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The size of the intra- and extraventricular cerebrospinal fluid compartments in children with idiopathic benign widening of the frontal subarachnoid space

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Abstract The aim of this study was to quantify the intra- and extraventricular cerebrospinal fluid (CSF) spaces in children with benign enlargement of the frontal subarachnoid space (BE). The infra- and supratentorial CSF compartments were measured in 61 CT examinations of children with BE, 3–27 months old, and compared with those of 96 CT examinations considered normal. Measurements of the ventricular system, and the pontine and chiasmatic cisterns were related to cranial size. In all children with BE the lateral and third ventricles were dilated and the chiasmatic cistern was widened. The subarachnoid space was wider than the upper limits in the control group, in the frontal region (4 mm), and the anterior interhemispheric (4 mm) and Sylvian (3 mm) fissures. The infratentorial

CSF compartments, the occipital subarachnoid space, the posterior part of the interhemispheric fissure and, in most cases, the cortical sulci were normal in size in children with BE. The majority were macrocephalic or had rapid head growth but there were also normocephalic children with normal head growth. The size of the posterior fossa was within the normal range in all children with BE. Idiopathic BE is not uncommon in children up to about 3 years old who are healthy or have minimal neurological disturbance and is characterised by a specific pattern of widening of the supratentorial CSF compartments.

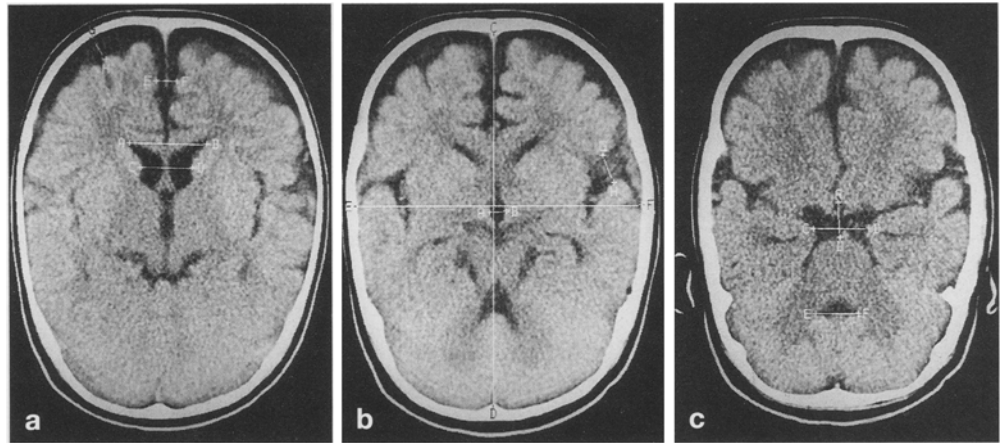
Key words Brain, infants and children · Subarachnoid space, benign enlargement · Macrocephaly · External hydrocephalus

Introduction

Widening of the frontal subarachnoid cerebrospinal fluid (CSF) space on CT examinations of children has been related to a wide spectrum of conditions during infancy or early childhood, including genetic syndromes [1–4], prematurity [5, 6], previous intraventricular or subarachnoid haemorrhage [6], meningitis [1, 4], cerebral atrophy or subdural collections [1, 7]. Enlargement of the frontal CSF compartment may also be an idiopathic condition of benign nature in infants with macrocephaly or rapid head growth and minor neurological disturbance [5, 8]. Benign enlargement of the anterior CSF spaces (BE) is observed in the frontal or

frontoparietal and frontotemporal regions, the interhemispheric and Sylvian fissures and the chiasmatic cistern [1, 4, 5]. Various terms have been used to describe BE: external hydrocephalus, benign subdural effusion, benign extra-axial collections or pseudohydrocephalus-megalocephaly [4, 5, 8]. The diagnosis is usually made by excluding other conditions with similar radiological findings. Thus, the history, clinical examination, and CT or MRI findings suggesting brain anomalies, subdural collections, meningitis atrophy have to be taken into consideration [1, 4, 9]. Differential diagnosis is important, since patient management and prognosis in BE differ from other conditions [5, 9]. The subarachnoid space in BE is subject to morphological

Fig.1 Measurements of cerebrospinal fluid spaces: **a** anterior horns (A-B), between caudate nuclei (C-D), frontal region (G-H), interhemispheric fissure (E-F); **b** third ventricle (A-B), Sylvian fissure (G-H), maximum internal skull diameters (C-D), (E-F); **c** the chiasmatic cistern (A-B, C-D) and fourth ventricle (E-F)



changes, and a systematic study of the extent of the intra- and extraventricular and infra- and supratentorial CSF spaces could be helpful in diagnosis. Furthermore, such a study might be of value to those investigating the pathogenesis of this not so infrequent idiopathic condition.

Materials and methods

We studied the CT examinations of 49 boys and 12 girls, 3–27 months old with benign enlargement of the anterior subarachnoid space, i.e. symmetrical widening of the frontal or frontoparietal CSF space and enlargement of the chiasmatic cistern, Sylvian fissures, and the anterior part of the interhemispheric fissure, without abnormal CT findings in the brain or the posterior cranial fossa. All children were hospitalised during the last 3 years and examined after sedation with 80–100 mg/kg chloral hydrate. They underwent CT for one or more of the following indications: increased head circumference (24), rapid head growth (15), delayed gross motor development (29), hypotonia (25), facial asymmetry with pronounced frontal regions (2), recent simple head trauma (14), sporadic convulsions (7) and facial haemangioma (1). There were 38 children 3–12 months old, 19 were 12–24 months old and 4 24–27 months old. In 14 children with normal head circumference, examined for head trauma or convulsions, no information was available about their head growth rate. Children with genetic syndromes, prematurity, a history of intraventricular or subarachnoid haemorrhage, old head trauma or central nervous system infection were excluded, as were those with CT findings of atrophy, according to the criteria proposed by Maytal et al. [1], or with conditions that may cause brain atrophy (perinatal asphyxia, malnutrition, administration of adrenocorticotrophic hormone, steroids, or chemotherapeutic agents).

Measurements of the maximal width of the extraventricular subarachnoid space (Fig.1) were made in the frontal region; the middle of the anterior part of the interhemispheric fissure; the Sylvian fissures; the pontine cistern; and the chiasmatic cistern, of which the maximal anteroposterior and transverse diameters were added. Measurements were also made of the minimum width of the bodies of the lateral ventricles; the maximum transverse diameter of the anterior horns; the minimum bicaudate nucleus distance; and the maximum width of the third and fourth ventricles. The maximum anteroposterior and transverse internal diameters

of the skull and posterior cranial fossa were also measured. All measurements in children with BE were compared with measurements obtained from 96 CT examinations, with no abnormal findings, of children 3–27 months old, in 3-month age groups, 12 CT examinations per group. These children were referred for CT because of simple head trauma, sporadic convulsions, an abnormal EEG or for staging of extracranial malignancies. The widths of the lateral and third ventricles, and pontine and chiasmatic cisterns were divided by the sum of the maximum anteroposterior and transverse internal diameters of the skull or the posterior cranial fossa, to give ratios which relate the size of the CSF spaces to the size of the skull [10]. The width of each CSF compartment in children with BE was compared with the corresponding age group of the controls (normal range: mean value \pm 2 standard deviations); gender was not taken into account because we have already established that the normal CSF ratios do not differ between boys and girls [10].

Results

Measurements of the ventricular system and the pontine and chiasmatic cisterns obtained from the 96 normal examinations are presented in Table 1. In most cases the CSF spaces in the frontal regions, the interhemispheric and Sylvian fissures, or the convexity sulci were too small to measure. However, when measurable, especially in infants, the maximum width was 4 mm in the frontal regions, 3 mm in the Sylvian fissures, 4 mm in the interhemispheric fissure, and 2 mm in the cortical sulci.

In the children with BE the following CSF compartments were found larger than normal: the bodies of the lateral ventricles in 46 of 61 (lateral ventricle ratio 0.121–0.157); the anterior horns in 40 (0.126–0.162); the bicaudate nuclei in 61 (0.045–0.058); the third ventricle in 61 (0.012–0.038), and the chiasmatic cistern in 61 (0.161–0.187). The size of the fourth ventricle and pontine cistern was within the normal range. It will be seen that the width of the frontal subarachnoid space, Sylvian fissures, and anterior part of the interhemispheric fissure was greater than normal in all the children with BE,

Table 1 Ranges (mean value \pm 2 SD) of normal cerebrospinal fluid ratios and maximum internal skull and posterior cranial fossa diameters during early childhood

Months	Number of patients	Lateral ventricle ratio	Anterior horn ratio	Bicaudate ratio	Fourth ventricle ratio	Pontine cistern ratio	Third ventricle ratio	Chiasmatic cistern ratio	Sum internal skull diameters (cm)	Sum posterior cranial fossa diameters (cm)
3-6	12	0.093-0.114	0.090-0.113	0.029-0.034	0.068-0.087	0.045-0.054	0.005-0.009	0.134-0.167	21.8-26.0	11.2-13.7
6-9	12	0.099-0.116	0.095-0.120	0.031-0.036	0.071-0.088	0.042-0.051	0.006-0.010	0.133-0.162	23.1-27.2	11.5-14.4
9-12	12	0.104-0.120	0.102-0.125	0.033-0.038	0.072-0.089	0.040-0.048	0.006-0.009	0.132-0.158	23.3-28.6	11.8-15.1
12-15	12	0.105-0.121	0.104-0.125	0.034-0.038	0.069-0.086	0.039-0.045	0.007-0.011	0.131-0.153	23.6-28.7	12.4-15.2
15-18	12	0.105-0.124	0.107-0.126	0.035-0.039	0.068-0.085	0.039-0.044	0.006-0.010	0.131-0.148	24.7-28.7	12.6-15.4
18-21	12	0.107-0.124	0.110-0.127	0.037-0.041	0.071-0.086	0.035-0.041	0.006-0.012	0.131-0.145	24.7-28.8	12.9-15.5
21-24	12	0.103-0.123	0.105-0.126	0.035-0.039	0.073-0.087	0.034-0.041	0.007-0.010	0.127-0.144	25.2-29.1	13.2-15.6
24-27	12	0.101-0.118	0.104-0.123	0.034-0.038	0.072-0.086	0.034-0.040	0.006-0.009	0.127-0.142	25.9-29.3	13.5-15.6

ranging between 6-23 mm, 8-24 mm, and 8-17 mm respectively. The sulci over the convexity were widened in 5 of 61 cases. In no child was the occipital subarachnoid space enlarged. Measurements of the anterior horns and between the caudate nuclei correlated positively with the width of the frontal subarachnoid space and the interhemispheric fissure ($0.57 < r < 0.71$, $P < 0.01$). In all children with increased head circumference the sum of the maximum anteroposterior and transverse internal cranial diameters was larger than normal. However, in all children with BE the sum of the posterior cranial fossa diameters was normal.

Discussion

Benign enlargement of the frontal subarachnoid space is an idiopathic condition which resolves without treatment, leaving no sequelae [5, 11], but its pathogenesis is unclear [4]. It usually appears with macrocephaly or rapid head growth in infants with minor neurological disturbance, such as mild gross motor delay or symmetrical hypotonia, but with good developmental prognosis [5]. The diagnosis is based on radiological demonstration of symmetrical widening of the frontal CSF space, the anterior part of the interhemispheric fissure, the chiasmatic cistern and the Sylvian fissures, without abnormalities in the brain parenchyma [1, 5, 12]. However, there are conflicting views concerning the size of the lateral ventricles in BE [1, 8, 13], and the size of the infratentorial CSF compartment and the third ventricle have not been examined previously.

According to our data, the lateral and third ventricles were enlarged in all children with BE. Furthermore, the degree of dilatation of the lateral ventricles was roughly proportional to the width of the frontal subarachnoid space. In previous studies the lateral ventricles have been reported as normal or dilatated [1, 6, 8, 13, 14]. However, assessment was subjective or by linear measurements without reference to cranial size. The latter is an important parameter in children with BE, since the majority undergo CT for macrocephaly or rapid head

growth. Normal cranial size in children can be represented by the maximum transverse and anteroposterior internal diameters of the skull [10, 15]. According to this study the sum of these diameters adequately represented cranial size in children with increased head circumference. Therefore, all ventricular measurements were divided by that sum to examine the relative extent of the intraventricular subarachnoid space in the skull.

The majority of the children with BE were macrocephalic or had rapid head growth. However, there were some normocephalic children with BE and normal head growth. Some previous studies of BE have included only children with macrocephaly or rapid head growth [5, 8, 9].

The subarachnoid space in the frontal regions, the anterior part of the interhemispheric fissure and the Sylvian fissures were widened in all children with BE. The chiasmatic cistern was also enlarged, especially in transverse diameter, a finding that seems to be consistent in BE. In a previous report [1] the cistern was found to be enlarged in two thirds of cases, but was assessed qualitatively by visual inspection.

In most of our children with BE, the convexity sulci were not widened and in all the children the occipital subarachnoid space and the posterior part of the interhemispheric fissure were normal.

Although the posterior cranial fossa is a major domain of the cranium, there is no information concerning its size or that of the infratentorial CSF space in children with BE. In this study the size of the posterior cranial fossa was normal, even in children with increased head circumference; the size of the fourth ventricle and the pontine cistern was also normal, indicating that BE is not accompanied by morphological alterations in the posterior cranial fossa.

In most previous reports [8, 16] study of BE was limited to children aged less than 12 months, but other reports [1, 11] underline that BE can be observed in children up to 3 years of age. In this study, two thirds of the children with BE were infants, at first diagnosis, and about one third were older than 12 months. The fact that about 80% of the children with BE were boys may be noteworthy.

References

1. Maytal J, Alvarez LA, Elkin CM, Shinnar S (1987) External hydrocephalus: radiologic spectrum and differentiation from cerebral atrophy. *AJR* 148: 1223–1230
2. Yamada H, Nakamura S, Tajima M, Kageyama N (1981) Neurological manifestations of pediatric achondroplasia. *J Neurosurg* 54: 49–57
3. Kapila A, Trice J, Spies WG, Siegel BA, Gado MH (1982) Enlarged cerebrospinal fluid spaces in infants with subdural hematomas. *Radiology* 142: 669–672
4. Odita JC (1992) The widened frontal subarachnoid space. A CT comparative study between macrocephalic, microcephalic, and normocephalic infants and children. *Childs Nerv Syst* 8: 36–39
5. Nickel RE, Gallenstein JS (1987) Developmental prognosis for infants with benign enlargement of the subarachnoid space. *Dev Med Child Neurol* 29: 181–186
6. Ment LR, Duncan CC, Geeher R (1981) Benign enlargement of the subarachnoid spaces in the infant. *J Neurosurg* 54: 504–508
7. De Vries LS, Smet M, Ceulemans B, Marchal G, Wilms G, Roo M de, Plets C, Casaer P (1990) The role of high resolution ultrasound and MRI in the investigation of infants with macrocephaly. *Neuropediatrics* 21: 72–75
8. Carolan PL, McLaurin RL, Towbin RB, Towbin JA, Egelhaff JC (1986) Benign extra-axial collections of infancy. *Pediatr Neurosci* 12: 140–144
9. Wilms G, Vanderschueren G, Demaerel PH, Smet MH, Van Calenbergh F, Plets C, Goffin J, Casaer P (1993) CT and MR in infants with pericerebral collections and macrocephaly: benign enlargement of the subarachnoid spaces versus subdural collections. *AJNR* 14: 855–860
10. Prassopoulos P, Cavouras D (1994) CT evaluation of normal CSF spaces in children: relationship to age, gender and cranial size. *Eur J Radiol* 18: 22–25
11. Alvarez LA, Maytal J, Shinnar S (1986) Idiopathic external hydrocephalus: natural history and relationship to benign familial macrocephaly. *Pediatrics* 77: 901–907
12. Barkovich AJ (1990) *Pediatric neuroimaging*. Raven Press, New York, pp 205–226
13. Chapman PH (1983) External hydrocephalus. *Concepts Pediatr Neurosurg* 4: 102–118
14. Briner S, Bodensteiner J (1980) Benign subdural collections of infancy. *Pediatrics* 67: 802–804
15. Hahn FJ, Chu WK, Cheung JV (1984) CT measurements of cranial growth: normal subjects. *AJR* 142: 1253–1255
16. Mori K, Handa H, Masatoshi I, Okino Y (1981) Benign subdural effusion in infants. *J Comput Assist Tomogr* 4: 466–471