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CT Profile of Hydrocephalus in Children at the Charles de Gaulle Pediatric Teaching Hospital in Ouagadougou

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Abstract

Aim of the Study: The aim is to analyse the epidemiological, clinical and CT aspects of hydrocephalus in children. **Method:** This was a cross-sectional descriptive study with retrospective collection from 1 June 2021 to 31 December 2022 within the radiology department of Charles De Gaulle Pediatric Teaching Hospital in Ouagadougou, Burkina Faso. The study included the records of patients with hydrocephalus who underwent cerebral computed tomography within this radiology department. **Results:** Hydrocephalus is due to a disorder of the hydrodynamics of the cerebrospinal fluid causing an increase in the volume allocated to this fluid in the brain and being accompanied by an increase in the pressure of this fluid. Its diagnosis is established by Doppler ultrasound or MRI prenatally, transfontanellar ultrasound in newborns and young children whose fontanel is permeable and by CT or MRI in older children, who can also determine the etiology. MRI remains an imaging technique that is less available and less accessible than CT in developing countries like ours. In Burkina Faso, MRI is only available in two private health facilities. The objective of this study was to describe the epidemiological, clinical and computed tomography aspects of hydrocephalus in children at the Charles de Gaulle pediatric teaching hospital in order to contribute to the diagnostic assessment and better management of this pathology. Over 19 months, 105 cases of hydrocephalus were recorded out of a total population of 115 children, or an average of 6 cases per month. The mean age was 17.52 months, with extremes of 03 days and 13 years, and the sex ratio was 1.38. Macrocrania, convulsions and psychomotor retardation were the main clinical signs, with rates of 49%, 34% and 30% respectively. On cerebral CT scan, hydrocephalus was triventricular (41.90%), tetraventricular (40%), and predo-

minantly non-communicating (60%), with a mean Evans score of 0.53. The aetiologies were malformations in 34.28% of cases, tumours in 10.47% and infections in 5.71%. Among the malformations, Arnold Chiari II syndrome associated with *spina bifida* and Dandy Walker syndrome were the most common, accounting for 25% each. Tumour causes were dominated by craniopharyngioma and astrocytoma, each accounting for 27.30% of cases. **Conclusion:** The incidence of hydrocephalus was high in our study. In the absence of MRI (due to its unavailability and inaccessibility), CT revealed hydrocephalus that was predominantly tri- and tetraventricular, and predominantly non-communicating.

Keywords

Hydrocephalus, Malformations, Cerebral, Tomography

1. Introduction

Hydrocephalus is defined as a disorder of the hydrodynamics of the cerebrospinal fluid (CSF) resulting in active dilatation of the ventricular cavities and often the subarachnoid spaces [1]. It may occur before or after birth and may be communicating or non-communicating [2] [3]. It is a frequent multifactorial pathology in paediatrics. Its annual incidence is estimated at 3 per 1000 live births worldwide [2] [3] [4]. Its frequency is higher in developing countries than in developed countries. In sub-Saharan Africa, more than 200,000 new cases are recorded each year in children [5]. Hydrocephalus is of particular interest in children because of its neuropsychological sequelae, which can be life-threatening.

It is diagnosed by prenatal Doppler ultrasound or Magnetic Resonance Imaging (MRI), transfontanellar ultrasound in newborns and young children with a permeable fontanelle, and by computed tomography (CT) or MRI in older children. These tests can also be used to determine the aetiology. MRI is better than CT for investigating hydrocephalus in children because, as well as being non-irradiating, it provides 3D slices with very good resolution. It also explores the posterior fossa more effectively and enables the volume and flow of intracranial CSF to be calculated. However, MRI, although available, is less accessible than CT in our context. The aim of this study was to investigate the CT aspects of hydrocephalus in children at the Charles de Gaulle Pediatric Teaching Hospital (CHUP-CDG) in order to contribute to the diagnosis and improved management of this condition.

2. Patients and Method

This was a cross-sectional descriptive study with retrospective data collection covering the period from 1 June 2021 to 31 December 2022. The study took place in the medical imaging, surgical and pediatric medical departments of the CHUP-CDG in Ouagadougou, Burkina Faso. The study population consisted of patients aged 0 - 14 years who had undergone a brain CT scan during the study

period. Sampling was exhaustive, including all patients who underwent a cranioencephalic CT scan in the radiodiagnostic and medical imaging department of the CHUP-CDG during the study period and whose report suggested hydrocephalus.

Patients whose CT reports were incomplete and patients whose hydrocephalus had been surgically treated prior to the brain scan were not included in the study.

The study variables were:

- epidemiological: age and gender;
- clinical: personal and family history, vital signs on admission, clinical signs;
- tomodensitometry: anomalies or lesions of the skull bones, lesions of the meninges, lesions of the cerebral parenchyma, lesions of the structures of the median line, lesions of the cerebellar parenchyma and lesions of the spine.

Data were collected from reports of brain CT examinations in the medical imaging department, outpatient registers in the medical paediatrics and paediatric surgery departments, and patients' clinical records in the medical paediatrics department.

The data were collected on a standardised and anonymised individual form designed for this study.

The first step was to identify all patients aged between 0 and 14 years who had undergone a cerebral CT scan in the CHUP-CDG medical imaging department and who suggested hydrocephalus. Then, depending on the patient's department of origin, we visited the departments concerned to access the patients' medical records or outpatient registers in order to complete the clinical and socio-demographic data.

The data collected on the individual form were entered on a microcomputer using SPHINX V5 software (Paris, France). SPSS 25 (IBM, New York) and EPI INFO 7.2.3 (CDC, Atlanta) were used to analyse the data. Tables and graphs were formatted using Microsoft Excel 2019 (Windows). Text entry and processing were carried out using Word 2013 (Microsoft Windows).

3. Results

Socio-demographic data

Over the 19 months studied, we identified 115 patients with CT findings suggestive of hydrocephalus and retained 105 patients with complete and usable findings, *i.e.* an average of 6 cases of hydrocephalus per month.

The mean age of the patients was 17.52 months, with extremes of 3 days and 13 years. Table 1 shows the distribution of patients by age group.

There were 61 male patients (58%) and 44 female patients (42%), with a sex ratio of 1.38.

Clinical data

The functional signs that prompted consultation were, in order of frequency, convulsions, psychomotor retardation in 24.52% (13/53) of cases each, fever in 20.75% (11/53) of cases, macrocrania and altered consciousness in 13.20% (7/53)

Table 1. Distribution of patients according to age group (total number = 105).

Age group (year)	Number	Percentage (%)
[0 - 1[	60	57.14
[1 - 5[	38	36.19
[5 -14[	7	6.67
Total	105	100.00

of cases each. The indications for requesting a CT scan were: assessment of hydrocephalus on transfontanellar ultrasound in 42 cases (40%), assessment of *Spina bifida* and convulsions in 16 cases each (15.24%), and psychomotor retardation and assessment of macrocrania in 14 cases each (13.33%).

CT scan data

Bone lesions were observed in 53 patients, or 50.47% (total number = 105): disjunction of the sutures in 47 cases (89%), digitiform impressions in 34 cases (64%) and sellar enlargement in one case (02%). One patient had multiple bone lesions. Figure 1 shows a 3D bone window reconstruction suggestive of hydrocephalus with suture disjunction associated with digitiform impressions in a 51-day-old infant born with a painless lumbosacral swelling.

Meningeal abnormalities were observed in 8 patients or 7.61% (total number = 105): cephalocele was the most frequent meningeal abnormality, reported in 5 patients or 62.50%. Hygroma and cyst arachnoid were observed in 25% each.

Cerebral lesions were observed in 70 patients (67%). These are shown in Table 2.

Hydrocephalus was tri-ventricular in 44 cases (41.90%), tetra-ventricular in 42 cases (40%), bi-ventricular in 17 cases (16.20%) and uni-ventricular in 02 cases (01.90%). It was of the non-communicating type in 63 patients, or 60% (total number = 105). Fifty patients (47.62%) had an Evans index of between 0.3 and 0.5, 34 patients (32.28%) had an index of between 0.5 and 0.7 and 21 patients (20%) had an index of between 0.7 and 0.9.

Transependymal resorption was observed in 21 patients or 20% (total number = 105) and dilatation of the cisterns in 22 patients or 21% (total number = 105). Agenesis of the corpus callosum was found in 03 patients or 2.90% (total number = 105): it was partial in 02 cases and total in 01 cases. Subfalcoral involvement was observed in 03 patients, or 02.90% (total number = 105). Lesions of the cerebellar parenchyma were found in 07 patients or 07% (total number = 105) and are listed in Table 3.

Associated malformations were observed in 30 patients, or 29% (total number = 105), with 16 spinal malformations, or 53.33% of cases. Spinal deformities that occurred on one or more floors at the same time are shown in Table 4. Figure 2 and Figure 3 show respectively a craniopharyngioma of the mesencephalic acqueduct responsible for triventricular hydrocephalus and a *spina bifida* associated with an Arnold Chiari malformation causing triventricular hydrocephalus.

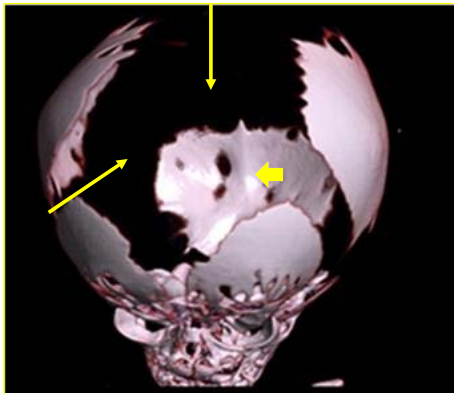

Figure 1. 51-day-old patient, painless lumbosacral swelling (spina bifida); cranioencephalic CT scan, 3D reconstruction, upper view of bone window showing disjunction of sutures (arrows) and digitiform impressions.

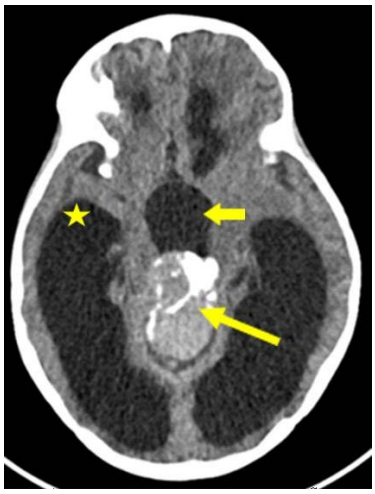

Figure 2. 18-month-old patient, 03 episodes of convulsions and vomiting, gaze levelling off, non-febrile context; cerebral CT axial section parenchymal window, partially calcified tissue expansive process (arrow) projecting from the acqueduct of the midbrain responsible for dilatation of the lateral ventricles (star) and V3 (arrowhead).

Table 2. Distribution of hydrocephalus in children by type of brain lesion, Ouagadougou 2022, Burkina Faso (total number = 70).

Type of brain injury	Number of cases	%
Enlarged cortical sulci	49	70.00
Thinned or laminated cortex	37	53.00
Cortical furrows erased	21	30.00
Cerebral ischaemia	16	23.00
Parenchymal calcification	9	13.00
Craniopharyngioma	1	1.42
Pilocytic astrocytoma	1	1.42
Interventricular septal cyst	1	1.42

NB: The same patient could have several associated brain lesions.

Table 3. Distribution of hydrocephalus in children by type of cerebellar lesion, Ouagadougou 2022, Burkina Faso (total number = 7).

Types of cerebellar lesions	Number of cases	%
Craniopharyngioma	2	29
Pilocytic astrocytoma	2	29
Medulloblastoma	1	14
Blastocytoma	1	14
Cerebellar ischaemia	1	14
Total	7	100

Table 4. Distribution of patients with spina bifida according to spinal level affected (total number = 16).

Spinal stage	Number of cases	%
Lumbosacral	9	56.25
Thoracic-Lumbar-Sacral	3	18.75
Lumbar	2	12.50
Cervico-Thoraco-Lombo-Sacral	1	6.25
Cervico-Lumbar	1	6.25
Total	16	100.00

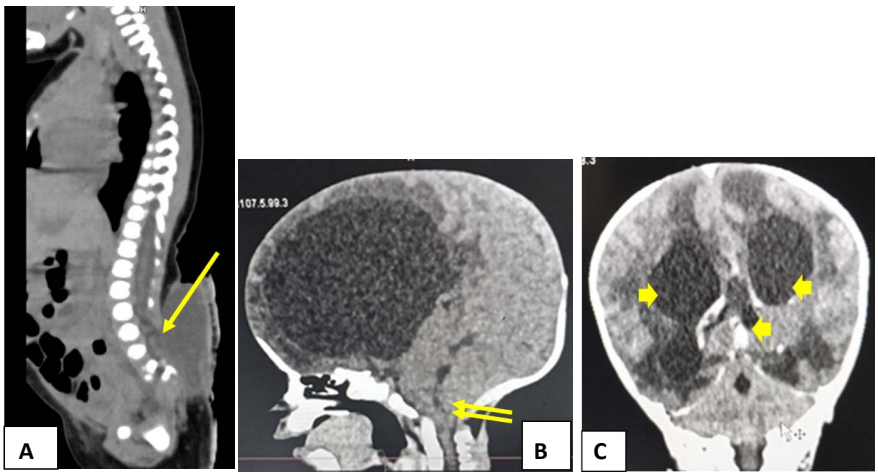

Figure 3. Same patient as in **Figure 1**; spinal CT scan, sagittal reconstruction soft tissue window showing myelomeningocele (A) with bone defect between L3 and S5 (arrow); Cerebral CT scan with parenchymal windows, sagittal reconstruction (B) showing ptosis of the cerebellar tonsils (double arrow): Arnold Chiari II malformation); coronal reconstruction (C) showing dilatation of the lateral ventricles and V3 (arrowheads).

Aetiological data

The CT scan results correlated with the indications for CT scan requests showed 36 cases (34.28%) of malformations, 11 cases (10.47%) of tumour processes and 6 cases (5.71%) of infections, giving a total of 53 cases (50.47%) of lesions caus-

ing hydrocephalus. For the remaining 52 patients (49.52%), no aetiology was found. Table 5 shows the distribution of the types of malformations responsible for hydrocephalus. The different types of tumour causing hydrocephalus are listed in Table 6.

Infectious causes included 5 cases (83%) of meningoencephalitis and one case of cerebral toxoplasmosis (17%).

Table 5. Distribution of patients according to type of malformation (total number = 36).

Types of malformations	Number of cases	%
Arnold Chiari II + *Spina bifida*	9	25
Dandy Walker	9	25
Cephalocele	5	14
Spina bifida	3	8
Aneurysm of the vein of Galen	3	8
Agenesis of the corpus callosum	3	8
Arnold Chiari I + *Spina bifida*	2	6
Spina bifida + Low attached spinal cord	1	3
Arnold Chiari II + *Spina bifida* + MAB* (MAB)	1	3
Total	36	100

*MAB: Lower Muscle Attachment.

Table 6. Breakdown of patients by tumour etiology (total number = 11).

Types of tumours	Number of cases	%
Craniopharyngioma	3	27.30
Pilocytic astrocytoma	3	27.30
Arachnoid cyst	2	18.10
Interventricular septal cyst	1	9.10
Blastocytoma	1	9.10
Medulloblastoma	1	9.10
Total	11	100.00

4. Discussion and Comments

Our study, because of its retrospective nature, had limitations, due to the fact that:

- A number of patient clinical records were not found in the medical pediatrics and pediatric surgery departments;
- Epidemiological and clinical data were incomplete, such as area of residence, monitoring and course of pregnancy, clinical signs.

A particular aspect of our study is that it concerned the postnatal period and the choice of CT, despite its irradiating nature for children, was linked to the low availability and accessibility of MRI.

Nevertheless, we were able to compare our results with data from the literature.

The monthly average of six cases of hydrocephalus in our study was higher than that of Magane [6], who found 1.78 in an earlier study in Ouagadougou. This difference may be explained by the fact that Magane's study was conducted at the Yalgado Ouédraogo Teaching Hospital, which is a general hospital, whereas ours was conducted at an exclusively paediatric hospital, which is also the reference paediatric hospital in Burkina Faso. This paediatric hospital receives all patients aged 0 - 14 referred from any health centre in the country. These days, there is greater availability and accessibility of diagnostic tools for early diagnosis and better management of hydrocephalus, which is clearly more common in paediatric patients.

Children aged less than 12 months were the most represented with 57.14%. Magane [6] and Barry [7] in Mali noted the same observations for the dominant age group in 65.40% and 77.38% respectively.

Clinical data:

Seizures and PMR were the two most frequent first clinical signs, observed in 24.52% each. The same trends have been reported in several studies [6] [8]. Barry [7], on the other hand, reported macrocrania as the most frequent first clinical sign in his study, with 49.50%. This sign was only observed in fourth position in our series (13.20%). According to Gil [9], macrocrania is the most constant sign of hydrocephalus in infants and acute intracranial hypertension is more frequent in children because of the rigidity of the cranium. Overall, the clinical signs found in our study corroborate the data in the literature [10] [11] [12] [13] [14].

CT scan data:

There was a predominance of triventricular (41.90%) and tetraventricular (40%) dilatations. The relatively high proportion of tetraventricular dilatations could be explained in part by a greater frequency of malformative and tumour-related aetiologies of the posterior cerebral fossa. Magane [6] and Soubeiga [14] noted a preponderance of tetraventricular hydrocephalus (47.16% and 48.60% respectively) and triventricular hydrocephalus (41.50% and 42% respectively). For Ngassam [12], this slight difference in the order of frequency of tetra- and triventricular hydrocephalus is mainly due to the disparity of aetiologies. In one study, he reported slightly different results using another investigative technique, transfontanellar ultrasound: triventricular hydrocephalus was observed in 71.42%, followed by biventricular hydrocephalus in 19.64% and tetraventricular hydrocephalus in 7.14%.

CT is one of the imaging techniques indicated to confirm the dilatation of the ventricles, to measure it accurately, to assess its global or segmental, uni, bi, tri or tetra ventricular character, thus orienting the aetiological search and the request for other investigations [15].

Transependymal resorption is generally correlated with the severity of hydrocephalus and intracranial CSF pressure. It was observed in 20% of cases in our study, reflecting good tolerance of hydrocephalus in the majority of our patients.

Magane [6] and Soubeiga [14] reported higher rates, respectively 58.49% and 56.07%. A CT scan can be used to assess the progression of the hydrocephalus and its "active" nature, which appears as irregular spontaneous periventricular hypodensity, predominating in the frontal and occipital horns, due to suffusion of CSF through the ependyma as a result of significant hyperpressure [16].

Cerebral cortical thinning was found in 53% of patients, close to the results of Soubeiga [14] who noted 50.94%. According to the literature, thinning and stretching of the cerebral mantle are the consequences of dilatation of the ventricular cavities. At a late stage, fibrosis and axonal degeneration develop, leading to cerebral atrophy and focal loss of the neuronal population [1] [14].

The role of imaging in investigating the aetiology of hydrocephalus has been clearly established in the literature [17] [18]. Combining radiological data, in particular CT scans, with clinical aspects can not only suggest aetiologies but also suggest appropriate therapeutic options [17] [19]. Barkovich [20] and other authors [17] recommend prenatal ultrasound, which can lead to interventional radiology procedures, and magnetic resonance imaging (MRI), which is better at establishing the extent of the lesion. Our work concerned the postnatal period and the choice of CT was linked to the limited availability and accessibility of MRI.

Malformations were the leading cause of hydrocephalus (34.28%), followed by tumour processes (10.47%) and infectious pathologies (6%), which represents a reversal of the epidemiological trends previously found in our context and elsewhere [5] [6] [12] [21] [22] [23] [24]. According to the literature, infectious causes of hydrocephalus predominate in sub-Saharan Africa [6] [12] [14] [17] [22] [25] [26] [27] [28]. Soubeiga [14], Magane [6], Ngassam [12], Ba [21] in Senegal, Avode [28] in Benin and Warf [29] in Uganda reported an infectious predominance of hydrocephalus in proportions of 43.40%, 44.86%, 35.57%, 46%, 72.72% and 60% respectively. However, this inversion of the aetiological profile of hydrocephalus in children, marked by the predominance of malformative causes over infectious causes, has also been observed by other authors [24]. These include Zabsonre *et al.* [24], Vaessen *et al.* [30] in Belgium, Tabarki *et al.* [31] in Tunisia and Broalet *et al.* [32] in the Ivory Coast, who reported rates of 61.90%, 35%, 81.39% and 45.23% respectively.

This reversal in the aetiological profile of hydrocephalus in children in our context can be justified by several factors: the decline in infectious causes, the persistence of malformative and tumoral aetiologies, diagnosis of which has improved nowadays with the advent of modern imaging techniques such as CT and MRI [24]. Indeed, the decrease in infectious causes in our study could be explained by the reduction in cases of meningitis and malaria in children thanks to the effective implementation of the Expanded Programme on Immunisation (EPI), with pneumococcal and *Haemophilus influenzae* B vaccination coverage reaching 100% in 2018 [24]. In addition, the introduction of the MenAfriVac vaccine into the EPI since March 2017, and the vaccination campaigns against meningitis and chemoprevention of seasonal malaria have encouraged early treat-

ment of these children's illnesses, such as meningitis and malaria.

The most frequent types of malformative hydrocephalus in our study were *Spina bifida* associated with Arnold Chiari II malformation and Dandy Walker malformation, with equal frequencies of 25%. Soubeiga [14] found that congenital stenosis of the aqueduct of Sylvius was the most common malformation (45%), followed by Arnold Chiari II malformation associated with myelomeningocele (25%), while Dandy Walker malformation accounted for only 5% [14]. Magane [6] found that Arnold Chiari II malformations associated with *spina bifida* predominated, followed by Dandy Walker malformations at 48.57% and 14.28% respectively.

Intracranial tumours were the second most common cause of hydrocephalus in children (10.47%), dominated by tumours of the posterior cerebral fossa. Our results are comparable to those of Soubeiga [14] and Vaessen *et al.* [30] who found 13.20% and 12% respectively, but are still lower than those of Magane [6] who found 17%. In terms of tumour type, craniopharyngioma and astrocytoma were the most common, with equal proportions of 27.30%. These same tumour types were observed in second place by Soubeiga [14] at equal rates of 14.28%. On the other hand, Magane [6] reported rates of 38.90%, 16.17% and 11.10% respectively for medulloblastoma, craniopharyngioma and astrocytoma.

Infectious aetiology was observed in 5.71% of hydrocephalus cases (3^{e} after malformations and tumours), a result close to those of Zabsonré *et al.* [24] and Vaessen *et al.* [30] who found 3.1% and 9% respectively, due to the progress made in our country in the prevention and management of infectious diseases.

There was a relatively high proportion of undetermined aetiologies of hydrocephalus in children (49.52%), in contrast to other authors such as Zabsonré *et al.* [24], Magane [6] and Vaessen *et al.* [30] who observed rates of less than 17.50%, 1.87% and 15% respectively. We believe that some patients may have hydrocephalus, the aetiological diagnosis of which would require more refined medical imaging examinations such as MRI.

Other patients may have idiopathic hydrocephalus, the frequency of which should not be overlooked. Further investigations (chromosomal testing, enzyme assays or tests for hypervitaminosis (A) could reduce their frequency. In addition, because of the retrospective nature of our study, some missing data, particularly clinical data, made it impossible to determine the aetiology of hydrocephalus in a large number of patients.

5. Conclusion

Hydrocephalus remains a pathology of concern in paediatrics in our context. In our study, the majority of children aged 0 - 1 years were affected. Convulsions and psychomotor retardation were the most frequently observed clinical signs. Medical imaging, particularly CT scans, plays an important role in the diagnosis of this pathology. It also showed a high proportion of triventricular and tetraventricular hydrocephalus, which could be related to a greater frequency of mal-

formative and tumour aetiologies, particularly of the posterior cerebral fossa. In almost half the cases, no aetiology for the hydrocephalus was found, so MRI, a non-irradiating imaging technique with better performance than CT, would be better indicated for a more accurate diagnosis of the lesion.

Conflicts of Interest

The authors declare no conflict of interest.

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