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Cribside Neurosonography: Real-Time Sonography for Intracranial Investigation of the Neonate

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A prospective study was made of 94 real-time sonographic sector scans of 56 neonates in a 6 month period. The examinations were performed using the anterior fontanelle as an acoustic window. In 17 cases, computed tomography (CT) head scans were available for comparison. In no case did the CT and sonographic examination disagree as to the size of the lateral ventricles. Abnormalities detected by sonography include ventriculomegaly, intracerebral hematomas, a congenital glioma, and several cystic lesions. Sonographic sector scanning produces excellent, detailed images of dilated lateral and third ventricles, uses no ionizing radiation, is less expensive than CT, and can be performed in the isolette, minimizing the risk of hypoxia and hypothermia. At Methodist Hospital Graduate Medical Center, sonography has replaced CT as the initial method of investigation of ventricular size. CT plays a complementary role in the evaluation of the posterior fossa, intracranial hemorrhage, and mass lesions.

Since the first report of the clinical application of echoencephalography in 1956 [1], there has been much interest in the sonographic demonstration of intracranial pathology [2, 3]. Recent advances in sonographic technology have produced high resolution contact scanners and the Octason, an automated water delay scanner [1, 4, 5]. These instruments produce images of the neonatal intracranial contents with sufficient detail to permit accurate evaluation of ventriculomegaly and certain other intracranial lesions [1, 4–6]. The development of a compact transducer head for wide-angle real-time sector scanning (ATL real-time digital scanner) has permitted the use of the anterior fontanelle as an acoustic window. Since the sonographic beam is not attenuated by the skull, a clear demonstration of intracranial anatomy is achieved [6–8]. In this paper, we describe our initial experience with real-time sonographic sector scanning in the intracranial investigation of neonates and infants less than 1 year of age.

Subjects and Methods

A prospective study was made of 94 sonograms in 56 neonates and infants during a 6 month period. Several neonates with abnormal scans were reexamined at 1 week to 1 month intervals to monitor ventricular size, particularly after ventriculoperitoneal shunt placement. The age of the patients was 1 day to 11 months. Computed tomography (CT) scans were available for comparison in 17 cases. The CT scanner used was an EMI 1005 dedicated head unit with a 60 sec scanning time. The sonographic scanner was an ATL real-time digital scanner with a 5 MHz transducer producing 90° sector images. The compact, 3 cm diameter transducer head was easy to manipulate and the scanning technique was relatively easy to learn. Multiple views of the ventricles were obtained in the coronal and sagittal projections through the anterior fontanelle. When possible, additional views through the posterior fontanelle were obtained to better demonstrate the posterior fossa. The maximum time required for the examination was 5 min. The sonograms were obtained in the isolette, and when necessary, the scans were obtained by placing the transducer through the arm porthole of the isolette preserving a constant temperature and oxygen concentration.

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The scans were interpreted as positive for hydrocephalus if the lateral ventricular ratio was greater than 0.30. The lateral ventricular ratio is defined as the ratio of the width of the lateral ventricles to the greatest internal diameter of the cranial cavity [2]. Several authors have used this measurement to evaluate fetal and neonatal ventricular size [2, 5, 6, 9, 10]. Although the sector scan is limited to a 90° arc, there was no difficulty measuring the diameter of the cranial cavity or the width of the lateral ventricles. The average lateral ventricular ratio is reported as 0.25 at term, the 99% upper limit of confidence measurement is 0.29 [2]. Because the earliest dilatation of the ventricle frequently appears in the atria of the lateral ventricles [5, 6], a scan was interpreted as consistent with minimal or borderline ventricular dilation if the atria of the lateral ventricle were dilated even though the frontal horns of the lateral ventricles were not.

Scans were obtained through the fontanelles at various angles to the midsagittal and coronal planes. Figure 1 illustrates the scanning angles used. Because similarly angled images have not been reported previously, sections were obtained of normal neonatal brains from autopsy specimens for correlation with the scans. Because ventricular anatomy is more clearly demonstrated in scans of infants with ventricular dilation than of normal infants, labeled scans from an infant with moderate ventriculomegaly are compared with the normal autopsy specimens in figures 2 and 3.

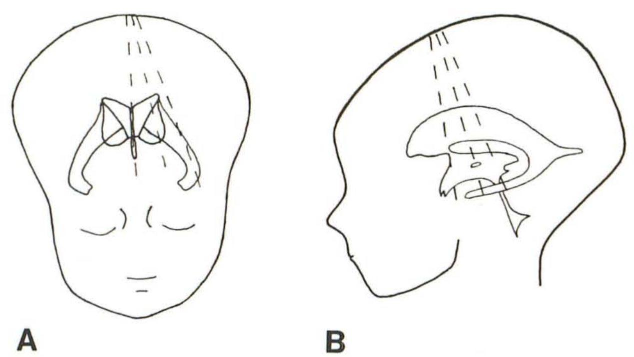

Fig. 1.—Scanning angles in sagittal (**A**) coronal (**B**) planes.

Results

Ventricular enlargement was diagnosed in 21 neonates. CT correlation was available in 17 cases and in no case did sonography and CT disagree as to the degree of ventriculomegaly. Generally, sonography demonstrated greater detail of the ventricular system than did CT. In the presence of ventricular enlargement, many structures previously undetected or poorly visualized by sonography or CT can routinely be seen, including the anterior recesses of the third ventricle, the massa intermedia, the foramina of Monro, iter, and the suprapineal recess. In the normal neonate the ventricles are frequently slitlike structures and less anatomic detail is demonstrated [4]. The demonstration of posterior fossa structures and the brain stem is less satisfactory, and the fourth ventricle is rarely seen even in the presence of ventricular dilation.

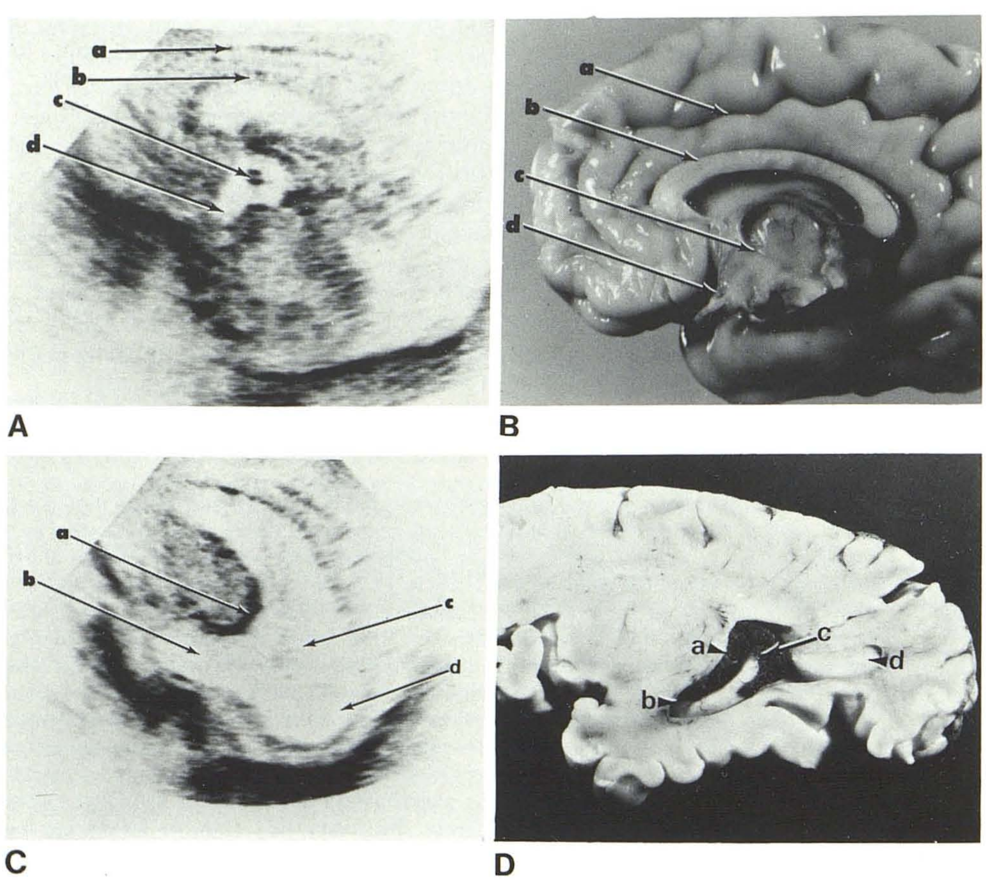

Fig. 2.—**A**, Midline sagittal scan of moderately hydrocephalic neonate. **B**, Sagittal brain section of normal neonate. a = cingulate sulcus, b = corpus callosum, c = massa intermedia, d = anterior recesses of third ventricle. Sagittal scan (**C**) and brain section (**D**) angled laterally. a = choroid plexus, b = temporal horn, c = atrium, d = occipital horn.

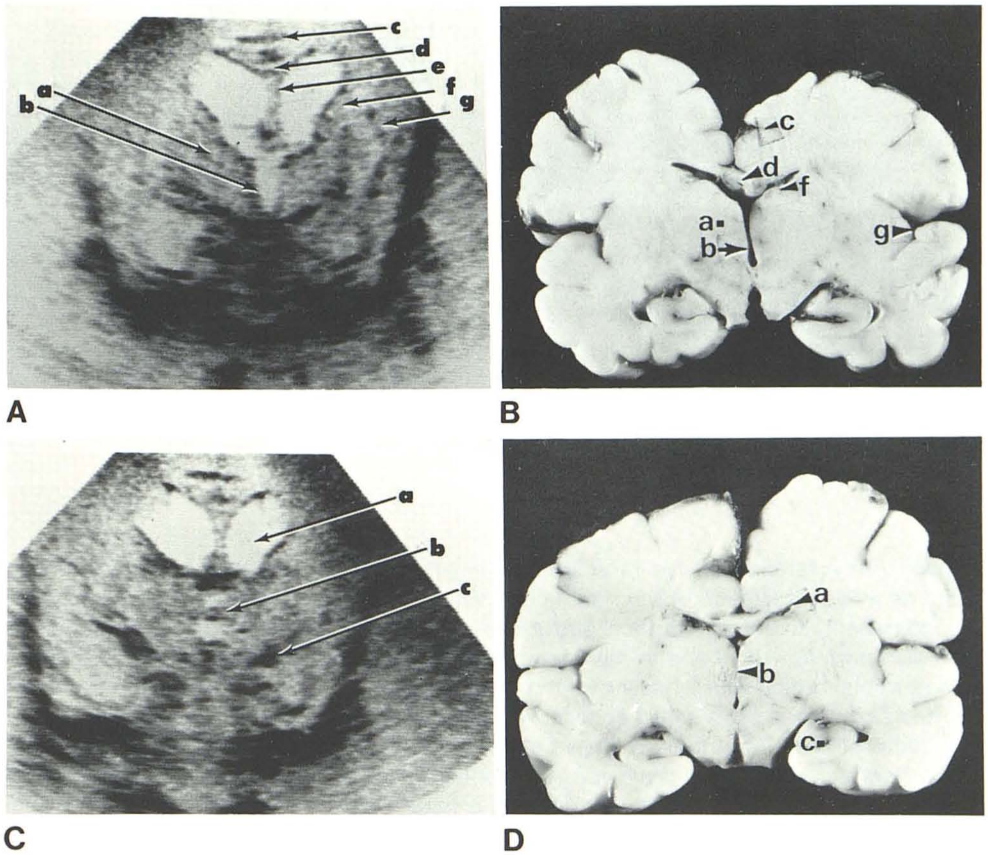

Fig. 3.—Coronal scan (**A**) and brain section (**B**) at level of foramina of Monro. a = thalamus, b = third ventricle, c = cingulate sulcus, d = corpus callosum, e = septum pellucidium, f = caudate nucleus, g = sylvian fissure. Coronal scan (**C**) and brain section (**D**) at level of massa intermedia. a = lateral ventricle, b = massa intermedia, c = hippocampus.

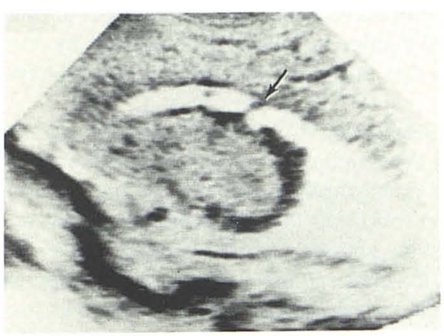

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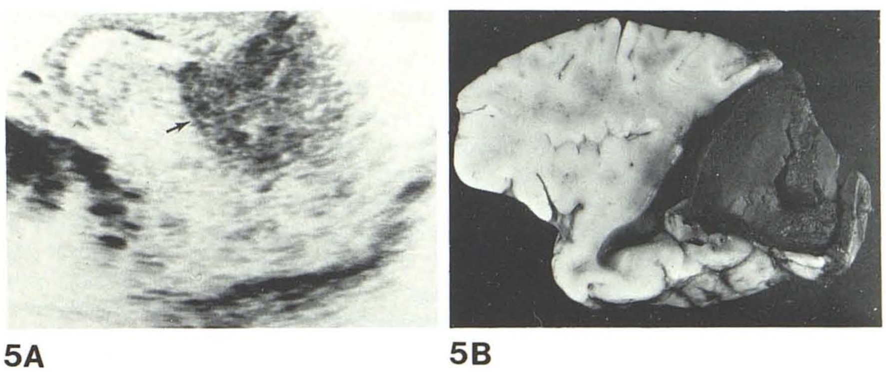
Fig. 4.—Ventricular band (*arrow*) in body of lateral ventricle.



5A **5B**

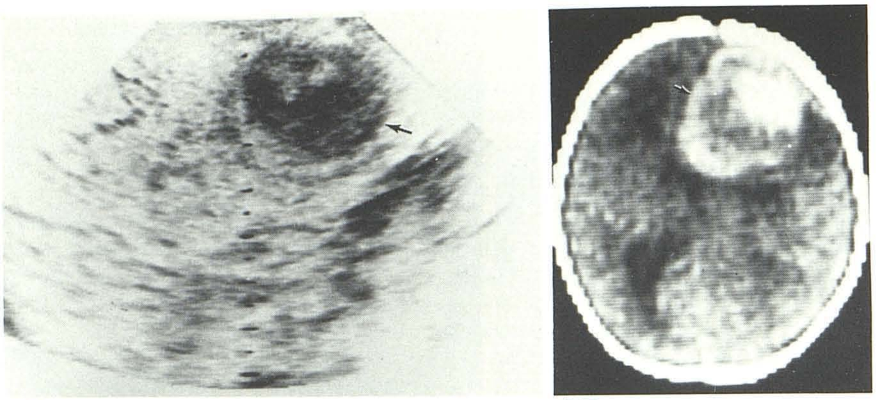
Fig. 5.—**A**, Large retrosylvian collection of solid echoes (*arrow*) believed to represent intracerebral hematoma in infant with disseminated intravascular coagulopathy. **B**, Large hematoma found at autopsy.

TABLE 1: **Sonographic Findings**

Abnormality	No. (n = 56)
Normal	33
Ventriculomegaly	21
Ventricular band	2
Porencephalic cyst	2
Intraventricular hematoma	2
Subarachnoid cyst	1
Glioma	1
Intracerebral hematoma	1
Total	63

Although the primary aim of sonography was the evaluation of ventricular size, other abnormalities were occasionally recognized (table 1). These include subarachnoid cyst, porencephalic cyst, and ventricular bands (fig. 4). In three patients large collections of solid echoes were demonstrated in the cerebral hemispheres.

The first, a child with disseminated intravascular coagulopathy and a rapidly deteriorating course was found to have a large left parietooccipital collection of solid echoes (fig. 5). The lesion was interpreted as an intracerebral hematoma. A midline shift to the right was demonstrated as well as marked dilation of the right lateral ventricle. At



6A 6B

Fig. 6.—**A**, Large frontal mass with central fluid echoes (*arrow*). **B**, Hemorrhage within mass (*arrow*). Glioma was removed at surgery.

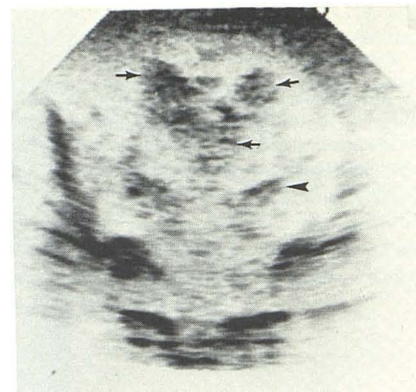


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Fig. 7.—Large solid hematomas (*arrows*) in lateral and third ventricles. Hippocampus (*arrowhead*).

autopsy 2 days later a massive intracerebral hematoma was found as well as dilatation of the right lateral ventricle. The second patient, an infant with focal seizures but apparently otherwise normal, was found to have a large solid mass in the left frontal region with a midline shift to the right (fig. 6). The mass contained central fluid echoes. No hydrocephalus was demonstrated. At surgery a large hemorrhagic glioma with a necrotic center was removed. A collection of solid echoes was found in the lateral ventricles of a third infant corresponding to large intraventricular hematomas (fig. 7).

Discussion

Many authors have recently demonstrated the value of sonography in the evaluation of neonatal intracranial pathology [4–6, 8]. The Octason scanning system using a water tank and an array of eight sonographic transducers can produce clear images of the intracranial contents in several angles as well as the usual CT plane [4]. The neonates must be transported to the radiology department and removed from their isolettes for their Octason examination. Contact sonographic scanning has been formerly limited by the poor transmission of the sonographic beam through the skull and the difficulty obtaining good transducer coupling to the irregularly shaped surface of the head [4, 6]. The development of a compact transducer head primarily designed for real-time cardiac scanning has permitted the use of the fontanelles as acoustic windows in the neonate. The scans are limited to a 90° pie-shaped image, but this is not a serious disadvantage since the transducer can easily be angled to image the entire cerebral convexity.

Intraventricular and subarachnoid hemorrhage is a common problem in premature infants, and has been reported in one-third to one-half of infants weighing less than 2,000 g at birth [4, 11]. Because all fluid collections appear as similar cystic spaces on sonography, hemorrhage into the fluid-filled ventricles cannot be detected unless the hemorrhage has developed into a solid hematoma. Two infants in our series with normal sonograms were found to have intracranial hemorrhage on CT. Therefore, CT is more accurate than sonography in the detection of recent intracranial hemorrhage [11]. Communicating hydrocephalus, a frequent complication of intracranial hemorrhage, can be monitored with accuracy by either CT or sonography, but sonography is preferred at our institution in the follow-up of intracranial hemorrhage [12].

Sonography has been successful in the diagnosis of cystic lesions such as Dandy-Walker cyst, porencephalic cyst, subdural hematoma, subdural hygroma, and hemorrhage [4]. Our series includes several infants with similar abnormalities, including two infants with porencephalic cyst, two with ventricular bands, and one with a subarachnoid cyst. The usefulness of the sonography is not limited to the evaluation of fluid collections, which is illustrated by the three infants with large intracerebral collections of solid echoes.

In summary, cribside sonographic sector scanning offers many advantages in the evaluation of neonatal intracranial pathology. Because sonography produces clear, detailed images of the dilated third and lateral ventricles, accurate evaluation of ventricular size can be performed quickly at the cribside without ionizing radiation and at less expense than CT. At our institution sonography has been used as the procedure of choice in the screening of neonates with suspected ventricular enlargement, particularly those with an enlarged occipital frontal circumference. If ventricular enlargement is detected with sonography, and the infant's condition permits, the child is usually then taken to the radiology department for a CT scan in an attempt to determine the etiology of the ventricular enlargement. Sonography is generally used for subsequent examinations.

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