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Developmental outcome of infants with severe intracranial-intraventricular hemorrhage and hydrocephalus with and without ventriculoperitoneal shunt

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Abstract. Thirty-six infants who developed grade III and IV intraventricular hemorrhages during the neonatal period were followed up to determine their developmental quotient. All of these infants had ventriculomegaly and 15 of them required a ventriculoperitoneal (VP) shunt during the neonatal period prior to discharge from Intensive Care Nursery. The mean developmental quotient for the infants with the VP shunt was 67.93. The mean developmental quotient for the infants with ventriculomegaly but no VP shunt was 88.71 ($P < 0.02$). Among the nonshunted group of infants, 13 (61.9%) had developmental quotients greater than 85, and among the shunted group 5 infants (33.3%) had developmental quotients greater than 85. Fifty percent of the total group of infants had normal developmental quotients at a mean chronological age of 16.25 ± 7.5 months (and corrected age 14 months). Infants developing posthemorrhagic hydrocephalus and requiring VP shunts had a poorer developmental outcome compared to those who did not require shunts.

Key words: Intraventricular hemorrhage – Developmental quotient – Ventriculoperitoneal shunt – Ventriculomegaly – Hydrocephalus.

Intraventricular hemorrhage is one of the major problems encountered in the management of very low birth weight infants. With the use of CT and realtime ultrasound scans, the reported incidence of intraventricular hemorrhage has been from 40% to 60% in different centers [8, 12]. Various classifications of these hemorrhages have been used, with the help of CT and ultrasound scans [8, 12]. Even though there are reports of poor prognosis for infants with grade III and IV intraventricular hemorrhage, it is not certain whether the ventriculomegaly that develops after the intraventricular hemorrhage or the severity and the extent of the hemorrhage is responsible for the brain damage [9, 16]. Grade III intraventricular hemorrhage is defined as intraventricular hemorrhage with ventricular distension and grade IV hemorrhage is defined as intraventricular hemorrhage with evidence of intraparenchymal hemorrhage with or without ventriculomegaly. If ventriculomegaly is primarily responsible for the neurological sequelae, then prevention or early treatment of ventriculomegaly should result in better outcome. In order to test this hypothesis, we studied the developmental outcome of infants with grade III and IV intraventricular hemorrhages diagnosed during the neonatal period, comparing the outcome of infants with and without VP shunts.

Materials and methods

Using a realtime ultrasound sector scanner with 5 mHz transducer (Advanced Technology Laboratories), infants were scanned through the anterior fontanelles. Infants with grade III and IV intraventricular hemorrhages were selected for the follow-up study. Both coronal and sagittal views were obtained each time, and they were scanned on a weekly basis during the neonatal period. All infants with grade III and IV intraventricular hemorrhages diagnosed by ultrasound scans were also followed with daily head circumference measurements. When progressive dilation of the ventricles was documented on serial ultrasound scans, the infants were subjected to daily spinal taps. The spinal taps were done in the L3–4 interspace, in the sitting or lateral decubitus position, using a 22-gauge spinal needle with a stylet. The spinal taps were discontinued if no fluid was obtained on 2 successive days or after 2 weeks. After the spinal taps were discontinued, if the ventricular size progressively enlarged, or if the head circumference increased by more than 1.5 cm per week, the infants were treated with VP shunt, which was inserted at postnatal ages ranging between 30 and 90 days.

There were 15 infants who required VP shunts and 21 infants whose ventriculomegaly was arrested, as documented by serial ultrasound scans (non-VP shunts).

Follow-up evaluations were performed on all infants using the Denver Developmental and Bayley Scales of Infant Development. The mean birth weight of these infants was $1,240 \pm 498$ g, and the mean gestational age of the group of infants was 29.1 (range 24–40) weeks. The mean chronological age at the time of follow-up was 16.25 ± 7.5 months at a corrected age of 14 ± 8.6 months. Beyond 24 months of age, no further correction for prematurity was carried out. Fifteen infants (41.6% of the infants)

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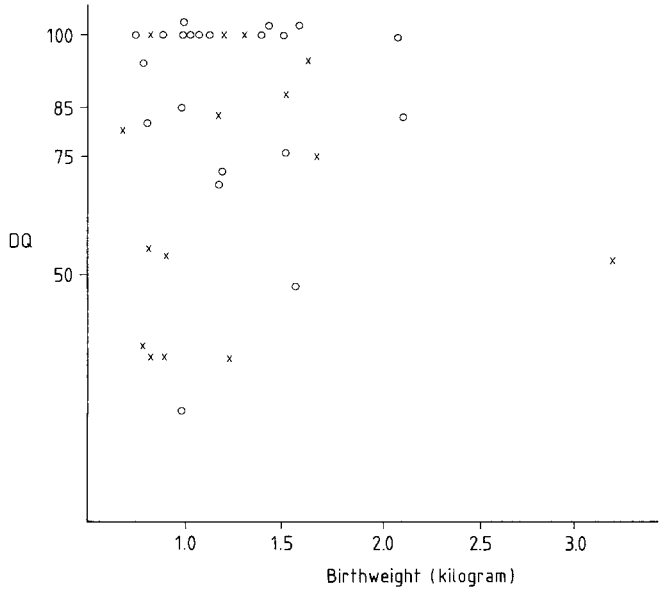

Fig. 1. Developmental outcome of infants of various birthweights with (VPS) and without ventriculoperitoneal shunt (NVPS). ○, NVPS; ×, VPS

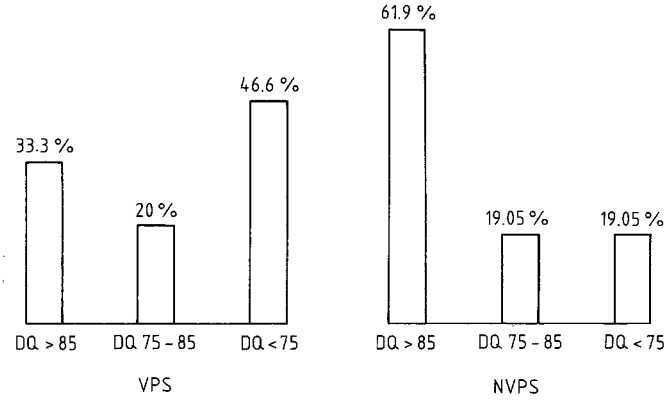

Fig. 2. Percentage of normal (DQ > 85), suspect (DQ 75–85), and abnormal (DQ < 75) developmental outcome in infants with (VPS) and without (NVPS) ventriculoperitoneal shunt

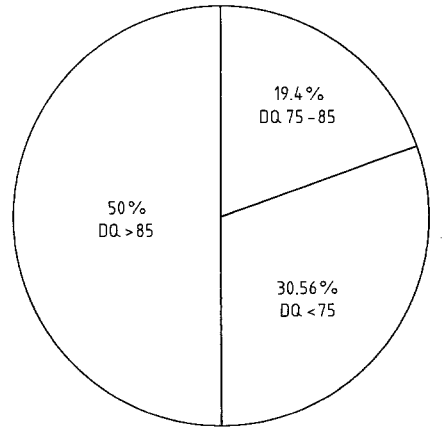

Fig. 3. Developmental outcome of infants with grades III and IV intraventricular hemorrhage classified into normal (DQ > 85), suspect (DQ 75–85) and abnormal (DQ < 75) groups

Table 1. Results of the follow-up data and characteristics of the two groups of infants with and without VP shunt

	VP shunt ($N=15$ mean ± SD)	Non-VP shunt ($N=21$ mean ± SD)	P
Developmental quotient	67.93 ± 26.5	88.71 ± 22.07	< 0.02
Chronological age	15.53 ± 8.47	16.76 ± 7.4	NS
Corrected age	13.3 ± 9.1	14.51 ± 8.35	NS
Birth/weight (grams)	1,243.3 ± 631.9	1,237.6 ± 395	NS
Age (weeks)	29 ± 4.1	29.28 ± 2.95	NS
PH	7.20	7.20	NS
PCO_2	52.2	55.6	NS
Apgar (1 min)	4	4.4	NS
Apgar (5 min)	5.7	6	NS

were treated with VP shunts, and 21 infants did not require a shunt. Developmental quotient (DQ), which is the value of the functioning age divided by the chronological age (corrected for prematurity) × 100, was used for analysis of infants in the various groups (see Fig. 1). We classified DQs of more than 86 as normal, 75–85 as suspect, and less than 75 as abnormal. Among the VP shunt group of 15 infants, 5 (33.3%) had DQs greater than 85, 3 infants (20%) had DQ between 75–85, and 7 (46.6%) had DQ of less than 75 (see Fig. 2). The mean DQ of this ventricular peritoneal (VP) shunt group was 67.93, which was significantly lower than the non-VP shunt group of 88.71 ($P < 0.02$).

Results

All infants with a VP shunt survived. Two of the shunted infants required revisions within 24 h because of shunt blockage. No further complications were noted. There was no incidence of sepsis in any of these infants. Fourteen of the 15 infants who required VP shunts required mechanical ventilation during the immediate neonatal period because of respiratory distress syndrome. All infants among the non-VP shunt group required mechanical ventilation. There were no differences in the mean birth weight or gestational ages of infants between the two groups of VP shunt and non-VP shunt. Further, we also recorded the following data and found no differences between the two groups: the admitting pH, PCO_2, and Apgar scores at 1 and 5 min (Table 1). The duration of hospitalization was the same in the VP and non-VP groups.

Our results indicated that infants who required a VP shunt had a significantly lower developmental quotient on the follow-up examination. There were no statistically significant differences between the chronological age and the corrected age between the two groups of shunted and non-shunted infants. Among the non-shunted infants, there were 13 of 21 (61.9%) who had DQs greater than 85, 4 infants (19.05%) belonged to the suspect group of DQ between 75–85, and 4 infants had a DQ of less than 75. Of the total group of 36 infants, 18 had DQs greater than 85.

This corresponds to the figure of 50% being normal in outcome with grade III and grade IV intraventricular hemorrhage. Seven of these infants (19.4%) belong to the suspect group of DQ 75–85, and 11 infants (30.56%) had DQs less than 75 (see Fig. 3).

Discussion

We elected to study the infants with grades III and IV intraventricular hemorrhage primarily because there is insufficient data on these groups; also, infants with grades I and II intraventricular hemorrhages are reported to have a better outcome [9, 15]. Posthemorrhagic hydrocephalus is reported to have a poor prognosis in the study of Chaplin et al. [2]. However, these infants were born between 1969 and 1978. The data for that particular group were from 1969 until 1974 for the VP shunt group. Many improvements have since been made in the care of sick infants, improvements which might improve their long-term outlook. In another report, severe handicaps were seen in only 20% of the infants with intraventricular hemorrhages and 40% were mildly abnormal [5]. Among our patients who developed ventricular dilatation, 50% of the infants were normal at a mean age of 16 months.

We have tried to control the ventriculomegaly with serial daily spinal taps and, if these were found to be unsuccessful, by ventricular peritoneal shunt. We did not encounter any complications from the daily lumbar punctures. There are conflicting reports on the effectiveness of serial lumbar punctures to prevent the development of hydrocephalus [4, 7, 10]. We did not use drugs for the control of posthemorrhagic hydrocephalus. This was not a controlled study to find out the effectiveness of daily spinal tap treatment on the developmental outcome of infants with severe intraventricular hemorrhage.

Among the VP shunt group of infants, no postneonatal complications were noted. All infants survived after the VP shunt. We also noted that in 3 infants the ventricular size became normal after the VP shunt, and these 3 infants had DQs of 100 upon follow-up. It is quite possible that ventriculomegaly, as detected on serial ultrasound scans, was not due to obstruction of the cerebral spinal fluid drainage in all cases of intraventricular hemorrhage. It is possible that those infants whose ventricular size did not become normal after VP shunt placement might be those infants who developed periventricular infarction. In these infants, the developmental outcome was poor. Follow-up of infants with grades III and IV intraventricular hemorrhages has shown that approximately half of them have neurological deficits detected at a very young age. However, those who required VP shunts had a poorer prognosis, whereas those who developed arrested hydrocephalus have a better outlook.

It is to be noted that our evaluations were done at such a young age that many more subtle abnormalities may become evident in later life. However, grossly abnormal DQs were evident by the time we performed the developmental evaluation on these infants. It is quite probable that infants with DQ of 75–85 eventually may perform worse or better in developmental evaluation. Our data indicate that even with the development of grades III and IV intraventricular hemorrhages, it is difficult at present to predict the long-term outcome. Ultrasound, which is commonly employed in the diagnosis of intraventricular hemorrhage, is not able to distinguish between periventricular infarction associated with intraventricular hemorrhage and obstructive hydrocephalus. Therefore, developmental outcome is difficult to predict when infants develop grades III and IV intraventricular hemorrhage [11, 13].

Infants with VP shunts were reported to have a very poor outcome in another series [6]. Our results indicate that these infants do not have a uniformly poor prognosis, even though generally their outlook is poorer than the non-VP group. However, one-third of that group turned out to be normal (DQ > 85) in our series, and 20% were in the suspect group. Nearly half of all infants with VP shunts had definitely abnormal DQ.

We feel that reduction of the increasing ICP caused by poor cerebral spinal fluid reabsorption may be helpful. Those infants whose ventricular size became normal after VP shunts had a normal outlook in our series. This might be due to the fact that these infants did not suffer periventricular infarction.

Our findings indicate that brain damage cannot be entirely determined at the time of the development of IVH. Brain blood flow determinations, made by PET scan, [17] may help in this determination. This has been found to be difficult to predict, depending on the size of the hemorrhage. We have previously reported that ultrasound scans done at the time of discharge from neonatal intensive care units have a higher predictive value for developmental outcome [14]. Recently, De Vries et al. have reported the developmental outcome of infants with severe periventricular/intraventricular hemorrhage and found that 50% of their group of infants had normal outcome [3]. However, in their series, severe mental retardation and cerebral palsy were detected in all infants who had developed cystic periventricular leucomalacia. Since the etiology of the latter is presumed to be ischemic in nature, the disturbance in cerebral circulation with the development of IVH, as demonstrated by PET scan, makes one suspect that these lesions are interrelated. It is quite possible to develop cystic leucomalacia without an IVH. These lesions are not detected in the immediate neonatal period, which is usually when the IVH develops. Hence, ultrasound follow-up of these infants at the time of discharge would be helpful in predicting neurodevelopmental outcome.

At this time, we feel that aggressive support should be extended to all infants on ventilators (including early VP shunt) who have suffered grades III or IV IVH. VP shunt infants do not have increased morbidity as far as the length of hospitalization is concerned.

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