Surgical intervention in pediatric intracranial hypertension: incidence, risk factors, and visual outcomes

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PURPOSE To evaluate the incidence of surgical intervention in pediatric intracranial hypertension (IH), evaluate the visual outcomes of surgically managed patients, and identify potential predictors for surgical intervention.

METHODS The medical records of patients with primary and secondary IH at Nationwide Children's Hospital from 2010 to 2017 were reviewed retrospectively. Presenting characteristics of medically and surgically managed patients were compared, and the clinical courses of surgically managed patients were reviewed.

RESULTS A total of 129 medically and 14 surgically managed patients were included. The surgical incidence was 9.8%. Final visual acuity in 27 of 28 surgically managed eyes was 20/25 or better. In combined primary and secondary IH patients, elevations in body mass index (BMI; OR = 1.06; 95% CI, 1.01-1.11; $P = 0.022$) and lumbar puncture opening pressures $\geq$52 cm H_2O (OR = 6.17; 95% CI, 1.93-19.67; $P = 0.002$) were significantly associated with the likelihood of surgical intervention when assessed by univariate logistic regression; grade of papilledema >2 was of marginal significance. After controlling for BMI, a lumbar puncture opening pressure of $\geq$52 cm H_2O was more likely to result in surgery (adjusted OR = 4.69; 95% CI = 1.39-15.98; $P = 0.013$).

CONCLUSIONS Most pediatric IH can be treated medically. Patients with lumbar puncture opening pressures $\geq$52 cm H_2O at the time of diagnosis are at a higher risk of surgical intervention and should be monitored closely. Elevations in presenting BMI and grade of papilledema may also increase the odds of surgery. (J AAPOS 2019;23:96.e1-7)

Headache and vision loss are the two main indications for treatment in patients with intracranial hypertension (IH).[1,2] To date, there have been no prospective clinical trials in the pediatric population to determine the optimal treatment regimen for IH, but available therapies are similar to those used in adults.[1,3,4] Management with medications such as acetazolamide, furosemide, and topiramate is usually sufficient.[1] However, surgical therapies are available for patients who cannot tolerate medical therapy, have persistent or progressive headache or vision loss despite maximally tolerated medications, or present with fulminant disease.[1-3,5,6] Fulminant IH (FIH) is characterized by the acute onset of IH symptoms and rapidly progressive vision loss.[2,7,8] Urgent surgical intervention has been suggested for patients with FIH.[2,7] Surgical therapies include cerebrospinal fluid diversion via temporary lumbar drains, ventriculoperitoneal (VPS), and lumboperitoneal shunts (LPS); cerebral venous sinus stenting; and unilateral or bilateral optic nerve sheath fenestrations (ONSF).[3]

The primary goal of this study was to calculate the incidence of surgical intervention in pediatric IH patients. Secondary outcomes included evaluation of the presenting characteristics, surgical courses, and visual outcomes amongst surgically managed patients; identification of the differences in presentation between medically and surgically managed patients; and identification of the potential predictors for surgical intervention.

Subjects and Methods

This study was conducted in accord with US Health Insurance Portability and Accountability Act of 1996 and was approved

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by the Nationwide Children's Hospital Institutional Review Board.

The medical records of 345 pediatric patients (≤18 years old at diagnosis) referred to the IH clinic at Nationwide Children's Hospital between January 2010 and December 2017 were reviewed. Patients diagnosed with primary IH and secondary IH under the criteria suggested by Aylward[9] in 2013 were included. The following characteristics at the time of diagnosis were recorded: age, sex, body mass index (BMI), visual acuity, Frisen grade of papilledema, lumbar puncture opening pressure, and visual field testing results.[10] Additional information was collected from patients who required surgical intervention: indications for surgery, surgical procedure(s) performed, and the time between diagnosis and surgical intervention. The visual acuity and visual field testing results at the last ophthalmologic examination were also recorded for the surgically managed patients. Patients were characterized as having FIH if they fit within the descriptions of the condition provided by Thambisetty and colleauges[7] and Friedman and Jacobson.[2]

Exclusion criteria were as follows: >30 days between initial eye examination and lumbar puncture; missing examination data or initial evaluation/treatment at an outside institution; complicated lumbar puncture (incorrect positioning, clot formation, opening pressure not recorded); structural etiologies for IH; infectious etiologies for IH; pseudopapilledema, diagnoses inconsistent with IH, or other concurrent diagnosis obscuring the clinical picture.

Statistical Analysis

Summary statistics for presenting examination findings were calculated. Group comparisons between the presenting characteristics of medically and surgically managed patients were performed using two-sample *t* tests with unequal variances for age and BMI and Fisher exact tests for categorical variables (sex, dichotomized opening pressure, and grade of papilledema). The highest grade of papilledema recorded between the two eyes of a given patient was used for analysis. Due to the small sample size, lumbar puncture opening pressure and grade of papilledema were dichotomized with their respective optimal cutoff points for better prediction of the need for surgical intervention. The cutoff points were estimated from the Liu method, which maximizes the product of the sensitivity and specificity.[11] Odds ratios (OR) predicting the probability of surgical intervention were calculated for each presenting variable. Predictors with significant *P* values were evaluated in a multivariable logistic regression with a backward stepwise algorithm to eliminate insignificant predictors. Analyses were performed for primary and secondary IH patients together as well as for primary IH patients alone. Secondary IH patients were not assessed separately, because there was only one surgical secondary IH patient in the study. All statistical tests were conducted using two-sided *P* values and were considered statistically significant with *P* values < 0.05. All Analyses were performed using Stata v.15.0 (Statacorp LLC, College Station, TX).

Results

A total of 143 patients (primary IH, 109; secondary IH, 34) were included. Of these, 96 primary and 33 secondary IH patients were medically managed, whereas 13 primary and 1 secondary IH patient underwent surgery. Four of the surgically managed patients had FIH. The total incidence of surgical intervention was 9.8%. Etiologies for secondary IH included growth hormone, doxycycline, minocycline, or desmopressin use; history of acute lymphoblastic leukemia, Burkitt's lymphoma, or non-Hodgkin's lymphoma; dural venous sinus thrombosis; and steroid withdrawal or steroid use. Patients with a history of lymphoma or leukemia had normal cerebrospinal fluid studies at the time of their secondary IH diagnosis.

The optimal cutoff points to predict the probability of surgical intervention were found to be 52 cm H_2O for lumbar puncture opening pressure and 2 for grade of papilledema. For lumbar puncture opening pressure, the sensitivity and specificity at the cutoff point were 0.50 and 0.86, respectively, yielding an area under the curve value of 0.68. At the cutoff point for grade of papilledema, the sensitivity and specificity were 0.64 and 0.63, respectively, with an area under the curve value of 0.66.

With primary and secondary IH patients combined, the average lumbar puncture opening pressure and the percentage of patients with lumbar puncture opening pressures ≥52 were statistically higher amongst surgically managed patients at presentation ($P = 0.003$). There was also a significant difference in presenting BMI between medically and surgically managed patients ($P = 0.046$). Statistical significance was found for these same variables when looking at primary IH patients alone. There was no statistically significant difference when comparing presenting age, sex, or grade of papilledema between groups (Table 1).

Considering primary and secondary IH patients together, opening pressure ≥52 cm H_2O (unadjusted OR = 6.17; 95% CI, 1.93-19.67; $P = 0.002$) and BMI (unadjusted OR = 1.06; 95% CI, 1.01-1.11; $P = 0.022$) at presentation were significantly associated with the need for surgical intervention; grade of papilledema >2 was borderline significant (unadjusted OR = 3.14; 95% CI = 0.99-9.92; $P = 0.051$). In primary IH patients alone, BMI (unadjusted OR = 1.06; 95% CI, 1.01-1.11; $P = 0.031$), opening pressure of ≥52 cm H_2O (unadjusted OR = 10.01; 95% CI, 2.81-35.8; $P < 0.001$), and grade of papilledema >2 (unadjusted OR = 3.59; 95% CI, 1.03-12.49; $P = 0.045$) were significantly associated with the need for surgery. Presenting age and sex were not associated with the need for surgical intervention (Table 2).

Multivariable logistic regression predicting the probability of surgical intervention was performed using lumbar puncture opening pressure of ≥52 cm H_2O adjusted for presenting BMI. Grade of papilledema was not included in the multivariate analysis as it was found to be of borderline significance in the univariate analysis. Comparing primary IH and secondary IH patients, a lumbar puncture opening pressure ≥52 cm H_2O significantly predicted the odds of surgical intervention (adjusted OR = 4.69; 95% CI, 1.39-15.86; $P = 0.013$). Results were similar for

Table 1. Comparison of presenting characteristics between medically and surgically managed patients

Primary and secondary IH	All (n = 143)	Medical (n = 129)	Surgical (n = 14)	*P* value
Age, years	11.6 ± 4.5	11.4 ± 4.4	13.4 ± 4.6	0.14[a]
BMI, kg/m^2	27.9 ± 10.7	27.2 ± 10.4	34.3 ± 11.8	0.046[a]
Sex				0.23[b]
Female	97 (67.8)	85 (65.9)	12 (85.7)	
Male	46 (32.2)	44 (34.1)	2 (14.3)	
Opening pressure, cm H_2O				0.003[b]
<52	118 (82.5)	111 (86)	7 (50)	
≥52	25 (17.5)	18 (14)	7 (50)	
Mean	38.2 ± 12.1	37.3 ± 11.1	46.6 ± 17.3	
Grade of papilledema				0.08[b]
≤2	87 (60.8)	82 (63.6)	5 (35.7)	
>2	56 (39.2)	47 (36.4)	9 (64.3)	
Median	2 (0-5)	2 (0-4)	3 (0-5)	
Primary IH only	**All (n = 109)**	**Medical (n = 96)**	**Surgical (n = 13)**	***P* value**
Age, year	11.8 (4.5)	11.6 (4.4)	13.3 (4.8)	0.25[a]
BMI, kg/m^2	29 (10.9)	28.1 (10.6)	35.4 (11.6)	0.049[a]
Sex				0.10[b]
Female	77 (70.6)	65 (67.7)	12 (92.3)	
Male	32 (29.4)	31 (32.3)	1 (7.7)	
Opening pressure, cm H_2O				0.001[b]
<52	92 (84.4)	86 (89.6)	6 (46.2)	
≥52	17 (15.6)	10 (10.4)	7 (53.8)	
Mean	38 ± 11.9	36.7 ± 10.3	47.5 ± 17.6	
Grade of papilledema				0.07[b]
≤2	63 (57.8%)	59 (61.5%)	4 (30.8%)	
>2	46 (42.2%)	37 (38.5%)	9 (69.2%)	
Median	2 (0-5)	2 (0-4)	3 (0-5)	

BMI, body mass index; *IH*, intracranial hypertension; *SD*, standard deviation.
Summary statistics presented are mean ± SD, no. (%), or median (min-max).
[a]Two-sample *t* test with unequal variance.
[b]Fisher exact test.

primary IH patients alone. While BMI was found to be a significant predictor during the univariate analysis, it was not statistically significant in the multivariate model (Table 3).

Surgically Managed IH Patients

Thirteen primary IH patients and 1 secondary IH patient underwent surgical intervention (Table 4). At the time of diagnosis, the average age of these patients was 13.4 years (median, 15; range 3-17), average BMI was 34.3 kg/m^2 (median, 35.4 kg/m^2; range, 15.8-51.8 kg/m^2), and the average lumbar puncture opening pressure was 46.6 cm H_2O (median, 44.5 cm H_2O; range, 27-77 cm H_2O). Of the 14, 12 (86%) were female. The specific surgical procedures performed in each case is given in Table 5.

Presenting visual acuity was 20/40 or worse in 7 of 28 eyes (25%), and 5 of 7 of these eyes were in patients presenting with FIH. Vision at presentation was 20/30 or better in the remaining 21 eyes. Visual acuity testing at last follow up revealed that 18 of 28 eyes (64.3%) were 20/20, 9 eyes (32.1%) were 20/25, and 1 eye (3.6%) was 20/40.

Of the 28 eyes, 20 (71.4%) had initial visual field testing available for review: 4 were normal and 16 eyes demonstrated some form of visual field loss. Eighteen eyes (64.3%) had final visual field testing available for review: 9 were normal, 8 eyes demonstrated some form of visual field loss, and 1 visual field was unreliable. Of the 8 eyes with persistent visual field defects, 5 were in patients with FIH. In the 18 cases in which comparison of presentation and final visual fields was possible, all were either stable or improved.

Surgically Managed Patients with FIH

Of the 14 surgically managed patients, 4 had clinical presentations consistent with FIH (patients 5, 8, 10, 13) and all were idiopathic in nature. The average age of these patients at presentation was 15 years (median, 15; range, 13-17), average BMI was 43.85 kg/m^2 (median, 43.85 kg/m^2; range, 33.3-51.8 kg/m^2), and the average lumbar puncture opening pressure was 65.5 cm H_2O (median, 65 cm H_2O; range, 55-77 cm H_2O). All 4 FIH patients were female and had symptoms for 4 weeks or less at the time of presentation. Presenting visual acuity was 20/40 or worse in 5 eyes (62.5%) and 20/30 or better in 3 eyes (37.5%), with grades of papilledema ranging from 3 to 5 on the Frisen scale. All FIH patients had marked visual field loss at presentation (Tables 4 and 5).

All 8 eyes in the FIH group had 20/25 or better visual acuity at last follow-up; however, 5 of 8 eyes had some

Table 2. Unadjusted odds ratio based on presenting characteristics for predicting probability of surgical intervention

Primary and secondary IH (n = 143)	Unadjusted OR	95% CI	*P* value
Age, year	1.13	0.97-1.31	0.12
BMI, kg/m^2	1.06	1.01-1.11	0.022
Sex			0.15
Female	Ref	—	
Male	0.32	0.07-1.50	
Opening pressure, cm H_2O			0.002
<52	Ref	—	
≥52	6.17	1.93-19.67	
Grade of Papilledema			0.051
≤2	Ref	—	
>2	3.14	0.99-9.92	
Primary IH only (n = 109)			
Age, year	1.10	0.95-1.28	0.21
BMI, kg/m^2	1.06	1.01-1.11	0.031
Sex			0.10
Female	Ref	—	
Male	0.17	0.02-1.40	
Opening pressure, cm H_2O			<0.001
<52	Ref	—	
≥52	10.01	2.81-35.8	
Grade of papilledema			0.045
≤2	Ref	—	
>2	3.59	1.03-12.49	

BMI, body mass index; *IH*, intracranial hypertension; *OR*, odds ratio.

Table 3. Adjusted odds ratio (OR) of opening pressure and body mass index (BMI) for predicting probability of surgical intervention

Primary and secondary IH (n = 143)	Adjusted OR	95% CI	*P* value
BMI, kg/m^2	1.04	0.99-1.10	0.138
Opening pressure, cm H_2O			0.013
<52	Ref	—	
≥52	4.69	1.39-15.86	
Primary IH only (n = 109)			
BMI, kg/m^2	1.03	0.97-1.09	0.40
Opening pressure, cm H_2O			0.004
<52	Ref	—	
≥52	7.70	1.91-31.04	

CI, confidence interval; *IH*, intracranial hypertension.

form of residual visual field loss. These defects affected at least 1 eye in each patient. When able to compare final visual fields to those from presentation, all were either stable or improved.

Time to Surgery

The average time from diagnosis to first surgical intervention was 16.5 days (median, 2.5 days; range, 1-60 days) in the 4 FIH patients, 530 days (median, 542.5; range, 280-755) in patients who underwent surgery for persistent headache related to IH, and 97 days (median, 61; range, 3-334) in the remaining IH patients who had presentations that were less severe than those with FIH (Table 5).

Discussion

Surgical intervention was required in 9.8% of our study population and was used in the management of both acute and chronic disease. Our data support the assertion that the majority of pediatric IH cases can be managed successfully with medical therapy.[1,4]

The majority of surgically managed patients demonstrated visual acuities of 20/25 or better and visual field testing that was improved or stabilized from presentation. Indications for surgery included persistent headache on maximally tolerated medications, examination findings concerning for visual compromise (loss of visual acuity, visual field constriction, development of an APD) despite maximally tolerated medications or escalating therapy, and papilledema that was unresponsive to medical therapy. Several of these factors comprise the definition of FIH; consequently, presenting with FIH may also be considered an indication for surgery. The main indication for surgery in patients who were too young to cooperate with supplemental testing was persistent papilledema, because this posed a significant risk for continued optic nerve damage. This was the case for patients 2 and 11 (Table 5) in our study.

There was no standardized surgical approach and a variety of surgical procedures were utilized (Table 5). Temporary lumbar drains, ventriculoperitoneal or lumboperitoneal shunts, and unilateral or bilateral optic nerve sheath fenestrations were performed, either alone or in combination.

Our data showed that a lumbar puncture opening pressure of ≥52 cm H_2O at the time of diagnosis was the most significant predictor for surgical intervention. While average BMI was significantly different between the surgically and medically managed patients at presentation, and the odds of surgery was shown to increase with every unit increase in BMI, the significant relationship between BMI and odds of surgery was not maintained in the multivariate analysis. Additionally, grade of papilledema >2 was only borderline significant in its ability to predict the need for surgery in the univariate analysis. The limited association of presenting BMI and grade of papilledema with the need for surgery may be related to the small number of surgical patients included in this study, and this would be better analyzed with a larger sample size.

FIH patients can preset with decreased visual acuity, marked visual field defects, and severe papilledema.[2,7] The risk of permanent visual impairment is high within this group of patients, and as a result, urgent surgical intervention has been recommended upon diagnosis.[2,7,8] Currently, there is no consensus on the ideal management for pediatric patients presenting with FIH, and there is limited literature available for review on the topic.

Thambisetty and colleagues[7] described 16 patients aged 14-39 with FIH who were surgically managed with either ONSF, VPS, or LPS. Eight patients (50%) underwent sur-

gery 3-37 days after presentation and were legally blind at follow-up. The patients who demonstrated significant improvement in their visual function underwent surgical intervention no more than 4 days after diagnosis, prompting their suggestion to consider urgent surgical intervention in FIH patients.[7]

A single case of FIH published in 2013 by Shaikh and colleagues[12] described an 18-year-old patient who underwent placement of a VPS 5 days after presentation with no light perception visual acuity. A lumbar drain was placed emergently before surgery, and intravenous methylprednisolone and furosemide were administered. Final visual acuity was 20/30 in each eye, with mild peripheral visual field constriction.[12]

A recent study by Jiramongkolchai and colleauges[8] described 2 cases of pediatric FIH managed with a single surgical procedure. These patients, who were referred after failing 2 weeks of medical therapy, were treated with intravenous acetazolamide, methylprednisolone, and lumbar drains, without the need for additional surgeries.[8]

In our study there were 4 patients (13-17 years old) who underwent surgical management for FIH. They had visual acuities of 20/25 or better at last follow-up and either stabilization of or improvement in presenting visual fields. Despite excellent central visual acuity, all of our FIH patients had some form of permanent visual field loss. Lack of complete visual recovery with treatment may be the result of irreversible damage to the optic nerves prior to diagnosis.[8] Considering the rapid and severe onset of FIH, stabilizing presenting visual function may still be considered a successful treatment outcome in these patients.

The ideal timing for surgical intervention in pediatric IH has not been well defined. In our study, the average time to surgery was shortest in FIH patients and longest in patients who had persistent headaches related to IH. Based on visual outcomes, delaying surgery was acceptable for patients with less severe IH presentations (patients 2, 4, 6, 7, 11, 12) and for those with persistent headaches (patients 1, 3, 9, 14). It is notable; however, that these groups still demonstrated overlap in surgical timing (Table 5). For example, patient 8 (diagnosed with FIH) underwent surgery 60 days after presentation, because she initially responded to medical management. This was in stark contrast to the timing of surgery in the remaining FIH cases (1-3 days after presentation). Conversely, patient 12 (not diagnosed with FIH) had surgery within 3 days of presentation based on the overall severity of her clinical picture. The variability in surgical timing demonstrates the importance of tailoring treatment to meet each individual patient needs, regardless of disease severity or classification.

Temporary lumbar drains were successfully used, either alone or in combination with additional surgical procedures, in 2 of 4 of our FIH cases. This has also been reported by Shaikh and colleauges[12] and Jiramongkolchai and colleagues.[8] Lumbar drain placement can acutely and

Table 4. Presenting examination information for all surgically managed patients

	IH	Presenting symptoms or signs	Age, years	Sex	BMI, kg/m^2	VA (OD, OS)	Grade of papilledema	LPOP, cm H_2O	Initial visual field
1	P	Headaches × 1 yr	16	F	35.2	20/40, 20/25	2	27	Normal OU
2	P	Esotropia × 3 mos	3	F	15.8	CSM, CSM	3	27.5	NATP (age)
3	P	Diplopia, headaches × 6 wks	16	F	33.8	20/25, 20/30	1	31	EBS OD, normal OS
4	P	Headaches, blurry vision × 4 wks	15	M	46.8	20/20, 20/20	2	36	Normal OD, possible EBS OS
5[a]	P	Headache, tinnitus, blurry vision × 1 wk	17	F	33.3	20/50, 20/60	3	66	Generalized constriction OD, superior altitudinal and inferior arcuate OS
6	P	Headache, blurry vision, tinnitus, TVOs × 3 wks	16	F	35.6	20/20, 20/20	4	65	EBS OU
7	P	Headache, tinnitus × 2-3 wks	17	F	39.7	20/20, 20/20	3	53	EBS OU
8[a]	P	Headache, tinnitus, blurry vision, TVOs, diplopia × 2 wks	15	F	49.4	20/60, 20/125	4	55	EBS, Superior altitudinal, and inferonasal step OD; generalized constriction OS
9	P	Behavioral changes, headaches × 1-2 wks	12	F	20.1	20/20, 20/20	0	33	Not performed at initial exam
10[a]	P	Headache, blurry vision, tinnitus, diplopia × 3 wks	13	F	51.8	20/30, 20/40	4	77	Inferonasal step and early superior arcuate OD; EBS, inferior arcuate, and superonasal step OS
11	P	Headache, behavioral changes × 6 mos	3	F	17.6	CSM, CSM	3	28.4	NATP (age)
12	P	Headaches, tinnitus × 4 wks	15	F	39.9	20/30, 20/40	5	55	EBS OU
13[a]	P	Headaches, TVOs, diplopia, tinnitus × 2-3 wks	15	F	40.9	20/25, 20/20	5	64	EBS, superior and inferior nasal step OD; EBS and generalized constriction OS
14	S (DVST)	Headaches, TVOs × 4-6 mos	15	M	20.9	20/20, 20/20	0	34	Not performed at initial exam

BMI, body mass index; *CSM*, central, steady, maintained; *DVST*, dural venous sinus thrombosis; *EBS*, enlarged blind spot; *IH*, intracranial hypertension; *LPOP*, lumbar puncture opening pressure; *NATP*, not able to perform; *OD*, right eye; *OS*, left eye; *OU*, both eyes; *P*, primary; *S*, secondary; *TVO*, transient visual obscuration; *VA*, visual acuity.
[a]Fulminant IH patient.

Table 5. Surgical details and examination information at last follow up for all surgically managed patients

	Indications for surgery	Surgical procedure(s)	Days to surgical procedure(s)	Final VA (OD, OS)	Final visual field
1	Persistent headaches on maximally tolerated medications	VPS	692	20/25, 20/20	Not available
2	Persistent papilledema on maximally tolerated medications, difficulty following visual function given age	Bilateral ONSF	86	20/20, 20/25	Mild superior peripheral defects OD, EBS OS
3	Persistent headaches on maximally tolerated medications	VPS	280	20/20, 20/20	Not available
4	Persistent papilledema and high lumbar puncture opening pressures on escalating medical therapy	Bilateral ONSF, VPS	18, 49	20/25, 20/20	Not available
5[a]	Significant decrease in vision, acute development of an APD, severe papilledema	LPS	3	20/25, 20/25	Unreliable OD, superior arcuate OS[b]
6	Persistent severe papilledema and new APD on escalating medical therapy	LPS	36	20/20, 20/20	Normal OU[b]
7	Worsening vision and visual fields, persistent papilledema in the setting of medication non-compliance	VPS	105	20/40, 20/25	Not available
8[a]	Visual field constriction, persistent papilledema and elevated opening pressures on maximum medical therapy	VPS	60	20/20, 20/20	Normal OD[b], generalized constriction OS[b]
9	Headaches and persistent elevation in opening pressures on maximally tolerated medications	VPS	755	20/25, 20/25	Normal OU
10[a]	Persistent papilledema on maximally tolerated medications, visual field loss	LD	2	20/20, 20/20	Normal OD[b], slight EBS and inferonasal step OS[b]
11	Persistent papilledema on maximally tolerated medications, difficulty following visual function given age	Unilateral ONSF	334	20/20, 20/20	NATP (age)
12	Severe papilledema, high opening pressures, increasing OCT RNFL thickness	LD, bilateral ONSF, VPS	3, 6, 14	20/25, 20/20	EBS OD[b], normal OS[b]
13[a]	Severe papilledema, significant visual field constriction, increasing OCT RNFL thickness	LD, bilateral ONSF, VPS	1, 6, 13	20/20, 20/20	Superonasal and inferonasal step OD[b], EBS OS[b]
14	Persistent headache on maximally tolerated medications, improved symptoms with LD	LD, VPS	393, 597	20/20, 20/20	Normal OU

EBS, enlarged blind spot; *LD*, lumbar drain; *LPS*, lumboperitoneal shunt; *NATP*, not able to perform; *OD*, right eye; *ONSF*, optic nerve sheath fenestration; *OS*, left eye; *OU*, both eyes; *VA*, visual acuity; *VPS*, ventriculoperitoneal shunt.
[a]Fulminant IH patient.
[b]Visual field was able to be compared to presenting visual field.

effectively alleviate elevated intracranial pressure, allowing time to maximize medical therapies and possibly avoid more permanent forms of surgical intervention. If additional surgery is indicated, lumbar drain placement offers the benefit of safely increasing the amount of time between diagnosis and the planned procedures, which can be emotionally beneficial for patients and families. Finally, if an ONSF is planned, placement of a temporary lumbar drain may allow for partial recovery of severely swollen optic nerves and decrease the risk of postoperative ischemic optic neuropathy.[1]

This study is limited by its retrospective nature and by the low number of surgical patients available for review. Nevertheless, our results demonstrate that surgical intervention is still an important therapeutic consideration. This study also adds to the limited pool of information that is currently available on the surgical management of pediatric IH and supports the assertion that the majority of cases can be treated medically. In general, patients with FIH should be considered for more urgent surgical intervention to avoid permanent vision loss and optic atrophy. Patients with lumbar puncture opening pressures $\geq$52 cm H_2O at the time of diagnosis are at a higher risk of surgical intervention and should be monitored closely. Elevations in presenting BMI and grade of papilledema may also increase the odds of surgery.

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