ORIGINAL ARTICLE

Oman Medical Journal [2016], Vol. 31, No. 5: 365-369

Trends in CT Request and Related Outcomes in a Pediatric Emergency Department

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ARTICLE INFO

Article history:
Received: 24 February 2016
Accepted: 3 July 2016

Online:
DOI 10.5001/omj.2016.72

Keywords:
Pediatric Medicine, Computed Tomography; Radiation Exposure.

ABSTRACT

Objectives: To study and to establish the overall trends of computed tomography (CT) use and associated outcomes in the pediatric emergency department (PED) at Royal Hospital, Oman, from 2010 to 2014. ***Methods***: The hospital electronic medical record was retrospectively searched to find children (from birth to 12 years old) who had visited the PED and the number of CT requests between 1 January 2010 and 31 December 2014. The types of CT examinations ordered were analyzed according to anatomical location and were as follows; head, abdomen/pelvis, chest, cervical spine/neck, and others. ***Results:*** There were a total of 67 244 PED visits during the study period, 569 of which received 642 CT scans. There was a remarkable rise in CT uses per 1000 visits from 7 in 2010 to 12 in 2014. There was a 56% hike in CT requests from 87 in 2010 to 175 in 2014 while the number of pediatric emergency visits rose by about 28% from 11 721 to 15 052. Although head CT scans were the most common, cervical spine CT scans had the highest rate of increase (600%) followed by the chest (112%), head (54%) and abdomen (13%). There were no significant changes in other CT scan requests. The cost of CT scans increased from $18 096 to $36 400 during the study period, which increased the average PED cost by about $2 per visit. The average time between a CT being requested and then performed was 1.24 hours. ***Conclusions:*** CT use in the pediatric emergency department has risen significantly at a rate that markedly exceeds the growth of emergency visits. This is associated with an increase in PED costs and longer waiting times.

Doctors in pediatric emergency departments (PEDs) are often encouraged to manage patients correctly in a short time and to decide proper care.[1] Computed tomography (CT) has become an important diagnostic tool in the assessment and management of children in emergency care because of its diagnostic superiority.[2]

The overuse of medical imaging has become a source of great anxiety for parents, health professionals, and regulators due to its expense and the potential cancer risks associated with radiation exposure.[2-8] Therefore, there needs to be a balance between making a timely diagnosis and minimizing the exposure of radiation.

Recent studies revealed that CT use in the emergency department has continued to rise.[9–15] No data is available from Oman.

The main objective of this study was to determine the trends in CT request and related outcomes in the PED, Royal Hospital, Oman, which is a tertiary 650-bed teaching hospital.

METHODS

We conducted a single-center, retrospective review of pediatric emergency visits to Royal Hospital, Oman, between 1 January 2010 to 31 December 2014, to identify the trends in CT usage and their relation to PED outcomes. The Royal Hospital ethical committee approved the study protocol.

All CT modalities were available around the clock throughout the study period. The cost of a plain CT is about $210 per anatomic location. Informed verbal consent was obtained before the CT examinations. CT images were immediately transferred to the pediatric radiology department and PED through the picture archiving and communication systems and a formal written report was given shortly after. SOMATOM Definition Flash CT scanners (Siemens Healthcare, Forchheim, Germany) were used. The CT images were classified by body part into five groups: head, cervical, chest, abdomen, and others (face, orbit, and bones). A normal CT report was defined as: "the organs and structures being examined are normal in appearance".

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The electronic medical record was reviewed to identify all pediatric patients (≤ 12 years old) who visited the PED and received CT scans during the five-year study period. For each visit, the following information were collected: (1) date and time of registration; (2) patient age and gender; (3) patient nationality; (4) patient registration number; (5) whether the patient underwent a CT scan and the type of CT request; (6) disposition location; (7) time of CT requested and performed; (8) date and time of disposition; and (9) CT cost.

CT scans were requested for six common chief complaints. They were head trauma, seizures, headache, acute central nervous system (CNS) infection, abdominal pain, and miscellaneous (ventriculoperitoneal shunt block, structural brain disorders, global developmental delay).

The majority of cervical, chest, and abdominal CTs were performed as a part of the standard care for road traffic accidents.

The PED was staffed with pediatric emergency consultants from 7:30 am to 11:30 pm. Registrars and medical officers present in the PED round the clock. During the study period, CT image requests were at the sole discretion of the ordering doctor as there were no formal clinical guidelines or protocols on CT utilization in PED. The radiology department was staffed by pediatric radiologists from 7:30 am to 2:30 pm on weekdays and by registrars and medical officers outside these hours and at the weekend. There are no screening or approval processes from the imaging department regarding CT requests.

The total number of pediatric visits and the number of CT performed were assessed, and the rate of CT requests per thousand visits was calculated. The increased rate of CT scans performed was also calculated as follows[15]:

$$\text{Increased rate of CT} = \frac{\text{Number of CT images per 1000 visits in 2014} - \text{Number of CTs per 1000 visits in 2010}}{\text{Number of CTs per 1000 visits in 2010}} \times 100$$

The number of children who underwent multiple CT scans was also determined. Children that had several CT images on one occasion were recorded separately.

RESULTS

There were 67 244 PED visits in the five-year study period with 569 (344 boys and 225 girls) of these having a 642 CT scans [Table 1]. During the study period, there was an about 28% rise in the number of PED visits, from 11 721 in 2010 to 15 052 in 2014; 39 039 (58%) were male, and 28 205 (42%) were female. Newborns to one-year-olds accounted for 32 919 (49.0%) visits, 2–5 year olds 19 328 (28.7%), and 6–12 year olds for 14 997 (22.3%) of visits [Table 2]. Of the patients who received CT scans, 573 were Omanis and 69 were expatriates.

There was a 56% rise in the CT scan rate per 1000 visits in five years from 7 in 2010 to 12 scans per 1000 visits in 2014. The rate of CT scans in the PED was out of proportion to the rate of increase in patient volume.

Head (n =537; 83.6%) and abdominal CT scans (n = 47; 7.3%) made up the majority of the total scans followed by cervical (n = 35; 5.5%), chest (n = 18; 2.8%) and others (n = 5; 0.8%). Although head CT scans were the highest proportionally, cervical CT scans showed the highest rate of increase (600%), from two in 2010 to 18 in 2014, followed by chest

Table 1: Sample characteristics of pediatric emergency department visits according to year.

Variables, n	2010	2011	2012	2013	2014	Total
Number of visits	**11 721**	**13 637**	**12 806**	**14 028**	**15 052**	**67 244**
Visits with CT scans	**87**	**120**	**121**	**139**	**175**	**642**
CT scan location						
Head	72	102	108	113	142	537
Abdomen	9	9	6	10	13	47
Chest	3	3	3	1	8	18
Cervical	2	4	4	7	18	35
Other	1	2	0	2	0	5
Visits with CT use, %	0.74	0.88	0.95	0.99	1.16	0.95

CT: computed tomography.

Table 2: Demographic characteristics of the study population.

Characteristics	2010	2011	2012	2013	2014	Overall
Gender						
Male	6828	7885	7412	8169	8745	39 039
Female	4693	5752	5344	5858	6307	28 205
Age, years						
0–1	5970	6552	6069	6745	7556	32 919
2–5	3213	4051	3828	4065	4153	19 328
6–12	2558	3034	2835	3214	3356	14 997

Table 3: Rate of increase in computed tomography (CT) requests per 1000 visits by scan location.

Location	2010	2011	2012	2013	2014	Rate of increase
Total CT scans per 1000 visits	7.42	8.79	9.44	9.90	11.62	56
Head	6.14	7.47	8.43	8.05	9.43	54
Abdomen	0.76	0.65	0.46	0.71	0.86	13
Cervical spine	0.17	0.29	0.31	0.49	1.19	600
Chest	0.25	0.21	0.23	0.071	0.53	112
Other	0.04	0.14	0.00	0.14	0.00	-

Table 4: Association between computed tomography (CT) utilization and PED outcomes.

Variables	2010	2011	2012	2013	2014	Overall
Visits	11 721	13 637	12 806	14 028	15 052	67 244
CT cost*	18 096	24 960	25 168	28 918	34 600	133 542
Average cost rise per visit*	1.54	1.83	1.96	2.06	2.14	2
Mean waiting time, hours	1.20	1.33	1.19	1.23	1.27	1.24
Admission with CT scan	37	51	63	52	73	276
Admission without CT scan	2292	2526	2346	2990	3037	13 191

**In USD.*

CT scans (112%) from 3 to 8, head CT scans (54%) from 72 to 142, and abdominal CT scans (13%) from 9 to 13 for the same period. The others CT scan category remained constant [Table 3].

Of the patient sample, 13 191 (19.6%) patients were admitted to the hospital. Among these patients, 276 (44%) patients who received CT examinations were admitted compared to 20% of patients who did not have a CT scan. Eighty-one (12%) patients were transferred to other hospitals because of a lack of expertise at Royal Hospital and 285 (44%) were sent home. Among the 642 CT requests, 419 (65.3%) were reported normal and 223 (34.7%) were reported abnormal (acute patients, 25%; chronic patients, 10%). Abnormal head CT scans found intracranial bleeds, increased intracranial pressure, space occupying lesion (SOL) in the brain, brain atrophy, and structural brain abnormalities. Abnormal abdomen CT scans detected intra-abdominal bleeds, visceral injury, and SOL in the abdomen. Abnormal chest CT scans detected chest contusion, pneumothorax, and bleeds. A detailed description of all abnormal CT scan reports is beyond the scope of this study.

There was a progressive increase in emergency department CT scan costs in all study years from $18 096 in 2010 to $36 400 in 2014 with an average cost increase of $2 per visit [Table 4]. The average waiting time between a CT being requested and then performed was 1.24 hours. The minimum waiting time recorded was 25 minutes, and the maximum was six hours. The waiting time increased successively during the study period except in 2012 during which had the shortest waiting time (1.19 hours). However, there was no statistically significant difference compared to other years. It

was noted that 200 (35.1%) patients who received CT scans required sedation (using midazolam, ketamine and chloral hydrate) to perform the scan. The procedure was carried out according to procedural sedation guidelines, and no immediate complications were reported because of either the procedure or sedation.

DISCUSSION

We identified a significant rise in CT scan use in the PED at our hospital compared to the growth of patient volume during the study period. This is the first study in Oman to determine any trend. Approximately 12 patients per 1000 visits had a CT scan in 2014 compared to seven patients in 2010. The increase in CT scans was associated with an increased admission rate, high costs to the PED, and a longer emergency stay.

Our results were similar to those of other studies.[9–15] Factors that probably contributed to the overuse of medical imaging include easy access, the noninvasive nature of the test, advances in imaging and CT machines resulting in reduced scanning time and high-resolution 3D images, and the reduced need for sedation.[16–18] There are also increasing pressure on doctors to perform scans from over-worried parents. Additionally, physicians' themselves may lack awareness of the radiation risks and rising incidence of medico-legal issues.[19–21]

CT scans yield a remarkable source of ionizing radiation exposure. A single CT scan provides from 0.03 to 69.2 mSv of radiation[22] depending on the age of exposure, gender, image type, and body part irradiated. The effective radiation doses for children are higher than those for adults if same radiation parameters are used, due to their smaller body size. Moreover, the risk of death from radiation-induced malignancies is considered high for the pediatric population because of their longer life expectancy.[22–24] CT scan with an effective dose of 10 mSv may be associated with an increase in cancer risk of about 1 chance in 2000.[3,22–27]

All recent studies demonstrated the remarkable rise in CT cost.[9–15] Our study also showed that CT usage raised the PED cost by an average of $2 per visit.

In this study, the average waiting time was 1.24 hours for children who underwent CT and 43% of patients who required CT were admitted to hospital compared to those who did not request a scan (20%).

Appropriate utilization of medical imaging could yield potential benefits in both financial savings and reducing radiation exposure. Since doctors and parents have been found to underestimate the radiation risk,[19,20] media such as billboards, placards, and television adverts could be used in the emergency and radiology department to make current information regarding the radiation risk and possible long-term consequences more available, both to clinicians and parents. Additionally, CT scans should be performed only when it is necessary and alternative diagnostic modalities should be considered whenever possible, including ultrasonography and magnetic resonance imaging (MRI). Moreover, both the physician and the radiologist must assess whether the benefits to the patients outweigh the risks associated with the radiation. If a CT scan is determined to be the only modality of choice for a specific clinical scenario, meticulous optimization of the exam should be performed by using dose-saving techniques, scanning the indicated area, and avoiding repeat and multiphasic exams. Finally, an appropriate imaging guideline must be published.[28,29]

This study has few limitations. First, it was a single center study and may not reflect the patterns of CT use across the country and Gulf region. Secondly, it did not specifically assess the clinical usefulness or radiation risk from CT use for the patients. Finally, given the small starting numbers, percentage increases may be misleading. However, the principal aim of this study was to assess the trends of CT usage in the pediatric population in Oman.

CONCLUSION

The rate of CT utilization per 1000 visits increased by 56% from 2010 to 2014 and was associated with higher emergency department costs and longer waiting times.

Disclosure
The authors declared no conflicts of interest. No funding was received for this study.

Acknowledgements
We would like to thank Dr. Padma Mohan. J Kurup, Superintendent, Communicable Disease Surveillance and control, DGHS, Muscat, for methodological support.

REFERENCES

1. Kovacs G, Croskerry P. Clinical decision making: an emergency medicine perspective. Acad Emerg Med 1999 Sep;6(9):947-952.
2. Frush DP, Donnelly LF, Rosen NS. Computed tomography and radiation risks: what pediatric health care providers should know. Pediatrics 2003 Oct;112(4):951-957.
3. Brenner DJ, Hall EJ. Computed tomography–an increasing source of radiation exposure. N Engl J Med 2007 Nov;357(22):2277-2284.
4. Hillman BJ, Goldsmith JC. The uncritical use of high-tech medical imaging. N Engl J Med 2010 Jul;363(1):4-6.
5. Smith-Bindman R. Is computed tomography safe? N Engl J Med 2010 Jul;363(1):1-4.
6. US Food and Drug Administration. White paper: initiative to reduce unnecessary radiation exposure from medical imaging. [cited 2015 September 25]. Available from: http://www.fda.gov/Radiation-EmittingProducts/ Radiation Safety/ Radiation Dose Reduction/ ucm199994.
7. International Atomic Energy Agency. Dose reduction in CT while maintaining diagnostic confidence: a feasibility/ demonstration study. IAEA-TECDOC-1621. Vienna, Austria: International Atomic Energy Agency, 2009.
8. Brenner DJ, Hricak H. Radiation exposure from medical imaging: time to regulate? JAMA 2010 Jul;304(2):208-209.
9. Larson DB, Johnson LW, Schnell BM, Salisbury SR, Forman HP. National trends in CT use in the emergency department: 1995-2007. Radiology 2011 Jan;258(1):164-173.
10. David B. Larson, Lara W. Johnson, Beverly M. Schnell (2011) Rising Use of CT in Child Visits to the Emergency Department in the United States,1995–2008. Radiology: Volume 259: Number 3—June 2011:793-801.
11. Broder J, Fordham LA, Warshauer DM. Increasing utilization of computed tomography in the pediatric emergency department, 2000-2006. Emerg Radiol 2007 Sep;14(4):227-232.
12. Zhou J-C, Zheng S-W, Yu Y-X, Rouleau K, Jiang W-L, Jin CW, et al. Trends in computed tomography utilization and association with hospital outcomes in a Chinese emergency department. PLoS One 2012;7(7):e40403.
13. Menoch MJ, Hirsh DA, Khan NS, Simon HK, Sturm JJ. Trends in computed tomography utilization in the pediatric emergency department. Pediatrics 2012 Mar;129(3):e690-e697.
14. Korley FK, Pham JC, Kirsch TD (2010) Use of advanced radiology during visits to US emergency department for injury-related conditions, 1998–2007. JAMA2010 304: 1465-1471.
15. Oh HY, Kim EY, Kim JE, Kim YJ, Choi HY, Cho J, et al. Trends of CT use in the pediatric emergency department in a tertiary academic hospital of Korea during 2001-2010. Korean J Radiol 2012 Nov-Dec;13(6):771-775.
16. Donnelly LF. Reducing radiation dose associated with pediatric CT by decreasing unnecessary examinations. AJR Am J Roentgenol 2005 Feb;184(2):655-657.
17. Pappas JN, Donnelly LF, Frush DP. Reduced frequency of sedation of young children with multisection helical CT. Radiology 2000 Jun;215(3):897-899.
18. Sacchetti A, Carraccio C, Giardino A, Harris RH. Sedation for pediatric CT scanning: is radiology becoming a drug-free zone? Pediatr Emerg Care 2005 May;21(5):295-297.
19. Lee CI, Haims AH, Monico EP, Brink JA, Forman HP. Diagnostic CT scans: assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. Radiology 2004 May;231(2):393-398.
20. Boutis K, Fischer J, Freedman SB, Thomas KE. Radiation exposure from imaging tests in pediatric emergency medicine: a survey of physician knowledge and risk disclosure practices. J Emerg Med 2014 Jul;47(1):36-44.
21. Chinese doctors are under threat. Lance 2010 Aug 28;376(9742p):657.
22. Miglioretti DL, Johnson E, Williams A, Greenlee RT, Weinmann S, Solberg LI, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. JAMA Pediatr 2013 Aug;167(8):700-707.
23. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR Am J Roentgenol 2001 Feb;176(2):289-296.
24. Paterson A, Frush DP, Donnelly LF. Helical CT of the body: are settings adjusted for pediatric patients? AJR Am J Roentgenol 2001 Feb;176(2):297-301.
25. Smith-Bindman R, Lipson J, Marcus R, Kim KP, Mahesh M, Gould R, et al. Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. Arch Intern Med 2009 Dec;169(22):2078-2086.
26. Feng ST, Law MW, Huang B, Ng S, Li ZP, Meng QF, et al. Radiation dose and cancer risk from pediatric CT examinations on 64-slice CT: a phantom study. Eur J Radiol 2010 Nov;76(2):e19-e23.
27. Hall EJ, Brenner DJ. Cancer risks from diagnostic radiology. Br J Radiol 2008 May;81(965):362-378.
28. Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, et al. The Canadian CT Head Rule for patients with minor head injury. Lancet 2001 May;357(9266):1391-1396.
29. Smits M, Dippel DW, de Haan GG, Dekker HM, Vos PE, Kool DR, et al. Minor head injury: guidelines for the use of CT–a multicenter validation study. Radiology 2007 Dec;245(3):831-838.