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Prospective Comparative Study on Cost-Effectiveness of Subthalamic Stimulation and Best Medical Treatment in Advanced Parkinson's Disease

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Abstract: This is an open, prospective, longitudinal study designed to compare two cohorts of patients with advanced Parkinson's disease during 1 year, one undergoing bilateral subthalamic stimulation (STN-DBS) and the other receiving the best medical treatment (BMT), with respect to the clinical effects observed and the medical expenses produced. Assessments were done by using clinical measures and a generic health related quality of life scale. A questionnaire was used to collect direct healthcare resources. As a measure of cost-effectiveness, we calculated life years gained adjusted by health-related quality of life (QALY) and the incremental cost-effectiveness ratio (ICER). Clinical and demographic variables of both groups were comparable at baseline. Total UPDRS scores improved from 50.5 ± 3.6 to 28.5 ± 3.8 in STN-DBS patients and worsened from 44.3 ± 3.3 to 54.2 ± 4 in the control group. Pharmacological costs in the operated patients were 3,799 ± 940€, while in the BMT group the costs were 13,208 ± 4,966€. Other medical costs were 1,280 ± 720€ in the STN-DBS group and 4,017 ± 2,962€ in BMT patients. Nondirect medical costs were 4,079 ± 1,289 in operated patients and 2,787 ± 1,209€ in the BMT group. Mean QALYs were 0.7611 ± 0.03 in STN-DBS and 0.5401 ± 0.06 in BMT patients. In STN-DBS patients, the ICER needed to obtain an improvement of one point in the total UPDRS score was of 239.8€ and the ICER/QALY was of 34,389€. Cost-effectiveness parameters were mostly related to the degree of clinical improvement and the reduction of pharmacological costs after STN-DBS. An ICER of 34,389€/QALY is within appropriate limits to consider subthalamic stimulation as an efficient therapy. © 2007 Movement Disorder Society

Key words: Parkinson disease; subthalamic stimulation; cost-efficacy; expenses; QALY.

Parkinson's disease (PD) is one of the commonest neurodegenerative diseases with prevalence of 1.26 to 1.5% in Spain, in population consisting of people aged 65 years or more.[1-3] Although symptomatic medical and physical therapies are valuable, the development of drug-related clinical complications and the appearance of non-dopaminergic responsive symptoms dominate the mid and late course of the disease.[4] The prolonged duration of the disease along with the existence of many different pharmacological therapies make PD one of the most costly neurological conditions treated on an out-patient basis.[5]

In patients with inadequate control of parkinsonian symptoms by medical treatments, bilateral subthalamic nucleus deep brain stimulation (STN-DBS) has emerged as a surgical choice for advanced PD and has been shown to improve motor function, motor fluctuations, and health-related quality of life (HRQoL) and to reduce medication usage and drug-induced dyskinesia.[6-12] DBS was approved by the Food and Drug Administration (FDA) and the European Agency for the Evaluation of Medical Products (EMEA) for the treatment of advanced PD and is extensively used in many Western countries, but it is still considered a relatively expensive therapy. Authorities are concerned because of the increased health expenses and are taking containment measures based on the principle that the distribution of resources

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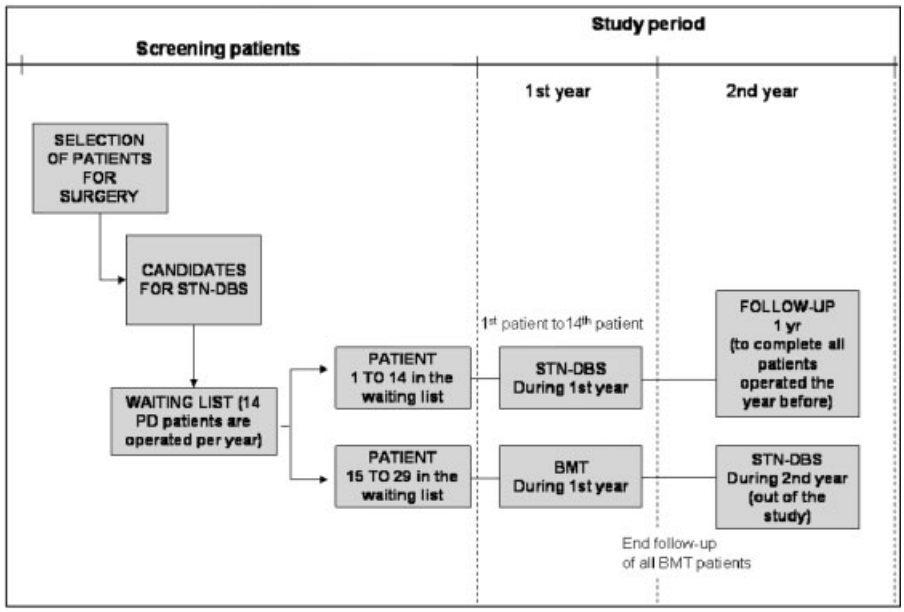

FIG. 1. Design of the study. We enrolled 14 patients in the STN-DBS group to include only those patients with PD who were going to be operated within 1 year. The patients considered for the control group, the next fifteen in the waiting list, were scheduled for STN surgery in the subsequent year. Extending the duration of the study more than 1 year was not considered, since it would have generated a prolongation of the waiting period for patients in the BMT arm.

must be supported by the efficiency and not exclusively by the direct clinical benefit.[13,14] A cost-effectiveness study can be useful to compare medical and surgical therapies in PD. We conducted a prospective study to investigate the clinical effects produced and the medical expenses generated by two different cohorts of patients during 1 year. One group of patients was treated with the best medical treatment (BMT) and the other group with STN-DBS.

METHODS

Study Design

This was an open, prospective longitudinal study comparative of the cost, effectiveness, and health-related quality of life (HRQoL) between the treatment with STN-DBS and BMT in patients with advanced PD. The study was conducted at *Hospital Clinic Universitari*, in Barcelona, capital of the Autonomic Community of Catalonia, Spain. In this Institution, the Functional Neurosurgery Programme is entirely supported by public funds and the neurological and neurosurgical teams have a 12-year experience with functional surgery for movement disorders.

Inclusion and exclusion criteria for patients to participate in the study were those used for the selection of candidates for STN-DBS.

Inclusion Criteria: Advanced PD with severe disability related to motor fluctuations, tremor or dyskinesias in which antiparkinsonian drugs had been proved to be insufficient in improving clinical conditions.

Exclusion Criteria: Age of more than 75 years, dementia or severe cognitive impairment, presence of invalidating remaining symptoms while "on," general conditions contraindicating surgery, marked brain atrophy or brain lesions on neuroimaging, less than 7 years since the diagnosis of PD, insufficient comprehension of the surgical procedure and its possible consequences, and inadequate psychosocial support.

Twenty-nine patients were enrolled in the study. All were included in a waiting list for STN-DBS at our center. The study was approved by the Ethics Committee at our Institution. All participating patients signed an informed consent form. Among the patients in the waiting list for STN-DBS, the first consecutive 14 patients were enrolled in the treatment group and the last consecutive 15 patients were enrolled in the control group. The treatment group was assigned to STN-DBS; the control group was assigned to BMT. We used an approach to allocate patients to each group that did not alter the waiting period for any patient. Twenty patients with different movement disorders are scheduled for functional neurosurgery per year but only 14 or 15 patients

TABLE 1. *Baseline characteristics of the patients included in the study*

	STN-DBS	BMT
Age and gender		
% Males	50	73
Age	59.9 ± 6.8	63.8 ± 6.4
History of the disease		
Years since diagnosis	16.9 ± 1.2	13.6 ± 1.2
Years with L-dopa	16.3 ± 1.1[a]	12.1 ± 1.2[a]
Total UPDRS	50 ± 3.2	44 ± 3.3
UPDRS-I	1.4 ± 0.5	1.5 ± 0.5
UPDRS-II	15.9 ± 1.3	11.9 ± 1.3
UPDRS-III	23.7 ± 2.3	21.1 ± 2.3
UPDRS-IV	9.6 ± 0.6	9.5 ± 0.6
Hoehn and Yahr "off" (median, range)	3.7 (2–4)	3.8 (2–4)
Hoehn and Yahr "on" (median, range)	2.4 (1.5–3)	2.5 (1.5–3)
AIMS	12.4 ± 1.1	12.4 ± 1.5
Antiparkinsonian therapy[b]		
Mean L-dopa equivalent daily dose (mg)	1343 ± 119	1305 ± 134
Daily dose of apomorphine Penject (mg)	10 ± 0 (1 patient)	15 ± 9 (4 patients)
Daily dose of apomorphine infusion (mg)	100 ± 0 (1 patient)	40 ± 34 (2 patients)

Results are shown as a mean ± standard deviation.

[a]$P = 0.02$ in the comparison of STN-DBS with BMT group.

[b]L-dopa equivalent doses were calculated using the following multiplying factors: L-dopa × 1; pergolida, pramipexol, cabergoline × 100; bromocriptine and apomorphine × 10 ; L-dopa plus entacapone × 1.3; controlled release L-dopa × 0.75.

with PD are operated in 1 year (Fig. 1). During the study, five follow-up visits were performed in the treatment group: baseline evaluation 1 month before surgery; postoperative control 10 days after surgery; and then, 3, 6, and 12 months after surgery. Patients in the BMT group received the same follow-up evaluations. A battery of standard scales were administered during each visit to determine and categorize symptoms and the clinical stage of the disease: the Unified Parkinson's Disease Rating Scale (UPDRS) and the Abnormal Involuntary Movement Scale (AIMS) administered during patients' early morning "on" condition, Hoehn and Yahr staging (measured in "on" and "off"); Activities of Daily Living score of Schwab and England (measured in "on" and "off"). Patients HRQoL outcomes were measured with a generic questionnaire (EQ-5D) validated for the Spanish population.[15] A detailed list of all medications and adverse events were collected at each visit and carefully recorded. Calculations of L-dopa equivalent doses (Table 1) were done according to previously published multiplication factors.[16]

All clinical evaluations were made by the same neurologist (OM), who was aware of the type of therapy received but who was not directly implicated in the treatment.

Healthcare Resources Utilization

The study estimated only direct costs. We divided them into two categories:

a. Direct medical costs, related to costs for goods and services used in the prevention, diagnosis, treatment, and rehabilitation of the illness (for example, costs for medical visits, hospitalization, and pharmaceuticals).
b. Direct nonmedical costs, generally assumed by the patient, including expenses related to the disease (for example, transportation, social services, adaptation of accommodation and any kind of special equipment, facilities or orthopedic material).

Data on healthcare resources consumed by the patients were collected individually per patient during each visit. Baseline data were retrospectively taken from the three previous months to verify that patients in both groups were comparable. General expenses were obtained as the product of each resource by its unitary cost in euros (€). These costs were obtained from a healthcare cost database available from a Spanish research center (SOIKOS), which provides analytical services to the public sector, industry, private insurers, and to clinical researchers.[17] Pharmacological expenses were calculated as an average cost per milligram according to the Spanish Official Price List.[18] Costs were then multiplied by the daily dose and the treatment duration for each individual patient separately.

Monthly costs for professional home care or professional care centers were obtained directly from the patients or from the specific centers. The cost of STN-DBS was obtained from the official rate paid by the Catalonian

TABLE 2. *Changes in the UPDRS and AIMS in both groups of patients at the different follow-up evaluations*

	STN-DBS		BMT	
	Total UPDRS	AIMS	Total UPDRS	AIMS
Baseline	50.5 ± 3.6	12.3 ± 1.2	44 ± 3.3	12.3 ± 1.2
3 Months	31.9 ± 3.5[a]	2.1 ± 1.2[a]	49.5 ± 3.4[a]	13.1 ± 1.2
6 Months	30.7 ± 3.5[a]	1.8 ± 1.2[a]	52.1 ± 3.4[a]	13.3 ± 1.3
12 Months	28.5 ± 3.8[a]	2.3 ± 1.4[a]	54.2 ± 4.0[a]	12.6 ± 1.2

Results are shown as a mean ± standard error.
[a]$P < 0.005$ in the comparison of STN-DBS with BMT group

Autonomous Health System (*Institut Català de la Salut*) to our hospital.[19] This rate includes all expenses related with the surgical procedure, including hospitalization, medication, operating room expenses, diagnostic procedures, DBS electrodes (Model 3389-40, Medtronic, Minneapolis, MN), the extension wires (7495-51 cm, Medtronic, Minneapolis, MN), and the dual program neurostimulator (Kinetra® Model 7428, Medtronic, Minneapolis, MN).

Cost-Effectiveness

We used the changes in UPDRS scores at 12 months compared to baseline scorings as a measure of effectiveness. Patients were asked to complete the EQ-5D questionnaire, which is an established tool to measure health-related quality of life, also in PD.[20] EQ-5D defines health in terms of five dimensions. Furthermore, EQ-5D scores may be transformed into utility values for the Spanish population (social tariff),[15] these values being usable for econometric evaluations.

Computed costs and effectiveness results permitted the calculation of the incremental cost-effectiveness ratio (ICER) that expresses the extra cost per additional unit of effectiveness when a therapeutic option is chosen instead of another. Two different ICERs were calculated:

$$\text{ICER} = \frac{\text{Cost(DBS)} - \text{Cost(BMT)}}{\text{Total UPDRS(DBS)} - \text{Total UPDRS(BMT)}}$$

$$\text{ICER} = \frac{\text{Cost(DBS)} - \text{Cost(BMT)}}{\text{QALYs(DBS)} - \text{QALYs(BMT)}}$$

The EQ-5D scores were transformed into utility values using the method previously described for the Spanish population.[15] Once the transformation from EQ-5D health states to utilities was done, QALYs could be calculated. QALYs are represented by the area under the curve, in this case shown as the sum of the different geometric areas. A QALY is "a year of future life expectancy adjusted by quality of life."[21] QALYs are a measure of effectiveness for the outcome of actions (either individual or treatment interventions) in terms of their health impact. Adjustment for quality of life bears a weighting factor ranging from 0 (death) to 1 (perfect health). If an action gives a person an extra year of healthy life expectancy, that counts as one QALY. If an action gives an extra year of unhealthy life expectancy (partly disabled or in some distress), it provides a value lower than 1. Death is rated as zero.

Statistical Analysis

Primary outcome measurements were on-medication UPDRS and EQ-5D scores and health-related costs during the 12-month follow-up. Statistical analysis of expenses, clinical measurements, and HRQoL were carried out using repeated measures ANOVA on Ranks followed by post hoc *t*-tests corrected for multiple comparisons with the method of Student–Newman–Keuls. A two-tailed probability level of 5% ($P < 0.05$) was considered significant. Statistical analysis was performed using the SPSS 10.0 software package for Windows. Patients of both groups were clinically homogeneous but an important interpersonal variability regarding the costs was observed. For this reason, results are given, except when indicated, as the mean and the standard error.

RESULTS

Baseline Demographic and Clinical Data

Table 1 shows that both groups (STN-DBS and BMT) were largely comparable in their clinical and demographic variables including mean L-dopa equivalent doses. Patients in the STN-DBS group presented a slightly longer duration of the disease ($P = 0.06$) and, accordingly, longer duration of L-dopa therapy (average treatment of 16.3 ± 1.1 in the STN-DBS group vs. 12.1 ± 1.2 years in the BMT group, $P = 0.02$).

Clinical Effects of STN-DBS

Total UPDRS scores improved from 50.5 ± 3.6 to 28.5 ± 3.8 in STN-DBS patients and worsened from

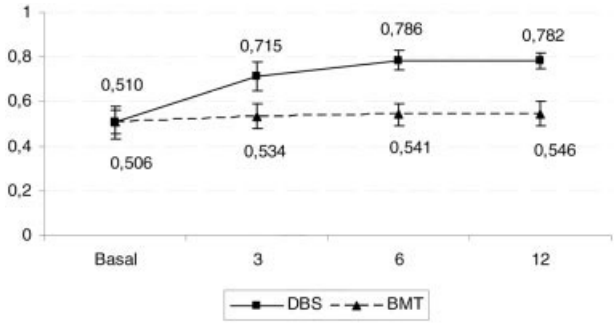

FIG. 2. Mean utilities obtained in each group of patients and in each visit. These utilities were calculated from EQ-5D punctuations applying a validated methodology for the Spanish setting. QALYs can be obtained as the area under the curve for each therapy.

44.3 ± 3.3 to 54.2 ± 4 in the control group. Changes in total UPDRS and AIMS scores during the study are shown in Table 2. In addition to the improvement of Parkinsonism observed in operated patients, dyskinesias also presented a striking reduction. The AIMS scores remained stable (from 12.4 ± 1.5 to 12.6 ± 1.4) in BMT patients; by contrast, a reduction greater than 80% (from 12.4 ± 1.1 to 2.4 ± 1.1) was observed in the operated patients.

The following adverse events were reported in the STN-DBS group: One patient presented an episode of postoperative confusion and cephalalgia that was attributed to a pneumoencephalon, which was resolved in a few days. One patient presented a lung atelectasis of the right inferior lobe in the postoperative period. After 3 months from STN-DBS treatment, one patient had an infection in the site of the STN-DBS lead connection to the extension. The infection required hospitalization and endovenous antibiotic treatment. The single adverse event reported in the BMT group was an episode of acute delirium, which required prolonged hospitalization and antipsychotic therapy.

Figure 2 shows the mean utilities reported by the patients in each visit of the study. The QALYs can be obtained by calculating the area under the curve for each group of patients, so in our study a total of 0.7611 ± 0.03 and 0.5401 ± 0.06 QALYs in STN-DBS and BMT group, respectively, were obtained.

Expenditure Related to Healthcare Services

Table 3 shows the resources consumed by each group, except medication, during the study period. The cost for the entire STN-DBS procedure was 18,456€, according to the official fare of the Catalonian Autonomous Health System (*Institut Català de la Salut*). Patients in the STN-DBS group required a higher number of neurosurgical control visits. By contrast, patients in the BMT group accumulated more emergency room visits and hospitalization days in Neurology and other Hospital Units. Most of these visits were related to PD motor complications, or adverse effects of medication. The average number of hospitalization days was higher in the BMT group mainly because of one patient who suffered a prolonged hospitalization due to dopaminergic psychosis. Despite the need for adjustment of stimulation and medication after surgery, operated patients required less visits in the Neurology Service outpatient clinic than BMT patients did during the follow-up period. Expenses from laboratory and other diagnostic tests were similar in both groups. STN-DBS patients presented slightly higher nonmedical-related costs. None of these patients had to be institutionalized in a care center and they incurred less expense for walking aids; nevertheless, STN-DBS patients spent more money on physiotherapy, speech therapy, and home care assistance than nonoperated patients. Transportation costs were also higher, since one patient of this group had to travel by plane.

Table 4 shows the different categories of pharmacological costs. Figure 3 shows the differences between groups in the cumulative costs derived from the use of antiparkinsonian and other medications used during the study period. It can be observed that pharmacological costs were similar in both groups at baseline. By contrast, in the follow-up period, the pharmacological expenses generated by STN-DBS patients were reduced by more than threefold when compared with those observed in the BMT group.

Cost-Effectiveness

A summary of the cost-effectiveness results is shown in Table 5. The ICER needed to obtain an additional improvement of one unit in the total UPDRS score was 239.8€. The incremental cost-effectiveness per QALY was of 34,389€.

Sensitivity Analysis

We performed sensitivity analyses under different situations. When we excluded the BMT patient group patient who had a prolonged hospitalization from the analysis, the incremental cost per QALY was of 44,078€ (X1.3). In this study, 2 patients in the BMT group were treated with continuous apomorphine infusion, a known expensive therapy. Consequently, we also calculated the cost-effectiveness of STN-DBS when excluding these patients, obtaining a result of 62,148€ per QALY (X1.8).

DISCUSSION

Cost-effectiveness studies compare both expenses and outcomes of different therapeutic strategies to improve

TABLE 3. *Medical and nonmedical resources in each group of patients*

	Number of items			Total costs (€)	
	STN-DBS	BMT	Cost per item	STN-DBS	BMT
Medical resources					
STN-DBS procedure	14	0	18,456	258,384	0
Number of visits					
Neurology	93	122	52.6	4,891.8	6,417.2
Neurosurgery	17	2	52.6	894.2	105.2
Emergencies	3	14	107.9	323.7	1,510.6
Others	1	11	52.6	52.6	578.6
Hospitalization (days)					
Neurosurgery[a]	17	0	372.6	6,335.4	0
Neurology	0	14	308.3	0	4,316.2
Others	0	122	282.1	0	34,407
Other procedures					
X-ray	6	5	25.4	152.3	127
TC	0	2	92	0	184
Electrocardiogram	0	1	14.6	0	14.6
Holter	1	0	119.8	119.8	0
Lab tests	3	12	11	33	132
Nonmedical resources					
Speech therapy (hr)	17	9	3.0	230.9	123.0
Physiotherapy (hr)	276	217	133	3,657.0	2,876.2
Wheelchair	2	6	331.7	663.3	1,990.8
Walking frame	2	0	153.6	307.2	0
Crutch	1	0	21.1	21.1	0
Walking stick	9	19	24.23	218.1	460.4
Home care[b]	—	—	—	38,133.4	20,009.6
Care center[b]	—	—	—	0	20,485.6
Transportation[b]	—	—	—	12,876	5,547
Others[c]	—	—	—	852.0	142.0

Unitary cost per item was obtained from a Spanish Healthcare National Database.

[a]The expenses coming from hospitalization for STN-DBS are included in the general expenses of the procedure. This item makes reference to hospitalization in the neurosurgical ward not related to electrode implantation but to subsequent complications.

[b]Total monthly cost was considered.

[c]Includes psychotherapy and swimming, which were prescribed in 2 patients.

efficiency of resource allocation and maximal population health coverage from the available resources. We designed a prospective survey to investigate the cost-effectiveness of STN-DBS compared with a control group of patients treated with the BMT. This study shows an important improvement of the total UPDRS score in the STN-DBS group compared with the patients in the BMT group and a clear reduction of pharmacological expenses in the STN-DBS group. These findings are in line with the extensive literature on this topic showing the STN-DBS antiparkinsonian efficacy and the possibility for dopaminergic medication reduction after surgery.[6-12,22-26] Current management of advanced PD includes combinations of expensive drugs and therefore savings after STN-DBS were mainly attributable to the reduction of pharmacological expenses. None of the patients in the present study required the use of apomorphine infusions after STN-DBS and oral medication was also markedly

TABLE 4. *Cumulative expenses of antiparkinsonian medication*

Medication	Cost average	
	STN-DBS	BMT
L-dopa	440 ± 85.8 [400; (90, 1,270)]	615 ± 115 [510; (149, 1,689)]
Dopamine agonists	1,588 ± 291 [1,519; (161, 3,214)]	2,390 ± 432 [2,139; (52, 6,167)]
Apomorphine	1,182 ± 1,000 [0; (0, 14,132)]	8,920 ± 4768 [0; (0, 60,081)]
ICOMT	238 ± 78 [0; (0, 706)]	883 ± 303 [0; (0, 3,567)]
Other	352 ± 276 [68; (0, 3,933)]	401 ± 311 [8; (0, 4,717)]
Total	3,799 ± 940 [3,132;(889, 14,747)]	13,208 ± 4,966 [5,950;(468, 68,432)]

Results are expressed as mean ± standard error [median; (min,max)]).

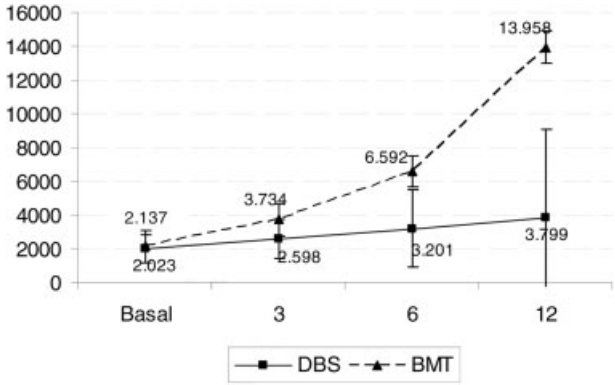

FIG. 3. Accumulative pharmacological costs during the study in both groups of patients.

reduced. Other authors also reported a reduction of 32% of the pharmacological costs 1 year after DBS in a retrospective study in 16 patients.[27] However, in our experience, savings derived from reduced pharmacological expenses did not completely compensate for the initial investment needed for STN-DBS.

The cost-effectiveness results for STN-DBS obtained in the present study, ICER per unit of improvement of the total UPDRS of 239.8€ and ICER/QALY of 34,389€, reasonably support the efficiency of STN-DBS in a Spanish setting. Other studies have shown similar results: a retrospective cost-effectiveness study of DBS in Germany in 46 parkinsonian patients[28] showed an ICER of 979€ for one point improvement of the UPDRS-III in 1 year; in this survey the annual pharmacological expenses were of 11,230€ 1 year before the implantation while of only 4,449 € 2 years after surgery. A multicentric French survey[29] observed similar improvement of UPDRS scores and decrement of PD costs. In another survey, a prospective analysis, the incremental cost per total UPDRS unit improvement turned out to be 920€.[30]

The economic burden of some therapies used in advanced PD is shown by the sensitivity analysis that we performed excluding the patients on apomorphine infusion pumps; under these conditions, the ICER/QALY for STN-DBS increased by 1.8.

The meaning and usefulness of QALY is still debated. Perfect health is hard to define and determining the level of health depends on measures that place a disproportionate importance on physical pain or disability over mental health. The interpretation of the results of cost-effectiveness analysis can be difficult, making it problematic for governmental agencies to decide whether or not a given treatment should be adopted. At present, some healthcare systems seek to approach the process by establishing a threshold monetary value for an extra QALY, but this value is significantly different across countries. For example the range of 50,000$ to 100,000$ per QALY has often been used as a rough benchmark by the United States agencies.[31] In Europe, this threshold has not been established by health authorities, but therapies with an ICER under 30,000€/QALY were considered to be efficient.[32-34]

The present specific economic parameters should be taken with caution when trying to extrapolate them to other countries or other medical centers, since expenses of STN-DBS procedure, including surgery, hospitalization, and the implanted material, were defined by the cost acknowledged by the local Sanitary Authorities instead of being calculated directly as it is done in other series. Furthermore, the use of expensive therapies like apomorphine infusions that was frequent in our patients is probably not as common in other contexts.

The present study has limitations: patients were not randomized in the two different arms but we used a widely accepted way to allocate patients in the two different therapeutic groups. All patients were in a wait-

TABLE 5. *Summary of the costs and cost-effectiveness calculations for each group of patients*

	STN-DBS	BMT	Absolute difference
STN-DBS device and procedure	18,456 ± 0	—	
Pharmacological	3,799 ± 940 [3,132; (889, 14,747)]	13,208 ± 4,966 [5,950; (468, 68,432)]	
Direct medical (except medication)	1,280 ± 720 [473; (263, 10,580)]	4,017 ± 2,962 [2,962; (316, 45,317)]	
Direct nonmedical costs	4,079 ± 1,287 [2,347; (159, 14,771)]	2,787 ± 1,209 [1,020; (224, 18,385)]	
Total cost	27,614 ± 1,788 [25,161; (20,662, 38,806)]	20,013 ± 7,777 [8,400; (1,066, 119,118)]	7,601 ± 2,060
Change total UPDRS	−21.5	10.2	31.7
ICER (€ per unit of improvement UPDRS in each group)			239.8
QALYs	0.7611 ± 0.04[0.8; (0.57, 0.96)]	0.5401± 0.05 [0.57; (0.06, 0.81)]	0.221
ICER (€ per QALY)			34,389

Results are expressed as mean ± standard error [median; (min,max)]).

ing list for surgery, which required strict inclusion criteria, making it unlikely that the two groups had different clinical characteristics; evaluations were not blinded to the arm group, but all of them were carried out by a neurologist who was not implicated in the neurosurgical program; indirect costs were not assessed in our study, despite the potential relevance of this type of information,[35] but all patients were on permanent sick leave at the beginning of the study and all of them remained in the same condition after STN-DBS. Consequently, the impact of this type of costs was probably of little magnitude.

A cost-effectiveness study has been published with the aim of assessing the long term cost-effectiveness of DBS versus best medical treatment.[36] The authors used modeling techniques to predict long-term clinical and economical consequences of using DBS and best medical treatment in advanced PD patients, showing that DBS may be an efficient therapy to treat PD patients. Such mathematical models can be useful to predict long-term cost-effectiveness, considering that long-term studies are difficult to perform in clinical practice. It is likely that such positive cost-effectiveness results would extend at least to the next 2 or 3 years after the intervention. This possibility was suggested in a survey, which showed a 32% increase in total costs during the first year after surgery but a reduction of 54% for the second year, when compared to preoperative values.[27] Our study had a 1-year follow-up, a period of time that can be considered to be too short. However, the present study has one of the longest follow-up periods when compared with previous surveys in this field.

Regardless of these limitations, the findings of the present survey strongly indicate that STN-DBS is a cost-effective therapy in the treatment of advanced PD. Cost-effectiveness is directly related to clinical improvement in parkinsonism and to the reduction of pharmacological expenses after the intervention. As shown by others,[27-30] the present survey in the Spanish setting shows that STN-DBS is within the adequate limits to be considered as an efficient therapy.

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