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The treatment of posthaemorrhagic hydrocephalus

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ABSTRACT

The paper presents the authors' analysis of their own treatments of intraventricular bleeding and posthaemorrhagic hydrocephalus in premature infants in the period from December 2009 to January 2016. Infants who are born before the 37th week of pregnancy are at a higher risk for perinatal complications. Intraventricular bleeding is a common complication in premature infants with low birth weight who are treated in units for intensive care and therapy.

Infants who are most at risk are those with low birth weight (under 1,500 g) and born before the 30th week of gestation. According to data from literature, 30 – 50% of infants born before the 30th week suffer intraventricular haemorrhage. More severe haemorrhage results in posthaemorrhagic hydrocephalus.

High morbidity and mortality require an early recognition, treatment and regular follow-up of these infants.

Key words: premature infant, intraventricular bleeding, hydrocephalus, treatment

INTRODUCTION

Hydrocephalus is a condition which is characterized by an abnormal accumulation of cerebrospinal fluid in the brain ventricles, causing them to become dilated.

Based on the time of the emergence of the condition, hydrocephalus is divided into:

1. prenatal (disorders in the development of the central nervous system, cytogenetic irregularities, congenital infections),
2. perinatal/neonatal (consequence of brain haemorrhage or infection),
3. postnatal (consequence of brain haemorrhage or infection).

Posthaemorrhagic hydrocephalus occurs as a result of haemorrhage, which may be intraventricular, subdural or subarachnoid. (1)

Subdural haemorrhage occurs as a result of severe birth injury caused by a too quick delivery or operative delivery (vacuum-assisted delivery). Too quick or traumatic shaping of the head results in the tears of the falx or tentorium, and the tears of the venal sinuses flowing inside them, thus causing haemorrhage in the subdural space. A common cause of subdural haemorrhage inside the skull is the tearing of the bridging veins, which cross into the sagittal sinus. Subdural haemorrhage into the posterior cranial fossa occurs as a result of the rupture of the vein Galeni, the straight and lateral sinuses. Hydrocephalus occurs as a result of a large subdural hematoma, which relocates the structures in the head, thus obstructing the flow of fluid. In the case of parietal hydrocephalus, the aqueduct of Sylvius is obstructed, while in the case of hematoma of the posterior cranial space, the foramen of Magendie and Luschke are obstructed.

Subarachnoid haemorrhage may be primary or secondary, with secondary occurring after an extensive intraventricular haemorrhage and the haemorrhaging through the foramen Luschke and Magendie into the subarachnoid space. Primary subarachnoid haemorrhage occurs because of the haemorrhage of smaller veins of the leptomeningeal plexus or larger veins, i.e. veins in subarachnoid space. The causes for subarachnoid haemorrhage may lie in the lack of vitamin E, congenital bleeding disorders, perinatal hypoxia and smaller birth injuries. Most subarachnoid haemorrhages are asymptomatic and only rarely cause hydrocephalus.

Intraventricular haemorrhages mostly occur because of the dilatation of subependymal haemorrhage from the location of the germinal matrix into the brain ventricles, and less commonly due to the haemorrhage from the choroid plexus. The neuropathological basis of intraventricular haemorrhage is the haemorrhage into the subependymal matrix tissue between the nucleus of thalamus and caudate nucleus near the foramen of Monro. The site of bleeding is dependent on the gestation age: before the 28th week, the haemorrhage is more common in the body, while later it more often affects the head of the caudate nucleus. The reason for this is the immature structure and blood circulation of the periventricular space. During the development of the central nervous system, the cells move from this space and form the layers of the cortex and the brain stem. The move is completed after the 26th week and after that the capillaries and veins of the periventricular space are badly supported and thus more sensitive to the changes in blood pressure. In the past it was thought that parenchymal haemorrhage occurs when subependymal haemorrhage spreads into the white matter of the brain. Today it is mainly thought that parenchymal haemorrhage occurs because of haemorrhage in the area of ischemia or as a consequence of venous infarction. A large clot in the germinal matrix or in the lateral ventricle causes an obstruction in the terminal vein and lowers the circulation of the white matter of the brain in the area which unfolds like a fan from the last lateral ventricle. The consequence is the haemorrhagic venous infarct of that area. This is the most difficult form of brain haemorrhage in premature infants, which occurs in approximately 15% of affected infants, mostly in the first two days after the beginning of the haemorrhage. (1 - 3)

In 80% of the cases, blood spreads from the subependymal space into brain ventricles and from there into subarachnoid space. At the location of parenchymal haemorrhage a porencephalic cyst is formed, which is joined with the lateral ventricle due to the destruction of ependym. Hydrocephalus is caused by numerous small clots which obstruct the flow of fluid in the aqueduct of Sylvius, and foramina of Luschka and Magendie and then obstruct the resorption of fluid in arachnoid granulations. All the types of brain haemorrhages are not equally fatal for premature infants. There have been several classifications according to the grade of haemorrhage. The most widely accepted classification today is the classification proposed by Papile et al. in 1978: (2)

- grade 1–subependymal haemorrhage restricted to germinal matrix
- grade 2–intraventricular haemorrhage without ventricular dilatation
- grade 3–intraventricular haemorrhage with ventricular dilatation
- grade 4–intraventricular haemorrhage with parenchymal haemorrhage.

The incidence of haemorrhage increases with a low gestation age. The prognosis for premature infants with brain haemorrhage is dependent on the grade. Most premature infants with the first and second grade haemorrhage survive and develop the same as infants without haemorrhage. The prognosis is totally different for infants who suffer intraventricular haemorrhage with ventricular dilatation or intraventricular haemorrhage with parenchymal haemorrhage (Figure 1). (1, 3 - 6)

The cause of haemorrhage is mostly the failure of autoregulation and consequent changes in the flow and blood pressure in capillaries and veins of the germinal matrix. They occur because of hypoxemia, acidosis, hypotension, hypercapnia, hyperosmolarity and consequential therapeutic measures. Retrospective studies have shown the connection to birth injury, birth in breech position, prolonged delivery, respiratory distress, pneumothorax, low birth weight and low gestation age. (6 - 8)

Clinical picture

Intraventricular haemorrhage (IVH) is clinically manifested through different symptoms and signs.

In 25-50% of cases IVH is manifested in the occurrence of lowered haematocrit or inappropriately raised haematocrit after a blood transfusion. In some cases it is manifested through neurological symptoms, such as loss of consciousness, hypotony, bulbomotoric disorders and central breathing disorders. In the most severe cases, it can come to disorder of consciousness resulting in a coma, apnoea, bradycardia, convulsions and nonreactive pupils. Posthaemorrhagic hydrocephalus is accompanied by symptoms and signs of increased intracranial pressure: increased head size, or a too quick head growth, swollen, tense large fontanelle, dilated cranial sutures, apnoea and bradycardia, gastrointestinal troubles, irritability and lethargy. (1, 8)

Diagnostics

Nowadays, the first method of choice which is used to confirm or exclude hydrocephalus in new-borns is an ultrasound examination through the front fontanelle. An ultrasound examination is a quick, safe and painless method, which is accompanied by the Doppler examination for the evaluation of blood flow and the calculation of the resistivity index. An ultrasound examination can also be used to evaluate the success of neurosurgical treatment. The post-operation supervision of the function of VP shunt is carried out exclusively through ultrasound. (7 - 9)

In some cases, the cause of the occurrence of hydrocephalus can be determined with other diagnostic methods such as computer tomography and magnetic resonance.

Treatment

Non-surgical treatment such as the use of diuretics and inhibitors of carbohydrase (acetazolamide) and osmotically active substances (isosorbide or glycerol) have not been proven efficient, moreover, they have a lot of side effects.

Surgical: relieving lumbar puncture, external liquor drainage and VP shunt as the permanent form of treatment for posthaemorrhagic hydrocephalus. (6, 10)

In certain cases of obstructive hydrocephalus and aqueductal stenosis, the method of choice is ventriculostomy of the third ventricle. (6, 11 - 13)

MATERIAL AND METHODS

The study took place in the Unit for Intensive Care and Therapy (UICT) of the Clinic of Paediatrics of the UCC Maribor. The sample was collected from a period of six years (December 2009 – January 2016) and included all the new-borns in whom the ultrasound determined an intraventricular haemorrhage and who consequently developed posthaemorrhagic hydrocephalus. We used the data from the Slovene perinatal information system, from the yearly reports for individual clinics and from the medical documentation of the affected new-borns. We examined the data about the incidence of intraventricular haemorrhage and the development of posthaemorrhagic hydrocephalus, the incidence of the grade of haemorrhage based on the gestation age and the time of the occurrence of haemorrhage. We also examined the data about which infants needed relieving lumbar punctures, external liquor drainage and surgical treatment.

RESULTS

Over the last 15 years there have been several retrospective studies which show the high morbidity and mortality of children born before the 30th week of gestation and with birth weight below 1,500 g. The purpose of our study was to determine the incidence, the follow-up and the success of the treatment of our infants with intraventricular haemorrhage and posthaemorrhagic hydrocephalus (PHH).

During the time of the study 13,621 live new-born infants were born in the Maribor maternity hospital. In the Unit for Paediatric Intensive Care and Therapy, 394 new-borns were hospitalized. In 69 infants we determined different grades of intraventricular haemorrhage (IVH), which we divided into grades I-IV (Classification according to Papile). (2)

We determined that in the six-year period the incidence of IVH was 17.5% in relation to the number of hospitalized infants in UICT, while the incidence of PHH was 4.6%.

From all the children included in the study, 10 children died, which means 14.5% mortality. From those who died, three children died because of massive intraventricular haemorrhage with the tamponade of ventricles and neonatal sepsis. The other seven children died from acute kidney failure while suffering from neonatal sepsis and extreme prematurity. (impossibility of dialysis in children with body weight less than 2,500 g)

We divided the infants included in the study into three groups according to their gestation age (GA). (Table 1)

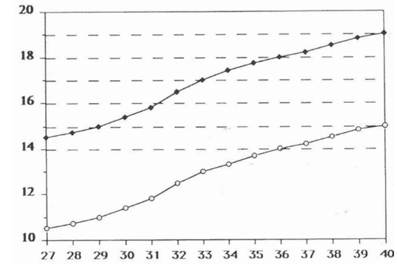

Figure 1. 97th centile of the width of lateral ventricles at the increasing pregnancy ages. The upper line marks the pathological dilatation of lateral ventricles and presents the limit over which we decide for treatment. (10)

Table 1. Grades of IVH in relation to GA in the period of 2009 – 2016

Gestation age	**Grade IVH**			
	I.	II.	III.	IV.
21-25 w	3	5	7	11
26-30 w	15	5	9	1
> 30 w	6	1	5	0

GA, gestation age
IVH, intraventricular haemorrhage

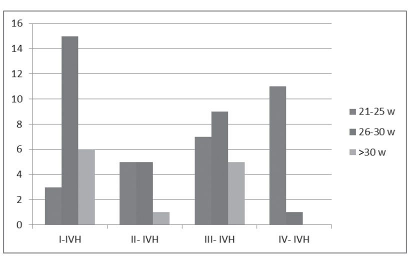

Figure 2. Grades of IVH in relation to GA in the period 2009-2016

GA, gestation age
IVH, intraventricular haemorrhage

DISCUSSION

We analysed the incidence of IVH in relation to the GA of the new-borns. There were 43.5% infants with GA between 26-30 weeks, which presented the majority, there were 17.4% infants with GA >30, and 37.7% of infants with GA between 21-25 weeks (Figure 2).

The data from world literature and our personal experiences show that infants with IVH of grades I and II live normally and develop the same as infants without haemorrhage. (16)

We determined a high proportion of severe IVH in infants with low gestation age, i.e. 18 infants in the group of 21-25 weeks, and 10 infants in the group of 26-30 weeks, which is consistent with the data from relevant literature.

A multicentre study implemented in the period of 1989-2005 showed that in the group of infants with low GA and with birth weight below 1500 g, intraventricular haemorrhage of a higher grade occurs in 35% of cases. (14)

For infants included in the study, we determined a higher incidence of infection, a higher need for artificial ventilation, hemodynamic instability, electrolytic disorders and thrombocytopenia, which is consistent with the data from the above multicentre study. (14, 15)

Table 2. Number of posthaemorrhagic hydrocephalus based on the grade of haemorrhage in the period of 2009-2016

	Intraventricular haemorrhage			
	I.	II.	III.	IV.
Posthaemorrhagic hydrocephalus	0	1	9	8

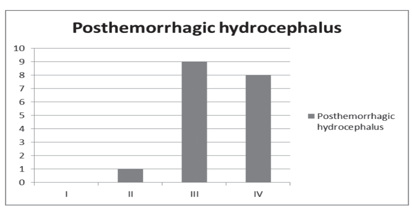

Figure 3. Number of posthaemorrhagic hydrocephalus based on the grade of haemorrhage in the period of 2009-2016

As a consequence of intraventricular haemorrhage of grades III and IV, 18 infants developed posthaemorrhagic hydrocephalus. 14 of them belonged to the group with gestation age below the 30th week, which confirms that extremely immature premature infants with low birth weight are the most susceptible to the occurrence of intraventricular haemorrhage and consequently, hydrocephalus. (Tables 2 and 3) (Figure 3)

According to the data from comparative studies, in the group of premature infants born before the 30th week of gestation and with birth weight below 1,500 g, 60% of infants develop posthaemorrhagic hydrocephalus in the case of haemorrhage of grades III and IV. (14, 15)

Table 3. Number of posthaemorrhagic hydrocephalus in relation to GA, average birth weight, time of occurrence of haemorrhage, and the number of deaths in the period of 2009 - 2016

	POSTHAEMORRHAGIC HYDROCEPHALUS	
	YES	**NO**
GA 21-25 w	9	17
GA 26-30 w	5	25
GA >30 w	4	9
birth weight	1188 g	1288 g
time of occurrence of haemorrhage	3.28 day	3.27 day
grade IVH 3 and 4	17	16
Deaths	3	7

GA, gestation age
IVH, intraventricular haemorrhage

Table 4. Number of infants with VP shunt in relation to GA

	Posthaemorrhagic hydrocephalus with VP shunt
GA 21-25w	3
GA 26-30w	2
GA > 30w	2

GA, gestation age
VP, ventriculoperitoneal

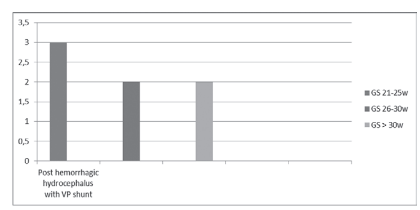

Figure 4. Number of infants with VP shunt in relation to gestation age
GS, gestation age
VP, ventriculoperitoneal

We also examined the time of the occurrence of intraventricular haemorrhage, which was the first three days since birth, while in literature it is given as the first five days since birth. (11)

In three of 18 infants we diagnosed communicant posthaemorrhagic hydrocephalus (4%). For these infants we used relieving lumbar punctures, which prevented a decompensation of the hydrocephalus and the need for surgical treatment. Relieving punctures were performed on the average five times in two days, releasing 15 ml of liquor per kilogram of body weight. Before and after every procedure we used an ultrasound examination to measure the ventricular index and determine the resistive index (RI). The repeated lumbar punctures were not accompanied by any complications. (18)

In seven infants (10%), external liquor drainage was inserted. We had the external liquor drainage inserted by a neurosurgeon. Before the insertion, we used ultrasound to determine the lateral ventricle which was drained. External liquor drainage was performed under the control of ultrasound, and during the procedure the location of the tip of the drainage tube was determined. After the drainage or lumbar puncture, the size of ventricles was measured and the RI determined. (18)

One of the infants had previously inserted subgaleal VP drainage due to the high levels of protein in the liquor (Ommaya reservoir).

From 69 infants with intraventricular haemorrhage, seven infants (10%) needed surgical treatment with the insertion of VP shunt. (Table 4) Of those, five infants (7%) belonged to the group of those born before the 30th week of gestation and with low birth weight. Compared to world literature, 25% of infants born before the 30th week of gestation and with birth weight below 1,500 g need surgical treatment. (Figure 4) (14, 15)

Based on all the above, we can conclude that early recognition, follow-up and treatment, as well as good communication between neurosurgeons and critical care paediatricians lower the need for surgical treatment of this risk group of infants. However, we can still confirm that extremely premature infants have high morbidity and consequent neurological deficits.

CONCLUSION

A retrospective analysis of a six-year period showed the incidence of IVH in the group of children with low GA and birth weight < 1,500 g. We determined that hydrocephalus is one of the most serious complications of brain haemorrhage in premature infants. Early recognition, follow-up and treatment as well as good cooperation between neurosurgeons and critical care paediatricians lower the need for surgical treatment.

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