: the results of a randomized controlled trial (SCHEDULE trial). Clin Transplant 2024; 38. doi: 10.1111/ctr.70028. [PubMed][CrossRef]

12. Havik OE, Sivertsen B, Relbo A et al. Depressive symptoms and all-cause mortality after heart transplantation. Transplantation 2007; 84: 97–103. [PubMed][CrossRef]

13. Nytrøen K, Rustad LA, Aukrust P et al. High-intensity interval training improves peak oxygen uptake and muscular exercise capacity in heart transplant recipients. Am J Transplant 2012; 12: 3134–42. [PubMed] [CrossRef]

14. Yardley M, Havik OE, Grov I et al. Peak oxygen uptake and self-reported physical health are strong predictors of long-term survival after heart transplantation. Clin Transplant 2016; 30: 161–9. [PubMed][CrossRef]

15. Broch K, Lemström KB, Gustafsson F et al. Randomized Trial of Cholesterol Lowering With Evolocumab for Cardiac Allograft Vasculopathy in Heart Transplant Recipients. JACC Heart Fail 2024; 12: 1677–88. [PubMed] [CrossRef]

16. Miller RJH, Clarke BA, Howlett JG et al. Outcomes in patients undergoing cardiac retransplantation: A propensity matched cohort analysis of the UNOS Registry. J Heart Lung Transplant 2019; 38: 1067–74. [PubMed][CrossRef]

Publisert: 22 October 2025. Tidsskr Nor Legeforen. DOI: 10.4045/tidsskr.24.0552
Received 21.10.2024, first revision submitted 9.1.2025, accepted 22.8.2025.