

ORIGINAL ARTICLE

A comparative study of resource use and costs of renal, liver and heart transplantation

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Summary

Organ transplantations are among the most expensive surgical treatments performed today, but estimates of the costs of organ transplantations vary widely between settings. The aim of this study is to estimate the costs of renal, liver and heart transplantation in a university hospital, adopting a similar costing methodology for all the three kinds of transplantation. Resource use data were collected from 803 patients transplanted between January 1995 and August 2001. Data about the time physicians and other hospital employees spent per transplantation were based on interviews. All costs from pretransplantation screening up to 3 years post-transplantation were taken into account and divided into costs of patient care and programme-related costs. Mean cost of renal transplantation varied from € 70 723 for cadaveric donor transplantations to € 76 577 for living donor transplantations. Mean costs of liver transplantation were € 141 510 and the mean costs of heart transplantation were € 171 828. Direct costs of patient care contributed to 79%, 87% and 92% of the costs of renal, liver and heart transplantation respectively. Inpatient hospital days were the largest contributor to the costs of patient care. The mean number of inpatient hospital days from pretransplantation screening to 3 years post-transplantation varied from 46 days for renal transplantation from a living donor to 58 days for renal transplantation from cadaveric donors, 83 days for heart transplantation and 108 days for liver transplantation. In conclusion, costs of liver and heart transplantation were approximately 2.0 and 2.5 times higher than the cost of renal transplantation. Length of inpatient hospital stay for transplantation did not change substantially over time between 1995 and 2001.

Introduction

In the last decades, solid organ transplantation has developed from a medical experiment to an effective therapeutic treatment option for severe organ failure. Increased knowledge about treatment, improved surgical skills and reduction of organ rejection rates have improved survival rates drastically [1,2]. In addition, it has been shown that 'patients experience a dramatic improvement in quality of life following transplantation, irrespective of the nature of the transplanted organ' [3]. Only a shortage of donor organs has prevented a further increase in the numbers of transplantations in many countries [4].

In spite of their success as end-stage treatment option, transplantations are still known to be complicated therapeutical interventions with important organizational and financial consequences for the transplantation centres and their physicians. Throughout the transplantation process, a large number of different hospital departments is involved and the knowledge and experience of different kinds of specialists are required. In addition, the dependency on donor organs and the impossibility to schedule cadaveric transplantations complicate the transplantation process and these factors may contribute considerably to the high costs of transplantations.

Organ transplantations are among the most expensive surgical treatments performed today [5]. However, available data show large variation in the costs per transplantation between studies. Estimates of the costs of liver transplantations, for instance ranged from \$203 000 in the US in 1995 to € 100 000 (exchange rate 1 August 2004: 1 € is 1.20 US\$) in the Netherlands in 1996 [6,7]. Likewise, estimates of the costs of renal transplantation in the US ranged from \$54 000 in 1996 to \$84 000 in 1990 [8,9]. It is difficult to interpret and compare the results of these studies because of the different settings in which they have been performed, the different methodology that has been adopted to calculate costs and because of the different time-periods that have been taken into account.

The aim of the current study is to estimate the costs of renal, liver and heart transplantation from pretransplantation screening up to 3 years post-transplantation in a university hospital. The study was based on detailed data about hospital admissions and outpatient visits of 803 patients transplanted in the Erasmus Medical Centre Rotterdam, the Netherlands. To enable the comparison of costs between different kinds of transplantations, similar costing methodology was adopted for all the three kinds of transplantation.

Patients and methods

Data collection

The study was performed in the Erasmus MC between June 2001 and April 2002. In this study, we adopted the perspective of the healthcare provider and included all costs relevant to the Erasmus MC. Data were collected retrospectively from the hospital information system. From all patients who received a kidney, liver or heart between January 1995 and August 2001, we collected data on hospital admissions, length of hospital stay at the ICU and general wards, and outpatient visits. Because of the large number of tests and procedures that are usually performed in patients with transplantations, the data collection of medical tests and procedures was restricted to a subgroup of 30 patients for each type of transplantation. Patients in these subgroups were randomly selected from patients transplanted between January 1999 and August 2001.

In addition to the data collected from the hospital information system, an important part of the investigation consisted of interviews with physicians and other employees of the Erasmus MC who were involved in transplantations. Approximately 40 interviews were conducted with transplantation physicians, transplantation coordinators, nurses, operating room personnel, social workers, physiotherapists and dieticians. Moreover, physicians of medical supportive departments like virology,

microbiology and haematology were interviewed. During all interviews, we asked for their involvement with each type of transplantation, their activities in case of complications and about their role during pretransplantation screening, during the transplant hospitalization (i.e. usually from the day before transplantation through discharge) and during the period up to 3 years post-transplantation. During all interviews, respondents were asked to estimate the time they spent on direct care for transplanted patients and the time they spent on transplantation-related activities that did not have a direct relationship with patient care. Based on these interviews, we estimated the time physicians and other personnel spent on (i) patient care, (ii) coordination and management, and (iii) research and teaching. Only the time nurses spent per inpatient day and the time laboratory personnel spent for routinely performed tests were included in the unit costs of these procedures and not measured and valued separately.

Unit costs

Average unit costs of inpatient days and outpatient visits were derived from the hospital's accounting system and included costs of nursing personnel, medical materials, hotel costs, as well as mark-ups for the costs of housing, general equipment and overheads. Unit costs of the transplantation procedure were based on the average occupation during the surgical intervention and included the costs of all personnel of the operating theatre including anaesthesiologic assistance. The costs of materials used during the procedures were based on existing operating theatre registrations of resource use (heart transplantation) or protocols (renal and liver transplantation). Costs of physicians and hospital employees were based on actual scale salaries and included mark-ups for social security and retirement premiums. Unit costs of diagnostic tests and other procedures were based on charges. Costs of medications were based on actual purchase prices with a mark-up for the costs of the pharmacist department. A selection of unit costs of the major resource use items is presented in Table 1.

Cost calculation

Costs were calculated by multiplying the unit costs with the estimated resource use and were divided into costs of pretransplantation screening, costs of the transplant hospitalization and the costs of post-transplantation up to 3 years after transplantation. In addition, a distinction was made in costs of direct patient care and programme-related costs. All costs of complications, readmissions to the transplantation or surgical departments and all

Table 1. Unit costs of major resource use items in 2001€.

	Renal cadaveric	Renal living-related	Liver	Heart
Inpatient day ward	340	340	300	1092
Inpatient day intensive care unit			1478	1468
Outpatient visits to specialist	57	57	51	42
Transplantation procedure	5872	12 864	11 374	7090
Medical specialist (cost/h)	96	96	96	96
Nurse (cost/h)	35	35	35	35

outpatient visits during this period were taken into account. Of the costs of organ procurement, only the costs borne by the Erasmus MC were included. In practice, this concerned all costs of organ procurement in case of living-related donor transplantations and only the costs of surgeon deployment in case of cadaveric transplantations. Costs of, for instance, operating theatres used for organ procurement in other hospitals or additional transportation or travel costs were not included. Of the patients who entered the pretransplantation screening stage, approximately 50% was not transplanted (not accepted, died while on the waiting list). Hence, to obtain an estimate of the cost per transplantation, the costs of pretransplantation screening were counted twice.

Sensitivity analysis

Because the initial transplant hospitalization has been reported to be one of the main cost drivers in transplantations [10], we further explored the impact of the length of hospital stay on the cost per transplantation. Therefore, we calculated the mean length of the transplant hospitalization for each type of transplantation stratified by the years (1995–2001). By assuming that all the costs made during transplant hospitalization (except for the costs of the surgical transplantation procedure) varied linearly with the length of hospital stay, we calculated the costs per transplantation for each year, included in our analysis. Costs during pretransplantation screening and costs after the transplant hospitalization were held constant.

In a second set of sensitivity analyses, we investigated the effect of varying the proportion between patients who underwent pretransplantation screening and patients who were actually transplanted. In sensitivity analysis 7, we assumed that all patients who entered pretransplantation screening were actually transplanted, while in sensitivity analysis 8 we assumed that only one of three patients selected for pretransplantation screening were transplanted.

Results

Patients

Data were obtained from a total number of 803 patients transplanted between January 1995 and August 2001. Of these patients, 474 underwent renal transplantation, 179 liver transplantation and 150 received heart transplantation. Of the renal transplantations, approximately 62% received a kidney from a cadaveric donor and 38% from a living donor. Mean (SD) age of patients varied from 42 (14) for patients with renal transplantation from a living-related donor to 50 (13) for patients with renal transplantation from a cadaveric donor. The proportion of female patients varied from 23% for heart transplantation to 44% for renal transplantations from living-related donors (Table 2).

Resource use

Mean resource utilization from pretransplantation screening to 3 years post-transplantation is presented in Table 3. The mean number of inpatient days for renal transplantation varied from 46 days for transplantations from living related donors to 58 days for transplantations from cadaveric donors. The mean number of inpatient days for heart transplantation was 83 days and for liver transplantation 108 days. About 5% of the inpatient days for heart transplantation and 16% of the inpatient days for liver transplantation were spent on an intensive care unit. The transplant hospitalization contributed to approximately 35% of all inpatient days in patients with renal transplantation to 45% in patients with liver transplantation. Fig. 1 shows the mean length of stay of the transplant hospitalization according to the year of transplantation. The figure shows that there is no clear pattern in the length of hospital stay over time. The mean (SE) length of hospital stay immediately after renal transplantation from a cadaveric donor varied from 32 days (4) in 1995 to 19 days (1) in 1998, while the mean length of

Table 2. Patient characteristics.

	Renal cadaveric	Renal living donor	Liver	Heart
Number of patients	295	179	179	150
Female: no. (%)	109 (37)	79 (44)	78 (44)	35 (23)
Male: no. (%)	186 (63)	100 (56)	101 (56)	115 (77)
Mean (SD) age at transplantation	50 (13)	42 (14)	47 (12)	49 (14)
Year of tx: no. (%)				
≤1997	156 (53)	63 (35)	72 (40)	81 (54)
1998–1999	86 (29)	58 (32)	51 (28)	41 (27)
≥2000	54 (18)	59 (33)	57 (32)	28 (19)

Table 3. Mean resource utilization of the major resource use items per transplantation from pretransplantation screening up to 3 years post-transplantation.

	Renal cadaveric	Renal living-related	Liver	Heart
Inpatient hospital days				
General ward	58.4	46.0	91.5	78.1
Intensive care unit			16.9	4.4
Outpatient visits				
Physician	38.0	50.7	38.4	23.5
Nurse			1.8	27.2
Physician time (h)				
Direct patient care	134.9	126.0	183.6	167.0
Coordination and management	30.9	33.0	48.5	44.4
Research and teaching	59.1	59.1	37.6	47.1
Time other personnel (h)				
Direct patient care	10.2	13.5	76.8	66.9
Coordination and management	58.4	135.6	186.2	52.3
Research	94.2	94.2	184.8	108.1

stay after liver transplantation varied from 44 days (5) in 1999 to 70 days (17) in 1997. The high length of stay after liver transplantation in 1997 is mainly caused by two patients with hospitalizations of 327 and 298 days respectively.

Table 3 also shows the mean time physicians and other personnel spent per transplantation. The total time of physicians for a renal transplantation was approximately 220 h, while the time for a liver and heart transplantation was approximately 270 and 258 h respectively. The proportion of physician time directly related to patient care varied from approximately 59% for renal transplantation to 68% for liver transplantation. The total time of other personnel per transplantation varied from 163 h for a renal transplantation from a cadaveric donor to 243 h for

a renal transplantation from a living donor, 227 h for a heart transplantation and 448 h for a liver transplantation.

Costs

Costs from pretransplantation screening up to 3 years post-transplantation are presented in Table 4. Mean costs per transplantation varied from € 70 723 in renal transplantations from a cadaveric donor to € 76 577 in renal transplantations from a living donor, € 141 510 in liver transplantation and € 171 828 in heart transplantation. Costs of patient care constituted approximately 79% of the costs of renal transplantation, 87% of the costs of liver transplantation up to 92% of the costs of heart transplantation. Inpatient hospital days were the largest contributor to the costs of patient care and made up approximately 25% of the costs in patients with renal transplantation from a living donor to 53% in patients with heart transplantation. Other major contributors to the costs of patient care were the costs of medical and diagnostic procedures and the costs of physicians.

Programme-related costs consisted of the time of physicians and other personnel for coordination and management and for research and teaching. The proportion of programme-related costs for research and teaching varied from 53% in liver transplantation to 71% in renal transplantation from a cadaveric donor and in heart transplantation.

Figure 2 shows the division of costs of patient care over different stages of the transplantation process. The transplant hospitalization contributes to 46% of the costs of patient care in patients with heart transplantation to 64% in patients with liver transplantation. Because of the lower absolute costs in patients with renal transplantation, the proportion of costs in the post-transplantation stage

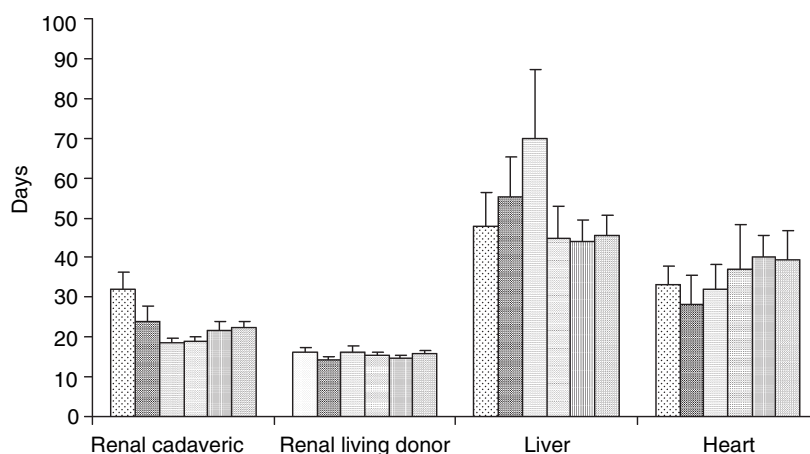
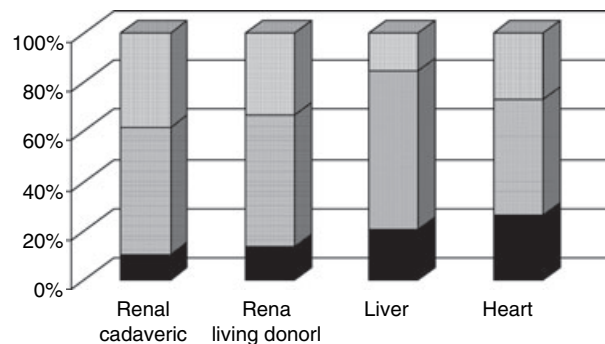
**Figure 1** Mean (SE) length of hospital stay of initial transplant hospitalization by year of transplantation. Bars in each series from left to right represent the mean length of hospital stay of the transplant hospitalization (from day before transplantation through discharge) of transplantations performed in 1995, 1996, 1997, 1998, 1999 and 2000/2001 respectively.

Table 4. Mean costs per transplantation from pretransplantation screening up to 3 years post-transplantation in 2001€.

	Renal cadaveric	Renal living donor	Liver	Heart
Costs of patient care				
Inpatient days ward	18 720	14 793	29 834	85 278
Inpatient days ICU			24 982	6461
Outpatient visits physician	2121	2826	1948	1024
Outpatient visits nurse			92	1130
Physician time	11 956	11 238	16 193	14 654
Time other personnel	54	55	2264	1229
Transplantation procedure	5872	12 864	11 374	7090
Medical/diagnostic procedures	12 137	13 114	30 713	47 867
Medication	5664	5438	13 215	8599
Subtotal	56 523	60 327	130 616	173 331
Programme-related costs				
Coordination/management	4168	6218	9257	4542
Research and teaching	10 032	10 032	10 351	11 054
Subtotal	14 200	16 250	19 608	15 596
Costs per transplantation	70 723	76 577	150 224	188 928

**Figure 2** Costs according to the stage of the transplantation. Bottom surface of each bar: costs made during pretransplantation screening; middle surface: costs made during the transplant hospitalization (from day before transplantation through discharge); and upper surface: costs of post-transplantation including all costs after the transplant hospitalization up to a maximum of 3 years.

was considerably higher for this type of transplantation (approximately 35%) than in patients with liver (15%) and in patients with heart transplantation (27%).

Sensitivity analysis

Sensitivity analyses 1–6 in Table 5 represent the mean direct costs of patient care when the length of stay of the transplant hospitalization is based on 1995, 1996, 1997, 1998, 1999 and 2000/2001 respectively. Costs of renal transplantation from a cadaveric donor varied from almost € 53 000 in sensitivity analysis 3 (based on 1997

Table 5. Sensitivity analysis on direct costs of patient care.

	Renal cadaveric	Renal living donor	Liver	Heart
Base case analysis	56 523	60 327	130 616	173 331
SA 1: los 1995	66 897	61 592	129 727	174 450
SA 2: los 1996	58 494	59 315	140 535	163 266
SA 3: los 1997	52 892	61 718	162 153	172 214
SA 4: los 1998	53 307	60 580	124 988	182 727
SA 5: los 1999	56 108	59 948	123 804	190 108
SA 6: los 2000/2001	56 938	61 086	126 025	188 542
SA 7: 1 evaluation for each transplantation	53 500	56 219	117 058	150 447
SA 7: 3 evaluations for each transplantation	59 546	64 434	144 714	196 215

los, Length of inpatient stay; SA, sensitivity analysis; SA1–SA6, costs based on length of stay of the transplant hospitalization (from day before transplantation through discharge) in 1995, 1996, 1997, 1998, 1999 and 2000/2001 respectively.

length of stay) to approximately 67 000 in sensitivity analysis 1 (1995 length of stay). Estimates of the costs of renal transplantation from a living donor varied much less and were all close to € 60 000. Estimates of the costs of heart transplantation varied between € 163 266 in sensitivity analysis 2 (1996 length of stay) and € 190 108 in analysis 5 (1999 length of stay). Estimates of the costs of liver transplantation were all between € 123 804 and € 140 535. Only in sensitivity analysis 3, the costs were much higher (€ 162 000) because of the increased mean length of hospital stay in 1997.

Sensitivity analyses 7 and 8 represent the mean direct costs of transplantations, when the proportion between patients selected for pretransplant screening and transplanted patients varied. Cost of heart transplantation were most sensitive to this proportion varying from € 150 447 when all patients selected for pretransplantation screening were actually transplanted to € 196 215 when three patients were screened for each patient transplanted.

Discussion

To our knowledge this is the first paper in which a direct comparison is made between the costs of renal, liver and heart transplantation. It was found that the cost from pretransplantation screening up to 3 years after transplantation varied from € 70 723 for a renal transplantation from a cadaveric donor to € 76 577 for a renal transplantation from a living donor, € 150 224 for a liver transplantation and € 188 928 for a heart transplantation. Costs of patient care contributed to 80% of the costs of renal transplantations and to 90% of the costs of heart transplantations.

Inpatient hospital days were the main driver of the direct costs of patient care. They contributed to approximately 25% of the costs of patient care in patients with renal transplantation from a living donor to more than 50% in patients with heart transplantation. The high costs of inpatient days for heart transplantation are remarkable, especially because the mean number of inpatient hospital days for heart transplantation was lower than for liver transplantation (82.5 and 107.4 days respectively). The high costs of heart transplantation are because of the unit cost of an inpatient day on the heart transplantation unit (€ 1092), which was approximately 3 times as high as the unit cost for an inpatient day on a ward for renal (€ 340) and liver transplantation (€ 300). An explanation can be found in different admission policies for different kinds of transplantations. Patients after liver transplantation remain on the ICU until they are stable enough to be nursed on a regular ward. On the contrary, treatment of patients undergoing heart transplantation is concentrated at the heart transplantation unit. Patients in all stages of the transplantation are admitted to this unit and may only be admitted to the ICU just before and after the transplantation. Consequently, ICU stay after heart transplantation was much shorter than after liver transplantation, but unit costs of the heart transplantation unit were much higher than on a regular ward. Another explanation for the high unit cost of the heart transplantation unit is found in the necessity for heart rhythm monitoring of patients after heart transplantation. Monitoring not only takes place during the early stages after transplantation when patients are still haemodynamic and unstable, but may also be necessary in later stages (i.e. in case of infections and other complications).

The impact of inpatient days on the costs per transplantation was further investigated by analysing the length of stay of the transplant hospitalization for different years included in our study (Fig. 1). The variation in the length of hospital stay between years was relatively modest and we did not observe a clear trend of increasing or decreasing length of stay over time. Hence, the variation in costs in sensitivity analyses 1–6, in which the costs were varied according to the length of the transplant hospitalization, was also relatively small. The combined effect of a large impact of the transplant hospitalization on total costs and the small variation in costs found in this set of sensitivity analyses, suggests that we may feel confident about the estimates of the costs per transplantation presented in this study. The sensitivity analysis also showed that the costs per transplantation were more affected by the proportion between patients entering the pretransplantation screening stage and the patients actually transplanted. When the proportion between screened and transplanted patients was set to 1, the costs of liver and heart transplantation

decreased with 10% and 13% respectively. Likewise, when this proportion was set to 3, the cost per transplantation increased with these percentages. Hence, interventions affecting the proportion between screened and transplanted patients have a considerable impact on the costs per transplantation. A long waiting list for transplantations, for instance causing patients to dropout (worsening condition and mortality) after pretransplantation screening and before transplantation should be avoided from a cost-effective perspective.

An important feature of the cadaveric transplantations is the impossibility to schedule transplantations beforehand. This may have considerable organizational consequences for the transplanting hospital. Physicians and surgeons responsible for transplantations have to be available 24-h a day. Capacity has to be freed in the operating theatre and on the ICU or general ward. In addition, in case of transplantation it often proves necessary to postpone the scheduled operating programme in one of the operating theatres. This even is true, while many of the transplantation interventions are performed during the night. In spite of these organizational consequences for the hospital and the physicians, the impossibility to schedule transplantations is only partly expressed in the costs per transplantation. Postponement of the regularly scheduled operating programme is tedious for the patients it concerns, may hinder the acceptance of the transplantation programme by other specialists in the hospital and may cause negative exposure of the hospital. However, it is almost impossible to value and to incorporate these factors into the cost per transplantation. Likewise, the burden experienced by physicians to maintain a 24-h availability is much larger than incorporated in the costs per transplantation. Hence, the ability to schedule interventions is an important advantage of living-related donor transplantations. In the Erasmus MC, the proportion of renal transplantations from living donors has increased from approximately 26% in 1995 to more than 50% in 2001. The mean direct costs of patient care were almost the same for both types of renal transplantation (€ 56 523 and € 60 327 respectively). Living donor transplantations were characterized by the higher costs of surgery as they included all costs of the surgical intervention of the donor (€ 12 864 versus € 5872) and by increased costs of care by physicians and other personnel, especially during pretransplantation screening. These higher costs were largely offset by a reduction in the costs of inpatient days of approximately € 4000 per transplantation. This even was true while the costs of inpatient days of living donor transplantations included 3 inpatient days for the donor.

The costs calculated in this analysis may be specific for the Erasmus MC and may not unalterably apply to other

settings and countries. For instance, deployment and costs of medical staff and hospital employees are factors that are likely to differ considerably between settings and may be influenced by the size of a centre's transplantation programme or the organization of the transplantation process. In addition, our estimate of the number of patients entering pretransplantation screening relative to the number of patients transplanted may be influenced by the marked organ shortage in the Netherlands and differ strongly from countries where this is not the case. Sensitivity analyses 7 and 8 showed that this latter factor considerably influenced the estimates of the cost per transplantation. Nevertheless, this study provides additional insight into the magnitude of costs associated with solid organ transplantations. Costs of all three types of transplantations were calculated the same way, and there is not much reason to believe that the proportion in costs between different kinds of transplantations varies strongly between settings or countries.

In summary, we determined the comparative costs of renal, liver and heart transplantation from the perspective of the Erasmus MC from pretransplantation screening up to 3 years post-transplantation. Costs of liver and heart transplantation were approximately 2.0 and 2.5 times as high as the cost of renal transplantation. Hospital days, diagnostic and medical procedures and physician time were the main drivers of the direct costs of patient care. Length of inpatient hospital stay for transplantations did not change substantially between 1995 and 2001.

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References

1. Bourge RC, Naftel DC, Costanzo-Nordin MR, *et al.* Pre-transplantation risk factors for death after heart transplantation: a multi-institutional study. The Transplant Cardiologists Research Database Group. *J Heart Lung Transplant* 1993; **12**: 549.
2. Vogt DP, Henderson JM, Carey WD, Barnes D. The long-term survival and causes of death in patients who survive at least 1 year after liver transplantation. *Surgery* 2002; **132**: 775.
3. Beilby S, Moss-Morris R, Painter L. Quality of life before and after heart, lung and liver transplantation. *N Z Med J* 2003; **116**: U381.
4. Yoshida K, Endo T, Saito T, Ikeda M, Kamata K, Baba S. Cadaveric renal transplantation from non-heart-beating donors with graft survival for more than 10 years. *Transplant Proc* 2002; **34**: 2604.
5. Kim WR, Therneau TM, Dickson ER, Evans RW. Preoperative predictors of resource utilization in liver transplantation. *Clin Transpl* 1995; **9**: 315.
6. Showstack J, Katz PP, Lake JR, *et al.* Resource utilization in liver transplantation: effects of patient characteristics and clinical practice. NIDDK Liver Transplantation Database Group. *Jama* 1999; **281**: 1381.
7. van Agthoven M, Metselaar HJ, Tilanus HW, de Man RA, Jn IJ, Martin van Ineveld BM. A comparison of the costs and effects of liver transplantation for acute and for chronic liver failure. *Transpl Int* 2001; **14**: 87.
8. Evans RW, Kitzmann DJ. An economic analysis of kidney transplantation. *Surg Clin North Am* 1998; **78**: 149.
9. Aswad S, Devera-Sales A, Zapanta R, Mendez R. Costs for successful vs failed kidney transplantation: a two-year follow-up. *Transplant Proc* 1993; **25**: 3069.
10. Whiting JFHN, Zavala E, Hanto D. The influence of clinical variables on hospital costs after orthotopic liver transplantation. *Surgery* 1999; **125**: 217.