

Prominent Extraaxial CSF Space on Cranial Ultrasound in Infants: Correlation with Neurodevelopmental Outcome¹

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Purpose: To determine the clinical significance of prominent extra-axial CSF space (EACSFs) in infants, as seen on cranial ultrasound.

Materials and Methods: Between March 1996 and November 1997, all infants who had undergone head ultrasound at our institution and were found to have prominent EACSFs were evaluated. The width of the interhemispheric fissure was measured at three locations at the level of the frontal horn, body and atrium of the lateral ventricles. The depth of the CSF space over the convexity was also measured. The average of these measurements was calculated and each patient was assigned to one of three groups: mild, moderate, or marked. Ultrasound findings were evaluated for other associated abnormalities. Clinical neurodevelopment was evaluated by a pediatric neurologist, and ultrasound and neurodevelopmental findings were correlated.

Results: Prominent EACSFs was found in 153 patients, and neurodevelopmental evaluation up to a corrected age of 9 months was available in 133. One hundred and eight of 117 infants with normal neurodevelopment had no other associated abnormality (n= 81), or abnormality associated only with grade I subependymal hemorrhage or cyst (n= 27). Twelve of 16 infants with an abnormal neurodevelopmental outcome had major abnormalities including PVL, grade IV hemorrhage, and marked ventriculomegaly.

Conclusion: Prominent EACSFs alone does not appear to be clinically significant. An abnormal neurodevelopmental outcome is associated with major abnormalities seen on ultrasound. Follow-up examination for prominent EACSFs is not indicated unless the associated abnormality requires further evaluation.

Index words : Brain, growth and development
Brain, US
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Normal interhemispheric fissure, as seen on ultrasound, was initially described as an echogenic linear structure. Widening of the interhemispheric fissure and echolucent space between the bony calvarium and brain surface were thought to be abnormal findings representing subdural fluid collection or prominent CSF space, and follow-up ultrasound examination or CT scan was recommended for further evaluation (1-2). Due to significant improvement in the resolution of ultrasound in recent years, prominent subarachnoid space can be differentiated from subdural fluid collection. Mildly prominent extra-axial CSF space over the convexity extending to the interhemispheric fissure has, in addition, been more frequently observed on ultrasound. Most attention has been given to the finding of prominent EACSFS in macrocephalic but otherwise clinically normal infants, and this was thought to be an age-related self-limiting finding (3-9). Relatively little attention has been given to the finding of prominent EACSFS in infants without macrocephaly, and its clinical significance has not been clearly defined. The purpose of this study is to determine the clinical significance of prominent EACSFS, as seen on cranial ultrasound.

Materials and Methods

This study involved all infants who underwent head ultrasound at our institution between March 1996 and November 1997 and were found to have a prominent

EACSFS, and who also underwent neurological evaluation and developmental screening at least up to a corrected age of 9 months. We obtained additional coronal images using a 7-MHz linear array transducer in infants whose routine cranial ultrasound showed a fluid-filled space along the cerebral surface and/or between two cerebri. Routine cranial ultrasound images were obtained using real time ultrasound (Acuson 128 XP-10, Acuson Inc., Mountain View, Cal.) with a 5- or 7- MHz sector transducer. The infants were examined in the supine position through the anterior fontanel. Neither preparation nor sedation was necessary. The width of the interhemispheric fissure was measured at three locations on coronal linear images at the level of the frontal horn, body and atrium of the lateral ventricles. The depths of the right and left CSF space over the convexity were also measured (Fig. 1), and the average of these five measurements was calculated. The size of EACSFS was then divided into three groups according to the average measurements: mild (less than 3 mm), moderate (3-6 mm) and marked (greater than 6 mm). Cranial ultrasound was also examined with regard to ventricular size, evidence of intracranial hemorrhage and other brain parenchymal abnormality. Clinical evaluation including birth and perinatal history, head circumference, neurological findings and developmental status were obtained by a pediatric neurologist.

On cranial ultrasound, prominent EACSFS was observed in 153 infants. Among these, 133 (90 preterm

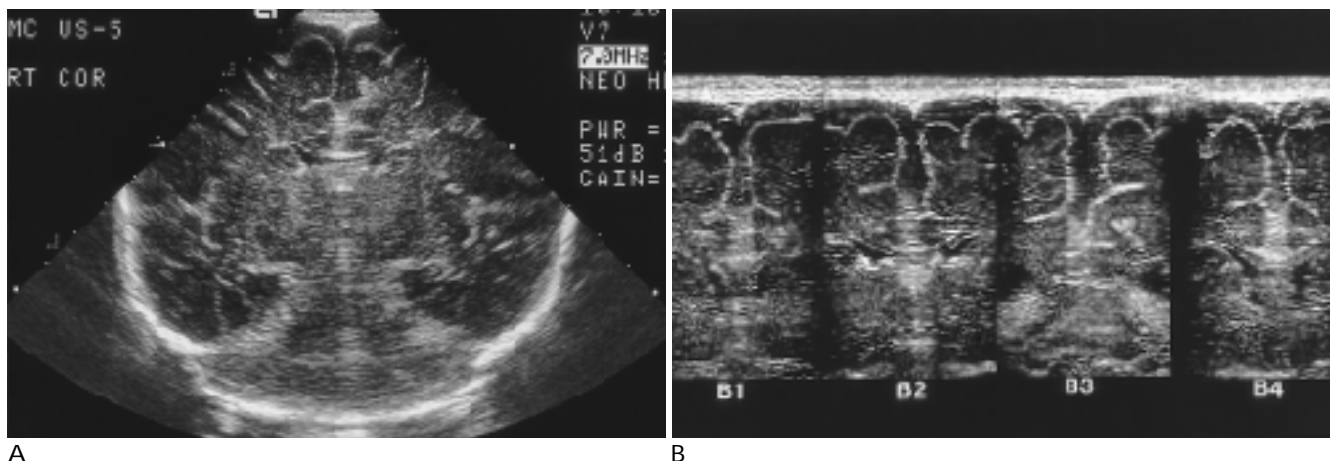


Fig. 1. 33 weeks gestation premature infant.

A. Routine coronal sector scan of head at 3 months old demonstrates prominent extraaxial CSF spaces. No other abnormality is seen.

B. 1-4. Coronal images with 7MHz linear array transducer. The width of widened interhemispheric fissure was measured at the level of frontal horns (B1), body (B2), and atrium (B3) of lateral ventricles. The depths of the right and left CSF space over the convexity were also obtained at the level of the frontal lobes (B4). The EACSFS was moderate in size. Average measurement was 4.5 mm. Neurodevelopmental evaluation at corrected age of nine and a half months was normal.

and 43 term) underwent continual follow-up for neurodevelopmental evaluation at a corrected age of 9-24 months. In 20 patients, clinical follow-up was discontinued before the corrected age of 9 months. Eleven infants died and nine were lost to follow-up. Initial head ultrasound, which showed increased EACSFs, was obtained between 1 week and 7 months of age. Fifty-one infants underwent one or more follow-up ultrasound studies from 6 days to 10 months after the initial study.

The infants involved in this study were divided into two groups: neurodevelopmentally normal and abnormal. The cranial ultrasound and neurodevelopmental findings of each group were correlated and compared.

Results

The ultrasound findings of each group are summarized and compared in Table 1. In most cases, the degree of prominent EACSFs was moderate in both neurologically normal and abnormal groups. All eight infants with marked EACSFs were in the normal group. In the abnormal group, the size of EACSFs was either mild or

moderate. Ultrasound revealed a much higher incidence of associated abnormalities in the neurodevelopmentally abnormal group (81%) than in the normal group (31%). The most common associated abnormalities in this latter group were subependymal hemorrhage

Table 1. Head Ultrasound Findings

N= 133 infants			
US findings	Neurodevelop. outcome	Normal (N= 117)	Abnormal (N= 16)
EACSFs prominence			
Mild (< 3 mm)		29	2
Moderate (3-6 mm)		80	14
Marked (> 6 mm)		8	0
Associated abnormality			
None		81	3
Subependy. hem./cyst only		27	1 1: Marked c thal. hem.
Ventriculomegaly	2 Mild		3 2: Mild c thin CC
Cystic PVL	0		6 1 c SEH
Grade IV hemorrhage	0		1
Others	7		2

CC : corpus callosum

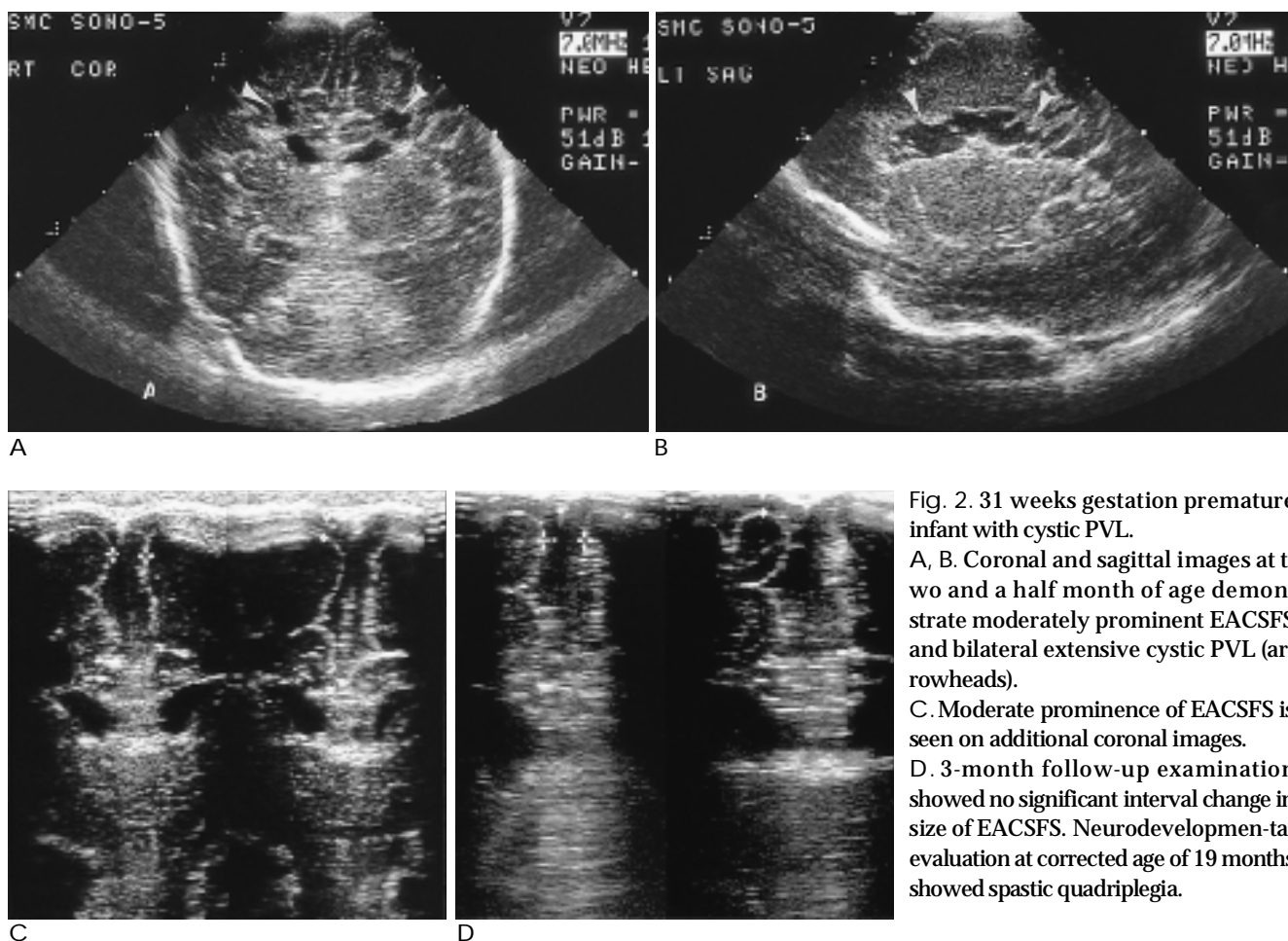


Fig. 2. 31 weeks gestation premature infant with cystic PVL.

A, B. Coronal and sagittal images at two and a half month of age demonstrate moderately prominent EACSFs and bilateral extensive cystic PVL (arrowheads).

C. Moderate prominence of EACSFs is seen on additional coronal images.

D. 3-month follow-up examination showed no significant interval change in size of EACSFs. Neurodevelopmental evaluation at corrected age of 19 months showed spastic quadriplegia.

Table 2. Follow-up Ultrasound

N = 51 infants		
US findings \ Neurodevelop. outcome	Normal (N= 44)	Abnormal (N= 7)
Prom. EACSFs		
Resolved or decreased	7	0
Unchanged	24	5
Increased	13	2

Table 3. Head Circumference

N = 114 infants		
Head circumference \ Neurodevelop. outcome	Normal (N= 98)	Abnormal (N= 16)
Normocephaly	94	10
Microcephaly	2	6
Macrocephaly	2	0

or cysts; nine of the 117 infants it comprised had mild ventriculomegaly, small frontal and/or temporal cystic encephalomalacia, an echogenic area in the thalamus, or mild porencephalic dilatation of the frontal horn. The most common associated abnormality in the abnormal group was cystic PVL (Fig. 2); other associated abnormalities found in this group were marked ventriculomegaly, grade IV germinal matrix hemorrhage, thinning of the corpus callosum, small frontal cysts and multiple choroid plexus cysts.

Fifty-one infants underwent one or more follow-up cranial ultrasounds and the size of EACSFs, as seen on follow-up, was compared to the findings of the initial study shown in Table 2. In 58 % of infants, there was no significant change in the size of EACSFs, though follow-up ultrasound revealed that in 13 of 44 infants in the normal and two of seven infants in the abnormal group, EACSFs was larger.

In 114 infants, head circumference was known, and the findings are summarized in Table 3. Most infants in our study (96 % in the normal group and 63 % in the abnormal group) were normocephalic. Only two were macrocephalic, and six of eight infants with microcephaly were in the abnormal group.

Discussion

Widening of the EACSFs has been related to a wide spectrum of conditions occurring during infancy, including genetic syndromes, prematurity, previous intraventricular or subarachnoid hemorrhage, meningitis

and cerebral atrophy. It may also be an idiopathic condition of benign nature in infants with a large or rapidly growing head, and is thought to be due to disturbance in the resorption of CSF at the level of Pacchioni's granulations, possibly caused by delayed maturation of the arachnoid villi, and leading to dilatation of all subarachnoid spaces (8). Prominent EACSFs in infancy or early childhood may be a variation of normal development of the brain whereby there is a transient accumulation of CSF (10). With significant improvement in ultrasound resolution, an EACSFs is much more commonly found in infants both with or without a large head. Interpretation of this finding on ultrasound and management of these infants have been variable, causing unnecessary concern and follow-up examinations in many cases.

Using real-time ultrasound, Libicher et al. measured subarachnoid space in 89 healthy infants and described his findings of normal upper limits: 3 mm for sagittal sinocortical, 4 mm for craniocortical, and 6 mm for interhemispheric width in the coronal plane at the level of the foramen of Monroe (11). In our study, all eight infants who showed an average of five measurements greater than 6 mm, abnormal according to Libicher's criteria, were in the normal neurodevelopmental group. In the abnormal group, the size of the EACSFs was either mild or moderate, while in the normal group there were more infants in whom the space was markedly prominent. The size of the EACSFs does not predict neurodevelopmental outcome. There was a much higher incidence of associated abnormalities in the neurodevelopmentally abnormal group than in the normal group, and between the two groups, the type of associated abnormality was quite different. The most common associated abnormality in the normal group was subependymal hemorrhage or cyst, which has been considered clinically insignificant unless the hemorrhage extends into the ventricles. In contrast, associated abnormalities in the abnormal group were clinically very significant and included cystic PVL, marked ventriculomegaly and grade IV germinal matrix hemorrhage. It thus appears that an abnormal neurodevelopmental outcome is related to associated abnormalities. Our study also showed that changes in the size of the EACSFs, as seen on follow-up study, do not correlate with neurodevelopmental outcome.

According to our study, prominent EACSFs is more often noted in normo- or microcephalic infants than in those who are macrocephalic. As is to be expected, there appears to be a correlation between abnormal neurode-

velopment and microcephaly, which was found in 38 % of the abnormal group but only 2 % of the normal group.

In summary, neurodevelopmental outcome is related to the associated abnormalities seen on ultrasound. However, there appears to be no significant relationship between the size of the EACSFS, as seen on initial ultrasound, or changes in its size, as seen on follow-up ultrasound, and neurodevelopmental outcome. A prominent EACSFS has more clinical significance in infants with microcephaly than in those with macrocephaly.

In conclusion, a prominent EACSFS does not of itself appear to be clinically significant. Follow-up examination for prominent EACSFS is not indicated unless associated abnormalities require follow-up for further evaluation.

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