Original Article

Renal Transplantation in Singapore

Vathsala A,[1,2] *MD (USA), FRCP (Edin), FAMS*, Khuan Yew Chow,[3] *MB BCh (NUI), FRACGP, MMed (Public Health) (Singapore)*

Abstract

Introduction: Renal transplantation is the best treatment for kidney failure. As the demand far exceeds the supply, various legislative measures have been put into place in Singapore to increase kidney transplant rates. This paper evaluates the impact of these measures and reports on the outcomes for kidney transplant recipients in Singapore. Materials and Methods: Patient demographics, recipient and donor characteristics, and co-morbidities occurring in incident transplant patients were extracted from Singapore Renal Registry (SRR) Reports from 1997 to 2006, tabulated and summarised. Graft and patient survivals data, which were calculated by Kaplan-Meier analysis until return to dialysis/pre-emptive renal re-transplant or patient death respectively, were extracted from SRR Reports. Published data from the United States Renal Data System (USRDS) and Organ Procurement and Transplantation Network (OPTN) were used for comparisons with data from the SRR. Results: The introduction of the Human Organ Transplant Act increased the rate of deceased donor (DD) kidney transplants from 4.7 per year from 1970 to 1988, to 41.4 per year from 1988 to 2004. In 2006, the overall DD and living donor (LD) rate for kidney transplants performed locally for Singaporeans and permanent residents of Singapore was 22.6 per million population (pmp); taking into account overseas kidney transplants, the kidney transplant rate was 33.0 pmp. One and 5-year graft survivals for local LD and DD transplanted between 1999 and 2006, as reported by the SRR, were 98.1% and 95.3% versus 88.9% and 81.3%, respectively (P <0.001). Patient survivals at 1 and 5 years were likewise significantly better for LD versus DD (99.4% and 96.6% vs. 96% and 89.1%, respectively; P = 0.005). Conclusions: The local kidney transplant rates were lower than those reported by the USRDS for the USA, Spain, Norway and Australia but higher than other Asian countries. While 1-year outcomes for transplants reported to the SRR were similar to that reported by the OPTN, 5-year survivals were significantly higher, possibly due to the selection of patients with fewer co-morbidities for kidney transplantation in Singapore. These results suggest that while outcomes are excellent, there is much more to be done to increase kidney transplantation rates in Singapore so as to meet the needs of end-stage renal failure patients in the country.

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Key words: Presumed consent, Singapore Renal Registry, Living donor, Kidney transplant, Deceased donor kidney transplant, Graft survival

Introduction

Kidney transplantation is the best treatment for end-stage kidney failure. In comparison to dialysis, it offers the greatest potential for longevity and a superior quality of life. The first kidney transplant was performed in Singapore on 8 July 1970.[1] Over the next 6 years, only 17 deceased donor (DD) kidney transplants were performed. A living donor (LD) kidney transplant programme was initiated in 1976.[2] Over the 38 years since the first kidney transplant, there have been various legislative initiatives to increase the numbers of transplants and to enhance the programme. Likewise and *pari passu* with similar changes elsewhere in the world, advances in therapy have expanded the scope of kidney transplantation. Nevertheless, the demand for kidney transplants far exceeds the available supply. This has led to an increase in the numbers waiting for a kidney transplant and the consideration of strategies to further increase the numbers of transplants. This article provides an overview of kidney transplantation in Singapore and summarises the results of transplantation between 1999 and 2006, based on Singapore Renal Registry (SRR) Reports.

[1] Department of Medicine, Yong Loo Lin School of Medicine, National University of Singapore
[2] Division of Nephrology, National University Health System, Singapore
[3] National Registry of Diseases Office, Singapore
Address for Correspondence: Prof Vathsala A, Department of Medicine, Yong Loo Lin School of Medicine, National University of Singapore, 5 Lower Kent Ridge Road, Singapore 119074.
Email: vathsala@nus.edu.sg

Historical Background

Kidney transplantation developed in Singapore against a historical background of a high incidence of end-stage renal failure (ESRF). The incidence of ESRF in these early years were largely unknown. A dialysis programme was started in 1968 when 2 chronic ESRF patients were initiated on regular haemodialysis.[1] Amidst an anticipated shortage of dialysis facilities in the 1970s, the first kidney transplant was performed in Singapore on 8 July 1970 from a DD. The 5-year graft and patient survivals for these early DD renal transplants receiving Azathioprine-Prednisolone immunosuppression was 42.4% and 62.1%, respectively.[3]

The Medical (Therapy, Education and Research, MTERA) Act, passed in 1973, was the legislation by which DD kidney transplantation was performed in these early years.[4] Under this legislation, individuals could opt-in or pledge their organs, thereby permitting the removal of their organs after death for the purpose of transplantation. Unfortunately, the legislation met with limited success, as by 1987, no kidneys had been procured from individuals who had pledged their organs during their lifetime and all organs procured under this legislation were obtained following consent from the next of kin of DD. Furthermore, over the 18 years between 1970 and 1988, only 85 DD kidney transplants or 4.7 DD kidney transplants annually, had been performed in Singapore (Fig. 1), prompting the consideration of opting-out legislation.

To supplement the low numbers of DD kidney transplants performed, LD kidney transplantation was initiated and the first LD kidney transplant was performed in Singapore on 31 July 1976.[2] Although the number of LD kidney transplants increased steadily over the years (Fig. 2), these numbers were not enough to meet the increasing demand for kidney transplants. Attempts were also made to boost the number of local transplants by importing kidneys from foreign organ procurement agencies between 1983 and

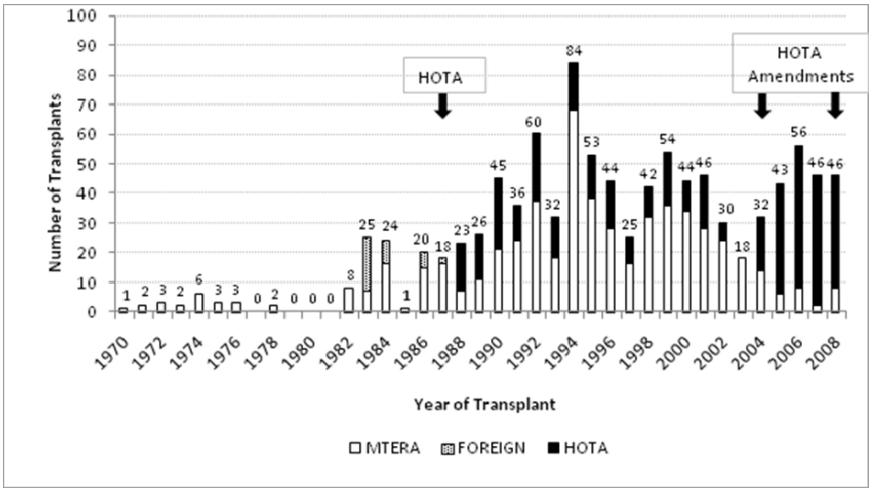


Fig. 1. Numbers of deceased donor kidney transplants in Singapore, 1970-2008.*
* Information provided by National Organ Transplant Unit, Ministry of Health, Singapore.

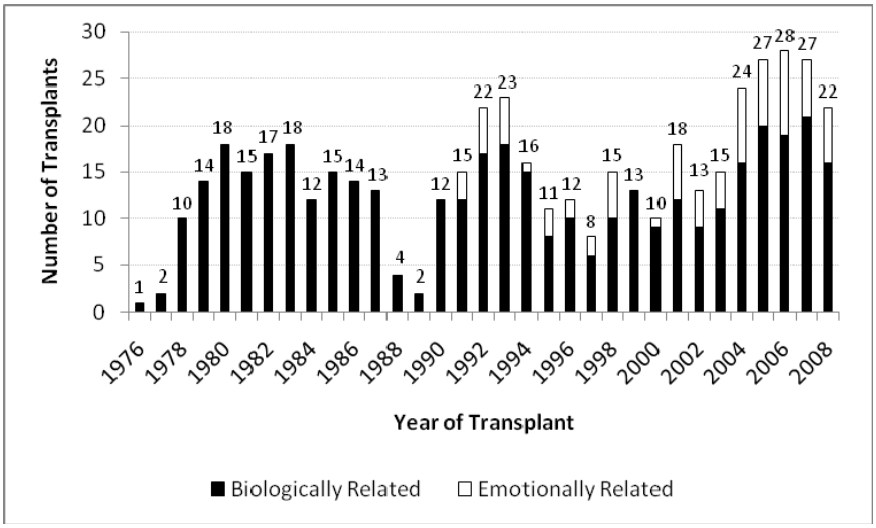


Fig. 2. Numbers of living donor kidney transplants in public sector hospitals in Singapore, 1976-2008.*
* Information provided by National Organ Transplant Unit, Ministry of Health, Singapore.

1987.[2] However the prolonged ischaemia time for these kidneys and the human leukocyte antigen (HLA) disparity between donor and recipients led to poor outcomes for the majority of these grafts. Moreover, these measures failed to allow kidney transplants to keep pace with the growing number of ESRF patients in Singapore.

Thus, after consultation with the medical community and the public, opting-out legislation known as the Human Organ Transplant Act (HOTA) was enacted in 1987 to allow for the removal of kidneys from Singaporeans and Permanent Residents of Singapore who had died in hospitals after an accidental death.[4] Under HOTA, individuals of sound mind between the ages of 21 and 60 years were presumed to have consented to kidney removal unless they had objected during their lifetime; Muslims had been then excluded from the terms of HOTA due to concerns from Muslim religious leaders. Objectors to HOTA had their objection registered with the Ministry of Health, Singapore; transplant coordinators were obliged to check the Register of Objectors prior to evaluation of potential DD for suitability for donation. The immediate impact of HOTA was an increase in the number of DD kidney transplants: over the 16 years from 1988 to 2004, 662 DD kidney transplants were performed, yielding an average of 41.4 DD kidney transplants yearly.[4,5]

However, the increasing incidence of ESRF over this time interval led to a progressive increase in the numbers of patients on the waiting list for a transplant.[5] Whereas in 1988, there were only 208 ESRF patients on the waiting list for a DD kidney transplant, by 2003, there were 673 patients.[4,5] Furthermore and notwithstanding the initial increase in DD kidney transplants following the introduction of HOTA, rates progressively fell from 2002 prompting consideration of further amendments to HOTA in 2004 (Fig. 1). The demand for other DD transplants such as those of the liver, heart and cornea and the need to provide for a regulatory framework for LD kidney transplants also served as an impetus to amend HOTA. The first amendments of HOTA, in 2004, extended the legislation to all causes of death and allowed for the inclusion of liver, heart and cornea under presumed consent legislation. The 2004 amendment also provided for the regulation of LD kidney transplants by providing for the appointment of hospital Transplant Ethics Committees (TEC). The latter were to provide oversight over LD transplants so as to ensure the absence of fraud or undue influence over the informed consent obtained from LD and to prevent organ trading. In 2008, HOTA was further amended to include Muslims. Since the amendments in 2004, the numbers of DD and unrelated LD kidney transplants have begun to increase; it remains to be seen if this increase is sustained over the coming years (Figs. 1 and 2).

As with advances in immunosuppressive therapies and techniques elsewhere in the world, the introduction of more potent immunosuppression such as Cyclosporine (CyA) in the mid 1980s and tacrolimus and mycophenolate in the 1990s also allowed the expansion of LD kidney transplants to spousal donors from 1989 and to non-related LD from 2003.[6,7] Increased experience with adult LD transplants prompted the initiation of paediatric LD and DD kidney transplantation in 1989 and 1994, respectively. Use of laparoscopic donor nephrectomies instead of the conventional open method since 2002 may have also contributed to the increase in LD kidney transplants in recent years.[8]

Current Status of Kidney Transplantation in Singapore

Currently, there are 2 public sector hospitals that perform both LD and DD kidney transplants and 3 private sector hospitals that perform LD kidney transplants in Singapore. Due to the shortage of DD kidney transplants, LD kidney transplantation is the first option for renal replacement therapy offered to ESRF patients; pre-emptive LD kidney transplantation is performed whenever possible. Potential LD, who may be related or unrelated to the recipient, are evaluated by an independent physician to ensure medical suitability and both donor and recipient are subjected to an evaluation by a psychiatrist/medical social worker to assess psychosocial suitability. After confirmation of suitability, approval must be sought from the TEC of the hospital which is entrusted with the responsibility of ensuring that informed consent acknowledging the risks of kidney donation has been obtained and that there was no evidence of coercion or any contractual obligation to donate. The TEC has to give written authorisation before the LD transplant can proceed. Individuals making a false declaration in the course of application for authorisation for LD kidney transplant would be deemed guilty of an offence and be liable on conviction to pay a fine, imprisonment or both.[9] Since 2004, outcomes of all applications for LD transplants to the TEC have to be reported to the National Organ Transplant Unit (NOTU), an organisation under the aegis of the Ministry of Health.

Dialysis patients without a willing or suitable LD are placed on the National Transplant Registry (NTR) to await a DD kidney transplant. ESRF patients over the age of 60 and those likely to have poor survival such as those with ischaemic heart disease, cerebrovascular disease and significant liver disease have been hitherto excluded from DD kidney transplantation so as to maximise utilisation of a scarce resource and to optimise outcomes. As of end 2008, there were 511 ESRF patients waiting for a DD kidney transplant in Singapore and the median waiting time for patients undergoing DD kidney transplant in Singapore was 9.44 years (Fig. 3).[5] Potential DD between

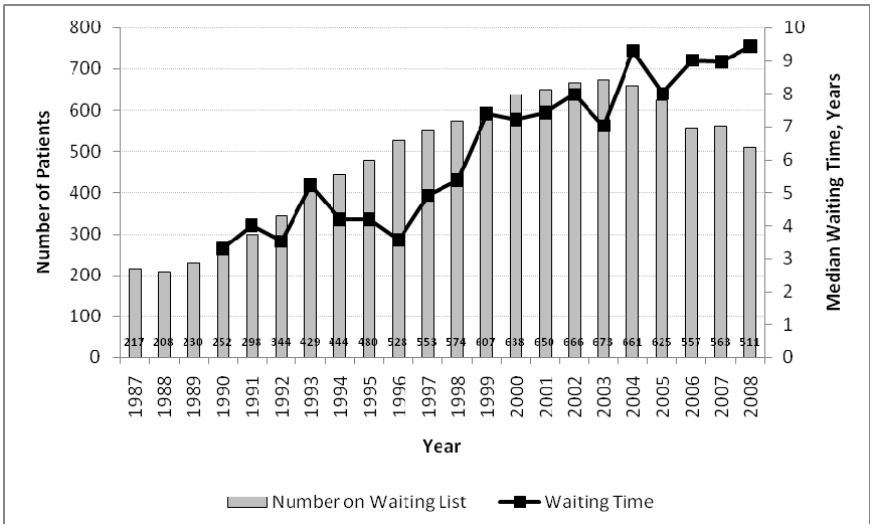


Fig. 3. Numbers of end-stage kidney failure patients on the national transplant waiting List and median waiting time for a deceased donor kidney transplant in Singapore, 1987-2008.*
* Information provided by National Organ Transplant Unit, Ministry of Health, Singapore.

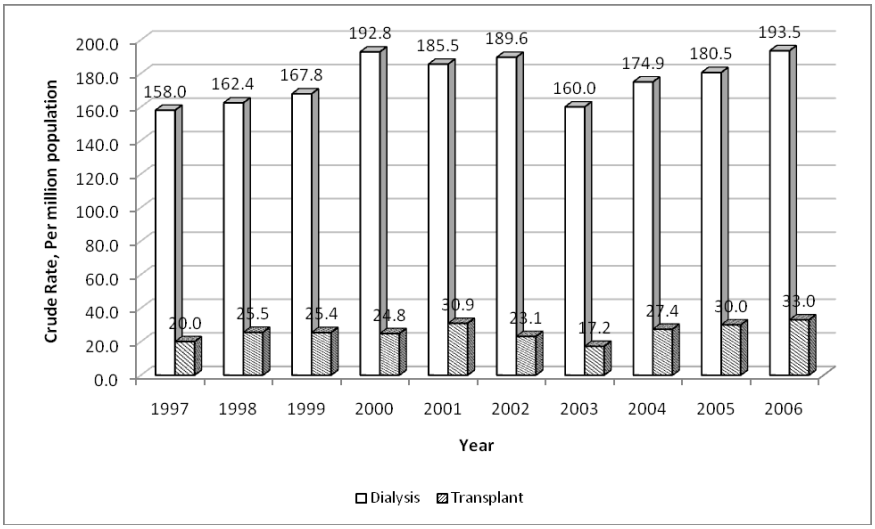


Fig. 4. Crude incident rates of end-stage kidney failure and kidney transplantation for Singaporeans and Permanent Residents, 1997-2006.*
* Information extracted from Singapore Renal Registry Reports, 1997 to 2006.[10-15]

the ages of 4 and 70 years meeting the criteria for brain stem death in intensive care units in Singapore are referred to transplant coordinators and evaluated for suitability to donate. Whereas potential DD between the ages of 21 and 60 years who had not objected during their lifetime and meeting HOTA criteria are considered under that legislation, non-objectors and those falling outside HOTA criteria are considered for suitability under MTERA. DD kidneys are transplanted into blood group identical, T-cell crossmatch negative ESRF patients on the NTR who score the highest points. Allocation is by a computerised system that attributes positive points to HLA typing and waiting time on dialysis and negative points for panel-reactive lymphocytotoxic antibodies, hepatitis and other systemic disease. Mechanisms to perform urgent DD kidney transplant for ESRF patients with poor dialysis access or severe recalcitrant anaemia have been put into place so as to take into account medical priority for kidney transplant for such cases. Audit and maintenance of data on DD referrals and transplants and administration of the Organ Donor Registry under MTERA and the Objector's Register under HOTA and the NTR also fall under the purview of NOTU.

Between 1970 and 31 December 2008, 1003 DD and 486 LD kidney transplants have been performed at public sector hospitals in Singapore. Although data on LD kidney transplants performed in private hospitals in Singapore prior to 2004 is incomplete, data has been captured by the SRR since 1997 for Singaporeans and Permanent Residents of Singapore treated with dialysis or kidney transplantation.[10-15] The present analysis includes data for Singaporeans and Permanent Residents of Singapore who had kidney transplants performed locally or outside Singapore between 1997 and 2006, whose data was captured by the SRR.

Patients and Methods

Patient demographics, recipient and donor characteristics, and co-morbidities occurring in incident and prevalent

transplant patients who are Singaporeans or Permanent Residents of Singapore were extracted from SRR Reports, tabulated and summarised. While data provision to the SRR is voluntary, it is estimated that the data are 95% complete. Incident rates for kidney transplants were extracted from the SRR Reports from 1997; data on demographics and characteristics was extracted from reports from 1999 to 2006 and that for donor characteristics from 2001 to 2006.[10-15] Published data on survival analysis were extracted from the SRR Report for 2005/2006; graft and patient survivals had been calculated by Kaplan-Meier analysis until return to dialysis/pre-emptive renal re-transplant or patient death, respectively. Published data from the United States Renal Data System (USRDS) and Organ Procurement and Transplantation Network (OPTN) were used for comparisons with data from the SRR. The USRDS is the largest and most comprehensive database for information on ESRF and kidney transplantation worldwide. While most data from this database is for ESRF and transplant patients receiving care in the USA, many international renal registries also report to the USRDS on a voluntary basis.[16] The OPTN oversees the national database of clinical information for all transplants performed in the USA.[17]

Results

Over the decade from 1997 to 2006,[10-15] the incidence of Singaporeans and Permanent Residents with new onset ESRF commencing dialysis has increased steadily, from a crude rate of 158 per million population (pmp) to 193.5 pmp (Fig. 4). The incident rates for kidney transplants for Singaporeans and Permanent Residents also increased from 20 pmp to 33.0 pmp over this time period. Indeed, the 22.5% increase in the crude rate of incident ESRF has been surpassed by a 66.5% increase in kidney transplant rate, attesting to the increasing importance of kidney transplantation as a form of renal replacement therapy in Singapore. Nevertheless and despite the increase, at best, only approximately 17% of incident ESRF patients receive kidney transplants annually. Among prevalent ESRF patients, the crude rates as of year-end 2006 for dialysis and kidney transplants were 1003 pmp (3774 patients) and 306.7 pmp (1154 patients), respectively.[15]

Recipient Characteristics

Seven hundred and thirty-six incident patients undergoing kidney transplantation between 1999 and 2006, whose data were reported to the SRR, were included in the study population for this analysis.[12-15] As shown in Table 1, the incident recipient population was predominately Chinese, in their mid-forties with glomerulonephritis (GN) as the main cause of ESRF. Although diabetic nephropathy was a cause of ESRF in 9.8%, a larger proportion (20.8%) had underlying diabetes reported as a co-morbidity. Of note was the increasing age and increasing incidence of diabetic nephropathy as cause of ESRF in incident transplants over the years (Fig. 5). Indeed in 2006, more than 50% of incident transplant patients were over the age of 49 years old. Co-morbidities of diabetes, ischaemic and cerebrovascular disease have increased over the years among incident patients, while hepatitis C has decreased over this interval (Fig. 5).

Table 1. Characteristics of Incident Transplant Recipients, 1999-2006*

	No. (%)
Number of kidney transplants	736
Male gender	408 (55.4%)
Ethnicity	
Chinese	608 (82.6%)
Malay	69 (9.4%)
Indian	48 (6.5%)
Others	11 (1.5%)
Age (y)	
0-19	20 (2.7%)
20-29	59 (8.0%)
30-39	148 (20.1%)
40-49	260 (35.3%)
50-59	215 (29.2%)
60-69	29 (4.0%)
70-79	5 (0.7%)
Cause of end-stage renal failure†	
Diabetic nephropathy	72 (9.8%)
Primary glomerulonephritis (GN)	503 (68.3%)
Autoimmune disease/GN with systemic manifestations	33 (4.6%)
Hypertension and renovascular disease	35 (4.8%)
Polycystic kidney disease/other cystic diseases	43 (5.8%)
Vesicoureteric reflux/chronic pyelonephritis	11 (1.5%)
Obstruction	3 (0.4%)
Miscellaneous	18 (2.4%)
Unknown	18 (2.4%)
Co-morbidities†	
Diabetes mellitus	153 (20.8%)
Ischaemic heart disease	76 (10.3%)
Cerebrovascular disease	22 (3.0%)
Peripheral vascular disease	12 (1.6%)
Chronic obstructive airways disease	19 (2.6%)
Current smoking	30 (4.1%)
Positive hepatitis B S antigen serology	18 (2.4%)
Positive anti HCV serology	36 (4.9%)

* Information extracted from Singapore Renal Registry Reports, 1999 to 2006.[12-15]

† Information available from Singapore Renal Registry Reports for 572 incident kidney transplant patients undergoing transplantation between 2001 and 2006.

Donor Characteristics

Overall, 45.7% of DD kidney transplants and 13.1% of LD kidney transplants had been performed at overseas

Table 2. Donor Characteristics for Incident Transplant Recipients, 2001-2006*

Number of deceased donor kidney transplants	414
Donor hospital for deceased donor transplants	
Local	54.3%
Overseas	45.7%
Number of living donor kidney transplants	160
Donor hospital for living donor transplants	
Local	86.9%
Overseas	13.1%
Donor relationship for living donor transplants	
Biologically related	64.4%
Emotionally related	26.3%
Neither biologically or emotionally related	9.4%

* Information extracted from Singapore Renal Registry Reports, 2001 to 2006.[13-15]

transplant centres in the period between 2001 and 2006 (Table 2).[13-15] Among LD kidney transplants, while overall, 10% were neither biologically nor emotionally related to the recipient, none of these unrelated transplants had been performed in public sector hospitals in Singapore (Fig. 2). Among 1154 prevalent patients with a functioning graft at end 2006, 29.3% had received their transplant overseas.[15]

Outcomes

Graft and patient survivals for local LD as reported by the SRR were significantly higher than for local DD transplants (Table 3).[15] As data for overseas transplants who had graft loss or patient death prior to their return to Singapore would not have been captured in the SRR database, graft survival was re-analysed after censoring for these events occurring at less than 30 days post-transplant. Censored graft survival for local LD was significantly superior (5-year graft survival of 96.5% for local LD vs. 88.1%, 87.2% and 90.7 for overseas LD, local DD or overseas DD kidney transplants, respectively; $P = 0.01$). Although there was no impact of gender or ethnicity on graft or patient survival, recipients over ≥60 years of age had significantly worse patient survival than those younger than 60 (5-year patient survival of 76.5 vs. 91.4%, $P = 0.03$).[15] Patient survivals for those with diabetic nephropathy as the underlying cause of ESRF was not significantly different (5-year patient survival 80.8% vs. 91.7%, diabetic nephropathy vs. non-diabetic nephropathy; P = NS).

Chronic rejection/chronic allograft nephropathy was the leading cause of graft loss, contributing to 76.8% of graft losses, while acute rejection caused 4.2% of graft losses recorded between 2003 and 2006 by the Renal Registry.[14,15] During this time period, the leading causes of death for kidney transplant recipients were infections (46.9%) and cardiovascular causes (21.9%).

Table 3. Outcomes for Transplant Recipients, 1999-2006*

Graft survival	
Overall 1-year	93.2%
Local living donor, 1-year†	98.1%
Local deceased donor, 1-year	88.9%
Overall 5-year	86.6%
Local living donor, 5-year†	95.3%
Local deceased donor, 5-year	81.3%
Patient survival	
Overall 1-year	96.8%
Local living donor, 1-year‡	99.4%
Local deceased donor, 1-year	96%
Overall 5-year	90.9%
Local living donor, 5-year‡	96.6%
Local deceased donor, 5-year	89.1%

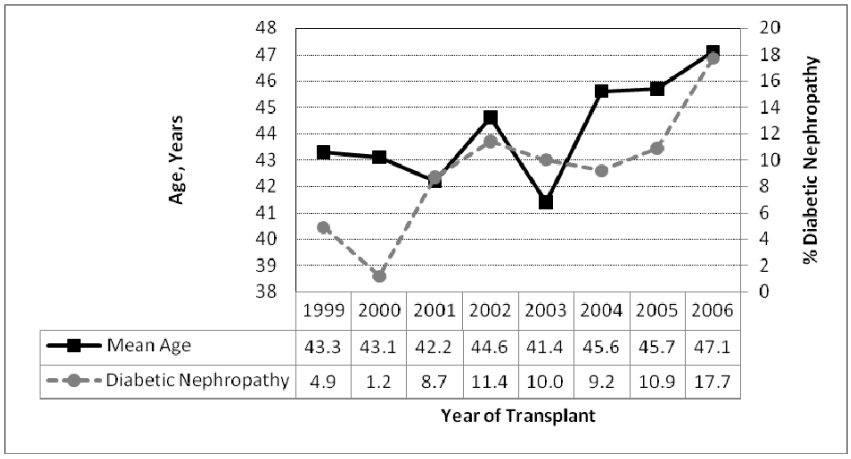
* Information extracted from Preliminary Singapore Renal Registry Report 2005/2006.[15]

† P <0.001 for graft survival of local living donor vs. local deceased donor kidney transplants.

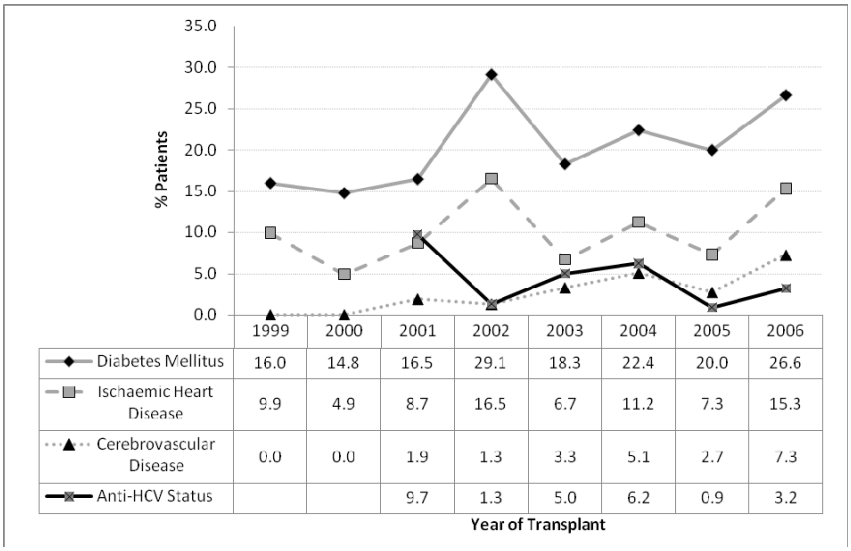
‡ P = 0.005 for patient survival of local living donor vs. local deceased donor kidney transplants.

Discussion

Many legislative measures have been put into place in Singapore to increase the availability of kidneys for transplantation and these have allowed a steady increase in the incident kidney transplant rates in the country. Nevertheless, the rates in 2005 and 2006 for kidney transplants performed locally for Singaporeans and Permanent Residents were only 18.3 and 22.6 pmp. These rates are much lower than the incident kidney transplant rates of 60.3, 60.2, 45.3 and 31.1 pmp, respectively, for 2006 in the USA, Spain, Norway, and Australia, respectively.[16] Among other Asian countries reporting to the USRDS, incident kidney transplant rates in Singapore are similar to that of the Republic of Korea (18.8 pmp) but higher than that for Malaysia (4.5 pmp), Philippines (8 pmp) or Hong Kong (9.6 pmp). This data would suggest that the legislative initiatives have helped to overcome social and cultural barriers to transplantation among Asians.[18] However, much more needs to be done in Singapore to achieve the transplant rates achieved by countries such as the USA and Spain. Indeed, approximately another third of kidney transplants registered with the SRR had received their transplants overseas. This rate of overseas transplants is higher than that reported from other registries. For instance, among 490,443 wait listed for a DD kidney transplant in the USA between 1987 and 2006, only 373 patients were removed from the wait list for reasons of foreign transplantation.[19] Given that high rates of overseas transplantation appear to occur in countries with low rates of local transplantation, it has been suggested that although overseas transplants may increase access to transplantation in the short term, they may serve instead as a hindrance to



	1999	2000	2001	2002	2003	2004	2005	2006
Mean Age	43.3	43.1	42.2	44.6	41.4	45.6	45.7	47.1
Diabetic Nephropathy	4.9	1.2	8.7	11.4	10.0	9.2	10.9	17.7



	1999	2000	2001	2002	2003	2004	2005	2006
Diabetes Mellitus	16.0	14.8	16.5	29.1	18.3	22.4	20.0	26.6
Ischaemic Heart Disease	9.9	4.9	8.7	16.5	6.7	11.2	7.3	15.3
Cerebrovascular Disease	0.0	0.0	1.9	1.3	3.3	5.1	2.7	7.3
Anti-HCV Status			9.7	1.3	5.0	6.2	0.9	3.2

Fig. 5. Trends in mean age, diabetic nephropathy as cause of end-stage renal failure and co-morbidities among incident kidney transplant recipients, 1999-2006.*
* Information extracted from Singapore Renal Registry Reports, 1999 to 2006.[12-15]

the development of successful transplant programmes within that country in the long term.[20]

Also of note is that the local kidney transplant rate reported herein of 22.6 pmp for 2006 is lower than that reported for other countries with presumed consent legislation.[16,21] The median kidney transplant rates for 15 countries with presumed consent legislation as reported for 2005 or 2006 to the USRDS was 39.5 pmp (range, 11.6 to 60.2 pmp). On the one hand, among countries with presumed consent legislation, Singapore is the only country that has an age limit on potential donors. Given the high life expectancy in Singapore, it would appear that restricting the legislation to those below the age of 60 may well prevent realisation of the full potential of HOTA. Conversely, in a systematic review of the impact of presumed consent legislation on organ donation rates, Rithalia et al[22] concluded that presumed consent was associated with an increase in organ donation rates; however, they were unable to discriminate the independent impact of infrastructure for transplantation, wealth and investment in healthcare, and public attitudes on donation rates.

The results presented herein also demonstrate the excellent outcomes for kidney transplant recipients on follow-up in Singapore. Outcomes for transplants performed between 1999 and 2006 were superior to that in the earlier azathioprine-prednisolone era of immmuno-suppression. For LD transplants performed locally from 1999 to 2006, the unadjusted 1-year graft survival of 98.1% is comparable to the unadjusted 95.1% 1-year graft survival reported by the OPTN, USA for 1997 to 2005.[17] However, 5-year graft survival for local LD grafts from our study population was significantly better at 95.3% compared to the 5-year, 80.2% graft survival reported for patients from the OPTN database. Likewise, although the 1-year patient survival for LD grafts from our study population of 99.4% was comparable to the 98% reported for patients from the OPTN database, 5-year patient survival was 96.6% for our patient population, while it was 90.3% for the USA population.

For DD grafts, a direct comparison of outcomes is not easy, as data from the OPTN is stratified by the type of donor into extended criteria donors (ECD) versus standard criteria (SC) donors, whereas data from a similar

stratification for DD transplants in Singapore is unavailable. Notwithstanding, the 1-year graft and patient survival rates for local DD grafts reported herein (88.9% and 96%, respectively) are similar to the 91.3% and 96.8% graft and patient survivals reported for SC donors from the OPTN. However, 5-year survival rates for local DD grafts were remarkably higher (81.3% and 89.1% for graft and patient survivals, respectively) than that reported by the OPTN (69.8% and 82.8%, respectively).

Whether differences in patient and donor demographics and characteristics between transplants from the 2 registries could account for the differences in 5-year outcomes was considered. The age profiles of recipients from both registries were remarkably similar. Indeed, older recipients in both Registry reports had worse graft and patient survivals than their younger counterparts. However, with reference to the underlying cause of ESRF, whereas 21% of kidney transplants are performed for diabetics in the USA, only 9.8% of kidney transplants in Singapore overall have underlying diabetic nephropathy. For instance, graft and patient survivals at 5 years were lower for diabetics receiving LD grafts in the OPTN Registry (75.9% vs. 82.1% graft survival and 83.2% vs. 93.9% patient survival for diabetes and glomerular disease, respectively). Likewise, SC DD grafts in diabetics in the OPTN database also had lower survival at 5 years (graft survival of 64.6% vs. 71.6% and patient survival of 72.1% vs. 89% for diabetes and glomerular disease, respectively). The results of worse long-term survival among diabetics from the OPTN database are in contrast to the similar outcomes among diabetics and non-diabetics from the SRR. On the one hand, the numbers of diabetics with kidney transplants in Singapore may be too small to detect significance. Alternatively, pre-selection of diabetics with fewer co-morbidities for kidney transplantation in Singapore may account for better 5-year survivals among our kidney transplant recipients. The impact of other factors such as donor characteristics, ischaemia times, immunosuppressive regimens and compliance could not be evaluated as this data is not currently available in the SRR.

The worse survivals for LD transplants undergoing kidney transplants overseas, in comparison to local LD transplants as reported herein is of concern. A similar worse outcome among recipients of commercial kidneys was reported by Rizvi et al for LD from Pakistan.[23] The authors suggested that a high prevalence of co-morbidities in the recipients prior to transplantation as well as high hepatitis rates among vendors contributed to the poor outcomes among recipients of commercial LD transplants seen at their centre. Although speculative, greater HLA mismatch between local recipients with overseas donors may have also contributed to worse outcomes among overseas LD kidney transplants.

Finally, whereas the leading causes of death for kidney transplant recipients from the USRDS database from the USA were cardiovascular causes, followed by infections, the leading causes of death for kidney transplant recipients from the SRR were infections followed by cardiovascular causes. Pre-selection of those without underlying ischaemic heart disease for kidney transplantation in Singapore may have altered the causes of death and improved 5-year patient survivals among kidney transplant recipients in the SRR. Alternatively, a different spectrum of infections with higher mortality may have contributed to a higher contribution of infections in the local context. More information on the types of infections and immunosuppressants used among study patients may also shed light on the differences in causes of mortality among local patients.

Conclusion

In summary, over the last 38 years of kidney transplantation in Singapore, there have been many organisational and legislative initiatives that have led to an increase in the incident kidney transplant rates. The introduction of HOTA legislation in Singapore in 1987 has led to a nearly 10-fold increase in DD transplants; likewise promotion of LD, together with a framework for informed consent without coercion of LD has led to an increase in LD kidney transplants. However, the rate of 22.6 pmp in 2006 still falls short of the demand and annually less than 20% of ESRF patients undergo a kidney transplant. Indeed, approximately one third receive their kidney transplants overseas, further highlighting the need to adopt additional measures to slow the progression of renal failure, and to further increase kidney donation rates in Singapore. The results reported herein also demonstrate the excellent outcomes for transplants in Singapore, likely in part due to the stringent selection criteria for potential recipients. The challenge for the future is how to provide this best form of renal replacement therapy to suitable patients in a timely manner.

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