Paediatr Croat. 2021; 65 (Supl 1): 118-121

Pregled
Review

COMPUTED TOMOGRAPHY IN PEDIATRICS

SANDRA VEGAR-ZUBOVIĆ[1], ADI BEHMEN[1], HARIS BEKTEŠEVIĆ[1], SABINA PREVLJAK[1], IRMINA SEFIĆ-PAŠIĆ[1], AMRA DŽANANOVIĆ[1], MELIKA BUKVIĆ[1], DANIN ZUBOVIĆ[2]

Introduction: Exposure to ionizing radiation during childhood causes a higher risk of cancer than adequate exposure in adulthood, therefore children deserve special care in the protection against it. Pediatric computed tomography (CT) should be planned individually for every child. Fast CT scanners have reduced the need for sedation and most examinations can now be performed without breath-holding. The main indications for the use of CT in the pediatric population are emergencies (foreign body, trauma, inflammatory diseases), tumors, interstitial and systemic diseases, vascular malformations and congenital anomalies.

The aim of this study is to outline the underlying conditions that justify the use of CT in the pediatric population.

Methods: A retrospective analysis of CT scans performed on the pediatric population over the last three years at the Radiology Clinic of the Clinical Center University of Sarajevo has been conducted, whereas the most common indications justifying the CT scan have been presented.

Results: Over the last three years a total of 780 CT scans were performed in the pediatric population, where we have identified indications that are among the main cases for use of CT in children. Here we presented 5 conditions that justify CT scans.

Conclusion: CT scans should only be performed when indicated regardless of age, whereas alternative modalities such as ultrasound and MRI should be considered when appropriate. Multiphase scans double the radiation dose, they are rarely indicated in pediatrics and can only be used when necessary, while adjusting CT parameters.

Descriptors: COMPUTED TOMOGRAPHY, PEDIATRIC POPULATION, IONIZING RADIATION

Children deserve special care in radiation protection since exposure to radiation during childhood causes a greater additional risk of cancer than adequate exposure in adulthood. A pediatric CT scan should always be planned individually for each child. Fast CT scanners have reduced the need for sedation and most examinations can be performed without breath-holding. The total number of CT scans in the US in 1980 was 3.3 million. That number has increased ten-fold in just 18 years, reaching 33 million at the end of 1998. At the end of 2000 in the US, the total number of CT scans for children under the age of 15 was 2.7 million. The number of CT examinations in the first decade of the new millennium increased by 10% per year, so that the total number of CT examinations at the end of 2007 was 68.7 million. The criteria for a good CT scan are: adequate, diverse and customized imaging practices, minimizing scan length according to indication and history, and acceptable image quality (eg, noise level and scan thickness used in the examination) so that patient exposure is reduced to a minimum. Indications for CT examination in the pediatric population are emergency conditions (foreign body, trauma, complications of inflammatory conditions…), tumors (tumor staging), interstitial and systemic diseases, as well as vascular malformations and congenital anomalies.

In order to produce this pictorial essay, a retrospective analysis of CT examinations performed on the pediatric population in the last three years was conducted at the Radiology Clinic of the Clinical Center University of Sarajevo, where the most frequent examinations justifying the CT scan are presented.

Over the last three years a total of 780 CT scans were performed in the pediatric population, where we have identified indications that are among the main cases for use of CT in children. In this paper we presented 5 conditions that justify CT scans.

Inflammatory diseases

We found five cases with inflammatory conditions and complications of inflammation, namely, retropharyngeal abscess, acromioclavicular joint abscess,

[1]Clinical Center University of Sarajevo, Clinic of Radiology
[2]Sarajevo School of Science and Technology

Address:
Sandra Vegar-Zubović, MD PhD
Head of Diagnostic Disciplines
Clinical Center University of Sarajevo
71000 Sarajevo, BiH, Bolnička 25
E-mail: sandra.vegar@gmail.com

complicated pneumonia with atelectasis and pleural effusion, lung TB, and splenic echinococcal cyst (Figure 1). The most common causes of bacterial infections in children younger than one month are beta hemolytic Streptococcus and Escherichia coli, in children 1-3 months of age Streptococcus pneumoniae and beta hemolytic Streptococcus, and in children older than 3 months Streptococcus pneumoniae and Haemophilus influenzae (1, 2).

Figure 1.
Pneumonia complicateby atelectasis and pleural effusion

Tumors

Tumors were found in six cases including the Giant cell tumor of the maxilla, the anterior mediastinal lymphoma, intestinal lymphoma, the Wilms tumor, and two neuroblastomas, one in the abdominal cavity and the other in the cervical region (Figure 2). Among children under 14, the most common malignant tumors are leukemia, followed by central nervous system tumors, lymphomas, sarcomas, neuroblastomas and kidney tumors. In children aged 15-19 the most common malignancies are central nervous system tumors and lymphomas, followed by leukemia, gonadal germ cell tumors, thyroid tumors and melanoma (3).

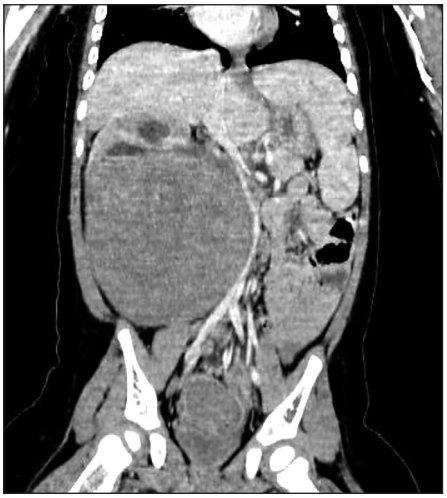

Figure 2.
Wilms' tumor

Trauma

In three cases, traumatic lesions were reported, with one child having an iatrogenic esophageal rupture with subsequent mediastinitis after a foreign body, one having a liver rupture and one having a splenic rupture (Figure 3). Ndour et al. in their 2014 study demonstrated that non-operative management of spleen trauma was the method of choice and was successful in 98.7% of cases. Of the 83 cases of children with spleen trauma, complications occurred in only 4 cases, namely three splenic artery pseudoaneurysms and one spleen pseudocyst with good prognosis (4).

Figure 3.
Spleen rupture

Congenital anomalies

Diversity of congenital anomalies was observed in six children, including branchial cleft cyst, ventricular septal defect, double superiorvena cava, pulmonary sling, ductus arterio suspersistens and MAPCA (Figure 4). About 7.9 million children are born with major congenital anomalies a year (5). The prevalence of congenital anomalies is 6.3%, most commonly present on the cardiovascular and digestive systems. Mortality among newborns with congenital anomalies is 10.4% (6).

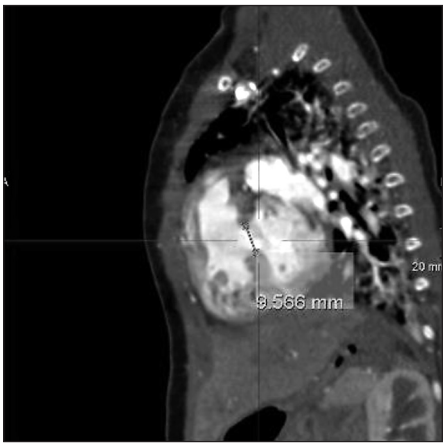

Figure 4.
Ventricular septal defect

Systemic diseases and foreign bodies

One case was presented with cystic fibrosis and one with a foreign body in the right main bronchus (Figure 5). Cystic fibrosis is a rare disease that affects many organs and can lead to a significant shortening of life.

Figure 5.
Cystic fibrosis

Discussion: Although the benefit of CT scans is unquestionable, overuse of this diagnostic method has raised concerns about the potential risk for the development of malignancies resulting from direct radiation from CT scans. The doses of ionizing radiation generated during the CT examination are on average between 5-50 mGy for each examined organ.

A recent retrospective study conducted in a pediatric population in the UK studied the risk of leukemia and brain cancer in 180.000 patients between 1985 and 2002 who were less than 22 years old at the time of examination. Leukemia occurred in 74 patients and brain cancer in 135 patients. The relative risk for the development of leukemia was 0.036 mGy, and for the development of brain cancer 0.023 mGy (7).

A cumulative radiation dose of 50 mGy in children nearly triples the risk of developing leukemia, whereas a cumulative dose of 60 mGy can triple the risk of developing brain cancer in children. The highest number of CT scans in children in the United States was performed for suspected appendicitis. More recent studies do not show significantly greater diagnostic significance in comparison with ultrasound findings when suspecting this pathological entity (8).

Justification and optimization:

- When a CT scan is indicated it should be performed with the lowest possible radiation exposure required for diagnosis.
- Simply put: the right patient, the right examination, at the right time, done the right way.
- Children are different from adults in a number of important ways relevant to radiation exposure. Compared to adults children are smaller, children grow up and children have a longer life expectancy.

CT Scan Optimization Basics:

- scanning parameters;
- dose and image quality (noise and contrast);
- Use of radiation protection;
- preparation for examination (sedation, anesthesia).

Parameters

Planning image - the scope of scans is determined from the planning image (scout image or topogram). Planning images should be large enough to cover the entire area of interest, but unnecessarily large scans should be avoided. Beam Width and Scan Thickness - Using a beam collimator, the beam width is mechanically limited as desired. The nominal scan thickness can be selected from technical selections (eg 0.625 mm).

Conclusion: Radiation dose reduction strategies follow the ALARA principle (as far as possible); ie. performing diagnostic tests at the lowest possible doses. CT scans should only be performed when indicated regardless of age, whereas alternative modalities, such as ultrasound and MRI, should be considered when appropriate. Multiphase scans double the radiation dose, they are rarely indicated in pediatrics and can only be used when absolutely necessary, while adjusting CT parameters as much as possible. The principles of justification and optimization are the basis for both requiring and conducting diagnostic imaging examinations.

The study has been conducted at Radiology Clinic, Clinical Centre University of Sarajevo, BiH.

NOVČANA POTPORA/*FUNDING*
Nema/*None*

ETIČKO ODOBRENJE/*ETHICAL APPROVAL*
Nije potrebno/*None*

SUKOB INTERESA/*CONFLICT OF INTEREST*
Autori su popunili *the Unified Competing Interest form na www.icmje.org/coi_disclosure.pdf (dostupno na zahtjev)* obrazac i izjavljuju: nemaju potporu niti jedne organizacije za objavljeni rad; nemaju financijsku potporu niti jedne organizacije koja bi mogla imati interes za objavu ovog rada u posljednje 3 godine; nemaju drugih veza ili aktivnosti koje bi mogle utjecati na objavljeni rad./ *All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.*

LITERATURE

1. Centers for Disease Control and Prevention. Progress toward eliminating Haemophilusinfluenzae type b disease among infants and children, United States, 1987-1997. MMWR 1998; 47: 993-8.
2. Black SB, Shinefleld HR, Hansen J, Elvin L, Laufer D, Malinoski F. Post-licensure evaluation of the effectiveness of seven valent pneumococcal conjugate vaccines. Pediatr Infect Dis J 2001; 20: 1105-7.
3. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2018. CA: A Cancer Journal for Clinicians 2018; 68 (1): 7-30.
4. Ndour O, Forgues D, Kalfa N, Buibal MP, Ndoye M, Galifer RB. Results of non-operative management of splenic trauma and its complications in children. J Indian Assoc Pediatr Surg. 2014; 19 (3): 147-50.
5. Ndibazza J, Lule S, Nampijja M, Mpairwe H, Oduru G, Kiggundu M et al. A description of congenital anomalies among infants in Entebbe, Uganda. Birt Defects Res A ClinMolTeratol. 2011; 91: 857-61.
6. Oestergaard MZ, Inoue M, Yoshida S, Mahanani WR, Gore FM, Cousens S et al. Neonatal mortality levels for 193 countries in 2009 with trends since 1990: a systematic analysis of Progress, projections, and priorities. PLoS Med. 2011; 8: e1001080.
7. Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, Kim KP et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet 2012; 380: 499-505.
8. Miglliorettі DL. The Use of Computed Tomography in Pediatrics and the Associated Radiation Exposure and Estimated Cancer Risk. Washington. Jama Pediatrics. 2013.

Sažetak

KOMPJUTERIZIRANA TOMOGRAFIJA U PEDIJATRIJI

Sandra Vegar-Zubović, Adi Behmen, Haris Bektešević, Sabina Prevljak, Irmina Sefić-Pašić, Amra Džananović, Melika Bukvić, Danin Zubović

Uvod: U zaštiti od ionizirajućeg zračenja djeca zaslužuju posebnu skrb, jer izloženost ionizirajućem zračenju tijekom djetinjstva uzrokuje veći rizik od karcinoma nego ekvivalentna izloženost u odrasloj dobi. Iz navedenog razloga se pedijatrijska kompjuterizirana tomografija (CT) treba planirati individualno za svako dijete. Brzi CT skeneri smanjili su potrebu za sedacijom, a većina pregleda može se provesti bez zadržavanja daha. Osnovne indikacije za primjenu CT-a u pedijatrijskoj populaciji su potreba za brzom dijagnostikom u hitnim uvjetima (strano tijelo, trauma, komplikacije upalnih stanja), tumori, intersticijske i sistemske bolesti, vaskularne malformacije i kongenitalne anomalije. Cilj ovog rada je prikazati osnovna stanja koja opravdavaju korištenje CT-a u pedijatrijskoj populaciji.

Metode: Retrospektivna analiza CT pregleda koji su obavljeni zadnje tri godine na pedijatrijskoj populaciji u Klinici za radiologiju Univerzitetskog kliničkog centra Sarajevo, od kojih su najvažnije indikacije koje opravdavaju CT pretragu prikazane u ovom radu.

Rezultati: Od ukupno 780 CT pregleda provedenih posljednje tri godine u pedijatrijskoj populaciji, izdvojili smo indikacije koje su među najvažnijima za korištenje CT-a kod djece. U ovom radu ćemo prezentirati 5 takvih indikacija.

Zaključak: U svim dobnim skupinama CT pregled mora se provoditi samo kada je indiciran te je potrebno razmotriti alternativne metode kao što su ultrazvuk i magnetska rezonanca. Višefazni protokoli udvostručuju dozu zračenja, stoga su rijetko indicirani u pedijatrijskoj populaciji. Moraju se koristiti samo kada su apsolutno indicirani, s podešavanjem parametara uređaja što je više moguće.

Deskriptori: KOMPJUTERIZIRANA TOMOGRAFIJA, PEDIJATRIJSKA POPULACIJA, IONIZIRAJUĆE ZRAČENJE

Primljeno/Received: 10. 2. 2020.
Prihvaćeno/Accepted: 12. 3. 2021.