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# Statistical Analysis of Normal CT Scans in Children Aged 10 and Below at Shahid Sadoughi Hospital, Yazd: A Two-Year Study

Yasin Shafiei[1], Reza Nafisi Moghadam[2], Ali Rajabi[3], Kazem Razavi[2], Rashid Namordi[2], Nasim Namiranian[4], Fatemeh Khaleghi[*2]

[1] School of Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[2] Department of Radiology, Shahid Sadoughi University of Medical Sciences, Yazd, Iran
[3] Department of Tissue Engineering and Applied Cell Science, Shiraz University of Medical Sciences, Shiraz, Iran
[4] Department of Social Medicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

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**Corresponding author:**
Fatemeh Khaleghi

**Email:**
fateme.khaleghi2016@gmail.com

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**ABSTRACT**

**Background:** With the growing frequency of CT scans in children and the importance of limiting radiation exposure in early life, this study investigated the prevalence of normal CT scans among CT examinations in children aged ≤ 10. The research conducted a two-year period (2020-2022) aimed to describe on the distribution of normal and abnormal CT scan results in pediatric patients, emphasizing the need for prudent use of CT imaging.

**Methods:** A descriptive cross-sectional study was carried out, examining the medical records of children aged ≤10 years who underwent CT scans at Shahid Sadoughi Hospital in Yazd from 2020 to 2022. Organ-specific distributions of CT scans by anatomical region were analyzed, and the relationship between CT results, gender, age, and type of CT scan was assessed.

**Results:** From a total of 945 CT scans conducted on children, 30.3% were normal, while 69.7% showed abnormalities. Organ-specific distributions varied across anatomical regions, with lung (55.6%) being the most examined organ. There was no statistically significant association between CT results and gender or type of CT scan. The findings emphasize the necessity for judicious use of CT imaging in pediatric patients to minimize potential health risks associated with excessive radiation exposure.

**Conclusion:** The study showed that 30.3% of CT scans in children were normal, underscoring the importance of appropriate CT scan utilization. While CT scans are beneficial when medically necessary, overuse could pose potential public health challenges. Public awareness and education are essential to ensure the judicious and justified use of CT scans in pediatric healthcare.

## Introduction

Computed Tomography (CT) scans offer detailed three-dimensional images with high resolution, proving to be a crucial tool for precise diagnostics and disease management [1]. The utilization of CT scans has increased rapidly in the United States and globally, especially over the past decade [2]. Notably, there has been a significant rise in CT scans performed on children in the last two decades, with approximately 11% of CT scans conducted annually in the U.S. pertaining to pediatric patients [3].

The high radiation dose associated with CT scans, ranging from 100-500 times that of conventional radiography, has raised significant health concerns [2, 3]. Children, being more radio-sensitive than adults, face heightened risks of radiation-induced carcinogenesis due to their developing bodies and extended lifespan [3, 4]. Long-term studies have highlighted the increased risk of malignancies stemming from childhood radiation exposure, with even low-dose radiation leading to a significant rise in cancer risk over a child's lifetime [3].

Studies by Pearce et al. and Berrington et al. have demonstrated the elevated risks of leukemia and brain tumors in children associated with cumulative doses from CT scans in children [2]. Projections suggest a considerable number of future cancer cases attributable to childhood CT scans [5]. In response to these concerns, various protocols and strategies such as ALARA (As Low as Reasonably Achievable) have been implemented to reduce radiation exposure and minimize the risk of malignancy in pediatric patients undergoing CT scans [3].

To mitigate radiation exposure in pediatric imaging, several strategies can be adopted, including:

1. Implementing guidelines for appropriate imaging requests based on clinical conditions.

2. Educating healthcare providers, patients, and the community to avoid unnecessary CT scan requests.

3. Managing self-referrals for imaging requests.

4. Introducing and promoting alternative imaging modalities like MRI and ultrasound as primary diagnostic tools for certain pediatric conditions.

For pediatric imaging, ultrasound should be considered the initial imaging choice for conditions involving the abdomen, pelvis, pleura, and selected mediastinal conditions. Before conducting a CT scan, ultrasound localization of the pathology is recommended to limit radiation exposure to the targeted area. Additionally, MRI serves as a safe imaging modality for assessing chest wall and cardiovascular conditions in children.

Customizing CT scan parameters based on the specific disease and anatomical location can help reduce radiation exposure. Specialized CT scan techniques with lower radiation levels can be employed, especially for conditions like pectus excavatum and bone tissue imaging. It is crucial to consider that focusing the scan on specific areas may lead to increased radiation at the ends of the imaging range, particularly in helical CT scans [6]. Addressing this challenge can involve incorporating additional filters in the radiation path to mitigate unnecessary exposure. By implementing these strategies and advancing radiation reduction practices, the goal is to enhance the safety and efficacy of pediatric CT imaging while minimizing the potential risks associated with radiation exposure in children. With proper preparation of the patient before imaging and the appropriate use of sedation, it is feasible to prevent the acquisition of inadequate images and the necessity for repeat imaging [7]. Considering the increasing trend of pediatric CT scans and the imperative to restrict radiation exposure in the initial years of life, our study aimed to ascertain the prevalence of normal CT scan findings at the Shahid Sadoughi Educational-Therapeutic Hospital Complex in Yazd. This establishment serves as the most well-equipped pediatric hospital in the province which enabled us to

evaluate both normal and potentially unnecessary scans.

## Materials and Methods

### Patient Selection and Study Design

Children aged ≤10 years, who underwent CT imaging at Shahid Sadoughi Hospital in Yazd between 2020 and 2022, were included in the study. Patients with incomplete demographic or imaging data were excluded.

**Data Collection Method:**

Following approval from the Yazd Medical Sciences Ethics Committee, the study encompassed 945 children aged ≤10 years who visited the radiology department at Shahid Sadoughi Hospital in Yazd from 2020 to 2022. Data recorded included patient age, gender, type of CT scan (with or without contrast administration), and the specific organ examined.

**Data Analysis**

Statistical analysis was performed using SPSS version 22 software (version 22, IBM Corporation, Armonk, NY). Descriptive statistics was utilized to determine prevalence, and intergroup comparisons were conducted using one-way analysis of variance for continuous variables and the chi-square test for categorical variables. A significance level of $P < 0.05$ was employed to denote statistical significance.

## Results

Demographic analysis revealed that 44.1% (417 individuals) were female, while 55.9% (528 individuals) were male. CT scans were conducted on 76.3% (n = 721) of subjects without contrast, 22.0% (n = 208) with contrast, and 1.7% (n = 16) both with and without contrast. Table 1 summarizes the patients' demographic information.

**Table 1:** Demographic Characteristics and CT Scan Types of the Study Population

| | | Number (%) |
|---|---|---|
| Gender | Female | 417 (44.1) |
| | Male | 528 (55.9) |
| CT type | With injection | 721 (76.3) |
| | Without injection | 208 (22) |
| | With & Without injection | 16 (1.7) |

The distribution of examined organs in the study showed the following percentages:

- Lung: 55.6% (n = 525)
- Brain: 16.4% (n = 155)
- Abdomen and Pelvis: 14.1% (n = 133)
- Eyes: 5.1% (n = 48)
- Face and Sinus: 3.4% (n = 41)
- Neck: 2.2% (n = 21)
- Limbs: 1.0% (n = 9)
- Spine: 0.5% (n = 5)
- Ear: 0.4% (n = 4)
- Thoracic Aorta: 0.2% (n = 2)
- Carotid: 0.1% (n = 1)
- Abdominal Aorta: 0.1% (n = 1)

Frequency Analysis of CT Scan Results:

The analysis indicated that 69.7% (n = 659) of the scans displayed abnormal findings, while 30.3% (n = 286) were normal.

Gender Disparity in CT Scan Results:

About 31.6% (n = 167) of female participants had normal results, compared to 28.5% (n = 119) of male participants, with no statistically significant difference (P = 0.319).

Effect of CT Scan Type on Normative Results:

The type of CT scan was not significantly associated with the proportion of normal findings. These findings are summarized in Table 2.

**Table 2:** Frequency and Percentage of CT Scan Findings by Gender

| Variable | | Frequency (%) Abnormal | Normal | P |
|---|---|---|---|---|
| Gender | Female | 361 (68.4) | 167 (31.6) | 0.319 |
| | Male | 298 (71.5) | 119 (28.5) | |
| Ct Type | With Injection | 493 (68.4) | 228 (31.6) | 0.149 |
| | Without Injection | 155 (74.5) | 53 (25.5) | |
| | With & Without Injection | 11 (68.8) | 5 (31.3) | |

The organs with the highest percentages of normal results were the abdominal aorta, orbit, brain, and thoracic aorta, although these differences were not statistically significant (Figure 1).

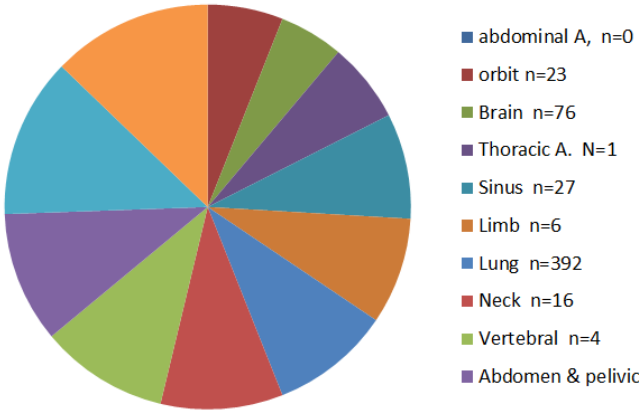


**Figure1:** Frequency and Percentage of Abnormal CT Results by Organ

Based on Table 3, the highest percentage of normal results was observed in children aged 5 years. The highest percentage of abnormal results was observed in children aged 2 and 10 years, with these differences being statistically significant (P = 0.007).

**Table 3:** Frequency and Percentage of CT Findings by Age

| Variable | | Frequency (%) | | P |
|---|---|---|---|---|
| | | Abnormal | Normal | |
| Age (Years) | <1 | 102 (75.6) | 33 (24.4) | 0.007 |
| | 1 | 100 (71.4) | 40 (28.6) | |
| | 2 | 65 (80.2) | 16 (19.8) | |
| | 3 | 53 (71.6) | 21 (28.4) | |
| | 4 | 53 (61.3) | 31 (36.9) | |
| | 5 | 50 (56.2) | 39 (43.8) | |
| | 6 | 47 (61.8) | 29 (38.2) | |
| | 7 | 44 (65.7) | 23 (34.3) | |
| | 8 | 37 (67.3) | 18 (32.7) | |
| | 9 | 35 (66) | 18 (34) | |
| | 10 | 73 (80.2) | 18 (19.8) | |

## Discussion

The primary finding of this research reveals that 30.3% of CT scans conducted on children during the two-year study period were normal. Analysis of the results indicated that there was no statistically significant relationship between CT results and gender or the type of CT scan (with or without contrast injection). The organs with the highest percentage of normal results were the abdominal aorta, orbit, brain, and thoracic aorta, while the carotid, ear, abdomen, pelvis, and spine were associated with the highest percentage of abnormal results, showing statistical significance (P = 0.01). Age-wise, the highest normality rate was observed in children aged 5 years, with the lowest in those aged 2 and 10 years, signifying a statistically significant difference. As no directly comparable studies were found, the results were discussed in the context of related research in the field.

CT scans offer a versatile imaging modality that aids in diagnosing a wide array of medical conditions. Advanced CT scanners deliver precise organ imaging efficiently, with faster scan times that reduce exposure and enhance image clarity, particularly beneficial when imaging children[8]. CT scans allow simultaneous imaging of bone, soft tissue, and blood vessels, offering realistic internal body images. Compared to MRI, CT is less sensitive to patient movements and can be performed even in the presence of implanted medical devices.

The accuracy of diagnostic procedures like needle biopsies and aspirations is enhanced with CT imaging. In some cases, ultrasound serves as an alternative guidance tool for procedures, especially in pediatric cases, potentially avoiding the need for exploratory surgery and biopsy [8].

CT imaging remains a vital tool in modern medicine, enabling the diagnosis of a broad spectrum of diseases. The evolving technology in CT devices has paved the way for diverse clinical applications in healthcare. While there has been a surge in CT usage and machine placements, it is crucial to prioritize patient safety by minimizing unnecessary radiation exposure while ensuring accurate diagnoses [9].

While CT scans are widely used and recommended for most cases, recent research has emerged to explore potential side effects.

The heightened ionizing radiation in CT scans, particularly concerning in children due to their increased radiation sensitivity, poses a risk, with studies indicating increased likelihood of leukemia even from low radiation doses. Thus, caution and judicious use of CT scans are essential to balance diagnostic benefits against potential radiation exposure risks in pediatric populations [10].

The widespread availability of advanced diagnostic imaging technologies like CT scans has resulted in their frequent use, leading to an indiscriminate increase in radiation exposure and healthcare expenditures. Notably, the impact of radiation exposure differs between adults and children, with children being significantly more vulnerable due to their rapid growth and cell division rates. Their prolonged life expectancy further heightens the potential for radiation-induced cancers. Individuals undergoing multiple CT scans before age 15 face an increased risk of developing leukemia, brain tumors, and other malignancies in the subsequent years. Despite the comparatively low risk, about an estimated one cancer case per 10,000 scans performed on children can be attributed to CT scans [10]. A study by Salimi et al. (2020) revealed that 89.9% of CT scans for children presenting with head trauma resulted in normal findings [8].

Fallah et al. (2008) also reported that 61% of CT scans in children yielded normal results [11]. In another study, Mitchell et al. (1993) highlighted the limited necessity of routine CT scans in patients with headaches, emphasizing that significant CT findings were usually accompanied by abnormal neurological symptoms [12]. In addition, Thomas et al. (2015) explored CT scan outcomes in patients with chronic headaches, noting that only a small percentage had significant findings indicative of the necessity for CT scans [13].

While the cancer risk from low-level radiation remains inconclusive, minimizing radiation exposure is crucial in diagnostic imaging. The principle of ALARA (As Low as Reasonably Achievable) advocates for using the lowest radiation levels essential for diagnostic accuracy [10]. Additionally, diagnostic procedures should only be conducted when deemed necessary to reduce radiation exposure risks and ensure patient safety. By adhering to ALARA principles and prudent diagnostic decision-making, healthcare providers can optimize patient care while mitigating radiation-related hazards associated with diagnostic imaging procedures. These approaches are essential in striking a balance between accurate diagnostic information and minimizing potential risks linked to radiation exposure in medical imaging practices.

## Conclusion

The study revealed that 30.3% of CT scans conducted on children aged ≤10 years at Shahid Sadoughi Hospital in Yazd over the two-year study period yielded normal results. It is imperative to underscore that, in medically necessary cases, the benefits of CT scans generally outweigh individual risks. However, the escalating number of scans and inappropriate ordering practices pose a potential public health concern. Hence, raising public awareness and enhancing education are essential to address these concerns. Further research is required to address existing limitations, which may lead to more precise and generalizable results.

**Limitations:**

The retrospective nature of the data limited the scope of the study to the information available in medical records. Given that the study was confined to patients referred solely to the radiology department at Shahid Sadoughi Hospital in Yazd, the generalizability of the findings to a broader population across the country should be interpreted with caution.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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**Ethical Considerations**

The study was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd, Iran (Code: IR.SSU.MEDICINE.REC.1400.391).

**Author's Contribution**

Conceptualization, Y.Sh. and F.Kh.; Methodology, F.Kh. and R.N.M.; Data collection and analysis, Y.Sh. and A.R.; Interpretation of results and literature review, K.R., R.N., and N.N.; All authors have read and approved the final manuscript.

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