Tentorial Subdural Hemorrhage in Term Newborns: Ultrasonographic Diagnosis and Clinical Correlates

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Tentorial subdural hemorrhage with its supratentorial and infratentorial extensions were diagnosed by cranial ultrasonography and computed tomography in 9 term newborns. Vacuum extraction or forceps delivery was used in 6 patients. Abnormal neurologic manifestations developed after a period of normality in 8 patients. Increased intracranial pressure was the most common presentation. All patients had hemorrhage at the falcotentorial junction near the incisura; 5 also had hemorrhage around the tentorial leaflet. Posterior fossa retrocerebellar subdural hemorrhage developed in 5 patients and posterior interhemispheric subdural hemorrhage developed in 4. All 6 patients who received conservative treatment had normal neurodevelopmental outcomes. Of the other 3 patients upon whom suboccipital craniotomies were performed, only 1 had a normal outcome. Although it localized the tentorial subdural hemorrhage either at the incisura area or at the tentorial leaflet, ultrasonography failed to identify all patients with retrocerebellar or posterior interhemispheric subdural hemorrhage. Parturitional tentorial subdural hemorrhage may not be uncommon. Ultrasonography and computed tomography are complementary in the diagnosis. Surgical decompression of the posterior fossa subdural hematoma is necessary only in the presence of acute hydrocephalus or signs of brainstem compression.

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Introduction

Subdural hemorrhage that occurs during the newborn period often is caused by tentorial tearing. The tearing may result from abnormal pressure, exerted by vacuum, forceps, or breech presentation, on the molded skull during delivery [1]. This tearing causes rupture of the underlying sinus or bridging veins [2,3]. The hemorrhage may extend both supratentorially and infratentorially. Early and noninvasive diagnosis of tentorial subdural hemorrhage with posterior fossa extension is of great value because early identification of an affected newborn will lead to careful search for early signs of brainstem compression and potentially life-saving interventions [3,4].

With the introduction of computed tomography (CT), neonatal subdural hemorrhage has been diagnosed antemortem with increasing frequency [4]. CT not only localizes the hematoma, but also defines its spread [1]. Coronal views are usually necessary to diagnose precisely the infratentorial type of subdural hemorrhage [5]. Cranial ultrasonography (US) has proved to be a valuable tool in the diagnosis of neonatal intracranial hemorrhage; however, the diagnosis of tentorial subdural hemorrhage and its supratentorial and infratentorial extensions by US has not been reported in detail. In our report, we compared the diagnostic efficiency of US and CT by the clinical manifestations, modes of delivery, birth conditions, and treatment outcome of 9 patients with neonatal tentorial subdural hemorrhage.

Methods

All patients had symptoms within 5 days of birth and diagnoses of tentorial subdural hemorrhage were suggested by cranial US and confirmed by CT.

The delivery presentations and modes of delivery were recorded. The clinical manifestations, including age at onset of symptoms, neurologic symptoms and signs, treatment, and outcomes, were studied. Neurologic and developmental examinations were assessed on all surviving patients for a period of 6 months to 2 years (mean: 13 months).

Cranial US was performed with a 5.0 MHz sector transducer Aloka Scan® SSD-630 unit. The sonograms were obtained via the anterior fontanel in the coronal, sagittal, and parasagittal planes. US examinations were performed immediately after admission and regularly until the infants were 2 months of age. CT scans also were performed soon after the first US examinations.

Tentorial subdural hemorrhage was diagnosed by US and CT and located either at the median falcotentorial junction near the incisura or at the tentorial leaflets with their attachments near petrous temporal bones. The extensions of the tentorial subdural hemorrhage were also categorized as either posterior interhemispheric fissure hemorrhage or retrocerebellar subdural hemorrhage.

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Table 1. Perinatal histories and clinical manifestations

Pt No.	Sex	GA (wks)	BW (kg)	Apgar Score (1/5 min)	Labor History	Age of Symptom Onset	Initial Presentations	CSF
1	M	40	3.5	9/10	G2,P2,V	24 hrs	Enlarged head, tense fontanel, irritability	NP
2	M	40	4.1	10/10	G1,P1,V	17 hrs	Enlarged head, tense fontanel, apnea, cyanosis	Bloody
3	M	42	3.6	8/10	G1,P1,V	*	Enlarged head, cleft lip and palate	NP
4	M	40	3.7	10/10	G2,P2,B	22 hrs	Enlarged head, irritability, seizures, apnea, cyanosis	Bloody
5	F	41	2.8	9/10	G1,P1,N	24 hrs	Irritability, tense fontanel, seizures	Bloody
6	M	39	3.0	5/8	G1,P1,N	24 hrs	Seizures, apnea, stupor, vomiting	Bloody
7	M	40	3.8	8/9	G3,P2,V	22 hrs	Seizures, irritability, fever	Bloody
8	M	40	2.6	8/10	G2,P2,N	5 days	Opisthotonos, tense fontanel, irritability	Bloody
9	M	40	3.2	7/9	G3,P2,V	4 days	Enlarged head, tense fontanel, shock, apnea	NP

* Without any neurologic symptoms.

Abbreviations:
B = Breech and forcep delivery
BW = Birth weight
CSF = Cerebrospinal fluid
GA = Gestational age
N = Spontaneous delivery
NP = Not performed
V = Vacuum

Results

Perinatal History. Table 1 summarizes the perinatal histories. All 9 patients (8 males, 1 female) were delivered vaginally at term. The mean birth weight was 3,367 gm (range: 2,600-4,100 gm). None of the mothers was short in stature; 4 mothers were primiparous. With regard to the type of delivery, 8 patients were of cephalic presentations and only 1 was extracted in breech presentation with forceps. There were 3 patients born by spontaneous delivery and 5 patients by vacuum extractions. None of the patients was born after precipitous or prolonged labor. Only Patient 6 had a transiently low 1 min Apgar score; all others had good Apgar scores at 1 and 5 min. None presented with macrocephaly at birth. Patient 9 was admitted with shock and disseminated intravascular coagulation; all others had normal platelet count, prothrombin time, and partial thrombin time. Marked anemia was observed in 3 patients.

Clinical Manifestations at Admission. Table 1 summarizes the clinical manifestations. Six patients had cephalohematoma which was evidence of cranial trauma. All, except Patient 3, developed neurologic symptoms and signs after a period of normality ranging from 17 hours to 5 days after birth. Patient 3 had cleft lip and palate, no neurologic symptoms, and macrocephaly; tentorial subdural hemorrhage was diagnosed incidentally when a screening cranial US examination for brain malformation was performed. Increased head circumference after birth and tense fontanel were observed in 5 patients each. Apnea and seizures developed in 4 patients each. Irritability was demonstrated in 4 patients. Opisthotonos was observed in 1 patient who also had intraventricular hemorrhage and acute hydrocephalus.

Lumbar puncture was performed at admission in 6 of the 9 infants to eliminate the possibility of meningitis. The cerebrospinal fluid (CSF) was bloody in all 6 patients. None exhibited clinical deterioration after the procedures.

Locations of Subdural Hemorrhage. Table 2 lists the locations of the subdural hemorrhages. Initial US and CT scans were obtained within 5 days of birth, except for Patient 7 who had neurologic symptoms at the age of 22 hours but was not transferred to our hospital for treatment

Table 2. Locations of subdural hemorrhages

Pt No.	Tentorial Hemorrhage: Median Incisura	Tentorial Hemorrhage: Leaflets	RSH	PIH	Outcome*
1	+	Unilateral	+	+	Normal
2	+	Unilateral	–	+	Normal
3	+	Bilateral	–	+	Normal
4	+	–	–	–	Normal
5	+	Unilateral	+	+	Normal
6	+	–	+	–	Normal
7†	+	–	+	–	Normal
8‡	+	–	–	–	Delay
9	+	Unilateral	+	–	Died

* Mean follow-up period was 13 months.
† VP shunt for posthemorrhagic progressive hydrocephalus.
‡ VP shunt for intraventricular hemorrhage with acute hydrocephalus.

Abbreviations:
PIH = Posterior interhemispheric hemorrhage
RSH = Retrocerebellar subdural hemorrhage

until the age of 10 days. According to the US and CT findings, all 9 patients had tentorial subdural hemorrhage in the median falcotentorial junction area (Figs 1A-1D), but 5 patients also had hemorrhages around the tentorial leaflet with attachment near the petrous temporal bone (Figs 2A-2D,3A-3C) and Patient 3 had bilateral involvement. Regarding the extensions of tentorial subdural hemorrhage, there were 5 patients with subdural hemorrhage located at the posterior fossa retrocerebellar area (Figs 4A-4D) and 4 patients with subdural hemorrhage located at the posterior interhemispheric fissure (Figs 5A-5C). Although 7 patients presented with intracranial hypertension (increased head circumference and tense fontanel), only Patient 8 demonstrated acute hydrocephalus at the time of initial CT.

Diagnostic Accuracy of US. Table 3 compares the US and CT findings. Tentorial subdural hemorrhages could be diagnosed by US as an increased and widening echogenic lesion over the tentorial area on coronal and sagittal views. All patients with hemorrhage located either at the central incisural area or at the lateral leaflet could be diagnosed by US and confirmed by CT; however, US detected only 2 of the 5 patients with subdural hemorrhage in the retro-

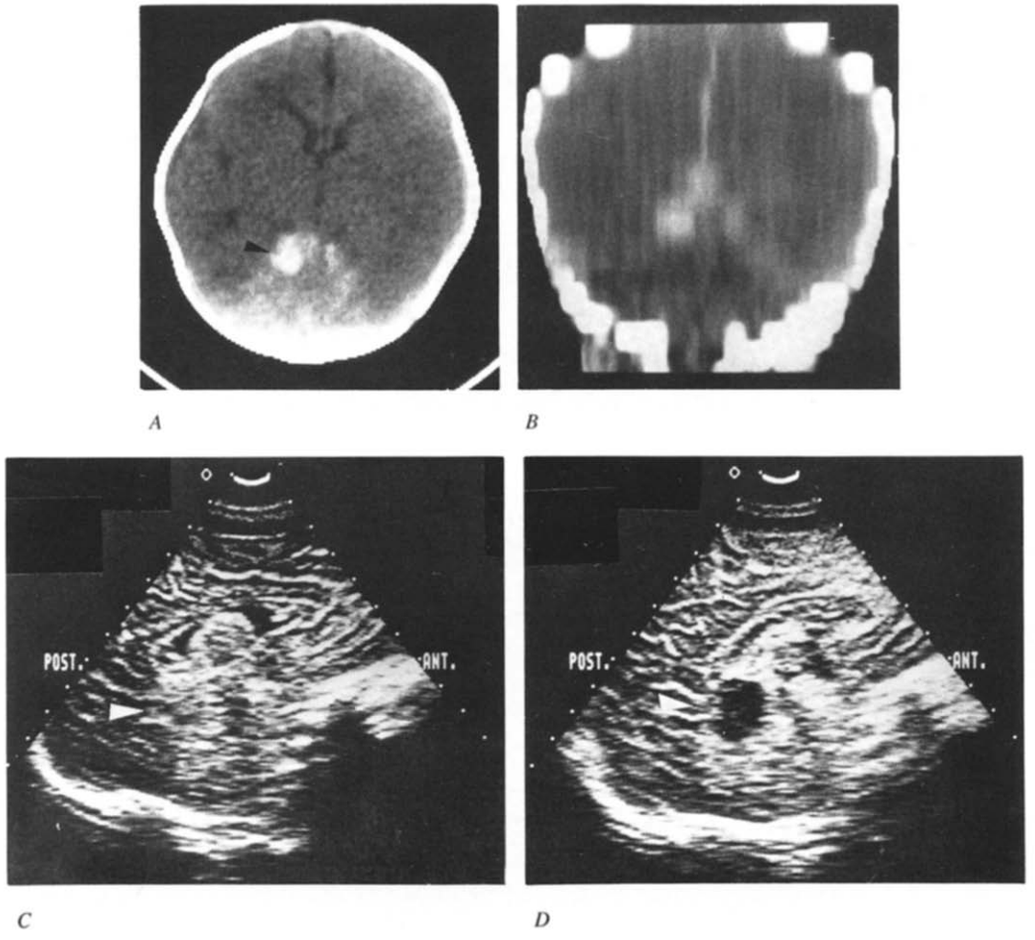

Figure 1. Tentorial subdural hemorrhage at the falcotentorial junction near the incisura area (Patient 1). (A) CT along the free margin of tentorium, demonstrating the blood accumulated at the quadrigeminal areas (arrowhead). (B) CT coronal reconstruction view disclosing the hemorrhage located at the falcotentorial junction. (C) Midsagittal US demonstrating an echogenic lesion at the quadrigeminal area (arrowhead) which downwardly displaces the cerebellar vermis. (D) Midsagittal US 7 days later revealing the previous echogenic hemorrhage resolved into an echolucent lesion (arrowhead).

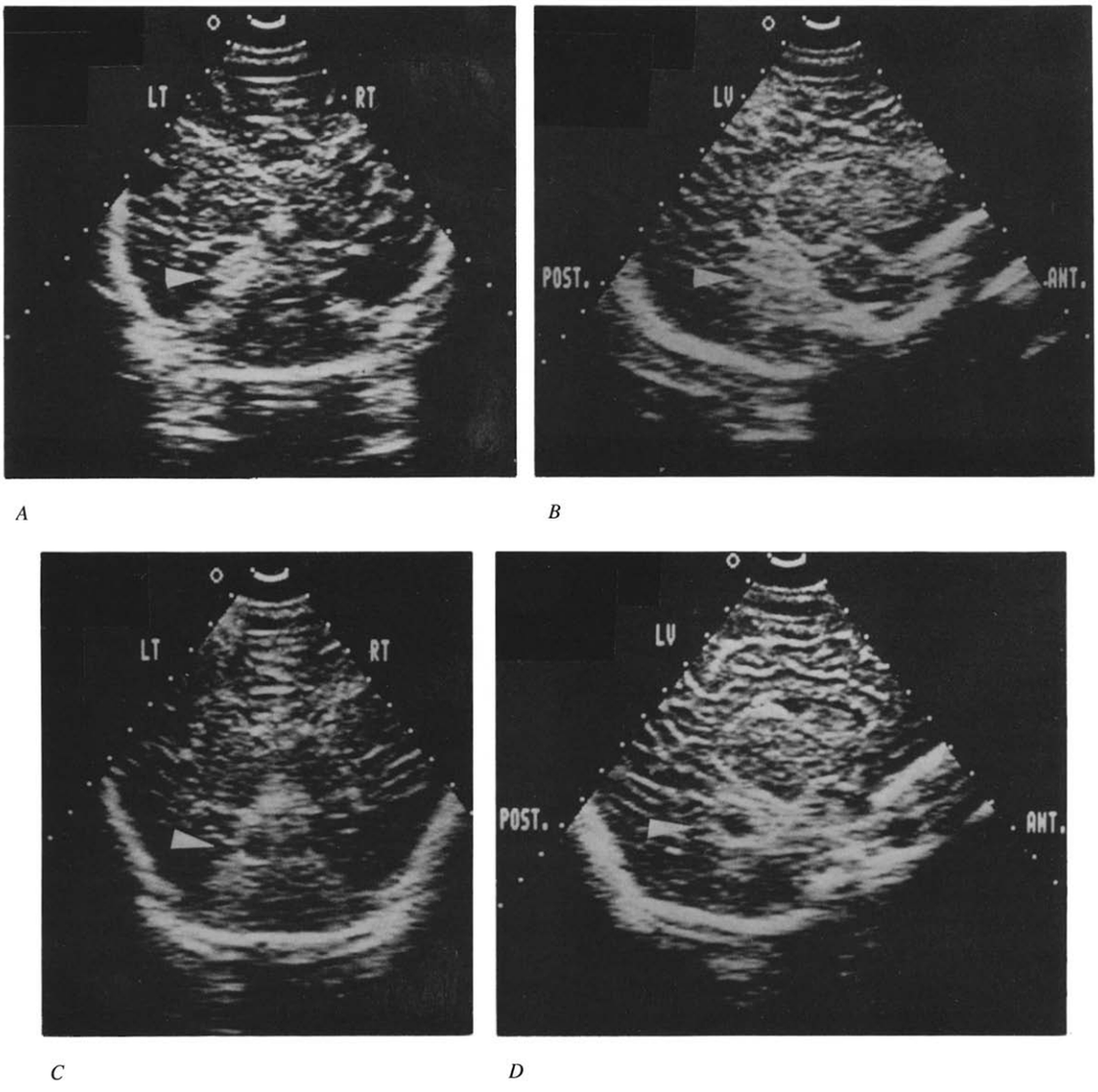

Figure 2. US of subdural hemorrhage at the tentorial leaflet and its petrous attachment (Patient 2). (A) Coronal US documenting a widening and increased echogenic lesion over the left tentorial area (arrowhead). (B) Parasagittal US revealing an echogenic lesion (arrowhead) above the cerebellar hemisphere. (C,D) Coronal and parasagittal US 6 days later; the center of the hemorrhage now evolves into an echolucent area (arrowhead).

cerebellar area, and 3 of the 4 patients with hemorrhage in the posterior interhemispheric fissure.

Treatment and Outcomes. Patients 1-6 received supportive treatment without surgical intervention and were frequently monitored by neurologic and sonographic examinations. None of these 6 patients exhibited neurologic deterioration or progressive hemorrhage enlargement. Only Patient 3 demonstrated mild and transient ventriculomegaly. None developed hydrocephalus during the follow-up period. No neurologic or developmental abnormalities were observed in these 6 patients.

In Patients 7-9, suboccipital craniotomy was performed to remove the hematoma due to persistently increased intracranial pressure and disturbance of consciousness. Ventriculoperitoneal shunts were required in Patient 7 who developed progressive hydrocephalus at age 4 weeks, and Patient 8 who presented with acute hydrocephalus at 6 days of age. Patient 9 died of shock, disseminated intravascular coagulation, and apnea. Developmental delay, spasticity, and microcephaly were observed in Patient 8.

Discussion

In a major tear of the tentorium with rupture of the vein of Galen, straight sinus, or transverse sinus, the hemorrhage extends into the posterior fossa, compresses the cerebellum, obstructs the fourth ventricle, and rapidly results in lethal brainstem compression [2,3]. A smaller tear of the tentorium or rupture of the bridging veins from the superior cerebellum, which may be more common, can result in subacute symptoms; a lag period of a few hours to a few days may appear between birth and the time neurologic symptoms appear [2]. Initially, the patient may display weak crying, irritability, vomiting, tense fontanel, and loss of Moro reflex, which may be followed by irregular respiration, hypotonia, skew deviation of the eyes, oculomotor paralysis, apnea, and frequently mortality [3,6,7].

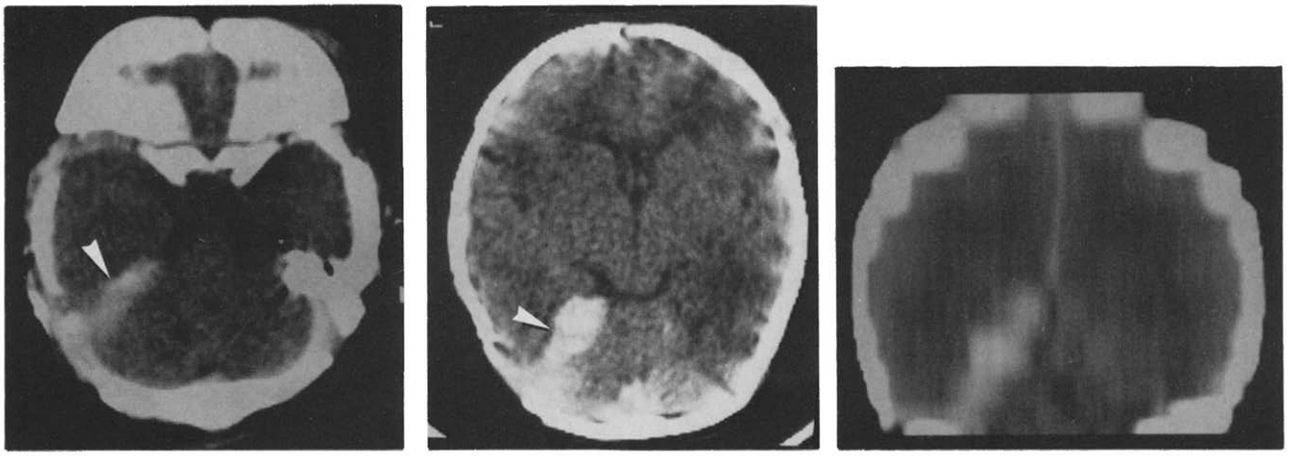

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Figure 3. CT of the subdural hemorrhage at the tentorial leaflet in Patient 2. (A) Hemorrhage at the tentorial petrous attachment (arrowhead). (B) Bleeding at the tentorial leaflet (arrowhead). (C) Coronal reconstruction view demonstrating hemorrhage along the tentorial leaflet.

Most of the early findings are suggestive of increased intracranial pressure, as in our patients, but are nonspecific for localization of tentorial subdural hemorrhage. None of our patients developed cranial nerve palsy, nystagmus, or bradycardia which Ravenel described as more typical manifestations of posterior fossa hemorrhage [6]. US and CT results confirmed the diagnoses, enabling further appropriate monitoring and treatment.

The male preponderance in this study was similar to that reported by Natelson and Sayer [8]. The reason for the sex-related disparity may be in part due to greater occipitofrontal circumferences in male newborns. Although the incidence of primiparae and breech presentation was lower in our study, as compared with others [1,9], the incidence of vacuum delivery (56%) was higher than in the reports by Takagi et al. [9], Takashi et al. [1], or Hernansanz et al. [4]. These findings support the important relationship between the type of delivery and the formation of tentorial subdural hemorrhage.

Three patients (33%) were born by spontaneous delivery. All of our patients had good 5 min Apgar scores. Patient 3 was diagnosed incidentally. These observations suggest that tentorial subdural hemorrhage may occur in normal deliveries [1] and the incidence of neonatal subdural hemorrhage may not be uncommon. In addition to the fatal acute onset and subacute progressive onset of clinical manifestations [2,3], milder tearing of the tentorium with smaller amounts of bleeding may produce only minor signs (e.g., transient irritability, vomiting, and hypotonia); recovery may be spontaneous without diagnosis.

Table 3. Correlation between US and CT findings in 9 patients

Findings	US	CT
SDH incisura	9	9
SDH tentorial leaflet	5	5
SDH retrocerebellum	2	5
SDH interhemisphere	3	4

Abbreviation:
SDH = Subdural hemorrhage

In our patients, falcotentorial junction around the incisura was the most vulnerable site in parturitional tentorial injury. Leaflets of the tentorium cerebellum with petrous attachments were the second most common site of injury. It is possible that during vaginal delivery the molding force on the skull, complicated by forceps or vacuum use, becomes strong enough to tear the tentorial attachments to the falx and petrous bones, and causes bleeding.

The tentorial subdural hemorrhage in most of the patients reported by Takashi et al. extended mainly supratentorially [1]. In the 23 autopsied patients with posterior fossa subdural hemorrhage reported by Takagi et al., only 7 patients had supratentorial subdural involvements [9]; however, 4 of our 9 patients had complications with supratentorial interhemispheric hemorrhage and all had infratentorial subdural involvement. Infratentorial retrocerebellar hemorrhage was also observed in 5 patients with tentorial injury. This finding suggests that besides tentorial hemorrhage, the blood also frequently extends supratentorially or infratentorially or both.

Although CT scans can definitively localize the hemorrhage to the interhemispheric fissure and retrocerebellum, difficulties may arise in correctly localizing the subdural hemorrhage with respect to the tentorium [5,10]. Coronal views usually are helpful in demonstrating whether the hemorrhage is both supratentorial and infratentorial; however, CT coronal views in neonates are difficult to obtain. Cranial US in coronal, sagittal, and parasagittal views can easily delineate the hemorrhage locations with respect to the tentorium [11]. Hemorrhage at the location of the falcotentorial junction usually extends both supratentorially and infratentorially. As the tentorial leaflets tear, the hemorrhage usually localizes between the superior surface of the cerebellum and the leaflets of the tentorium [2,5].

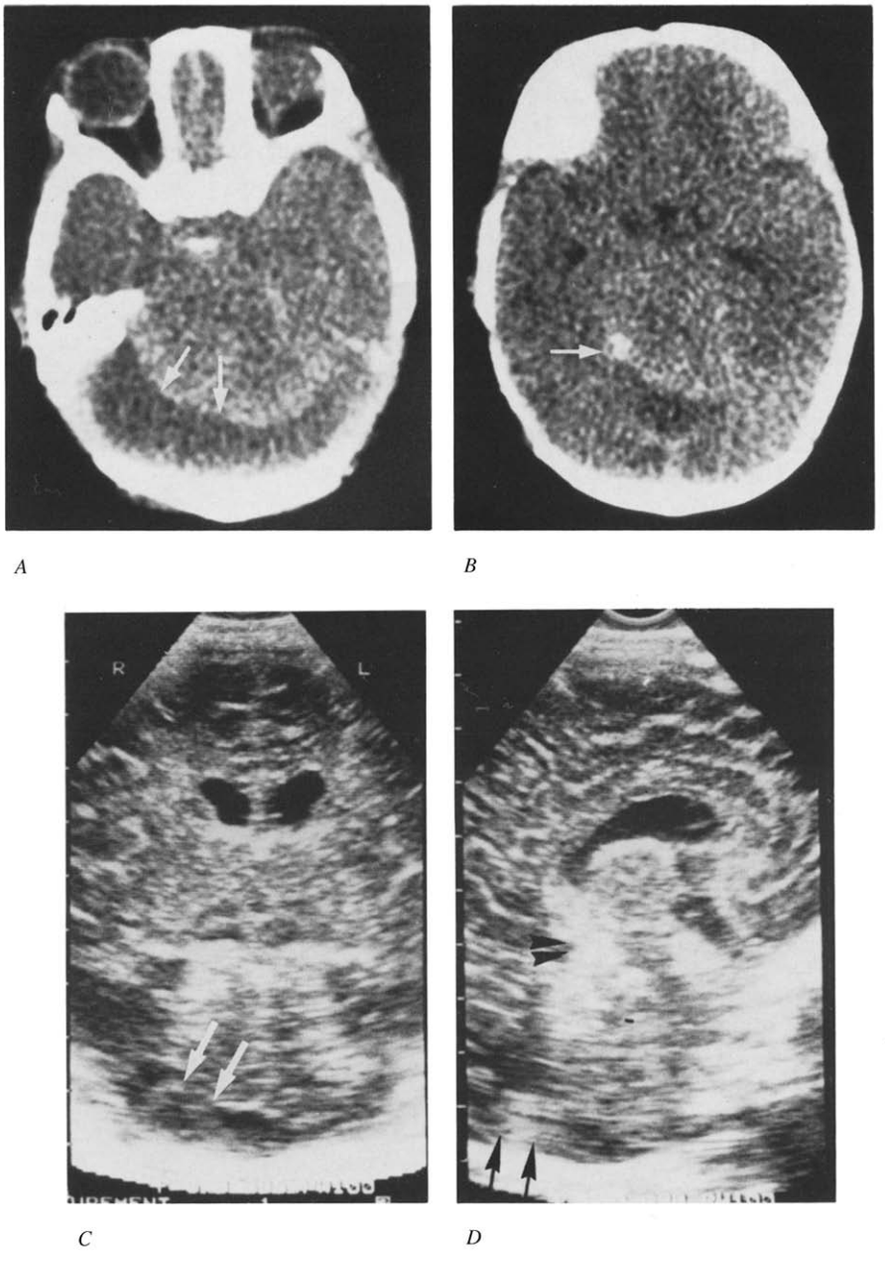
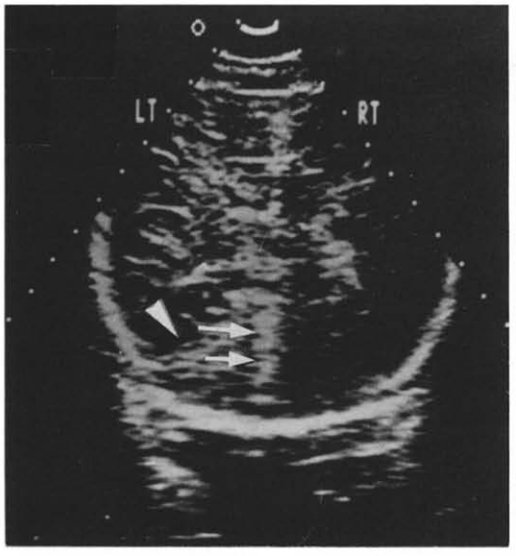


Figure 4. Hemorrhage over the retrocerebellar space in Patient 7. (A) At 12 days of age, CT demonstrating the retrocerebellar subdural hemorrhage (arrows). (B) CT disclosing the hemorrhage at the tentorial incisura area (arrow). (C) Coronal US documenting a mixed echogenic retrocerebellar lesion (arrows). (D) Midsagittal US revealing a retrocerebellar lesion (arrows) displacing the cerebellar vermis and an echogenic lesion at the quadrigeminal area (arrowheads).

No report has described the ultrasonic diagnosis of neonatal tentorial subdural hemorrhage and their supratentorial and infratentorial extensions. Most reports focused primarily on intracerebellar hemorrhage [12-14]. Retrocerebellar hemorrhage is difficult to visualize on US, except when massive bleeding has caused displacement of the cerebellum. In contrast to the findings by Gontard et al. [15], US is very useful in the diagnosis of tentorial subdural hemorrhage and CT is more diagnostic in the detection of retrocerebellar hemorrhage. Cranial US and CT scans are complementary in the diagnosis of neonatal tentorial hemorrhage and its supratentorial and infratentorial extensions.

The diagnosis of tentorial subdural hemorrhage with infratentorial extension is not an *a priori* indication for immediate surgery [16]. In contrast to the surgical intervention stressed by Hernansanz et al. and others [4-7], all patients treated conservatively (Patients 1-6) survived without sequelae. All of these patients had a decrease in intracranial pressure and improvement in neurologic functions within 3-5 days of admission. Surgical decompression of the posterior fossa subdural hematoma is necessary only whenever acute hydrocephalus or signs of brainstem compression occur, as in Patients 7-9.

Only 1 patient developed acute obstructive hydrocephalus during the early stage of illness; of the 2 patients who



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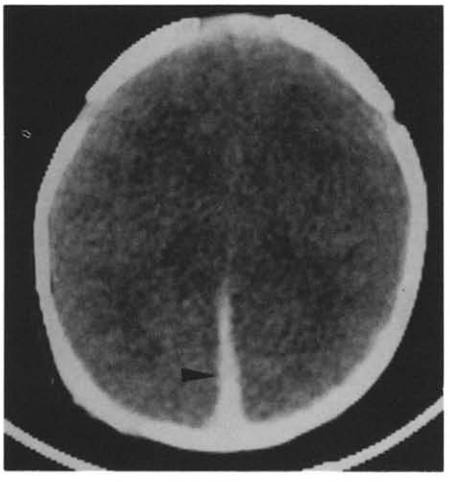

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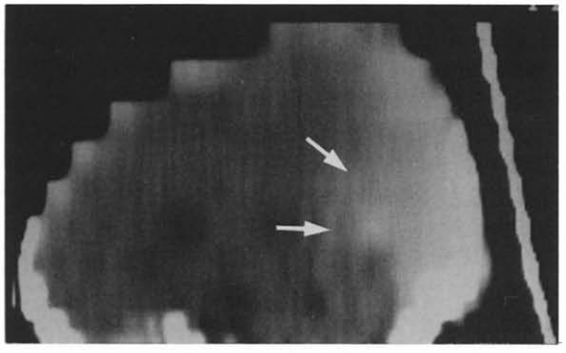

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Figure 5. Subdural hemorrhage over posterior interhemispheric fissure in Patient 5. (A) Coronal US demonstrating widening and echogenic lesions over the interhemispheric fissure (arrows) and tentorial area (arrowhead). (B) CT documenting subdural hemorrhage at the interhemispheric fissure (arrowhead). (C) CT sagittal reconstruction view displaying the extent of the falx hemorrhage (arrows).

displayed ventriculomegaly at 1 month of age, only 1 received ventriculoperitoneal shunt because of progressive hydrocephalus. Only 1 of our patients had biphasic ventricular dilatation as described by Tanaka et al. [17]. Tentorial subdural hemorrhage in neonates caused by molding of the head during vaginal delivery is frequently associated with subarachnoid hemorrhage. Subarachnoid hemorrhage, in contrast to the report by Tanaka et al. [17], does not always result in ventricular dilatation.

Any newborn with a molded head, who after a period of normality, develops signs of intracranial hypertension should raise the suspicion of tentorial injury with possible posterior fossa hemorrhage. US and CT are capable of providing early diagnosis of tentorial subdural hemorrhage. When clinical signs are stable and neither deterioration in neurologic function nor persistently increased intracranial pressure exists, supportive treatment with frequent neurologic and cranial US examinations, instead of immediate surgical intervention, is the proper course.

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