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Abnormal Findings in Brain CT Scans Among Children

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Background: CT scan is one brain imaging method, being used to a greater extent than the past.
Objectives: This study aimed to investigate the prevalence of abnormal findings in brain CT scans among children as well as the reasons for brain CT scan requests.
Patients and Methods: In the present case series, demographic information and CT scan reports of 167 patients referred to Taba Radiology Center in Shiraz from April 2010 to August 2011 were collected. The major complaints of the patients were gathered through phone contacts. Descriptive statistics and Pearson chi-Square tests were used. $P < 0.05$ was considered statistically significant.
Results: Among the 167 patients, 84 (50.3%) were males and the average age of the patients was 12.5 ± 4.7 years. Twenty patients (11.98%) had abnormal CT scans. The most prevalent abnormal findings were arachnoid cyst in 4 (20%), cerebral hemorrhage in 3 (15%), atrophic change in 3 (15%), hydrocephaly in 3 (15%), and congenital underdevelopment in 2 (10%) cases. The most common major complaints included headache in 73 (60.8%), head injury in 14 (11.5%), and seizure in 12 (10%) patients. Only 2.7% of the patients with headaches showed abnormal findings in CT scans, compared with 17% of patients with other complaints; this difference was significant ($P = 0.013$).
Conclusions: Headache, seizure, and trauma are the main reasons for CT scan requests. About 12% of the brain CT scans were abnormal. Being knowledgeable about the indications of imaging, unnecessary imaging can be prevented, and consequently, its risks can be minimized.

Keywords: Tomography, X-Ray Computed; Child; Complications

1. Background

After the development of CT scan, a revolution occurred in diagnostic radiology and since 1970, the method has been used more and more extensively. It has been estimated that more than 62 million CT scans are performed annually in the US, 4 million or more of which are related to children, while one-third of them seem to be are unnecessary (1, 2). In spite of all the advantages of CT scans as the golden standard in diagnosis of a large number of diseases, the statistics of the dosages associated with CT are higher than those of other radiological examinations. The radiation dose from one abdominal CT scan is commonly reported to be equivalent to that of 100 to 250 chest radiographs (3-5). Use of CT scans in children to deliver cumulative doses of about 50 mGy may triple the risk of leukemia and doses of about 60 mGy may triple the risk of brain cancer (6). Organizations responsible for evaluating the risk of radiation agree that there is no specific threshold of radiation to induce cancer. However, children are much more radiosensitive than adults. For example, a one-year-old infant is 10-15 times more likely than a 50-year-old adult to develop a malignancy from the same doses of radiation (7). This higher sensitivity might be due to longer life span and possession of a higher count of dividing cells in children (6-9).

In general, it is the responsibility of the physician to restrict the utilization of ionizing radiations, in conditions where advantages are clearly higher than the related risks. According to the as low as reasonably achievable (ALARA) principle, the reasonably achievable dose for any diagnosis can be obtained by using appropriate apparatuses and correct techniques (9-12). Based on what is mentioned above, the basic way for minimizing CT scan radiation dose is preventing unnecessary scans among children.

2. Objectives

The present study aimed to investigate the frequency of abnormal findings in brain CT scans among children based on higher demands for their performance, deter-

Implication for health policy makers/practice/research/medical education:
This article shows the reason for unnecessary of many requests for brain CT scans among children. Being knowledgeable about the accurate indications, radiation risks can be minimized.

mine the reasons for such requests, and propose the notion that many image requests are unnecessary.

3. Patients and Methods

Demographic information and brain CT scan reports of the children referring to Taba Radiology Center, Shiraz, Iran, with diverse major complaints between April 2010 and August 2011, were retrospectively collected through the field method. The data had been documented on computer by a relevant radiologist. All children between 1 month and 18 years were enrolled in the study. At the same time, major complaints by patients were collected through phone contacts. Consequently, 167 patients were investigated. All the statistical analyses were performed using the SPSS statistical software (version 19). Descriptive statistics and tables were used to express the observation results. Inferential statistics, P values, and the Pearson chi-Square test were also utilized. $P < 0.05$ was considered statistically significant.

4. Results

The data of 167 patients referred to Taba Radiology Center from April 2010 to August 2011 were collected. Among the patients, 50.3% (84) were males and 49.7% (83) were females. The major complaints of 120 of them were gathered through telephone contact. Their ages ranged from 1 to 18 years with the average of 12.5 ± 4.7 (Table 1). Besides, the average age of males and females were 12.45 ± 4.45 and 12 ± 4.96 years, respectively (Table 1). The average age of the patients with normal and abnormal brain CT scans were 12.56 ± 4.63 and 12.45 ± 5.2 years, respectively. Twenty patients (11.98%) had abnormal CT scans and at least one abnormal finding was detected in their scans (CI: 95%, 8-16%) (Table 2). The most prevalent abnormal findings were arachnoid cyst in 4 (20%), cerebral hemorrhage in 3 (15%), atrophic change in 3 (15%), hydrocephaly in 3 (15%), congenital underdevelopment in 2 (10%), and encephalomalacia in 2 (10%) cases. The most common principal complaints were headache in 73 (60.8%), head injury in 14 (11.5%), and seizure in 12 (10%) (Table 3). Among the 120 patients, 19 (15.8%) had undergone CT scans as a result of family persistence (CI: 95%, 9 - 22%).

Among the 47 patients whose major complaints were not available, 10 (21.3%) had abnormal findings in their CT scans, while of the 120 patients whose major complaints were available, 10 (8.3%) had abnormal findings in their scans (Table 3). Among the 10 patients, the major complaints were headache in two (one suffering from major thalassemia), mental retardation in two, abnormal mass on scalp in two, and cardiac arrest, head injury, paralysis due to hypoxia at birth, and shunt evaluation due to hydrocephaly in the remaining four cases. The average ages of patients with normal and abnormal CT scans were 12.5 ± 4.6 and 12.4 ± 5.2 years, respectively, and the difference was not statistically significant (P = 0.919). According to the study results, 92.8% of females and

Table 1. Demographic Data, CT Scans, and Major Complaints of Patients [a, b, c]

Variable	Mean ± SD/No. (%)
Age	12.55 ± 4.70
Male	12.45 ± 4.45
Female	12 ± 4.96
Normal CT	12.56 ± 4.63
Abnormal CT	12.45 ± 5.20
Gender	
Male	84 (50.30)
Female	83 (49.70)
CT scan	
Normal	147 (88.02)
Abnormal	20 (11.98)
Abnormal CT scan	
Male	14 (70)
Female	6 (30)
Parental request for CT scan	
Male	12 (63)
Female	7 (37)
Knowledge of patient complaint in abnormal CT	
Yes	10 (50)
No	10 (50)
Major complaints in patients with abnormal CT	
Headache	2 (20)
Developmental delay	2 (20)
Head injury	1 (10)
Abnormal mass on scalp	2 (20)
Cardiac arrest	1 (10)
Paralysis by asphyxia at birth	1 (10)
Shunt evaluation due to hydrocephaly	1 (10)

[a] Average ± SD for continuous variables.
[b] No. (%) for categorical variables.
[c] T-test for continuous variables and chi-square or Fisher exact test for categorical variables.

Table 2. Abnormal Findings in Brain CT Scans

Abnormal Findings in Brain CT Scans	Results, No. (%)
Subdural hematoma	1 (5)
Epidural hematoma	1 (5)
Hematoma in temporoparietal region	1 (5)
Leukodystrophy	1 (5)
Arachnoid cyst	4 (20)
Encephalomalacia due to previous ischemic process	1 (5)
Congenital undevelopment of brain tissue	2 (10)
Lipoma of corpus callosum	1 (5)
Shunt insertion and hypodensity due to previous surgery	1 (5)
Hydrocephaly	1 (5)
Intracranial metastatic lesion due to sarcoma of bone	1 (5)
Thickening of frontal bone - the possibility of extra medullary hematopoiesis	1 (5)
Encephalomalacia due to traumatic process	1 (5)
Atrophic change and hydrocephaly	2 (10)
Ischemic change and atrophic change	1 (5)
Total	20 (100)

Table 3. Major Complaints (MC) of Patients

Variable	Chief Complaints Before CT Scan, n = 120, No. (%)	Chief Complaints Before CT Scan in the Children With Abnormal Scans, n = 10, No. (%)
Headache	73 (60.80)	2 (20)
Head injury	14 (11.50)	1 (10)
Seizure	12 (10)	0
Vertigo	3 (2.50)	0
Mental retardation	2 (1.60)	2 (20)
Large head circumference	3 (2.50)	0
Abnormal mass on scalp	4 (3.3)	2 (20)
Cardiac arrest	1 (0.83)	1 (10)
Paralysis due to hypoxia at birth	1 (0.83)	1 (10)
Shunt evaluation due to hydrocephaly	1 (0.83)	1 (10)
Others	6 (5)	0

83.8% of males had normal CT scans; thus, females had a greater number of normal CT scans compared to males. Although this difference was not significant at 0.05 significance level (P = 0.06), it can be considered significant at 7% error level. Among the 19 patients, 12 (63%0) of males and 7 (37%) of females insisted on performing brain CT scans; however, the difference was not statistically significant (P = 0.116). Results of the current study revealed abnormal findings in only 2.7% of the patients with headaches (total: 73 patients), compared with 17% of those with other complaints (total: 47 patients). This difference was statistically significant (P = 0.013). Moreover, 7.1% of the 14 patients with head injuries and 8.5% of the 106 with other major complaints had abnormal CT scans; however, no significant difference was found between the two groups ($P \approx 1.000$). None of the patients who had complained about seizure had abnormal findings in their CT scans. On the other hand, 9% of the 108 patients with other major complaints had abnormal scans. Nonetheless, the difference was not statistically significant (P = 0.596).

5. Discussion

After sonography which is the preferred imaging method for screening the central nervous system (CNS) during the infancy (13), CT scan is the next preferred method for all other ages. Moreover, it is offered as the first choice in emergency and acute clinical diagnoses (14). Despite that, the risks of this method should be considered alongside its advantages. It seems that many scans are unnecessary. In a large number of studies, pathological findings in brain CT scans of children have been reviewed and actual indications of performing CT scans have been mentioned based on the prevalence and frequency of the

findings. These results have emphasized on the necessity of performing CT scans under varied circumstances. However, due to lack of ionizing radiation and high accuracy, magnetic resonance imaging (MRI) is preferred in special cases (15-22). The current study was performed on 167 patients, of which major complaints for 120 were available. Among the 167 patients, 88.02% and 11.98% had normal and abnormal CT scans, respectively. The most prevalent abnormal finding was arachnoid cyst (4, 20%) followed by different types of cerebral hemorrhage (subdural, epidural, and parenchymal, each in 1, 15%), hydrocephaly (3, 15%) atrophic changes (3, 15%), and congenital underdevelopment of the brain tissue (2, 10%). The study results revealed no significant relationship between the age of the children and existence of abnormal findings in the CT scans. None of the 12 patients (10%) who had complained about seizure showed abnormal findings in their CT scans.

Khodapanahandeh conducted a retrospective study in Tehran in 2006 and investigated the medical records of 125 patients between 1 month and 15 years, who had suffered from new-onset afebrile seizure (23). CT scans and MRIs were performed for 108 and 11 patients, respectively, and the results were normal in 90% of the cases. Of the 12 patients with abnormal images, 10 showed abnormal findings in the neurological examination, as well. The most prevalent abnormal findings were different types of cerebral hemorrhage (subdural, epidural, and parenchymal). Other findings included medulloblastoma tumor, calcification (tuberous sclerosis), acute disseminated encephalomyelitis, lupus, cerebral ischemia, and arachnoid cyst. The study results revealed a significant relationship between focal seizures as well as age (under 2 years) and abnormal neuroimaging. Gaillard et al. conducted a study in the US in 2009 and investigated 30 retrospective and prospective studies in which CT scan or MRI had been used for evaluation of new-onset seizures (24). The results showed that 50% of the images were abnormal in children with local seizures. The study emphasized that in the absence of a history of localization-related seizure, abnormal neurological examination and abnormal EEG (electroencephalography), significant abnormality in the image are rare. In the present study, among the 120 patients whose main complaints were available, headache was the most common major complaint (73 patients, 60.8%). Among these cases, 2.7% had abnormal CT scans. In one case, the abnormal finding was arachnoid cyst and increasing intensity of the frontal bone of the patient suffering from major thalassemia.

In this study, 19 of the 120 patients had undergone CT scan under family persistence. Among the 19 patients, the major complaint of 14 was headache and none had abnormal CT scans. Abnormal CT scans were detected in only 2.7% of the cases with headaches (total: 73 patients) compared with 17% of those with other complaints (total: 47 patients); this difference was statistically significant ($P = 0.013$). Therefore, the probability of abnormal findings in CT scan of patients suffering from headache was significantly lower than those with other complaints. Rho et al. conducted a retrospective study in Japan in 2011 and investigated 1562 patients who reported recurring headaches (25). Brain imaging was performed for 77.1% of the patients 9.3% of whom revealed abnormal findings. In that study, 50% of the children with abnormal neurological examinations, 12.9% with change in the type of headaches, 10.8% with neurological function disorder, 10.1% who had undergone imaging due to their parents' insistence, and 7% with severe headaches had abnormal findings in their images. In addition, the results revealed no significant relationships between abnormal imaging and age, sex, or type of headaches. The study showed that neuroimaging is rarely necessary unless the history or neurological examination suggests structural etiologies. In the current study, head injury was the most common major complaint after headache (14 of the 120 patients, 11.5%). Among these cases, abnormal findings were detected in only one case (7.1%). Richard Lichenstein et al. also conducted a prospective study between 2004 and 2006 (26). CT scan was performed for 15,907 of 43,398 children, reported to 25 emergency services affiliated to the Pediatric Emergency Care Research Network in USA with blunt head injury. Among these cases, intracranial injuries were found in CT scans of 1,156 cases (7.3%). Other studies (27, 28) revealed that patients suffering from traumatic brain injury were classified into Low, moderate and high-risk groups. CT scan is the first step for hemorrhage exclusion only in moderate and severe injuries with central nervous system instability.

Limitations of the present study included lack of access to the patients' physical examination records and that the information in only one center was investigated.

In conclusion, headache, seizure, and trauma are the main reasons for CT scan requests. This study showed that about 12% of the brain CT scans were abnormal. Being knowledgeable about the indications of imaging, unnecessary imaging can be prevented, and consequently, the risks can be minimized.

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Authors' Contribution

The data was collected by Faride Rashidi. Concept and design were determined by Mahnaz Haghighi. The manuscript was prepared by Mahnaz Haghighi and Zahra Kheirandish. Statistical analyses were performed by Mehrab Sayadi.

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