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Good outcome in patients with normal-pressure hydrocephalus and factors indicating poor prognosis

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Object. The authors set out to describe the outcome in a subgroup of patients with normal-pressure hydrocephalus (NPH) in whom prognostic factors were poor. This subgroup of patients who had received shunts was selected according to strict criteria.

Methods. From a cohort of 56 patients with NPH in whom shunts were placed, the authors selected a subgroup with four of the factors traditionally considered to indicate poor prognosis: idiopathic type, cortical atrophy, longstanding symptoms, and presence of dementia in addition to old age. Twelve patients met the inclusion criteria.

After receiving shunts, 92% of the patients showed clinical improvement on the NPH scale; gait improved in 100% of patients, sphincter control in 90%, and dementia in 33%. Improvement was significant for gait and sphincter control, general NPH score, and most daily life activity scales. No significant differences regarding clinical, cognitive, or functional changes following surgery were found in comparison with the rest of patients (the good prognosis subgroup).

Conclusions. The clinical condition of patients with NPH who present with traditionally accepted markers of poor prognosis can improve after surgery, especially as regards gait and sphincter control. The authors assert that the presence of these markers should not be considered to be an absolute criterion for ruling out shunt surgery in cases of NPH syndrome.

Key Words • normal-pressure hydrocephalus syndrome • surgery • neuropsychological test • prognosis • outcome

The indications for placing shunts in patients with NPH syndrome are still controversial, because surgery in these fragile patients does not always lead to a good outcome or improve quality of life. Several authors have investigated the predictive values of distinct symptoms and ancillary methods for improving prognoses. The following factors have traditionally been associated with unfavorable outcome: idiopathic form,[4,18,33,36] prolonged disease duration,[5,9,18,21,22,33,37] presence of cerebral atrophy in neuroradiological examinations,[2,21,32,33] severe dementia,[5,15,20,21,31] incomplete clinical triad,[2,12] and absence of periventricular lucencies.[3,33] The presence of some of these factors, whether isolated or in combination, does not mean, however, that outcome after surgery will necessarily be poor. To our knowledge, no study has been focused on the outcome in patients with NPH who show accepted markers of poor prognosis prior to surgery.

In a recent paper,[24] members of our department studied the influence of several known prognostic factors in patients with a confirmed diagnosis of NPH. We found that the factors clearly related to better neuropsychological and functional recovery after shunt procedures included the presence of a complete clinical triad, obliterated or normal cortical sulci size, and periventricular lucencies. Age, symptom duration, degree of preoperative dementia, and ventricular dilation were not definitively related to neuropsychological or functional changes after surgery when these factors were evaluated by an independent neuropsychologist; however, clinical or radiological factors classically associated with a poor prognosis are increasingly found in patients with suspected NPH or in those who have a mixed-type dementia (NPH associated with other neurodegenerative disorders such as Alzheimer disease or vascular dementia). Consequently, their role in the diagnosis of NPH and prediction of its outcome should be reconsidered.

The main objective of this paper was to challenge the widespread belief that patients with the classic symptoms or signs of bad outcome cannot improve after shunt procedures, especially when more than one of these signs are present. To achieve this goal, we describe the clinical and neuropsychological outcome 6 months after shunt surgery in a pilot study of a subgroup of patients with NPH who simultaneously presented the following four factors traditionally considered to be markers of poor prognosis (in addition to old age): idiopathic hydrocephalus, cortical atro-

Abbreviations used in this paper: CSF = cerebrospinal fluid; DLAS = Daily Life Activities Scale; ICP = intracranial pressure; IQCODE = Informant Questionnaire on Cognitive Decline in the Elderly; MMSE = Mini-Mental State Examination; NPH = normal-pressure hydrocephalus; R_{out} = resistance to outflow; RDRS-2 = Rapid Disability Rating Scale-2; SLS = Stein and Langfit Scale; TMT = Trail Making Test; WMS = Wechsler Memory Scale.

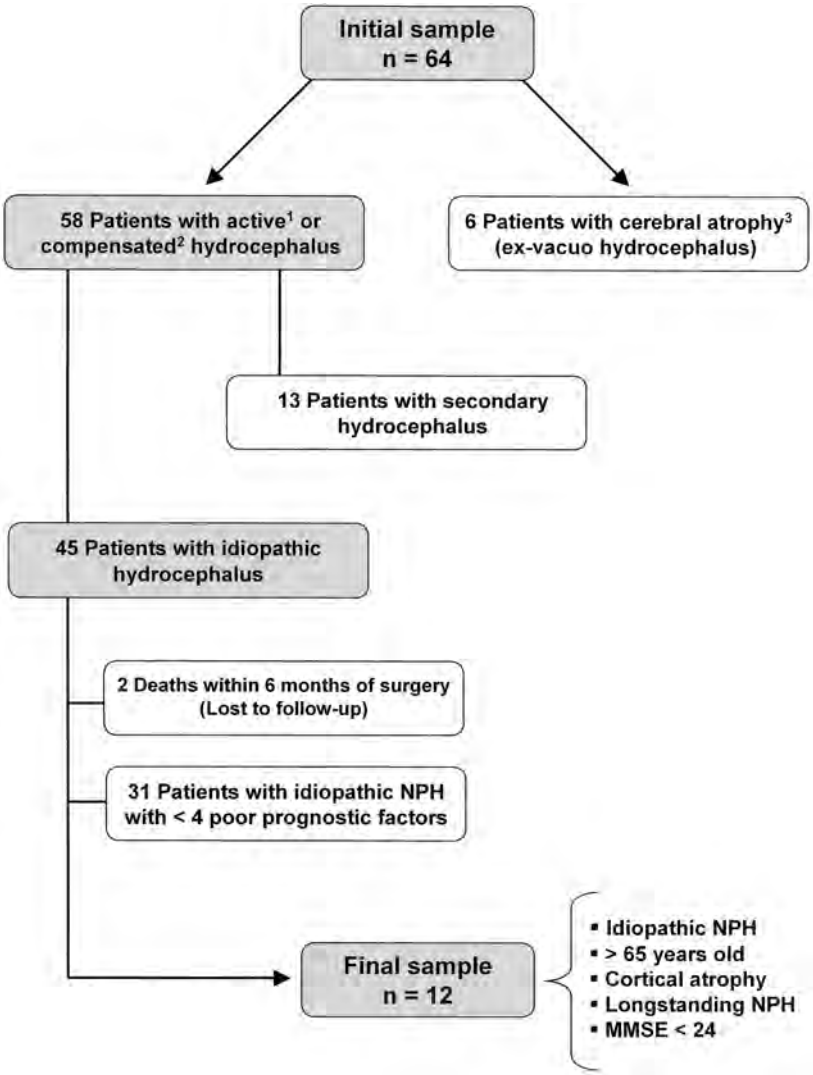

FIG. 1. Algorithm demonstrating patient selection in this study. 1) Active hydrocephalus: mean ICP greater than 12 mm Hg with the presence of A and/or B waves. 2) Compensated hydrocephalus: mean ICP less than or equal to 12 mm Hg with the presence of A and/or B waves. 3) Ex-vacuo hydrocephalus: mean ICP less than or equal to 12 mm Hg, with no pathological wave and an R_{out} less than 10 mm Hg/ml/min.

phy, prolonged disease duration, and dementia. These patients were also included in a study of 43 patients recently published by us.[24]

Clinical Material and Methods

Patient Population

Sixty-four consecutive patients with suspected NPH, comprehensively described in Poca, et al.,[24] were evaluated at the Department of Neurosurgery, Vall d'Hebron University Hospital, between February 1994 and September 1997. All patients presented with ventricular dilation (Evans Index ≥ 0.30) and at least one of the following clinical symptoms, unexplained by other neurological or nonneurological conditions: gait dysfunction, sphincter incontinence, cognitive deficits, and/or Parkinson disease refractory to treatment. Ex-vacuo ventricular dilation was diagnosed in six patients on the basis of the results of continuous ICP monitoring and CSF dynamics studies (all six patients presented with a mean ICP $\leq$ 12 mm Hg but with no pathological waves in the total recording time and an $R_{out} < 10$ mm Hg/ml/min) and were not considered candidates for shunt placement. Two patients died of unrelated causes (pulmonary neoplasm and cardiac infarct) before the follow-up assessment. Of the remaining 56 patients with NPH who had received shunts, we selected a subgroup with four of the factors traditionally considered to be markers of poor prognosis: idiopathic form, cortical atrophy (enlarged cortical sulci size), long disease evolution time ($>$ 12 months),[21,33] and presence of dementia (MMSE score $<$ 24). In addition, we considered patients older than 64 years only because age is considered one of the most significant variables in neurological recovery and can preclude aggressive treatment. Twelve patients met these criteria. Figure 1 summarizes the selection criteria of patients included in the present study. All patients underwent complete neurological, neuro-

TABLE 1

*Clinical and demographic characteristics in patients in the poor and good prognosis groups**

Characteristic	Poor Prognosis No. (%)	Good Prognosis No. (%)
no. of patients	12	44
sex		
male	8 (67)	29 (66)
female	4 (33)	15 (34)
no. of bad-prognosis factors		
0	0 (0)	4 (9)
1	0 (0)	11 (25)
2	0 (0)	15 (34)
3	0 (0)	14 (32)
4	12 (100)	0 (0)
diagnosis		
idiopathic NPH	12 (100)	31 (71)
after subarachnoid hemorrhage	0 (0)	2 (5)
postmeningitis	0 (0)	2 (5)
aqueductal stenosis	0 (0)	3 (7)
unop posterior fossa tumor	0 (0)	3 (7)
posthemorrhage IVT	0 (0)	1 (2)
other	0 (0)	2 (5)
clinical symptoms		
complete clinical triad	10 (83)	35 (80)
gait & cognitive deficits	1 (8)	6 (14)
cognitive dysfunction only	1 (8)	3 (7)
hydrodynamic diagnosis		
active hydrocephalus	5 (42)	15 (34)
compensated hydrocephalus	7 (58)	29 (66)
total % B waves		
<10	1 (8)	5 (11)
11–49	6 (50)	24 (55)
≥50	5 (42)	15 (34)
plateau waves (mm Hg)		
day >40	1 (8)	2 (5)
night >40	0 (0)	1 (2)
night 20–40	0 (0)	1 (2)
absent	11 (92)	40 (91)
shunt-related complications		
none	10 (83)	36 (82)
headache from overdrainage	0 (0)	2 (5)
subacute subdural hematoma	1 (8)	2 (5)
infection of distal catheter	0 (0)	1 (2)
asymptomatic subdural hygroma	1 (8)	2 (5)
shunt malfunction	0 (0)	1 (2)
bilat subdural hematoma	0 (0)	0 (0)

* IVT = intraventricular.

imaging, and neuropsychological evaluations prior to surgery and were reassessed at 6 months postoperation. Tables 1 and 2 show the clinical and demographic description of the 12 patients who met the poor prognosis selection criteria and the rest of the 44 patients who composed the good prognosis group.

Clinical Assessment

The disease affects three main areas—gait, sphincter control, and cognitive functioning—which were evaluated according to the NPH scale (Table 3).[30] The minimum possible score of three points indicates a patient who is bedridden or unable to walk, has no contact with the environment, and has urinary and fecal incontinence (is vegetative or in a minimally conscious state). The maximum score (15 points) indicates normal functioning in the three domains.

TABLE 2

Summary of characteristics in patients in the good and poor prognosis groups

Characteristic	Poor Prognosis Group			Good Prognosis Group		
	No. of Patients	Median Value	IQR	No. of Patients	Median Value	IQR
patient age (yrs)	12	75	7.3	44	69.5	12.5
mos of evolution	12	30	24	44	16	38.8
ICP (mm Hg)	11	12	14	40	10	12.75
R_{out} (mm Hg/ml/min)	4	12.1	5.93	17	15.6	9.05
Evans Index	12	0.38	0.1	44	0.39	0.1

* IQR = interquartile range.

Neuropsychological Assessment and Daily Life Activities Evaluation

The neuropsychological examination included tests of verbal and visual memory, speed of mental processing, and frontal lobe functioning as well as a brief screening test for dementia. Patients were administered the WMS,[35] which consists of seven subtests: 1) personal and current information; 2) orientation in time and space; 3) mental control; 4) logical memory; 5) memory span for digits; 6) visual reproduction; and 7) associate learning. Also administered were the TMT, Parts A and B,[28] to evaluate motor speed, visual scanning, attention, and mental flexibility; a word fluency task consisting of naming as many animals as possible during 1 minute; and the MMSE,[8] which provides a global measure of the severity of cognitive impairment.

Patients' functional behavior and changes in daily life activities were evaluated using several rating scales: the

TABLE 3

*Items included in the NPH scale used to assess the clinical triad**

Scale Component	Score
GE	
patient bedridden or unable to ambulate	1
ambulation possible w/ help	2
independent walking possible but unstable or patient falls	3
abnormal but stable gait	4
normal gait	5
CF	
patient vegetative	1
severe dementia	2
severe memory problems w/ behavior disturbances	3
memory problems reported by patient or family	4
cognitive disturbances found only by specific tests	5
SD	
urinary & fecal incontinence	1
continuous urinary incontinence	2
sporadic urinary incontinence	3
urinary urgency	4
no objective or subjective sphincter dysfunction	5

* NPH score = GE + CF + SD. Abbreviations: CF = cognitive function; GE = gait evaluation; SD = sphincter disturbance.

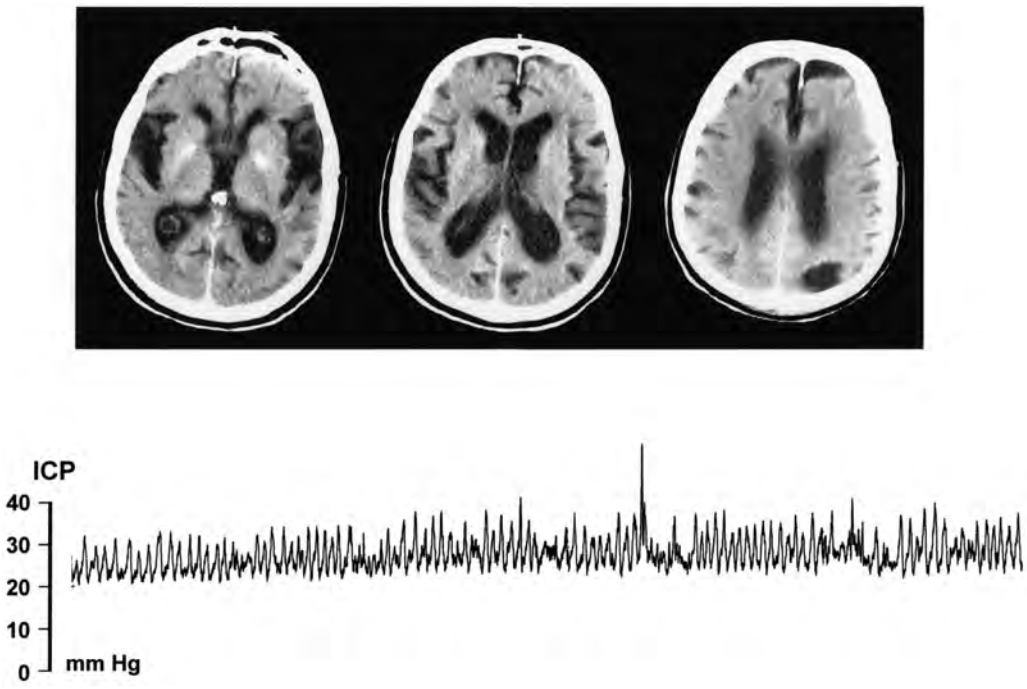

FIG. 2. Computerized tomography scans *(upper)* and ICP reading *(lower)* from a patient with NPH. Despite enlarged sylvian fissures and cortical sulci, the patient demonstrated intracranial hypertension on the ICP tracing, with 51% of high-amplitude B waves. Clinically, the patient showed a predominance of gait alterations and urinary incontinence, with subtle recent memory deficit and no other symptomatology.

IQCODE,[13] consisting of 17 items each scored from 1 (much worse) to 5 (much better); the RDRS-2,[19] which includes 18 items scored on a scale of 1 to 4 (a minimum score of 18 points indicates total independence and the maximum score of 72 indicates total dependence); a modification of the SLS,[3] which ranges from 0 (a patient able to work or perform the same duties as before) to 5 (the patient is bedridden or vegetative, with no spontaneous activity or verbal contact); the DLAS,[7] which evaluates how much help a person needs to perform five activities of daily life (mobility, shopping, cooking, household tasks, and money management) on a three-point scale (0, unable; 1, with help; 2, without help); and, finally, the Clinical Dementia Rating,[11] which globally rates cognition, behavior, and functional capacity and ranges from 0 (no dementia) to 3 (severe dementia).

Monitoring of ICP, CSF Dynamics Studies, and Criteria for Shunt Procedure

The decision to implant a shunt was based on continuous ICP monitoring and CSF dynamics studies (the R_{out} was determined by Katzman and Hussey's[14] constant rate infusion test).[24,25] The type of hydrocephalus in this study was classified according to the presence or absence of A and/or B waves and the mean ICP values obtained from an epidural sensor.[24,30] To avoid artifacts and overriding related to the use of epidural sensors, ICP values measured from the sensors were compared and corrected with the simultaneous pressure values obtained from a lumbar puncture performed in some of the patients to study CSF dynamics. In our center, ICP is monitored in each patient for at least 48 hours, including at least an overnight recording, using a fiberoptic extradural device (LADD Research Industries, Inc., Burlington, VT). We registered mean ICP and the presence and percentage of the total recording time of A waves (ICP elevations at least 20 mm Hg above the resting line, with abrupt onset and end, and lasting between 5 and 20 minutes) and B waves (0.5–2 ICP waves/minute, lasting for at least 10 minutes). Accordingly, each patient received one of the following classifications: 1) active hydrocephalus (mean ICP $>$ 12 mm Hg with the presence of A and/or B waves); 2) compensated hydrocephalus (mean ICP $\leq$ 12 mm Hg, with the presence of A and/or B waves); and 3) ex-vacuo hydrocephalus (mean ICP $\leq$ 12 mm Hg, with no pathological wave).[30] Figure 2 features data in a patient with active hydrocephalus, and Fig. 3 a patient with compensated hydrocephalus. Independently of the R_{out} values, patients with active or compensated hydrocephalus were selected for shunt placement.

Type of Shunt Selected

A differential low-pressure valve system was implanted in all patients. A Hakim–Medos valve system (closing pressure range 40 $\pm$ 10 mm H_2O; Medos S.A., Le Locle, Switzerland) was used in six patients. In five patients, this valve was combined with an infraclavicular gravity-compensating accessory (NMT Neurosciences Implants S.A., Sophia Antipolis Cedex, France). A low-pressure diaphragm valve (American Heyer-Schulte Corp., Santa Barbara, CA) was implanted in one patient. A Delta valve with a performance level of 0.5 and an incorporated antisiphon device (Medtronic PS Medical, Goleta, CA) was implanted in the re-

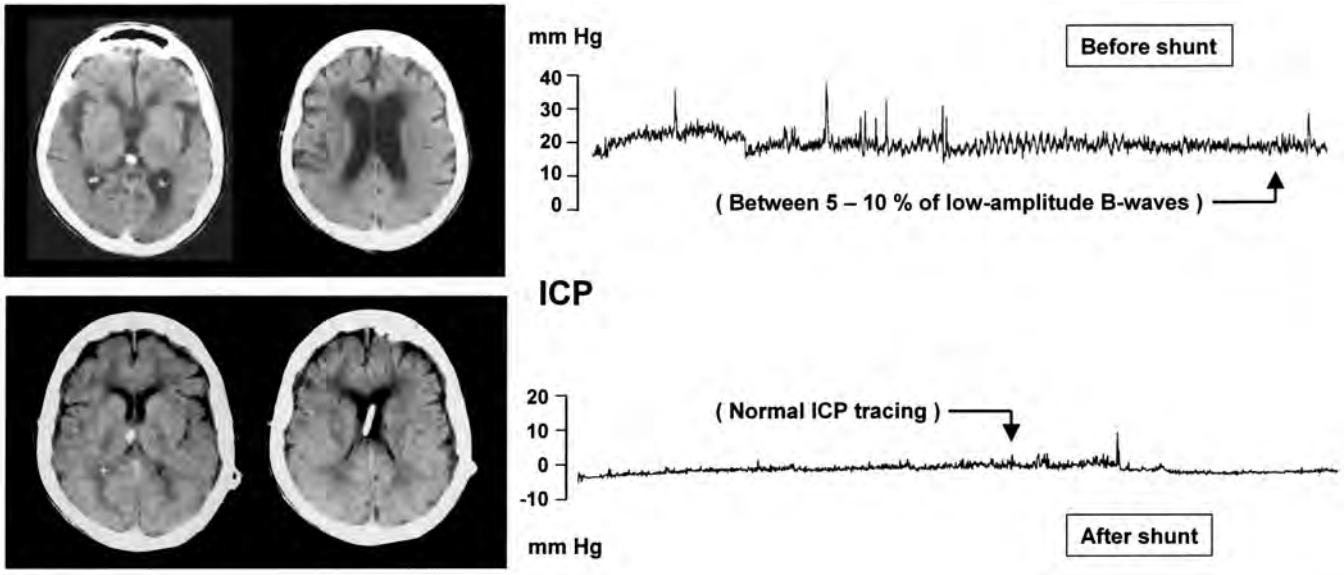

FIG. 3. Computerized tomography scans *(left)* and ICP readings *(right)* from a patient with NPH before *(upper)* and after *(lower)* a shunt procedure. Before shunt implantation, the patient was unable to ambulate, suffered continuous urinary and fecal incontinence, and had severe memory problems with behavior disturbances. Note that the presurgical scan revealed only moderate ventricular enlargement (Evans Index = 0.33) with dilated cortical sulci, whereas the ICP tracing revealed between 5 and 10% of low-amplitude B waves (< 10 mm Hg). After shunt placement, this patient experienced marked improvement (abnormal but independent and stable gait, normal sphincter control, and fewer self-reported memory problems—all of which persist to date, 8 years after the shunt was inserted).

maining five patients. Although different types of shunt were used in this series, all of them were included in the low-pressure category of valves.

Surgical Management Protocol

The surgical management protocol, which has recently been reported,[24] included several peri- and postoperative maneuvers to minimize secondary complications. Briefly, one dose each of sulfamethoxazole (1600 mg) and trimethoprim (320 mg) were used as prophylactic antibiotic agents during induction of anesthesia, followed by a further three doses every 12 hours. The head and body were washed twice (once in the ward and again after induction of anesthesia). The surgical field was then painted with Betadine solution and covered with Betadine-soaked gauze strips for at least 3 minutes. The dura mater was opened by coagulation and as far as possible the size of the hole was limited to the diameter of the ventricular catheter. To clean the catheter's lumen and prevent infection, an intraventricular bolus of vancomycin (20 mg) was administered in all patients. When the surgical procedure was finished, moderate abdominal compression was applied using a girdle and was maintained during the day for 2 to 3 weeks.

In the subgroup of patients with a differential-pressure valve and no antisiphon or gravity-compensating accessory, the beds were kept flat for at least 7 to 9 days, after which ambulation was begun. In patients with an antisiphon or a gravity-compensating accessory, the beds were inclined at a 45° angle for the 1st postoperative week. At discharge, the patients were advised to try to maintain this bed position at home until the first follow-up examination, which was routinely performed approximately 3 months later. In this subgroup of patients, ambulation was started on the 3rd day after shunt insertion.

Therapeutic Evaluation

Outcome was independently assessed by the neurosurgeon and neuropsychologist 6 months after the shunt procedure by using the NPH scale. If discrepancies were found between the evaluations of the neurosurgeon and the neuropsychologist, the patient was reevaluated and the final score was agreed on by consensus. Neuropsychological tests and quality-of-life scales were administered to the patients while they were in the hospital for presurgical studies, and again 6 months later. Because a small change in the NPH scale score represents a substantial change in the patient's functional status, we defined moderate improvement as a one-point increase and marked improvement as an increase of two or more points. Improvements in neuropsychological and behavioral features were analyzed using the percentage of change between baseline and postoperative scores. Complications in the early postoperative period (1st month after shunt placement) and at 6 months after shunt insertion were evaluated by the neurosurgeon in charge of the patient.

Statistical Analysis

Nonparametric analyses were used. The Wilcoxon matched-pairs signed-rank test was used to compare presurgical and postsurgical data. The Mann–Whitney U-test and the Wilcoxon rank-sum W-test were used for between-group comparisons.

A percentage of change between baseline and postoperative conditions was also calculated as follows: ([control − baseline]/baseline) × 100. Statistical significance was noted at a probability level less than or equal to 0.01.

TABLE 4

*Clinical and radiological information in 12 patients with NPH**

Case No.	Age (yrs), Sex	PVL	B Waves (%)†	R_{out} (mm Hg/ml/min)	Evans Index (pre/post)	Duration of Disease Evolution (mos)	NPH Scale			MMSE (pre/post)	SLS (pre/post)
							GE (pre/post)	CF (pre/post)	SD (pre/post)		
1	77, M	N	27	NA	0.41/NA	60	1/4	3/4	1/5	19/23	4/3
2	72, M	Y	51	NA	0.36/0.35	48	2/3	4/4	4/4	23/26	2/2
3	76, F	Y	18	7.5	0.40/0.31	24	1/4	4/4	1/3	23/25	4/2
4	69, M	N	18	NA	0.40/0.34	24	4/5	4/5	4/5	21/26	1/0
5	75, F	N	5	12	0.33/0.21	120	1/3	3/3	1/5	23/27	4/3
6‡	81, M	N	53	1.8	0.41/NA	48	5/5	4/4	5/5	22/21	2/2
7	75, F	Y	18	7.5	0.40/0.36	36	3/5	4/4	3/5	19/14	2/2
8	77, M	Y	85	30.7	0.45/0.41	24	1/3	2/3	1/2	9/11	4/4
9	74, F	N	70	16	0.35/0.31	18	2/5	4/5	3/5	16/28	4/0
10	65, M	Y	12	14.5	0.31/0.33	36	3/5	4/4	5/5	23/19	2/1
11	80, M	Y	14	NA	0.36/0.37	18	3/5	4/4	4/5	22/26	2/1
12	68, M	N	40	NA	0.36/0.34	24	2/5	4/4	1/3	18/23	4/2

* N = no; NA = not available; pre = presurgery; post = postsurgery; PVL = periventricular lucencies; Y = yes.
† Percentage of B waves previous to shunt insertion.
‡ Patient's condition did not improve.

Results

Clinical Symptoms of NPH

Before treatment, 10 patients had the complete clinical triad, one patient had cognitive dysfunction only, and another patient had gait and cognitive disturbances but no sphincter incontinence. All patients had some level of cognitive impairment (Table 4). Five patients had active hydrocephalus (Fig. 2), and seven patients had compensated hydrocephalus (Fig. 3).

According to the NPH scale, 11 patients showed clinical improvement (defined as an increase of 1 or more points on the NPH scale). Gait improved in all of the patients who had presented with gait abnormalities at the baseline assessment, sphincter dysfunction improved in nine of 10 patients who had presented with sphincter incontinence at the presurgical assessment, and cognitive impairment improved in four patients. No worsening was observed in any patients (Table 5 and Fig. 4).

Following surgery, patients improved significantly in gait ($Z = -2.93$, $p = 0.003$), sphincter control ($Z = -2.67$, $p = 0.008$), and in the global NPH score ($Z = -2.93$, $p = 0.003$). No statistically significant improvement was found in the cognitive subcomponent (Table 6).

Neuropsychological Assessment and Daily Life Activities Evaluation

At the baseline assessment, six patients were completely dependent on others for daily life activities (Grade 4 on the SLS), five patients required some supervision (SLS Grade 2), and one patient was independent for daily life functioning (SLS Grade 1). Six months after shunt placement, only one patient remained totally dependent (SLS Grade 4), seven patients required supervision (SLS Grades 2 and 3), and four patients were independent for daily life activities (SLS Grades 0 and 1; Table 4).

As shown in Table 6, following shunt procedures, significant improvement was found on most daily life activity scales, including the RDRS-2 ($Z = -2.59$, $p = 0.01$), the SLS ($Z = -2.52$, $p = 0.011$), the DLAS ($Z = -2.55$, $p = 0.011$), and the IQCODE ($Z = -2.67$, $p = 0.008$).

A tendency toward improvement ($p < 0.05$) was found in several neuropsychological tests used to evaluate attention (Digit Span Forward and mental control) and verbal memory (associate learning).

Comparison Between Prognosis Groups

We compared the poor prognosis group with the rest of

TABLE 5

Changes in patients who underwent shunt surgery for NPH, according to the NPH scale

Change Category	No. of Patients (%)			
	Global Score	GE Score	CF Score	SD Score
no effect	1 (8.3)	0 (0)	8 (66.7)	1 (8.3
moderate improvement*	1 (8.3)	2 (16.7)	4 (33.3)	3 (25)
marked improvement†	10 (83.4)	9 (75)	0 (0)	6 (50)
normal‡	0 (0)	1 (8.3)	0 (0)	2 (16.7)

* A change of one grade.
† A change of two or more grades.
‡ No abnormality in presurgical evaluation.

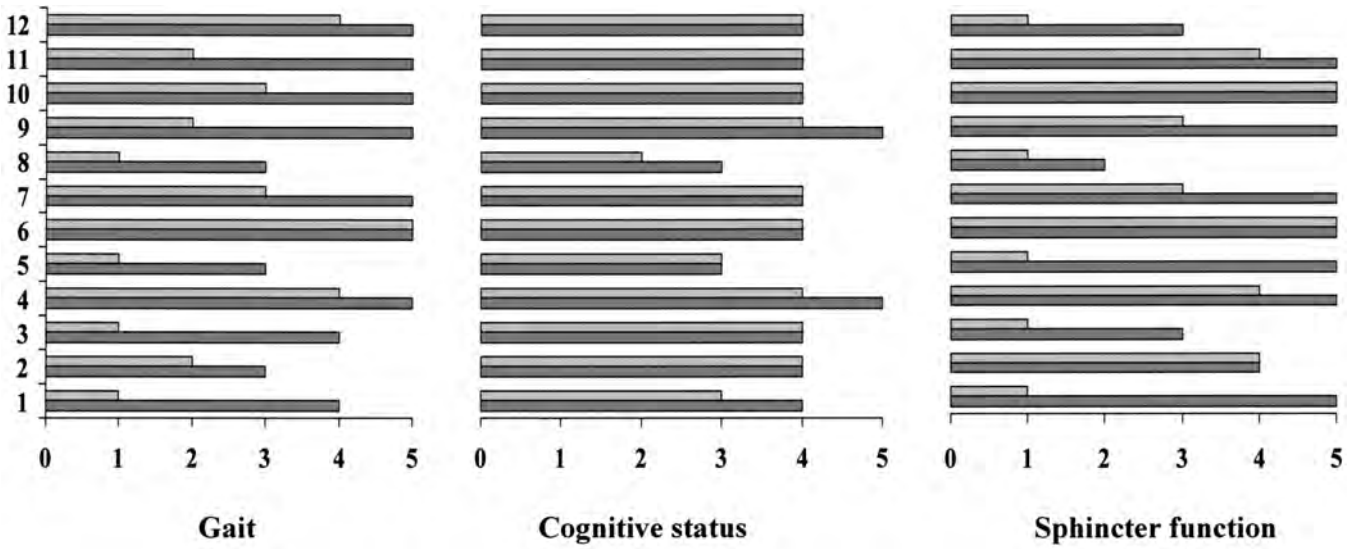

FIG. 4. Bar graphs demonstrating baseline conditions and clinical conditions after surgery according to the NPH scale. *Light gray bars*, before surgery; *dark gray bars*, 6 months after surgery.

the sample, which comprised 44 patients with NPH who had undergone shunt placement. The comparisons between the poor prognosis group and the good prognosis group for percentage of change in each clinical and neuropsychological variable showed no significant differences; however, a tendency emerged toward more improvement in patients with poor prognosis in gait functioning (NPH gait: $U = 160.5$, $p = 0.04$) and toward less improvement in attention and speed (TMT, Part A: $U = 55.5$, $p = 0.03$) and in general information (personal and current information from the WMS: $U = 148.5$, $p = 0.03$).

Postsurgical Complications

There was no treatment-related death. Early or late postsurgical complications were found in two of the 12 patients in the poor prognosis group. Subacute subdural hematoma was diagnosed in a patient before discharge from the hospital. Evacuation of the subdural collection was performed without sequelae. One additional patient had an asymptomatic subdural collection (self-limiting hygroma) during the months after shunt placement.

Discussion

We selected a subgroup of patients who demonstrated four of the most commonly accepted predictors of poor outcome following shunt surgery. All patients had idiopathic hydrocephalus, cortical atrophy, long disease evolution, and dementia; in addition, all were old. Surprisingly, the outcome of this subgroup of patients at 6 months was similar to that of the rest of the sample, and 92% of patients improved clinically following surgery. A highly significant improvement was seen in gait and sphincter functioning as well as in almost all daily life activity and functional scales.

Many authors have reported a slight or moderate improvement in patients with NPH following shunt placement;[10,34] more recently, however, authors have found a high proportion of good results when exhaustive diagnostic and treatment protocols were applied.[18,24,30] The wide variability in the results of shunt procedures has mainly been attributed to patient-selection criteria and to the type of shunt used.[1,10,26] In the present series, all patients had several indicators of poor prognosis, but all of those with gait alterations (11 of 12 patients) experienced marked improvement after surgery, and nine of 10 patients with sphincter dysfunction had better sphincter control. We believe these results to be related to the diagnostic and treatment protocols used in this study.

The diagnostic criteria used in these patients relies on continuous ICP monitoring.[24,25] Although less invasive tests such as CSF dynamics studies or the tap test are very useful when the patient's response is positive (tests with high sensitivity), caution should be exercised when the response is negative (tests with low specificity). In our experience, continuous ICP monitoring is mandatory when, despite compatible clinical and radiological data, the tap test is negative or the R_{out} is within a normal range. The percentage of B waves that patients with NPH can demonstrate is highly variable; in the present series, we found wide variation in the percentage of B waves in patients who improved after shunt procedures. Several other authors support the view that continuous ICP monitoring is the most useful diagnostic test in evaluating NPH.[16,17,23,27,29,30]

Although different types of shunt were used in this series, all of them included a valve in the low pressure category. Eleven of the 12 implanted valves were also combined with an antigravity device, which probably reduced the number of subdural collections in these patients. Moreover, the surgical management protocol included other maneuvers before, during, and after shunt placement that could also have influenced the low complication rate and, consequently, the percentage of improvement after shunt insertion.

In our group of patients, cognition improved little in comparison to gait and sphincter changes. Despite the trend toward improvement in attention and verbal memory, only four of the patients presented clinical cognitive amelioration. In addition, in some of the tests that indicated a ten-

TABLE 6

*Comparison between pre- and postoperative scores in the neuropsychological test battery and behavioral scales**

Measure	Preop			Postop			p Value	% Change
	Median	IQR	No.	Median	IQR	No.		
neuropsychological test								
memory quotient	84.50	25.75	8	86.00	24.50	12	NS	5.46
personal & current information	5.00	1.00	11	5.00	2.00	11	NS	0.00
orientation	3.00	3.00	11	4.00	3.00	11	NS	0.00
mental control	2.00	4.00	11	4.00	5.00	11	NS	0.00
logical memory	6.00	7.00	11	5.00	7.00	11	NS	0.00
Digit Span Forward	5.00	0.00	11	6.00	1.00	11	NS	20.00
Digit Span Backward	3.00	3.00	11	3.00	3.00	11	NS	0.00
visual reproduction	2.00	5.25	10	2.00	3.00	11	NS	0.00
associate learning	6.25	2.00	10	9.00	4.00	11	NS	26.79
TMT-A	80.00	140.00	7	190.00	100.50	8	NS	−51.25
TMT-B			1			1		
word fluency	8.00	6.00	11	10.50	7.50	12	NS	0.00
MMSE	21.50	4.75	12	24.00	6.50	12	NS	17.79
behavioral scale								
NPH score	9.50	6.50	12	13.50	3.00	12	≤0.01	53.33
GE	2.00	2.00	12	5.00	2.00	12	≤0.01	108.33
CF	4.00	0.75	12	4.00	0.00	12	NS	0.00
SD	2.75	3.00	12	5.00	1.75	12	≤0.01	66.67
RDRS-2	32.50	22.50	12	26.00	13.75	12	≤0.01	9.87
SLS	3.00	2.00	12	2.00	1.75	12	≤0.01	37.50
DLAS	4.00	5.50	12	6.00	5.25	12	≤0.01	36.67
Clinical Dementia Rating	7.50	5.25	12	4.50	8.00	11	NS	25.00
IQCODE	64.50	18.75	12	37.50	23.25	12	≤0.01	43.71

* NS = not significant.

dency toward improvement, such as the associate memory subtest of the WMS, we cannot avoid or rule out a possible retest effect, given that the same stimuli were used in the two presentations.

Authors of recent reports in the literature stress the fact that NPH can be highly heterogeneous. All of our patients presented cortical atrophy, which was one of the selection criteria. The presence of cortical atrophy, dementia, and old age may well raise the probability of the coexistence of other brain diseases. This factor would explain the poor improvement in cognition in comparison to gait and sphincter changes.

Most authors agree about the importance of selecting for shunt placement patients who are very likely to respond. Many investigators have tried to elucidate which factors are associated with a favorable outcome in this patient population; however, an effective means of predicting shunt responsiveness remains elusive. Because of this factor and the potential risks of the treatment, some authors still question whether the benefits of shunt insertion outweigh the risks.[6,34] In a recent literature analysis of the predictive value of different preoperative tests in 44 published studies, Hebb and Cusimano[10] conclude that there is no reliable way to select those whose condition will definitely improve. Our study data partially confirm these results, because traditional prognostic factors cannot help to predict response to a shunt and thus should not be used as criteria for ruling out shunt surgery in patients with NPH. Our results do show that a good outcome can be obtained and that significant surgical complications can be avoided even in this subgroup of patients (many of whom would not have been given shunts at other centers). Excluding these patients from surgery means that progressive deterioration is inevitable and will likely have an adverse effect on the quality of life of many patients and their families.

Conclusions

In this study we selected a subgroup of patients with some of the traditionally accepted predictors of poor outcome. Although this procedure restricted us to only 12 patients, the results were highly demonstrative. The clinical condition of patients with NPH who present traditionally accepted markers of poor prognosis can improve after surgery (especially as regards gait and sphincter control), indicating that the presence of these markers should not be considered as an absolute criterion for ruling out shunt surgery. Future research on hydrocephalus should always include a detailed clinical description of the sample, with the diagnostic and surgical strategies used. Attention to new genetic and biochemical factors as well as to new neuroimaging procedures may shed new light on this old but still little-known entity.

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