Discrepancy Rates in Radiograph Interpretations between Pediatric Urgent Care Providers and Radiologists

Urgent message: Many pediatric urgent care centers lack 24/7 pediatric radiologist coverage and rely on the urgent care provider for initial interpretation and subsequent clinical management. If misdiagnosed, this could represent a potential patient safety concern.

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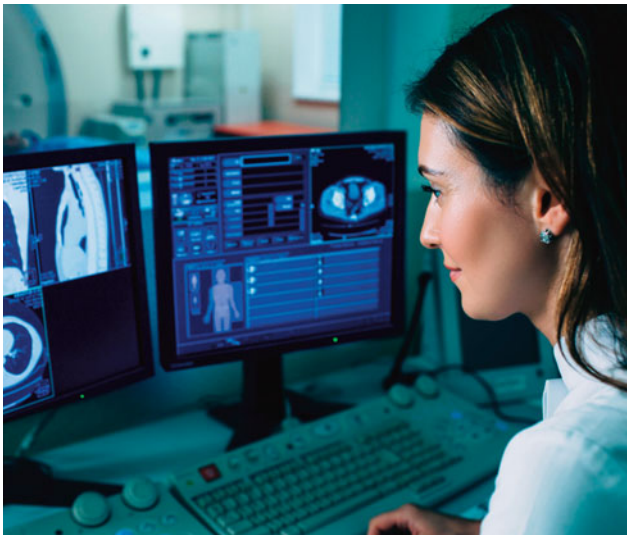

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Introduction

There has been an increase in the number of patients utilizing urgent care facilities as families seek to lower healthcare costs, increase convenience, and avoid long wait times and overcrowding typically seen in the emergency department.[1] The number of pediatric urgent care centers has been increasing in many metropolitan areas, offering a new method of delivering medical care to parents with acute care needs for their children.[2]

Most urgent care centers have the capability of performing plain radiographs to evaluate common pediatric conditions, including pneumonia and fractures. Often, pediatric EDs or pediatric urgent care centers do not have pediatric radiologist coverage during all operating hours and therefore must rely on the expertise of the ordering provider for initial interpretation of radiographs.[3] The variety of providers with differing roles and levels of expertise in a pediatric urgent care center (eg, advanced practice providers [APPs], board-certified pediatricians, and pediatric emergency medicine phys-

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Table 1. Total and Clinically Significant Discrepancies

	False positive (%)	False negative (%)	Total discrepant (%)	Clinically significant discrepant (%)	Total film number
Chest	142 (3.0)	166 (3.5)	308 (6.5)	129 (2.7)	4,712
Upper extremity	395 (6.5)	272 (4.5)	667 (11.0)	444 (7.3)	6,075
Lower extremity	361 (5.8)	276 (4.4)	637 (10.2)	357 (5.7)	6,270
Clavicle	4 (2.0)	3 (1.5)	7 (3.4)	2 (1.0)	203
Total	902 (5.2)	717 (4.2)	1,619 (9.4)	932 (5.4)	17,260

Table 2. Discrepancies and Change in Management

Film	Change in follow-up (%)	Change in therapy (%)	Return for evaluation (%)	Total with any change in follow-up, therapy, or return for evaluation (%)	Total of films ordered
Chest	45 (0.1)	108 (2.3)	12 (0.3)	129 (2.7)	4,712
Upper extremity	395 (6.5)	201 (3.3)	34 (0.6)	458 (7.5)	6,075
Lower extremity	328 (5.2)	103 (1.6)	21 (0.3)	343 (5.5)	6,270
Clavicle	2 (1.0)	0 (0)	1 (0.5)	2 (0.1)	203
Total	770 (4.5)	412 (2.4)	68 (0.4)	932 (5.4)	17,260

icians) could contribute to variations in the accuracy of radiograph readings.

Numerous studies have evaluated the discrepancy rates in the reading of plain radiographs between emergency physicians and radiologists in adult and pediatric ED settings. In ED studies involving pediatric patients, the discrepancy rate has ranged from 1% to 28%.[4-11] Clinically significant discrepancy (CSD) rates, defined as a radiographic discrepancy requiring a subsequent change in medical management, have ranged from 0.41% and 6.3%.[4-11] In several studies, chest radiographs were shown to be the most commonly misinterpreted study.[4,6-10] Pediatric orthopedic radiographs were also frequently misinterpreted between 8% and 21% of the time, by non-radiologists due to the presence of growth plates.[4-11] One study delineated that the discrepancy rate was higher in less experienced physicians.[6]

The main aim of the current study was to describe the overall discrepancy rate and the CSD rate in pediatric chest and orthopedic radiographs between pediatric urgent care providers and pediatric radiologists and to compare the discrepancy rates of physicians and APPs.

Methods

This observational, retrospective study reviewed plain radiographs (chest, clavicle, upper extremity, and lower extremity), ordered between the hours of 17:00 and 23:00 from January 2016 to December 2018. Data were collected from four pediatric urgent care centers within one children's health network. The centers are located approximately 10 to 25 miles away from a tertiary academic, freestanding children's hospital in a metropolitan area in the United States. Other imaging modalities (eg, computed tomography, magnetic resonance imaging, ultrasound) as well as pelvic, abdominal, and spinal x-rays were excluded. Patients were excluded if they were transferred to the ED due to clinical condition.

Pediatric APPs, board-certified pediatricians, or board-certified pediatric emergency physicians were responsible for providing the preliminary reading on plain radiographs and determining the initial plan of care and follow-up. On the following morning, a board-certified pediatric radiologist reviewed all films and placed a final read within the chart. If there was a discrepancy in readings, the radiograph study was placed in an electronic discrepancy folder within the computer system. Each day, the urgent care provider in charge at each center reviewed this folder, then notified the family of the discrepancy and discussed whether any changes in management were required. The pediatric radiologist's interpretation was used as the gold standard. The urgent care provider then documented the discussion with the family in the EHR, including any changes in management or follow-up recommendations.

Three research team members divided the sample of all discrepant charts, in which a radiology discrepancy

Table 3. Physician vs APP and Discrepancy

	Total discrepancies (%)		Clinically significant (%)	
	Physician	APP	Physician	APP
Chest	176/2,650 (6.6)	132/2,062 (6.4)	75/2,650 (2.8)	54/2,062 (2.6)
Upper extremity	305/2,778 (11)	362/3,297 (10.9)	190/2,778 (6.8)	254/3,297 (7.7)
Lower extremity	284/2,626 (10.8)	353/3,644 (9.7)	159/2,626 (6.1)	198/3,644 (5.4)
Clavicle	4/98 (4.1)	3/105 (2.9)	1/98 (1.0)	1/105 (1.0)
Total	425/8,152 (5.2)	850/9,108 (9.3)	425/8,152 (5.2)	507/9,108 (5.6)

APP, advanced practice practitioner

was identified during the study period, and reviewed every chart. If the chart indicated that the urgent care provider noted the correct diagnosis or documented the correct finding in the medical decision-making section, these cases were excluded from chart review analysis. True discrepancies were denoted as a false positive (ie, the abnormality was noted by the urgent care provider but not by the pediatric radiologist) or a false negative (ie, the abnormality was noted by the pediatric radiologist but not by the urgent care provider). Charts were then reviewed to determine whether there was a required change in clinical management including any changes in follow-up, changes in therapy, or returns for evaluation. If the family could not be reached, or if there was not a clear statement as to how clinical management changed, it was designated as not documented. If review of a discrepant patient's chart revealed that the patient was deceased at the time of the chart review (all charts were reviewed at a minimum of 1 year after the index urgent care center visit), it was recorded as potentially related to the care received in the urgent care center if the death occurred within 1 year of the index visit.

Data were presented as frequencies and percentages. Chi-square test or Fisher's Exact test were used to compare the rate of discrepancy between APPs and physicians. A 5% sample of the true discrepancies was randomly selected for inter-rater reliability among research members performing chart review. Fleiss' kappa was performed to determine inter-rater reliability. All statistical tests were performed using R 3.6.3 (Vienna, Austria). All statistical tests were two-sided, and $p<0.05$ was considered as statistically significant.

This study was approved by the Institutional Review Board (IRB) at Eastern Virginia Medical School.

Results

A total of 17,282 radiographs were performed between the times of 17:00 and 23:00 during the study period at the four pediatric urgent care centers. There were 22 films that were excluded from analysis, as these patients were directly transferred from urgent care to the ED. Of the remaining 17,260 films, there were 4,712 chest films, 203 clavicle films, 6,270 lower extremity films, and 6,075 upper extremity films; of these, the interpretations were provided by physicians (n=8152, 47.2%), physician assistants (n=6,104, 35.4%), and nurse practitioners (n=3,004, 17.4%). The mean patient age was 9.1 years (SD 5.1 years); 50.1% were female. Prior to conducting discrepancy analyses, 78 (5%) charts were reviewed by three research team members to assess inter-rater reliability. There was a moderate degree of agreement between reviewers with a kappa score of 0.77.

A total of 1,706 films were designated as discrepant. After chart review, 87 of these films were found to not be true discrepancies, leaving a total of 1,619 true discrepancies for with an overall discrepancy rate of 9.4%. Of the discrepancies, there were 902 false positives (5.2%) and 717 false negatives (4.2%) (**Table 1**).Of the 1,619 discrepant films, 1,346 (83.1%) had documentation of whether change in follow-up was required and 1,016 (62.8%) had documentation of whether change in therapy was required. Total CSD rate was 5.4% (n=932); none resulted in any mortality (**Table 2**).

The total number of discrepancies by physicians was comparable with APPs and did not differ significantly. Similarly, the CSD rate was comparable and no statistically significant differences were noted (**Table 3**).

Discussion

With both the number and utilization of pediatric urgent care centers increasing, it is important to evaluate the ability of urgent care providers to accurately interpret radiographs when pediatric radiologists are not available.

This retrospective study is the first one that we are aware of to evaluate the discrepancy rate and CSD rate among chest, clavicle, upper extremity, and lower ex-

tremity radiographs between pediatric urgent care providers and pediatric radiologists. Current study findings suggest an overall discrepancy rate of 9.4%, which is comparable to other studies that have evaluated discrepancies among pediatric radiographs (ranging from 1% to 28%, *Med* 11.9%).[4-11] The CSD rate of 5.4% was also comparable to previous studies which range from 0.4-6.3% (*Med* 1.3%).[4-11]

One difference when comparing the current study to previous work is that the current study only included chest, upper extremity, lower extremity, and clavicle radiographs, whereas other studies also included axial skeleton and abdominal radiographs.[4-8,9-11] Notably, the axial and abdominal radiograph discrepancy rates in these studies were generally lower than the discrepancy rates of the other films.[4-8,9-11]

In previous research, chest radiographs were found to be the most frequently discrepant with a range of 10% to 41.7% (*Med* 25.3%).[4,6-10] Our study, however, found upper extremity radiographs to have the highest discrepancy rate (3.9%) as well as the highest CSD rate of 7.3%. This was followed by lower extremity (3.7% and 5.7%, respectively), chest (1.8% and 2.7%), and clavicle (0.04% and 1%). These findings may be explained due to differences in frequency of radiograph type ordered; however, it is also important to note the continual challenge in interpreting pediatric orthopedic radiographs, specifically due to the presence of growth plates as well as subtle signs that could indicate an underlying occult fracture.

Limitations

Limitations of this study include a study cohort that was limited to a network of pediatric urgent care centers associated with a single tertiary care pediatric health system. Despite the multiple pediatric urgent care centers included, data may not be generalizable to other pediatric urgent care practices and systems. Given that this was a retrospective study, it is unknown whether providers (either within the same provider role or between different roles) had discussed radiograph interpretations among each other prior to the management and discharging of patients. In addition, despite there being no documentation of mortality within 1 year of urgent care visit, it is possible that patients who died could have presented to another facility during that time frame. However, our facility is the only children's hospital in the region and receives all critically ill patients as transports from the regional emergency departments, so this is unlikely. Furthermore, documentation of change in management was clearly noted in the majority of patient charts; however, there were charts that could not be included in our analysis due to lack of a clear description as to how clinical management did or did not change. This is a common limitation in data abstraction in retrospective studies and occurred in a limited number of charts.[12] When documentation was provided, the kappa score showed moderate inter-rater reliability, which strengthened our study's findings.

Conclusion

Of the studies that have evaluated discrepancy in the pediatric population, the low rate of clinically significant findings has allowed emergency physicians to safely disposition patients without leading to significant morbidity or mortality. In addition to similar discrepancy and clinically significant rates, this study found there were no statistically significant differences in rates between physicians and APPs. These findings suggest that a pediatric urgent care center, without continuous radiologist coverage, can provide relatively low discrepancy rates for pediatric patients requiring radiographs. Findings also provide supportive evidence for urgent cares to operationalize their staffing and consultative services in a model that provides high-value care to the patient population being served. ■

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