ORIGINAL ARTICLE

Visual Outcomes from Shunting for Idiopathic Intracranial Hypertension

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ABSTRACT

A retrospective notes review was conducted for 50 consecutive patients who underwent shunt surgery for idiopathic intracranial hypertension (IIH). The decimal visual acuity and the mean radial degrees (MRD) of the I4e isopter of the Goldmann visual field were measured pre-operatively and after a mean follow-up period of 1123 days (range: 13–3551 days). A ventriculo-peritoneal shunt was the first procedure in 38 patients and a lumbo-peritoneal shunt in 12. The mean decimal visual acuity of the worse affected eye improved from 0.75 to 0.84, $p=0.011$. The MRD score of the worse affected eye improved on average from 25.6° to 35.5°, $p<0.0001$. In those with significant pre-operative visual impairment in their worse affected eye (defined as an MRD score $\leq 30^\circ$), the MRD score improved on average from 10.3° to 26.5°, $p=0.0008$. The mean number of surgical procedures for each patient was 2.8 (range: 1–15). Taking all surgical procedures into account, post-operative complications were experienced by 30 patients. At last follow-up, 28 patients still complained of headache, 8 of whom had the intervention performed primarily for headache. Shunting can improve visual function in patients with IIH. There is significant post-operative morbidity and often the need for repeated procedures. Headache also commonly remains in these patients. There is a need for a randomised controlled trial of operative interventions in IIH. Sample size calculations for such a trial to treat significant vision loss are presented.

Keywords: Idiopathic intracranial hypertension, lumboperitoneal shunt, ventriculoperitoneal shunt, visual fields

INTRODUCTION

Idiopathic intracranial hypertension (IIH) is a clinical syndrome, predominantly in females, of unknown aetiology in which intracranial pressure is raised in the absence of a vascular or space-occupying lesion and without enlargement of the cerebral ventricles.¹ It is a disease linked with obesity, and, in line with increasing levels of obesity in the population, its incidence is increasing.² Its importance lies in the fact that it can lead to irreversible vision loss.³

To date, there are key unanswered questions in the management of IIH in terms of both the aetiology and

its treatment. Despite the potentially blinding nature of the condition, there have been insufficient trials performed to elucidate the optimum management of the condition.⁴ Randomised controlled trials of treatment that have been performed in IIH have been underpowered, including a recently reported trial of acetazolamide in patients with mild to moderate visual loss.⁵ The trial was powered to detect a treatment effect of 1.3 dB in the mean deviation of 24-2 SITA Humphrey perimetry, but only a more modest improvement of 0.71 dB was detected in the acetazolamide-treated arm compared with the placebo treatment arm, the clinical significance of which

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is uncertain. It has been recently shown that a very low calorie diet in IIH leads to significant weight loss with resultant decreases in intracranial pressure, reduction in papilloedema, and decrease in headache symptoms.⁶ However, most subjects regain weight after coming off such a diet.⁷

Where conservative methods of managing IIH are unsuccessful, particularly in cases where sight is threatened, there are several surgical options that are employed. Approaches include optic nerve sheath fenestration (ONSF)⁸ and venous sinus stenting,⁹ although the mainstay of surgical management in many centres remains shunting, usually with either a lumbo-peritoneal (LP) shunt¹⁰ or a ventriculo-peritoneal (VP) shunt.¹¹ Correlating with the increasing incidence of IIH, the number of shunting procedures performed each year for IIH in the USA is increasing.¹²

There have been no randomised control trials of surgical intervention in the management of this condition, with the result that the optimal surgical method of managing IIH has yet to be established, in terms of both efficacy and safety. In this paper, the outcomes from a relatively large cohort of patients with IIH who underwent shunt surgery are presented. From the results sample size calculations for trials of surgical intervention in IIH are presented.

METHODS

A retrospective review of the case notes of 50 consecutive patients who underwent LP or VP shunting for IIH at the Royal Hallamshire Hospital, Sheffield, United Kingdom, between 2000 and 2010 was performed. Patients were identified from operative records. IIH was diagnosed according to the Friedman-Jacobson criteria.¹³ From the case notes, the following were recorded: the decimal visual acuity pre-operatively and at last follow-up; the number of surgical procedures required per patient; any operative complications; the presence of headache at last follow-up; and medication use for IIH at last follow-up.

The mean radial degrees (MRD) of the I4e isopter from Goldmann visual fields (Haag-Streit, Köniz, Switzerland), taken pre-operatively and at the last clinic visit (with some missing data points), were measured according to the method outlined by Newman et al.¹⁴ Significant vision loss pre-operatively was defined as having an MRD $\leq 30^\circ$.¹⁴

Statistical analysis was performed using XLSTAT version 2014.1.05 (AddinsoftTM, New York, USA). Pre-operative and follow-up visual acuity and visual field scores were compared using paired-sample *t* tests. Visual acuity and visual field improvements between patients having LP or VP shunts as their primary intervention were compared using independent-sample *t* tests. To decide whether significantly more

re-operations were required after a primary LP shunt compared with a primary VP shunt, Fisher's exact test was performed.

A clinical trial of surgical intervention in IIH will target those with poor vision. Therefore, in order to perform sample size calculations, patients with a pre-operative MRD $\leq 30^\circ$, with no signs of functional vision loss on the visual field,¹⁵ and who had a follow-up visual field performed 6–18 months post-operatively were selected. The average improvement in MRD and standard deviation (SD) of that improvement was recorded. From these results sample sizes for trials of surgical intervention for severe vision loss in IIH were calculated.

RESULTS

The demographics of the patients are presented in Table 1. The vision scores are presented in Table 2 and Figure 1. Paired pre-operative and follow-up visual acuity scores were available for 49 patients. Visual acuity improved in 23 (46.9%), was unchanged in 17 (34.7%), and worsened in 9 (18.4%). Paired pre-operative and follow-up MRD scores were available for 41 patients. The MRD improved in 31 (75.6%), was unchanged in 1 (2.4%), and worsened in 9 (22.0%). There was no significant difference in the improvement in MRD ($p=0.45$) or visual acuity ($p=0.60$) between those patients having an LP shunt or VP shunt as their primary procedure.

Thirty patients required more than one operation, with an overall mean number of surgical procedures per patient of 2.8 and a median of 2.0 (range: 1–15). This included 4 patients who required subtemporal decompression (1 bilaterally). Of these 30 patients requiring further operations, 8 (out of 12, 75%) had had a primary LP shunt and 22 (out of 38, 57.9%) had had a primary VP shunt. The proportion requiring a

TABLE 1 Patient demographics.

Gender	All female
Mean age	32 (range: 18–51)
Mean weight	98.0 kg (range: 70.1–141.3)
Mean body mass index	37.2 kg/m ² (range: 26.1–48.9)
Mean delay from presentation to operation	822.3 days (range: 5–4161)
Primary reason for operation	34 Worsening vision 12 Persistent headache 2 Persistent optic disc swelling 1 Inability to lose weight 1 CSF rhinorrhoea
First procedure	38 VP shunt 12 LP shunt
Mean follow-up	1118 days (range: 13–3551)

CSF = cerebrospinal fluid; LP = lumboperitoneal; VP = ventriculoperitoneal.

repeat procedure was not significantly different between the two groups ($p=0.74$, Fisher's exact test).

Taking all surgical procedures into account, 44 different post-operative complications were experienced by 30 patients. These included 14 with abdominal pain, 7 with infections, 3 with intracranial haemorrhage, 3 with cerebrospinal fluid leak, 2 with hip pain, 2 with neck pain, and 1 each of memory problems, deep venous thrombosis, cerebral oedema, chest pain, syncope, back pain, leg pain, facial pain, palpitations, dyspnoea, shoulder pain, Chiari malformation, and paraesthesia.

At the last recorded follow-up, 28 patients (56%) still complained of headache, 8 of whom had the intervention primarily for headache. Twenty-one of

TABLE 3 Sample size calculation per arm for an equivalence trial of operative intervention for severe vision loss in idiopathic intracranial hypertension (IIH).

Equivalence limit of MRD	80% power	90% power
<u>Alpha of 0.025</u>		
2.9°	336	416
(25% of SD of treatment effect)		
5.8°	84	104
(50% of SD of treatment effect)		
<u>Alpha of 0.05</u>		
2.9°	274	346
(25% of SD of treatment effect)		
5.8°	64	87
(50% of SD of treatment effect)		

MRD = mean radial degrees.

TABLE 2 Vision scores pre-operatively and at follow-up.

Measure	Pre-operative mean (SD)	Follow-up mean (SD)	<i>p</i> Value
Decimal visual acuity	0.75 (0.37) $n=50$	0.84 (0.38) $n=49$	0.011
MRD score	25.6° (18.0°) $n=44$	35.5° (18.2°) $n=48$	<0.0001
MRD score in those with severe vision loss pre-operatively*	10.3° (8.5°) $n=23$	26.5° (19.5°) $n=21$	0.0008

MRD = mean radial degrees; SD = standard deviation.

*Defined as MRD $\leq 30^\circ$.

FIGURE 1 Pre-operative and follow-up mean radial degree scores.

TABLE 4 Previous case series of shunting for idiopathic intracranial hypertension.

Study	Number of patients	Primary reason for operation	Type of shunt first inserted	Length of mean follow-up	Complications	Number of operations required	Vision outcome	Number with headache at last visit
Rosenberg et al. (1993) ¹⁰	37	30 (81%) vision loss 7 (19%) headache	37 (100%) LP shunts	31 months	Complications requiring shunt revision: Low-pressure headaches in 14 (38%) Infection in 3 (8%) Abdominal pain in 3 (8%) Radicular pain in 2 (5%) Operative complications in 2 (5%) CSF leak in 1 (3%) Plus additional low-pressure headaches, radicular pain and hindbrain herniation headaches, although numbers were not specified	19 (51%) required further operations Mean 2.2 procedures per patient	Improved vision in 13 (35%) Improvement in 1 eye in 2 (5%) Unchanged vision in 16 (43%) Worsening vision in 6 (16%)	Not stated
Eggenberger et al. (1996) ¹⁸	27	14 (52%) vision loss 13 (48%) headache	27 (100%) LP shunts	77 months	Complications requiring shunt revision: Shunt obstruction (65% of all revisions) Low-pressure symptoms (15%) Catheter migration or dislocation (4.5%) Radiculopathy (4.5%) Shunt related infection (1.5%) Abdominal pain (1.5%)	15 (56%) required further operations Mean 3.4 procedures per patient	Of those operated on for vision loss: Vision normalised in 5 (36%) Vision improved in 4 (28.5%) Vision stable in 4 (28.5%) Not stated in 1 (7%)	10 (37%), although headaches improved
Burgett et al. (1997) ¹⁹	30	Out of 17 seen: 12 (70.5%) vision loss 4 (23.5%) headache 1 (6%) CSF rhinorrhoea	30 (100%) LP shunts	35 months	Complications requiring shunt revision when recorded (unknown denominator): Raised intracranial pressure in 13 Low intracranial pressure in 2 Infection in 1 CSF fistula in 1 Sciatica in 1	19 (63%) required further operations Mean 4.2 procedures per patient	Of 28 eyes with abnormal pre-operative Goldmann visual field: 5 (18%) normalised 13 (46%) improved 8 (31%) unchanged	2 (7%)

(continued)

TABLE 4 Continued

Study	Number of patients	Primary reason for operation	Type of shunt first inserted	Length of mean follow-up	Complications	Number of operations required	Vision outcome	Number with headache at last visit
Maher <i>et al.</i> (2001) ¹¹	13	Not stated	13 (100%) VP shunts 7 with prior ONSF 9 with prior shunts	15 months	Complications requiring shunt revision: Proximal obstruction in 1 Distal obstruction in 1 Not stated in 1	3 (23%) required further operations Mean 1.2 procedures per patient	Vision improved in 5 (38.5%) Vision stable in 8 (61.5%)	4 (31%)
Bynke <i>et al.</i> (2004) ²⁰	17	11 (65%) vision loss 6 (35%) headache	17 (100%) VP shunts	77 months	Complications requiring shunt revision: Failure of the peritoneal catheter in 6 Infection in 2 Malposition of the ventricular catheter in 1 In addition, 4 patients developed transient low-pressure headache	7 (41%) required further operations Mean 1.5 procedures per patient	VA improved by >2 lines in 3 eyes and remained essentially unchanged in 31 eyes Visual fields normalised in 11 eyes, improved in 11 eyes and were unchanged in 12 eyes	Not stated
McGirt <i>et al.</i> (2004) ²¹	42	42 (100%) headache	Not stated	3 years	Complications requiring shunt revision: Obstruction in 55 (48%) of all shunts Over-drainage in 16 (14%) Distal catheter migration in 5 (5%) Shunt infection in 4 (3.5%) CSF leak in 3 (3%) Other complications: Abdominal pain in 4 (23% of all VP shunts) Back pain in 4 (5% of all LP shunts) Tonsillar herniation in 3 (4% of all LP shunts) Complications requiring shunt revision:	23 (55%) required further operations Mean 2.7 procedures per patient	Not stated 20 (48%) eyes	
Abu-Serieh <i>et al.</i> (2007) ²²	9	6 (67%) headache 1 (11%) vision loss	9 (100%) VP shunts	44 months		6 (67%) required	Stable vision in 2 (22%) patients	Not stated

TABLE 4 Continued

Study	Number of patients	Primary reason for operation	Type of shunt first inserted	Length of mean follow-up	Complications	Number of operations required	Vision outcome	Number with headache at last visit
Yadav <i>et al.</i> (2012) ²⁶	24	Not stated	24 (100%) LP shunts	51 months	Abdominal pain in 1 Malposition of catheter tip in 1 In addition, there was 1 intracerebral haemorrhage, although the patient also had hypertension) Complications requiring shunt revision: Shunt blocked in 1 (4%) Shunt blocked and CSF leak in 1 (4%) In addition, temporary over drainage occurred in 15 (62.5%)	2 (8%) required further operations Mean 1.1 procedures per patient	Improved VA in 10 (42%) No change in VA in 11 (46%) Worse VA in 3 (12%)	2 (8%) had no change in headache
Huang <i>et al.</i> (2014) ²⁷	19	17 (89.5%) vision loss 2 (10.5%) headache	19 (100%) VP shunts 6 with prior ONSF	21 months	Meningitis with gangrenous small bowel in 1 Other complications and indications for revision not recorded	8 (42%) required further operations Mean 1.7 procedures per patient	Improvement in median VA from 20/200 in the worse eye to 20/60 ($p=0.002$) Improvement of 2.1 dB in the 24-2 HVF MD in the worse eye ($n=9$, $p=0.27$) Improvement in mean VA from 0.75 to 0.84 ($p=0.011$) Improvement in average MRD on Goldmann visual fields from 25.6° to 35.5° ($p<0.0001$)	Not stated
Present study	50	34 (68%) vision loss 12 (24%) headache 2 (4%) optic disc swelling 1 (2%) inability to lose weight 1 (2%) CSF rhinorrhoea	38 (76%) VP shunts 12 (24%) LP shunts	36 months	Abdominal pain in 14 Infection in 7 Intracranial haemorrhage in 3 CSF leak in 3 Hip pain in 2 Neck pain in 2 1 each of memory problems, DVT, cerebral oedema, chest pain, syncope, back pain, leg pain, facial pain, palpitations, dyspnoea, shoulder pain, Chiari malformation, and paraesthesia	30 (60%) required further operations Mean 2.8 procedures per patient	Improvement in mean VA from 0.75 to 0.84 ($p=0.011$) Improvement in average MRD on Goldmann visual fields from 25.6° to 35.5° ($p<0.0001$)	28 (56%)

these were taking medication for headache, including 6 taking regular analgesia alone; 4 taking amitriptyline alone; 3 taking amitriptyline and analgesia; 3 taking topiramate alone; 2 taking acetazolamide and analgesia; 1 taking acetazolamide and amitriptyline; 1 taking acetazolamide, amitriptyline, and gabapentin; and 1 taking topiramate and gabapentin.

Fourteen patients had an initial MRD $\leq 30^\circ$, with no signs of functional vision loss and had a follow-up visual field performed 6–18 months post-operatively (mean: 389 days, range: 227–513). Nine of this group had primary VP shunting and 5 had primary LP shunting. The average improvement in MRD was 10.3° , with an SD of 11.6° ($p=0.0055$). Based on these results, sample size calculations for an equivalence trial^{16,17} are presented in Table 3. For example, to show that an operative intervention in IIH produced equivalent improvement in MRD to shunting with an equivalence limit (the largest difference that is clinically acceptable)^{16,17} of 5.8° , 80% power and an alpha of 0.025 (i.e. a type I error rate of 2.5%) would require 84 patients in each arm.

DISCUSSION

The results from this case series are in line with results of previous studies of shunting in IIH, which are summarised in Table 4.^{10,11,18–27} There is some heterogeneity in how the results are expressed and the length of follow-up, so it is difficult to accurately compare studies. There is also heterogeneity in the type of surgical approach, be it LP or VP shunt, whether stereotactic methods were used to access the lateral ventricles or whether programmable shunts were employed. The complication rate from the present study appears higher than the other studies because the total surgical morbidity was recorded from all operations, not just from the primary operation or the reason for shunt revision. However, when comparing surgical methods, it is important to consider the morbidity from the total patient pathway, not just the results from the initial surgery after a short follow-up period.

What can be concluded from the results of all these series is that shunt surgery can improve visual function in patients with IIH, although in most of the studies listed the amount of improvement was not quantified. There is significant post-operative morbidity and often the need for repeated procedures. Headache also commonly remains in these patients.

It is not clear what is the optimum method of surgical intervention. Shunting, venous sinus stenting and ONSF all have their proponents.^{28,29} In a review comparing reported visual outcomes for shunting, venous sinus stenting and ONSF in patients with visual loss due to IIH, Feldon found that there was improvement in vision in 38.7% of patients after VP

shunt placement, 44.6% of patients after LP shunt placement, 47% of patients after stent placement and 80% of eyes after ONSF. However, there was no clear definition of what constituted visual loss and it was also felt that since the ONSF patients were more likely to have more detailed post-operative visual assessments than patients having other procedures subtle improvements may have been more likely to have been detected. Also, the magnitude of visual improvement from each method could not be ascertained.³⁰ In practice, the choice of method usually depends on local availability. There is a need for a randomised controlled trial of operative interventions in IIH.

There are three main components to assessing the results of surgery in IIH. These are the preservation and improvement of vision, the degree of headache reduction, and the operative morbidity. It may be that there may not be one single optimum method in terms of all three components.

An equivalence trial design is not powered to show superiority of one treatment over another but to show that the two treatments have no clinically meaningful difference, i.e. that they are clinically equivalent.¹⁶ Equivalence trial designs are usually employed to test a new treatment against an established treatment to demonstrate both clinical equivalence but also whether the new treatment has other advantages over the established treatment, such as having less side effects or being cheaper.³¹ Since all the proposed surgical options in IIH to date have been shown to have some effect in improving vision, then it may be quite difficult to show a clinically meaningful difference between the treatments in terms of improving vision. However, it will be useful to know if one method of surgical intervention has much less associated morbidity than another, even if the effects on vision are similar. It is important for there to be a degree of equipoise in the choice of intervention (i.e. no clear preference between them), otherwise there will be a failure to recruit patients.³²

As the numbers in either sort of trial design are large, the trial would have to be run at multiple centres in order for recruitment to be completed within an acceptable time frame. There would have to be standardisation across the trial centres in the surgical techniques employed on both sides of the trial, in the make of hardware implanted, and in measurements of vision and other secondary endpoints with appropriate quality assurance procedures in place. For visual field assessment, Octopus perimetry (Haag-Streit) has advantages over Goldmann perimetry, being semi-automated so standard protocols can be employed.³³ There are advantages and disadvantages with kinetic perimetry compared with static threshold perimetry as employed by the Humphrey perimeter.³⁴ The one major advantage of kinetic perimetry is the ability to measure effects on

the peripheral visual field, which is where vision is lost first in IIH.

Although such a study would not be double blinded, since the patient will know which intervention they had had, the outcome measures, such as visual acuity, visual field score, optic disc grading, and optical coherence tomography, could be measured with the observer blinded as to which intervention had occurred, so meaningful results could be obtained. Also, the complication rates and the need for re-operation will be meaningful outcomes from a trial.

There are therefore considerable hurdles to be overcome in setting up such a trial; however, without such a trial, the debate as to the optimum surgical management for IIH will continue.

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REFERENCES

- [1] Dhungana S, Sharrack B, Woodroffe N. Idiopathic intracranial hypertension. *Acta Neurol Scand* 2010;121: 71–82.
- [2] Raoof N, Sharrack B, Pepper IM, Hickman SJ. The incidence and prevalence of idiopathic intracranial hypertension in Sheffield, UK. *Eur J Neurol* 2011;18:1266–1268.
- [3] Best J, Silvestri G, Burton B, Foot B, Acheson J. The incidence of blindness due to idiopathic intracranial hypertension in the UK. *Open Ophthalmol J* 2013;7:26–29.
- [4] Lueck C, McIlwaine G. Interventions for idiopathic intracranial hypertension. *Cochrane Database Syst Rev* 2005;3: CD003434.
- [5] The NORDIC Idiopathic Intracranial Hypertension Study Group Writing Committee. Effect of acetazolamide on visual function in patients with idiopathic intracranial hypertension and mild visual loss. *JAMA* 2014;311: 1641–1651.
- [6] Sinclair AJ, Burdon MA, Nightingale PG, Ball AK, Good P, Matthews TD, Jacks A, Lawden M, Clarke CE, Stewart PM, Walker EA, Tomlinson JW, Rauz S. Low energy diet and intracranial pressure in women with idiopathic intracranial hypertension: prospective cohort study. *BMJ* 2010;341: c2701.
- [7] National Task Force on the Prevention and Treatment of Obesity. Very low-calorie diets. *JAMA* 1993;270:967–974.
- [8] Pineles SL, Volpe NJ. Long-term results of optic nerve sheath fenestration for idiopathic intracranial hypertension: earlier intervention favours improved outcomes. *Neuro-Ophthalmology* 2013;37:12–19.
- [9] Ahmed RM, Wilkinson M, Parker GD, Thurtell MJ, Macdonald J, McCluskey PJ, Allan R, Dunne V, Hanlon M, Owler BK, Halmagyi GM. Transverse sinus stenting for idiopathic intracranial hypertension: a review of 52 patients and of model predictions. *AJNR Am J Neuroradiol* 2011;32:1408–1414.
- [10] Rosenberg ML, Corbett JJ, Smith C, Goodwin J, Sergott R, Savino P, Schatz N. Cerebrospinal fluid diversion procedures in pseudotumor cerebri. *Neurology* 1993;43: 1071–1072.
- [11] Maher CO, Garrity JA, Meyer FB. Refractory idiopathic intracranial hypertension treated with stereotactically planned ventriculoperitoneal shunt placement. *Neurosurg Focus* 2001;10:1–4.
- [12] Curry WT, Butler WE, Barker FG. Rapidly rising incidence of cerebrospinal fluid shunting procedures for idiopathic intracranial hypertension in the United States, 1988–2002. *Neurosurgery* 2005;57:97–108.
- [13] Friedman DI, Jacobson DM. Diagnostic criteria for idiopathic intracranial hypertension. *Neurology* 2002;59: 1492–1495.
- [14] Newman WD, Tocher K, Acheson JF. Vigabatrin associated visual field loss: a clinical audit to study prevalence, drug history and effects of drug withdrawal. *Eye (Lond)* 2002;16: 567–571.
- [15] Hickman SJ. Neuro-ophthalmology. *Pract Neurol* 2011;11: 191–200.
- [16] Julious SA. Sample sizes for clinical trials with Normal data. *Stat Med* 2004;23:1921–1986.
- [17] Lange S, Freitag G. Choice of delta: requirements and reality—results of a systematic review. *Biom J* 2005;47: 12–27.
- [18] Eggenberger ER, Miller NR, Vitale S. Lumboperitoneal shunt for the treatment of pseudotumor cerebri. *Neurology* 1996;46:1524–1530.
- [19] Burgett RA, Purvin VA, Kawasaki A. Lumboperitoneal shunting for pseudotumor cerebri. *Neurology* 1997;49: 734–739.
- [20] Bynke G, Zemack G, Bynke H, Romner B. Ventriculoperitoneal shunting for idiopathic intracranial hypertension. *Neurology* 2004;63:1314–1316.
- [21] McGirt MJ, Woodworth G, Thomas G, Miller N, Williams M, Rigamonti D. Cerebrospinal fluid shunt placement for pseudotumor cerebri-associated intractable headache: predictors of treatment response and an analysis of long-term outcomes. *J Neurosurg* 2004;101: 627–632.
- [22] Abu-Serieh B, Ghassempour K, Duprez T, Raftopoulos C. Stereotactic ventriculoperitoneal shunting for refractory idiopathic intracranial hypertension. *Neurosurgery* 2007;60: 1039–1044.
- [23] Abubaker K, Ali Z, Raza K, Bolger C, Rawluk D, O'Brien D. Idiopathic intracranial hypertension: lumboperitoneal shunts versus ventriculoperitoneal shunts—case series and literature review. *Br J Neurosurg* 2011;25:94–99.
- [24] Sinclair AJ, Kuruvath S, Sen D, Nightingale PG, Burdon MA, Flint G. Is cerebrospinal fluid shunting in idiopathic intracranial hypertension worthwhile? A 10-year review. *Cephalalgia* 2011;31:1627–1633.
- [25] Tarnaris A, Toma AK, Watkins LD, Kitchen ND. Is there a difference in outcomes of patients with idiopathic intracranial hypertension with the choice of cerebrospinal fluid diversion site: a single centre experience. *Clin Neurol Neurosurg* 2011;113:477–479.
- [26] Yadav YR, Parihar V, Agarwal M, Bhatele PR, Saxena N. Lumbar peritoneal shunt in idiopathic intracranial hypertension. *Turk Neurosurg* 2010;22:21–26.
- [27] Huang LC, Winter TW, Herro AM, Rosa PR, Schiffman JC, Pasol J, Trombly RS, Tawfik M, Lam BL. Ventriculoperitoneal shunt as a treatment of visual loss in idiopathic intracranial hypertension. *J Neuroophthalmol* 2014;34: 223–228.
- [28] Spitze A, Malik A, Al-Zubidi N, Golnik K, Lee AG. Optic nerve sheath fenestration vs cerebrospinal diversion procedures: what is the preferred surgical procedure for the treatment of idiopathic intracranial hypertension failing maximum medical therapy? *J Neuroophthalmol* 2013;33: 183–188.

- [29] Ahmed R, Friedman DI, Halmagyi GM. Stenting of the transverse sinuses in idiopathic intracranial hypertension. *J Neuroophthalmol* 2011;31:374–380.
- [30] Feldon SE. Visual outcomes comparing surgical techniques for management of severe idiopathic intracranial hypertension. *Neurosurg Focus* 2007;23:E6.
- [31] Piaggio G, Elbourne DR, Altman DG, Pocock SJ, Evans SJW, CONSORT Group. Reporting of noninferiority and equivalence randomized trials: an extension of the CONSORT statement. *JAMA* 2006;295:1152–1160.
- [32] van der Graaf R, van Delden JJ. On what we will lose in giving up on clinical equipoise: a reply to Miller. *Clin Trials* 2012;9:628–629.
- [33] Nowomiejska K, Vonthein R, Paetzold J, Zagorski Z, Kardon R, Schiefer U. Comparison between semiautomated kinetic perimetry and conventional Goldmann manual kinetic perimetry in advanced visual field loss. *Ophthalmology* 2005;112:1343–1354.
- [34] Wall M, George D. Idiopathic intracranial hypertension. A prospective study of 50 patients. *Brain* 1991;114:155–180.