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Complicated Infantile Meningitis: Evaluation by Real-Time Sonography

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Real-time sonographic findings in 20 infants with bacterial meningitis are reported. The spectrum of features included normal scans, ventricular enlargement, focal areas of increased cortical echogenicity, ventricular bands, and cerebral abscess. Areas of increased cortical echogenicity on sonography representing meningoencephalitis corresponded to areas of contrast enhancement seen on computed tomography (CT). Excellent correlation was found between CT and sonography. Because of the advantage of obtaining sonographic scans at the bedside, it appears that sonography offers an attractive alternative to CT in the evaluation of infantile meningitis and meningoencephalitis.

There has been considerable recent interest in the use of real-time sonography for the evaluation of ventricular size in infants [1–4]. As the use of sonography has increased, other applications have proved useful, including the evaluation of intracranial hemorrhage, tumors, meningomyelocele, and other congenital anomalies [5–7]. The purpose of this paper is to describe our experience in the use of real-time sonography in the evaluation of infantile intracranial infectious disease.

Materials and Methods

From a group of more than 80 infants under 2 years of age who have been treated at our institution for meningitis, a retrospective review was undertaken of 20 infants with both bacterial meningitis and meningoencephalitis. These infants generally had symptoms of complicated meningitis, including seizures, enlarging head circumference, and focal neurologic defects. They were the only children with symptoms severe enough to warrant cerebral imaging. Several were reexamined at weekly intervals to monitor ventricular shunt placement. One child with large bifrontal abscesses was reexamined after 6 months to evaluate the abscess and ventricular size. The infants were 1 week to two year old (average, 6 months).

Altogether, 45 sonograms were available for review. Sonograms were obtained by placing the transducer on the anterior fontanelle and scanning at angles to the coronal and midsagittal planes. The sonographic examinations were better in younger infants with larger fontanelles. The procedure was adequate for measuring the ventricular size and demonstrating structures directly beneath the fontanelle in infants 1–2 years old, but the images did not consistently include the entire lateral convexity in older infants.

An ATL real-time sector scanner with a 5 mHz transducer and a 90° field of vision was used to perform all sonographic examinations. Of the 20 infants, 15 had computed tomography (CT) within 1 week of sonography. CT scans were obtained with an EMI 1005 dedicated head scanner with a 60 sec scan time.

Results

Infantile intracranial infection presented a spectrum of sonographic findings (table 1). In uncomplicated meningitis, the sonogram was usually normal. In

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TABLE 1: **Infantile Meningitis: Sonographic Findings**

Finding	No. Infants (n = 20)
Normal	8
Ventriculomegaly	12
Increased cortical echogenicity	6
Ventricular band	2
Abscess	1

complicated meningitis, increased cortical echogenicity was demonstrated. Ventricular enlargement was a frequent complication and was associated with ventricular bands if there was ventriculitis in addition to meningitis. Abscess was an infrequent finding, occurring only once in our series.

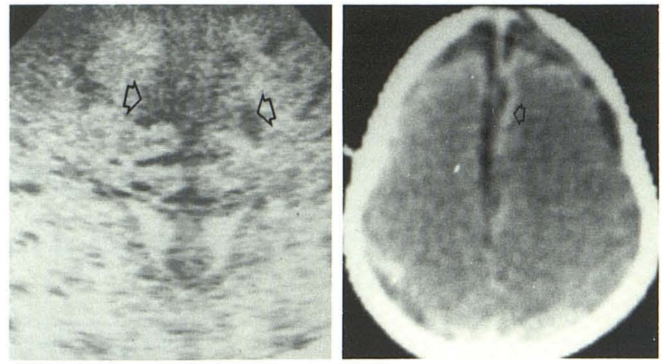
Increased Cortical Echogenicity

The earliest sonographic abnormality seen in meningitis and meningoencephalitis was a focal increase in the echogenicity of the cerebral cortex. This cortical echogenicity corresponded to focal areas of contrast enhancement on CT, due to invasion of the underlying parenchyma by the inflammatory process causing localized meningoencephalitis [8]. Increased cortical echogenicity was demonstrated in six of our 20 patients. In four of the infants, the increased echogenicity was seen predominately in the region of the cortical gray matter, causing marked accentuation of the gray-white matter interface (fig. 1). Sonograms of two infants showed increased echogenicity deeper within the cerebral cortex, possibly related to early abscess formation (fig. 2). The focal echodense areas resolved within 2 weeks of antibiotic treatment, except in one infant who developed large intracerebral abscesses.

One child with meningococcal meningitis died 2 weeks after sonography. At autopsy, in addition to thickened meninges and thick fibrous exudate, petechial hemorrhages of the underlying cortex were described. Microscopic examination of sections of subjacent cerebral cortex showed areas of intense inflammatory response characteristic of meningoencephalitis. The cortex was edematous and congested. Perivascular accumulation of inflammatory cells and areas of fibroblastic and gliotic reaction were demonstrated. Meningoencephalitis of the subjacent cortex similar to this case is a frequent finding at autopsy in patients dying of chronic meningitis [9].

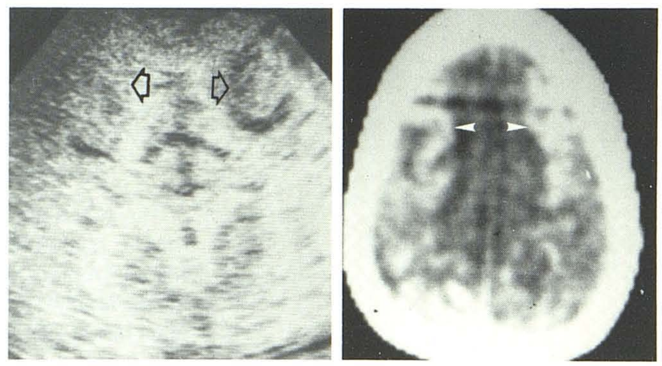
Abscess

Large areas of diminished attenuation with associated contrast enhancement were seen on the initial CT scan of a 1-week old infant with *Proteus mirabilis* sepsis (fig. 3). Sonography the same day showed dense, bifrontal, solid lesions in the areas of abnormality seen on CT. Sonography 3 days later showed cavitation within the area of echogenicity seen on the previous study. The radiologist performing the examination reported seeing chunks of debris falling from the echogenic part into the cystic space during scanning. CT 2 weeks later showed contrast enhancement around the periphery of the frontal lesions and sonography showed increased echogenicity in the same areas. The lesions were believed to represent abscess cavities, although cerebral infarction with possible superinfection from the *Proteus* sepsis was considered. An aspirate of the frontal cavities was productive of grossly purulent material from which *Proteus mirabalis* was cultured. The infant was treated with a 6 week course of intravenous antibiotics, then discharged from the hospital. Despite the persistent large frontal cavities, the infant gained weight and improved clinically in the next 3 months. CT at that time showed enlargement of the cavities, from which sterile fluid was aspirated. The child subsequently developed seizures. This case is similar to three infants described by Smith and Mellor [10]. In their experience, *Proteus* meningitis was complicated by frontal abscesses, presumably secondary to septic emboli.



A **B**

Fig. 1.—3-month-old infant with *H. influenzae* meningitis. **A**, Moderate ventricular enlargement and areas of increased echogenicity of cerebral cortex with accentuation of gray-white matter interface (*arrows*). **B**, Focal areas of contrast enhancement (*arrow*) correspond to areas of echogenicity on sonogram.

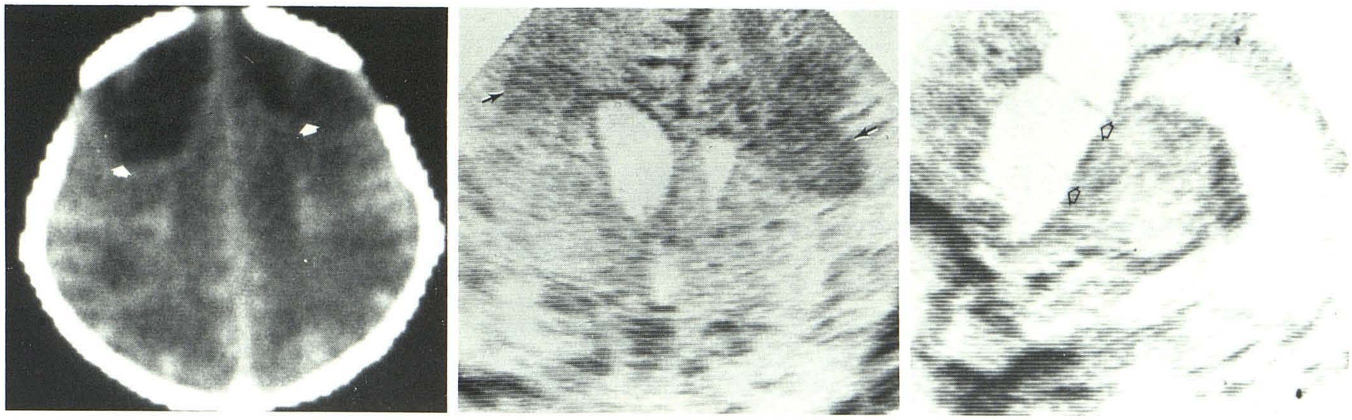


A **B**

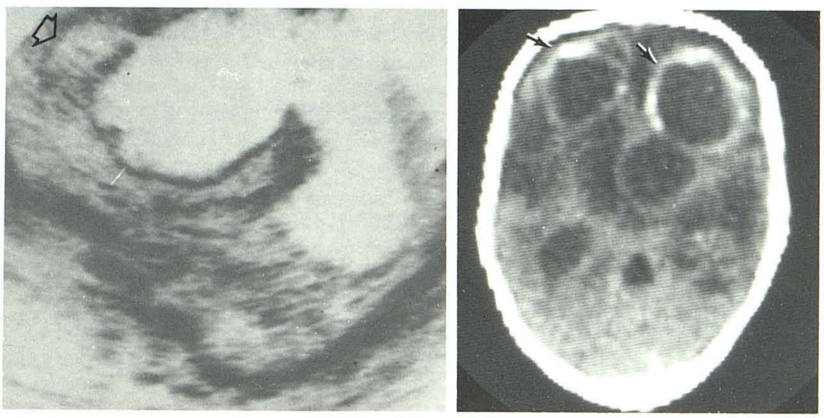
Fig. 2.—6-month-old infant with meningococcal meningitis. **A**, Ventricular enlargement and focal areas of cortical echogenicity most prominent on left (*arrows*). **B**, 1 week later. Bilateral contrast enhancement in cerebral cortex (*arrowheads*). Enhancement on right is more prominent than echogenicity on sonogram, possibly because of 1 week delay between studies.

Ventricular Bands

Ventricular bands were demonstrated in two patients in our series (fig. 4). These bands were late sequelae of



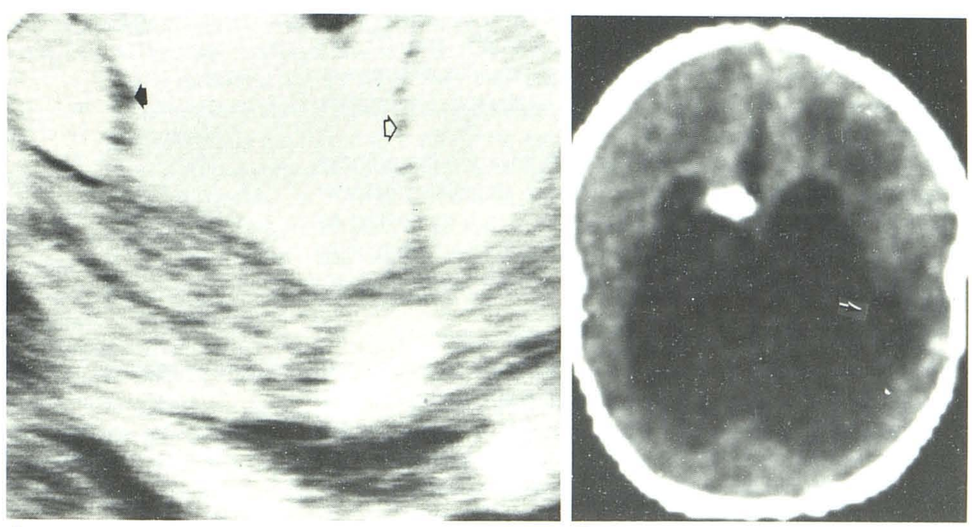
A B C



D E

Fig. 3.—1-week-old infant with *Proteus mirabilis* sepsis. **A**, Contrast-enhanced scan. Large areas of diminished attenuation believed to be due to cysts, abscesses, or infarcts (*arrows*). No enhancement is seen. **B**, Coronal sonogram. Large bifrontal echogenic lesions (*arrows*) believed to be due to cerebritis. **C**, Sagittal sonogram 3 days later. Cavitation (*arrows*) in area of echogenicity in **B**. Chunks of debris were seen falling from solid part into cystic space during examination. **D**, 2 weeks later. Increased echogenicity in periphery of abscess cavities (*arrow*). **E**, Same day. Enhancement of margins of abscesses (*arrows*).

Fig. 4.—Infant 2 months after episode of meningitis examined for possible shunt malfunction. **A**, Coronal sonogram. Lateral ventricular enlargement. Ventricular band (*closed arrow*). Septum pellucidum (*open arrow*). **B**, Ventricular enlargement; ventricular band is less clearly seen (*arrow*).



A B

ventriculitis complicating meningitis, occurring more than 2 months after the acute phase of the illness. Such arachnoidal adhesions form within the infected ventricles and tend to obstruct drainage of cerebrospinal fluid, either through the normal drainage pathways or through the shunt tube [11]. They may contribute to persistent or recurrent shunt failure or shunt infection. The ventricular band, being a solid septum in a cystic space, is demonstrated very clearly on sonograms, but may be less sharply seen by CT because of volume averaging of the thin septum.

Ventricular Enlargement

Ventriculomegaly was a complication of meningitis in 12 of the 20 infants in our series. The accuracy of sonographic evaluation of ventricular size is well established, and has been found equal to CT [1-4]. In three infants in our series, the ventricular size was mildly increased within 2 weeks of the onset of symptoms, but returned to normal 1 month later.

Discussion

Patients with meningitis and meningoencephalitis present with a well recognized spectrum of findings on CT examination. Although CT is frequently normal, it may demonstrate focal areas of contrast enhancement, edema, subdural effusions, abscess formation, and subdural empyema [8, 12-14]. We have found that many of these features can also be demonstrated in infants under 2 years of age using real-time sector sonography. Meningoencephalitis secondary to meningitis causing cortical enhancement on CT has been described, but, to our knowledge, there has been no previous report of increased echogenicity by sonography in patients with meningoencephalitis [8]. The abnormal echodense lesions represent areas of inflammatory perivascular response in the subjacent cortex and correspond to areas of contrast enhancement on CT.

Moderate to severe ventriculomegaly is a frequent complication of infantile meningitis, occurring in 17%-35% of cases in neonates [14]. Mild ventricular widening, usually of a reversible nature, is more common and has been observed in 67% of children with bacterial meningitis [15]. Because of the ease and accuracy of sonography in determining ventricular size, sonography has become the primary method at our institution of monitoring ventricular size in infants with complicated meningitis.

Our experience with sonography in the evaluation of intracerebral abscess is limited to one case, but our preliminary experience indicates that sonography and CT are complementary in the investigation of infantile abscesses. Enzmann et al. [16] described similar findings in experimental brain abscesses in dogs.

A major disadvantage of sonography through the anterior fontanelle is its inability to consistently visualize posterior fossa structures clearly [1]. Sonography is also limited by the narrow anterior fontanelle in older infants and may miss effusions in the lateral subdural space associated with meningitis.

Real-time sonography and CT produce comparable images of infants with meningitis and meningoencephalitis, but sonography offers a number of advantages. The sonograms can be obtained rapidly at the bedside without removing the critically ill infant from the intensive care environment, there is no risk of ionizing radiation, and the cost of the examination is considerably less than CT. For these reasons, despite some disadvantages, it appears that sonography may become an increasingly attractive alternative to CT in the evaluation of complicated infantile meningitis and meningoencephalitis.

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