**Economic Analysis of the Treatment of End-stage Renal Disease Treatment: Living-donor Kidney Transplantation Versus Hemodialysis**


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**ABSTRACT**

Introduction. End-stage renal disease (ESRD) is a major public health problem in the Spanish health system. Kidney transplantation is the treatment of choice, offering better survival and cost-effectiveness than other alternatives. This study aimed to compare the cost of living-donor kidney transplantation (LDKT) during the first year after transplantation with that of hemodialysis (HD).

Method. A prospective, descriptive study of cost and efficacy was performed in the Hospital Clinic in Barcelona from January to December 2011. We included 106 patients (57 undergoing HD and 49 receiving a LDKT). The costs of LDKT (donor and recipient) and HD were calculated based on our economic database program.

Results. The mean age of recipients and donors was 46 ± 15 and 52 ± 10 years, respectively, and 67% of the recipients were men. In HD patients, the mean age was 67 ± 11 years and 62% were men. The total cost of LDKT was €29,897.91 (€8,128.44 for donors and €21,769.47 for recipients). The total cost of HD was €43,000.88 (€37,917 for HD and related procedures plus €5,082 for transport). LDKT represented a savings of €13,102.97 per patient/year and the payback period was less than 1 year. Quality-adjusted life years were higher in LDKT than in HD patients.

Conclusion. LDKT is cost effective during the first year after transplantation and is associated with enhanced quality of life. From both the medical and economic points of view, pre-emptive LDKD should be encouraged in Spain to reduce the health budget for ESRD.

**CHRONIC KIDNEY DISEASE (CKD)** is one of the main public health problems in the Spanish health system. Currently, there are various alternatives for the treatment of end-stage renal disease (ESRD), such as hemodialysis (HD) and renal transplantation, but the costs and effectiveness of these treatments differ. Because of the continual growth in the population with ESRD in Spain, and given the current economic crisis, the greater interest of the health system in cost control and cost-effectiveness considerations are an increasingly important factor in the selection of ESRD treatment.

Renal transplantation is the treatment of choice for patients who are eligible because of their age or risk factors for ESRD because it offers better overall survival and higher quality of life than other alternatives [1]. However, the scarcity of deceased donors often leads to unacceptably long waiting lists for a kidney transplant and these patients must remain in an HD program with the consequent reduction in survival and higher costs [2,3].

Pre-emptive living-donor kidney transplantation (LDKT) has become an increasingly used option in patients on the waiting list because it improves survival and quality of life and is more effective and less costly than other alternatives [4]. In 2010 a total of 3970 patients were undergoing HD in Catalonia and the mean waiting time for a kidney transplant was 36.5 months. During the same period, only 27% of kidney transplants were from living donors. This percentage...
is much lower than that in other countries where 50% of kidney transplants are received from living donors [5,6].

The aim of this study was to compare the cost of LDKT during the first year after transplantation with that of HD during the same period and to analyze the time period that a graft would need to continue functioning to amortize the cost and make LDKT economically viable.

METHOD
A prospective, descriptive study of costs and efficacy was performed in the Hospital Clinic de Barcelona from January to December 2011. We included 106 patients (57 undergoing HD and 49 who receiving LDKT). The costs of LDKT (donor and recipient) and HD were calculated, based on our financial data program.

Calculation of Transplantation Cost
Transplantation costs included prior patient evaluation (imaging, biochemical, serological, immunological, and other tests), post-transplantation follow-up during the first year after the procedure (imaging, biochemical and serological tests, therapeutic drug monitoring of immunosuppressive therapy, re-admissions, medication, and follow-up visits), and the cost of the surgical intervention (including recipient and donor).

The cost of the surgical intervention was divided into three parts. 
Firstly, there was the expense of the surgery itself. There were staff costs including surgeons, anesthesiologists, nurses, and administrators—some of whom were paid per intervention whereas others were on-call (LDKT was considered not to have on-call cost because it is a planned procedure). There were also costs for the surgical material involved in the procedures.

Secondly, it is important to consider the expenses regarding hospitalization. These include the hospital stay (days of hospitalization by cost of hospital stay per day), hospital medical care (cost of ward staff per day of stay), laboratory use (biochemical, microbiology, etc), imaging tests (radiology, ultrasonography, etc), blood bank, drugs, and dialysis sessions.

Thirdly, there were also indirect costs to consider, including typical resources such as electricity and water, etc.

Calculation of HD Costs
The cost of HD was defined as the number of dialysis sessions per year multiplied by the cost of each session. According to the 2010 statistics report of the Catalan registry of patients with kidney disease, 96.7% of patients undergoing HD have three sessions per week. The unit cost of HD was calculated by dividing the cost of the HD session by the total number of HD sessions in 2011. This cost also included the cost of drugs, admissions, medical appointments, the cost of creating or repairing vascular access, and indirect costs.

Quality-adjusted Life Years
Quality-adjusted life years (QALYs) indicate how many extra months or years of life with a reasonable quality a patient might gain as a result of treatment. We used the results of Churchill et al [7]. Health was scored on a scale of 0 for death and 1 for perfect health. The mean values for HD and transplantation in the hospital were 0.57 and 0.80, respectively.

We compared the result of dividing the cost of transplantation by the cost of HD with the result of dividing the QALYs of transplantation with those of HD.

Statistics
The data are expressed as mean ± standard deviation or range, as appropriate. Comparisons between groups were performed using the Mann-Whitney U-test, χ² test, the Fisher exact test, or the Wilcoxon Z-test as appropriate.

RESULTS
Demographic Data
The mean age of transplant recipients was 46 ± 15 years and that of donors was 52 ± 10 years. A total of 67% of the recipients were men, the mean body mass index was 26.22 ± 11 in the recipient group, and for 89% it was a pre-emptive transplantation. The main ESRD cause was interstitial in 20%. The mean age of patients undergoing HD was 67 ± 11 years and 62% were men. The cause of the ESRD was diabetes in 29.8%. The time on HD was 27 ± 10 months, 53 patients were on the transplant waiting list (4 patients were excluded by comorbidity).

Costs of LDKT
The mean annual cost of LVKT in the first year after transplantation was 29,897.91 €.

Donor. Donor costs amounted to 27% (8,128.44 €) of the cost of LDKT. The cost of preliminary evaluation before transplantation was 1,210 € (representing 14.9% of total donor costs) and the most important component was diagnostic tests. However, the highest proportion of costs corresponded to the surgical area, representing 44.7% (3,639 €) of total donor costs (Table 1).

Other important components were days of hospital stay (the mean number of days was 5 ± 1 [3–9] in donors) and indirect costs, representing 15.5% (1,261 €) and 5.2% (419 €) of the total cost, respectively. Also important was the cost of post-transplantation follow-up, representing 11.2% (911 €) of total costs.

Recipient. Recipient costs represented 73% (21,769.47 €) of LDKT costs.

The cost of preliminary evaluation was 950 € (4.4% of total recipient costs). Surgical costs accounted for 11% (2,423 €) of total costs (Table 2). During hospital admission, the most important component corresponded to medication, representing 14.5% (3,154 €), followed by the cost of hospital stay.

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<th>Table 1. Living-donor Kidney Transplantation: Donor Costs</th>
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<td><strong>Donor Cost (€)</strong></td>
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(13.1%, 2,856.96€) and in-hospital medical care (3.5%, 754€). Indirect costs represented 3.5% (765€) of overall recipient costs. Post-transplantation follow-up represented 45.3% (9,852€) of the cost, mainly due to readmissions, chronic medical treatment (immunosuppressive drugs), and follow-up consultations.

Hemodialysis Costs

The cost of HD was 43,000.88€, of which 37,917€ corresponded to HD procedure and activity related to HD and the remainder (5,082€) to transportation (Fig 1).

**HD Sessions.** We calculated a cost of 145.3€/session and a total of 156 sessions per year/patient (96.7% had three HD sessions per week). This calculation gave a mean cost of 22,667€ per year/patient, representing 52.7% of the total cost.

**Vascular Access.** An arteriovenous fistula was used in 72.9% of the patients under HD, a tunneled catheter in 19.6%, distinct types of grafts in 4.2%, and percutaneous catheters in 3.45%. The mean annual cost of vascular access for all patients was 2,957€ (6.9% of the total cost of HD).

**Drug Consumption.** We analyzed the four most important drug groups. The first included erythropoiesis-stimulating agents. In 2010, 89.9% of patients undergoing HD required these drugs. This datum was used to obtain a cost of 2,542€/patient/year (5.9% of the overall cost of HD). The second group of drugs consisted of drugs for the treatment of calcium-phosphorus-metabolism disturbances, representing 5.7% (2,464€/patient/year) of the total cost of HD. The third and fourth groups consisted of iron and urokinase, with a mean annual cost of 400€/patient/year and 300€/patient/year, respectively. Drug costs represented 13.3% of HD costs.

**Hospitalizations.** Only hospitalizations due to CKD were included (admissions to the nephrology unit). With this restriction, the mean cost per patient/year undergoing HD was 2,370€ (5.5% of the total HD cost).

**Diagnostic Tests.** The diagnostic tests used were X-rays, ultrasonography, and scanners, as required. The mean cost was 1,540€/patient/year (3.6% of the overall cost of HD).

**Transport.** In our catchment area, collective ambulances are used for patient transport. The mean number of journeys per week was six (two per day of HD). The mean cost per patient/year was 5,082€ (11.8% of the total cost of HD).

**Indirect Costs.** Among indirect costs, we included water consumption, electricity, telephone costs, equipment maintenance, and the cost of cleaning, laundry, and administration. These costs amounted to 2,679€/patient/year (6.2% of the total cost of HD).

**Cost Effectiveness**

The difference between the total costs of the two treatment modalities was 13,102.97€ (29,897.91€ for LDKT versus 43,000.88€ for HD).

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\frac{LDKT}{HD} = \frac{29,897.91€}{43,000.81€} = 0.7
\]

\[
\frac{QALY}{QALY} = \frac{0.80}{0.57} = 1.45
\]

These two ratios show that the higher quality of life among transplant recipients was not associated with higher costs. Indeed, LDKT represented a saving of 13,102.97€/patient/year.

**DISCUSSION**

This study shows that LDKT is more cost-effective than HD, representing a savings of 13,102.97€ per patient/year. The cost recovery period for this type of transplantation is less than a year, and patients have enhanced quality of life.

Renal transplantation is the treatment of choice for suitable candidates who have CKD because it offers better survival than other alternatives, improves quality of life, and is cost-effective [4]. LDKT is a common procedure that produces excellent long-term clinical outcomes and lower morbidity than deceased-donor transplantation [8].

The results in our center show that LVKT represents a saving of 13,102.97€ patient/year compared with HD. The most important element increasing the cost of HD was the

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cost of HD sessions (52.7% of the final cost). The main cost of LDKT corresponded to the recipient (73%). Compared with the mean cost of HD in Spain (46,254 to 33,130€) and with the costs reported in other European studies [9–11], the cost of HD in our center was intermediate (40,136€).

Our results are consistent with those of other studies showing a lower cost for LDKT than for HD. QALY also showed better results in LDKT and lower cost [4,12]. In Catalonia in 2010, 360 patients undergoing HD received a transplant; among these, 27% (97 patients) received a kidney from a living donor [13]. With these data, and with only 97 patients, the savings in 2010 was 1,271,000€.

Until now, the cost recovery period in transplantation compared with HD has been reported as being 2 years because of the cost of the surgical intervention immunosuppressive therapy and re-admissions during the first year. In contrast to previous descriptions, our study shows a savings during the first year. Moreover, even in the second year after LDKT, the cost was approximately 11,000€/year, 74% less expensive than HD.

Some investigators have proposed that living donation be remunerated to increase the number of kidneys available for transplantation and to increase the cost-effectiveness of the treatment of ESRD [14]. Although donor remuneration could encourage kidney donation, thus reducing morbidity and mortality, it is prohibited in Spain. Kidney donation should be voluntary and altruistic. Consequently, we propose that LDKT be encouraged by promoting paired, or exchange, kidney donation. Selecting the best strategy to increase kidney donation could benefit many patients, increasing their survival and quality of life and reducing the costs of CKD [15].

Our study has some limitations. The data were drawn from a small population with LDKT and we did not include patients with deceased-donor transplants. The costs used for each procedure were obtained from the standard costs in our hospital and QALYs were extrapolated from another study [7].

In conclusion, LDKT is already cost-effective in first year after transplantation and is associated with an increase in QALYs. Both from the medical and economic points of view, pre-emptive kidney transplantation should be promoted in Spain to improve survival and quality of life in patients with CKD and to reduce the cost of this disease for the health system.

REFERENCES