Correlation of ventricular size and head circumference after severe intra-periventricular haemorrhage in preterm infants

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Abstract. No detailed information is available about the timing and correlation of objectively gauged ventricular width (VW) and the rate of growth of the occipitofrontal circumference in premature infants with intraventricular haemorrhage preceding progressive ventricular dilation. For this study, two groups were selected according to clinical course: group A (n=6) had ventriculomegaly with no signs of raised intracranial pressure, while patients in group B (n=7) developed progressive ventricular dilation after a period of latency. A VW between 0.9 and 1.4 cm (group A) did not affect normal head growth, whereas a VW greater than 1.5 cm was always associated with the development of hydrocephalus. Our data further suggest that the widely used criterion of a head growth rate of more than 2 cm/week is a relatively poor criterion for the definition of post-haemorrhagic hydrocephalus.

Key words: Preterm infants - Intraventricular haemorrhage - Ventricular width - Occipitofrontal circumference - Post-haemorrhagic hydrocephalus - Ventriculomegaly

Intra-/periventricular haemorrhage (IVH/PVH) is the most common and serious neurological disorder in premature infants of less than 35 weeks’ gestation. Posthaemorrhage ventricular dilation is a well-known complication and its evolution and course depend on the severity of the initial IVH/PVH. Fifty-five percent of the survivors of severe IVH with periventricular involvement will develop progressive ventricular dilation [13].

For differentiation between progressive ventricular dilation, i.e. post-haemorrhagic hydrocephalus (PHH), and ventriculomegaly (VM), the increase in occipitofrontal head circumference is used as an important determinant. However, to date no detailed information has been available about the timing and correlation of objectively gauged ventricular size and the rate of growth of head circumference.

The aims of this study were to determine the critical ventricular size above which a pathological rate of head growth occurs and to estimate the maximum degree of ventricular dilatation that does not induce pathological head growth. Thirdly, we asked whether there is development of hydrocephalus in any patients without a head growth rate of 2 cm/week or more.

Patients and methods

From March 1986 to January 1988 50 neonates with an intraventricular haemorrhage (IVH) were admitted to the neonatal intensive care unit. Thirty-two had an IVH grade 3 and 18 were suffering from an IVH grade 3 plus periventricular haemorrhage (PVH). The grading of IVH was according to the classification of J. J. Volpe [13]. Twenty-eight patients died (56%), 10 developed PHH (20%), and 12 showed remission (24%). The selection criteria for this study were: IVH grade 3 or IVH plus PVH and dilation exceeding 0.5 cm of at least one lateral ventricle.

Of the 22 patients who survived the acute episode of haemorrhage, 13 met the criteria for entry into this study. Three patients with PHH (1 patient had excessive leukencephalomalacia that did not allow accurate measurement of the lateral ventricles; 1 patient underwent surgical evacuation of the blood clot; 1 patient already had hydrocephalus on admission) and 6 patients who showed remission (3 were transferred and therefore did not undergo control measurements; 3 never reached a ventricular width of 0.5 cm) had to be excluded.

The 13 infants who met the entry criteria were divided into two groups. Group A consisted of 6 infants who either showed a spontaneous remission after an initial delay (2 patients) or developed persistent VM (4 patients), while 7 infants who developed PHH formed group B.

Hydrocephalus was defined as dilation of at least one lateral ventricle, with a ventricular width of 1.5 cm or more, in addition to a pathological increase of occipitofrontal circumference of more than 1 cm/week [4, 7, 11].

Ventriculomegaly was defined as a ventricular width above 0.5 cm without pathological increase of occipitofrontal circumference or clinical signs of raised intracranial pressure (ICP). Ventricular width was defined as the widest measurement taken perpendicular to the longest axis of the coronal section of the lateral ventricle in a plane which included the III ventricle just behind the foramina of Monro [10]. Measurement were taken at least once weekly using a real-time-sector scan (ATL Mark 600, 5 and 7.5 MHz). Measure-
ment of the occipitofrontal circumference was done weekly as well, using the percentiles for head circumference from the Hammersmith Hospital, London [3].

Trans-fontanelle measurement of ICP (LADD Monitor) was performed only if clinical signs of raised ICP were apparent. All patients except two received acetazolamide (50 mg/kg day) [8, 9, 12]. All measurements took place before the start of any invasive diagnostic intervention or therapy (e.g. lumbar puncture, ventricular puncture, external drainage or shunt implantation) that would reduce the volume of cerebrospinal fluid.

**Group A**

The median gestational age of these 6 patients was 31 weeks (range: 29–33 weeks). The median birth weight was 1370 g (1010–2030 g). The haemorrhage occurred after a median life period of 5.5 days (5–9 days). The median observation period was 10 weeks (7–22 weeks). The median maximum ventricular diameter (either right or left) was 0.8 cm (0.6–1.4 cm; Table 1). The patients reached the point of maximum ventricular dilation after a median period of 22.5 days (7–37 days). In none of the patients did the dilation of one lateral ventricle exceed 1.5 cm. The median lateral diameters during the whole period of observation (n=59 measurements) were: right 0.8 cm (0.1–1.4 cm), left 0.8 cm (0.2–1.3 cm). In this period the median increase in occipitofrontal circumference was 0.6 cm/week (0–1.5 cm/week). The median maximum head growth was 1.2 cm/week (1.0–1.5 cm/week). None of the patients in this group had an occipitofrontal circumference exceeding the 50th percentile. None of the patients showed clinical signs of raised ICP.

**Group B**

The median gestational age in this group was 32 weeks (29–38 weeks). The median birth weight was 1730 g (1160–3200 g). The haemorrhage occurred after a median life period of 3 days (1–8 days). If diagnostic or therapeutic procedures that would result in a reduction of the volume of cerebrospinal fluid were necessary, observation for the purposes of this study was terminated.

We divided the observation period in two parts and called these period 1 (Bp1) and period 2 (Bp2). Bp1 covered the time between onset of haemorrhage and reaching a ventricular dilation of 1.5 cm, while Bp2 was the period between the point at which a ventricular diameter of 1.5 cm was exceeded and invasive intervention started.

The patients reached the point of dilation of at least one lateral ventricle of 1.5 cm after a median duration of 17 days (10–40 days). In this period of ventricular dilation, the median of occipitofrontal circumference was 0.6 cm/week (0.3–1.5 cm/week). The median maximum growth rate of the occipitofrontal circumference was 0.8 cm/week (0.4–1.5 cm/week). In this period no clinical signs of raised ICP were observed.

**Results**

**Group A**

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**Table 1.** Ventricular width, maximum ventricular width, occipitofrontal circumference and maximum occipitofrontal circumference groups A and B (median and range). VW, Ventricular width; OFC, occipitofrontal circumference

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 6)</th>
<th>Group B (n = 7)</th>
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<tr>
<td></td>
<td>Period 1</td>
<td>Period 2</td>
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<tr>
<td>Median VW (cm): right</td>
<td>0.8</td>
<td>&lt;1.5</td>
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<td>(0.1–1.4)</td>
<td>(1.5–3.6)</td>
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<tr>
<td>left</td>
<td>0.8</td>
<td>&lt;1.5</td>
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<td>(0.2–1.3)</td>
<td>(1.5–2.5)</td>
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<tr>
<td>Median maximum VW (cm)</td>
<td>0.8</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>(0.6–1.4)</td>
<td>(1.7–3.6)</td>
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<tr>
<td>Median OFC (cm/week)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>(0–1.5)</td>
<td>(0.3–1.5)</td>
</tr>
<tr>
<td>Median maximum OFC (cm/week)</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>(1.0–1.5)</td>
<td>(1.6–2.4)</td>
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After a ventricular width of 1.5 cm was exceeded the median increase in occipitofrontal circumference was 1.6 cm/week (0.1–2.4 cm/week). There was a highly significant difference between the two periods (P < 0.0005, Wilcoxon rank sum test). The median maximum rate of growth of the occipitofrontal circumference was 1.9 cm/week (1.6–2.4 cm/week), showing a significant difference in comparison to Bp1 (P < 0.001) and to group A (P < 0.0025). Furthermore, there was a significant difference between the median increase in occipitofrontal circumference in group Bp2 and the maximum median increase in occipitofrontal circumference in group A (P < 0.025, Wilcoxon rank sum test). The median duration of observation in period 2 in group B was 3 weeks (1–6 weeks).

A ventricular width exceeding 1.5 cm was in all cases followed by a pathological rate of growth of the occipitofrontal circumference in the following 7 days (Fig. 1). In all but two patients it was also the maximum growth rate. Only 2 of 7 patients with PHH had an occipitofrontal circumference above the 90th percentile.

![Fig. 1. Correlation of the increase in ventricular width above 1.5 cm and the subsequent degree of accelerated growth rate of the occipitofrontal circumference (OFC) in group B](image-url)