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CT Scanning in Children in a Country with Limited Resources (Burkina Faso)

Ouedraogo Nina-Astrid[1,2*], Some Judicael Melchisedech[3], Ouedraogo Pakisba Ali[3], Zanga Moussa Sore[1,4], Napon Aischa Madina[1,4], Lougue Leonie Claudine[1,4]

[1]Diagnostic Radiology and Medical Imaging Laboratory, Health Sciences Training and Research Unit, Joseph Ki Zerbo University, Ouagadougou, Burkina Faso
[2]Radiology Department, Bogodogo University Hospital, Ouagadougou, Burkina Faso
[3]Radiology Department, Ouahigouya Regional University Hospital, Ouahigouya, Burkina Faso
[4]Radiology Department, Charles de Gaulle University Paediatric Hospital, Ouagadougou, Burkina Faso
Email: *ninawed@hotmail.com

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Abstract

Objectives: To carry out the assessment of CT scans in children at the Charles de Gaulle University Hospital Center (CGUPH). **Patients and Methods**: This was a retrospective collection descriptive cross-sectional study conducted from July 1 to November 29, 2021 in the Radiology Department of the CGUPH, having included computed tomography (CT) reports of patients under 18 years of age. The variables explored were the data reported on CT reports (type of scan, reason for examination, dose delivered, and abnormalities described). **Results:** Two hundred and ninety explorations were collected. The average age was 2.93 years with extremes of 0 and 17 years. The sex ratio was 1.35. Computed tomography scans mainly explored the cranioencephalic, spinal and abdominal stages. The most common reasons for exploration were fetal suffering and head injuries. The most frequently described lesions were anoxo-ischemic sequelar lesions. Mean irradiation doses were 1096 ± 670 mGy·cm for the cranial-encephalic stage, 603 ± 332 mGy·cm for the spine and 311 ± 395 mGy·cm for the thoracic stage. **Conclusion:** CT in children mainly explored the brain and concerned children under 5 years. Anatomical irradiation doses were higher than diagnostic reference levels in several countries. Optimization of scanning protocols and availability of MRI would reduce ionizing radiation in children.

Keywords

Child, Computed Tomography, Radiation Protection, Burkina Faso

1. Introduction

In sub-Saharan Africa, there has been a boom in imaging, particularly in computed tomography (CT). The number of CT scans performed is growing worldwide, both in adult and pediatric pathological settings [1]. In Netherlands, the number of CTs has tripled in 20 years [2]. Advances in medical imaging are undeniable, even in pediatrics where the use of ionizing radiation brings a certain gain to the evaluation of several pathologies [3].

However, the scanner is the most irradiating diagnostic procedure in medical imaging. The child has an increased susceptibility to the effects of ionizing radiation [4]. Several studies have focused on radiation-induced cancers. Statistically significant risks have been associated with leukemia or brain cancer in children who have been scanned [1].

The principle "ALARA" (As Low As Reasonably Achievable) developed and applied in several countries states that non-irradiating imaging should be preferred in children in imaging. These include ultrasound and magnetic resonance imaging (MRI).

To improve the management of children, the CGUPH, pediatric reference center in Burkina Faso, has since 2021 a CT scanner in the imaging department, strengthening the existing technical platform (standard radiography and ultrasound). This hospital does not yet have an MRI. In Burkina Faso, the policy of free care for subjects under 5 years allowed the population to have access to sectional imaging. But MRI is not widely available or accessible and is only available in the private sector. As well, the average cost of this exam is 3 - 4 times the guaranteed minimum wage.

We have set ourselves the goal of mapping CT scans performed in children in a country with limited resources, in order to propose solutions to optimize the use of ionizing radiation in pediatric settings.

2. Materials and Methods

Our study took place in the medical imaging department of the CGUPH. This hospital is a reference center for the management of children and is located in Ouagadougou, capital of Burkina Faso. This service offers services in conventional radiology and ultrasound. Since May 2021, a computed tomography is available. This was a cross-sectional descriptive study with retrospective collection from May 1 to December 31, 2021.

The target population consisted of reports of CT scans performed at the CGUPH. The source population was CT reports in children aged 0 to 18 years.

We conducted a non-probability sampling of convenience, consisting of CT reports conducted at the CGUPH during the study period. We included all CT reports from children aged 18 and over in the radiology department of the CGUPH for the duration of the study. We excluded reports with uninformed items (socio-demographic data, examination technique, results and conclusion) (**Figure 1**).

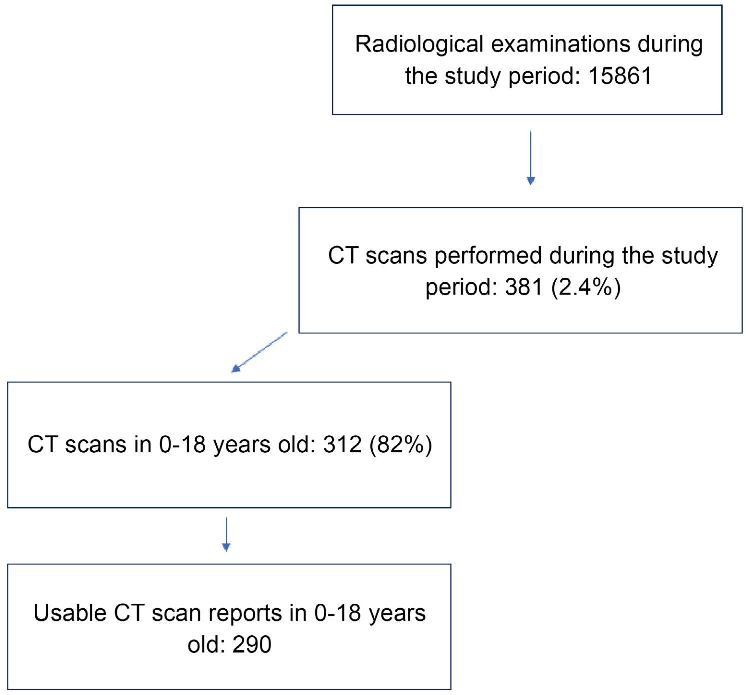

Figure 1. Flow chart of CT scan selection in our study.

The data was collected from a data sheet. The variables collected were subject socio-demographic data, the type of scan, the reason for performing the scan, the scan dose, the description of lesions noted and the conclusion of the scan.

Data capture and analysis was performed on a microcomputer using Microsoft office Word 2016 software; Microsoft office Excel 2016 and Epi info version 7.2

Quantitative variables were presented as an average with standard deviations. Qualitative variables were presented as a proportion.

An authorization was obtained from the management of the CGUPH. The confidentiality of the data and the anonymity of the reports were respected.

3. Results

During the study period, 381 CT scans were performed. Three hundred and twelve computed tomography scans performed, or 81.88%, concerned subjects from 0 to 18 years. Two hundred and ninety reports of CT were exploitable, corresponding to 92.94% of CT performed for subjects under 18 years of age.

Male subjects made up 58% of the sample (n = 167) or a sex ratio of 1.35. The average age was 2.93 years with extremes of 0 and 17 years. The modal class was that of 0 to 5 years with a rate of 81.03%. The distribution of subjects according to age groups is listed in Table 1.

In 58% of cases, patients came from the CGUPH. The general pediatric department prescribed the most CT in 61% of cases, followed by neurosurgery in 23% of cases.

Cranio-encephalic, spine, abdomen and thoracoabdominal region were the

Table 1. Distribution of children by age group.

Age (in year)	Frequency (n)	Percentage (%)
[0 - 5]	235	81.03
]5 - 10]	30	10.34
]10 - 17]	25	8.62
TOTAL	**290**	**100**

most frequently performed examinations in respectively 79.31%, 7.58%, 4.14% and 3.45% of cases. Chest, urinary tree, osteoarticular scans accounted for 5% of CT scans. **Table 2** shows the types of explorations performed in children under 18 years of age.

The reasons for the most frequent CT were related to neurological signs in 61.43% of cases. These were essentially psychomotor delays and head injuries. **Table 3** shows the distribution of CT scans by reason of the study.

CT was performed with iodine contrast injection in 83.45% (n = 242). No reports mentioned a notion of sedation or not.

Mean irradiation doses were 1096 ± 670 mGy·cm for the cranial-encephalic stage, 603 ± 332 mGy·cm for the spine and 311 ± 395 mGy·cm for the thoracic stage. The mean age-specific anatomical exposure doses are shown in **Table 4**. The age distribution of DLP means of cranio-cerebral, thoracic, abdominopelvic CT are shown in **Table 5**.

In 70% of cases, CT scans were pathological. Cranioencephalic CT was abnormal in 72.71% of cases (n = 211). Brain atrophy, brain malformations and ventricular dilatation were the predominant lesions in 31%, 17% and 8% of cases. All spinal CT were pathological with predominance of spina bifida and spondylodiscitis in 63.63% (n = 13) and 18.18% (n = 2) of cases, respectively. Nephroblastoma extension assessment accounted for 42.85% of cases (n = 9) of abdominal-pelvic and thoraco-abdominal-pelvic explorations, followed by traumatic contusion lesions in 2 cases.

4. Discussion

CT scans were more frequently performed in children under 5 years of age. They mainly concerned the exploration of the cranio-encephalic, spinal, abdominal, and thoraco-abdominal stages. Neurological signs were the most frequently observed exploration patterns and the lesions described were mainly related to sequelar lesions of encephalic anoxo-ischemia.

The policy of free care set up by the government in 2016, has allowed people, regardless of their socio-economic level, to benefit from access to care including some medical imaging explorations. In our context, MRI is not functional in the public sector and is only available in the private sector. Moreover, it is not very accessible to the population, with an average cost representing 3 to 5 times the guaranteed minimum wage in Burkina Faso. This context could explain that CT,

Table 2. Distribution of children by type of CT scan.

CT Type	Frequency (n)	Percentage (%)
Cranio-cerebral	**230**	**79.31**
Lumbar spine	22	7.58
Abdominopelvic	12	4.14
Thoraco-Abdomino-Pelvic	10	3.45
Thoracic	7	2.41
Uro scanner	4	1.38
ORL	4	1.37
Osteoarticular	1	0.34
TOTAL	**290**	**100**

Table 3. Distribution of Reasons for Requesting Modern Tissue Testing in Subjects Under 18.

INDICATION	Frequency (n)	Percentage (%)
Psychomotor delay	84	25.79
Head injury	33	11.38
Macrocrânie	19	6.55
Motor deficit	23	7.92
Spina bifida	24	8.30
Hydrocephalus	11	3.80
Maxillocervical-thoracic mass	11	3.80
Retinoblastoma	10	3.45
Craniofacial swelling	10	3.44
Nephroblastoma	7	2.41
Headache	5	1.72
Coma	5	1.72
Exophthalmitis	5	1.72
Abdominopelvic mass	5	1.72
Dyspnea	4	1.38
Loss of consciousness	5	1.72
Polymalformative syndrome	5	1.72
Abdominal-pelvic pain	3	1.03
Fever	3	1.03
Leucocoria	5	1.72
Post-operative control	2	0.69
Chest pain	2	0.69
Burkitt's lymphoma	2	0.69
Meningoencephalocele	2	0.69
Purulent otitis	2	0.69
Other	3	1.03
TOTAL	**290**	**100**

Table 4. Average distribution of PLD by anatomical region.

Anatomical region	Average (mGy·cm)	Standard Deviation
Abdomen and Pelvis	527	697
Skull	1096	670
Spine	603	332
Rock	1428	-
Sinus	762	697
Thorax	311	395

Table 5. Age distribution of DLP means of cranio-cerebral, thoracic, abdominopelvic CT.

Age (Years)	Brain CT		Chest CT		Abdominopelvic CT	
	Medium (mGy·cm)	Standard deviation	Medium (mGy·cm)	Standard deviation	Medium (mGy·cm)	Standard deviation
[0 - 1]	1014.93	816.64	158.6	210.21	134	57.71
]1 - 5]	1066.48	545.42	578.25	588.2	248.75	121.18
]5 - 10]	1316	589.42	0	0	441.88	498.97
]10 - 17]	1515.61	621.68	208	179.15	1038.16	1073.65

a modality available in the public, and included in the free care for 0 to 5 years, is mainly performed in children of this age group.

Cranioencephalic explorations were predominant, as noted in several international and regional studies [2] [5] [6] [7]. However, some studies have noted that tumour and traumatic etiologies are predominant in CT scans of children [8] [9].

In our study, the primary reason for cranioencephalic CT exploration was signs of neurological distress in % of cases. Indeed, in our context, neurological pathologies in children are frequent in connection with the sequelae of perinatal anoxo-ischemia and infections [10]. There is a morbid high perinatal mortality, linked to the conditions of monitoring pregnancy and delivery conditions, causing fetal or neonatal suffering providing neurological sequelae. Neonatal suffering comes in 5th position of neonatal conditions at BF. Psychomotor delay, which is one of the signs of cerebral palsy, is a real public health problem in our country.

The low accessibility of MRI and the impossibility of performing transfontalar ultrasound in children older than 9 months due to the physiological closure of the anterior fontanel, may explain that the high prevalence of cranial CTencephalic for non-traumatic causes. The encephalic CT may be limited especially for the exploration of white matter, gyration and cerebellum. Patel *et al.* [11] noted that 80% of CT scans performed in children for seizures were without visible abnormalities.

Cranioencephalic trauma was the second reason for performing encephalic

CT. This examination is recommended in cases of persistent or worsening neurological disorders, focal neurological signs or obvious brain injury, to search for bone and brain lesions [12]. Some studies have shown, however, that other criteria that may influence the achievement of CT in the case of head-brain injury, namely an age greater than 2 years and the occurrence of trauma during the weekend [13].

The exploration of the spine came in second place after the cranio-encephalic stage. Regarding spinal pathology, the recommendations of the American College of Radiology suggest the use of imaging in case of nocturnal spinal pain or inflammatory gait or in case of persistent pain after 4 weeks. If standard radiography is indicated in 1intentionto eliminate isthmolysis, MRI is the reference exam for the exploration of other spine and spinal pathologies. CT is not recommended as a first-line treatment in children, as it delivers significant radiation delivered to children [14]. The spinal pathologies in our case were essentially of malformative, infectious or inflammatory origin and would have justified the realization of an MRI.

The nephroblastoma extension assessment was the most frequent examination performed on the abdominopelvic and thoraco-abdomino-pelvic levels. It is a frequent tumor of the child, coming in the literature in 3th rang tumors of the child. It is the first renal tumor in children, with a peak of occurrence between 2 and 3 years [15]. In Burkina Faso, this tumor is the most common of the retro peritoneal masses. Savadogo *et al*. [16] noted a clear preponderance of nephroblastomas among retroperitoneal masses (78.4%). In front of an abdominal-pelvic mass or urinary signs, ultrasound is often the first-line examination in children. CT or MRI is performed to perform extension assessment and post therapeutic monitoring. If MRI is by far preferred for safety reasons, CT, more accessible is often more widely performed. These two explorations have relatively the same sensitivity for lymph node extension. However, MRI has a better sensitivity for the detection of extracapsular ruptures of nephroblastoma, the detection of small contralateral foci, the evaluation of the tumor after chemotherapy and during postoperative surveillance.

The CT scan of the chest may be justified in our context because of delays in consultation and diagnosis of this condition. Indeed, Douamba *et al*. [17] reported that 79.1% of nephroblastomas were metastatic at the time of diagnosis, due to late consultation, justifying thoracic exploration.

Chest CT scans alone were poorly performed. Indeed, standard chest radiography is often sufficient and delivers a lower radiation dose. Infectious or thoracic malformative etiologies were infrequent. Thoracic CT was most often included in the nephroblastoma extension assessment. Indications in hematology represented the majority of chest explorations according to Esser *et al*. [18].

Exploration of abdominal trauma was infrequent. This may be justified by the fact that radiography and ultrasound are often the first-line examinations performed in bruises of the chest and abdomen. Fenton *et al.* [19] reflected on the relevance of CT in traumatic pediatric settings. He showed a high rate of normal scans and a low rate of post traumatic surgery, particularly in the abdominal region.

The doses delivered to children according to age groups and the area explored was generally higher than the diagnostic reference levels in the literature [20]. These results may be related to non-optimized scan protocols. Several studies have begun to study the radiation doses delivered to children in order to develop recommendations to optimize the use of these explorations [8] [21] [22].

Adambonou *et al.* [23] had shown that about 53% of CT applications in children were not justified, referring to the guide to the proper use of medical imaging examinations.

The indication must be relevant and the protocols applied on a case-by-case basis. Alternative CT examinations should be offered (standard radiography, ultrasound, magnetic resonance imaging) depending on their availability and accessibility both geographically and financially. In the study by Solomon *et al* [24], 6.5% of CT applications in children were not a priori justified and a non-irradiating exploration was proposed as a substitute.

Although CT is a useful paraclinical examination in the management of several conditions, the benefit-risk ratio must always be studied. Some children with early irradiation may develop radiation-induced cancer [25].

5. Conclusions

Despite the monocentric nature of our study, we were able to map CT scans in children at the CGUPH. The most frequently performed CT examinations were cranioencephalic explorations, mainly for psychomotor delays. These were the first indications for MRI, a non-irradiating examination that is still not very accessible to the general public. These examinations were most often carried out on children in the age group eligible for free healthcare. However, the doses delivered to children were higher than the international diagnostic reference levels.

We need to make it easier for people, particularly children, to access non-irradiating imaging such as MRI. We also need to look at ways of optimising and reducing the radiation delivered to subjects who are particularly sensitive to the effects of ionising radiation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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