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The cost effectiveness of lung transplantation compared with that of heart and liver transplantation in the Netherlands

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Abstract This study was performed to assess the main reasons for the unfavorable cost effectiveness of lung transplantation compared with that of heart and liver transplantation. Costs, effects, and cost-effectiveness ratios of Dutch lung, heart, and liver transplantation programs were compared. The data are based on three Dutch technology assessments of transplantation, with minor adjustments for time and methods. In result, mainly follow-up costs of lung transplantation are higher than costs of heart and liver transplantation – US $150,300, US $121,500, and US $95,300, respectively – in the first 3 years after transplantation. The survival gain realized by lung transplantation is small (4.4 years) compared with heart (8.8 years) and liver (14.7years) transplantation. Costs per life-year gained were US $77,000, US $38,000, and US $26,000 for lung, heart, and liver transplantation, respectively. The unfavorable cost effectiveness of lung transplantation is largely related to a relatively small survival gain and high follow-up costs.

Keywords Cost-benefit analysis · Lung transplantation · Liver transplantation · Heart transplantation

Introduction

In 1990 the Dutch Health Care Insurance Board initiated a comprehensive medical technology assessment (MTA) of the commencing Dutch lung transplantation program (single-center). Between 1992 and 1995, the clinical effectiveness [10], cost effectiveness [1, 7, 8], and quality of life of lung transplant candidates before and after transplantation were assessed [17]. From study results it could be concluded that lung transplantation substantially improves the survival and quality of life of lung transplant candidates. However, costs were considerable: costs per life year gained and per quality-adjusted life year (QALY) gained were US $77,000 and US $61,000, respectively [8]. Compared with the ratios found in earlier MTAs of transplants in the Netherlands (liver transplantation: costs/life year gained = US $23,300 and costs/QALY gained = US $25,600 [16]; heart transplantation: costs/ life year gained = US $29,600 and costs/QALY gained = US $36,900 [14]),

the ratios after lung transplantation are relatively high. In 1998, the Dutch Minister of Health Affairs, nevertheless, decided to include lung transplantation in the benefit package and simultaneously instituted an elucidation of factors that might improve the cost effectiveness of the program. In the present study, a head-to-head comparison between costs and effects of lung transplantation in comparison with those of heart and liver transplantation was performed.

Materials and methods

All human studies in the different transplantation programs were reviewed by the appropriate ethics committee and were, therefore, performed in accordance with the ethical standards laid down in an appropriate version of the 1964 Declaration of Helsinki. All persons gave their informed consent prior to being included in one of the mentioned transplantation programs in our study.

Data

Data from three comprehensive studies on organ transplants in the Netherlands were used: those of heart, liver, and lung transplantation [4, 5, 11, 15]. The MTA of the liver transplantation program described the results of 221 screened patients and 81 transplant recipients between 1978 and 1987, with a median follow-up after transplantation of approximately 1 year (range 0–9 years). The MTA of heart transplantation provided information on 346 screened patients and 76 transplant recipients between 1984 and 1987, with a median follow-up after transplantation of about 1.5 years (range 0–3.5 years). Finally, the MTA of lung transplantation was based on data from 303 screened and 57 transplant recipients between 1992 and 1995, with a median follow-up after transplantation of 1.1 years (range 0–5 years).

Intentionally, similar designs and methods were used in the three studies to make comparison possible. In all cases, costs and effects of existing transplantation programs were compared with estimated costs and effects if the program did not exist. The costs and effects without program needed to be estimated, since a properly controlled study in all cases was regarded as unethical for its assumed negative outcome in control patients. At second best, control data were based on careful analysis of survival and treatment costs of patients on the waiting list. In all three studies, survival gain, improvement in quality of life, and incremental costs per transplant recipient and (quality-adjusted) life year gained, among others, were assessed, from the formulae presented in Table 1.

We calculated QALYs by multiplying the life years by the average utility scores (= valuations of quality of life), and utility scores in the three different MTA studies by using EuroQol questionnaires [9]. Costs induced by patients in the program, who were ultimately not accepted for transplantation, who so far had not received a transplant, or who died before transplantation, were added to the costs of the transplant recipients. Estimates of long-term survival and treatment costs were based on data from the literature, extrapolations of collected data, and expert information.

Notwithstanding the high comparability of the three MTAs, there were some differences that should be noted. First of all, direct non-medical costs (primarily traveling costs) were considered only in the MTAs of liver and lung transplantation, whereas indirect non-medical costs (production losses due to absence from work) were included only in the latter one. Secondly, the price level at which costs were assessed differed; while costs in the MTAs of heart and liver transplantation were based on 1987 prices, costs in the MTA of lung transplantation were based on 1992 prices. Third, the time horizon of the studies differed; for the liver transplants, costs and effects were estimated until 25 years after transplantation, while in the other two programs, costs and effects were estimated from a lifetime perspective, that is, until death of the patients.

Table 1 Assessments of costs and effects in three Dutch transplantation programs: values, definitions, and formulae used

Value	Definition	Formula used
Incremental costs	Difference in costs between the situation with and without transplantation	C(i) = (C1–C2) C(i) = incremental costs C1 = cost situation with TX program C2 = cost situation without TX program (usual treatment of end-stage organ failure)
Life years gained	Gain in survival (in years) due to transplantation	S(g) = (S1–S2) S1 = survival after transplantation (in years) S2 = survival if not transplanted (based on waiting list survival)
QALYs	Quality-adjusted life years	QALYs = (survival × utility) Utility = valuation of quality of life from 0 to 1.0 (e.g., 1.5-year survival valued at 0.6 becomes 0.9 QALYs)
Gain in QALYs	Gain in quality-adjusted survival due to transplantation	Q(g) = (Q1–Q2) Q1 = QALYs with transplantation Q2 = QALYs without transplantation
Cost-effectiveness ratio	Relation between costs and effects. Effects measured in natural unit, in this case, the survival gain	Cost effectiveness ratio = C(i)/S(g) = costs per life year gained
Cost-utility ratio	Relation between costs and quality-adjusted survival	Cost-utility ratio = C(i)/Q(g) = costs per QALY gained

Comparison of the three transplantation programs

To make a fair comparison between the results of the three transplantation programs, we re-calculated for each program costs per phase and per patient, including the direct medical costs only. We indexed the costs of the heart and liver transplantation programs to 1992 prices by using price index figures of the Dutch healthcare sector. Also, we assessed the costs of liver transplantation from a lifetime perspective.

Besides costs, survival figures were also adjusted. For heart and liver transplantation, the expected number of life years after transplantation was derived from recent national data [3, 18]. From here, cost-effectiveness and cost-utility ratios of all three programs were re-calculated and compared.

Results

For lung, heart, and liver transplantation, direct medical costs per patient and per phase of the transplantation program are presented in Table 2. With the exception of the transplantation phase, average costs are lowest for liver transplants in all phases. Overall, costs are highest for lung transplants, and, particularly, costs of follow-up. In the first 3 years of follow-up, total direct medical costs per patient are US $150,300, US $121,500, and US $95,300, respectively, for lung, heart, and liver transplants.

Table 3 presents survival and quality-adjusted survival data for the different Dutch transplants. Survival after lung transplantation is low compared with that in the other two programs. Survival without transplantation is relatively high. Consequently, the survival gained by lung transplantation is small compared with the gains realized by heart and liver transplantation. When looking at quality-adjusted survival, we found that differences between the programs are somewhat smaller, but the gain is still low for lung transplantation compared with the other two programs.

The improvement in quality of life realized by transplantation is somewhat higher for lung and heart transplantation than for liver transplantation. The quality of life after transplantation is highest for lung transplantation.

Costs (including direct medical costs only) per life year and per QALY gained for lung, heart, and liver transplantation are presented in Fig. 1. Both costs per life year and per QALY gained are much higher for lung transplantation than for the other two programs (between +27% and +196%). Differences in costs per QALY gained are smaller than differences in costs per life year gained. In comparison with the other programs, liver transplantation has the most favorable ratios.

Discussion

In this study, a comparison of the cost effectiveness of Dutch lung, heart, and liver transplantation programs

Table 2 Direct medical costs of the Dutch lung, heart, and liver transplantation programs. Costs per patient and per phase of the program in US $ (1992 prices)

Phase	Lung transplantation	Heart transplantation	Liver transplantation
Screening	15,600	17,100	6,500
Transplantation operation	16,000	12,300	14,800
Follow-up			
First year[a]	92,400	73,100	61,800
Second year	30,200	24,200	14,900
Third year	27,700	24,200	18,600
Fourth year and beyond	21,700	24,200	12,900

[a]Including hospitalization in intensive care and normal care after the transplantation operation

Table 3 Average survival and quality of life (utility scores) of lung, heart, and liver transplant recipients in the Netherlands

Parameter	Lung transplantation	Heart transplantation	Liver transplantation
Survival (in years)			
With transplantation	7.4	10.2	16.6
Without transplantation	3.0	1.4	1.9
Life years gained	4.4	8.8	14.7
Quality of life: utility scores[a]			
Before transplantation	0.40	0.20	0.50
After transplantation	0.86	0.70	0.75
Improvement	0.46	0.50	0.25
QALYs			
With transplantation	6.4	7.1	12.5
Without transplantation	1.2	0.3	1.0
QALYs gained	5.2	6.8	11.5

[a]Average utility scores of patients during the period before and after transplantation. If utility scores were measured at several moments in time, we calculated the average utility score for the total period by dividing the number of QALYs by the number of survival years

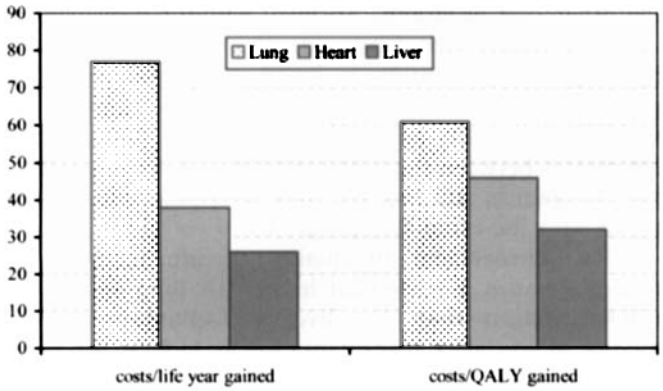

Fig. 1 Costs (including direct medical costs only) per life year (1992 prices) and QALY gained for three Dutch transplantation programs in US $ (*1000)

was made. The comparison was based on results from three Dutch transplantation studies after some adjustments for methods and differential timing of the studies. The present analysis shows that the cost effectiveness of lung transplantation is unfavorable compared with that of heart and liver transplantation. There are two main reasons for this unfavorable cost effectiveness. First of all, the survival gain is relatively small for lung transplant recipients. This is partly due to the relatively low survival after transplantation because of (1) the high risk of acute rejection, (2) the high risk of infection, and (3) the invariably high risk of bronchiolitis obliterans syndrome (BOS). Another reason for the low survival gain is the long survival of lung transplant patients on the waiting list, resulting in rather good control survival. Reasons for this high survival on the waiting list are the relatively large proportion of patients with chronic obstructive pulmonary disease or emphysema (usually with a long survival and very low quality of life while on the waiting list) and the difficulty to determine the optimal moment to place a patient on the waiting list. Well-defined and explicit criteria do not exist for determining end-stage patients for most pulmonary diseases, in contrast to heart and liver failure. A bias towards premature placement of patients on the waiting list may also be caused by the shortage of donor lungs and the allocation algorithm (first in, first out) of transplant organization. This shortage of donor lungs is also the reason that some of the patients in the lung transplantation program gain no survival at all. Especially, patients with a rapidly progressive lung disease, such as idiopathic pulmonary fibrosis or primary pulmonary hypertension, often die while on the waiting list.

A second reason for the unfavorable cost effectiveness of lung transplantation is the high follow-up costs of lung transplant recipients compared with those of heart and liver transplant recipients. High follow-up costs are mainly caused by frequent rejection and infection problems, which regularly involve hospitalization. Moreover, they can be attributed to the frequent performance of routine tests, such as ventilation and perfusion scintigraphy, bone densitometry, and bronchoscopy, in our program.

We believe that a decrease in follow-up costs or improvement in survival after transplantation are the main targets if one wants to improve the cost effectiveness of lung transplants substantially to get this program more in line with heart and liver transplantation. Observed survival rates of lung transplants in the Netherlands confirm those published by others [6, 12], and, therefore, no substantial improvements in survival are expected in the short term. Perhaps, new immunosuppressive drugs such as mycophenolate mofetil and rapamycin may improve survival.

Local or national differences with respect to waiting list management, organ donation, follow-up management after transplantation and, consequently, costs of a transplantation program, may occur. However, long waiting lists and donor organ shortage are universal problems [13, 19, 20]. MTA studies about transplantation programs with large series of patients are scarce. The calculated costs for lung transplantation in our study show approximately similar results to a recently published multicenter study from the UK [2].

A decrease in follow-up costs may be more feasible with, as primary candidate, an evaluation of frequency and number of routinely performed tests done during follow-up. Important questions are: how large would the cost savings be if a particular service (e.g., a certain laboratory test/routinely performed investigation) were to be totally or partially removed, and what would the consequences of those removals be for the survival and quality of life of the patients. Those questions are answered in an additional study that has recently been finished. In that study, the opportunities for improving the efficiency of patient screening, diagnosis, treatment, and follow-up were investigated. Besides that, the influences of changes in patient inclusion criteria and number of donor lungs on cost effectiveness were determined. The results of that study were expected at the end of 2001 and will probably provide some concrete possibilities to improve the cost effectiveness of lung transplantation.

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