ORIGINAL ARTICLE

# Frequency of Abnormal CT Scans and the Correlation with Patients Complaints in Emergency Department

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## ABSTRACT

### Objectives

Computed tomography (CT) scans are one of pediatric emergency departments' most informative and widely used techniques. The research aimed to investigate the frequency of abnormal brain CT scan and determine its correlation with patient complaints in the emergency department.

### Materials & Methods

A retrospective review was conducted on the records of children who presented with various neurological complaints at the Bahrami Children's Hospital, a referral hospital in Tehran, Iran, over a five-year period (2016-2020). The study included patients who had undergone an emergency brain CT scan within the first 24 hours of their consultation.

### Results

Two hundred eligible children, with a mean age of 5.47±3.81 years, were included in this study. They were categorized into seven groups according to their chief complaints. Based on the findings, 113 patients (58.5%) had normal CT scan reports. The remaining CT scan findings, in order of frequency, included imaging results related to the primary diagnosis (19%), incidental findings (12%), and indications of preexisting disorders (10.5%). Seizure was the most common complaint, leading to a brain CT scan (34%). Children presenting with focal neurological symptoms accounted for the highest frequency of CT scan abnormalities.

### Conclusion

This study concluded that most children presenting with neurological complaints have either normal or insignificant findings on their brain CT scans. Given the potentially harmful effects of radiation exposure, as well as considerations of healthcare costs and time, it is essential to adhere to precise protocols when conducting these scans.

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## Introduction

Computed tomography (CT) scanning is a highly informative technique extensively utilized in pediatric emergency departments in various urgent situations (1, 2). Given the broad diagnostic capabilities of CT scans, it is not surprising that their application has been on the rise since their introduction (1, 2). Several factors have contributed to physicians' preference for CT scans as an imaging modality. One of the key reasons is the ability to produce high-quality images in a relatively short period (2, 3). However, these factors can occasionally lead to unnecessary scanning. As a result, CT scans have often been used to confirm basic diagnoses, even in cases where they may not offer additional benefits (4, 5).

Interestingly, CT scans are predominantly used in children presenting with neurological complaints, including symptoms such as vertigo, dizziness, gait disorders, loss of consciousness, headaches, and seizures. However, this approach seldom uncovers the primary cause of these symptoms (6). Furthermore, research involving children with headaches has indicated that most these scans either yield normal results or identify a benign lesion (7). Indeed, the necessity for sedation in pediatric patients during scanning is undeniable. Meanwhile, due to the potential risks associated with the ionizing radiation emitted by CT scans, their use should be limited to selected children (8). Notably, children, particularly infants, are at greater risk due to the ongoing development of their brains. As such, exposure to unnecessary radiation should be stringently limited (9). Another crucial consideration is the cost-effectiveness of CT scan protocols and other imaging techniques (10). Physicians should adhere to specific practical guidelines, which can provide them with a clear understanding of the cost-benefit implications of their imaging choices for the healthcare system (11).

The current study aimed to evaluate the frequency of abnormal CT scans and to investigate the correlation of patient complaints with brain CT scan findings in the first 24 hours of admission among patients referred to an emergency department with specific chief complaints, including loss of consciousness, acute neurological focal deficits, gait disturbances or imbalances, headaches, seizures, and complex febrile convulsions (FCs).

## Materials & Methods

This cross-sectional retrospective research, conducted between March 2016 and March 2020, included children aged six months to 17 years. Patients who exhibited any of the following seven neurological complaints were included in this study: Loss of consciousness, balance disturbances or gait disorders, acute neurological focal deficits, headaches, seizures, seizures with fever, and falling. These patients were admitted to the emergency department of a referral children's hospital, and a non-contrast CT scan was performed within the first 24 hours of their admission.

Two hundred children were recruited for this study. Each patient's demographic information (e.g., sex, age, and clinical manifestations) and CT scan findings (e.g., significant findings, incidental findings, findings related to preexisting disorders, and normal findings) were extracted from their medical records and documented in a checklist. All CT scans were conducted in the same radiology department and interpreted by a single radiologist. Any abnormal findings were rechecked and confirmed. Subsequently, the patients were categorized into seven groups

according to their chief complaints. The data from these groups was then analyzed to determine the frequency of abnormal CT scan findings and to investigate the correlation between patient complaints and the findings of brain CT scans.

**Statistical analysis**

The data was analyzed using SPSS Version 28.0 (Chicago, IL, USA). Quantitative variables were expressed using mean and standard deviation (SD), while qualitative variables were represented by frequency and percentage. A P-value less than 0.05 was considered statistically significant.

## Results

The present study included 200 children, aged between six months and 17 years, who were categorized into seven groups based on their initial clinical manifestations. The mean age of the children was 5.47±3.81 years (age range: 0.5-17 years). Overall, 108 children (54%) were male, and 92 (46%) were female. The mean age of the female group was 5.33±3.81 years, while that of the male group was 5.60±3.82 years.

Seizure was the most common complaint, leading to a brain CT scan (28%). Other complaints included headaches (21%), falling (17%), loss of consciousness (14.5%), seizures with fever (11.5%), acute focal neurological deficits (5%), and balance disturbances or gait disorders (3%), respectively. The CT scan findings were reported as normal in 117 (58.5%) out of the 200 cases. The abnormal CT scan findings were categorized as follows: Specific findings (refers to findings associated with the final diagnosis ((19%, n=38), incidental findings (refers to findings not related to the final diagnosis and have no clinical value, such as arachnoid cysts, the thickness of the mucous membrane of the sinuses, and others.) (12%, n=24), and indications of preexisting disorders (refers to findings that related to previous disorders, such as brain atrophy, brain structural disorders, and the like.) (10.5%, n=21), respectively. The results of the brain CT scans, categorized by the primary manifestations, are summarized in Table 1.

Among patients suspected of having a space-occupying lesion, the most common chief complaint was a headache (50%); in these instances, the CT scan yielded positive results in 66.67% of cases. The distribution of patients with normal CT scan findings was as follows: 24% with headaches, 22% with seizures, 19% with falls, 14.5% with FCs, 13% with loss of consciousness, 4% with a focal neurological deficit, and 3.4% with a balance disorder. These findings suggest that CT scans may not always accurately identify the primary disorder in such cases. Furthermore, they may delay diagnosis and treatment, harming the patient's outcome.

## Discussion

The increased utilization of CT scans in emergency departments can be attributed to their accessibility, efficiency, and accuracy. They offer rapid results, aiding in urgent, potentially life-saving decisions. There are clear guidelines for the use of CT scans in trauma cases. These guidelines assist physicians in maximizing the benefits of CT scans while minimizing the risks of radiation exposure in children and also help reduce healthcare costs (12). Despite the widespread use of CT scans, clear guidelines are still lacking for when an emergency CT scan is essential in neurological emergencies. Interestingly, despite the increased use of CT scans, the rate of positive findings in children referred to emergency departments has remained unchanged; this suggests that the overuse of CT

**Table 1.** Brain CT scan findings according to patients' initial complaints (n=200)

| Chief complains | CT Scan Findings | | | | Total |
|---|---|---|---|---|---|
| | Normal N(%) | Significant* N(%) | Accidental** N(%) | Previous Disorders*** N(%) | |
| Seizure | 26 (46.4) | 9 (16.1) | 12 (21.4) | 9 (16.1) | 56 (100) |
| Headache | 28 (66.7) | 8 (19) | 4 (9.5) | 2 (4.8) | 42 (100) |
| Falling | 22 (64.7) | 8 (23.5) | 3 (8.8) | 1 (2.9) | 34 (100) |
| Loss of consciousness | 15 (51.7) | 6 (20.7) | 3 (10.3) | 5 (17.2) | 29 (100) |
| Febrile Convulsion | 17 (73.9) | 3 (13) | 0 (0) | 3 (13) | 23 (100) |
| Focal neurologic deficit | 5 (50) | 4 (40) | 1 (10) | 0 (0) | 10 (100) |
| Imbalance | 4 (66.7) | 0 (0) | 1 (16.7) | 1 (16.7) | 6 (100) |

* Imaging results that related to the final diagnosis

** Imaging results that not related to the final diagnosis and without clinical value

*** Imaging results that related to preexisting disorders

scans may not necessarily lead to more accurate diagnoses (2). Importantly, in specific situations, CT scans may be more time-consuming and less beneficial than anticipated. Furthermore, the potential complications of radiation exposure in children should be noticed. This is due to their developing systems and longer life expectancy, which could increase the probability of adverse effects compared to adults (13, 14). Nonetheless, alternative methods, such as ultrasonography and magnetic resonance imaging (MRI), can sometimes be more beneficial, given their lower radiation exposure rates (2).

In the present study, most CT scan requests (approximately 60%) yielded expected results. Conversely, in the remaining cases that reported abnormalities, about 20% presented new findings. Notably, abnormal results were found in roughly half of the CT scans on patients experiencing seizures without fever. Nearly 16% of these scans yielded new findings, while the rest indicated either incidental or preexisting findings. In this regard, the results of a study by Novak et al. are consistent with our findings, as 50.4% of their cases had normal CT scan findings (15). Additionally, in a study by Khodapanahandeh et al. on 125 children experiencing their first afebrile seizures, 90% of the CT scans showed normal results (16). Similarly, in 2020, Machingaidze et al. concluded that most CT scans performed on children with acute neurological symptoms yielded normal results (17).

Furthermore, in a study conducted on 51 children (age range: 2-13 years) with their first afebrile seizures, neuroimaging abnormalities were reported in 47% of the cases (18). In another study on 71 patients with seizures without fever, 19.7% had significant CT findings (19). Furthermore, in Bergman's study on risk stratification of children experiencing their first onset of seizures,

it was found that 28.4% of the CT scans showed abnormal results (20). Notably, this study was specifically conducted on children with afebrile seizures, so the reported values differ from the current study. Another study found that out of 107 children with seizures who underwent emergency brain CT scans, only 19 exhibited abnormalities (21). Meanwhile, Harden proposed that the yield from emergency CT scans is notably low in children with epilepsy and breakthrough seizures. It was recommended to avoid emergency CT scans for known seizure cases (22).

Given the substantial discrepancies in the outcomes of various studies, it is advisable to establish specific criteria for the necessity of performing emergency brain CT scans in children experiencing their first afebrile seizures. According to the literature, most studies suggest the following indications for an emergency brain CT scan: Focal seizures, focal abnormalities in postictal neurological examinations, age <2 years, seizures lasting ≥5 minutes or of unknown duration, Todd's paralysis, and multiple seizures (16, 19-23).

Among the studied patients who presented with complex FCs, 74% of the CT scans were normal, and 13% revealed significant findings. In contrast, Karimi et al. reported that only four (1.5%) out of 268 children with complex FCs showed abnormal findings in neuroimaging (24). In another study, head CT scans were conducted on 28% of patients with complex FCs, none of which revealed significant findings (25). Evidently, these studies suggest that the chances of finding intracerebral pathologies in these patients are quite low when no other neurological signs or symptoms are present. The risk is the lowest in patients with recurrent febrile seizures. Therefore, it is recommended to conduct imaging only in cases of focal FCs (24, 25).

In the current study, out of 42 children who presented with headaches, 28 had normal brain CT scan findings, while eight revealed significant findings. In contrast, Akpek's study on 592 patients over three years of age found that 92% of these children had normal CT scan findings with no severe intracranial pathology (26). The results of another study evaluating 241 neuroimaging tests in children with headaches showed that only 9.5% of the tests led to a change in treatment. In contrast, nearly 20% reported benign disorders that did not affect the management of the condition. In cases with no abnormal neurological signs, the likelihood of obtaining valuable imaging results was quite low, at approximately 1.2% (27). Therefore, based on the findings of these studies, it can be inferred that the likelihood of identifying significant findings in the brain CT scans of children presenting with headaches but without any abnormal neurological examination is quite low.

The present study diagnosed encephalopathy in 5% of the cases. Notably, encephalopathy can manifest in various clinical forms, including conditions such as epilepsy (28). In In this analysis, out of 29 cases that experienced loss of consciousness, 15 had normal brain CT scans, and only six (20%) revealed significant findings. Previous studies have suggested MRI as the preferred imaging method for these patients. Consequently, even in cases where the CT scan is normal, there is a potential for additional findings to be detected via MRI. However, abnormal findings in a CT scan increase the probability of discovering abnormalities in an MRI (29, 30). In this research, involving 34 trauma patients, 22 had normal brain CT scan findings, while eight cases revealed significant findings. Importantly,

established guidelines for conducting brain CT scans in cases of head trauma are routinely followed in clinical practice (31).

While CT scans are invaluable imaging tools in emergency departments due to their ability to provide quick results and facilitate timely decisions, their overuse can be mitigated. This can be achieved by introducing other imaging modalities that pose lower risks to children and also by establishing new decision rules and protocols in emergency departments. These measures can guide physicians to reduce the frequency of CT scan orders, increasing their productivity and efficacy. Furthermore, enhancing clinical skills and conducting precise physical examinations can be the best guide for CT scan requests, enabling the clinical detection of the primary pathology.

Limitations: This study had limitations, including a small sample size and being conducted in a single pediatric center. Additionally, the retrospective design of the study may have influenced the results. Consequently, the obtained results may not be generalizable. Future studies should involve a larger sample size and a more thorough analysis for a more thorough understanding.

## In Conclusion

The obtained findings suggest that most children with acute neurological complaints have normal or insignificant findings on their head CT scans. Given the potential harmful effects of radiation exposure, as well as the need to reduce healthcare costs and time, it is crucial to establish precise protocols. We advocate for developing evidence-based guidelines to determine when CT scanning is indicated in children with neurological emergencies. This study discussed some of these cases.

## Acknowledgment

This retrospective study used confidential medical records to source patient information. The Ethics Committee of Tehran University of Medical Sciences (Tehran, Iran) approved this study, under the code IR.TUMS.MEDICIN.REC.1398.393.

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## Authors Contribution

Nahideh Khosroshahi, Simin Khayatzadeh-Kakhki, Seyed Mehdi Alehossein, and Kambiz Eftekhari.contributed to conception and design, acquisition of data, analysis and interpretation of data. Nahideh Khosroshahi, Simin Khayatzadeh-Kakhki and Kambiz Eftekhari. contributed to drafting the article or revising it critically for important intellectual content. All authors contributed to final approval of the version to be published.

## Conflict of Interest

None declared.

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