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Hydrocephalus in Newborns: Clinical Conditions and Primary Surgical Treatment

Wodogłowie u noworodków – uwarunkowania kliniczne a pierwotne zaopatrzenie chirurgiczne

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article; **G** – other

Abstract

Background. Hydrocephalus is a state in which excessive accumulation of cerebrospinal fluid occurs in intracranial space as a result of disorders of its circulation hydrodynamics.
Objectives. The aim of this study was to analyze the clinical conditions and primary surgical treatment of hydrocephalus in the newborns examined in the study.
Material and Methods. The data was gathered using a retrospective analysis of the medical and nursing records of 57 newborns treated for hydrocephalus at the Department of Pediatric Surgery of the Dr. A. Jurasz University Hospital in Bydgoszcz, Poland.
Results. In the years 2008–2009 at the Department of Pediatric Surgery of Dr. A. Jurasz University Hospital in Bydgoszcz, 57 newborns were treated for hydrocephalus. In all patients (100% of the study group) regardless of sex, age, place of residence or etiology, the doctors used surgical therapy.
Conclusions. There is a connection between selected causes of hydrocephalus in the study group and sociodemographic characteristics such as the place of residence or age. Sociodemographic data (sex, age, place of residence) have no effect on the treatment of hydrocephalus in newborns. In all cases of hydrocephalus in the study, the treatment used was implantation of a drainage system. Rickham reservoirs are more rarely implanted in full-term newborns than in premature ones, while ventricle-peritoneal valves are more frequently used in full-term newborns than in premature babies. Regardless of the reason for hydrocephalus formation, the treatment is based on surgical intervention and the most common drainage system used to correct the defect is the ventricle-peritoneal valve (**Adv Clin Exp Med 2013, 22, 2, 237–243**).

Key words: full-term newborn, premature baby, hydrocephalus, drainage system.

Streszczenie

Wprowadzenie. Wodogłowie to stan, w którym na skutek zaburzeń hydrodynamiki krążenia płynu mózgowo-rdzeniowego dochodzi do jego nadmiernego gromadzenia się w przestrzeni wewnątrzczaszkowej.
Cel pracy. Analiza uwarunkowań klinicznych i pierwotnego zaopatrzenia chirurgicznego wodogłowia u badanych noworodków.
Materiał i metody. Materiał został zebrany metodą retrospektywnej analizy dokumentacji medycznej (lekarskiej i pielęgniarskiej) 57 noworodków leczonych z powodu wodogłowia w Klinice Chirurgii Dziecięcej Szpitala Uniwersyteckiego im. dr. A. Jurasza w Bydgoszczy.
Wyniki. W latach 2008–2009 w Klinice Chirurgii Dziecięcej Szpitala Uniwersyteckiego im. dr. A. Jurasza w Bydgoszczy leczono 57 noworodków z wodogłowiem. U wszystkich dzieci bez względu na płeć, wiek urodzeniowy, miejsce zamieszkania, czy etiologię zastosowano leczenie chirurgiczne.

Wnioski. Istnieje związek między wybranymi przyczynami powstania wodogłowia u badanych a cechami socjodemograficznymi, takimi jak miejsce zamieszkania oraz wiek. Dane socjodemograficzne nie mają wpływu na zastosowane leczenie wodogłowia u noworodków. We wszystkich przypadkach wodogłowia zastosowano implantację układu drenującego. Zbiornik Rickhama znacznie rzadziej wszczepia się u noworodków donoszonych niż wcześniaków, a zastawkę komorowo-otrzewnową znacznie częściej stosuje się u noworodków donoszonych niż wcześniaków. Bez względu na przyczynę powstawania wodogłowia leczenie jest oparte na interwencji chirurgicznej, a najczęściej wykorzystywanym układem drenującym do zaopatrzenia wady jest zastawka komorowo-otrzewnowa (**Adv Clin Exp Med 2013, 22, 2, 237–243**).

Słowa kluczowe: noworodek donoszony, wcześniak, wodogłowie, układ drenujący.

Hydrocephalus is a state in which excessive cerebrospinal fluid (CSF) accumulates in intracranial space and the ventricular system due to disorders of its circulation hydrodynamics. It is also defined as an imbalance between the amount of fluid produced in the choroid plexus and the amount of fluid absorbed in the subarachnoid spaces [1–13]. It is determined by various disease processes of the central nervous system and requires surgical intervention [1–13].

A primary aim in treating hydrocephalus is to ensure the best possible child development. Surgical interventions are undertaken in cases where an active disease process is progressing, and the main indication is a broadening of the brain ventricular system with the clinical symptoms of increased intracranial pressure. The necessity for surgical treatment is indubitable in cases of acute hydrocephalus in older children, teenagers and adults, but the indications for surgery in newborns and various forms of chronic hydrocephalus in all age groups are often difficult to determine [8].

Pharmacological treatment allows only for temporary alleviation of the symptoms of intracranial hypertension while waiting for a procedure. At present hydrocephalus treatment based primarily on surgical methods with the use of valve systems is the most important and common way to proceed [1–19]. The aim of treatment using a valve system is the normalization of intracranial pressure by providing constant draining of excess CSF from the ventricular system to a place in the organism from where it can be absorbed into the blood stream without any obstacles. Peripheral drains of valves can be inserted into the atrium, pleural cavity, ureter or gallbladder, but nowadays the peritoneal cavity is considered the safest place. This is the type of drainage that is most often used among children [2, 8, 15].

Endoscopic techniques are being used in treating various forms of hydrodynamic disorders of CF circulation. In cases of hydrocephalus these techniques are used in the course of aqueduct stenosis and neoplasms of areas of the pineal body, tectal lamina of the mesencephalon and thalamus [1, 2, 6, 8, 18, 20]. The most common neuroendoscopic method at the moment is the so-called ventriculostomy or ventriculocisternostomy of the third brain ventricle, used mainly in noncommunicating hydrocephalus when causal treatment is not possible or must be postponed. It is the first stage procedure in cases of "pure" hydrocephalus [1, 2].

The aim of the present study was to analyze the clinical conditions and primary surgical treatment of hydrocephalus in a group of newborns, as well as the treatment and surgical intervention. Detailed research problems have been formulated in the form of the following questions:

Is there a connection between the cause of hydrocephalus formation and selected sociodemographic features (age, sex and place of residence)?

Did the selected sociodemographic elements (age, sex and place of residence) have any influence on the hydrocephalus treatment used on the children examined?

What is the influence of the selected sociodemographic variables (age, sex and place of residence) on the type of surgical intervention?

Is there a relationship between the etiology of hydrocephalus in the patients and the type of treatment and drainage system used?

Material and Methods

The study involved 57 newborns treated for hydrocephalus in the Pediatric Surgery Clinic of the Dr. A. Jurasz University Hospital in Bydgoszcz in the years 2008–2009.

The study group included 20 female newborns (35%) and 37 male newborns (65%). Most of the newborns were full-term babies (correct fetal age, born between the 38th and 42nd week of pregnancy, with loud crying, cough or sneezing, correct limb tension in flexion, cardiac activity over 100, and pink body color) [13]; 10 of the babies (18%) were premature (newborns born prematurely, from pregnancies lasting over 28 weeks and not longer than 37 weeks, with weights below 2500g, and morphologically and physiologically immature) [13]. Most of them (63%) were born to mothers who were city residents.

In almost half of the examined children the cause of hydrocephalus was encephalomyelocele; in about 30%, defects of the central nervous system were the cause. Cases of congenital, posthemorrhagic, post-inflammatory and post-traumatic hydrocephalus were also noted.

In most cases (82%) surgical treatment was used, which consisted in correcting the flaw with an appropriate type of draining system. In 10 children, conservative therapy was initially introduced, followed by implanting a ventricle-peritoneal valve after the patients had reached a suitable age to perform this procedure.

The most frequently used method for treating hydrocephalus is correcting the flaw with a draining system. In the whole study group during the first stage treatment the following systems were used: ventricle-peritoneal valves (29 times), Rickham reservoirs (24 times) and external drainage (4 times) – see Table 1.

In the study the following medical documentation were analyzed: medical records: the history of the disease, results of radiologic & ultrasonographic examinations, computer tomography, magnetic resonance as well as microbiological, laboratory and medical consultation cards; nursing records: the patient observation cards, the process of nursing, nursing reports; operating room records: the documentation of operations performed and surgical records.

This documentation was used for collecting both the sociodemographic data (age, sex and place of residence) and the clinical data (the etiology of the hydrocephalus in each case, the kind of treatment and the type of drainage system used).

The research data was compiled with the use of Microsoft Office Excel 2007. An analysis of the correlations between qualitative features was carried out using the chi-squared test for bipartite tables. Correlations were considered statistically significant when the p level was < 0.05.

The research study was approved by the Bioethical Committee of the Nicolaus Copernicus University Collegium Medicum (NCU CM) in Bydgoszcz, Poland.

Results

In the study group encephalomyelocele was the most common cause of hydrocephalus in both female and male newborns. It was diagnosed in over half of the females (55%) and 15 of the males (41%). Hydrocephalus related to defects of the central nervous system was found in six of the females (30%) and in 10 of the males (27%). Congenital hydrocephalus was noted in three of the females (15%) and nine of the males (24%). Posthemorrhagic hydrocephalus was found in four females (20%) and seven males (19%). Post-inflammatory hydrocephalus occurred in three males (8%), and post-traumatic hydrocephalus was noted in one female (5%) and one male (3%) – see Table 2.

The differences between the subgroups female and male infants in particular kinds of hydrocephalus turned out to be statistically insignificant (Table 2). The results for post-inflammatory and post-traumatic hydrocephalus should not be regarded as definitive due to the low number of cases (below 5%); the results would need to be confirmed or corrected by examining a larger sample.

Analyzing the etiology of hydrocephalus in relation to birth age, among full-term newborns, encephalomyelocele was the cause of disease in 51% of the cases; defects of the central nervous system in 14 cases (30%); congenital hydrocephalus in 10 cases (21%); posthemorrhagic hydrocephalus in 13%; post-inflammatory and post-traumatic hydrocephalus were the causes in 6% and 4% respectively of the full-term cases. In the subgroup of premature newborns, there were two cases of hydrocephalus accompanying encephalomyelocele (18%); two cases caused by CNS defects (18%); two cases of congenital hydrocephalus (18%); posthemorrhagic hydrocephalus was noted in 50% and postinflammtory and post-traumatic did not occur at all (Table 2).

As Table 2 shows, most of the differences in etiology related to birth time turned out to be statistically insignificant. Posthemorrhagic hydrocephalus, however, was significantly more common in premature infants (50%) than in full-term newborns (13%) ($p < 0.05$).

The analysis showed that 90% of the babies born to mothers who live in the countryside were full-term newborns and 10% were premature. Among the babies born to city residents 78% were full-term and 22% were premature. Considering cases of hydrocephalus caused by encephalomyelocele, it can be stated that it occurs more often in children from the countryside (48%) than in those from a city (44%). Similarly, hydrocephalus caused by CNS defects occurs more frequently in children from the countryside (33%) than in those from a city (25%). Congenital hydrocephalus was more common among children from the country (24%) than children from cities (19%). However, these are not statistically significant differences (Table 2).

Checking the correlations between posthemorrhagic hydrocephalus and the place of residence, it turns out that it occurs in 28% of the urban subjects and 5% of the rural ones – a statistically significant difference. Post-inflammatory hydrocephalus was

Table 1. Characteristics of the study group

Tabela 1. Charakterystyka grupy badanej

Analyzed feature (Cecha)		N	%
Sex (Płeć)	female	20	35
	male	37	65
Age (Wiek)	full-term	47	82
	premature	10	18
Place of residence (Miejsce zamieszkania)	city	36	63
	countryside	21	37
Etiology of hydrocephalus (Etiologia wodogłowia)	encephalomyelocele	26	46
	hydrocephalus accompanying CNS defects	16	28
	congenital hydrocephalus	12	21
	posthemorrhagic hydrocephalus	11	19
	post-inflammatory hydrocephalus	3	5
	post-traumatic hydrocephalus	2	4
Initial treatment used (Wstępne leczenie)	surgical	47	82
	conservative	10	18
Type of drainage system (Rodzaj drenażu)	Rickham reservoir	24	42
	ventricle-peritoneal valve	29	51
	external drainage	4	7

found only in children from the country (14%); that difference was also statistically significant. Post-traumatic hydrocephalus was diagnosed in two children from the countryside (10%) and in no children in the urban subgroup; that correlation was close to statistically significance (Table 2).

Regarding the type of treatment, it was noted that surgical treatment was used as the initial treatment a bit more often in males than in females, but the difference was not statistically significant. Analyzing the study group in detail, surgical intervention was not postponed among 38 of the full-term newborns (81%) and nine of the premature ones (90%); however, that difference is not statistically significant. Rickham reservoirs were implanted with almost equal frequency in females (45%) and males (41%), whereas ventricle-peritoneal valves were implanted slightly more often in females (55%). Ventricle-peritoneal valves were also used more often among full-term newborns (60%) – a statistically significant difference. In 90% of the premature babies, a Rickham reservoir was implanted. That difference turned out to be statistically significant as well: $\chi^2 = 11.412$; $p = 0.001$. External drainage was used only in full-term newborns, in four cases (9% of the subjects operated on). These data are shown in Tables 2 and 3.

Discussion

Having analyzed the medical documentation, the authors can state that gender does not have a significant effect on frequency of hydrocephalus occurrence among newborns. The fact that in the current study the disease occurred more often in males can be explained by the small study group. There may be a similar correlation with the patients' place of residence although in the study group newborns from cities were in the majority (63% of the whole group). However, according to Roszkowski**,** the incidence of hydrocephalus in the general population is unknown; epidemiological data are fragmentary and basically differ depending on the source [2].

The birth age of the infant has a fundamental significance in hydrocephalus occurrence [18]. In the current study the analysis of the medical documentation showed that among full-term newborns (82% of the entire group), the majority of the cases (51%) were sequels of encephalomyelocele; the second most frequent among full-term infants was hydrocephalus associated with defects of the central nervous system. In the premature subgroup (18% of the entire group) 50% of the cases were posthemorrhagic hydrocephalus, which was a se-

Table 2. Etiology of hydrocephalus and socio-demographic variables

Tabela 2. Etiologia wodogłowia a zmienne socjodemograficzne

	Child's sex (Płeć dziecka)				Child's age (Wiek dziecka)				Place of residence (Miejsce zamieszkania)			
	female		male		full-term		premature		city		countryside	
	n	%	n	%	n	%	n	%	n	%	n	%
Encephalomyelocele (Przepuklina mózgu i rdzenia)	11	55	15	41	24	51	2	20	16	44	10	48
χ^2	1.094				3.207				0.053			
p	0.296 (ns)				0.073				0.817 (ns)			
Hydrocephalus accompanying CNS defects (Wodogłowie z towarzyszącymi wadami o.u.n.)	6	30	10	27	14	30	2	20	9	25	7	33
χ^2	0.056				0.391				0.456			
p	0.812 (ns)				0.532 (ns)				0.499 (ns)			
Congenital hydrocephalus (Wrodzone wodogłowie)	3	15	9	24	10	21	2	20	7	19	5	24
χ^2	0.679				0.008				0.152			
p	0.410 (ns)				0.928 (ns)				0.692 (ns)			
Posthemorrhagic hydrocephalus (Pokrwotoczne wodogłowie)	4	20	7	19	6	13	5	50	10	28	1	5
χ^2	0.009				7.340				4.511			
p	0.921 (ns)				0.007				0.034			
Post-inflammatory hydrocephalus (Pozapalne wodogłowie)	0	0	3	8	3	6	0	0	0	0	3	14
χ^2	1.711				0.0				5.428			
p	0.191 (ns)				0.0				0.020			
Post-traumatic hydrocephalus (Pourazowe wodogłowie)	1	5	1	3	2	4	0	0	0	0	2	10
χ^2	0.202				0.0				3.553			
p	0.633 (ns)				0.0				0.059			

quel of ventricular bleedings. In his book devoted to hydrocephalus Roszkowski asserts that this kind of hydrocephalus in premature babies is a side-effect of improvements in prenatal care: There is an increasing survival rate, but not an increase in the actual frequency of hydrocephalus occurrence in this group [2]. The next most common cause of hydrocephalus among full-term and premature newborns was congenital hydrocephalus and post-inflammatory and post-traumatic changes of brain. Congenital hydrocephalus is defined as hydrocephalus occurring during intrauterine life [2]. The most common reasons for this kind of hydrocephalus are cerebral and medullary hernia, Arnold-Chiari syndrome, lack of opening or closure of the fourth ventricle outflow hole, Dandy-Walker syndrome, congenital cysts, vascular defects, hypoplasia of arachnoidea villi, inflammatory processes (infections) of the brain and meninges, neoplasms of congenital origin and hypertrophy of the choroid plexus [2].

In the examined group surgical treatment was used in 100% of the cases, regardless of sex, birth age, place of residence or etiology. Even in the ten children in whom conservative therapy was implemented at the first stage, surgical intervention eventually became necessary for various reasons. Zakrzewski thinks that despite many in-

Table 3. Type of treatment and socio-demographic variables

Tabela 3. Rodzaj zaopatrzenia wodogłowia a zmienne socjodemograficzne

	Child's sex (Płeć dziecka)				Child's age (Wiek dziecka)				Place of residence (Miejsce zamieszkania)			
	female		male		full-term		premature		city		country-side	
	n	%	n	%	n	%	n	%	n	%	n	%
Rickham reservoir (Zbiornik Rickhama)	9	45	15	41	15	32	9	90	17	47	7	33
Ventricle-peritoneal valve (Zastawka komorowo-otrzewnowa)	11	55	18	49	28	60	1	10	18	50	11	52
External drainage (Drenaż zewnętrzny)	0	0	4	11	4	8	0	18	1	3	3	14

conveniences and problems, treatment with the use of valve systems currently remains the most important and the most frequently used procedure [1]. The purpose of the operative procedures is the reduction or normalization of increased intracranial pressure by removing the cause of disease, implanting a drainage system to provide constant draining of excess CSF from the ventricular system. Although neither sex, birth age, place of residence nor the etiology of hydrocephalus affected the surgical intervention, there was a direct dependence between sociodemographic and clinical details and the type of draining system implanted. According to Zakrzewski, ventricle-peritoneal valves are most commonly used in children [1]. Czepko states that such valves make it possible to place surplus peripheral drain into the peritoneal cavity, which enables long-term functioning of the valve during the child's development, facilitates operative revisions in case of obstruction and the potential complications are only minor [16]. In the present study, ventricle-peritoneal valves were implanted in 51% of the entire patient group. A detailed analysis of the relations between the type of drainage system used and birth age, a valve system was implanted in 60% of the full-term babies and in 10% of the premature babies.

Jankowski [15] and Roszkowski [2] both state that a Rickham reservoir connected with a ventricular drain located in a trephine opening under a child's skin is only moderately invasive and allows easy access to cerebrospinal fluid in the ventricle. This is helpful in collecting CSF for tests, making its losses, antibiotic-therapy or multiple measurement of intracranial pressure [2, 15, 20, 21]. In the present study a Rickham reservoir was implanted 24 times in the total group of 57 newborns. A detailed analysis revealed that a child's birth age, birth weight and degree of morphological maturity were all significant in implanting a Rickham reservoir. Among full-term newborns Rickham reservoirs were used in 32% of the cases, whereas in premature ones they were used in 90% of the cases.

In his chapter devoted to valvular systems Zakrzewski [1] points out that external ventricular drainage is placed in order to temporarily decrease pressure in the brain ventricular system. In the current study external ventricular drainage was only used in four full-term newborns, comprising 9% of the draining systems used.

Hydrocephalus is the most common pathology of the central nervous system in children which requires neurosurgical intervention. It may develop as a result of bleeding in the central nervous system, developmental defects, inflammatory processes, neoplasms and traumas. At the moment of diagnosis an evaluation of sequels, results and the final prognosis is not possible. The last twenty years have shown that the potentials of operative activities in pediatric neurosurgery have broadened very much. Constant improvements to valve systems as well as updated traditional and endoscopic surgical methods allow for the implantation of draining systems as early as during the neonatal period. In Roszkowski's opinion this enhances the chances not only for survival but also for improved functioning and quality of life for patients with hydrocephalus [2].

There is a connection between selected causes of hydrocephalus in the study group and sociodemographic characteristics such as the place of residence or age.

The authors concluded that sociodemographic data (sex, age and place of residence) have no effect on the treatment of hydrocephalus in newborns. In all cases of hydrocephalus in the study, the treatment used was implantation of a drainage system.

Rickham reservoirs are more rarely implanted in full-term newborns than in premature ones, while ventricle-peritoneal valves are more frequently used in full-term newborns than in premature babies. Regardless of the reason for hydrocephalus formation, the treatment is based on surgical intervention and the most common drainage system used to correct defects is the ventricle-peritoneal valve.

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