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Evolution of intracranial pressure during the immediate postoperative period after endoscopic third ventriculostomy

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Summary

Objective. To establish a more accurate indication for endoscopic third ventriculostomy (ETV) in patients with noncommunicating hydrocephalus through the analysis of the evolution of postoperative mean intracranial pressure (ICP_M).

Method. Intracranial pressure (ICP) was recorded overnight during 8-hour periods with an intraventricular probe. A personal computer connected to the ICP monitor minutely recorded the values of ICP. Twenty-four patients were monitored from day 1 to day 3 after ETV. The evolution of ICP_M was analysed with an ANOVA test for repeated measures. The relevance of different factors (age, etiology, size of the lesion leading to hydrocephalus, clinical course and outcome) on the evolution of ICP_M was explored with a two-factor ANOVA.

Results. ICP_M progressively decreased from day 1 to day 3 after ETV ($p = 0.03$). ICP_M on the first postoperative day was 15.81 ± 2.04 mm Hg (mean $\pm$ standard error) and 13.43 ± 1.44 mm Hg on the third postoperative day. Different patterns in the evolution of ICP_M have been detected according to the age of the patient and the clinical course of hydrocephalus.

Conclusion. ICP_M progressively decreases after ETV. This pattern is not constant. It has been clearly detected in children and in acute forms of hydrocephalus.

Keywords: Noncommunicating hydrocephalus; endoscopic third ventriculostomy; intracranial pressure.

Introduction

Noncommunicating hydrocephalus is a protean clinical entity. The diagnosis is not always straightforward. Patients may present an acute intracranial hypertension syndrome lasting for a few days and, on the other hand, the diagnosis may be done in the presence of a more indolent clinical picture heralded by a gait disturbance, a memory disorder or chronic headache lasting for several months or even years. Endoscopic third ventriculostomy (ETV) has gained acceptance as the treatment of choice for this entity. If such different clinical scenarios should be treated with an ETV has not been convincingly answered [9].

The main hypothesis sustaining the design of this study is the existence of a transmantle pressure gradient in the early stage of development of hydrocephalus. Experimental models [2] and the introduction of biomechanics [4, 6, 7] to the study of hydrocephalus support this assumption. However, a pressure gradient with a higher pressure in the ventricles than in the subarachnoid space has not been clearly demonstrated in a clinical setting and in chronic forms of hydrocephalus there is no transmantle pressure gradient [8].

If ETV is an effective treatment for noncommunicating hydrocephalus, intracranial pressure (ICP) determined at the ventricular level should immediately or gradually decrease after surgery. Through the analysis of the evolution of the mean intracranial pressure (ICP_M) in the postoperative period, our goal has been to establish a more accurate indication for ETV in patients with noncommunicating hydrocephalus.

Methods

Overnight ICP recording was performed with an intraventricular probe (Probe 3, Spiegelberg GmbH & Co., Germany) during the first 3 postoperative days in 24 patients with noncommunicating hydrocephalus treated with ETV. ICP was monitored during 8-hour periods. In thirteen patients ICP monitoring was extended until the fifth postoperative day. The ICP monitor (Spiegelberg CPP Monitor) is connected to a personal computer. A software (Midas CPP Collection Program Version 3.0, developed by Ian Piper, Glasgow) minutely records the value of ICP. This yields a total of 480 lectures during an 8-hour period. The data are stored in an ASCII format file. These data are imported by common software to calculate the value of ICP_M every day.

The evolution of ICP_M in the immediate postoperative period was analysed with an ANOVA test for repeated measures. The level of

Table 1. *Baseline characteristics of the series analysed: 24 patients with noncommunicating hydrocephalus treated with endoscopic third ventriculostomy and postoperative ICP monitoring*

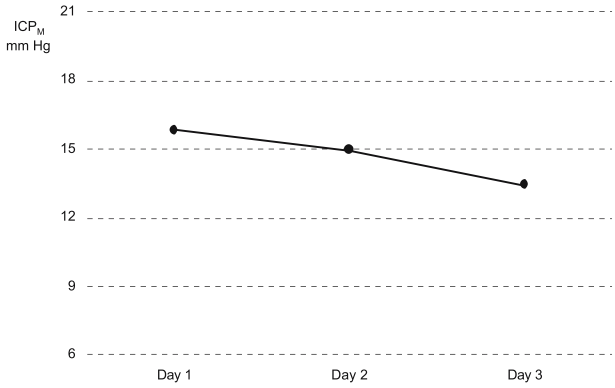
Characteristic	n	%
Sex		
– Male	9	*37.5*
– Female	15	*62.5*
Age		
– Adults (>15 yrs)	20	*83.3*
– Children (<15 yrs)	4	*16.7*
Etiology		
– Intracranial mass	16	*66.7*
– Primary aqueductal stenosis	8	*33.3*
Size		
– >30 mm	13	*54*
– <30 mm	11	*46*
Clinical onset		
– Acute intracranial hypertension	18	*75*
– Chronic hydrocephalus	6	*25*
Outcome		
– Satisfactory	21	*87.5*
– Shunt	3	*12.5*

significance chosen for this contrast was $p = 0.05$. A two-factor ANOVA with repeated measures on one factor (one within, one between factor) was used to analyse the influence of different factors of clinical relevance on the evolution of ICP_M. These factors include: age, etiology, size of the lesion leading to hydrocephalus, clinical course of the disease and outcome. The level of significance chosen for the interaction was $p = 0.10$. Informed consent was obtained from every patient. This study was approved by the Local Ethics Committee of Clinical Investigation.

This is an adult-based series (median age 51 yrs). Table 1 summarizes the baseline characteristics. Age was subdivided in two groups; children (≤ 15 yrs) and adult patients. Etiology in primary aqueductal stenosis or intracranial mass. The size of the lesion leading to hydrocephalus was categorized as larger or smaller than 30 mm according to its maximal diameter. The clinical course of the disease was subdivided in acute and chronic forms of hydrocephalus. The former comprises patients with symptoms and signs of intracranial hypertension lasting less than 2 weeks. Chronic forms of hydrocephalus are characterized by a more indolent clinical picture lasting several months or even years usually heralded by gait disturbances, headache, memory disorders or a cognitive deficit detected by neuropsychological testing. The outcome has been classified as satisfactory, for those patients who improved and have remained clinically well up to their last follow-up visit, and failures or shunted patients in those cases in which clinical symptoms of hydrocephalus either returned or never resolved and the patients required additional surgery for treatment of hydrocephalus [5].

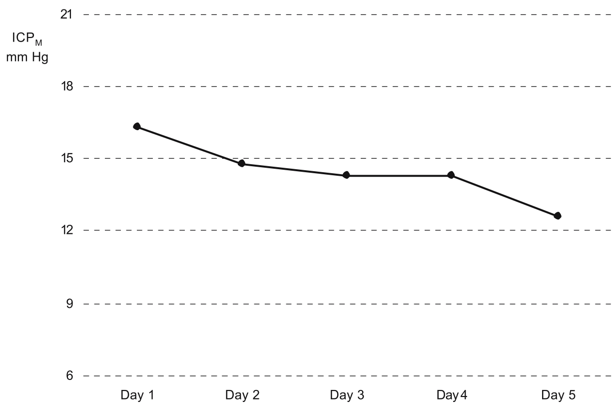
Results

ICP_M gradually decreased during the immediate postoperative period ($p = 0.03$). ICP_M on the first postoperative day was 15.81 ± 2.04 mm Hg (mean $\pm$ standard error) and 13.43 ± 1.44 mm Hg on the third postoperative day (Fig. 1). The gradient during this 48-hour period was 2.38 mm Hg. The same accounts



	n	Mean	SD	SE
Day 1	24	15.81	10.02	2.04
Day 2	24	14.95	8.66	1.76
Day 3	24	13.43	7.08	1.44

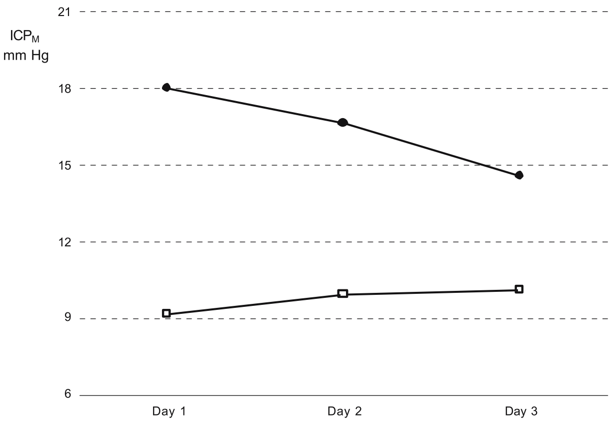
Fig. 1. Evolution of ICP_M during the first 3 postoperative days after endoscopic third ventriculostomy. *n* Number of patients; *SD* standard deviation; *SE* standard error



	n	Mean	SD	SE
Day 1	13	16.28	9.24	2.56
Day 2	13	14.77	8.09	2.24
Day 3	13	14.31	6.97	1.93
Day 4	13	14.31	6.60	1.83
Day 5	13	12.59	6.50	1.80

Fig. 2. Evolution of ICP_M during the first 5 postoperative days after endoscopic third ventriculostomy. *n* Number of patients; *SD* standard deviation; *SE* standard error

for the subset of patients who were monitored during five days ($p = 0.01$). The gradient is larger when a more extended period of time is analysed (Fig. 2). ICP_M on the first postoperative day was 16.28 ± 2.56 mm Hg and 12.59 ± 1.80 mm Hg on the fifth



	ACUTE			CHRONIC		
	n	Mean	ES	n	Mean	ES
Day 1	18	18.02	2.42	6	9.18	2.32
Day 2	18	16.63	2.11	6	9.93	2.28
Day 3	18	14.55	1.69	6	10.06	2.45

Fig. 3. Interaction between the clinical course (acute or chronic hydrocephalus) and the evolution of ICP_M. –●– ACUTE; –□– CHRONIC

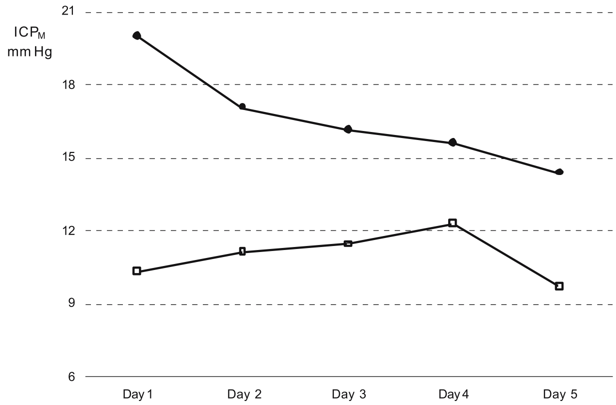
postoperative day, which represents a difference of 3.69 mm Hg.

Influence of the clinical course on the evolution of ICP_M: acute and chronic hydrocephalus

Patients with acute hydrocephalus displayed a trend towards higher values of ICP_M than patients with chronic hydrocephalus. The pattern of the evolution of ICP_M after ETV was different in both groups of patients ($p = 0.01$). ICP_M progressively decreased in acute hydrocephalus. By contrast, ICP_M in chronic forms of hydrocephalus remained stationary throughout the immediate postoperative period (Figs. 3 and 4).

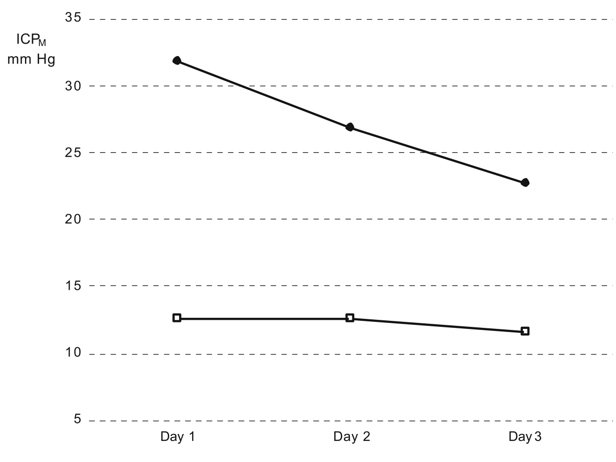
Influence of age on the evolution of ICPM: children and adult patients

Children with noncommunicating hydrocephalus have higher ICP_M than adults. This subdivision of age determines different patterns of the evolution of ICP_M after ETV ($p = 0.002$). In the pediatric subset of patients there is a decrease of ICP_M from 31.81 ± 5.75 mm Hg on the first postoperative day to 22.73 ± 4.26 mm Hg on the third postoperative day. The magnitude of the descent is 9.08 mm Hg. In adults, the slope is much less pronounced (Fig. 5).



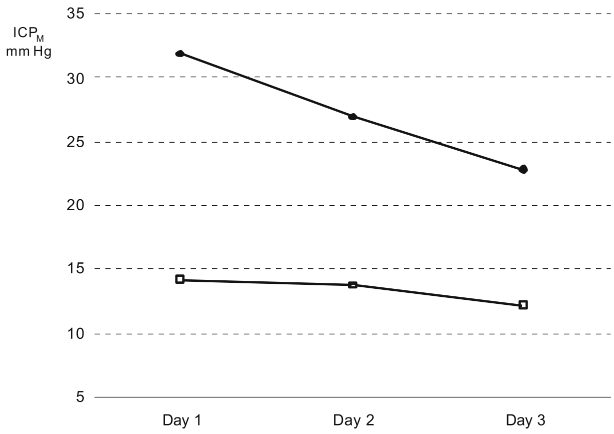
	ACUTE			CHRONIC		
	n	Mean	ES	n	Mean	ES
Day 1	8	20.01	3.30	5	10.31	2.48
Day 2	8	17.07	3.16	5	11.10	2.40
Day 3	8	16.12	2.64	5	11.43	2.50
Day 4	8	15.57	2.14	5	12.29	3.40
Day 5	8	14.39	2.39	5	9.71	2.44

Fig. 4. Interaction between the clinical course and the evolution of ICP_M throughout 5 postoperative days. –●– ACUTE; –□– CHRONIC



	CHILDREN			ADULTS		
	n	Mean	ES	n	Mean	ES
Day 1	4	31.81	5.75	20	12.61	1.34
Day 2	4	26.88	6.08	20	12.57	1.25
Day 3	4	22.73	4.26	20	11.57	1.17

Fig. 5. Interaction between the age (children or adults) and the evolution of ICP_M. –●– CHILDREN (>15 yrs); –□– ADULTS (>15 yrs)



	CHILDREN with ACUTEHYD			ADULTS with ACUTEHYD		
	n	Mean	ES	n	Mean	ES
Day 1	4	31.81	5.75	14	14.08	1.52
Day 2	4	26.88	6.08	14	13.70	1.45
Day 3	4	22.73	4.26	14	12.22	1.33

Fig. 6. Interaction between the age and the evolution ICP$_M$ in the acute stage of hydrocephalus. —●— CHILDREN with acute hyd; –□– ADULTS with acute hyd

All pediatric patients had acute hydrocephalus. Adult patients with chronic hydrocephalus were deleted to avoid the confounding effect of the clinical course of the disease (Fig. 6). This yielded 18 patients with acute hydrocephalus monitored from day 1 to day 3 after ETV. The effect of age is maintained when only acute forms of hydrocephalus are considered ($p = 0.01$).

The etiology ($p = 0.68$), the size of the lesion ($p = 0.31$) and the outcome at the end of the follow-up period ($p = 0.34$) according to the above mentioned subdivision did not effect the postoperative evolution of ICP$_M$.

Discussion

ICP$_M$ gradually decreases during a 48-hour interval in the immediate postoperative period after ETV. The magnitude of the gradient is in the range of 2 to 3 mm Hg. Larger gradients are detected when the period of ICP monitoring is extended until the fifth postoperative day, confirming a progressive decline of ICP$_M$ throughout the immediate postoperative period after ETV.

This pattern, however, is not uniform. The age of the patient and the clinical course of the hydrocephalus seem to definitely effect the postoperative evolution of ICP$_M$. In the acute stage of development of hydrocephalus ICP$_M$ steeply decreases, while in chronic forms of hydrocephalus ICP$_M$ remains stationary. The subdivision of age in children and adults also effected a different response of the ICP$_M$ evolution of as a logical reflection of changes in stiffness and in elastic properties of the brain parenchyma related with age. The descent of ICP$_M$ in children is much more striking while the response in adults was less perceptible.

By contrast, other factors considered of clinical relevance did not seem to condition the postoperative evolution of ICP$_M$. Such factors include: subdivision of etiology in intracranial mass or primary aqueductal stenosis; the size of the lesion leading to hydrocephalus according to its largest diameter and the outcome at the end of the follow-up period.

Although ETV is a well-established indication for noncommunicating hydrocephalus, the scenario widely varies in terms of age at presentation, etiology, clinical manifestation and duration of symptoms. This variability may in part explain the rather consistent failure rates in the range of 30% reported in most unselected series of patients with noncommunicating hydrocephalus [1, 3]. Such results and the heterogeneity of the disease lead to define more precisely which patients with noncommunicating hydrocephalus are really candidates for ETV and which will be better treated with a shunt. The role of ETV in adult patients with chronic forms of noncommunicating hydrocephalus should be carefully considered. Both conditions are associated with a pattern of the evolution of ICP$_M$ in which changes are hardly detectable.

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