Intraventricular Haemorrhage in the Preterm Infant: Diagnosis by Real-Time Ultrasound

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Summary

One bundled and seventy preterm infants were *scanned serially using real-time ultrasound to diagnose the presence of intraventriculai haemorrhage (IVH). Clearly present IVH occurred in 38 (23 %) of the 170 infants and in 24 (52%) of 46 infants with a birth-weight of 1500 g. or less. No infant of 35 or 36 weeks gestation developed IVH. Repeated scanning timed the development of IVH in 36 infants and in 28 (78%) ultrasonic evidence was present within 72 hours of birth. Autopsies were performed in 13 of the 14 infants who died. The overall agreement between definite ultrasound diagnosis and autopsy findings was 92%. It is concluded that real-time ultrasound is a valuable non-invasive and safe means for the diagnosis of IVH in the at-risk preterm infant.*

Despite advances in neonatal care resulting in the improvement in the survival of preterm infants[1], intraventricular haemorrhage (IVH) continues to be a major cause of mortality and morbidity[2]. Using both computerised tomography[3] and real-time ultrasound scanning[4,5] it has been shown that IVH occurs in a much larger proportion of preterm infants than was previously realised and that the traditional criteria used for the diagnosis of IVH are unreliable[6,7]. It is now apparent that IVH not only occurs in critically ill preterm infants, but may develop in those infants who are clinically thought to have no intracranial pathology. As IVH may be important in the development of the physical and mental handicap associated with preterm infants, accurate diagnosis of this condition is of direct relevance to the clinican. In the present paper we report the incidence and severity of IVH in a group of preterm infants using cranial ultrasonography.

Patients and Methods

During a 12 month period ending December 1982, 170 infants of 24-36 weeks gestation and with a birthweight of 610-2500 g. had ultrasound scanning of the brain. The population comprised 82% of preterm infants admitted to the neonatal intensive care unit during that period; the person (P.G.) who performed all the scans was unavailable to examine the remainder. Thus the babies were not a selected group of preterm infants, and included many who were completely asymptomatic. Twenty-two of the 170 infants (13%) were referred to the I.C.U. from other hospitals.

A Toshiba Sonolayer L SAL 20A real-time ultrasound scanner with a 5MHz linear array transducer was used throughout the study. The equipment is mobile and the infants, while in hospital, received the scans in the neonatal intensive care unit in their incubator or cot. Thus minimal disturbance occurred and a complete scan took less than five minutes. Abnormal scans were recorded using Polaroid black and white prints.

The babies were scanned in two planes with the transducer placed over the anterior fontanelle which acted as an acoustic window. Initially the transducer was orientated in the coronal plane and was rocked forwards and backwards with the anterior fontanelle as the fulcrum to image the cerebral structures. Special emphasis was placed on the section of the brain through the caudate nucleus where intraventricular haemorrhage is most likely to originate[8].

Figure 1 shows a coronal scan of a preterm infant of 29 weeks gestation at the level of the caudate nucleus. The lateral ventricles are clearly visualised on either side of the mid-line with a butterfly-wing configuration. Between the ventricles lies the hypoechoeic cavum of the septum pelluci-dum. The caudate nucleus is situated infero-lateral to the ventricles. On complection of the coronal scan the transducer was turned 90°, so that it was lying over the sagittal suture. It was then angled outwards from the midline to permit visualisation of each lateral ventricle in turn producing parasagittal scans.

Intraventricular haemorrhage was graded according to the criteria described by Thorburn et al.[19] which were very similar to those of Papile et al.[3] who used computerised tomography for the diagnosis of IVH; grade I, germinal layer haemorrhage and/or IVH occupying less than one half of one or both lateral ventricles; grade II, unilateral or bilateral IVH occupying more than one half of either lateral ventricle but without

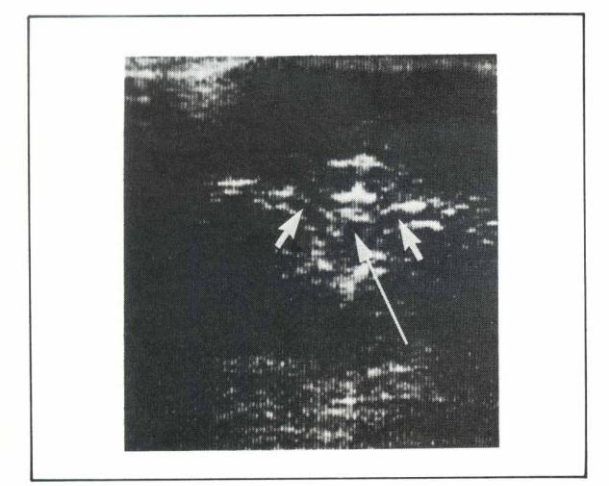


Fig. 1(a): Normal Coronal Section.

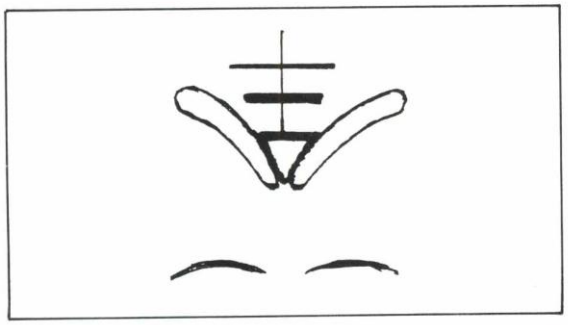


Fig. 1(b): Line drawing of coronal views illustrating those structures seen in (a). The lateral ventricles and cavum of the septum pellucidum are now depicted in white.

distension; grade III, IVH distending any part of a lateral ventricle, grade IV, IVH with extension into the parenchyma of the brain. Figure 2 shows examples of coronal scans with varying severity of IVH.

Results

The 170 infants had a total of 808 scans, each baby having between one and 29 scans. 101 infants (59%) were scanned within 24 hours of delivery and all had at least one scan between days 4 and 9 except when death occurred before that time. Clearly visualised IVH occurred in 38 of the infants (23%) but only 10 (6%) of the total had severe haemorrhage (grades III and IV). In three infants the diagnosis was uncertain as unclear transient echoes were present.

Table 1 demonstrates that the incidence of IVH decreased with advancing gestation and all infants less than 27 weeks gestation had evidence of IVH. No infant of 35 or 36 weeks gestation developed IVH. Analysis according to birth-weight (Table 2) showed an inverse relationship between the incidence of IVH and the birth-weight of the infants scanned. More than half (52%) of the infants with birthweight of < 1500 g. had IVH on ultrasound scan.

The timing of the onset of IVH to the nearest day was possible in 36 of the 38 infants as a result of seguential scanning. Sixteen (42%) occurred within 24 hours, 19 (50%) within 48 hours and 28

Table 1
Incidence of IVH by Gestational Age

Gestation (wk)	Infants	IVH
≤27	8	(100%)
27 — 28	11	6 (55%)
29 — 30	16	8 (50%)
31 — 32	41	13 (32%)
33 — 34	47	3 (6%)
35 — 36	47	0 (0%)
24— 36	170	38 (23%)
24 — 34	123	38(31%)

(78%) within 72 hours of birth. Only three infants had haemorrhage after the first week of life.

The short term outcome of the infants was related to the extent of haemorrhage (Table 3). Although there was no appreciable difference in mortality between the babies with a normal scan and those with a grade I or II IVH, survival was significantly worse for infants with grade III or IV haemorrhage ($X.^2$ = 13.3, P < 0.001).

Table 2
Incidence of IVH by Birthweight

Birthweight (g.)	Infants	IVH
< 1000	16	12 (75%)
1001—1500	30	12 (40%)
1501—2000	61	11 (18%)
2001—2500	63	3 (5%)
<1500	46	24 (52%)

The autopsy confirmed IVH in eight of the nine infants in whom there was evidence on ultrasound scanning. One neonate with unclear echoes on scanning was shown not have had an IVH. In the infants who had normal ultrasound scans, autopsy did not show any abnormality. Thus the overall agreement between definite ultrasound diagnosis and autopsy findings was 92%. No false negatives occurred.

Table 3
Mortality

	Infants	Died
No IVH	132	4 (3%)
IVH Grade I	16	2 (13%)
Grade II	11	1 (9%)
Grade III	7	4 (57%)
Grade IV	4	3 (75%)

Discussion

Intraventricular haemorrhage has been shown to occur in approximately 50%-70% of preterm infants at autopsy.[10,11] In 1977, Voipe concluded that only 15-20% of infants with IVH survive the initial insult[12] though he pointed out that the mortality rate was difficult to establish because of problems with diagnosis. With the use of real-time ultrasound scanning of the brain our results

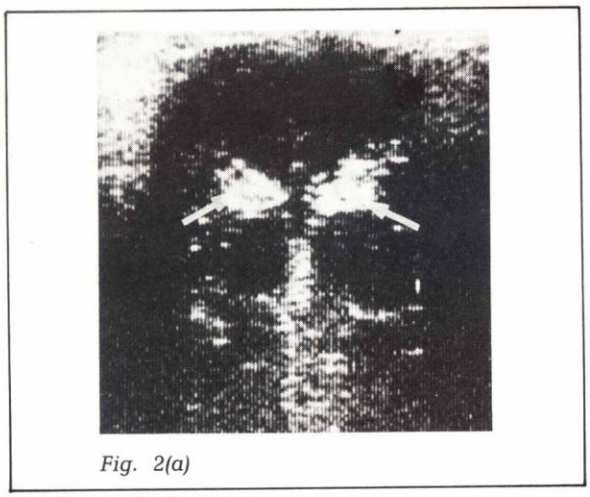


Fig. 2(a)

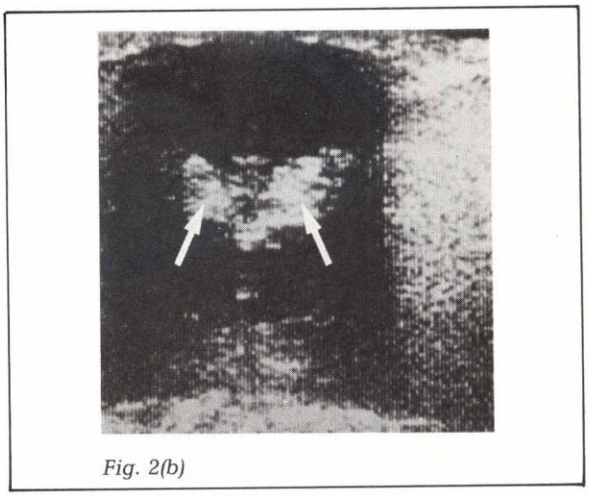
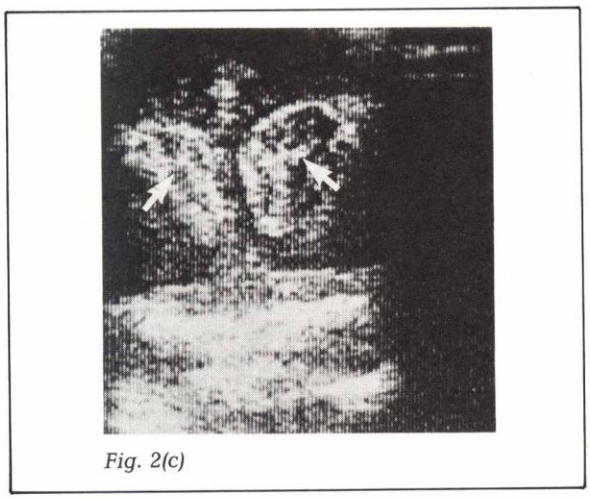


Fig. 2(b)



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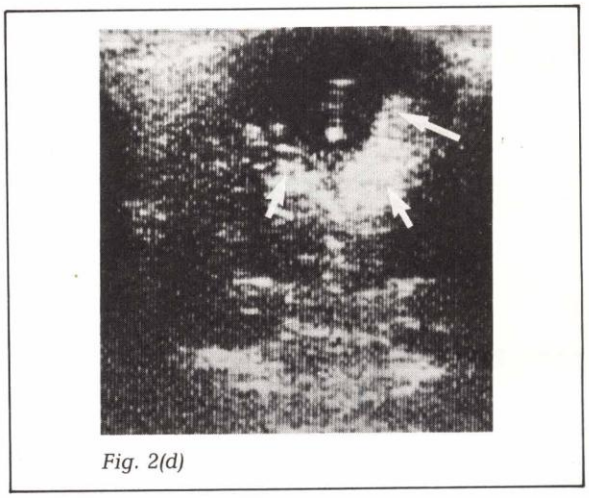

Fig. 2(d)

Fig. 2(a), (b), (c) and (d): Grades of Intraventricular Haemorrhage.

indicated that 23% of preterm infants developed IVH, with a survival rate of 71%. The overall incidence of IVH in our study was lower than in previous reports using ultrasound to diagnose haemorrhage, as the more mature preterm infants in those studies were under-represented. However, when the infants of 35 and 36 weeks gestation were excluded, our findings were in accordance with other workers; IVH occurred in 31% of our babies < 34 weeks gestation which lies in the range of the 30% to 37% reported in other studies, i3,i4,i5 when similar groups of infants had cranial ultrasonography.

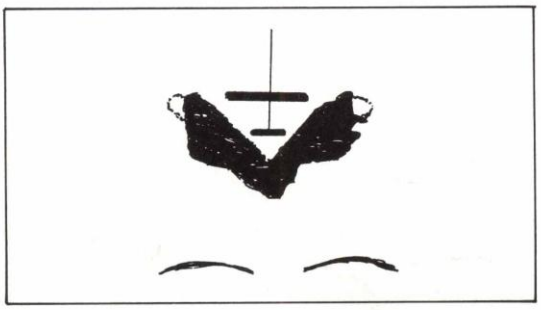

Fig. 2(e): Line drawing corresponding to Fig. 2(b) The blood in the ventricular system is depicted in black.

We found a progressive decrease in the incidence of IVH with advancing maturity. This was not surprising as the most accepted proposed patho-genesis of IVH is related to an increase in blood flow to the subependymal germinal matrix[16] causing haemorrhage which subsequently extends into the ventricular system. The vascular bed of the germinal matrix consists of fine capillaries interspersed with larger irregular vessels to form an immature vascular network in infants of 24-32 weeks gestation[8]. With maturity the vascularity of the germinal layer begins to involute and there is a gradual shift in cerebral blood supply to a predominantly cortex orientated circulation. Thus IVH occurs much less commonly after 32 weeks gestation and in these cases is more likely to originate from the choroid plexus[17].

Sequential scanning permitted the timing of the haemorrhage in most of our infants. 78% of the IVH occurred within 72 hours of birth. This result is similar with that recorded by Levene et al[14] who also used ultrasound scans and Tsiantos et al [n] who used clot analysis at autopsy, but markedly contrasts with the report of de Crespigny et al[18] who found that 71% of haemorrhage occurred within 6 hours of birth. There is no readily available explanation for this

large discrepancy but it may be that the babies in the study of de Crespigny[18] had many more adverse ante- and intra-partum factors present.

It was not considered justifiable to use routine computerised tomography during the study period and thus this was not performed to compare with the findings on ultrasound scan. However, from the autopsy data there was excellent agreement between ultrasound and the pathological diagnosis of haemorrhage. This correlation was as good as had been previously found with CT scanning[19,20] which has the problems of transport to the CT scanner as well as the hazard of ionising radiation; this is especially relevant in the case of repeated scans. Thus, ultrasound scanning is the preferred method for the diagnosis of IVH, as a complete scan can be performed in a few minutes in the incubator or cot with no sedation required and ultrasound, at the energy level used, is without known hazard.

The present study has demonstrated the value and reliability of cranial ultrasonography in the diagnosis of IVH. The use of real-time ultrasound especially when employed in conjunction with Doppler ultrasound to evaluate cerebral blood flow[21,22] should improve our understanding of the pathophysiology of IVH. In the clinical setting the diagnosis of IVH and post-haemorrhagic hydrocephalus may prove useful in the attempt to reduce or prevent the associated handicap by early intervention in the treatment of ventricular dilatation[23]. Furthermore, by identifying the infants most at risk from permanent handicap, close monitoring of neurological function and development may allow appropriate treatment to improve their ultimate outcome.

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