American Journal of Emergency Medicine xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Radiologic discrepancies in children with special healthcare needs in a pediatric emergency department

Ara Festekjian, MD MS *, Karen Y. Kwan, MD, Todd P. Chang, MD MAcM, Hollie Lai, MD, Margil Fahit, BS, Danica B. Liberman, MD MPH

Division of Emergency Medicine & Transport, Children's Hospital Los Angeles, 4650 Sunset Blvd. Mailstop 113, Los Angeles, CA 90027, United States

ARTICLE INFO

Article history:
Received 12 September 2017
Received in revised form 19 December 2017
Accepted 19 December 2017
Available online xxxx

Keywords:
Radiography
Diagnostic errors
Pediatric emergency medicine
Children with disabilities

ABSTRACT

Background: After-hours radiologic interpretation by nonradiology attendings or resident radiologists introduces the risk of discrepancies. Clinical outcomes following radiologic discrepancies among pediatric emergency department (ED) patients are poorly described. In particular, children with special healthcare needs (CSHCN), have more opportunities for discrepancies and potential consequences than non- CSHCN. Our objective was to determine the rates and types of radiologic discrepancies, and to compare CSHCN to non-CSHCN.

Methods: From July 2014 to February 2015, all children who underwent a diagnostic imaging study at a free-standing children's ED were included. Data collected included radiologic studies - type and location – and clinical details - chief complaint and CSHCN type. Differences between preliminary reads and final pediatric radiology attending reads were defined as discrepancies, and categorized by clinical significance. Descriptive statistics, z-tests, and chi-square were used.

Results: Over 8 months, 8310 visits (7462 unique patients) had radiologic studies (2620 CSHCN, 5690 non-CSHCN). A total of 198 (2.4%) radiologic discrepancies [56 (28.3%) CSHCN, 142 (71.7%) non-CSHCN] were found. Chief complaints for CSCHN were more often within the cardiac, pulmonary and neurologic systems ($p < 0.001$ for each), whereas non-CSHCN presented with more trauma ($p < 0.001$). The rates of discrepancies (CSHCN 2.1%, non- CSHCN 2.5%, $p = 0.3$) and severity of clinical consequences ($p = 0.6$) were not significantly different between CSHCN and non-CSHCN.

Conclusion: Though the frequency and type of radiologic studies performed between CSHCN and non-CSHCN were different, we found no significant difference in the rate of radiologic discrepancies or the rate of clinically significant radiologic discrepancies.

1. Introduction

Radiologic imaging, such as radiographs (X-rays) and computed tomography (CT) scans, is an important diagnostic tool for a range of presenting symptoms in the emergency department (ED). The current ED standard of care for off-hours radiology is for emergency medicine (EM) physicians and/or radiology trainees to perform their own preliminary interpretations of radiologic studies, which are subsequently reviewed by an attending radiologist the next day. An attending radiologist's revision that overrides a preliminary read is considered a radiologic discrepancy, sometimes referred to as an 'over-read.' The literature reflects discrepancy rates of 0.1% to 9.0% in adult populations [1-3] and a broader range of 0.1% to 28% in children [4-7]. Over-reads can result in changes in management, including repeat imaging, specialist follow up, and hospital admission [5].

Children with special healthcare needs (CSHCN) are medically complex patients with frequent ED encounters often involving radiologic imaging studies. Examples of disease processes that define patients as CSHCN include asthma, autism, diabetes mellitus, and cystic fibrosis. CSHCN represent a growing part of the pediatric population – an estimated 15–20% of US children age 0–17 – and have four times the number of hospitalizations than other children [8]. With more interactions with the health care system for maintenance of their devices and chronic conditions, CHSCN have more opportunities to experience diagnostic errors and thus are likely to be at heightened risk for negative outcomes due to those errors. The rate of radiologic discrepancies for CSHCN is currently unknown. CSHCN's significant representation among total ED visits, especially in tertiary care hospitals, can be high, and their clinical complexity justifies efforts to further investigate CSHCN specifically.

The objective of this study was to report the rate of radiologic discrepancy in CSHCN, compared to that of the general pediatric ED population, and to determine differences in the types of radiologic diagnostic errors in CSHCN. Additionally, clinical consequences from radiologic

* Corresponding author.
E-mail address: afestekjian@chla.usc.edu (A. Festekjian).

https://doi.org/10.1016/j.ajem.2017.12.041
0735-6757/

discrepancies were scored and compared between CSHCN and non-CSHCN. Given their complex medical conditions and more frequent exposure to radiologic tests, it was hypothesized that the rate and impact of radiologic discrepancy for CSHCN is significantly greater than that of their peers.

2. Methods

2.1. Setting and population

From July 2014 to February 2015, all children who underwent a diagnostic imaging study during their visit to the ED of an urban tertiary care free-standing children's hospital were included in the study cohort. The pediatric emergency department (PED) at this hospital has over 80,000 unique visits annually, and up to 40% of patients seen in any part of the hospital are CSHCN. For this study, CSHCN were defined using the Maternal and Child Health Bureau definition, "those who have or are at increased risk for a chronic physical, developmental, behavioral, or emotional condition and who also require health and related services of a type or amount beyond that required by children generally." [9-10] The radiology department at this hospital performs >26,000 radiologic studies every year for patients being evaluated in the PED. Pediatric radiologists are available to read diagnostic imaging studies during normal business hours, from approximately 8 am to 5 pm on weekdays. During off hours, imaging studies are read by PED practitioners [board certified in Pediatrics and/or Pediatric Emergency Medicine (PEM)] and/or resident radiologists, and confirmed the following morning by the attending radiologist. Resident radiologists review all studies until midnight and CT scans until the following morning. Radiologic discrepancies are discussed and documented daily with the PEM attending by the attending radiologist.

We defined radiologic discrepancies when the final interpretations of diagnostic imaging by the attending radiologist differed from the preliminary read by *either* the resident radiologist or PED practitioner. The clinical consequence of the discrepancy was then reviewed in the medical record and classified on the following 4-level scale, created specifically for this study by the study team: *no consequence* (no change or already addressed in the PED), *mild consequence* (requiring a simple phone call such as new antibiotics or follow-up with a clinic), *moderate consequence* (requiring the patient to return to the ED for further evaluation or imaging), and *high consequence* (requiring immediate admission, operation, or child abuse evaluation). Discrepancies were considered equivocal when a radiologic finding didn't correlate clinically (i.e. calcification in the right lower quadrant which could be appendicitis in the right clinical setting). The study was approved by the Institutional Review Board.

We included any PED visit in which diagnostic imaging was performed during the 8-month study period. Diagnostic images for this study were defined as studies that are commonly read by emergency physicians and radiology trainees: all plain X-rays were included (including studies with contrast), and computed tomography studies (CTs) of the brain or abdomen-pelvis, and ultrasounds of the abdomen, pylorus, and pelvis. Studies were excluded if they were performed on patients over the age of 18, or if they were ordered on patients who were not actively being treated in the PED. We excluded all other imaging not commonly interpreted by emergency physicians, such as magnetic resonance imaging (MRI) and fluoroscopy. ED point-of-care ultrasounds were similarly excluded.

2.2. Data collection & variables

A trained research assistant (MF) reviewed all imaging studies performed on PED patients and, after reviewing the patient's medical chart in the electronic medical record, categorized them into CSHCN or without SHCN using the definition cited above. Any conflicts on categorization between CSHCN and children without SHCN were resolved by investigator consensus (AF, DL, TC). Discrepancies were retrieved from a discrepancy log book which was kept as part of standard of care. These discrepancies were abstracted by the same trained research assistant and verified by a PEM investigator (AF, DL, TC). Clinical significance of diagnostic imaging discrepancies was determined by a board-certified PEM physician (AF) and attending radiologist (HL), who was not the clinical radiologist on record. Discrepancies on patients admitted from the ED were not documented in the ED records and therefore excluded from this study.

Data were abstracted for factors at the patient and system levels. Patient-level variables included: age, sex, type of CSHCN, presence of medical equipment, tubes, or implants, the anatomic region imaged by the study and type of imaging study. Visit-level variables included: time of day, hospital census, and ED census as a proxy for ED crowding. Primary outcome variables included radiologic discrepancy and level of clinical consequence resulting from the discrepancy. Secondary outcome variables included types of chief complaints and radiologic studies performed.

2.3. Data analysis

The unit of analysis in this study was the PED visit encounter, not the patient, as both emergency physicians and radiologists treat each radiologic study and visit independently. Descriptive statistics were used to summarize the data. Two-sample z-test and chi-square examined associations between imaging discrepancy and CSHCN status. Chi-square or Fisher Exact Test was employed to examine associations with CSHCN status and other visit-level variables and radiologic study. Continuous data as confounders were analyzed using point-biserial correlation. All analyses were two-tailed with an alpha of 0.05 and were conducted using IBM Statistical Package for the Social Sciences Version 23 (IBM SPSS, Armonk, NY).

3. Results

3.1. Descriptive statistics

Over the 8-month study period, 8310 discrete visits had radiologic studies, representing 7462 unique patients. Among the unique patients, 682 (9.1% of all patients) presented more than once during the 8-month period. The mean age at presentation was 8.0 +/− 5.8 years. CSHCN represented 2620 visits (31.5%) requiring radiographs. CSHCN patients tended to be older than non-CSHCN overall (9.1 vs. 7.5 years, $p < 0.001$), and a slightly higher proportion of CSHCN were male compared to non-CSHCN [56% (1460) vs 53% (3004), $p = 0.01$]. The clinical features and medical equipment characterizing CSHCN visits are listed in Table 1.

PED census ranged from 124 to 321 patients per day (mean 215.2 +/− 39.3). Only 226 of the 8310 visits (2.7%) were within 48 h of a prior PED visit.

Primary Question.

From 8310 visits, there were a total of 198 (2.4%) documented radiologic discrepancies. Of these, 7 were classified as false positives and 134 as false negatives; the rest consisted of equivocal findings. Nearly half (100/203, 49.3%) required notification and a change in plan for the patient (Table 2), but the clinical action required due to the discrepancy was not found to be different between CSHCN vs. non-CSHCN ($p = 0.60$).

The proportion of discrepancies found in CSHCN (56/2620, 2.1%) was not significantly different than the proportion found in non-CSHCN (142/5690, 2.5%, z = 1.1, $p = 0.88$). The association between CSHCN status and radiologic discrepancy was not significant ($X^2 = 0.990$ $df = 1$, $p = 0.32$), and the distribution of the type of discrepancy was also not significant ($X^2 = 1.967$ $df = 3$, $p = 0.60$). Additionally, PED census and imaging study time of day were not associated with differences in discrepancy rates ($r_{pb} = 0.003$, $p = 0.76$).

Please cite this article as: Festekjian A, et al, Radiologic discrepancies in children with special healthcare needs in a pediatric emergency department, American Journal of Emergency Medicine (2017), https://doi.org/10.1016/j.ajem.2017.12.041