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Thoracic Organ Transplantation in the United States, 1995–2004

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This article reviews trends in thoracic organ transplantation based on OPTN/SRTR data from 1995 to 2004. The number of active waiting list patients for heart transplants continues to decline, primarily because there are fewer patients with coronary artery disease listed for transplantation. Waiting times for heart transplantation have decreased, and waiting list deaths also have declined, from 259 per 1000 patient-years at risk in 1995 to 156 in 2004. Fewer heart transplants were performed in 2004 than in 1995, but adjusted patient survival increased to 88% at 1 year and 73% at 5 years. Emphysema, idiopathic pulmonary fibrosis and cystic fibrosis were the most common indications among lung transplant recipients in 2004. Waiting time for lung transplantation decreased between 1999 and 2004. Waiting list mortality decreased to 134 per 1000 patient-years at risk in 2004. One-year survival following transplantation has improved significantly in the past decade. The number of combined heart-lung transplants performed in the United States remains low, with only 39 performed in 2004. Overall unadjusted survival, at 58% at 1 year and 40% at 5 years, is lower among heart-lung recipients than among either heart or lung recipients alone.

Note on sources: The articles in this report are based on the reference tables in the *2005 OPTN/SRTR Annual Report*, which are not included in this publication. Many relevant data appear in the figures included here; other tables from the *Annual Report* that serve as the basis for this article include the following: Tables 1.3, 1.6, 11.1a, 11.2b, 11.3. 11.4, 11.5, 11.6a, 11.6g, 11.6i, 11.7, 11.8, 11.11, 11.13, 11.14, 12.1a, 12.1b, 12.2, 12.3, 12.4a, 12.6a, 12.6e, 12.6g, 12.6i, 12.7a, 12.9a, 12.11, 12.12a, 12.13a, 13.1a, 13.2, 13.3, 13.4, 13.7, 13.11, 13.12, 13.14, and 13.15. All of these tables may be found online at http://www.ustransplant.org.

Key words: Deceased donors, graft survival, heart transplantation, heart-lung transplantation, living donors, lung transplantation, organ donation, patient survival, SRTR, waiting list

Introduction

This article reviews the OPTN/SRTR data on thoracic organ transplantation in the United States in 2004 and the previous decade. These robust data provide an opportunity to describe the current state of heart, lung and heart-lung transplantation with regard to waiting list characteristics and transplant outcomes. Although there have been substantial advances in medical therapy since the mid 1990s, thoracic organ transplantation remains an important treatment option for selected patients with a failing heart, failing lungs or both. Despite better donor organ selection and utilization, the number of transplants performed has declined in recent years and is still limited by the number of donor organs available. Despite the decrease in the overall transplant volume, outcomes for thoracic transplantation have improved, as is evident in the increased short-term patient survival rates. Among heart transplant recipients, short-term (3-month and 1-year) patient survival has been improving since 1995, while long-term (3-year and 5-year) survival has remained steady. Both short- and long-term patient survival rates have improved since 1995 for lung transplant recipients.

In May 2005, a new deceased donor organ allocation system for lung transplantation was introduced (1,2). The new system determines priority for receiving a lung transplant based primarily on severity of illness rather than time spent on the waiting list. The long-term impact of this new system is still to be determined; the development of the new system is addressed in an accompanying article in this report (3).

Unless otherwise noted, the statistics in this article are drawn from the reference tables in the *2005 OPTN/SRTR Annual Report*. A companion article in this report, 'Analytical Methods and Database Design: Implications for Transplant Researchers, 2005,' explains the methods of data collection, organization and analysis that serve as the basis for this article (4). Additional detail on the methods of analysis employed herein may be found in the

reference tables themselves or in the Technical Notes of the *OPTN/SRTR Annual Report*, both available online at http://www.ustransplant.org.

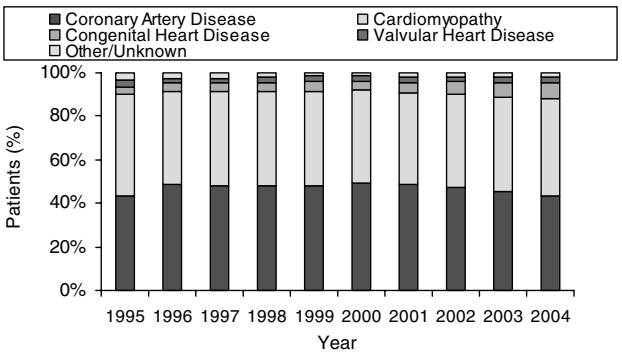
Heart

Heart waiting list characteristics

The waiting list characteristics presented here represent potential transplant recipients on the waiting list at the end of each calendar year from 1995 to 2004. The total number of patients active on the heart waiting list continued to decline during this time period, which is primarily a reflection of the decline in the percentage of transplant candidates with a coronary artery disease classification (Figure 1). There was a general reduction in the percentage of patients aged 35–64 years, the peak age range for candidates with coronary artery disease (Figure 2). This may reflect better outcomes resulting from improvements in medical, interventional and surgical treatments for coronary disease. The decline in the percentage of 35–64 year-old patients began in 1997 and continued through 2004.

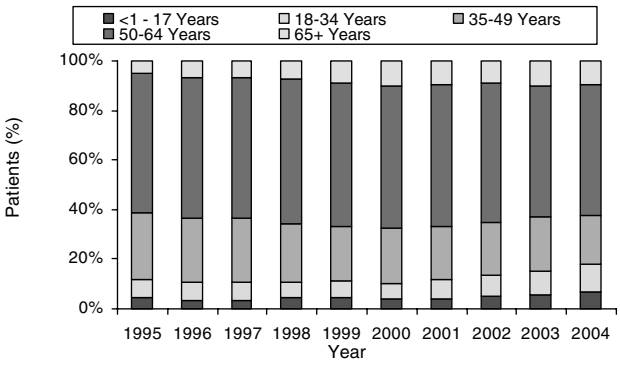
Other trends in characteristics of waiting list patients, such as blood type and country of residence, did not change. The number of female patients on the waiting list continued to increase, from 20% in 1995 to 23% in 2004. There was also an increase in the percentage of patients with a previous organ transplant, from 3% in 1995 to 5% in 2004. Reflected in these percentages is the increase in the percentage of candidates with a previous heart or heart-lung transplant, from 2.6% in 1995 to 4.3% in 2004.

Patients' status at the end of each calendar year has changed significantly since the creation of Status 1A and Status 1B in 1999. The percentage of Status 2 patients declined from 84% in 1997 to 72% in 2004. At the same time, the percentage of Status 1B patients steadily increased, from 14% in 1999 to 21% in 2004 (Figure 3). This change indicates that a relatively large percentage of patients shifted from Status 2 to Status 1B.



Source: *2005 OPTN/SRTR Annual Report*, Table 11.1a.

Figure 1: Primary diagnoses of patients active on the heart waiting list at year-end, 1995–2004.



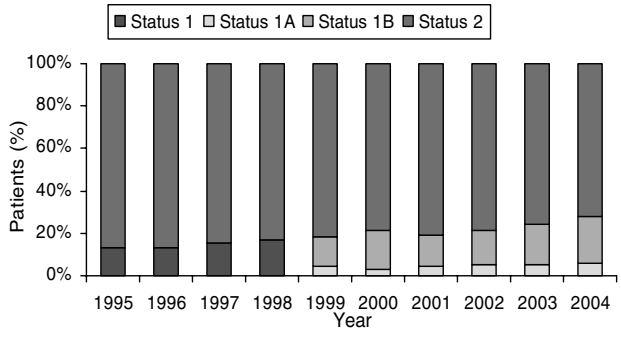
Source: *2005 OPTN/SRTR Annual Report*, Table 11.1a.

Figure 2: Age distribution of patients active on the heart waiting list at year-end, 1995–2004.

The rules for listing as Status 1A include a high risk of dying within 7 days of listing and having a ventricular assist device (VAD) in place or other complications such as a VAD infection or being on mechanical ventilatory support. As of January 1, 2004, 37% of patients listed as Status 1A remained listed as Status 1A at the end of 30 days. At 60 days, 18% of patients listed initially as Status 1A were still listed as Status 1A.

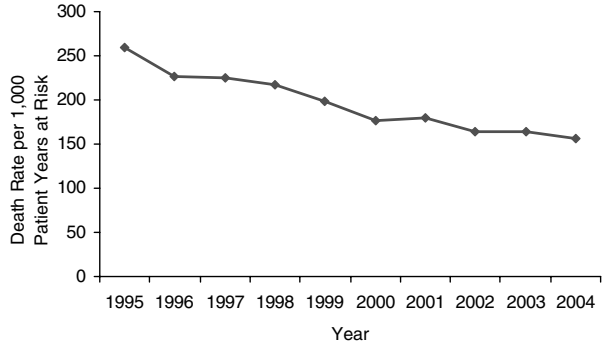
Deaths on the heart waiting list

Both the number and the rate of deaths of patients on the waiting list have declined significantly since 1995. Annual death rates per 1000 patient-years at risk declined from 259 in 1995 to 156 in 2004 (Figure 4). This may reflect improved medical therapy and mechanical support for patients with advanced heart failure (5–7). The improvements in death rates occurred across age, ethnicity/race, gender and blood type groups. From years 2000 to 2004, the death rate among Status 1A patients declined from



Source: *2005 OPTN/SRTR Annual Report*, Table 11.1a.

Figure 3: Waiting list status of patients active on the heart waiting list at year-end, 1995–2004.



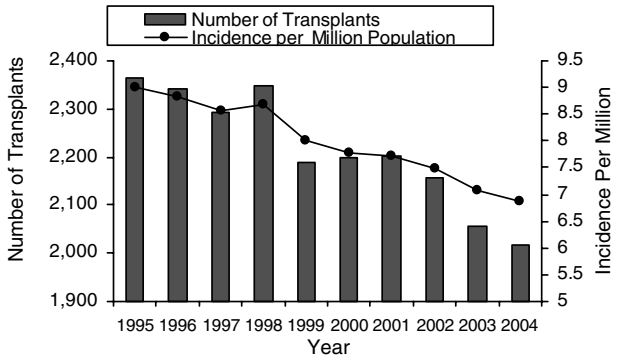
Source: *2005 OPTN/SRTR Annual Report,* Table 11.3.

Figure 4: Annual death rate of patients awaiting heart transplantation, per 1000 patient-years at risk, 1995–2004.

1124 to 548 deaths per 1000 patient-years at risk, while the death rates among Status 1B and Status 2 patients declined less sharply (from 380 to 333 per 1000 patient-years at risk among Status1B patients; and from 106 to 97 per 1000 patient-years at risk among Status 2 patients).

Heart transplant recipient characteristics

The number of transplant candidates undergoing heart transplantation increased steadily in the 1990s, reaching a peak in 1995, when 2363 heart transplant procedures were performed. Since then there has been a steady decline in the number of heart transplant procedures performed per year; 2016 transplants were performed in 2004 (Figure 5). The number of heart transplants per million population has also continued to decrease over the past decade (from 8.99 procedures per million population in 1995 to 6.87 procedures per million population in 2004). The most notable decline occurred among those ages 50–64 years; the incidence in this group dropped from 35.86 transplants per million population in 1995 to 19.12 transplants per million population in 2004.



Source: *2005 OPTN/SRTR Annual Report,* Tables 11.4 and 11.5.

Figure 5: Number of heart transplants and incidence of transplant per million population, 1995–2004.

One possible explanation for this gradual yet consistent decline is the improvement in medical and surgical management of patients with end-stage heart disease (5–9). Despite the decline in the total number of patients undergoing heart transplantation, the percentage of recipients aged 65 years and above remained in the range of 8.5–10.3% of all heart transplants in the years 2000–2004, which is still higher than in 1995, when only 6% of recipients were aged 65 years or older.

The waiting list status of heart transplant recipients at the time of transplantation has changed little since the inception of the new classification system in 1999. The percentage of heart transplant recipients who were Status 1A at the time of transplantation increased slightly between 2000 and 2004 (39.7% in 2000 to 40.6% in 2004). During the same interval, the percentage of recipients who were Status 1B at the time of transplantation decreased from 34.2% to 32.6%. The percentage of patients undergoing heart transplant at Status 2 has remained mostly unchanged since 2000, increasing only from 26.0% in 2000 to 26.7% in 2004. With wider geographic sharing of donor hearts for candidates who are Status 1A and 1B (if approved by the OPTN Board of Directors), the number of patients undergoing a heart transplant at Status 2 is expected to decrease in favor of sicker candidates. More notable is the decline in the percentage of transplant candidates on life support (defined as inotrope infusion, intra-aortic balloon pump or ventricular assist devices) at the time of transplantation, from 68% in 2003 to 53% in 2004. The reason for this 1-year decline is unknown. Heart transplant recipients' primary diagnoses have changed slightly since 1995, with an increase in the percentage of recipients diagnosed with cardiomyopathy as the primary diagnosis (from 43% in 1995 to 49% in 2004) and a decrease in the percentage of recipients diagnosed with coronary artery disease (47% in 1995 to 38% in 2004). The term 'cardiomyopathy' is broad and may include patients with ischemic cardiomyopathy. Therefore, the change in numbers may be a function of how the data were entered rather than a reflection of a change in disease prevalence. The percentage of heart transplant recipients with a diagnosis of congenital heart disease continues to increase (from 7% of recipients in 1995 to 10% of recipients in 2004).

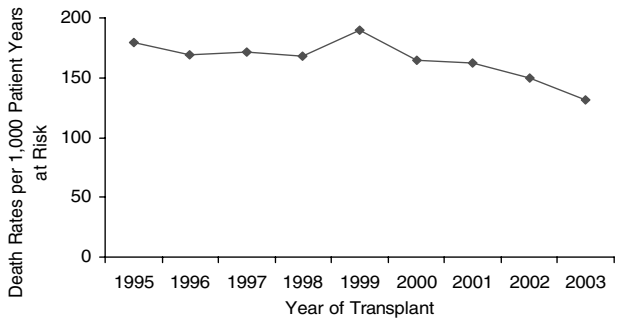
Immunosuppression therapy for heart transplantation

The immunosuppression regimen for heart transplantation has evolved over the past decade. Induction therapy was used in 47% of heart transplant recipients in 2004, compared to 35% of recipients in 1995. With regard to induction therapy agents, there has been a gradual decline in use of ATG/NRATG/NRATS and muromonab-CD3 (OKT3) and a gradual increase in use of rabbit antithymocyte globulin (Thymoglobulin), daclizumab (Zenapax) and basiliximab (Simulect). Triple drug therapy remains the cornerstone of immunosuppression therapy at 1 year after transplantation. Among recipients of heart transplants in 2003, 86% were on corticosteroids 1 year later,

compared to 90% of recipients of transplants in 1994. Similarly, 88% of 2003 transplant recipients were on antimetabolites a year later, compared to 91% of recipients of transplants in 1994. As expected, there has been a change in the calcineurin inhibitor regimen: In 1994, 90% of heart transplant recipients were receiving cyclosporine preparations and 3.5% were on tacrolimus. In 2003, 54% of heart transplant recipients were on cyclosporine preparations and 53% were on tacrolimus. Similarly, azathioprine use decreased significantly, from use by 88% of recipients in 1994 to use by 9% of recipients in 2003, while the percentage of recipients using mycophenolate mofetil increased from 2% to 78% during the same time period. Another notable trend in immunosuppression use in the past decade is the declining number of recipients who needed treatment for rejection episodes for 1 year following transplantation (32% of recipients in 2003 compared to 40% of recipients in 1994). The decline attests to the greater potency of the new immunosuppression protocols. Concurrent data on the incidence of infection and malignancy are not available.

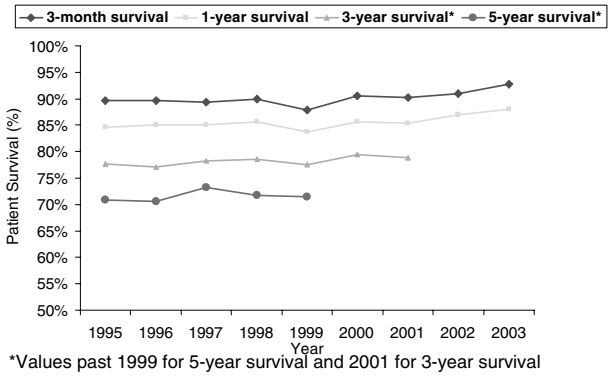
Heart transplant outcomes

Deaths in the first year after heart transplantation have steadily decreased, from 179 deaths per 1000 patient-years at risk in 1995 to 131 deaths in 2003 (Figure 6). Advances in medical and surgical management of heart transplant recipients have translated into a declining death rate in the first year following transplant that is irrespective of ethnicity, sex, blood type, presence or absence of life support, hospitalization status, primary diagnoses or the waiting list status at the time of transplantation. The most notable decline occurred in recipients less than 1 year old and recipients 11–17 years old. Death rates for recipients less than 1 year old decreased by about a third, and rates for recipients 11–17 years old decreased by more than half. In 2003, the death rate for waiting list Status 1A recipients in the first year after transplantation was still nearly twice the death rate for waiting list Status 2 recipients (156 deaths per 1000 patient-years at risk for Status 1A recipients vs.



Source: *2005 OPTN/SRTR Annual Report*, Tables 11.7.

Figure 6: Annual death rate of heart recipients in first year after transplantation, per 1000 patient-years at risk, 1995–2003.



*Values past 1999 for 5-year survival and 2001 for 3-year survival not determined due to insufficient follow-up.

Source: *2005 OPTN/SRTR Annual Report*, Table 11.13.

Figure 7: Unadjusted short- and long-term heart recipient survival, by year of transplant, 1995–2003.

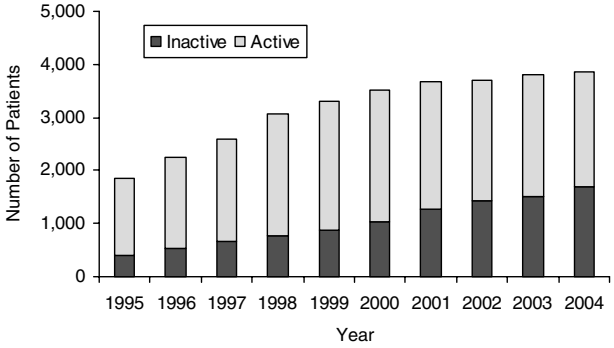
95 deaths for Status 2 recipients). Donor age appears to be an important predictor of posttransplant survival. In 2003, the recipient death rate in the first year after transplantation was 135 deaths per 1000 patient-years at risk for donors aged 50–64 years and 117 deaths per 1000 patient-years at risk for donors aged 35–49 years. This information should be interpreted within the context that no adjustment was made for recipient variables.

In 2003 adjusted patient survival rates at 3 months, 1 year, 3 years and 5 years were 92%, 88%, 80% and 73%. The adjusted 5-year survival rate was lowest among recipients 65 years old or older (68%). The 5-year adjusted patient survival rate was 70% among female recipients and 74% in male recipients. When examined at other time points—such as 3 months, 1 year and 3 years—female recipients continued to have inferior adjusted survival compared to male recipients. At this point in time, it is unclear why women would not fare as well. If this observation persists, additional studies aimed at better understanding this finding would be warranted. The 3-year and 5-year survival data are based on cohorts of recipients of transplants in 2000–2003 and 1998–2003, respectively. Adjusted graft survival was nearly identical to adjusted patient survival with similar trends in each recipient age group and both genders. The unadjusted patient survival rate at 3 months, 1 year, 3 years and 5 years increased steadily between 1995 and 2003 (Figure 7). As expected, the prevalence of people living with a functioning heart allograft increased from 11 644 in 1995 to 19 050 in 2004. This expanding population is a testament to advances in the medical and surgical therapies for end-stage heart disease and posttransplant care, and may warrant a new discipline in cardiac care.

Lung

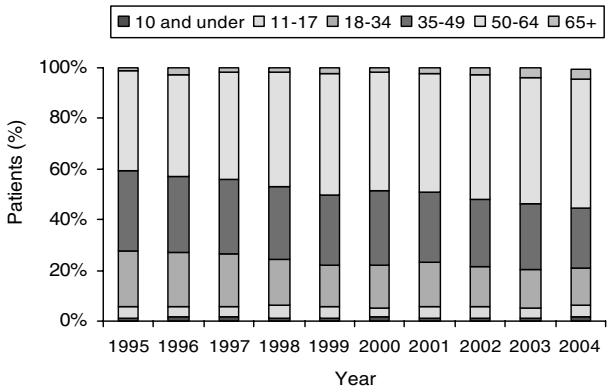
Lung waiting list characteristics

Lung transplantation currently remains a widely accepted therapy for patients with a variety of end-stage lung



Source: *2005 OPTN/SRTR Annual Report,* Tables 1.3 and 12.1a.

Figure 8: Active versus inactive lung waiting list patients at year-end, 1995–2004.



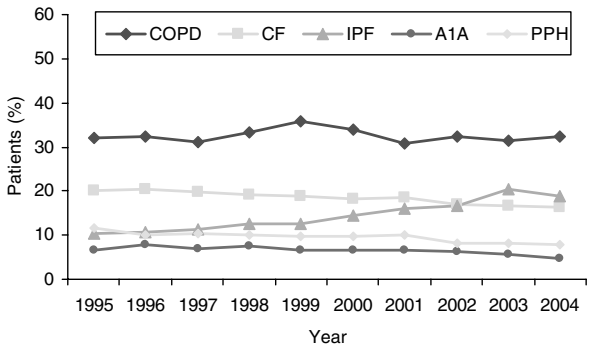
Source: *2005 OPTN/SRTR Annual Report,* Table 12.1a.

Figure 9: Age distribution of active lung waiting list at year-end, 1995–2004.

diseases. A new deceased donor organ allocation system was implemented in May 2005 (1,2). Whereas the previous allocation system was based solely on time spent on the waiting list, the new one is based on a priority score that is determined by the severity of illness of patients on the waiting list and by posttransplant survival. The long-term impact of the new system on waiting list characteristics has yet to be determined. The development of the new system is reviewed in another article in this report (3).

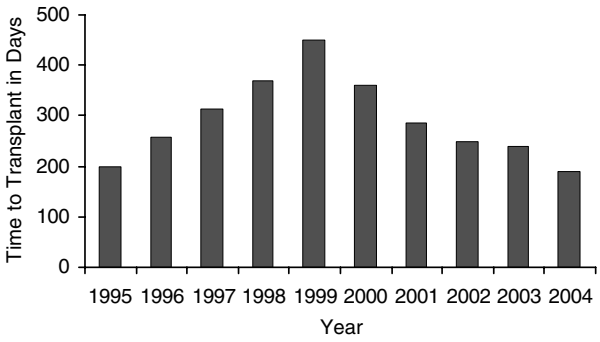
The total number of patients on the lung transplant waiting list was 3851 at the end of 2004, and has remained relatively stable since 2001. However, since 1995 there has been a slight increase in the ratio of inactive to active waiting list patients (Figure 8). In 2004, there were 2167 active waiting list patients and 1684 inactive patients. The increase in inactive patients probably has many causes, including the early listing of patients with less severe disease in order to accrue time on the waiting list (10). As the new donor allocation scheme is implemented, there may be significant changes in the number and distribution of patients on the waiting list. Another potential reason for the increase in the number of inactive patients on the waiting list is that therapies for end-stage lung diseases have been improved, particularly for primary pulmonary hypertension (PPH) (11). Indeed, there were more patients with PPH on the inactive waiting list than on the active waiting list in 2004 (18% vs. 8%, respectively).

The age distribution of patients on the active waiting list for a lung transplant has changed slightly over the past decade. In 2004, more than half of the patients on the waiting list were more than 50 years old. The percentage of waiting list patients between the ages of 18 and 34 years decreased slightly (Figure 9). The difference in the age distribution may represent the increasing number of active waiting list patients with idiopathic pulmonary fibrosis (IPF), which may have led to a decrease in the percentage of patients with cystic fibrosis (CF) and PPH. There were no significant changes in the gender or ethnicity of patients who were on the active waiting list in 2004 compared to previous years. In 2004, active waiting list patients were most commonly female (55%), white (83%) and blood type O (50%), and had not received a previous transplant (97%). Approximately 45% of active waiting list patients had already waited more than a year for a lung transplant. While the distribution of time since listing has been similar for patients on the list at the end of each year since 1999, it is clearly different than in 1995, when only 28% of patients had waited more than a year (compared to 45% in 2004). In 2004, the most common diagnoses of active waiting list patients were chronic obstructive pulmonary disease (COPD), or emphysema (32%), IPF (19%) and CF (16%). The distribution of diagnoses in 2004 was similar to the distribution in 2003, but since 1995 there has been an overall increase in the percentage of patients with IPF and a slight decrease in the percentage of patients with CF, PPH and alpha-1 antitrypsin deficiency-related emphysema (Figure 10).



Source: *2005 OPTN/SRTR Annual Report,* Table 12.1a.

Figure 10: Primary diagnoses of patients active on the lung waiting list, 1995–2004.



Source: *2005 OPTN/SRTR Annual Report*, Table 12.2.

Figure 11: Time to transplant for lung registrants, 25th percentile, 1995–2004.

The waiting time for new lung waiting list registrants decreased significantly among registrants ages 11 years and older between 1999 and 2004. In addition, time to transplant was shorter in all ethnic groups except Asians, and in both males and females, in 2004 compared to 2003. The 25th percentile of time to transplant is shown in Figure 11.

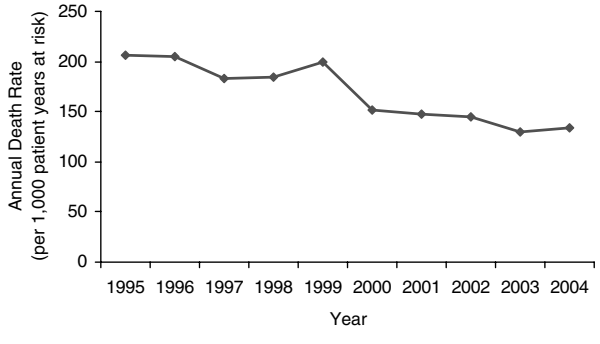
Deaths on the lung waiting list

Death rates among waiting list patients have decreased since 1995, but the rate in 2004 was similar to the rate in 2003 (Figure 12). The average death rate in 2004 was 134 deaths per 1000 patient-years at risk. In 2004, females continued to have a slightly lower death rate than males (123 compared to 149 per 1000 patient-years at risk), which is consistent with the previous 9 years. It is not clear whether the lower mortality rate among females is secondary to lower severity of illness, the distribution of underlying diagnoses, or the possible influence of gender on lung disease. Asians had a markedly lower death rate (83 per 1000 patient-years at risk) than did other ethnic groups. However, this result should be interpreted with caution, because the number of Asian patients on the transplant list is relatively small (76 patients). Patients aged 65 years and older and children between 1 and 5 years old had the highest death rates in 2004 (211 and 171 per 1000 patient-years at risk, respectively).

Deceased donor lung transplant recipient characteristics

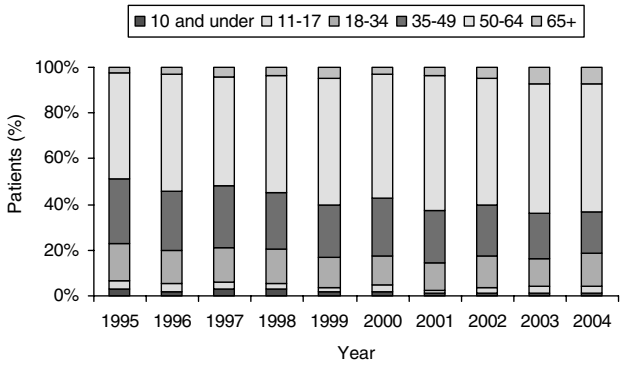
There were 1157 deceased donor lung transplants performed in 2004. This number has remained relatively stable since 2001, but represents an increase in the number of transplants per year since 1995. The majority of transplant recipients in 2004 were between the ages of 50 and 64 years. The percentage of recipients in this age group was similar to the percentage in 2003, but had increased significantly since 1995. There has been a respective decrease in the percentage of transplants performed among patients between the ages of 35 and 49 years since 1995 (Figure 13). There have been no changes in the gender (50% female), ethnicity (86% white) or blood group type (45% type O) distribution of recipients of deceased donor lung transplants since 1995.

In 2004, there were somewhat more bilateral lung transplants performed compared to single lung transplants (56% vs. 44%). This distribution differs from 1995, when 54% of the lung transplants were single lung transplants and 46% were bilateral lung transplants. The change probably reflects a growing preference among transplant centers for performing double lung transplants, because of the improved long-term survival among bilateral lung transplant recipients, particularly those with a diagnosis of emphysema (8). Emphysema remains the most common diagnosis among lung transplant recipients; 37% of all transplants were performed for this indication. IPF (24%) and CF (18%) were the next most common diagnoses. While this distribution is similar to the distribution in 2003, it has changed since 1995 (Figure 14).



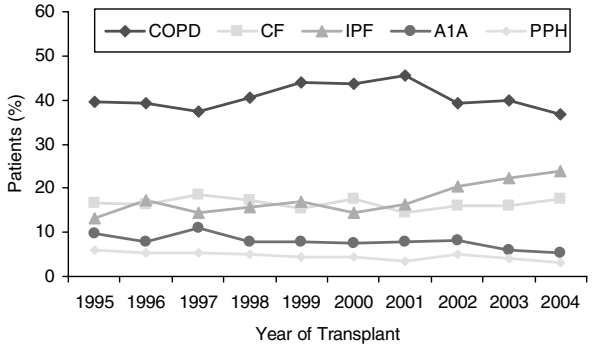
Source: *2005 OPTN/SRTR Annual Report*, Table 12.3.

Figure 12: Annual death rate of patients on the lung waiting list, per 1000 patient-years at risk, 1995–2004.



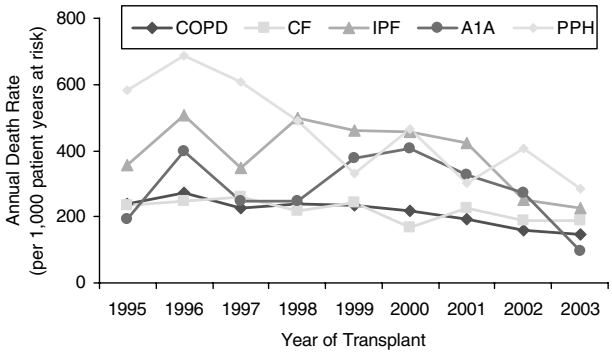
Source: *2005 OPTN/SRTR Annual Report*, Table 12.4a.

Figure 13: Age distribution of deceased donor lung transplant recipients, 1995–2004.



Source: *2005 OPTN/SRTR Annual Report,* Table 12.4a.

Figure 14: Primary diagnosis of deceased donor lung transplant recipients, 1995–2004.



Source: *2005 OPTN/SRTR Annual Report,* Table 12.7a.

Figure 15: Annual death rates during first year after deceased donor lung transplant by primary diagnosis, 1995–2003.

Immunosuppression therapy after lung transplantation

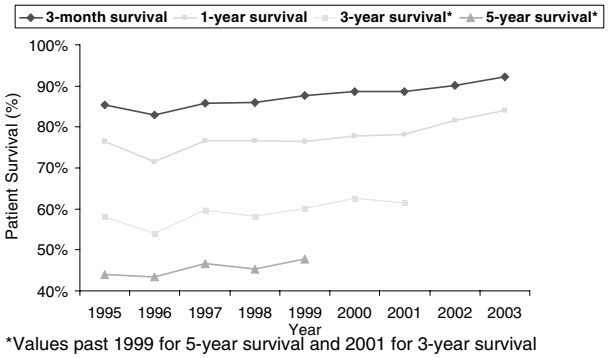
Immunosuppression after lung transplantation has changed significantly since 1995. Induction therapy was used in approximately 50% of all lung transplants performed in 2004, whereas it was used in only 29% of lung transplants in 1995. The induction therapies used most commonly in 2004 were basiliximab (23%) and daclizumab (15%). In 1995, antithymocyte globulin (ATG) induction therapy was the therapy used most commonly (in 23% of transplants). In 2004 baseline immunosuppression prior to discharge included corticosteroids (97%), tacrolimus (70%) and an antimetabolite, either azathioprine (44%) or mycophenolate mofetil (47%). Calcineurin inhibitor use has changed dramatically—from cyclosporine (77%) in 1995 to tacrolimus (70%) in 2004. For transplants in 2003, maintenance immunosuppression administered between discharge and 1 year posttransplant was essentially the same as immunosuppression prior to discharge, except that the use of sirolimus increased to 10% of lung transplant cases. The immunosuppressive agent used most commonly to treat acute rejection within the first year after transplant was corticosteroids, which were used in 96% of acute rejection cases.

Deceased donor lung transplant outcomes

Among recipients of deceased donor lung transplants in 2003, the average death rate in the first year after transplantation was 184 deaths per 1000 patient-years at risk, a decrease since 2002, when the rate was 215 deaths per 1000 patient-years at risk, and a significant decrease since 1995, when the rate was 291 deaths per 1000 patient-years at risk. Since 1995, the highest death rate has generally been in the group of recipients aged 65 years and above, who had a rate of 287 deaths per 1000 patient-years at risk among 2003 recipients. Death rates in the group aged 35–49 years decreased significantly from previous years to 146 per 1000 patient-years at risk in 2003 recipients. First-year death rates among most ethnic groups were similar, except among Hispanics/Latinos, who appeared to have a higher death rate (319 per 1000 patient-years at risk). The reason for this difference is not clear; it may simply be a reflection of the small number of Hispanics/Latinos who received transplants in 2003 (47 transplant recipients). In 2004 there were no significant differences in death rates by gender.

Lung transplant recipients who had received a previous transplant had a higher death rate (402 per 1000 patient-years at risk) than first-time recipients. In addition, recipients who were hospitalized, admitted to an intensive care unit, or on life support had a higher annual death rate in the first year after transplantation. Recipients with an underlying diagnosis of PPH continued to have the highest death rate in the first year after transplantation (285 per 1000 patient-years) compared to recipients with other diagnoses. They were followed by recipients with IPF (225 per 1000 patient-years) (Figure 15). There was a slightly higher death rate in the first year among recipients of double lung transplants than among those with single lung transplants. Recipients of lungs from donors who were 50–64 years old had a higher death rate (221 deaths per 1000 patient-years at risk) than did recipients of lungs from donors in the other age groups. Note, however, that these subgroup death rates have not been adjusted for other patient characteristics.

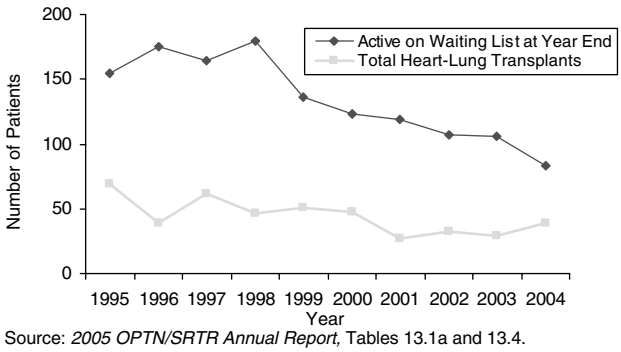
After adjusting for age, race, gender and diagnosis, patient survival rates for deceased donor lung transplant recipients at 3 months, 1 year, 3 years and 5 years were 91%, 83%, 64% and 48%, respectively. Recipients over the age of 65 years had a slightly lower 5-year survival rate (41%) than did younger recipients. An underlying diagnosis of PPH portended a poor 3-month survival rate (76%), but 5-year survival was comparable to rates for other diagnoses (55%). Lung transplant recipients with an underlying diagnosis of IPF or alpha-1 antitrypsin deficiency had lower survival rates at 5 years—44% and 46%, respectively. African Americans and multiracial/other patients tended to have



*Values past 1999 for 5-year survival and 2001 for 3-year survival not determined due to insufficient follow-up.

Source: *2005 OPTN/SRTR Annual Report*, Table 12.13a.

Figure 16: Unadjusted short- and long-term deceased donor lung patient survival by year of transplant, 1995–2003.



Source: *2005 OPTN/SRTR Annual Report*, Tables 13.1a and 13.4.

Figure 17: Number of heart-lung patients active on waiting list at year-end and number of heart-lung transplants, 1995–2004.

worse 5-year survival rates (41% and 22%) than did whites, Hispanics/Latinos and Asians. The latter three groups all had 5-year survival rates of 50%. While the cause of this difference is unknown, it may be related to racial disparities in human leukocyte antigen (HLA) matching. Adjusted graft survival rates for the same time intervals and recipient demographics are similar to adjusted patient survival rates, because lung retransplantation is rarely performed. The reason that so few patients receive second lung transplants is that the outcomes are worse than outcomes of first-time transplants. In an unadjusted graft survival model, recipients who had received a previous lung transplant had lower survival rates than first-time recipients at 3 months, 1 year, 3 years and 5 years (77%, 57%, 36% and 24%, respectively). In addition, lung transplant recipients who were hospitalized, in the intensive care unit, or on life support at the time of transplant had lower graft survival rates at 5 years (45%, 35% and 44%, respectively). Yearly transplant center volume has been reported previously to affect survival (1). Between 2003 and 2004, it became clear that centers with a volume greater than 21 transplants per year had a higher 5-year patient survival rate (54%) than did lower-volume centers (36–48%). However, there was no significant difference in 5-year patient survival rates among any of the other center volume categories. As was shown in previous SRTR reports, donor ages of 50–64 years and 65 years and above were associated with relatively lower 5-year patient survival rates (43% and 35%, respectively). Both short-term and long-term patient survival rates after lung transplantation have, in general, continued to improve since 1999 (Figure 16).

Heart-Lung

Heart-lung waiting list characteristics

For the sixth consecutive year the number of patients on the active waiting list for a heart-lung transplant continued to decrease. From a high of 179 patients in 1998, the total number of active patients decreased to 83 in 2004 (Figure 17). Among these, 68% were female and 33% were male, all were U.S. residents and none had received a transplant previously. The reason for the decline in the number of active waiting list patients is unclear, but difficulties in obtaining a combined heart-lung block and the relatively poor short- and long-term posttransplant survival outcomes could be factors. Most waiting list patients (81%) were adults older than 18 years. A total of 21% of the patients were older than 50 years, which is often considered the upper age limit for heart-lung transplantation. The most common diagnoses on the waiting list were congenital heart disease (35%), PPH (18%) and CF (2%).

The median time to transplant has remained relatively stable with the 25th percentile of time to transplant at 284 days in 2004. This is up from 225 days in 2003 and down from the decade high of 792 days in 1997. The increase since 2003 in time to transplant has resulted in an increase in the annual death rate, from 107 deaths per 1000 patient-years at risk in 2003 to 159 deaths in 2004. There does not appear to be any influence of age, sex, ethnicity or blood type on death rates on the waiting list, but the low number of waiting list registrants likely plays a role in this lack of detectable differentiation. The death rate per 1000 patient-years at risk among patients on the waiting list, by blood group, was 151 for type O, 170 for type A and 207 for type B. The rate could not be determined for type AB because there were too few patients.

Heart-lung recipient characteristics

There were only 39 combined heart-lung transplants performed in 2004, a decline from a high of 69 in 1995 and an increase from a low of 27 in 2001. Only 15% of the recipients were less than 18 years old, and 67% were between the ages of 18 and 49 years. Thirty percent of the recipients were hospitalized, and 26% were on life support at the time of transplant. Males and females were nearly equally represented, with males accounting for 49% of the recipients and females accounting for 51%. The most common

diagnoses were congenital heart disease (28% of diagnoses) and PPH (31% of diagnoses). This pattern has not changed over the past decade.

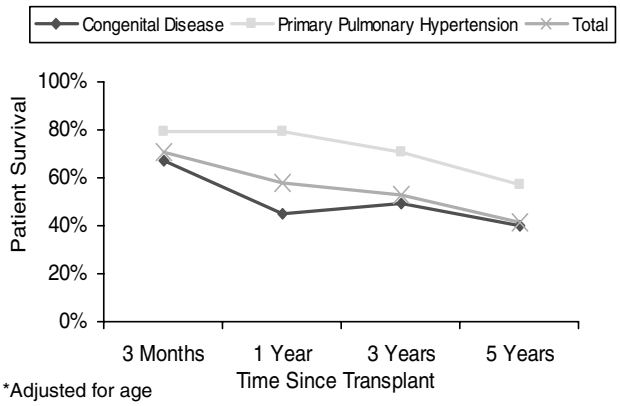
Blood type does not appear to have had a significant impact on any aspect of heart-lung transplantation. Candidates with blood type O represented 54% of the waiting list, while 31% of candidates had type A, 11% had type B and 4% had type AB. Similarly, among recipients, 49% had blood type O, 23% had type A, 23% had type B and 5% had type AB.

Heart-lung recipient outcomes

The SRTR database includes 55 transplant centers that performed heart-lung transplants between 1995 and 2004. Thirty-four of these centers (63%) did not perform a combined transplant in 2004. Most centers that did perform heart-lung transplants performed only one transplant. The greatest number of combined transplants performed at one center was five, and two centers performed four transplants.

Reported unadjusted patient survival rates at 3 months, 1 year, 3 years and 5 years were 70%, 58%, 52% and 40%. The age-adjusted survival rates appeared to be better (at all time points) for recipients with PPH than for recipients with congenital heart disease. Survival rates for PPH were 79%, 79%, 71% and 57% for the 3-month, 1-year, 3-year and 5-year periods. For recipients with congenital heart disease, survival rates were 67%, 45%, 49% and 40% (Figure 18). These results have not improved over the past decade.

The first-year posttransplant annual death rate, reported per 1000 patient-years at risk, was up to 857 for recipients with transplants in 2003, the last year with adequate follow-up. Fourteen of the 28 recipients of transplants that year died. Because the number of candidates on the active waiting list and the number of recipients are too small to permit multivariate analysis, the significance of these numbers is unknown. However, there is no evidence that the death rate in the first year after heart-lung transplantation was significantly related to place of residence, blood type, age or indication for transplant. First-year mortality rates seem to be higher among recipients in the intensive care unit and on life support at the time of transplant.



*Adjusted for age

Source: *2005 OPTN/SRTR Annual Report*, Table 13.11.

Figure 18: Adjusted heart-lung patient survival at 3 months, 1 year, 3 years and 5 years, by diagnosis.

The prevalence of people living with a functioning heart-lung transplant has changed little over the past decade, remaining in the 230–250 range. The steady prevalence reflects the fact that the number of transplant recipient deaths and the number of new recipients remain about the same from year to year. It also means that survival rates have not improved over the last decade, despite improvements in immunosuppression and general medical care.

Conclusion

Thoracic transplantation remains an important and viable treatment strategy for patients with end-stage heart and lung disease. The past few years have seen a decline in the total number of heart transplants performed and decreasing waiting list mortality. This is likely due to improvements in medical and surgical therapies for heart disease overall. The introduction of ventricular assist devices has changed the profile of patients waiting for and ultimately receiving heart transplants. In recent years, short- and long-term survival rates for lung transplant recipients have improved, with a more marked increase in short-term survival. Compared to previous years and despite the persistent problem of donor organ availability, more double lung transplants than single lung transplants are being performed. Although waiting list characteristics had not changed substantially through 2004, recent changes in the organ allocation system for lung transplantation will likely change the profile of patients on the waiting list and those receiving transplants in the future. More time is needed to assess the overall impact of this new system. A limited number of heart-lung transplant operations are performed each year in the United States, probably due in part to the limited availability of heart-lung organ blocks. The survival outcomes of combined heart-lung transplants remain lower than those of heart or lung transplants alone.

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This study was approved by HRSA's SRTR project officer. HRSA has determined that this study satisfies the criteria for the IRB exemption described in the "Public Benefit and Service Program" provisions of 45 CFR 46.101(b)(5) and HRSA Circular 03.

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