

Endoscopic Ventriculostomy versus Shunt Operation in Normal Pressure Hydrocephalus: Diagnostics and Indication

U. Meier, F. S. Zeilinger, B. Schönherr

Department of Neurosurgery, Unfallkrankenhaus Berlin, Berlin, Germany

In contrast to the shunt operation the indication for an endoscopic ventriculostomy in patients diagnosed for normal pressure hydrocephalus is not scientifically established. Between September 1997 and December 1999 we operated on 48 patients diagnosed for normal pressure hydrocephalus. The diagnosis was established by means of the intrathecal lumbar or ventricular infusion test, the cerebrospinal fluid tap test and MRI-CSF flow studies pre- and postoperatively. In 37 patients (77%) we have implanted a ventriculo-peritoneal shunt, and in 11 patients (23%) we performed the endoscopic assisted third ventriculostomy. With our created NPH recovery rate and use of the clinical grading for normal pressure hydrocephalus created by Kiefer and Steudel we compared the operative results of both groups of patients. In patients with a pathologically increased resistance to CSF outflow in the lumbar infusion test a shunt implantation is indicated. Patients whose outflow resistance is increased in the ventricular infusion test but with a physiological lumbar infusion test are suspected for a functional aqueduct stenosis and should be treated by means of endoscopic assisted ventriculostomy.

Key words: Endoscopic Ventriculostomy – Normal Pressure Hydrocephalus – Aqueduct Stenosis – Phase Contrast MRI

Introduction

In contrast to insertion of a ventriculo-peritoneal shunt the indication for an endoscopic ventriculostomy in patients diagnosed for normal pressure hydrocephalus (NPH) is not scientifically established. Our prospective clinical study was designed in order to find predictors for each operative method and to evaluate the long-term results.

Material and Method

48 patients with normal pressure hydrocephalus were operatively treated in the Department of Neurosurgery of the Unfallkrankenhaus Berlin between September 1997 and December 1999. Diagnosis of normal pressure hydro-

cephalus was obtained by the intrathecal infusion test on a lumbar and/or ventricular route, the cerebrospinal fluid tap test, and MRI cerebrospinal fluid flow studies pre- and postoperatively. The signs of each patient were registered, according to the clinical grading for normal pressure hydrocephalus by Kiefer and Steudel. We then compared the course of disease at a mean time interval of 7 months while using our created NPH recovery rate [12]:

$$\text{NPH recovery rate} = \frac{\text{clinical grading preoperative} - \text{postoperative}}{\text{clinical grading postoperative}} \times 10$$

The indication for shunt operation or endoscopic ventriculostomy was assessed by evaluating the clinical signs and the results of the intrathecal infusion test [8]. The outflow resistance is the main criterion for grouping patients into those with NPH and into those with cerebral atrophy. A pathological increased outflow resistance in the intrathecal infusion test represents an indication for an operative intervention. Patients with a physiological outflow resistance and increased compliance were diagnosed for cerebral atrophy and not treated operatively [8]. The mathematical fundamentals and standardized investigation procedures as well as the indications for the computer assisted intrathecal infusion test and pathophysiological basics we have already described previously [6–12].

Results

In 37 patients (77%) a ventriculo-peritoneal shunt with a Miethke Dual-Switch valve [13] was inserted, and in 11 patients (23%) we performed an endoscopic assisted third ventriculostomy. After evaluation of the clinical signs according to the clinical grading for normal pressure hydrocephalus the lumbar infusion test was accomplished [12]. The indication for shunt operation was assessed by means of measuring the intracranial pressure and a baseline pressure within physiological limits, a hydrocephalus of all ventricles visualised in CT scan or MRI and a pathological increased outflow resistance in the lumbar infusion test.

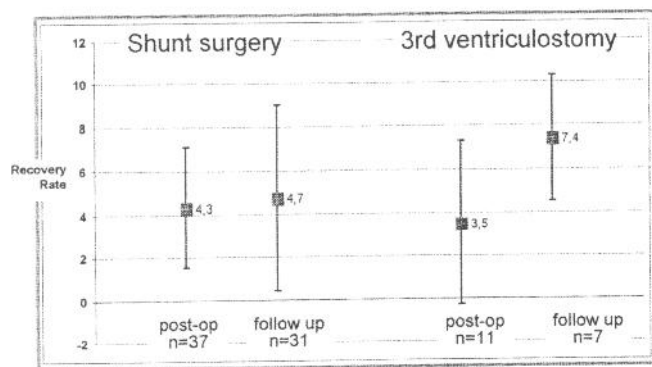


Fig. 1 NPH recovery rate according to clinical grading for NPH of Kiefer.

Indication for shunt operation in NPH

MRI/CT: hydrocephalus internus of all ventricles
Baseline ICP: within physiological limits
Lumbar infusion test: pathological resistance
Ventricular infusion test: pathological resistance

In cases with a suspicion for an aqueduct stenosis due to the MRI examinations and/or physiological outflow resistance in the lumbar infusion test a ventricular infusion test was indicated. With a pathological outflow resistance in the ventricular infusion test but physiological resistance in the lumbar infusion test we favor the third ventriculostomy (Fig. 2).

Indication for third ventriculostomy in NPH

MRI/CT: suspicion for aqueduct stenosis
Baseline ICP: within physiological limits
Lumbar infusion test: physiological resistance
Ventricular infusion test: pathological resistance

Patients with an elevated baseline ICP in the horizontal position were classified as pressure hydrocephalus and excluded from this study. The complications of both operative methods were analyzed regarding re-operation rate, operation related morbidity and lethality (Table 1). The comparison of the course of disease postoperative and katamnestic at a mean time interval of 7 months while using our own NPH recovery rate allows no statistical evaluation due to the small number of patients where we have performed a third ventriculostomy (Fig. 1). Our experiences with shunt therapy and different valve types were published elsewhere [8,9,11]. From 1997 onwards we inserted the Miethke Dual Switch valve [13,14] in patients with NPH exclusively.

Discussion

Indications for an intracranial endoscopy are, as stated by different authors [1,4,5,17], the obstructive hydrocephalus internus caused by intraventricular cysts and tumors. According to the Aachener workgroup [16] we favor the

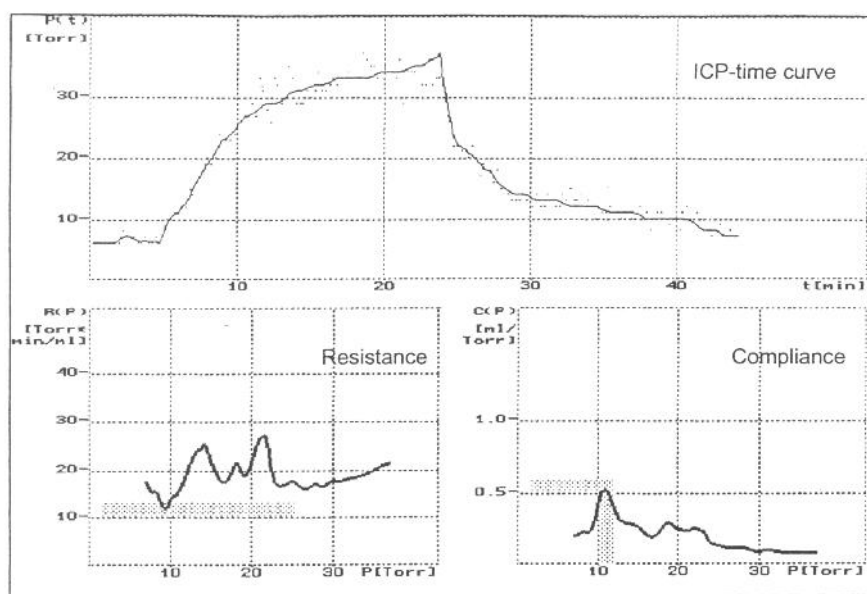
Table 1 Complications in shunt surgery and endoscopic ventriculostomy

	shunt surgery	3rd ventriculostomy
morbidity	24%	18%
infection	3	0
malfunction of valve	3	0
dislocation	1	0
SDH	2	0
pneumatocephalus	0	1
lesion of thalamus	0	1
2nd look surgery	8	0
lethality		
due to surgery	0	0
independent	2	1

combination of neuronavigation and endoscopic techniques for an intraoperative quality assessment. The type of normal pressure hydrocephalus described as functional aqueduct stenosis by our own workgroup is established while measuring a normal baseline ICP value in the horizontal position but an increased outflow resistance in the ventricular infusion test. The reason for this phenomenon is, in our opinion, a valve like mechanism in the region of the stenosis, which causes a pathologically increased resistance, mostly at ICP values between 15 and 30 Torr, which decreases gradually at higher ICP values, to normal range, due to the intrathecal infusion (volume-pressure-load) (Fig. 2). Pathophysiologically a reduced bulk flow of cerebrospinal fluid between third and fourth ventricles must be considered. This induces a dilatation of the lateral and third ventricle and when the intraventricular pressure exceeds the resistance of the stenosis CSF can flow. The physiological examination results in the lumbar infusion test prove that these patients have no disturbances in the extraventricular cerebrospinal fluid bulk flow.

According to Barlow and Ching [1] the ratio between patients with shunt operation and endoscopic ventriculostomy (150:23) is at about 15% and this is in accordance with our results (23%). These authors [1] conclude on the basis of their excellent clinical results after an endoscopic third ventriculostomy that ventriculostomy has the advantage of a reduced revision rate and reduced length of the hospital stay, which is a relevant economic factor. Due to the small number of patients in our study we cannot make an assumption about that. Regarding the complications in our patients we could not find significant differences with 24% after shunt insertion and 18% after third ventriculostomy. De Divitiis [2] reported about complications in 11%, which were mostly a temporary bleeding out of an external drainage after endoscopic ventriculostomy. In contrast to Mohanty et al. [15] who reported about acute subdural hematomas after endoscopic ventriculostomy this complication did not occur in our patients. The

Ventricular infusion test, NPH early stage



Lumbar infusion test, NPH early stage

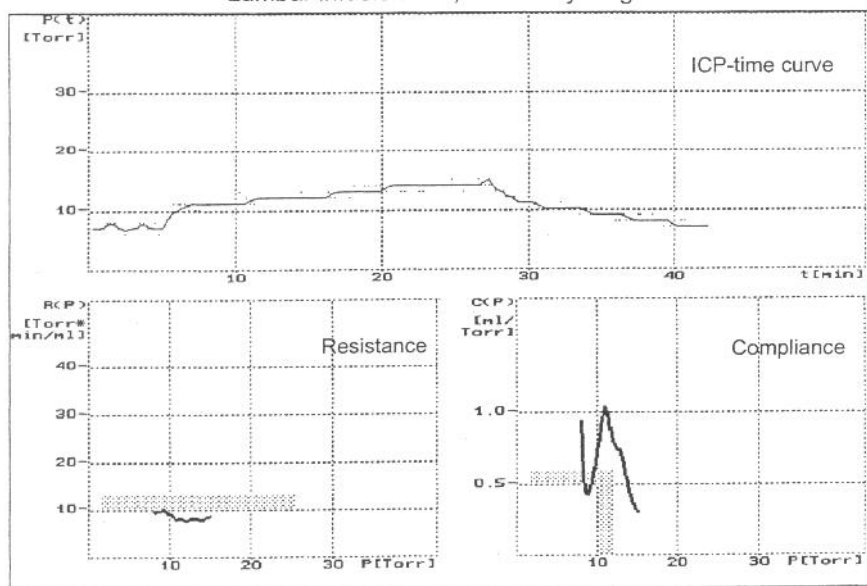


Fig. 2 Example of a patient with a NPH in an early stage. Examination protocol of ventricular infusion test (above) with an elevated ICP time-curve; pathological increased outflow resistance (above left); physiological compliance (above right). Examination protocol of lumbar infusion test (below) with a flat ICP time-curve; outflow resistance in the physiological range (below left); physiological compliance (below right).

operation related morbidity due to shunt operation has been discussed extensively on other occasions [13]. The lethality due to the operations was as in other workgroups [2,4] with 0% in both groups of patients fortunately low.

Foroutan et al. [3] points out that aside from the improved clinical symptoms the postoperative functional MRI confirms the right indication and operative therapy of the endoscopic ventriculostomy. We can thoroughly emphasize this statement. In contrast to Schwartz et al. [17] we did not recognize a marked reduction in ventricular width from patients with NPH. Contrary to pressure hydrocephalus a reduction of ventricle width cannot be expected in

normal pressure hydrocephalus in a chronic state because the bioplastic deformation has induced a decrease of parenchymatous tissue. Therefore the determining factors for a restitution are accomplished by the intracranial compensating mechanisms and the quantity of undamaged structures [13]. Bearing this in mind normal pressure hydrocephalus should be diagnosed at an early stage because disturbances of the cerebral autoregulation take place in the late stage and therefore the therapeutic results are worse after valve implantation or endoscopic ventriculostomy. Thus a delay in the diagnostic process reduces the rehabilitation potential of the patients due to an irreversible disturbance of their cognitive potential.

We conclude that for patients diagnosed for NPH with findings of a pathological outflow resistance in the lumbar infusion test the shunt operation is indicated. Patients whose outflow resistance is pathologically increased in the ventricular infusion test as well as with physiological results in the lumbar infusion test and signs of an aqueduct stenosis in MRI an endoscopic assisted third ventriculostomy is indicated. Postoperative a functional MRI with phase-contrast imaging supports the visualization of operative result. Follow up examinations, which are important for the evaluation of this method and for a quality assessment of this endoscopic operation method are still in progress.

References

- ¹ Barlow P, Ching HS. An economic argument in favour of endoscopic third ventriculostomy as a treatment for obstructive hydrocephalus. *Minim Invasive Neurosurg* 1997; 40: 37–39
- ² De Divitiis O. Provision of a neuroendoscopy service. The Southampton experience. *J Neurosurg Sci* 1998; 42: 137–143
- ³ Foroutan M, Mafee MF, Dujovny M. Third ventriculostomy, phase-contrast cine MRI and endoscopic techniques. *Neurol Res* 1998; 20: 443–448
- ⁴ Gaab MR, Schroeder HW. Neuroendoscopic approach to intraventricular lesions. *J Neurosurg* 1998; 88: 496–505
- ⁵ Gangemi M, Maiuri F, Donati P, Sigona L, Iaconetta G, De Divitiis E. Neuroendoscopy: Personal experience, indications and limits. *J Neurosurg Sci* 1998; 42: 1–10
- ⁶ Meier U, Michalik M, Reichmuth B. Computertomographie und Infusionstest bei einem posttraumatischen Hydrocephalus. *Psychiatr Neurol med Psychol* 1987; 39: 754–758
- ⁷ Meier U, Reichmuth B, Zeilinger FS, Lehmann R. The Importance of xenon-computed tomography in the diagnosis of normal pressure hydrocephalus. *Intern J Neuroradiology* 1996; 2: 153–160
- ⁸ Meier U. Der intrathekale Infusionstest als Entscheidungshilfe zur Shunt-Operation beim Normaldruckhydrozephalus. *Akt Neurologie* 1997; 24: 24–35
- ⁹ Meier U, Zeilinger FS, Kintzel D. Signs, symptoms and course of normal pressure hydrocephalus in comparison with cerebral atrophy. *Acta Neurochir* 1999; 141: 1039–1048
- ¹⁰ Meier U, Künzel B, Zeilinger FS, Riederer A, Kintzel D. Diagnostics in normal pressure hydrocephalus: A mathematical model for determination of the ICP-dependent resistance and compliance. *Acta Neurochir* 1999; 141: 941–948
- ¹¹ Meier U, Zeilinger FS, Kintzel D. Pathophysiologie, Klinik und Krankheitsverlauf beim Normaldruckhydrozephalus. *Fortschr Neurol Psychiatr* 1998; 66: 176–191
- ¹² Meier U. Zur klinischen Graduierung des Normaldruckhydrozephalus. *Akt Neurologie* 1999; 26: 127–132
- ¹³ Meier U, Zeilinger FS, Reyer T, Kintzel D. Klinische Erfahrungen mit verschiedenen Shuntsystemen beim Normaldruckhydrozephalus: Hydrostatische versus konventionelle Differentialdruckventile. *Zent bl Neurochir* 2000; 61
- ¹⁴ Miethke C, Affeld K. A new valve for the treatment of hydrocephalus. *Biomed Technik* 1994; 39: 181–187
- ¹⁵ Mohanty A, Anandh B, Reddy MS, Sastry KV. Contralateral massive acute subdural collection after endoscopic third ventriculostomy – a case report. *Minim Invasive Neurosurg* 1997; 40: 59–61
- ¹⁶ Rodhe V, Reinges MH, Krombach GA, Gilsbach JM. The combined use of image-guided frameless stereotaxy and neuroendoscopy for surgical management of occlusive hydrocephalus and intracranial cysts. *Br J Neurosurg* 1998; 12: 531–538
- ¹⁷ Schwartz TH, Yoon SS, Cutruzzola FW, Goodman RR. Third ventriculostomy: post-operative ventricular size and outcome. *Minim Invasive Neurosurg* 1996; 39: 122–129

Corresponding Author:

Privatdozent Dr. med. U. Meier

Head of Department
Department of Neurosurgery
Unfallkrankenhaus Berlin
Warener Straße 7
12683 Berlin
Germany

Phone: +49 30 5681-2701

Fax: +49 30 5681 2703

E-mail: UllrichM@ukb.de



Unfallkrankenhaus Berlin

Endoscopic Ventriculostomy versus Shunt-Operation in Normal Pressure Hydrocephalus: Diagnostic and Indication



Ulrich Meier, Bertram Schönherr, Phillip Bartels

Department of Neurosurgery, Unfallkrankenhaus Berlin, Germany

Introduction

In contrast to the shunt-operation the indication for an endoscopic ventriculostomy in patients diagnosed for normal pressure hydrocephalus (NPH) is not scientifically established. The aim of the present study is to find and demonstrate predictors for the operative method and to evaluate the long-term results.

Material and Methods

From September 1997 until December 1999 we operated 47 (37 shunt implantations / 11 third ventriculostomies) patients diagnosed for normal pressure hydrocephalus. The diagnosis was established by means of:

- the intrathecal lumbar and/or ventricular infusion-test
- a cerebrospinal fluid tap test
- MRI-CSF flow studies pre- and postoperatively

The signs and symptoms of each patient were evaluated according to the clinical grading for NPH created by Kiefer and Steudel. The long-term results were postoperatively and after 7 months compared while using a NPH-recovery rate.

After assessing the clinical signs and symptoms we performed a lumbar infusion test. In case of a physiological outflow resistance and a suspected aqueduct stenosis visualised in the MRI a ventricular measurement was indicated.

$$\text{NPH-Recovery Rate} = \frac{\text{Clinical grading preoperative} - \text{postoperative}}{\text{Clinical grading preoperative}} \times 10$$

Results

An operative therapy in NPH is indicated according to the clinical signs and symptoms and the results of the intrathecal infusion test. The main criteria is an increased outflow resistance in the intrathecal infusion test.

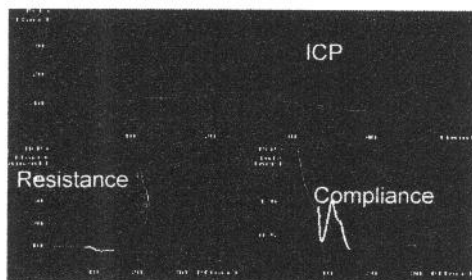
We have analysed the complications of both operative methods, the necessity for a revision operation, the operative induced morbidity and lethality.

Complications of the operative treatment

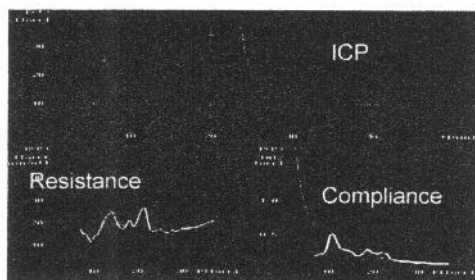
Complications	Shunt-Operation	third ventriculostomy
Revisions complete	5	0
Infections	3	0
Insufficiency	3	0
Dislocation	1	0
SDH	2	0
Thalamus lesion	0	1
Pneumatocephalus	0	1
Morbidity	23%	18%
Morbidity OP-related	9	2
Lethality OP-related	0	0
Lethality independent	2	1

Intrathecal Infusion Test

Lumbar route



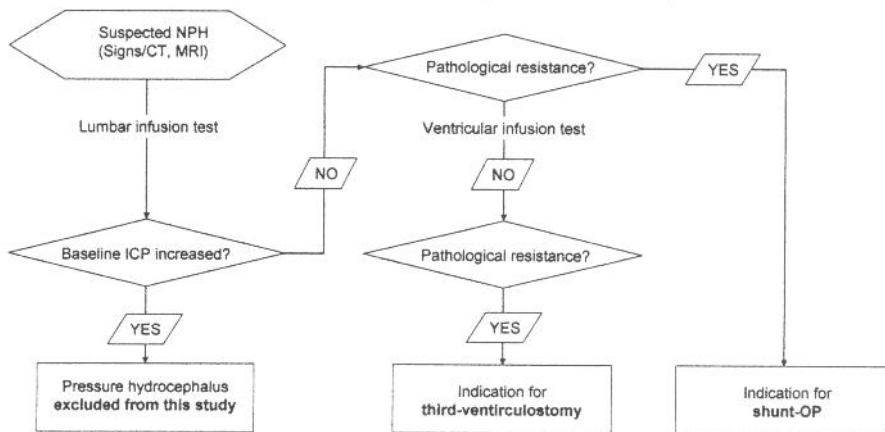
Ventricular route



Cine-MRT after Ventriculostomy

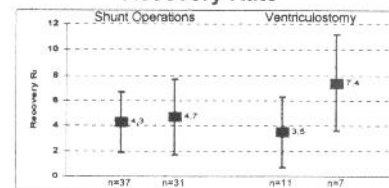


Indication for Ventriculostomy versus Shunt-Operation



Actually, a statistical analysis can not be conducted because there were only a few patients treated by means of a third ventriculostomy. But our data suggests that quality control of third ventriculostomy can be obtained with phase-contrast cine MRI.

Comparison of course of disease with Recovery Rate



Conclusions:

- In patients with a pathological increased outflow resistance in the lumbar infusion test caused by a NPH the shunt operation is recommended.
- Patients whose outflow resistance is increased in the ventricular infusion test but with a physiological outflow resistance in the lumbar infusion test caused by a functional aqueduct stenosis should be treated by an endoscopic assisted ventriculostomy. Postoperative a functional MRI can visualise the flow through the ventriculostomy.