Resolution of papilledema after endoscopic third ventriculostomy versus cerebrospinal fluid shunting in hydrocephalus: a comparative study

Clinical article

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Object. In this study the authors compare the efficacy of endoscopic third ventriculostomy (ETV) versus CSF shunting for resolution of papilledema in hydrocephalus.

Methods. This comparative case series study recruited 12 patients (24 eyes) with hydrocephalus who underwent either an ETV (Group 1, 6 patients [12 eyes]) or CSF shunt treatment (Group 2, 6 patients [12 eyes]). A complete ophthalmological examination including retinal nerve fiber layer (RNFL) evaluation by optical coherence tomography was provided for all patients before surgery and in the 1st week, 1st month, and 3rd month postoperatively. The 2 groups were compared for quantitative changes in RNFL thickness and, thereby, resolution of papilledema. Statistical evaluation was performed using the Mann-Whitney U-test with the aid of SPSS version 16.0.

Results. The mean preoperative RNFL thickness was 259.7 ± 35.8 µm in Group 1 and 244.5 ± 53.4 µm in Group 2 (p = 0.798). The mean decrease in RNFL thickness was 101.3 ± 38.8 µm, 141.2 ± 34.6 µm, and 162.0 ± 35.9 µm in Group 1 versus 97.0 ± 44.6 µm, 143 ± 45.6 µm, and 130.0 ± 59.8 µm in Group 2 for the postoperative 1st week, 1st month, and 3rd month, respectively. There was no significant difference between the two groups with respect to decrease in RNFL thickness during the 1st week, 1st month, and 3rd month (p = 0.563, p = 0.753, and p = 0.528, respectively).

Conclusions. This is the first study to quantitatively evaluate papilledema in assessing the success of ETV and CSF shunting. The authors’ results indicated that ETV is as effective as CSF shunting with respect to decreasing intracranial pressure and resolution of papilledema.

(http://thejns.org/doi/abs/10.3171/2014.2.JNS132002)

Key Words • endoscopic third ventriculostomy • CSF shunting • papilledema • hydrocephalus • intracranial pressure

HYDROCEPHALUS is the clinical condition characterized by enlargement of cerebral ventricles and associated symptoms caused by raised intracranial pressure (ICP). The main goal of treatment is to decrease raised ICP, either by CSF shunt treatment or endoscopic third ventriculostomy (ETV).⁶,⁹ Recently, due to higher morbidity rates and the issue of “shunt dependency” with CSF shunting, ETV has been highly recommended in appropriate cases.⁶,⁹ However, concern remains about the efficacy of ETV in decreasing raised ICP. The literature has rarely addressed a comparison of these procedures.

Increased ICP in patients with hydrocephalus can cause various systemic symptoms as well as neuro-ophthalmic complications. The most common of these complications is papilledema, caused by optic nerve ischemia, traction, or transsynaptic neuronal degeneration.⁵ In some cases, papilledema may be the first manifestation because of close association of the ventricular system and visual pathway.¹⁵ Resolution of the papilledema is commonly thought to be a good clinical indicator of decreased ICP after surgery.¹¹,¹⁸ Moreover, the existence of papilledema in the follow-up period is more predictive than radiologic findings regarding failure of the surgical procedure, especially in ETV.²

Abbreviations used in this paper: ETV = endoscopic third ventriculostomy; ICP = intracranial pressure; OCT = optical coherence tomography; ONSD = optic nerve sheath diameter; RNFL = retinal nerve fiber layer.
There are a few studies in the literature comparing the efficacy of CSF shunting and ETV in managing hydrocephalus. However, there is no clear consensus on which method is superior. Studies in the literature are mostly concerned with cost-effectiveness, ease of the procedure, and surgical outcomes, both clinical and radiological. Our study aimed to compare the effects of ETV and CSF shunting on recovery of optic nerve functions from raised ICP associated with hydrocephalus. The study used quantitative measures with optical coherence tomography (OCT) of the visual system.

Methods

This prospective comparative study adhered to the tenets of the Declaration of Helsinki, and the local ethics committee approved the study protocol. All patients gave informed consent for the study. The exclusion criteria were patient inability to cooperate with the ophthalmic examination, patients having previously undergone surgery because of hydrocephalus, and patients having an additional disease that could manifest as papilledema, such as hypertension, diabetes mellitus, vasculitis, and glaucoma. According to these criteria, the study recruited 12 patients (24 eyes) who had papilledema due to hydrocephalus or raised ICP. Patients underwent surgery based on the causative mechanism of the hydrocephalus. Group 1 comprised 6 patients who had undergone an ETV because of obstructive hydrocephalus. Primary pathologies were pineal tumor in 2 patients, third ventricle colloid cyst in 1 patient, unruptured basilar artery aneurysm in 1 patient, tectal glioma in 1 patient, and diffuse brainstem glioma in 1 patient. Group 2 comprised the 6 patients who had undergone CSF shunting (ventriculoperitoneal shunt placement) because of nonobstructive hydrocephalus. Primary pathologies in this group were subarachnoid hemorrhage in 3 patients, spontaneous intraventricular hemorrhage in 2 patients, and meningitis in 1 patient.

The ETVs were performed through a right frontal bur hole just anterior to the coronal suture at the midpupillary line. A rigid endoscope was inserted into the right lateral ventricle and then entered the foramen of Monro. After reaching the floor of the third ventricle, a small hole was created in the midline and anterior to the mammillary bodies via a 4-F Fogarty catheter. The hole then was enlarged by repetitively inflating and deflating its balloon until a 5-mm endoscope could be passed freely through this hole. For the CSF shunting procedure, a bur hole was created at the right parieto-occipital bone horizontal to the level of the nasion. Each patient received a ventriculoperitoneal shunt with medium-pressure valve design.

All patients underwent a complete ophthalmological examination, including dilated fundus examination, before and after surgery. In addition, retinal nerve fiber layer (RNFL) thickness measurement (Stratus OCT, Carl Zeiss, Meditec, Inc.) and fundus photography were obtained in all patients before surgery and in the 1st week, 1st month, and 3rd month postoperatively.

Before measurement with the OCT, patients were requested to sit, place their chin on the chin rest, and lean their forehead against the headrest of the device. They were asked to stare into the light in front of them and were told not to blink during the measurement. Measurements were recorded and interpreted. In case of loss of fixation or blink, the measurement was stopped and continued as soon as the patient regained fixation. The same, experienced technician performed all measurements. The RNFL thickness was measured by the fast RNFL protocol. The average thicknesses were used for comparison.

The success of both surgical procedures was assessed by clinical, radiological, and ophthalmological findings. Magnetic resonance imaging of the brain was performed in the 3rd postoperative month. Ventricle size was measured according to the Evans index. Surgical success was considered if there was improvement of clinical symptoms regarding ICP, improvement of radiological findings, such as decrease in ventricle size, periventricular edema, and increase in subarachnoid space with more prominence of cerebral sulci; and decrease in RNFL thickness on OCT.

Statistical Analysis

The two groups were compared for RNFL improvement and, thereby, resolution of papilledema in the 1st week, 1st month, and 3rd month postoperatively. Radiological evaluation of groups was performed by comparing Evans indices. Statistical analysis was performed using the Mann-Whitney U-test, with the aid of SPSS (version 16.0, SPSS, Inc.). Intragroup assessment of RNFL thickness was provided by Bonferroni analysis through a 1-way ANOVA test. For all tests, a p value < 0.05 was accepted as statistically significant.

Results

None of the patients had postoperative complications from the surgical procedure. The mean patient ages in Groups 1 and 2 were 35.0 ± 13.6 years (range 17–53 years; 3 males and 3 females) and 36.7 ± 13.1 years (range 23–56 years, 4 males and 2 females), respectively (mean ± SD). The mean preoperative RNFL thickness was 259.7 ± 35.8 μm in Group 1 and 244.5 ± 53.4 μm in Group 2 (p = 0.798).

Figures 1 and 2 show fundus photographs obtained in an ETV-treated and a shunt-treated patient, respectively, with respect to papilledema before and after operations.

In the ETV group, the mean RNFL thickness measurements in the 1st week, 1st month, and 3rd month postoperatively were 158.3 ± 21.1 μm, 118.5 ± 7.1 μm, and 95.5 ± 4.0 μm, respectively. There was a significant difference between preoperative and postoperative periods (p = 0.001 for all), while there was no difference between postoperative 1st month and 3rd month (p = 0.233) (Fig. 3 and Table 1).

In the CSF shunting group, the mean RNFL thickness measurements in the postoperative 1st week, 1st month, and 3rd month were 147.5 ± 54.1 μm, 101.5 ± 10.6 μm, and 89.5 ± 8.5 μm, respectively. There was a significant difference between preoperative and postoperative periods (p = 0.001 for all), while there was no difference between the 1st postoperative week and the 1st postoperative month (p = 0.146) or between the 1st and 3rd postoperative months (p = 0.3) (Fig. 3 and Table 1).
In the ETV group, the mean decreases in RNFL thickness in the postoperative 1st week, 1st month, and 3rd month were 101.3 ± 38.8 μm, 141.2 ± 34.6 μm, and 162.0 ± 35.9 μm, respectively. In the CSF shunting group, the mean decreases in RNFL in the postoperative 1st week, 1st month, and 3rd month were 97.0 ± 44.6 μm, 143 ± 45.6 μm, and 130.0 ± 59.8 μm, respectively. There was no significant difference between the two groups with respect to decrease in RNFL during the 1st week, 1st month, and 3rd month (p = 0.563, p = 0.753, and p = 0.528, respectively) (Table 2).

In intragroup evaluation of the ETV group, the mean decrease in RNFL thickness was significantly different between the 1st week and the 1st month (p = 0.011), while there was no significant difference after the 1st month (p = 0.821). In intragroup evaluation of the CSF shunting group, the mean decrease in RNFL thickness showed no significant difference between postoperative periods.
of the 1st week and 1st month or between the 1st month and the 3rd month (p = 0.152 and p = 0.176, respectively).

Clinical and ophthalmological examination findings were improved in all patients. Radiologically, on the 3rd postoperative month MRI studies, resolution of the preoperative periventricular edema, prominence of cerebral sulci, and decrease in ventricle size were seen in both groups. The mean preoperative Evans index was 0.373 ± 0.036 in the ETV group while it was 0.377 ± 0.048 in the CSF shunting group (p = 0.9). There was no significant difference between preoperative Evans indices of the groups. In the postoperative 3rd month, the mean Evans index decreased to 0.287 ± 0.034 and 0.239 ± 0.025 in Groups 1 and 2, respectively. There was a significant decrease in the Evans index in both groups (p = 0.028 for the ETV group and p = 0.022 for the CSF shunting group). The mean decrease in the Evans index was 0.086 ± 0.064 in the ETV group and 0.137 ± 0.024 in the CSF shunting group (p = 0.004). This difference was statistically significant.

**TABLE 1: Intragroup multiple comparisons of mean RNFL thickness in ETV and CSF shunting groups**

<table>
<thead>
<tr>
<th>Group &amp; Time Point</th>
<th>Mean RNFL (µm)</th>
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<tbody>
<tr>
<td>ETV*</td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>259.7 ± 35.8</td>
</tr>
<tr>
<td>1st postop wk</td>
<td>158.3 ± 21.1</td>
</tr>
<tr>
<td>1st postop mo</td>
<td>118.5 ± 7.1</td>
</tr>
<tr>
<td>3rd postop mo</td>
<td>95.5 ± 4.0</td>
</tr>
<tr>
<td>CSF shunting†</td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>244.5 ± 53.4</td>
</tr>
<tr>
<td>1st postop wk</td>
<td>147.5 ± 54.1</td>
</tr>
<tr>
<td>1st postop mo</td>
<td>101.5 ± 10.6</td>
</tr>
<tr>
<td>3rd postop mo</td>
<td>89.5 ± 8.5</td>
</tr>
</tbody>
</table>

* The p values for preoperative versus 1st postoperative week and 1st postoperative week versus 1st postoperative month are 0.001 (significant). The p value for 1st postoperative month versus 3rd postoperative month is 0.233 (not significant).
† The p value for preoperative versus 1st postoperative week is 0.001 (significant). The p values for 1st postoperative week versus 1st postoperative month and 1st postoperative month versus 3rd postoperative month are 0.146 and 0.3, respectively (not significant).

Discussion

Treatment of established hydrocephalus describes indications for both ETV and CSF shunting: CSF shunting can be used in both obstructive and nonobstructive hydrocephalus, whereas ETV is usually reserved for obstructive hydrocephalus. Because of certain disadvantages of CSF shunting, such as shunt dependency, high infection rates, and shunt malfunction, ETV is widely accepted as a primary treatment in obstructive hydrocephalus.2,6,12,20 In this study, the treatment choice for patients was based on the type of hydrocephalus. We performed ETV in patients who had obstructive hydrocephalus and CSF shunting in patients who had nonobstructive hydrocephalus.

There are few studies in the literature regarding comparison of outcomes of ETV and shunt surgery. Drake et al. reported that hydrocephalus patients who were treated with ETV had better life quality than those treated with a shunt.4 Rekate emphasized primary treatment of hydrocephalus patients with ETV.14 In addition, Hellwig et al. concluded that ETV would effectively control obstructive hydrocephalus in most patients and may be provided as a first-line therapy and an alternative to shunt surgery.9 Regarding failure rates, Tuli et al. reported no statistically significant difference between ETV and shunt surgery in children with hydrocephalus.21 In our study, we performed both CSF shunting (6 patients) and ETV (6 patients) as primary surgical interventions for treatment of hydrocephalus. All patients had neurological improvement and none had complications regarding the surgical procedure at 3 months follow-up.

Ventricle size, neurological status of the patient, ophthalmological examination, and optic nerve sheath diameter (ONSD) are the most commonly reported criteria when evaluating success of surgical procedures for hydrocephalus.2,10,13,15,20 The follow-up for shunt failure used to be a measuring of the size of the ventricular system. However, it has been reported that ventricle size may not be a valid predictor for success of surgical intervention, for either shunt treatment or ETV. Iskandar et al. reported a 33% false-negative interpretation of radiological findings as evidence of shunt failure.7 Buxton et al. concluded that clinical outcome was superior to radiological findings in assessing surgical success of ETV.2 Mizrachi et al. reported limitations of radiological diagnosis in 2 cases with elevated ICP.16 The authors emphasized the importance of ophthalmoscopy and concluded that the presence of papilledema may be a critical determinant of management. In this study, surgical success was achieved with improvement in clinical, ophthalmological, and radiological findings in all patients. Radiological findings regarding elevated ICP as well as ventricle size were improved in both groups on the MRI study obtained 3 months postoperatively. Although a decrease in ventricle size was achieved in both groups, it was significantly greater in the CSF shunting group (p = 0.004). Our study results indicate that the amount of decreased ventricle size does not affect the clinical and ophthalmological outcome as previously reported.

Singhal et al. used MRI to assess the ONSD and optic disc bulging and reported a significant reduction in
both after surgical intervention that resulted in clinically improved hydrocephalus. However, the authors were not able to describe a specific time course for these changes relative to clinical improvement. Jinkins et al. assessed clinical examination and MRI of the optic nerve head in patients with high ICP. However, measurement of the ONSD by MRI might be subjective and vary among physicians. Moreover, MRI may not be used in the 1st trimester of pregnancy and for patients who have incompatible metallic implants. Likewise, clinical examination via ophthalmoscopy might be difficult and nonobjective for untrained physicians, causing them to miss subtle changes. Optical coherence tomography is a noninvasive diagnostic technique used for cross-sectional assessment of the ocular structures, and it does not have any contraindications. This technique enables retinal images to be obtained as they are in histological preparations, and it can be used to monitor optic disc edema quantitatively through thickening of RNFL. Peripapillary RNFL thickness shows the amount of nerve fiber swelling around the optic disc area. Rebolloida and Muñoz-Negrete demonstrated the increased RNFL thickness in eyes with papilledema compared with normal eyes by using OCT. The authors also stated that there was a decrease in the mean RNFL thickness with regression of disc edema after treatment of patients having idiopathic ICP. A few studies have indicated OCT’s ability to detect RNFL thickening for quantitative assessment of papilledema. Skau et al. evaluated peripapillary RNFL thickness in idiopathic intracranial hypertension and concluded that OCT may be used for identification of subtle disc swellings. Savini et al. demonstrated peripapillary RNFL thickening in eyes with optic disc edema. In our study, we measured the mean RNFL thickness for assessment of papilledema preoperatively and at certain postoperative intervals. By doing this, we were able to assess the success of surgical intervention by a noninvasive method and protect against harmful radiation effects that might have been associated with other imaging modalities.

Nishiyama et al. demonstrated that patients with obstructive hydrocephalus would not achieve a shunt-independent state before 1 week after ETV. Schwartz et al. found that ventricular diameter may not reflect clinical outcome of ETV before 1 month. We evaluated the RNFL thickness as an indicator of papilledema in the preoperative period and then in the 1st week, 1st month, and 3rd month postoperatively. There was a significant decrease in RNFL thickness after both surgical interventions, whereas there was no significant difference between the two groups with respect to the decrease in RNFL during the 1st week, 1st month, and 3rd month. There was a significant amount of decrease in RNFL thickness in the 1st postoperative week after shunt surgery. Although there was a decrease at measured intervals after the 1st week, it was without statistical significance. This means that the shunt procedure demonstrated its maximum effectiveness in the 1st week, when there was a marked decrease in ICP. In the ETV group, the RNFL thickness continued to decrease significantly until the postoperative 1st month. This would mean that ETV caused a slower decrease in ICP and RNFL thickness.

Conclusions

To our knowledge, this is the first study to quantitatively evaluate papilledema in assessing the success of ETV and CSF shunting. Our study emphasizes that ETV is as effective as CSF shunting for early and late reduction of ICP. We also conclude that OCT can be used safely to evaluate papilledema in cases of increased ICP; but further studies with larger sample sizes and grading systems are needed.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Akdemir. Acquisition of data: E Koktekir, BE Koktekir, Karabagli. Analysis and interpretation of data: E Koktekir, BE Koktekir, Gedik. Drafting the article: E Koktekir. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: E Koktekir. Statistical analysis: BE Koktekir.

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Manuscript submitted September 15, 2013. Accepted February 25, 2014. Please include this information when citing this paper: published online March 28, 2014; DOI: 10.3171/2014.2.JNS132002. Address correspondence to: Ender Koktekir, M.D., Selcuk Universitesi Tip Fakultesi Norosirurji AD, Alaaddin Keykubat Kampusu, Konya 42100, Turkey. email: enderkoktekirnrs@hotmail.com.