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BRIEF COMMUNICATION

Acute post-traumatic hydrocephalus in children due to aqueductal obstruction by blood clot: a series of 6 patients

Pietro Spennato[1] · Claudio Ruggiero[1] · Raffaele Stefano Parlato[1] · Vincenzo Trischitta[1] · Giuseppe Mirone[1] · Maria Serena De Santi[1] · Giuseppe Cinalli[1]

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Abstract

Introduction Post-traumatic hydrocephalus following head injury is a well-known entity. Most cases occur in patients with severe head injuries, often following decompressive craniectomy. On the contrary, acute post-traumatic hydrocephalus, caused by aqueductal obstruction by a blood clot, following mild head injury is uncommon.

Clinical material Six patients aged between 6 and 15 months presented hydrocephalus secondary to a blood clot in the aqueduct. Because of intracranial hypertension at presentation, 4 patients were urgently treated with external ventricular drains (EVDs). Post-operative course was uneventful. In 2 cases, EVDs were removed without further treatments. In 2 cases, hydrocephalus recurred. These patients were successfully treated with endoscopic third ventriculostomy. The remaining two patients developed symptoms a few days after the trauma. One, that presented hydrocephalus at imaging, was managed with a ventriculo-peritoneal shunt; the other, that presented subdural hygroma, was managed with subduro-peritoneal shunt that was removed later. All patients had complete recovery.

Discussion and conclusion Hydrocephalus secondary to clot in the aqueduct may rarely be the result of mild head injury in young children. Usually, prompt surgical management warrants a very good outcome. Most children may be treated without a permanent shunt, by using external drains and endoscopic third ventriculostomy.

Keywords Hydrocephalus · Pediatric · Head injury · Shunting · Endoscopic third ventriculostomy · External ventricular drainage

Introduction

Post-traumatic hydrocephalus (PTH) following head injury is a well-known entity. Most cases occur in patients with severe head injuries usually a few weeks to months after the initial trauma. On the contrary, acute PTH following mild head injury is uncommon, with only sporadic cases reported in pediatric age [3–5, 7, 8]. We present the first small series of 6 young babies that developed acute PTH, secondary to aqueductal obstruction by a blood clot.

✉ Pietro Spennato
pierospen@gmail.com

[1] Department of Pediatric Neurosurgery, Santobono-Pausilipon Children's Hospital, Naples, Italy

Clinical material

In a 10-year period (2007–2017), 6 patients presenting with acute hydrocephalus following mild head injury were managed at Santobono-Pausilipon Children's Hospital in Naples, Italy (Table 1). Their ages ranged from 6 months to 15 months. All were admitted in the hospital following domestic injuries. All patients were conscious at the arrival in the hospital. Symptoms (vomiting and drowsiness) developed in few hours in 4 cases and in a few days (5 and 8) in two. All patients were studied with urgent computed tomography and magnetic resonance imaging (MRI). In four cases, CT scan of the head showed isolated intraventricular hemorrhage, with blood clot extending from the third ventricle to the fourth ventricle, obstructing the aqueduct (Fig. 1). In these cases, supratentorial hydrocephalus and symptoms were already present at the presentation. In the remaining two cases, intraventricular hemorrhage was associated with subarachnoid hemorrhage (SAH)

Table 1 Clinical features and outcome (*SAH*, subarachnoid hemorrhage; *VP shunt*, ventriculo-peritoneal shunt; *EVD*, external ventricular drainage; *ETV*, endoscopic third ventriculostomy)

Case	Age (mo), Sex	Trauma	Symptoms	Clinical presentation	Imaging CT	Surgery	Follow up (ys)	Outcome
1	8, F	Fall from the bed	Vomiting, drowsiness	Delayed (8 days after trauma)	Intraventricular hemorrhage (aqueduct) + cortical contusion and SAH Triventricular hydrocephalus (8 days later)	VP shunt	10	Good
2	14, M	Fall from the couch	Vomiting, drowsiness.	Acute	Intraventricular hemorrhage (III and IV ventricles) with aqueductal stenosis and hydrocephalus	EVD	6	Good
3	6, M	Fall from the bed	Vomiting, drowsiness	Acute	Intraventricular hemorrhage (aqueduct and IV ventricle) with aqueductal stenosis and hydrocephalus	EVD	5	Good
4	13, M	Fall from mother's arms	Vomiting, drowsiness	Acute	Intraventricular hemorrhage (aqueduct) with aqueductal stenosis and hydrocephalus	EVD, followed by ETV	4	Good
5	15, M	Fall from grandmother's arms	Vomiting, drowsiness	Delayed (5 days after trauma)	Diffuse intraventricular hemorrhage + cortical contusion and SAH Subdural hygroma (5 days later)	Temporary subduro-peritoneal shunt	2	Good
6	11, M	Fall from the bed	Vomiting, drowsiness	Acute	Intraventricular hemorrhage (aqueduct and fourth ventricle) with aqueductal stenosis and hydrocephalus	EVD, followed by ETV	1	Good

and cortical contusions. In these cases, there was no hydrocephalus, neither symptoms at presentation. These patients became symptomatic in the following days: in one case, CT scan revealed supratentorial hydrocephalus (Fig. 2); in the other, mild enlargement of the ventricles, but a significant enlargement of the convexity subarachnoid space. MRI with angiographic sequences ruled out vascular malformations.

Management and outcome Four patients underwent urgent surgery. External ventricular drains (EVDs) were implanted. Symptoms immediately resolved. The drains were kept open for 14–21 days until cerebrospinal fluid (CSF) cleared; therefore, they were clamped and CT scan obtained. The clamping was well tolerated in two patients and the drains were uneventfully removed. In 2 patients, hydrocephalus recurred following clamping. In both cases, endoscopic third ventriculostomy was successfully performed and EVD removed. Hydrocephalus did not recur during the follow-up.

In the remaining two cases, surgery was performed at the appearance of symptoms. In an 8-month-old male, a ventriculo-peritoneal shunt (VPS) was implanted 8 days after the trauma when a CT scan revealed hydrocephalus. The last case was managed by inserting subduro-peritoneal shunt at the time of appearance of subdural hygroma (Tables 1 and 2). The shunt was uneventfully removed 6 months later. In all patients, the outcome was very good, with complete recovery.

Illustrative case

An 11-month-old baby was admitted in the emergency room after a fall from the bed. The child was awake but irritable. In 2 h, he became drowsy and vomiting. Urgent CT scan showed a clot in the aqueduct and in the fourth ventricle, with triventricular hydrocephalus (Fig. 1a, b). A right frontal EVD was urgently implanted, with the return of bloody CSF under increased pressure. Symptoms were resolved in the subsequent hours. MRI with angiographic sequences ruled out vascular malformations (Fig. 1c). The drainage was kept open for 16 days, until CSF cleared; therefore, it was clamped and CT scan obtained. This attempt resulted in worsening in the conscious state and of hydrocephalus on CT scan. A new MRI showed patency of the aqueduct, but also the persistence of tonsillar herniation and crowding of the foramen magnum, possibly indicating CSF obstruction at this level (Fig. 1d). Endoscopic third ventriculostomy was successfully attempted despite aqueduct patency, and EVD was removed. The child is normal and shunt-free at 1-year follow-up (Fig. 1e).

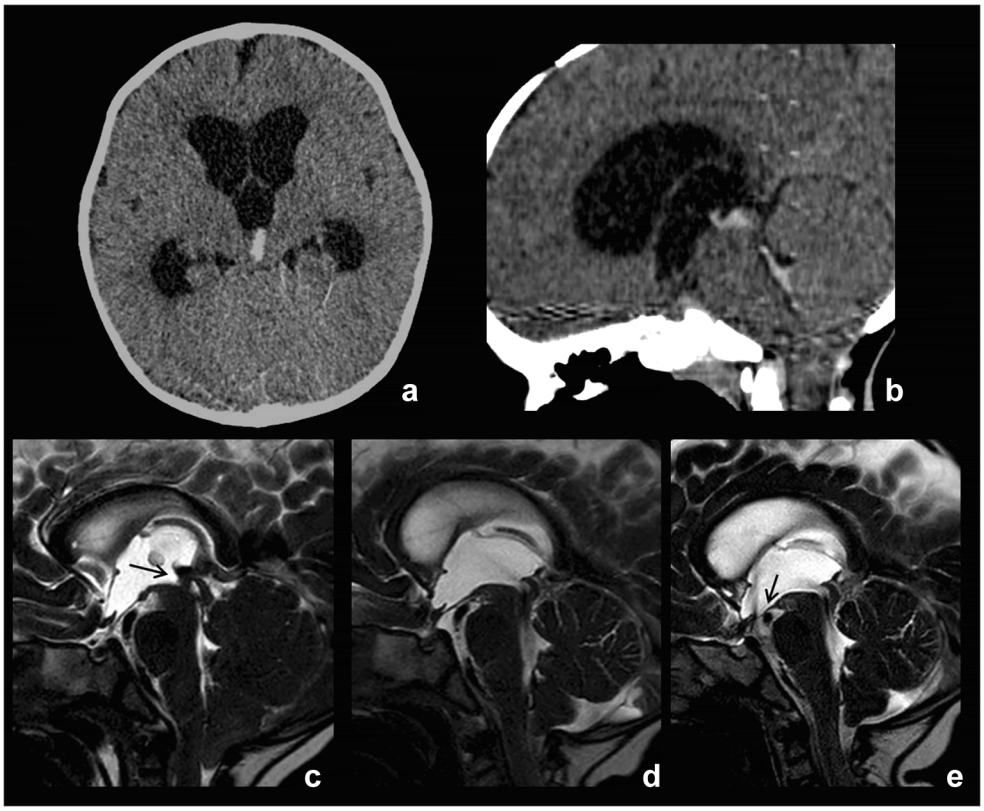

Fig. 1 (Case 6 of Table 1) **a**, **b** CT scan (**a** axial, **b** mid sagittal) at presentation showing blood clot in the aqueduct and in the fourth ventricle, with supratentorial hydrocephalus. **c** Midsagittal T2-weighted MRI during external ventricular drainage, note the clot in the aqueduct (*arrow*). **d** Midsagittal T2-weighted MRI before ETV, showing resolution of the clot, but the persistence of tonsillar herniation and crowding of the foramen magnum, possibly indicating CSF obstruction at this level. **e** Mid sagittal T2 WI MRI following ETV. Note the flow artifact at the level of the stomy (*arrow*)

Discussion

Post-traumatic hydrocephalus (PTH) is a common sequelae of TBI. In adults, the characteristics of PTH have been extensively studied, but in children, there is a relative lack of knowledge. Recently, two papers were published that investigated epidemiology, risk factors, and outcome [1, 6]. Rumalla et al. [6], using ICD-9-CM codes to identify all patients (age 0–20) with TBI and hydrocephalus, found that in a national sample of 124,444 pediatric hospitalizations, the incidence of PTH was 1.0%, (lower than the incidence in adults, which is estimated to range from 0.7 to 45% [2]). PTH had highest rates in shaken baby syndrome and firearm injury. Predictors associated with PTH included younger age (< 5), preexisting comorbidities, subdural hematoma, subarachnoid hemorrhage, surgical evacuation of the intracranial traumatic lesion, open injury (vs. closed) septicemia, and neurological complications. Bonow et al. [1] conducted a retrospective cohort study using administrative data from 42 pediatric hospitals. They found that 0.9% of children admitted with TBI required surgical management of hydrocephalus. They demonstrated that young age (< 1 yr), severe TBI, and abusive head trauma increased the likelihood of PTH. Also, children who underwent craniectomy without an early cranioplasty were at increased risk.

Therefore, in most cases, hydrocephalus occurs in severely affected children. Hydrocephalus secondary to isolated intraventricular hemorrhage that acutely obstructs the aqueduct is very rare, with only a few cases reported in the literature [3–5, 7, 8]. In 2008, Gupta et al. [5] reported a case very similar to ours. An 11-month-old baby presented with acute PTH secondary to aqueductal obstruction by an intraventricular blood clot, with no evidence of other brain injury. The child recovered completely following a VPS. All the reported cases were managed with EVD and/or VPS. Sakai et al. [7] reported two children with acute PTH secondary to intraventricular blood; both children improved with temporary EVD. Sasaki et al. [8] and Ikeda et al. [5] reported 1-year-old and 4-year-old children in which PTH spontaneously

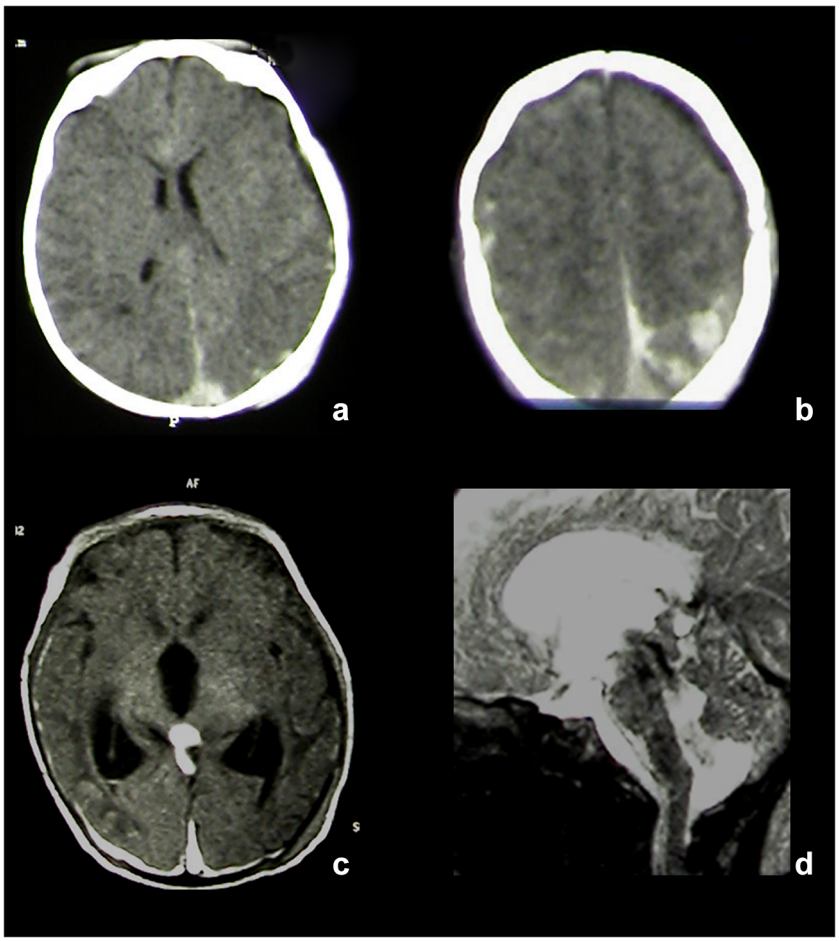

Fig. 2 (Case 1 of Table 1). **a**, **b** CT scan at presentation showing SAH and cortical contusions, with the normal ventricular system. **c**, **d** Axial T1 and midsagittal T2 MR images at the time of clinical worsening showing clot in the aqueduct and triventricular hydrocephalus

resolved. In our series, only one patient had a permanent shunt: it was at beginning of our experience and a VPS, rather than ETV, was chosen, considering the higher risk of failure in young babies with post-hemorrhagic hydrocephalus. After this, ETV was chosen in the two cases in which hydrocephalus recurred following EVD clamping. Both patients where studied with MRI: in one, the aqueduct remained stenotic despite resolution of blood clot; in the other, the aqueduct was patent, but tonsillar herniation and crowding of the foramen magnum were revealed, possibly indicating CSF obstruction at this level. ETV was successful in both cases: we think that intraventricular hemorrhage caused permanent impairment to CSF flow at the level of the aqueduct or at the level of the fourth ventricle outlets.

Table 2 Management of the 6 cases of acute post-traumatic hydrocephalus (*VP shunt*, ventriculoperitoneal shunt; *EVD*, external ventricular drainage; *ETV*, endoscopic third ventriculostomy)

Treatment	
VP shunt	1
Temporary EVD	2
EVD + ETV	2
Temp. subduro—P shunt	1

In conclusion, prompt recognition and surgical management of PTH secondary to an isolated blood clot in the aqueduct warrant very good outcome. Most children may be treated without a permanent shunt, by using external drains and endoscopic third ventriculostomy.

Compliance with ethical standards

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

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