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ORIGINAL PAPER

B. Balmer
E. Boltshauser
S. Altermatt
R. Gobet

Conservative management of significant epidural haematomas in children

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B. Balmer (✉) · S. Altermatt · R. Gobet
Department of Pediatric Surgery,
University Children's Hospital Zurich,
Steinwiesstrasse 75,
8032 Zurich, Switzerland
e-mail: Bettina.Balmer@kispi.unizh.ch
Tel.: +41-1-2667111
Fax: +41-1-2667170

E. Boltshauser
Department of Pediatric Neurology,
University Children's Hospital Zurich,
Zurich, Switzerland

Abstract *Objective:* A significant epidural haematoma (EDH) is generally treated by craniotomy and evacuation. This is a report of conservative management following an EDH on computerized tomography (CT) in a paediatric population. The authors examined whether conservative treatment of radiologically significant EDH is a successful and safe therapeutic option. *Methods:* Retrospective data were collected from charts of patients with conservatively treated EDH in the Department of Surgery of the University Children's Hospital Zurich between September 1993 and January 2004. Included were patients without focal neurological deficits, with a Glasgow Coma Scale (GCS) of 15 and an initial CT demonstrating an EDH with a minimal thickness of 1 cm. Mild clinical symptoms of raised intracranial pressure such as headache, nausea or vomiting were treated symptomatically. Follow-up included a standardized interview, a neuropaediatric examination and CT. *Results:* Thirteen children with EDH had successful conservative management. Only one 12-year-old female patient with a delayed diagnosed frontal EDH required surgical intervention 24 h after admission and 5 days after the accident. Clinical follow-up showed patients without neurological deficits, a Glasgow Outcome Scale of 5 and no post-traumatic sequelae over an average of 4 4/12 years (range 4 months to 10 4/12 years). Follow-up CT showed complete resolution of the EDH within 2 to 3 months. *Conclusions:* Our results demonstrate that significant EDH can be treated non-operatively in neurologically normal children. We recommend that such treatment be performed in specialised paediatric centres under adequate neurological observation since prompt emergency operation in case of neurological deterioration should be provided.

Keywords Epidural haematoma · Conservative treatment · Children

Introduction

Radiologically significant epidural haematoma (EDH) is usually treated by urgent craniotomy and evacuation of the epidural blood clot. Smaller EDH can be treated conservatively with perfect clinical and radiological outcome [4–6]. The aim of this study is to report the outcome after conservative management of children with a radiologically significant EDH who present with a normal neurological status.

Patients and methods

In a retrospective study, 13 children with radiologically significant EDH and conservative management were identified from September 1993 to January 2004. During the same time, 29 children were treated with craniotomy and evacuation of a significant EDH in our institution. We reviewed the charts of all children who were intended to follow a conservative treatment for their EDH if they were compatible

Table 1 Summary of the standardized interview (*N*=13)

In personal opinion, good recovery	13
History of headache/migraine	3[a]
Problems with vision/hearing	0
Normal school/education	13
Disability	0
Subjective good quality of life	13
Epileptic seizures	0
Regular need of analgesics	0

[a]Completely unchanged in relation to time (same sort of headache before EDH as after EDH)

with our study inclusion criteria, focusing on accident mechanism, initial neurological symptoms, time between accident and diagnosis, characteristics of computerized tomography (CT) findings, and neurological and radiological outcome. The authors have clinically followed all children during their hospital stay; one author (B.B.) has performed a neurological examination in all of these children.

Study inclusion criteria were:

- Glasgow Coma Scale (GCS) of 15 and no neurological deficits when admitted to the hospital (examination by a paediatric neurologist).
- Clinically none or only mild-to-moderate signs of elevated intracranial pressure. Moderate headache, nausea and vomiting were treated symptomatically.
- EDH on initial CT with thickness of more than 1 cm in axial images.

Patients were under close clinical observation in the intensive care unit for 24 to 72 h and on a surgical ward thereafter. A 24-h granted access to emergency surgery in case of deterioration was provided during the whole hospital stay. Regular follow-up included visits in the outpatient clinic after 3 months, 6 months and 1 year. CT was repeated until the EDH was resolved. In addition, we performed a standardized interview with the patient's parents and related to their age the patient as well as the prepared questionnaire (Table 1). All patients with conservative management of a significant EDH were followed with a detailed neurological examination in October 2001 and in January 2004.

Results

A total of 13 children with radiologically significant EDH were conservatively treated and fulfilled the study inclusion criteria. Age at the time of the accident ranged from 10

Table 2 Clinical data of 13 patients with intention of conservative management of an EDH

Patient number	Sex	Age (years)	Follow-up (years)	Time from accident to admission	Size of EDH (cm)	Localisation	Midline shift (max) (cm)	Lateral ventricle compression
1	M	13 8/12	9 2/12	48 h	1.5×4.2×2.5	Temporo-basal r	none	−
2	M	6 4/12	10 4/12	48 h	2.0×7.0×4.5	Fronto-basal l	0.3	+
3	F	13 1/12	9 8/12	24 h	2.2×7.0×5.0	Parieto-occipital l	0.6	+
4	M	13 6/12	8 9/12	96 h	1.1×7.0×5.0	Parieto-temporal l	0.3	(+)
5	M	13 3/12	4 5/12	4 h	1.0×4.0×4.0	Parieto-occipital l	0.2	(+)
6	M	8 6/12	4 2/12	48 h	1.9×4.0×5.0	Temporal l	0.5	+
7	F	6 11/12	2 7/12	72 h	2.5×6.0×5.0	Parieto-occipital l	0.3	+
8	M	10/12	2 3/12	72 h	2.0×7.5×6.5	Parietal r	0.2	(+)
9	F	5 3/12	1 9/12	48 h	2.5×5.0×7.0	Parietal r	1.0	+
10	M	3 3/12	1 5/12	24 h	1.5×7.0×8.0	Temporo-parietal l	0.5	(+)
11	F	11 5/12	1 3/12	48 h	1.5×7.5×8.0	Temporo-parietal r	0.5	(+)
12	F	12 1/12	4/12	96 h	4.0×5.0×7.0	Frontal r	1.0	+
13	M	14 11/12	4/12	2 weeks	1.6×9.0×6.0	Parietal r	0.3	(+)

−=no lateral ventricle compression; (+)=partial ipsilateral ventricle compression; +=complete ipsilateral ventricle compression
r Right side, *l* left side

months to 14 11/12 years (average age 9 6/12 years). The patients' data pertinent to the accident and the time delay between the accident and diagnosis are shown in Table 2. Injury mechanism in all cases included trauma to the head caused by falls from less than 1 m or accidents involving a bicycle or a kickboard, except for one patient who suffered from a high-velocity accident. In all but one patient, the indication for the diagnostic CT was persistent symptoms of concussion. Twelve of the 13 patients were transferred to our hospital more than 24 h after the trauma asking for neurosurgical treatment of the radiologically discovered significant EDH. One patient had a CT performed early after trauma, which revealed a parietal skull fracture and a small epidural fracture haematoma. Two weeks later, the referring hospital discovered a radiologically significant EDH in a routine CT control, and the patient was referred to our institution for further treatment.

The radiological characteristics of the EDH are described in Table 2 (see also Fig. 1a,b and Fig. 2a,b). The EDH was localised on the left side in seven cases, six times on the right side. All of them were localised supratentorially. A mild-to-moderate compression of the ipsilateral ventricle was found in 12 of 13 patients. Midline shift in CT was measured in its maximal extension, and there was found a shift of up to 1.0 cm (Table 2; patients number 9 and number 12).

Average duration of admission was 9.6 days. There was one patient who stayed in the hospital for 27 days because of a problem not related to the EDH (patient number 2, he suffered from diarrhoea). For the more recent patients, duration of hospitalisation was shorter, with an average of 5.4 days for the last five patients. There was only one patient (Table 2; number 12) in whom the conservative treatment had to be changed to a surgical procedure, with evacuation of the EDH after 24 h of observation (120 h after the trauma). She is also the only patient with a high-velocity accident. During observation, she complained about worsening headache, her vigilance deteriorated and a repeated CT revealed a slightly increasing size of the EDH.

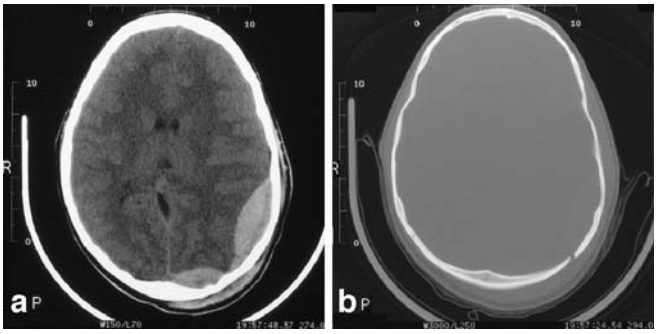

Fig. 2 **a** CT on admission of a 13 1/12-year-old girl with parieto-occipital epidural haematoma with compression of the ipsilateral lateral ventricle and a midline shift of 6 mm and **b** diastasis of the lambdoid suture (patient number 3)

Although her GCS was 15 and she had no focal neurological deficits, we decided to operate under the impression of aggravation of the situation. The patient recovered completely.

Average follow-up was 4 4/12 years (4 months to 10 4/12 years). The interview (n=13) revealed no head-injury-related complaints in any patient. All children and parents were completely satisfied and had no restrictions in life at all. None of them needed regular pain medication. None of them had a history of epilepsy or events similar to epilepsy. Three patients who already suffered once in a while from headache before the accident mentioned that they have the same frequency and same type of headache thereafter. All patients returned to their premorbid socio-intellectual state. Outcomes at standardized follow-up interviews correspond to a Glasgow Outcome Scale of good recovery for all patients. The clinical follow-up (n=13) and the neurological examination (n=11) were normal. Two patients were not available for this last examination (however, both followed the standardized interview): one of them stated that he was too busy to come to the hospital, and the other

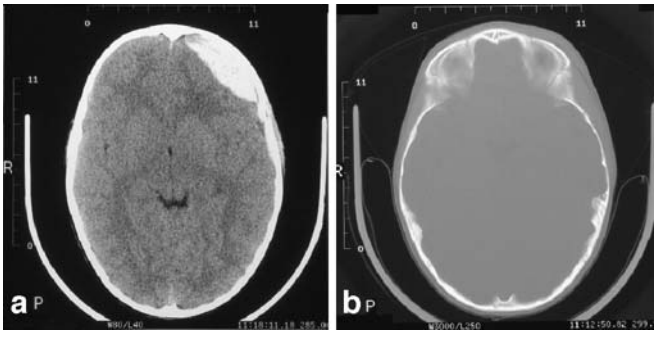

Fig. 1 **a** CT on admission of a 6 4/12-year-old boy with fronto-basal epidural haematoma with complete compression of both lateral ventricles and a midline shift of 3 mm and **b** fracture of the orbital roof (patient number 2)

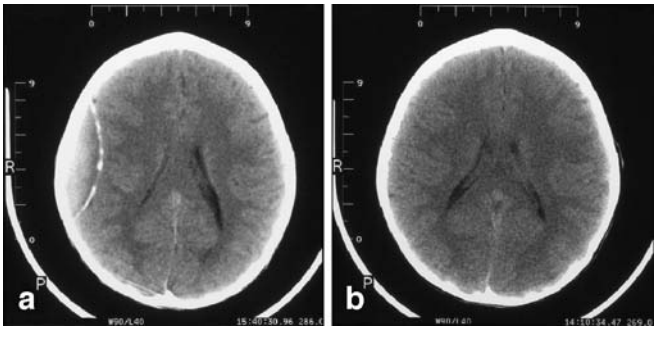

Fig. 3 **a** CT 18 days after diagnosis of an EDH under conservative management with dural calcification (patient number 9) and **b** CT 6 weeks later showing that the calcification has completely resolved

stayed abroad. A formal neuropsychological assessment was available in two patients, and it showed no abnormalities. One examination was done for legal purposes 1 year after the accident and showed average results in all tested fields (Table 2; patient number 9). The other was performed on the patient who had to undergo surgery after conservative treatment (Table 2; patient number 12) and showed completely normal findings.

The last available CT (n=13) demonstrated normal findings in all patients. On average, resolution of the EDH occurred within 2 to 3 months. One child had dural calcification 18 days after diagnosis (patient number 9; Fig. 3a). This calcification resolved spontaneously and completely as shown on a CT done another 6 weeks later (Fig. 3b). Since the patient showed no clinical symptoms and especially no seizures, anti-epileptic drugs were neither started nor required at any stage. There was no patient in this study who developed epilepsy or needed anti-epileptic drugs.

Discussion

This study shows that radiologically significant EDH can be treated conservatively and that size alone is not an indication for surgical treatment of EDH. Adequate observation in a specialised centre and the possibility to perform a craniotomy at any time are important to achieve a good outcome safely. This finding challenges the generally accepted treatment for radiologically significant EDH. It is standard procedure to perform craniotomy and an evacuation of the epidural blood clot in these cases. Performed in time and under stable clinical circumstances, this operation only carries minimal risk [2]. In our own institution, there were 31 children operated on for EDH between 1972 and 1990, with an excellent long-term outcome [7]. McLaurin and Towbin mentioned in 1989: “The definitive treatment of EDH should always be surgical removal, and delay of such treatment is unacceptable when the diagnosis has been established” [6]. On the other hand, it is well established that conservative treatment in small EDH shows perfect outcome in children [4, 5, 8]. Over the last years, there has only been scant literature published about operative vs conservative management in EDH in children. In a study in 1996, Bejjani et al. defined radiologically a third group of patients with so-called intermediate-size EDH, for whom they stress a careful individualized clinical judgement [1].

The option of conservative management of EDH in children relies on several specific pathophysiological mechanisms. First, especially young children tolerate an acute increase in intracranial pressure better than adults because they have unfused cranial sutures, open fontanelles, large extracerebral spaces and basal cisterns. Second, the origin of an EDH is often venous, whereas in adults, it is mainly caused by an arterial bleeding. Since the deleterious effects are dependent on various factors such as the size, location and configuration of the clot, the rapidity of accumulation, the presence of associated intradural lesions, the extracranial decompression of blood through skull diastases and the age of the patient [8], children are likely to be selected for conservative treatment. Even in adults, EDH thickness of less than 1.5 cm in CT, midline shift of less than 5 mm and volume of less than 30 ml predicted successful outcome of non-operative management [4]. Evolution over time influences the treatment of EDH significantly since patients who are diagnosed less than 6 h after trauma are at high risk of subsequent deterioration and may require evacuation, whereas patients diagnosed later may be managed conservatively with repeat CT and careful neurological observation because of the low risk of delayed deterioration [5]. Our study confirms this: there was only one patient who had conservative treatment of radiologically significant EDH diagnosed within 24 h.

In our experience, selection of the patients with significant EDH for a conservative management is the key factor for successful treatment. The fact that there was a delay between accident and diagnosis is certainly selective for a unique group of patients. Nevertheless, most of these patients were transferred for surgical treatment. Careful observation in a paediatric intensive care unit as well as the possibility to perform an immediate operation at any time is mandatory, as our patient with conversion from conservative to surgical treatment illustrates.

Postoperative follow-up and long-term results in children with conservative management in significant EDH are important to prove the validity of this therapeutic approach. All patients in this report showed a follow-up without problems; four of them could be followed over more than 8 years. In 1998, Cayli et al. compared the results of surgical and conservative management related to single photon emission computed tomography (SPECT) after 3 and 6 months and neuropsychological tests. They concluded in their preliminary report that minimally symptomatic or asymptomatic EDH causes no pathologic SPECT findings and that neuropsychological impairment and duration of the haematoma do not affect the results of conservative management [3].

In conclusion, radiologically significant EDH can be treated conservatively. The radiological size of an EDH is not an absolute indication for surgical treatment. Our retrospectively collected data from 13 patients with initially normal neurological findings and significant EDH on CT demonstrated safe and successful conservative treatment in 12 children and a safe and successful conversion in treatment with subsequent operation and evacuation of the EDH in one patient. If conservative treatment in radiologically significant EDH is considered, it is mandatory to secure adequate neurological observation and the possibility to perform an operation at any time.

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