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Cerebral palsy and stereotactic neurosurgery: long term results

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SUMMARY A retrospective study was performed on a group of 28 patients with cerebral palsy, who had undergone a stereotactic encephalotomy for hyperkinesia or dystonia. The mean postoperative follow up period was 21 years (range: 12–27). Eighteen patients were available for follow up, nine had died, and one could not be traced. A positive result was obtained in eight of the 18 reassessed patients. Determining factors for the outcome were the degree of preoperative disability, side effects of the operation, and ageing since operation. The more favourable results were obtained in patients with hyperkinesia, tremor, and predominantly unilateral dystonia.

Cerebral palsy, including the postnatal type, includes a group of non-progressive disorders occurring at any stage of development and maturation of the brain up to the age of 4 years, causing impairment of motor function. This impairment may include paresis, involuntary movement, lack of coordination or spasticity. Other symptoms may contribute to the seriousness of the disability, such as sensory disturbances, intellectual impairment, reduced vision, deafness, abnormal speech or language development and epilepsy. Motor disorders which are transient, the result of a progressive brain disease or abnormalities of the spinal cord are excluded.[1,2]

Stereotactic encephalotomy has been used since 1950 in the management of cerebral palsy for the symptomatic treatment of dyskinesia, rigidity and spasticity.[3] There have been conflicting results; the discrepancies are possibly due to patient selection, differences in operative technique, ways of assessing results, duration of postoperative follow up and type of follow up care.[4–16]

In this paper we describe the results of stereotactic surgery after a mean postoperative follow up period of 21 years and the factors influencing the outcome. The effects of the operation on social functioning and autonomy, and the place of stereotactic encephalotomy in the management of cerebral palsy are discussed.

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Patients and methods

In the spring of 1986 a retrospective study was carried out to analyse the outcome of stereotactic encephalotomy in 28 cerebral palsy patients, who had been operated upon during the period 1958–74. Pre-operative clinical and operative data are shown in table 1.

At the time of the first operation, eight patients were 5–14 years of age, 10 patients 15–19 years, and 10 patients 20 years of age or older. The aetiology was prenatal or perinatal in 18 patients, involving asphyxia in 11, prematurity in four, and unspecified in three. Eight patients developed symptoms in the postnatal period before 4 years of age; four owing to kernicterus and four to encephalitis. For two patients the aetiology was unknown. All patients were classified according to Balf and Ingram.[17] Dyskinesia was the main symptom in 16 patients with dystonic posturing and movement. Five of these patients also showed action/intention dyskinesia, two showed ballistic movements, two myorhythmia and one rest tremor. There was spasticity (diplegia spastica and "mixed type") in 11 patients. Seven patients had only unilateral symptoms.

The patients were divided into three groups according to the principal symptom at which surgical treatment was aimed (table 2). Group A consisted of seven patients with hemidystonia, and two patients, Nos 3 and 24, with a generalised dystonia. Spasticity was not an indication for operation.

A Dutch scale "Activities of Daily Life" (ADL) was used. This consisted of six items: mental function, communication, locomotion, feeding, dressing and hygiene. Each item was divided into a 6 point scale, ranging from 5 = normal functioning to 0 = severely disturbed or absence of function (see Appendix). The degree of disability was expressed by adding the score of the last four items of the ADL scale (locomotion, feeding, dressing, hygiene): 0–4 points (very severe disability) = Grade 0; 5–9 points (severe disability) = Grade 1; 10–14 points (moderate disability) = Grade 2; 15–

Table 1 *Patients' data*

No	Sex	Year of birth	Aetiology	Classification following Balf & Ingram[17]	Degree of disability	Principal operation symptom	Operation age (yr)	Operation Target point		Examined in 1986	Cause of death
1	M	1941	praematuritas	dyskinesia tetraplegic severe	0	generalised dystonia	17 18 18	GP Thal. GP	L R R	yes	
2	M	1928	encephalitis	mixed type hemiplegic severe	3	painful dystonic posturing	29 35 36	GP + Thal. Thal. GP	R R R	No	1983 unknown
3	F	1922	encephalitis	dyskinesia tetraplegic mod. severe	2	painful dystonic posturing	36	GP	R	No	1984, unknown
4	F	1940	kernicterus	dyskinesia hemiplegic mod. severe	2	painful dystonic posturing	19	GP	R	Yes	
5	M	1952	asphyxia	mixed type tetraplegic severe	0	generalised dystonia	8 8 21 21 22	GP GP dentatotomy dentatotomy GP + Thal.	L L L/R L/R R	No	1979, status epilepticus
6	M	1944	praematuritas	dyskinesia tetraplegic severe	0	generalised dystonia	16 16 17	(Sub)Thal. GP Thal.	R R L	No	1963, unknown
7	M	1942	asphyxia	dyskinesia hemiplegic mod. severe	3	painful dystonic posturing	19	GP	R	No	1986, pancrease carcinoma
8	F	1953	asphyxia	mixed type tetraplegic severe	2	action/ intention dyskinesia	8	Thal.	R	No	1967, unknown
9	M	1927	unknown	diplegia spastica severe	1	generalised dystonia	34	Thal.	L	Yes	
10	F	1941	asphyxia	dyskinesia tetraplegic mod. severe	2	ballistic movements	20	(Sub)Thal.	L	Yes	
11	M	1947	kernicterus	diplegia spastica severe	0	generalised dystonia	14	Thal.	R	Yes	
12	F	1955	asphyxia	dyskinesia tetraplegic severe	0	generalised dystonia	7 7 8	Thal. GP GP	R R L	No	1963, meningoencephalitis
13	F	1942	asphyxia	dyskinesia tetraplegic mod. severe	2	myorhythmia generalised dystonia	19 20 22	Thal. (Sub)Thal. (Sub)Thal.	L L R	Yes	
14	M	1912	congenital unspecified	mixed type hemiplegic severe	3	painful dystonic posturing	51	GP + Thal.	R	No	unknown
15	F	1921	asphyxia	dyskinesia tetraplegic mod. severe	3	myorhythmia generalised dystonia	42	Thal.	L	Yes	
16	F	1917	congenital unspecified	dyskinesia hemiplegic mod. severe	3	painful dystonic posturing	46 46	GP GP	R R	Yes	
17	F	1954	congenital unspecified	mixed type tetraplegic severe	0	action/ intention dyskinesia	9	Thal.	R	No	1968, pneumonia
18	M	1955	asphyxia	mixed type tetraplegic mod. severe	2	action dyskinesia	8	Thal.	L	Yes	
19	M	1946	unknown	dyskinesia hemiplegic mod. severe	3	painful dystonic posturing	18	Thal. + GP	L	No	
20	M	1947	asphyxia	mixed type tetraplegic severe	0	generalised dystonia	16 17	Thal. Thal.	L R	Yes	
21	F	1952	praematuritas	dyskinesia tetraplegic severe	0	generalised dystonia	12 13	Thal. Thal.	L R	Yes	

Table 1 (continued)

No	Sex	Year of birth	Aetiology	Classification following Balf & Ingram[17]	Degree of disability	Principal operation symptom	Operation age (yr)	Operation Target point		Examined in 1986	Cause of death
22	F	1946	encephalitis	mixed type tetraplegic severe	0	action/ intention dyskinesia hyperkinesia	19 22	Thal. Thal.	L R	Yes	
23	M	1943	praematuritas	mixed type tetraplegic mod. severe	3	action/ intention dyskinesia hyperkinesia	21 21	Thal. Thal.	R R	Yes	
24	M	1938	kernicterus	dyskinesia tetraplegic severe	1	painful dystonic posturing	30	GP	R	Yes	
25	F	1955	asphyxia	diplegia spastica mod. severe	2	generalised dystonia	13	Thal.	R	Yes	
26	F	1952	kernicterus	dyskinesia tetraplegic severe	1	ballistic movements dystonia	18	(Sub)Thal.	R	No	
27	F	1951	encephalitis	dyskinesia hemiplegic mod. severe	2	painful dystonic posturing	21	GP + (Sub)Thal. GP + Thal.	R R	Yes	
28	F	1958	asphyxia	dyskinesia tetraplegic mod. severe	3	rest tremor	16	GP+ Thal.	L	Yes	

GP: Globus Pallidus. Thal.: ventrolateral thalamic nuclei. (Sub)Thal.: ventrolateral thalamic nuclei and subthalamic areas. L: left side.. R: right side.

19 points (slight disability) = Grade 3 and Grade 4 = normal. In the case of a score of Grade 2 for mental function or communication the patient was down-graded 1 point on the disability scale. Before stereotactic surgery, all patients had received physiotherapy and medication.

The operation target was determined by reference to the line connecting the foramen of Monro (FM) and the posterior commissure (PC), revealed by air ventriculography on a lateral and A–P skull radiograph. The coordinates used were globus pallidus: x = 6–7 mm (FM–CP distance 25 mm), y = −2/−4 mm, z = 19 mm; ventrolateral thalamic nuclei: x = 15 mm, y = +2 mm, z = 15 mm. The lesions were made by temperature controlled electrocoagulation with an electrode 2 mm in diameter with a 2 mm long bare tip.[18] Most lesions had a calculated diameter of 7–9 mm and a length of about 11 mm. A total of 55 brain lesions were made in 48 operations (table 3). Although the globus pallidus has not been the target of choice for the operative treatment in hyperkinesia since 1962, we made thereafter a lesion in this area in seven patients. In five of these, a combined pallido-ventrolateral thalamic lesion was made, extending into the subthalamic area in one patient.

At follow up, 18 of 28 patients were still alive. Seventeen were re-examined and interviewed about the operation and the postoperative course. One patient, No 26, refused to be examined, but provided written information about her clinical state, handicaps and opinion of the outcome of the operation. Patient 19 could not be traced.

In order to assess the results of stereotactic encephalotomy in these 18 patients, we used the following parameters: (1) the principal indication symptom for surgery; (2) the ADL scale profile; (3) degree of disability; (4) hand function, separately scored for each hand and (5) the patient's opinion concerning the operative outcome.

For the ADL scale we looked at changes in the ADL profile of the individual patient, and the changes in the individual six items for all 18 patients. We scored the changes as follows: − significant improvement: +2 points; moderate-slight improvement: +1 point; no change; slight-moderate deterioration: −1 point; and severe deterioration −2 points. The same scoring was used for changes in the degree of disability. For hand function, a 5 point rating scale was used ranging from 4, normal hand function, to 0, no hand function.

In order to obtain an impression of the operative influence on the autonomy and social functioning of the patients, we looked at their place of residence, profession or occupation. We scored an overall positive result if the following conditions had been met: an improvement in the principal

Table 2 *Grouping of the patients according to principal symptom at which surgical treatment was aimed*

Group A:	painful spasms and (hemi-)dystonic posturing		9 patients
Group B:	generalised dystonia		9 patients
Group C:	hyperkinesia		10 patients
	—action, intention dyskinesia	5	
	—myorhythmia and dystonia	2	
	—ballistic movement and dystonia	2	
	—rest tremor	1	

Table 3 *Operation targets, and number of operations and lesions*

Operation target	Number of patients	Number of lesions	Unilateral	Bilateral
Globus pallidus	14	21	11 (3 re-operations)	3 (1 unilateral re-operation)
Thalamus	23	32	18 (3 re-operations)	5 (1 unilateral re-operation)
Cerebellum	1	2		1

Globus pallidus: internal segment of globus pallidus. Thalamus: ventrolateral nuclear complex. Cerebellum: dentate nucleus.

operative indication symptom, a positive opinion of the patient about the result of the operation and no aggravation of the disability due to postoperative complications.

To assess the operative results in those patients who had died, we relied on information obtained from neurologists, general practitioners, or relatives. For Patients 3, 8 and 14 the postoperative data available in the hospital files only covered a 3 month period. The mean postoperative follow up period from the last operation was 21 years (range: 12–27).

Results

The results for the 18 patients who were reassessed are shown in table 4. In eight of these 18 patients a benefit had been obtained, based on improvement in the principal symptom, the effect on the degree of disability and the patient's opinion of the result of the operation. It appeared that an improvement of the principal symptom leading to surgery did not cause a reduction in the degree of disability for most patients, as of 16 patients only five showed a slight improvement in the degree of disability.

Nine patients had a positive opinion concerning the outcome of the operation, although one, Patient 24, showed an increase in the degree of disability. Six patients had a negative opinion, owing to impairment of speech, deterioration of hand function or lack of any improvement. The remaining three patients had no definite opinion because of lack of improvement (Patient 21) and side effects due to the operation in the other two patients.

Activities of daily living

Mental functioning: There was a marked improvement in one patient due to a combination of reduced disability and postoperative rehabilitation and social guidance.

Communication: There was a severe deterioration due to speech impairment in two patients after unilateral thalamotomy. Another four patients, two of whom had only unilateral surgery, showed a slight to moderate speech deterioration. One patient, however, showed a significant improvement in her severe stuttering and still had a normal speech pattern 15 years after operation.

Locomotion: Deterioration of locomotion in seven patients was not directly related to the operation. Five patients became wheelchair dependent 3–18 years postoperatively through low back pain. For Patients

Table 4 *Results of surgery for the 18 reassessed patients*

Patient	Effects on principal target symptom for surgery	Disability degree	Activities of Daily Living Scale: Mental function	Communication	Locomotion	Feeding	Dressing	Hygiene	Handfunction: Right	Left	Place of residence	Profession/ occupation	Patient's opinion	Positive operation results
1	0	(0) 0	(2) 2	(2) 2	(1) 1	(3) 3	(2) 1	(1) 0	(0) 0	(1) 1	(3) 1	(1) 1	−	
4	+	(2) 3	(5) 5	(5) 5	(4) 4	(3) 4	(3) 4	(3) 4	(4) 4	(1) 2	(4) 4	(3) 3	−	
9	+	(1) 0	(5) 5	(4) 2	(1) 1	(3) 3	(1) 1	(1) 1	(2) 1	(2) 2	(3) 1	(1) 1	−	
10	+	(2) 3	(4) 4	(4) 4	(3) 3	(3) 3	(3) 3	(3) 4	(2) 2	(2) 2	(4) 2	(2) 2	+	+
11	±	(0) 0	(1) 1	(3) 1	(1) 1	(2) 2	(0) 0	(0) 0	(0) 0	(1) 0	(1) 1	(1) 1	−	
13	+	(2) 3	(5) 5	(5) 4	(3) 4	(3) 4	(3) 4	(2) 4	(0) 1	(2) 2	(4) 2	(2) 1	+	+
15	+	(3) 3	(5) 5	(5) 5	(4) 1	(4) 5	(5) 5	(4) 4	(2) 4	(3) 3	(4) 4	(3) 3	±	
16	+	(3) 3	(5) 5	(5) 5	(4) 1	(4) 4	(4) 4	(3) 4	(4) 4	(0) 1	(2) 1	(3) 1	+	+
18	+	(2) 3	(2) 5	(4) 4	(3) 2	(3) 3	(2) 3	(3) 3	(1) 1	(2) 2	(3) 2	(2) 2	+	+
20	+	(0) 0	(5) 5	(5) 5	(0) 0	(3) 3	(0) 0	(1) 0	(0) 0	(1) 0	(3) 3	(3) 3	−	
21	+	(0) 0	(5) 5	(2) 2	(1) 1	(3) 3	(0) 1	(0) 0	(0) 0	(2) 2	(3) 1	(2) 1	±	
22	+	(0) 0	(2) 3	(2) 1	(2) 1	(2) 3	(1) 1	(0) 0	(0) 0	(0) 2	(3) 3	(1) 1	±	
23	+	(3) 3	(5) 5	(5) 5	(4) 5	(4) 4	(3) 5	(3) 5	(2) 2	(2) 3	(4) 4	(3) 2	+	+
24	+	(1) 0	(5) 5	(5) 5	(5) 1	(3) 3	(0) 0	(0) 0	(0) 0	(2) 1	(3) 2	(3) 1	+	
25	+	(2) 2	(5) 5	(4) 4	(2) 1	(3) 4	(3) 4	(3) 3	(2) 2	(0) 2	(4) 4	(2) 3	+	+
26	+	(1) 1	(5) 5	(5) 4	(1) 1	(3) 3	(1) 2	(2) 2	(2) 2	(0) 0	(3) 1	(2) 1	−	
27	+	(2) 3	(5) 5	(2) 5	(4) 3	(3) 4	(3) 4	(4) 4	(4) 4	(0) 1	(3) 4	(2) 2	+	+
28	+	(3) 3	(5) 5	(5) 4	(4) 4	(4) 4	(4) 4	(3) 4	(1) 2	(3) 3	(3) 4	(2) 3	+	+

The figures in brackets indicate the preoperative score. Handfunction scale: 4—normal handfunction; 3—impaired, still able to write and fasten buttons; 2—limited function, able to grasp an object and put it down somewhere else; 1—minimal function, able to move hand and fingers; 0—no function. Place of residence; 4—at home, more or less dependent; 3—at home, fully dependent on others; 2—sheltered accommodation; 1—a nursing home. Profession scale: 3—able to work (part-time), attend normal school, carry out majority of household duties; 2—at social work shop, attending school for the physically handicapped, doing only light household duties; 1—unable to do anything, unable to attend school.

Table 5 *Relation of clinical classification, principal operation, symptoms, disability and operations target with outcome*

Classification according to Ralf & Ingram	*Principal operation symptom group*	*Degree of disability*	*27 GP*	*GP+Th*	*GP+ (S) Th*	*GP GP+Th*	*GP+(S)Th Th*	*Th*	*(S)Th*	*Th Th*	*(S)Th (S)Th*	*GP+Cereb. GP+Th.+Cereb*
Diplegia spastica mod. severe	B	2	+									
Diplegia spastica severe	B.B	1.0						−				
Dyskinesia hemiplegic mod. severe	(A.A)A.A.A	(3.3)3.3.2	(+)+ −	(−)	+							
Dyskinesia tetraplegic mod. severe	(A) C.C.C.C.	(2) 2.2.2.3	(+)	+				±	+		+	
Dyskinesia tetraplegic severe	A (B.B)B.B C	1 (0.0)0.0 1	−	(−)−			(−)	−		±		
Mixed type hemiplegic severe	(A.A)	(3.3)		(+.−)								
Mixed type tetraplegic mod. severe	C.C	2.3						+.+				
Mixed type tetraplegic severe	(B)B (C.C)C	(0)0 (2.0)0							(+.−)	−	±	(−)

For indices of principal operation symptoms, see table 2. In brackets are the deceased patients, +: positive outcome.—: negative outcome. ±: doubtful. GP: globus pallidus; Th: ventrolateral thalamus; (S) Th: subthalamic area and ventrolateral thalamus, cercb: dentate nucleus.

24, 25 and 27 this was due to residual axial dystonia. Patient 15 had a slight hemiparesis, retained a slight myorhythmia of one leg and became obese; while Patient 16 suffered from a combination of low back pain and postural instability since a total hip replacement operation for the unaffected side. None of the patients who were wheelchair bound or bedridden prior to the operation improved sufficiently to walk with crutches or a Zimmer.

Feeding, dressing, hygiene: Thirteen patients showed an improvement in at least one of these items, but only three for all the items. The two patients with a deterioration in this category belonged to the group of very severely disabled patients.

Hand function: There was an improvement of the function of one hand in nine patients. Of these, only one belonged to the very severely disabled group. None of the patients had an improvement in both hands.

Place of residence: Of the 16 patients living at home prior to surgery, eight were still at home, two of these, Patients 20 and 22, were fully dependent on others. Five were living in sheltered accommodation and the remaining five in nursing homes.

Profession: Two patients showed an improvement on the profession scale and both had a part-time job. Of the seven patients with a reduction on this scale, three had lost their jobs because of low back pain some years after operation.

Nine patients had died, two 5 months post-operatively, and the others 6–25 years after the last operation. The cause of death is known for four patients (table 1). A positive operation result was claimed for four of these nine patients. Patients 2 and 7 carried out their profession normally, and Patients 3 and 8 showed an improvement in their principal symptom. The four severely disabled patients did not improve and Patient 14 had been institutionalised because of suicide attempts.

The relationship between clinical classification, degree of disability, location of the surgical lesion and

Table 6 *Complications due to the operation*

	Transient	*Permanent*
Paresis	9	6
Central n. VII paresis (slight)		1
Hemihypaesthesia	2	
Numbness of upper lip		1
Speech impairment		6
Dysphagia	1	
Somnolence	2	
Urinary incontinence	1	
Depression		1
Neuroma of supraorbital nerve	1	
Death (meningoencephalitis)		1

the outcome of surgery for all 28 patients is shown in table 5. It appears that: (1) all patients with a (very) severe disability had a negative outcome; (2) there was an overall improvement in most patients belonging to the categories of painful dystonic posturing (Group A) and hyperkinesia (Group C) but for only one patient operated upon for generalised dystonia (Group B). All these improved patients had a slight to moderate degree of disability; (3) there was no difference in outcome between patients with a pallidal or (sub)-thalamic lesion.

Complications (table 6): Eighteen of the 28 patients showed side effects due to the operation. Six patients had a permanent hemiparesis, of whom two, Patients 11 and 20, lost their minimal preoperative hand function and the other four had only a slight hemiparesis. Of the six patients with speech impairment, four had a unilateral operation, for thalamic lesion in three and a combined pallidal and thalamic lesion in the fourth. Although only two of the eight patients with bilateral surgery showed deterioration in speech, five already had severe speech impairment before the operation. One patient died from a meningoencephalitis. She was the only patient with an implanted intracerebral stimulation electrode for 24 hours.

Discussion

In table 7 data from the literature are compared with our results. It appears that our results are less favourable, probably owing to the long term follow up. Seven of our patients had an increase of their disability due to a continuous strain of their musculoskeletal system because of some remaining axial dystonia, despite a favourable effect of surgery on the symptom that was the principal indication for operation. On the other hand our results confirm that a positive operation result cannot be expected for a cerebral palsy patient with a severe degree of disability. Other factors that influence outcome are: the degree of damage to the development of the motor system, intelligence and perseverence, and the quality of postoperative rehabilitation.

The target point for stereotactic encephalotomy and the size of the lesion are still disputed.[4-7,19-22] Some authors advocate a lesion in the thalamic ventrolateral nuclear group extending into the subthalamic area. We performed this extension in only five patients because of concern over side effects. The relatively frequent and most transient side effects, such as mood disturbances, oculomotor paresis, gaze deficit and involuntary movements are probably due to lesions in this lower part of the diencephalon as described by Broggi[23] and Laitinen.[7]

The calculated size of the lesions in our operations was fairly extensive compared with those of some other authors. However, we wonder whether the size of their lesions was not underestimated, considering the reported temperature at the electrode tip, or whether sufficient allowance was made for shrinkage of the lesion in the course of time.

Stereotactic encephalotomy appears to be ineffective in producing a lasting relief of spasticity, despite initial favourable reports of bilateral cerebellar dentatotomy and pulvinarotomy.[12 13 20 24-28] A bilateral dentatomy was performed in one of our patients without any improvement of spasticity and dystonia.

The relatively large numbers of re-operations and complications in our patients with cerebral palsy compared with stereotactic encephalotomy for essential and Parkinsonian tremor is in agreement with previous reports.[20 23] The fact that four patients showed a deterioration of speech after unilateral operation is probably due to diffuse cerebral damage pre-operatively, as three patients had a very severe

Table 7 *Data from the literature compared with our results*

Author	*n*	*Follow up (yrs)*	*n*	*Disability Bilateral* (very) severe	*Disability Bilateral* slight moderate	*Uni-lateral n*
Narabayashi[4]	80	5–8½	62			18
Laitinen[7]	55	1–7	39	39		16
Mundinger[8]	67	1–10				
Balasubramariam[9]	94	<6	70			24
Gros[10]	10	2–15	10			
Guidetti[12]	45	?	38			7
	13	?	13	13		
	6	?				2
Mundinger[13]	36	1–4	36			
Siegfried[19]	42	3–8	38			4
Narabayashi[16]	117	5–8	117	36	81	
Ohye[14]	8	1–8				8
Broggi[15]	33	1–4	19	10	9	14
Siegfried[20]	48	5	48	39	9	
Speelman	18	12–27	15	8	7	3

degree of disability.

It is our opinion that in a patient with moderate-severe dyskinetic cerebral palsy, a stereotactic thalamotomy (ventrolateral nuclear group) can lead to lasting symptomatic improvement of hyperkinesia. This is also true for predominantly unilateral dystonia with a pallidal or thalamic lesion. Patients with a severe tetraplegic or diplegic type of cerebral palsy are not recommended for stereotactic surgery.

Our data do not lead to a conclusion about the most appropriate age for the operation, but we now postpone surgery until the patient is at least 14 years of age. The operation can then be performed with local anaesthesia, the syndrome has developed fully and is stable, and one has a good idea of the mental function, perseverence, and cooperation of the patient.

We thank Mrs E van Dongen for secretarial help.

Appendix

A Dutch Scale for Activities of Daily Living

Mental functioning: 5 = normal intelligence, —memory, —emotionality; 4 = below normal level, needs help with daily activities; 3 = can be left alone, needs guidance (activation, emotional support, explanation), especially in complicated situations; 2 = cannot be left alone, can still be nursed at home; 1 = needs permanent attention and security, cannot be nursed at home; 0 = severe dementia and permanently requiring help (institutionalised in psychiatric nursing home).

Communication: 5 = normal speech, reading and writing; 4 = communication not faultless, but good contact; 3 = difficulties in making contact, but with help and repetitions, reasonable communication; 2 = despite efforts of the partner/relative, only moderate communication; 1 = some residual contact; 0 = no contact possible.

Locomotion: 5 = normal walking, cycling, use of public transport; 4 = slight limitation (reduced speed, distance), slightly abnormal pattern; 3 = needs some support during walking, able to pay visits; 2 = needs crutches or a Zimmer, car requires adaptation; 1 = wheel-chair patient; 0 = bed-ridden patient.

Feeding: 5 = no limitations, normal cutting of meat, bread, pouring tea, chewing, swallowing; 4 = slight limitations, slightly messy, avoidance of some food or drinks; 3 = needs some help, largely normal diet; 2 = unable to have part of a normal diet, even with help; 1 = dependent on others for feeding, adjusted diet; 0 = artificial feeding by tube.

Dressing: 5 = normal, independent; 4 = independent, but some limitations in choice of dressing, needs more time; 3 = largely independent, needs help with buttons, bootlaces; 2 = largely dependent; 1 = dependent, but able to give some assistance; 0 = fully dependent, no active support possible.

Hygiene: 5 = normal, 4 = independent, needs more time, difficulties with certain tasks; 3 = needs help for certain tasks, such as washing the lower part of the body, shower, bath; 2 = a few tasks can be performed with some assistance; 1 = very limited cooperation possible; 0 = totally dependent, no cooperation possible.

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Principal symptom for surgery				*Target point*					*Result %*			
hyperkinesia	*dystonia*	*tremor*	*spasticity*	*Globus Pallidus*	*Thalamus (VL nuclei)*	*subthalamus (Z.I.)*	*dentate nucleus*	*pulvinar*	*positive*	*negative*	*unchanged*	*doubtful*
	80		±	+					90		10	
19	23		16		+	+			65	20	15	
				+	+	+			50	20	23	
3	47?	12	71?		+		+		>70			
					+	+			50	33		
	17		28			+						
3	6		4					+	46	54		
	6					+		+	66			34
			36			+	+	+	78	11	11	
							+		50		24	
		10			+				72	10	18	
	2	6			+				100			
16	11	6			+	+			97	3		
	48			+	+				51		49	
7	10	1		+	+	+	+		44	50		6

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