Changes in Superior Sagittal Sinus Blood Velocities Due to Postural Alterations and Pressure on the Head of the Newborn Infant

Frances Cowan, MRCP, DCH, and Marianne Thoresen, PhD, MD

From the Department of Physiology, University of Oslo, and Department of Neonatal Paediatics, Ullevål Hospital, Oslo

ABSTRACT. A pulsed Doppler bidirectional ultrasound system has been used to measure alterations in the blood velocities in the superior sagittal sinus of the healthy term newborn infant in response to unilateral and bilateral jugular venous occlusion. These maneuvers were performed with the baby lying in different positions: supine, prone, and on the side (both left and right), the neck flexed or extended, and with the head in the midline or turned 90 degrees to the side (both left and right). Transfontanel pressure was also measured in these positions during occlusions. Results show that turning the head effectively occludes the jugular vein on the side to which the head is turned and that occluding the other jugular vein does not force blood through this functional obstruction. The effect of different forms of external pressure to the head on the superior sagittal sinus velocities was also examined. Alterations in velocities were frequently profound although they varied considerably from baby to baby. This work shows how readily large fluctuations in cranial venous velocities and pressures can occur in the course of normal handling of babies. *Pediatrics* 1985;75:1038–1047; *cerebral venous flow, Doppler ultrasound, neonate, posture, transfontanel pressure.*

The superior sagittal sinus blood velocities of the newborn infant are easily and considerably affected by manual occlusion of the jugular veins[1] and by intermittent positive pressure ventilation.[2] The effect on the velocities is often such that they are reduced to zero within one to three hearbeats from the onset of the jugular occlusion or the intermittent positive pressure ventilation despite the ability of the venous system to dilate and the neonatal skull to expand.[3,4] Rotation of the head can completely stop blood flow in the ipsilateral jugular vein, and occlusion of the contralateral jugular vein does not force blood through the obstruction.[5] Fontanel pressure measurements are higher when babies have their heads turned 90 degrees to either side as compared with being in the midline (zero degrees).[6,7] These findings support work in adults on the effect of head position and jugular venous occlusion on intracranial pressure and jugular venous blood flow.[8–12]

Invasive measurements show that superior sagittal sinus blood pressure is increased in infants being treated in a Gregory box, most likely due to obstruction to the jugular veins by the cuff.[13] The weight of the head when supine[14] and bands placed around the head[15] can force the occipital bone into the lumen of the superior sagittal sinus obstructing blood flow and increasing the incidence of cerebellar hemorrhage. Removal of such bands reduces fontanel pressure.[16]

Doppler ultrasound provides a safe, noninvasive way to measure the blood velocities in arteries and veins, and the neonatal fontanel allows access to the intracranial vasculature.[1,17] In this study,[18] we examined whether changes in head position and body posture alter the effect that unilateral and bilateral jugular venous occlusion have on the blood velocities in the superior sagittal sinus. We have also examined the effect of gentle head compression on these velocities and have also used a fontanometer[19] to measure fontanel pressure during all these same maneuvers.

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Reprint requests to (F.C.) Department of Physiology, University of Oslo, Karl Johans Gt47, Oslo 1, Norway.

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METHODS

The ultrasound recordings were obtained using the pulsed, bidirectional Doppler ultrasound velocitymeter UNIDOP.[20] A 6-MHz transducer, of a size large enough to cover the whole cross section of the vessel to be examined, was used. The transducer was hand-held over the vessel at as constant an angle as possible throughout any one set of registrations. Recordings were stored on tape and later analyzed by a computer which is programmed to calculate the velocity spectra and the time average of the mean of all the velocities across the entire cross section of the vessel, for each successive heartbeat.[21] One set of registrations would involve at least one minute of consecutive recording and rarely less than 120 heartbeats. Provided that the angle at which the vessel is insonicated remains constant, any changes in velocity should be proportional to changes in flow if the vessel diameter does not alter. In this study, all ultrasound measurements were made on the superior sagittal sinus, and the walls of this vessel are relatively fixed. Frequently, the velocities that we record alter and reach zero (this must indicate zero flow), but where the changes are not of such great magnitude, decreases in velocities will slightly overestimate decreases in flow and conversely increases in velocities will slightly overestimate increases in flow due to the ability of the superior sagittal sinus to alter in cross section to some degree.

The fontanometer used in our study was built from the design of Whitelaw and Wright[19] It is 1.3 cm in diameter and weights 1 g. It was attached to the unshaven fontanel with tape or adhesive rings but not glue, and it was held in place with a hat made from Fixonet, so that any pressure would be equally distributed over the whole cranium. It was connected to a Hewlett-Packard 78204B transducer and paper readout. Alterations in fontanel pressure recorded with this device will be, if not an accurate reflection of intracranial pressure, an underestimation of it, because of the problems of fixation to the scalp and the possibility that the whole device can move slightly up as the fontanel fills out. It should not overestimate pressure changes and it has been shown to correlate quite well with direct intracranial pressure measurements. For the purposes of this study, we were only interested in relative changes and not absolute values of intracranial pressure. It was obviously impossible to take simultaneous recordings from the Doppler velocitymeter and the fontanometer, because the size of the fontanel does not allow this, so the measurements were done sequentially and not always in the same order.

A total of 18 babies were studied: nine male and nine female. Their mean age at the time of recording was 6.4 days (range 3 to 19 days); their mean gestational age at birth was 39.9 weeks (range 38.5 to 41.8 weeks); and their mean weight was 3,683 g (range 3,000 to 4,655 g). All were healthy at the time of examination; they were lying horizontally throughout the measurements. Most recordings were made while the babies were in quiet sleep because at this time there were fewer movements and less effect from respiration on the venous velocities. The babies were fed at least 20 minutes before recordings were made. The study was performed in the Neonatal Department, Ullevål Hospital, Oslo. Ethical committee approval and informed parental consent were obtained. The parents were encouraged to be present should they so wish.

Measurements of the blood velocities in the superior sagittal sinus were made before, during, and after bilateral, right, and left jugular venous occlusions performed sequentially with the baby lying in eight different positions (Table 1). The probe was placed over the anterior fontanel and hence the superior sagittal sinus at an angle of approximately 45 degrees and moved slightly until the optimal venous signal was obtained. This was done by altering the depth focus of the ultrasound signal and using both the auditory signal and the on-line visual display of the velocity spectra. The probe was then held in this position, and the depth setting remained unchanged throughout any one set of measurements. Ideally, we would have liked to hold the probe without moving for all the recordings for one baby, but as we had to change the position of the child, this was impossible to achieve. However, it is unlikely that the angle at which the optimal signal is obtained, alters much because of the fixed depth setting. The baby was either supine with the occipital bone resting on the bed, or the baby was lying on its side with the parietal bone dependent. Other-

TABLE 1. Eight Different Positions in Which Babies Were Measured

		No. of Babies
I	Supine, head in midline and neck slightly flexed	18
II	Supine, head in midline and neck slightly extended	14
III	Supine and head turned 90 degrees to right	18
IV	Supine and head turned 90 degrees to left	18
V	Prone and head turned 90 degrees to right	12
VI	Prone and head turned 90 degrees to left	12
VII	Lying on right side with head in midline and neck slightly extended	12
VIII	Lying on left side with head in midline and neck slightly extended	12

wise the occlusions were performed in the manner described by Cross et al.[3] Not all babies were measured on in all eight positions (see Table 3) because we had originally decided to measure only in positions I, III, and IV. After obtaining our preliminary results in six babies, we extended the study to include the eight positions.

In some of the babies, we measured the superior sagittal sinus velocities during the maneuvers listed in Table 2. No occlusion of the jugular veins was involved in this part of the study, and the pressures applied to the head were of the same order as one would use to hold a baby still for a scalp vein puncture or a ventricular tap.

In five of the babies, all the jugular venous occlusions in the eight different positions were repeated with the fontanometer in place over the fontanel.

RESULTS

Supine Positions (I, III, and IV)

In Table 3 is shown the percentage decrease in superior sagittal sinus blood velocities occurring as a result of bilateral, right, and left jugular venous in the occlusions first 13 babies. The main results are found in the upper half of Table 3, ie, in a comparison between positions I, III, and IV. The changes in blood velocities during the occlusions are presented as the percentage decrease from those obtained before and after the occlusions. It can be seen that in most babies, bilateral jugular venous occlusion with the head in the midline position produces a 100% reduction in superior sagittal sinus velocities while right and left jugular venous occlusion produces sometimes symmetrical and sometimes asymmetrical effects.[1]

However, the alterations in superior sagittal sinus velocities are quite different when obtained with the head in the midline position than when it is turned 90 degrees to the side. Of 26 unilateral jugular venous occlusions (13 left and 13 right) in the midline position, only three had no effect on the superior sagittal sinus velocities, whereas when the head was turned to either side, 25 ipsilateral occlusions had no effect—baby 13 was the exception. In addition, whereas unilateral jugular venous occlusion had produced a 100% reduction in superior sagittal sinus velocities in only 4/26 occlusions before turning the head, it produced a 100% reduction in 20/26 occlusions after doing so when the contralateral jugular vein was occluded.

Bilateral jugular venous occlusion nearly always produced the same effect on the superior sagittal sinus velocities regardless of the position of the

TABLE 2. Different Methods Used to Exert External Pressure on Head

Maneuvers	No. of Babies
Lateral compression by pressing on parietal and temporal bones	11
Anteroposterior head compression by pressure on frontal and occipital bones	12
Pressure on posterior fontanel	7
Pressure on occipital bone	3

TABLE 3. Percentage Decrease in Superior Sagittal Sinus Blood Velocities Resulting from Right, Left, or Bilateral Jugular Venous Occlusion in 13 Babies*

	1	2	3	4	5	6	7	8	9	10	11	12	13
Position I													
Bilateral	100	100	100	100	100	100	100	75	100	100	85	75	75
Right	100	100	100	80	0	50	...	0	50	50	35	45	10
Left	10	40	0	80	100	50	...	75	50	20	55	55	40
Position III													
Bilateral	75	100	100	100	100	100	100	100	100	100	50	40	65
Right	0	0	0	0	0	0	0	0	0	0	0	0	0
Left	90	100	100	100	100	100	100	100	100	100	90	45	65
Position IV													
Bilateral	100	100	100	100	100	100	100	90	100	100	70	50	0
Right	100	100	100	100	100	100	100	100	100	100	0	50	0
Left	0	0	0	0	0	0	0	0	0	0	0	0	30
Position VII													
Bilateral	...	...	...	...	...	70	...	50	100	100	20	45	50
Right	...	...	...	...	...	40	...	40	50	30	30	0	35
Left	...	...	...	...	...	40	...	50	10	0	20	50	50
Position VIII													
Bilateral	...	...	...	...	...	60	...	50	100	100	50	60	55
Right	...	...	...	...	...	40	...	50	20	70	35	0	30
Left	...	...	...	...	...	40	...	60	50	30	30	50	30

* Results when baby lies supine in positions I (head in the midline and neck flexed), III (head turned 90 degrees to the right), and IV (head turned 90 degrees to the left), and results with baby in lateral positions with the head in the midline (position VII, right) and (position VIII, left); ... indicates that the baby was not tested in this position.

head. The few exceptions were all babies in whom bilateral jugular venous occlusion had not produced complete cessation of superior sagittal sinus velocities in position I.

The velocity recordings from the superior sagittal sinus in baby 9 when lying in positions I, II, III, and IV are shown in Fig. 1. This baby has complete stoppage of superior sagittal sinus velocities in response to bilateral jugular venous occlusion in all four positions. When the head is in the midline and the neck flexed (position I), right and left jugular venous occlusion both result in an approximately 50% reduction in velocities, ie, a symmetrical effect. This effect from unilateral jugular venous occlusion disappears when the neck is extended (position II) (see below). When the head is turned to the right (position III) or to the left (position IV), no alterations in the velocities are seen as a result of ipsilateral occlusions, and contralateral occlusions now bring about a 100% decrease in velocities, ie, the same as does bilateral jugular venous occlusion.

Fontanel Pressure Measurements

The results from the measurement of fontanel pressure and the superior sagittal sinus velocities during jugular occlusion in babies 14 to 18 in positions I, III, and IV are shown in Table 4. The increase in fontanel pressure is greatest in the same situation that produces the largest decrease in superior sagittal sinus velocities; the correlation coefficient between the two variables is .91 for the 45 pairs of results presented in Table 4. When the head is turned (positions III and IV), there is little or no alteration in fontanel pressure during occlusion of the ipsilateral vein, but a significant alteration during contralateral occlusion.

We have not presented all the results from the fontanometer recordings in all the other positions as they follow, in nearly all instances, the same pattern as outlined above and given in Table 4.

Prone Positions (V and VI)

The results obtained with the babies lying prone with their heads necessarily turned to left or right were essentially the same as those found when the babies were supine with the head at 90 degrees, although in a few instances they were less marked.

Lateral Positions (VII and VIII)

In the lower half of Table 3 is shown what occurs when the baby lies on its side with the head in the midline, and the weight of the head is supported by the parietal and temporal bones. The effect of jugular occlusion is similar though less severe than is found in position I and does not show the marked difference between right and left jugular venous occlusion that occurs when the head is rotated to the side. For example, in baby 6, when the head is rotated to the right (position III), right jugular venous occlusion has no effect where left jugular venous occlusion reduces the superior sagittal sinus velocities by 100% and visa versa when the head is to the left (position IV). However, in the lateral positions (VII and VIII), the effects of unilateral occlusions are similar and do not exceed a 40% decrease in velocities.

Neck Extension (Position II)

When extending the neck with the head in the midline and comparing the results with those from position I (neck flexed), we found that in half the babies the effect was the same, but in half the effect was less severe (see Fig 1). In no instance was the effect more marked. When comparing the lateral positions (VII VIII) with the extended neck position, the effect of bilateral jugular venous occlusion was the same in half the babies and less marked in the remainder, whereas the differences between unilateral jugular venous occlusion were marginal.

Velocity Differences Between Positions I and III or IV

Because of the difficulty of measuring accurately the angle between the probe and the vessel, we did not set out to attempt to compare the recorded velocities either between babies or within babies from one set of three measurements to another. However, a comparison of the superior sagittal sinus velocities recorded immediately before and after the head was first turned does show that all babies had a diminution of the velocities; the mean decrease in superior sagittal sinus velocities was 39.5% (n = 13, median 40%, range 11.1% to 57.1%). The value of 11.1% was by far the least reduction seen; all other values were between 28% and 57%. This phenomenon is demonstrated in Fig 1, in which velocities before and after occlusion are higher in positions I and II than in positions III and I. Velocities tended to return to preturning values by the time most experiments were finished, ie, usually about 3/4 hour after the head had first been turned.

External Pressure on Head

The four different maneuvers performed are listed in Table 2, and representative results are shown in Fig 2. There was considerable variation between the babies.

Lateral head compression affected the superior sagittal sinus velocities in all 11 babies in whom

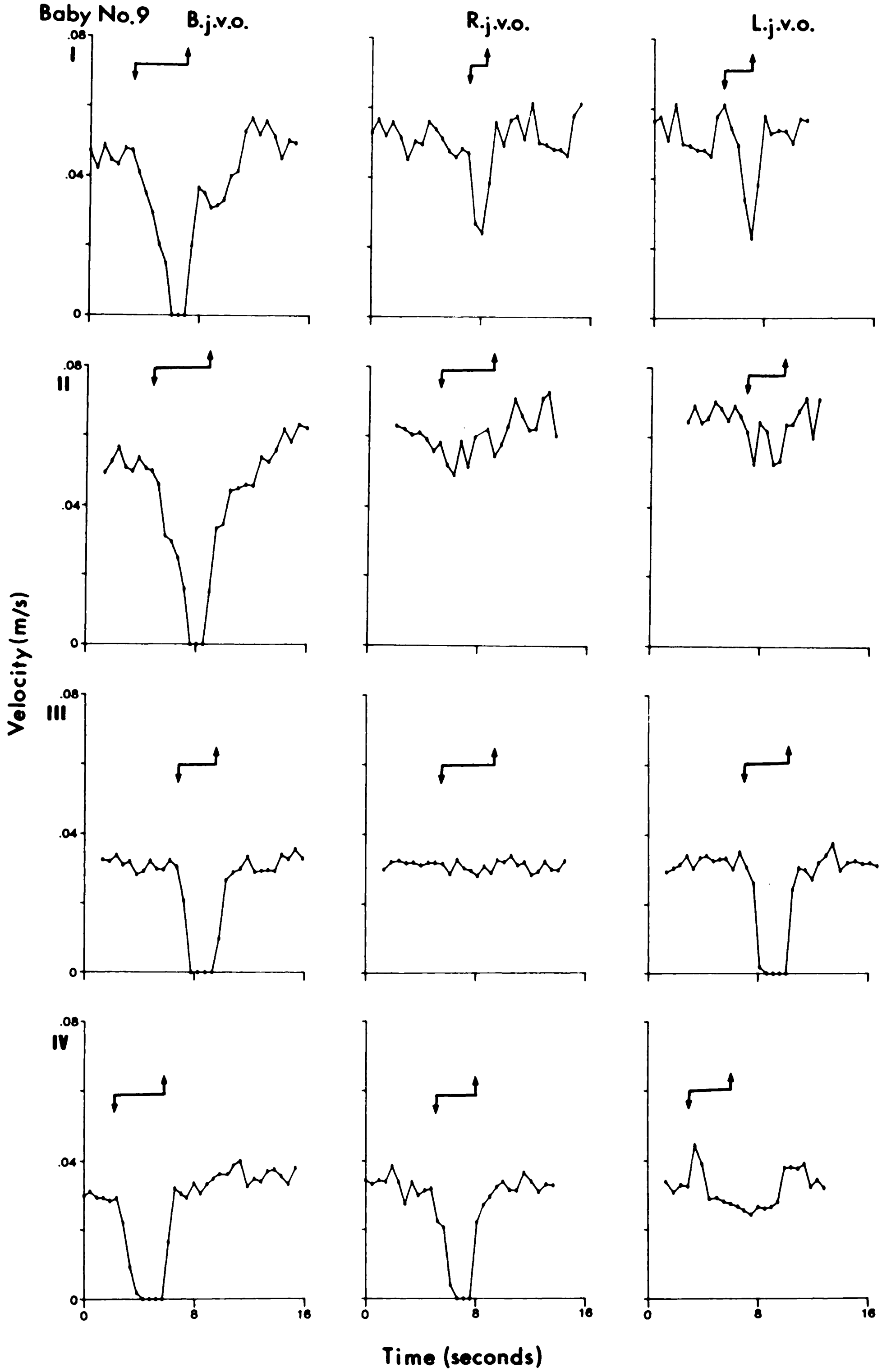

Fig 1. Set of ultrasound recordings from baby 9, showing effect of bilateral, right, and left jugular venous occlusion (B.j.v.o., R.j.v.o., and L.j.v.o.) on superior sagittal sinus blood velocities with baby lying in four different positions (I, II, III, and IV, see Table 1). Calculated results are shown in Table 3 (except for position II). Average mean velocity for each heartbeat is shown. Onset and offset of occlusion are marked with arrows. Arrow pointing down indicates onset of occlusion; arrow pointing up indicates offset of occlusion. Asymmetry in response to unilateral occlusions with head turned (lower two panels) is not seen with head in midline position (upper two panels). There are lower total resting velocities after rotation of the head.

TABLE 4. Percentage Decrease in Superior Sagittal Sinus Blood Velocities Resulting from Bilateral, Right, and Left Jugular Venous Occlusion and Alteration in Fontanel Pressure*

	Bilateral		Right		Left	
	Velocity	Fontanel Pressure (cm H_2O)	Velocity	Fontanel Pressure (cm H_2O)	Velocity	Fontanel Pressure (cm H_2O)
Position I						
Baby 14	70	3	20	1	30	1
Baby 15	90	5	10	1	10	1
Baby 16	100	6	85	4	20	1
Baby 17	100	5	0	0	40	2
Baby 18	90	5	50	3	30	1
Position III						
Baby 14	80	3	20	1	70	3
Baby 15	100	7	0	1	100	7
Baby 16	100	7	20	2	100	5
Baby 17	100	10	0	1	100	6
Baby 18	90	6	0	1	95	7
Position IV						
Baby 14	85	3	75	3	25	1
Baby 15	100	7	100	5	0	1
Baby 16	100	6	100	6	0	0
Baby 17	100	6	95	5	10	1
Baby 18	80	4	100	7	0	0

* Results for babies 14 to 18 are given for positions I, III, and V when they lie supine, head in the midline and neck flexed [I], supine with the head turned 90 degrees to the right [III], and supine with the head 90 degrees to the left [IV].

this was attempted. The pattern of results was usually to a greater or lesser degree as shown. In two babies, the velocities only decreased (to zero) before returning to base-line levels, and in two they only increased (one slightly and the other by 100%).

Anteroposterior compression produced an effect similar to that from lateral compression. Among 12 babies, six were as shown in Fig 2, three had only increases and three only decreases.

Pressure on the posterior fontanel always decreased superior sagittal sinus velocities (to zero in four babies) often followed by an increase above base-line levels after the pressure was released (not so in the example shown).

Occipital bone pressure in three infants diminished velocities in two and did not affect the third.

DISCUSSION

We have shown that turning the head 90 degrees to either left or right causes a functional obstruction of the jugular vein on the ipsilateral side. This was stated by Edwards[22] as early as 1931 and is in agreement with the findings of Watson[5] from observations made during cardiac catheterization studies in newborn infants and with the measurements made of the cross section of the jugular vein in adults before and after turning the head.[8] We found that this obstruction occurred whether the baby was lying supine or prone provided the head was turned, although in a few instances the effects were less marked in the prone position. This was probably due to the practical difficulty of manually occluding the jugular vein nearest the bed without disturbing the infant, occasionally the head would be less acutely turned in this position. The changes in fontanel pressure support these results as do the decreases in superior sagittal sinus velocities that occur when the head is first turned.

The results also confirm our previous studies,[1] namely that bilateral jugular venous occlusion and often unilateral jugular venous occlusion cause a rapid decline in the blood velocities in the superior sagittal sinus. We have now shown that they also cause an increase in fontanel pressure and hence intracranial pressure related to the degree of interference with cranial venous outflow. Our findings agree with those of Vert et al[13] who found that the superior sagittal sinus blood pressure was significantly increased in babies receiving continuous positive airway pressure (CPAP) via a Gregory box as compared with those having continuous positive airway pressure via a nasotracheal tube. The explanation for the increased pressure must be that the cuff of the Gregory box is, in fact, tight enough to occlude the jugular veins in the neck whereas the intrathoracic pressure generated in the intubated infants does not interfere with cranial venous drainage to the same degree.

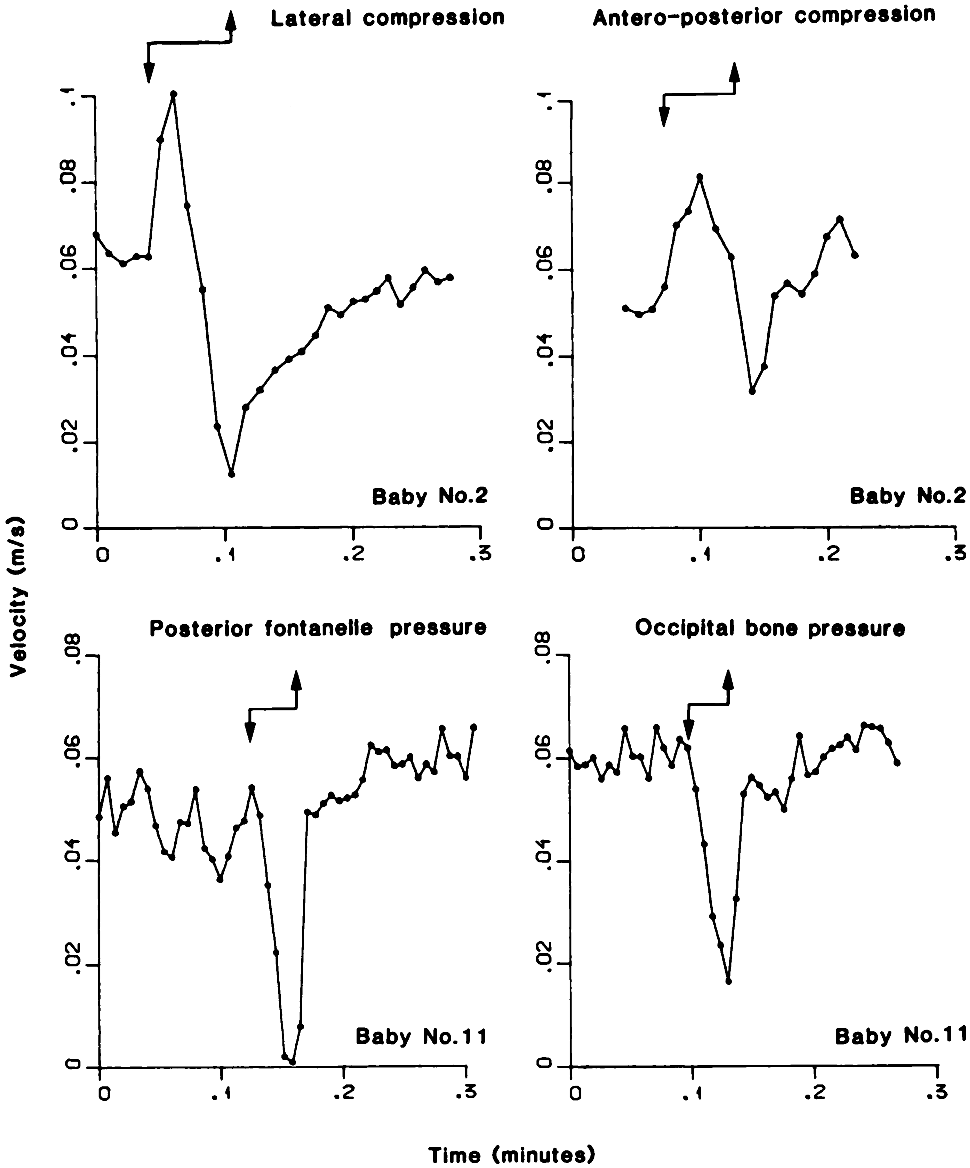

Fig 2. Effect of compressing the head in different ways (see Table 2) on velocities in superior sagittal sinus. Onset and offset of pressure are marked with arrows. Arrow pointing down indicates onset of occlusion; arrows pointing up indicates offset of occlusion. Recordings in upper panel are from baby 2 and in lower panel, from baby 11.

Extending the neck reduced the severity of the effects of jugular venous occlusion in most of the babies. When they were lying on their sides, the effects were less marked still and quite different from the asymmetrical results of turning the head. Alterations in the posture of the neck may facilitate the use of nonjugular venous drainage pathways. As shown in Fig 3, babies can open up vertebral veins when the jugular veins are obstructed. We have found that some babies can do this readily, ie, within two to three heartbeats of the jugular occlusion, others take longer, and some not at all. However, it is difficult to find these veins in the back of the neck, and a negative finding may just reflect this. In the adult, the vertebral venous plexus acts as a minor adjunct to the jugular venous drainage system when the subject is horizontal, but becomes the main drainage pathway for subjects in the upright position.[23] As all the babies we examined were horizontal and most babies spend their first few months in this position, it is unlikely that vertebral drainage plays a significant role in normal daily life[24,25] (see Fig 3 which shows an immediate return to zero velocities as soon as jugular occlusion ceased). Babies who can use nonjugular venous pathways all the time or are able to use them readily when major outflow tracts are obstructed may be those in whom bilateral jugular venous occlusion did not produce the same effect in all positions.

The small differences between the supine and

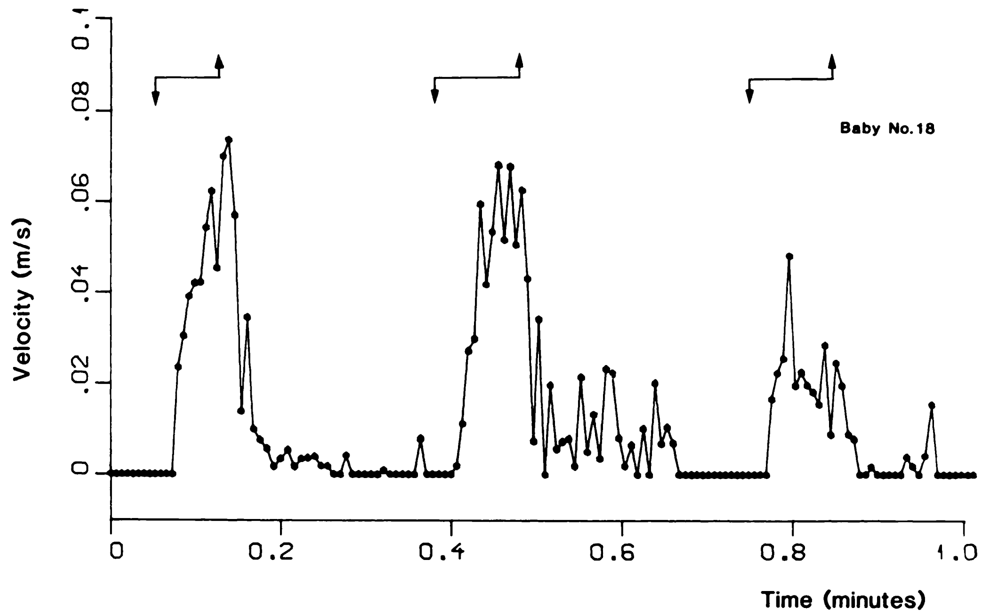

Fig 3. Ultrasound recordings from baby 18 taken from vertebral vein lying near vertebral artery at level of C-1 in back of neck during three successive occlusions of jugualr veins. Onset and offset of occlusion are marked with arrows. Arrow pointing down indicates onset of occlusion; arrow pointing up indicates offset of occlusion. Note that zero velocity has been raised up from the X axis for clarity.

lateral positions, in which the head is not turned, could be due to the fact that there is no pressure on the occipital bone when the baby lies in the latter position. In two of three babies, we found it easy to diminish the superior sagittal sinus velocities by gentle pressure on the occipital bone, although these were infants with wide sutures and who probably had skulls more compliant than the average. Nonetheless, the finding is interesting and agrees with the work of others.[14,15] The large fluctuations of external head pressure were surprising, large and although they varied considerably from baby to baby, the responses were consistent for any one baby and presumably related to the degree of skull compliance.

The Doppler ultrasound method used is capable of measuring velocity and not total flow. However, the fluctuations that we found were of such magnitude and contrast so dramatically with the steady velocities seen in the undisturbed child (variations of 5% to 8% between every heartbeat over a five-minute period) that we consider that they must reflect great alterations in flow. The measurements made in this study were all for short time periods, ie, one to two minutes and a whole set of registrations would not take longer than one hour. We can, therefore, make no valid comment on the long-term effects of such maneuvers on the cranial venous velocities.

We have assumed that both jugular veins are connected with each other, the superior sagittal sinus, and the straight sinus (which drains the deep cortical venous system) at the confluence of the sinuses or torcular herophili. This is the case in most humans,[26] although, occasionally the superior sagittal sinus connects only with one lateral sinus and the straight sinus only with the other. However, this is a rare anatomic occurrence, and in the majority it can be expected that during jugular venous occlusion, the deep and superficial systems will be similarly affected.

The superior sagittal sinus is associated with venous lakes or lacunae that lie on the surface of the brain and connect with it[27]; they may act as reservoirs. However, the superficial cortical veins most commonly drain directly into the superior sagittal sinus and not into the lakes. (It is generally stated that the fetus and newborn infant have poorly developed lacunae,[28,29] although from our own post-mortem injection studies of the cranial venous system in the newborn we have found some preterm and term infants with several large lacunae.) We have measurements on veins that lie alongside the superior sagittal sinus and drain into it, and these show the same variations in venous velocities that we find in the superior sagittal sinus itself.[30] Therefore, these draining cortical veins are not always protected from the fluctations seen in the major vessels.

SPECULATIONS AND RELEVANCE

Whether obstruction to cranial venous drainage and consequent alterations in intracranial pressure have a deleterious effect and a connection with the etiology of intracranial hemorrhage is unknown.

Among the factors thought to lead to the development of intracranial hemorrhage are pneumothorax,[31–33] intermittent positive pressure ventilation with high pressure and prolonged inspiratory times,[33] severe hyaline membrane disease[33,34] and high fluid input,[33,35] and possibly asphyxial heart failure[36]. All these clinical situations will be associated with interference with cranial venous drainage either due to raised intrathoracic pressure, large swings in intrathoracic pressure, or raised venous pressure from volume overload or right ventricular failure.[37] Experimentally, it has been shown in fetal lambs that intracranial hemorrhage occurs in association with increased venous pressure[38,39] and that intracranial hemorrhage in hypercapneic beagle puppies occurred most readily in those with increased arterial and venous pressures.[40]

Alterations in intracranial pressure as a result of venous occlusion must be dependent on the relationship between the alteration in intracranial blood volume and the ability of the skull to expand. Any measurement of intracranial pressure will underestimate the actual pressure increase in the sinuses. The cranial vasculature of the neonate is subject to variations in transmural pressure that would not occur if the bones of the skull were fused, and presumably the more compliant the skull and the less the increase in intracranial pressure, the larger is this effect.

All the measurements in this study were made on healthy term infants who had normal fontanel pressure and presumably normal intracranial pressure. In studies of intracranial pathology in adults in whom it has been possible to measure intracranial pressure directly during changes in head position and jugular venous occlusion and during routine nursing procedures, the increases in intracranial pressure have been shown to be far more severe if the resting intracranial pressure is already high.[9–12] It is likely that the same applies to infants and that those babies who already have an increased intracranial pressure are most at risk of severe increases associated with turning the head and jugular venous occlusion.

Our study demonstrates how easily alterations in cranial venous drainage can occur in normal life. Babies have lain, for time immemorial, in the positions in which we have measured them, without any apparent harm. Indeed, healthy babies obviously tolerate large fluctuations in venous velocities when they most effectively impede all venous drainage during crying. It is not, however, reasonable to assume that preterm and sick infants, especially in the first few days of life when they are most in danger of developing intracranial hemorrhage, can tolerate such fluctuations in the same way.

When nursing such sick infants, avoidance of sudden turning of the head, particularly through 180 degrees (ie, from 90 degrees to the left to 90 degrees to the right), and of lying supine with the head resting on the occipital bone may well be beneficial. It is easy to touch a baby's neck and obstruct the one functioning jugular vein when the baby is lying with its head turned at 90 degrees, and holding a baby firmly and still for the insertion of a scalp vein drip or lumbar puncture may well disrupt cranial venous outflow. Our results indicate that there is minimal interference with cranial venous drainage when the infant is in the left and right lateral positions and when the neck is slightly extended.

SUMMARY

Results of our study indicate that turning the head through 90 degrees effectively occludes the jugular vein on the side to which the head is turned and that manual occlusion of the other jugular vein does not force obstructed blood out through this functional obstruction. Alternative nonjugular venous pathways can be used, but these are not of sufficient capacity in the immediate short term, at least when the baby is in a horizontal position. Transfontanel pressure changes according to the severity of the interference with venous drainage. External pressure on the head of the degree used during investigative and treatment procedures, frequently causes profound effects on cranial venous velocities. The large fluctuations demonstrated in both velocities and pressure must represent a significant disruption to cranial venous drainage and may play a role in the etiology of intracranial hemorrhage in the preterm or term infant at risk.

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