

The Chiari Pseudotumor Cerebri Syndrome: Symptom Recurrence after Decompressive Surgery for Chiari Malformation Type I

Lisa H. Fagan Sherise Ferguson Reza Yassari David M. Frim

Section of Pediatric Neurosurgery, The University of Chicago Children's Hospital, Chicago, Ill., USA

Key Words

Chiari malformation · Pseudotumor cerebri · Failed Chiari decompression

Abstract

Introduction: The etiology of Chiari malformation type I (CM1) as well as other anomalies associated with CM1 remains poorly defined. We have noted the presence of elevated CSF pressures with small ventricles, consistent with the pseudotumor cerebri (PTC) syndrome in a group of CM1 patients that did not respond over the long term to posterior fossa decompression. In order to better understand this association, we reviewed a series of CM1 patients treated by posterior fossa decompression to define the prevalence and nature of post-Chiari PTC. **Methods:** We performed a retrospective chart review of 192 patients diagnosed with CM1 and treated by posterior fossa decompression. Patients who failed to respond to surgery were evaluated by CINE MR flow studies to assess presence of CSF flow at the foramen magnum and then by lumbar puncture if flow was present. The diagnosis of Chiari PTC was defined by recurrence of Chiari-like symptoms after decompression, elevated lumbar CSF pressure in the absence of ventriculomegaly, and transient resolution of symptoms with large volume lumbar CSF drainage. **Results:** Thirty-six of 192 patients did not improve with surgical decompression. Fifteen of

36 operative CM1 patients (41.6%) were found to have Chiari PTC. The most frequent symptoms of CM1/PTC patients were head pain, body aches, and balance difficulties. Three patients also experienced visual complaints. The mean maximum lumbar CSF pressure documented in this cohort was 26 cm of water in adults and 25.3 in children. All patients received treatment for the CM1/PTC that culminated with CSF shunt placement in 14/15. Seven of 9 pediatric patients had significant symptom resolution while 6/6 adult patients remained variably symptomatic. **Conclusion:** CM1 and PTC co-exist in a surprising percentage of failed operative CM1 patients and present with a syndrome that is difficult to treat. The etiology of this association after Chiari decompression is unclear, though perhaps posterior fossa surgery in the setting of abnormal anatomy and potentially anomalous CSF flow dynamics contributes to CSF malabsorption and resultant or coexistent PTC.

Copyright © 2006 S. Karger AG, Basel

Introduction

Chiari I malformation (CM1) is defined as downward displacement of the cerebellar tonsils through the foramen magnum into the cervical canal and was first described in 1891 [1]. It is generally considered a hindbrain maldevelopment that can be associated with syringomy-

elia [2] and has an incidence of 0.5% with a female:male ratio of 3:2 [3]. The symptoms are usually related to the anatomic crowding around the brainstem, lower cranial nerves, cerebellum, and spinal cord (table 1). However, CM1 patients can remain asymptomatic in up to 30% of cases [3] or present with general complaints leading to an initial diagnosis of migraine, chronic fatigue syndrome, multiple sclerosis or pseudotumor cerebri (PTC) [4, 5]. PTC is defined as a syndrome consisting of increased intracranial pressure with elevated CSF pressure in the absence of ventriculomegaly, mass lesions or infection [6]. Its pathogenesis is unclear but the main pathophysiological hypothesis classifies it as a CSF circulation defect [7]. Its association with CM1 has been documented in 2.7% of all patients diagnosed with PTC [8]. Interestingly, we have observed PTC in CM1 patients after failed posterior fossa decompression. The purpose of this retrospective study was to look at a cohort of CM1 patients who underwent posterior fossa decompression in order to examine the prevalence and nature of PTC in patients who fail surgical Chiari treatment.

Table 1. Several components of the clinical Chiari syndrome

Tussive headache	Papilledema
Visual changes	Absent gag reflex
Nystagmus (vertical and downbeating)	Hoarseness
Muscle weakness	Tinnitus
Sensory deficits	Hyperreflexia
Dysphagia	Hyporeflexia
Dysarthria	Positive Babinski
Ataxia	Positive Rhomberg
Tremor	Weakness
Syncope (drop attack)	

Patients and Methods

A retrospective chart review was conducted of 192 consecutive patients presenting to our clinic who had undergone posterior fossa decompression, C1 laminectomy, and duroplasty for CM1 either at our institution or an outside institution. Autologous pericranial duroplasty grafts were used in all cases operated at our institution in addition to sub-arachnoid exploration to assure adequate CSF outflow from the fourth ventricle was present. Failed Chiari surgery patients who presented to our institution with bone-only decompression or nonautologous duraplasty grafts were reoperated for duraplasty or replacement duraplasty with autologous material. Excluded were patients with concurrent diagnoses of myelodysplasia, hydrocephalus, or craniostyosis associated with the CM1.

During a follow-up period of up to 6 years, patients who had recurrent symptoms despite surgical intervention were identified. Indications for surgery in the group of patients that failed varied, but all of the failed surgical patients initially had presented with head pain of some sort, a variety of other symptoms included in the clinical Chiari syndrome (table 1), and cerebellar tonsillar herniation below the level of the foramen magnum within the definition of CM1 as recently presented by Milhorat et al. [4]. None of the failed surgical patients had initially presented with syringomyelia and none of these patients had preoperative CSF pressure measurements. These patients were evaluated by MRI CSF CINE flow study at the foramen magnum to identify the presence or absence of CSF flow out of the fourth ventricle. If flow through the foramen magnum was demonstrated on MRI, CSF pressure was directly measured by supine lumbar puncture with sedation if necessary. Bacteriological, chemical and hematological analyses were performed on all CSF samples and were without abnormality in all PTC patients. Patients with elevated CSF pressures underwent CSF shunt placement if therapeutic lumbar punctures (to 50% of the opening pressure) repeatedly led to a reliable reduction in their symptomatology. Individual data were grouped by age (pediatric, <17 years, and adult; tables 2, 3).

Three additional patients presented to our clinic during this time period who had been shunted (one from the ventricle and two from the lumbar space) for PTC diagnosed by headache, papilledema, and elevated CSF pressure. Incidental CM1 was known to be present in these patients, and they are analyzed and discussed below separately from the 192 consecutive operative CM1 patients reviewed above.

Table 2. Development of PTC after Chiari decompression in adults

Patient	Sex	Age at Chiari surgery	Interval before PTC developed	Maximum CSF pressure	Treatment	Outcome
1	f	32	0.7 months	52 cm H ₂ O	VP → LP Shunt	no improvement
2	f	31	9 months	24 cm H ₂ O	VP → LP shunt	no improvement
3	f	35	5 months	18 cm H ₂ O	LP shunt	no improvement
4	f	36	1 year	16 cm H ₂ O	VP shunt	no improvement
5	f	40	2 months	28 cm H ₂ O	medical	no improvement
6	f	32	6 months	18 cm H ₂ O	VP shunt	minimal improvement

VP = Ventriculoperitoneal; LP = lumboperitoneal.

Table 3. Development of PTC after Chiari decompression in children

Patient	Sex	Age at surgery	Interval before PTC symptoms developed	Maximum measured CSF pressure	Treatment	Outcome
1	f	3	8 months	30 cm H ₂ O	LPS	symptom resolution
2	f	4	8 months	28 cm H ₂ O	VPS	symptom resolution
3	m	14	1 year	19 cm H ₂ O	LPS	mild improvement
4	m	6	4 years	30.5 cm H ₂ O	LPS	mild improvement
5	m	12	8 months	22.5 cm H ₂ O	LPS	symptom resolution
6	f	15	1 year 9 months	13 cm H ₂ O	LPS	symptom resolution
7	m	7	1 month	27 cm H ₂ O	LPS	symptom resolution
8	m	7	7 months	34 cm H ₂ O	LPS	symptom resolution
9	f	12	3 months	24 cm H ₂ O	LPS	symptom resolution

VPS = Ventriculoperitoneal shunt; LPS = lumboperitoneal shunt.

Results

Thirty-six CM1 patients did not have complete resolution of their symptoms after posterior fossa decompression (or reoperation as described above if surgery was performed at an outside institution) and were classified as 'failed Chiari' patients. Fifteen of those patients with normal posterior CSF flow at the foramen magnum (6 adults and 9 children representing 41.6% of failed Chiari decompression patients) were found to have elevated lumbar CSF pressures (mean 25.6 cm of water) with small ventricles and were diagnosed with Chiari PTC (tables 2, 3). Mean age of the pediatric patients (n = 9) was 8.9 years with an average time interval of 12.9 months from initial surgery to recurrence of symptoms. Mean maximum CSF pressure of the pediatric group was 25.3 cm of water. In the adult group (n = 6), the average age was 34 years, the interval to symptom recurrence was 5.8 months on average, and the mean maximal CSF pressure was 26.0 cm of water similar to the mean maximal pressure in the pediatric patients. Adult patients with a postoperative diagnosis of PTC did not respond well to surgical intervention. Those that underwent shunt placement derived little symptomatic relief, though signs, such as visual impairment or optic nerve swelling, improved. The treatment of postdecompression PTC in the pediatric population was more successful: 7 patients markedly improved after shunting with near resolution of headaches; the remaining 2 patients had presented 8 and 48 months after initial CM1 decompression and after shunting remained with existing but reduced symptomatology.

Diagnosis of CM1 Subsequent to Diagnosis of PTC

In 3 patients with an initial diagnosis of PTC which included headache, papilledema, and elevated lumbar CSF pressures, an asymptomatic CM1 was demonstrated radiographically. All 3 underwent placement of CSF shunting systems (ventricular in one and lumbar in the others). However, symptoms referable to CM1 (e.g., tussive headache) eventually developed in all patients. They underwent CM1 decompression with resolution of the Chiari syndrome but persistence of the PTC as demonstrated by shunt dependence. Of note, 2 of the 3 patients (1 male, 1 of 2 females) were nonobese and PTC symptoms did not respond to moderate weight loss in either patient. These patients' symptomatology represent the concurrence of CM1 and PTC without a sequential progression marked by initial surgical intervention on the CM and may indicate a different relationship between CM1 and PTC.

Discussion

CM was first described in the 1890s by Chiari, who observed the anomaly in autopsy specimens [1]. CM1, or cerebellar tonsillar herniation through the foramen magnum, is often associated with spinal syrinx and/or hydrocephalus, and can be accompanied by the Chiari syndrome, including clinical symptoms of tussive headache, tinnitus, and ataxia (table 1).

Milhorat et al. [4] published a review of 364 CM1 patients, 91% of whom exhibited cerebellar tonsillar herniation of 5 mm or greater through the foramen magnum.

A significant percentage of the cohort presented with concurrent syringomyelia. The CM1 patients commonly manifested signs and symptoms of headache, lower cranial nerve deficits, and syringomyelia. Many presented with symptoms consistent with PTC. Milhorat et al. [4] identified significant cerebrospinal fluid flow abnormalities in this population characterized by a 40% reduction in total CSF volume, as well as a specific reduction in volume in the posterior cranial fossa. MRI CINE CSF flow data demonstrated decreased flow posteriorly through the foramen magnum in a large number of patients. The Milhorat cohort additionally demonstrated a genetic pattern of inheritance, with 12% of patients reporting a relative with CM1 or syringomyelia; Milhorat et al. [4] propose a mesodermal etiology of the disease, manifesting as an overcrowding of the posterior cranial fossa.

Other etiologies of CM1 have been described, including congenital/mesodermal, traumatic, and iatrogenic (via lumbar puncture, lumboperitoneal shunt, or subsequent to arachnoiditis) [9, 10]. Independent of etiology, disruption of normal CSF flow leads to the development of a pressure differential between the intracranial and spinal systems [11, 12]. Such a differential may be responsible for the development of CM1, syringomyelia or both, and can be theoretically corrected by suboccipital decompression [11–14].

Similar to CM1, PTC or benign intracranial hypertension is also considered to be a cerebrospinal fluid circulation defect. Nonne [15] used the term ‘pseudotumor’ to encompass a syndrome of increased intracranial pressure in the absence of intracranial neoplasm, hydrocephalus, encephalitis, or meningitis. The diagnosis of PTC is based on the findings of signs and symptoms of increased intracranial pressure and documented increased ICP, in the absence of focal neurological signs, mass lesion, infection, ventriculomegaly, or an identifiable precipitating factor [6]. Risk factors associated with the development of PTC include obesity, female sex and menstrual irregularity [16]. Attempts have been made to identify potential underlying pathophysiological mechanisms. Johnston and Patterson [17] demonstrated a decreased CSF absorption in the subarachnoid space using isotope cisternography. They suggested that PTC develops in response to a decrease in CSF absorption. This can potentially be due to a decreased pressure gradient between the subarachnoid space and the superior sagittal sinus leading to an alteration of fluid dynamics and impaired CSF absorption. Alternatively, a relative obstruction to CSF absorption due to increased resistance to flow across the subarachnoid

space could also cause PTC as in both cases the ventricles may not enlarge despite elevation in CSF pressure. Recordings of intracranial pressure in PTC have demonstrated a periodic pressure wave, suggesting a slow pressure build-up that vents CSF into the venous system as pressure in the subarachnoid space overcomes the pressure in the superior sagittal sinus or the resistance of CSF flow across the arachnoid villi. The specific causative agents in the development of PTC remain unknown.

In the present study, we encountered 15 patients (6 adults and 9 children) who had undergone decompressive surgery for CM1 with immediate symptom relief. However, after an average of 10 months, these patients had a recurrence of symptoms and were found to have the elevated ICP characteristic of PTC. They were subsequently treated with CSF shunts; nearly all the children had complete resolution of symptoms when the shunts were functioning, whereas the adults showed less remarkable improvement. This type of failed Chiari syndrome has also been described in adults by Bejjani et al. [18]; however, this is the first time that this syndrome has been described in children. Along with this earlier work, the present study lends support to the notion of a coexistence of Chiari and PTC (Chiari-PTC) as a separate syndrome in the spectra of Chiari and PTC syndromes.

Due to the clinical and treatment similarities between them, there has been much speculation about the relationship between CM1 and PTC. Sinclair et al. [8] describe a 12-year-old who presented with increased intracranial pressure and CM1. This relationship was deemed a coincidence because medical treatment of the PTC relieved the symptoms of elevated ICP without any change in the CM. On the other hand, Bejjani et al. [18] and Bejjani [19] have suggested that the relationship between tonsillar herniation and PTC is more than a chance association. Johnston et al. [5] found that 6% of adult patients with PTC had CM. This is eight times the believed incidence of CM1 in the normal population, suggesting that the relationship is more than coincidental. Moreover, Bejjani [19] suggested that in some populations of patients there might be a true causal relationship between PTC and CM1. In this relationship, brain edema that is thought to characterize PTC would lead to an increase in intracranial volume. This, in turn, would cause the cerebellar tonsils to herniate into the foramen magnum, particularly in the setting of a small posterior fossa, hence the diagnosis of CM1 by the classic radiological criteria.

This cause-and-effect relationship hypothesis may explain some of the results obtained in the present study, particularly in the pediatric patients. It is possible that

the children in the study were initially misdiagnosed; even though the presence of CM1 was clear, the symptoms may have actually been caused initially by the PTC and not by the CM1. In other words, a patient may have originally had PTC resulting in tonsillar herniation characteristic of CM1. Because of the similarity in symptoms between PTC and CM1, such a patient may have been subsequently diagnosed and treated for the CM1 with decompressive surgery. The surgery may have given temporary relief by altering the compliance of the skull, however, the underlying PTC would remain. This is an explanation for the transient relief and recurrence of symptoms that resolve with shunting. In this study we actually observed 3 PTC patients who subsequently were diagnosed with concurrent CM1 syndrome when it became symptomatic. Though there was symptomatic improvement relative to the CM1 after posterior fossa decompression, the PTC did not resolve. These cases may illustrate that the relationship between the Chiari anatomy and PTC is multi-dimensional and that, potentially, the syndrome is one of a CSF flow dyscrasia where CM1 and PTC are potential manifestations.

We found that CSF shunts were highly effective in resolving symptoms of failed Chiari PTC in children as opposed to adults. This is the first study to make such a comparison. This relative lack of efficacy in adults was rather surprising, especially considering the study by Bejjani et al. [18] which reported significant improvement in symptoms in 6 adults who underwent ventriculoperitoneal or lumboperitoneal shunt for treatment of failed adult CM. Moreover, the patient population in the Bejjani et al. [18] study was very similar to ours in terms of age, interval before symptoms developed, and average maximum pressure. However, both of the studies are small enough that the difference in findings may be attributed to chance. On the other hand, compared to adults, children had a much longer interval between their initial surgery and development of symptoms. The reason for the relative success of CSF shunting for PTC after failed Chiari decompression in children versus adults is difficult to explain because the pathophysiology of PTC and its subsequent relationship to CM1 is still uncertain.

The CM1-PTC disorders described in this case series are defined by two common themes: cerebrospinal fluid disruption and underlying structural anomaly. Chronic disruption of cerebrospinal fluid dynamics manifests in a constellation of clinical symptoms including headache, lower cranial nerve deficits, and gait disturbance. In spite of the potentially diverse etiologies of CM1 and PTC,

these patients exhibit signs and symptoms of both disease processes. CM1-PTC is prevalent in patients whose symptoms are resistant to suboccipital decompression.

It could be that patients with predisposition for the development of Chiari syndrome who have anatomical CM1, such as those with mesodermal/structural anomalies of the skull base, spinal cord tethering, or trauma could be at higher risk for developing an abnormality in CSF flow dynamics and maybe primary PTC. Surgical intervention itself could cause changes in CSF circulation due to postoperative scarring or CSF inflammation due to blood reabsorption. Such an imbalance in fluid circulation might lead to changes in the turgor of the brain parenchyma, or an increase in resistance across the arachnoid villi leading to the postoperative development of PTC. The etiology of this condition is likely multifactorial which makes interpretation of the results even more challenging.

In conclusion, there is growing evidence of a coexistent relationship between CM1 and PTC. Hence, in the setting of failed Chiari decompression complicated by symptoms of increased intracranial pressure, management with CSF drainage may be of use. Moreover, evaluation of patients for high CSF pressures prior to decompressive surgery may also be of some value in determining the likelihood of a positive surgical outcome.

References

- 1 Chiari H: Über Veränderungen des Kleinhirns in Folge von Hydrocephalie des Grosshirns. *Dtsch Med Wochenschr* 1891;17:1172–1175.
- 2 Guyotat J, Bret P, Jouanneau E, Ricci AC, Lapras C: Syringomyelia associated with type I Chiari malformation. A 21-year retrospective study on 75 cases treated by foramen magnum decompression with a special emphasis on the value of tonsils resection. *Acta Neurochir (Wien)* 1998;140:745–754.
- 3 Elster AD, Chen MY: Chiari I malformations: clinical and radiologic reappraisal. *Radiology* 1992;183:347–353.
- 4 Milhorat TH, Chou MW, Trinidad EM, Kula RW, Mandell M, Wolpert C, Speer MC: Chiari I malformation redefined: clinical and radiographic findings for 364 symptomatic patients. *Neurosurgery* 1999;44:1005–1017.
- 5 Johnston I, Jacobson E, Besser M: The acquired Chiari malformation and syringomyelia following spinal CSF drainage: a study of incidence and management. *Acta Neurochir (Wien)* 1998;140:417–427.
- 6 Johnston I, Hawke S, Halmagyi M, Teo C: The pseudotumor syndrome. Disorders of cerebrospinal fluid circulation causing intracranial hypertension without ventriculomegaly. *Arch Neurol* 1991;48:740–747.
- 7 Levine DN: Ventricular size in pseudotumor cerebri and the theory of impaired CSF absorption. *J Neurol Sci* 2000;177:85–94.
- 8 Sinclair N, Assaad N, Johnston I: Pseudotumor cerebri occurring in association with the Chiari malformation. *J Clin Neurosci* 2002;9:99–101.
- 9 Chumas PD, Armstrong DC, Drake JM, Kulkarni AV, Hoffman HJ, Humphreys RP, Rutka JT, Hendrick EB: Tonsillar herniation: the rule rather than the exception after lumboperitoneal shunting in the pediatric population. *J Neurosurg* 1993;78:568–573.
- 10 Sullivan HC: Fatal tonsillar herniation in pseudotumor cerebri. *Neurology* 1991;41:1142–1144.
- 11 Gardner WJ: Hydrodynamic factors in Dandy-Walker and Arnold-Chiari malformations. *Childs Brain* 1977;3:200–212.
- 12 Williams B: Cerebrospinal fluid pressure-gradients in spina bifida cystica, with special reference to the Arnold-Chiari malformation and aqueductal stenosis. *Dev Med Child Neurol* 1975;(suppl):138–150.
- 13 Oldfield EH, Muraszko K, Shawker TH, Patronas NJ: Pathophysiology of syringomyelia associated with Chiari I malformation of the cerebellar tonsils. Implications for diagnosis and treatment. *J Neurosurg* 1994;80:3–15.
- 14 Iskandar BJ, Hedlund GL, Grabb PA, Oakes WJ: The resolution of syringohydromyelia without hindbrain herniation after posterior fossa decompression. *J Neurosurg* 1998;89:212–216.
- 15 Nonne M: Über Fälle vom Symptomenkomplex ‘Tumor cerebri’ mit Ausgang in Heilung (Pseudotumor cerebri). Über lethal verlaufende Fälle von ‘Pseudotumor cerebri’ mit Sektionsbefund. *Dt Z Nervenheilk* 1904;27:169–216.
- 16 Johnston I, Paterson A: Benign intracranial hypertension. I. Diagnosis and prognosis. *Brain* 1974;97:289–300.
- 17 Johnston I, Paterson A: Benign intracranial hypertension. II. CSF pressure and circulation. *Brain* 1974;97:301–312.
- 18 Bejjani GK, Cockerham KP, Rothfus WE, Maroon JC, Maddock M: Treatment of failed adult Chiari malformation decompression with CSF drainage: observations in 10 patients. *Acta Neurochir* 2003;145:107–116.
- 19 Bejjani GK: Association of adult chiari malformation and idiopathic intracranial hypertension: more than a coincidence. *Med Hypotheses* 2003;60:859–863.