Compression of Superior Sagittal Sinus by Neonatal Calvarial Molding[1]

Thomas H. Newton, M.D., and Charles A. Gooding, M.D.

Compression of the superior sagittal sinus may result from overlapping of the parietal and occipital bones in the newborn infant. Such compression has been documented angiographically and the resultant decreased blood flow confirmed with a Doppler ultrasound probe. This compression may increase intracerebral venous pressures and thereby contribute to the high incidence of intracerebral hemorrhage in premature infants with respiratory distress syndrome.

INDEX TERMS: Brain, hemorrhage • Cerebral Blood Vessels • Infants, Newborn • Infants, Premature • Respiratory Distress Syndrome • Sinus, superior sagittal • Skull, pressure in

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OVERLAPPING of the parietal and occipital bones at the lambdoid suture is common in the newborn skull. Although previously considered to be benign, this molding may have serious consequences. Parietal-occipital overlap may compress the superior sagittal sinus (SSS) and slow cerebral circulation. Such compression may increase cerebral venous pressure and precipitate intracerebral hemorrhage, a common complication in neonatal respiratory distress syndrome.

This report examines the incidence of parietal-occipital overlap and its consequent effects on the superior sagittal sinus.

MATERIALS AND METHODS

Lateral radiographs of the skull in 122 infants, ranging in age from birth to 21 months, were obtained in two positions. The first exposure used a horizontal beam while the child lay supine with the head in a brow-up position. The head of the infant was then turned to the side and a second exposure was obtained with a vertical beam. The overlap of the parietal and occipital bones was measured in each of these two positions. The skull films analyzed were non-selected consecutive examinations obtained for a variety of clinical indications. Infants with enlarging head circumference were excluded.

The effect of parietal-occipital overlapping in one infant was shown by carotid arteriography and by venography of the sagittal sinus. Parietal-occipital overlap and its effect on the superior sagittal sinus were also studied by venography in 6 infant cadavers.

Changes in heart rate and blood flow in the superior

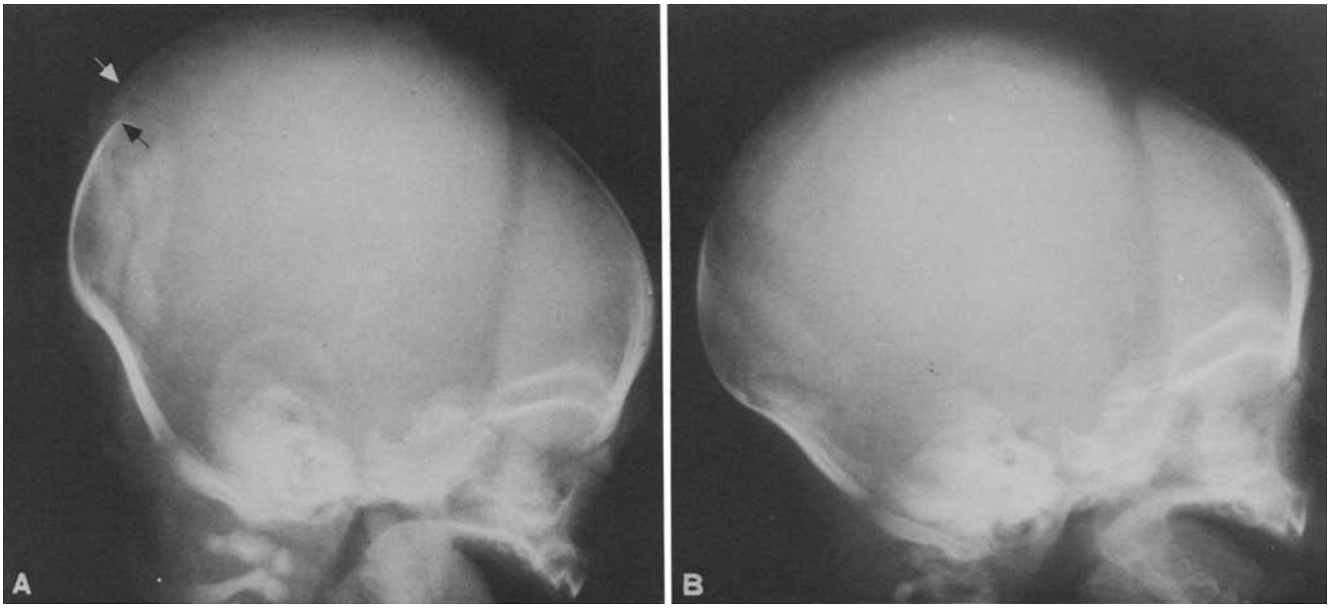

Fig. 1. Lateral radiographs of skull of newborn infant. A. Brow-up position with horizontal beam. The parietal bone overlaps the occipital bone (arrows).
B. Head turned to side with vertical beam. The overlap at the lambda has disappeared.

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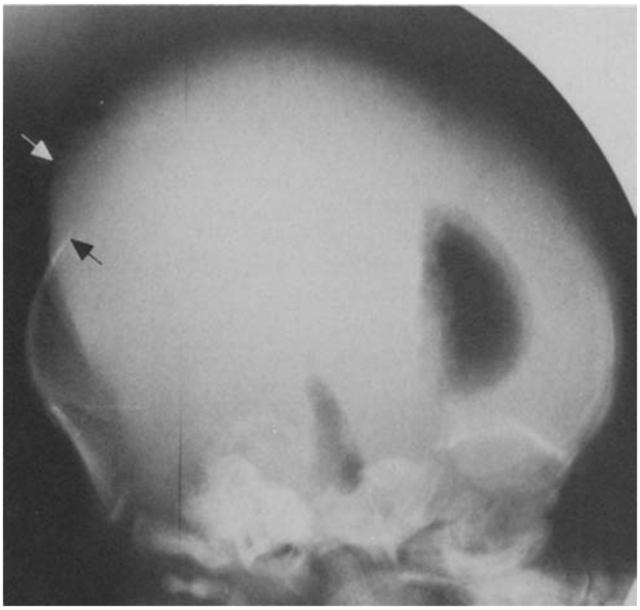


Fig. 2. Ventriculogram, brow-up lateral view. Following removal of ventricular fluid, parietal-occipital overlap of 10 mm is seen (arrows). Prior to removal of ventricular fluid, the overlap measured only 3 mm.

sagittal sinus associated with various degrees of anteroposterior compression of the skull were documented by electrocardiography and Doppler ultrasound in normal newborn infants.

The pressure in the SSS to varying degrees of obstruction was measured in six dogs. Under general anesthesia, two mid-sagittal burr holes were drilled, one over the bregma and one just anterior to the torcula. The SSS was cannulated through the anterior burr hole, and the cannula connected to a pressure transducer. Varying pressures were applied to the SSS through the posterior burr hole and continuously monitored on a polygraph recorder.

RESULTS

Twenty-five of the 122 patients analyzed demonstrated overlap of the parietal and occipital bones (20%). In these 25 children, overlap was demonstrated in the brow-up position only in 17 and in both positions in 8 (Table I). A variable degree of parietal-occipital overlap was demonstrated in most newborns when radiographs of the head were obtained in the brow-up position (Table II) (Fig. 1, A). This overlap promptly disappeared in most instances when the child's head was rotated to the side (Fig. 1, B).

In the first week of life, parietal-occipital overlapping was noted in 9 of 13 infants (69%); the degree of overlap ranged from 1 to 6 mm. In 4 of these 9 patients, overlapping was noted only in the brow-up position. Between the ages of one week and four weeks, overlapping was noted in 9 of 24 infants (37%) but was present only in the brow-up position in 8 of the 9 patients. The incidence of overlapping gradually decreased in the

Table I: Incidence of Overlap in 122 Patients

Age	Total Cases	Only in Brow-up Position	Both Positions	Per Cent
0–1 wk.	13	4	5	69
1–4 wk.	24	8	1	37
1–3 mo.	26	4	2	23
3–6 mo.	16	1	0	6
6–21 mo.	43	0	0	
Total	122	17	8	

Table II: Degree of Overlap of Parietal and Occipital Bones

	1–2 mm	3–4 mm	5–6 mm
0–1 wk.	3	5	1
1–4 wk.	6	1	2
1–3 mo.	4	2	0
3–5 mo.	1	0	0
Total	14	8	3

42 infants between one and six months of age and was not observed in 43 infants older than six months.

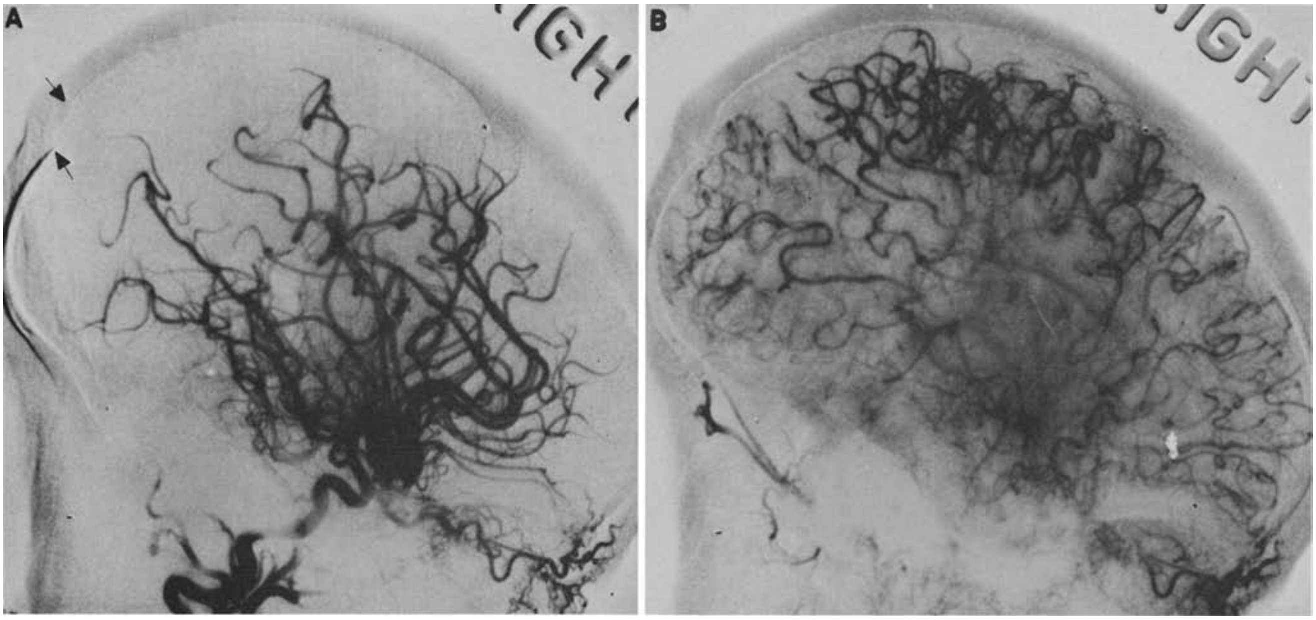
Parietal-occipital overlap was accentuated when the back of the head rested on a firm surface or when a compression band was applied. In one infant with communicating hydrocephalus, a marked increase in the overlap (3–10 mm) was observed after drainage of the ventricles (Fig. 2).

Carotid angiography in an 8-day-old infant, with moderate parietal-occipital overlapping, demonstrated extremely slow cerebral circulation (Figs. 3 and 4). The superior sagittal sinus did not fill and the veins drained toward the deep cerebral venous system. Direct injection into the superior sagittal sinus confirmed its patency and showed marked compression of the sinus at the point of parietal-occipital overlap (Fig. 5).

Superior sagittal sinograms in the 6 cadavers showed the degree of compression of the superior sagittal sinus to be directly related to the amount of anteroposterior compression applied to the head. With forceful pressure, parietal-occipital overlap was produced to a severe degree; this significantly compressed the superior sagittal sinus in all infants (Fig. 6).

Anteroposterior compression of the skulls of 6 normal infants decreased the blood flow in the sagittal sinus and reduced the heart rate, as measured by a Doppler ultrasound probe placed over the anterior fontanelle (Fig. 7). Bradycardia was confirmed by electrocardiogram (Fig. 8).

Intermittent pressure applied through the posterior burr hole to the SSS in dogs caused an abrupt rise in its pressure to a level two to three times normal baseline (Fig. 9). When obstruction was released, the SSS pressure returned to normal. The degree of SSS pressure was directly related to the degree of obstruction. No changes in heart rate were observed. We are currently studying the effects of chronic obstruction of the SSS with continuous pressure monitoring in dogs.



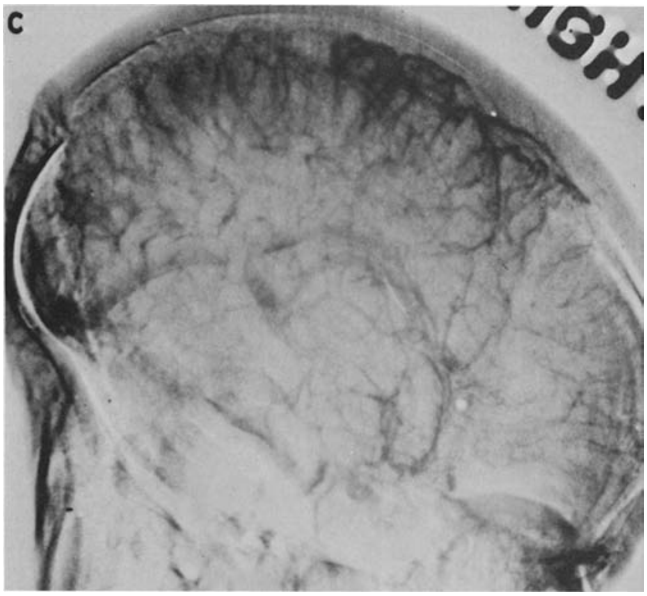


Fig. 3. Effect of parietal-occipital overlap on cerebral circulation: right common carotid arteriogram, lateral projection, with infant in brow-up position. A. Early arterial phase (1.5 seconds). Note overlapping at the lambda (arrows).

B. Late arterial phase (4.0 seconds). The cerebral arterial circulation is slowed markedly. The cerebral arteries are still filled with much contrast medium but the external carotid branches have almost emptied.

C. Venous phase (8.0 seconds). The superior sagittal sinus is not visible and the blood flows into the deep cerebral venous system (Courtesy of Dr. J. Gletne, Modesto, Calif.).

DISCUSSION

During the passage of an infant through the birth canal, a molding of the head with overlap of the parietal and occipital bones frequently occurs (1, 2). This overlap is a well-known phenomenon, varying in severity, and usually disappears by the third day of life. A few important aspects of this phenomenon have not been emphasized previously. Parietal-occipital overlap is most pronounced in the immediate neonatal period and is probably most severe in premature infants with wide sutures. Overlap may be produced after disappearance of initial molding when an infant is merely placed on its back. The overlap is accentuated when the supine position of the infant is prolonged, when the head is immobilized by a compression band, or when dilated ventricles are drained. Such overlap may compress the superior sagittal sinus sufficiently to impede normal cerebral circulation. The circulatory changes demonstrated angiographically were compression of the superior sagittal sinus, prolongation of cerebral circulation, and diversion of venous drainage into the deep venous system.

The consequences of this circulatory disturbance are probably most important in premature infants lying supine for a prolonged time. In such a position, the weight of the head tends to be supported by the occipital bone, with resultant parieto-occipital discontinuity at the lambdoid suture. A large group of patients maintained in this position for prolonged times are premature infants with neonatal pulmonary disease. In these infants, oxygen is often delivered by means of a face mask held manually or by a circumferential head band. These maneuvers may accentuate the degree of parietal-occipital overlap and result in SSS compression.

Intracerebral hemorrhage is one of the major causes of death in premature infants (3, 4, 6, 10). The inci-

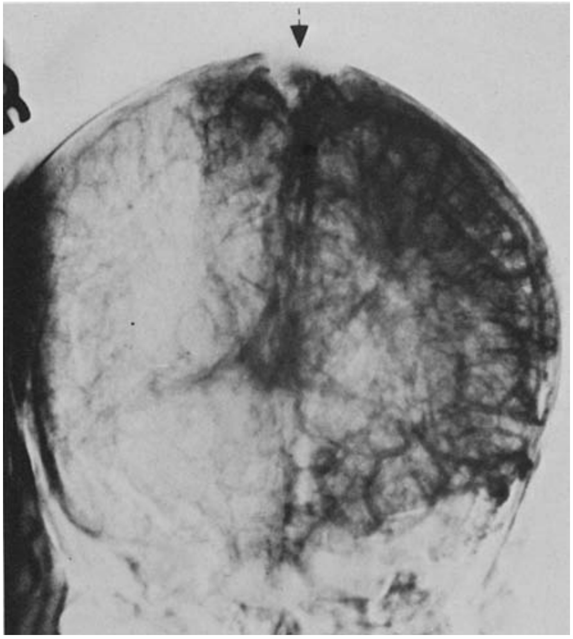


Fig. 4. Effect of parietal-occipital overlap on cerebral circulation. Left carotid arteriogram, frontal projection, with infant in brow-up position (arterial and capillary phases not shown). Venous phase (8.0 seconds). The cerebral circulation is markedly slowed and the superior sagittal sinus is not opacified (arrow). (Courtesy of Dr. J. Gletne, Modesto, Calif.).

Fig. 5. Superior sagittal sinus (SSS) venogram, lateral projection. The superior sagittal sinus is markedly compressed at the site of the parietal-occipital overlap (arrow).

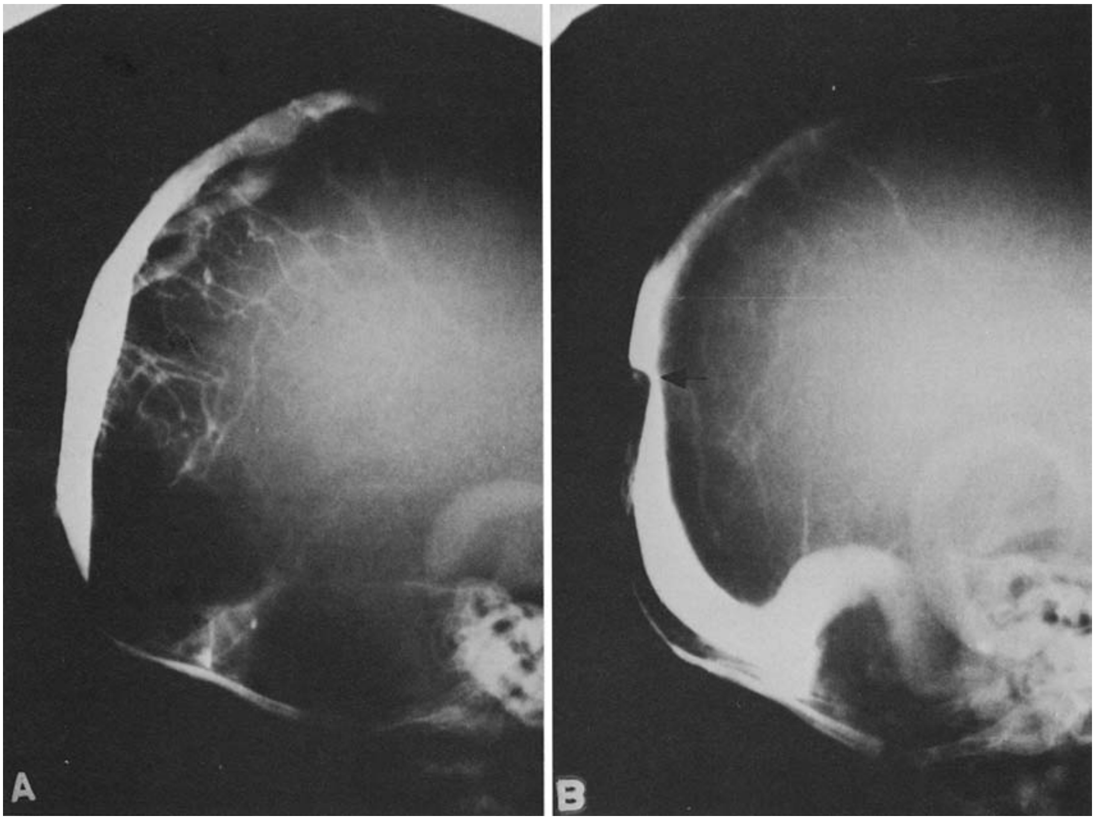


Fig. 6. Superior sagittal sinus venogram in infant cadaver, lateral projection. A. The superior sagittal sinus is fully patent when the head is supported without pressure on the occiput.

B. Compression of the superior sagittal sinus at the site of parietal-occipital overlap (arrow) occurs when moderate anteroposterior pressure is exerted on the head.

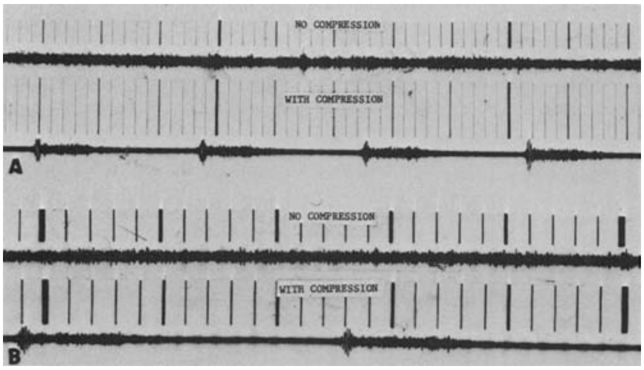


Fig. 7. Doppler ultrasound tracing of superior sagittal sinus flow measured at the anterior fontanelle. With anteroposterior pressure exerted on the forehead, a marked reduction in blood flow is noted.
A. Slight compression.
B. Marked compression.

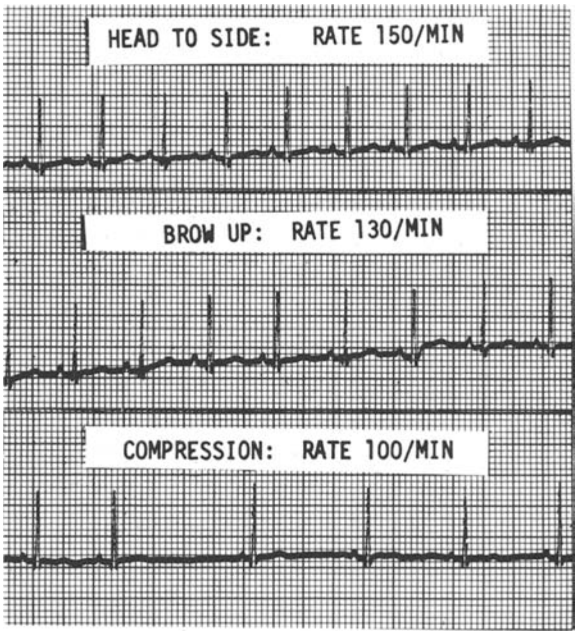


Fig. 8. Effect of head position in a normal newborn infant on heart rate as shown by electrocardiogram. Anteroposterior compression of the head in the brow-up position produces marked bradycardia.

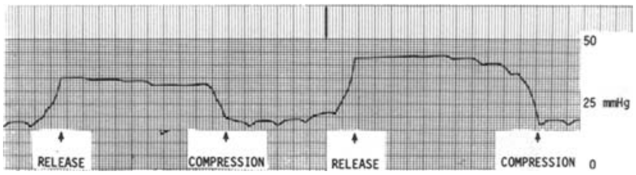


Fig. 9. Changes in pressure in the superior sagittal sinus of the dog caused by intermittent obstruction of the sinus posteriorly.

dence of this complication is particularly high in infants with idiopathic respiratory distress syndrome. Controversy exists regarding the cause of such hemorrhage (7, 9, 12) but the belief that deep cerebral hemorrhage is not of traumatic or arterial origin, but rather the result of venous infarction is now generally accepted (11). Premature infants are especially vulnerable to this catastrophe because their thin-walled, fragile cerebral veins, which lack supportive connective tissue, are susceptible to hypoxic injury (6, 9, 11, 12, 14).

We believe that compression of the superior sagittal sinus produced by overlapped parietal and occipital bones in these patients may increase the venous pressure in this sinus. In addition, it may cause venous stasis, with resultant subependymal venous infarction. This sequence of events may either lead to intraventricular hemorrhage and death, or result in mental retardation or cerebral palsy (5, 8, 11). Superior sagittal sinus compression may be minimized if the child is turned to lie on its side, or is maintained in the supine position with its head turned to the side. Excessive rotation of the head however, may compress the ipsilateral internal jugular vein and should be avoided (13).

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Department of Radiology
University of California
San Francisco, Calif. 94143

REFERENCES

1. Caffey J: Pediatric X-Ray Diagnosis. Chicago, Year Book Medical Pub, 1972, p 21
2. Dorst J: Changes of the skull during childhood. [In] Newton TH, Potts DG, ed: Radiology of the Skull and Brain. St. Louis, C. V. Mosby, 1971, p 118
3. Fedrick J, Butler NR: Certain causes of neonatal death. II. Intraventricular haemorrhage. Biol Neonate **15:**257–290, 1970
4. Friede RL: Residual lesions of infantile cerebral phlebothrombosis. Acta Neuropathol (Berlin) **22:**319–332, 1972
5. Haller ES, Nesbitt REL Jr, Anderson GW: Clinical and pathologic concepts of gross intracranial hemorrhage in perinatal mortality. Obstet Gynecol Surv **11:**179–204, Apr 1956
6. Harcke HT Jr, Naeye RL, Storch A, et al: Perinatal cerebral intraventricular hemorrhage. J Pediat **80:**37–42, Jan 1972
7. Hollard: Cited by Towbin (10)
8. Larroche JC: Hémorragies cérébrales intra-ventriculaires chez le prématuré. I. Anatomie et physiopathologie. Biol Neonate **7:**26–56, 1964
9. Simmons MA, Adcock EW III, Bard H, et al: Hypernatremia and intracranial hemorrhage in neonates. New Engl J Med **291:**6–10, 4 Jul 1974
10. Towbin A: Cerebral intraventricular hemorrhage and subependymal matrix infarction in the fetus and premature newborn. Am J Pathol **52:**121–139, 1968
11. Towbin A: Central nervous system damage in the human fetus and newborn infant. Mechanical and hypoxic injury incurred in the fetal-neonatal period. Am J Dis Child **119:**529–542, Jun 1970
12. Volpe J: Editorial: Neonatal intracranial hemorrhage: Iatrogenic etiology? New Engl J Med **291:**43–45, 4 Jul 1974
13. Watson GH: Effect of head rotation on jugular vein blood flow. Arch Dis Child **49:**237–239, Mar 1974
14. Yakolev PI, Rosales RK: Distribution of terminal hemorrhages in the brain wall in the stillborn, premature and nonviable neonates. [In] Angle CR, Bering EA Jr, ed: Physical Trauma as an Etiological Agent in Mental Retardation. Washington, D.C., U.S. Government Printing Office, 1970, pp 67–78