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Clinical application of 'Justification' and 'Optimization' principle of ALARA in pediatric CT imaging: "How many children can be protected from unnecessary radiation?"

Kushaljit S. Sodhi[a,*], Satheesh Krishna[a], Akshay K. Saxena[a], Anindita Sinha[a], Niranjan Khandelwal[a], Edward Y. Lee[b]

[a] Departments of Radiodiagnosis and Imaging, Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, India
[b] Departments of Radiology and Medicine, Pulmonary Division, Boston Children's Hospital and Harvard Medical School, 300 Longwood Ave. Boston, MA 02115, United States

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ABSTRACT

Rationale and objectives: Practice of ALARA (as low as reasonably achievable) principle in the developed world is currently well established. However, there is striking lack of published data regarding such experience in the developing countries. Therefore, the goal of this study is to prospectively evaluate CT request forms to assess how many children could be protected from harmful radiation exposure if 'Justification' and 'Optimization' principles of ALARA are applied before obtaining CT imaging in a developing country. This can save children from potential radiation risks including development of brain cancer and leukemia.

Material and methods: Consecutive CT request forms over a six month study period (May 16, 2013 to November 15, 2013) in a tertiary pediatric children's hospital in India were prospectively reviewed by two pediatric radiologists before obtaining CT imaging. First, 'Justification' of CT was evaluated and then 'Optimization' was applied for evaluation of appropriateness of the requested CT studies. The number (and percentage) of CT studies avoided by applying 'Justification' and 'Optimization' principle of ALARA were calculated. The difference in number of declined and optimized CT requests between CT requests from inpatient and outpatient departments was compared using Chi-Square test.

Results: A total of 1302 consecutive CT request forms were received during the study period. Some of the request forms ($n = 86$; 6.61%) had requests for more than one (multiple) anatomical regions, hence, a total of 1392 different anatomical CT requests were received. Based on evaluation of the CT request forms for 'Justification' and 'Optimization' principle of ALARA by pediatric radiology reviewers, 111 individual anatomic part CT requests from 105 pediatric patients were avoided. Therefore, 8.06% (105 out of 1302 pediatric patients) were protected from unnecessary or additional radiation exposure.The rates of declined or optimized CT requests from inpatient department was significantly higher than that from outpatient departments ($p < 0.05$).

Conclusions: A substantial number of pediatric patients, particularly coming from outpatient departments, can be protected from unnecessary or additional radiation exposure from CT imaging when 'Justification' and 'Optimization' principle of ALARA are applied before obtaining CT imaging in a developing country.

1. Introduction

Despite the improvements in the diagnosis and treatment of numerous medical conditions in pediatric patients by medical imaging, radiation exposure, particularly with CT imaging, continues to be worrisome for children who are more vulnerable than adults from radiation associated cancer development. In fact, a recent study indicates that a cumulative dose of 50 mGy triples the risk of leukemia and a dose of 60 mGy triples the risk of brain tumors in children [1].

Practice of 'Justification' and 'Optimization' principles of ALARA (as low as reasonably achievable) which can lead to elimination or reduction of unnecessary or additional radiation exposure associated with CT imaging is currently relatively well established

* Corresponding author. Tel.: +91 7087008634; fax: +91 172 2745768.
E-mail address: sodhiks@gmail.com (K.S. Sodhi).

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in the developed countries [2–4]. However, there is striking lack of published data regarding such experience in the developing countries. The experience of the developed countries cannot be directly extrapolated to the developing countries because of differences in infrastructure and clinical practice patterns. Thus, it would be important to assess if rigorous application of 'Justification' and 'Optimization' principles of ALARA in pediatric population in a developing country can lead to effective implementation of radiation protection and protect these children from unnecessary radiation exposure from CT imaging.

Therefore, the goal of this study is to prospectively evaluate CT request forms to assess how many children could be protected from harmful radiation exposure if 'Justification' and 'Optimization' principles of ALARA are applied before obtaining CT imaging in a developing country.

2. Materials and methods

2.1. Study population

The institutional review board approval was obtained for this prospective study. The need to obtain patient consent was waived, but patient confidentiality was protected in accordance with HIPAA guidelines. We prospectively reviewed all consecutive CT request forms in pediatric patients (≤18 years old) received by the pediatric radiology department of tertiary children hospital in India, during a six month period (from 16th May 2013 to 15th November 2013). The CT request forms were received from outpatient departments (n = 641; 49.23%) and inpatient departments (n = 661; 50.77%). The requests included both emergent (n = 287; 22.04%) and non-emergent (n = 1015; 77.96%) indications as received during routine daily practice (work hours 08:00–18:00 h).

3. CT request form: structure and evaluation

We used a standardized CT request form (Institutional form; Fig. 1) with preset form fields which had to be completed manually by the physician requesting the CT imaging. Forms were completed by the junior residents (residents in training with less than three years experience), senior residents (residents in training with more than 3 years experience) or by the consultants (any of the faculty member in pediatric medicine or surgical specialties). Of note, as per our institutional policy, residents are supposed to complete the CT request forms only after consultation with and approval from their respective consultants and not independently.

Completeness and adequacy of the data in CT request forms was ensured in all cases. We assessed if the history provided was adequate for justifying the scan requested. When the information was felt to be inadequate, completeness of the history was ensured by directly communicating with the requesting physician or requesting information from the patient files. Previous radiological investigations were also always routinely requested even if details were not provided in the CT request form.

All of CT request forms were carefully and thoroughly screened by one of the two pediatric radiologists (K.S.S. or A.K.S.), each with more than 10 years experience in pediatric CT imaging. In request forms with request for scanning more than one body part (for example, CT of both chest and abdomen regions), they were treated as two separate CT requests (i.e., one for CT chest and one for CT abdomen) and criteria/guidelines were applied individually to each of them.

Based on: (1) provided history; (2) prior imaging study results; and (3) appropriateness criteria, either approval or decline of the CT request was decided by one of the two consultant pediatric radiologists (KSS or AKS). In case the request was declined, the decision was communicated to the referring consultant along with the underlying reasons. In case one of the multiple scan requests (more than one anatomic region of interest) of a single request was deemed inappropriate, this was also communicated to the referring consultant and the rest of the scan(s) were carried out.

All pediatric patients for whom a CT request was declined or modified were followed up until their discharge from the hospital in case of inpatients in order to assess if the declined CT study was eventually required or would have made a difference in patient management. For outpatients, we assessed if the CT was re-requested within a period of one month.

4. Statistical analysis

Age, gender, and descriptive statistics are reported. The significance of difference between the number of requests rejected between inpatient and outpatient departments was calculated using Chi-Square test. The statistical analysis was obtained using Statistical Package for Social Sciences (SPSS Inc Chicago, IL). P values less than 0.05 were considered statistically significant [5].

5. Results

5.1. Study population

A total of 1302 consecutive CT request forms were received during the study period (6 months). Of these, 866 (66.51%) were for males and 436 (33.49%) were for females. 46 (3.53%) were <1 month old, 262 (20.12%) had ages between 1 month and one year, and the remaining 994 (76.34%) were aged over a year. Out of a total of 1302 CT request forms, 641 requests (49.23%) were received from outpatient departments of the hospital, while 661 CT requests were received from inpatient departments. 1245 forms (95.62%) were deemed to have adequate history required to request a CT. In the remaining 57 cases (4.38%) we either communicated directly with the referring physician or looked into the case files of the patient to obtain the complete history of the patient prior to final approval or rejection of the CT study.

There were a total of 1392 individual anatomic region CT requests from 1302 CT request forms because some of the request forms contained more than one anatomical regions (e.g., head and abdomen CT studies on the same CT request form). 1216 (93.4%) CT request forms had one anatomic body region request, 82 (6.3%) CT request forms had two anatomic body regions request, and 4 (0.3%) CT request forms had three anatomic body regions request.

The maximum number of requests we received were for CT imaging of the head region (780 out of 1392 requests: 56.03%). Of these, 343 (43.97%) CT request forms were for non-contrast scans and 382 (48.97%) were for contrast enhanced scans of the head and 55 forms (7.05%) had requested both a non-contrast as well as a contrast scan. In addition, there were CT imaging requests of the chest (251 requests: 18.03%) and abdomen (174 requests: 12.50%). The remaining CT imaging requests include the temporal bone (39 requests; 3.00%), neck (31 requests; 2.38%), orbit (26 requests; 2.00%), paranasal sinuses (25 requests; 1.92%), spine (12 requests; 0.92%), angiography of various body parts (44 requests; 3.38%) and CT imaging of musculoskeletal systems (10 requests: foot (n = 4); mandible (n = 2); shoulder (n = 2); tibia (n = 1); hip (n = 1)) (Table 1).

5.2. Appropriateness of CT request form

Complete data of the declined CT requests due to various reasons are summarized in Table 2. Overall, 64 (4.60%) CT requests from a