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ORIGINAL RESEARCH

Computed Tomography Use in Children With Minor Head Trauma Presenting to 21 Community Emergency Departments Within an Integrated Health-Care System

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Abstract

INTRODUCTION: Decreasing unnecessary cranial computed tomography (CT) use in pediatric head trauma patients remains important for emergency departments (EDs) across the US. Our study evaluated CT use in children with minor blunt head trauma in 21 community EDs within an integrated health-care system.

METHODS: We studied all children younger than 18 years old presenting to 21 community EDs between 2016 through 2018 with acute minor blunt head trauma, defined by an algorithm of ED chief complaints and diagnoses. We excluded patients with traumatic brain injuries diagnosed in the prior year, a CT within 24 hours prior to the ED visit, or an ED Glasgow Coma Scale score of less than 14.

RESULTS: Among 39,792 pediatric minor head trauma ED visits, the aggregate CT use proportion across all EDs was 12.9% [95% confidence interval (CI), 12.6–13.3%; facility-level range, 5.4–21.6%]. The 7 facilities that had previously received a clinical decision support system intervention implementing the Pediatric Emergency Care Applied Research Network rules during 2013 through 2014 had an aggregate mean CT ordering rate of 11.2% (95% CI, 10.7–11.7%; facility-level range, 5.4–14.3%) compared to 14.1% (95% CI, 13.6–14.5%; facility-level range, 7.3–21.6%) for the nonintervention facilities.

CONCLUSION: CT use for children with minor blunt head trauma in the community EDs of an integrated health-care system was low and stable across facilities from 2016 through 2018. This may be indicative of the safe stewardship of resources in the system, including the absence of financial or medicolegal incentives to scan very low-risk patients as well the availability of resources for close patient follow-up.

Introduction

More than 800,000 emergency department (ED) visits related to pediatric blunt head trauma were reported in the US in 2014, with roughly 50% of these children undergoing cranial computed tomography (CT) imaging.[1–3] To reduce the risk of malignancy associated with ionizing radiation exposure, considerable efforts have been made to decrease unnecessary imaging in children.

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Dustin W Ballard, MD, MBE, and David R Vinson, MD, obtained funding. David R Vinson, MD, Nathan Kuppermann, MD, MPH, Peter S Dayan, MD, E Margaret Warton, MPH, and Dustin W Ballard, MD, MBE, conceptualized and designed the study. E Margaret Warton, MPH, acquired and analyzed the data. E Margaret Warton, MPH, and Mary E Reed, DrPH, provided statistical expertise. Dustin W Ballard, MD, MBE, E Margaret Warton, MPH, and Judy Shan BS interpreted the data. Dustin W Ballard, MD, MBE, and Judy Shan BS drafted the manuscript. All authors reviewed and revised the manuscript for important intellectual content.

In 2009, the Pediatric Emergency Care Applied Research Network (PECARN) developed and published traumatic brain injury (TBI) prediction rules, which identify children who are at very low risk of clinically important TBI and can safely forgo CT imaging.[2] Since then, several studies have demonstrated that the implementation of clinical decision support (CDS) based on the PECARN rules can result in modest and safe decreases in CT use for children presenting to EDs with minor blunt head trauma.[4–8] However, cranial CT use in North American community ED settings remains highly variable, with reports of use rates ranging anywhere from 15% to 70%.[3,9–11]

Our observational study aimed to evaluate CT use within a large integrated health-care system that emphasizes responsible stewardship of medical resources and has distinctive features that make it well poised to achieve a safe floor of CT use in the pediatric head injury population. These features include a largely capitated payment model, an integrated system that allows for close patient follow-up, stable ED physician staffing models, region-wide emphasis on iterative feedback to physicians on imaging practices, and a comprehensive electronic health record (EHR) that supports CDS tools Seven of the 21 EDs had previously received a CDS system intervention implementing the PECARN rules during 2013 and 2014.[11] This CDS tool remained available but was not promoted actively at the 7 sites for the duration of this study.

Methods

We performed a retrospective observational study of pediatric (< 18 years old) minor blunt head trauma encounters from January 2016 to December 2018 across 21 community EDs within Kaiser Permanente Northern California (KPNC). KPNC is a private, nonprofit integrated health-care system that covers 4.4 million members, or approximately one-third of the region's population. KPNC members are comparable to the surrounding population with respect to age, gender, race, and ethnicity.[12] All care facilities (emergency, outpatient, inpatient) within KPNC use the same comprehensive integrated EHR (Epic, Verona, WI).[13]

To define our study patient population, we used a novel hierarchical algorithm based on previously validated "groupers" of ED chief complaints and diagnoses (Supplemental Figure S1).[2,14] The criteria were informed and refined through iterative medical record review. Prior retrospective work in our system had derived a grouper of 13 ED chief complaints with 86% sensitivity and 90% specificity for an ED head trauma diagnosis (unpublished data using previously described methods).[14] In our current study, we refined this grouper to define our head trauma inclusion criteria with the goal of capturing children with minor blunt head trauma who would likely be eligible for application of the PECARN rule. If a patient had a head trauma diagnosis or a chief complaint of head trauma or head laceration, they were included directly in the study cohort. For other encounters, we screened for alternative validated combinations of ED chief complaints and established two main groupers for alternative chief complaints: a mechanism grouper and a symptom grouper with an associated inclusion algorithm (Supplemental Figure S1). Effectively, this algorithm excluded patients without head trauma-related diagnoses from the ED encounter if their only chief complaint was headache (a symptom grouper), but included those with headache who also had a mechanism grouper or additional symptom grouper.

Because our patient population of interest did not include those with severe, prior, or subacute head trauma, we excluded those with a TBI diagnosis in the prior year, a cranial CT for any reason within 24 hours prior to the ED visit, or any documented Glasgow Coma Scale (GCS) scores <14 (from nursing flowsheet data). We also excluded patients transferred in from other facilities. We compared CT use rates between facilities that had previously received a CDS system intervention and those that had not, and tested for statistical significance with a 2-tailed *t*-test.

Results

Our study included 39,792 pediatric head trauma-related ED visits. We excluded 153 patients with TBI diagnoses in the prior year, 128 patients with a CT scan or claim in the prior 24 hours, and 108 patients with ED GCS scores < 14 (Figure 1). Our cohort consisted of 156 (0.4%) patient encounters with a GCS score of 14 and 8204 (20.6%) patients who were younger than 2 years of age. By year, aggregate CT ordering rates and facility-level ranges were as follows: 13.2% (range, 6.8–22.7%) in 2016, 12.3% (range, 3.5–21.9%) in 2017, and 13.2% (range, 6.0–23.3%) in 2018. Aggregate CT ordering rate across the 21 EDs throughout the study period was 12.9% [95% confidence interval

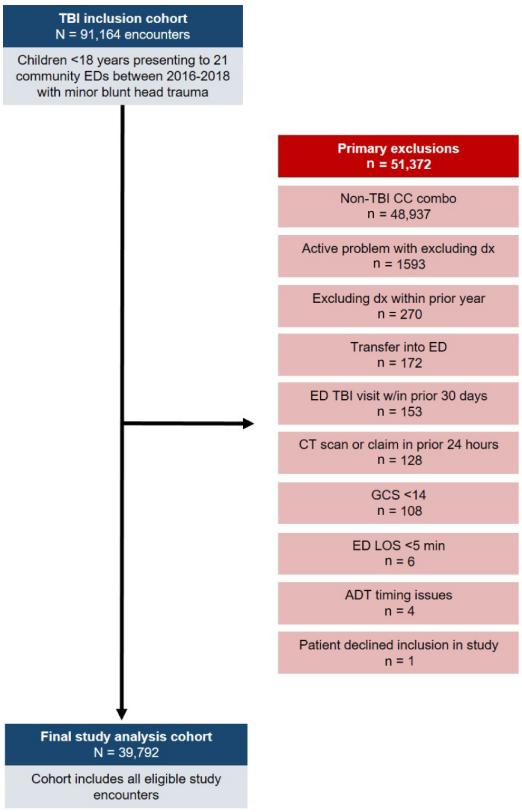

Figure 1: Children with head trauma presenting to 21 community emergency departments, 2016 through 2018 cohort assembly. ADT = arrival, departure, and transfer; CC = chief complaint; CT = computed tomography; dx = diagnosis; ED = emergency department; GCS = Glasgow Coma Scale; LOS = length of stay; TBI = traumatic brain injury.

(CI), 12.6–13.3%]. Facility-level ED CT ordering rates across the entire study period ranged from 5.4% to 21.6%. The 7 facilities that had received the CDS system intervention previously during 2013 and 2014 had an aggregate mean CT ordering rate of 11.2% (95% CI, 10.7–11.7%; facility-level range, 5.4–14.3%) compared to 14.1% (95% CI, 13.6–14.5%; facility-level range, 7.3–21.6%) for the nonintervention facilities (difference, 2.9%; 95% CI, 2.2–3.5%; $p < 0.00001$). The overall study period CT ordering rates for the 2 trauma sites (sites L and site T) were 14.3% (95% CI, 12.7–15.9%; yearly range, 13.6–14.7%) and 12.4% (95% CI, 11.3–13.5%; yearly range, 11.4–13.0%), respectively (Table 1, Figure 2).

Discussion

Our observational study revealed CT ordering rates to be low across 21 community EDs in an integrated health-care system over 2016 through 2018. Although intrafacility variation in yearly rates of CT use in our study was small (variation range, 0.3–6.5%), study-long variation between facilities was comparatively large, with CT use rates ranging from a low of 3.5% to a high of 23.3%. This was somewhat surprising given that all sites are part of an integrated delivery system, and use the same EHR, standardized documentation templates, order sets, and physician staffing group. Furthermore, the rate of severe pediatric head trauma is extremely low across the entire system (we found and excluded only 108 patients with GCS scores < 14). Although CT use was lower at PECARN CDS sites in this investigation (11.2% vs 14.1%), prior analyses did not reveal a significant pre-/post-implementation change in CT use at intervention sites compared to control sites, so it is unclear whether the observed difference is a result of the prior implementation or other unmeasured facility-level differences.[11]

Across the US, there is even greater variation in CT use for children presenting to EDs with minor blunt head trauma, with average reported rates hovering around 50%.[2,3] The cross-sectional study of Marin et al.[3] of 324,435 pediatric head trauma visits to 848 general EDs found a risk-adjusted median CT use rate of 56% (interquartile range, 46.4–64.7%), with nontrauma centers 10% less likely to perform a CT than trauma centers. The 5-year retrospective study of Mannix et al.[10] of 161,319 pediatric minor head injury encounters across 40 pediatric EDs revealed a median imaging rate of 36% (interquartile range, 29–42%; range, 19–58%) and found no significant association between institution-specific rates of serious head injury patients and CT use among minor head injury patients ($p = 0.44$). Lower CT use rates are found more frequently at sites using computerized CDS and/or with ongoing quality improvement initiatives.[11,15]

Our study used a unique case ascertainment method. Although previous studies have largely used International Classification of Diseases codes, singular chief complaints, and ED disposition diagnoses to derive their cohorts, we used GCS scores as well as combinations of ED diagnoses and chief complaints to define a minor blunt head trauma cohort.[5,7,16] We used previously validated inclusion criteria of chief complaints and diagnostic groupings in our cohort derivation and, rather than excluding patients with missing GCS scores, as has been done frequently with previous studies, we opted simply to exclude any patient with an explicitly documented GCS score that was less than 14.[14] We decided to include patients without documented GCS scores because iterations of chart review revealed that many of these patients were otherwise eligible for our study. Hence, by including these patients, we were able to assemble a more robust cohort that better captured the population of interest.

Site	2016			2017			2018			Overall study period		
	No scans, n	CT scans, n	Scan rate, %	No scans, n	CT scans, n	Scan rate, %	No scans, n	CT scans, n	Scan rate, %	No scans, n	CT scans, n	Scan rate, %
A	584	120	17.0	562	128	18.6	598	122	16.9	1744	370	17.5
B	361	56	13.4	348	40	10.3	358	52	12.7	1067	148	12.2
C	249	50	16.7	293	39	11.7	252	56	18.2	794	145	15.4
D	595	100	14.4	602	75	11.1	569	66	10.4	1766	241	12.0
E	332	75	18.4	392	90	18.7	371	84	18.5	1095	249	18.5
F	395	94	19.2	381	107	21.9	452	137	23.3	1228	338	21.6
G	346	52	13.1	376	61	14.0	332	70	17.4	1054	183	14.8
H	924	89	8.8	917	82	8.2	930	108	10.4	2771	279	9.2
I	240	24	9.1	244	18	6.9	262	17	6.1	746	59	7.3
J	568	74	11.5	535	80	13.0	578	83	12.6	1681	237	12.4
K	661	79	10.7	678	83	10.9	583	77	11.7	1922	239	11.1
L	502	86	14.6	515	81	13.6	503	87	14.7	1520	254	14.3
M	485	59	10.8	476	69	12.7	446	62	12.2	1407	190	11.9
N	570	167	22.7	583	133	18.6	626	136	17.8	1779	436	19.7
O[a]	501	74	12.9	490	56	10.3	493	44	8.2	1484	174	10.5
P[a]	509	53	9.4	527	39	6.9	461	50	9.8	1497	142	8.7
Q[a]	1176	221	15.8	1331	205	13.3	1377	224	14.0	3884	650	14.3
R[a]	812	77	8.7	756	100	11.7	765	95	11.0	2333	272	10.4
S[a]	231	18	7.2	277	19	6.4	250	20	7.4	758	57	7.0
T[a]	1060	157	12.9	974	125	11.4	892	133	13.0	2926	415	12.4
U[a]	398	29	6.8	418	15	3.5	374	24	6.0	1190	68	5.4
Grand total	11,499	1754	13.2	11,675	1645	12.4	11,472	1747	13.2	34,646	5146	12.9

Table 1: Cranial computed tomographic scan rate for children presenting with mild traumatic head injury to 21 emergency departments, 2016 through 2018
[a] These sites received a clinical decision support intervention during 2013 and 2014.
CT = computed tomography.

Although many studies discuss and explore the impact of CDS or quality improvement interventions on rates of CT use, there are few studies on trends of CT use in facilities not actively undergoing these initiatives. Our study captures both populations—demonstrating low CT use in settings with and without CDS interventions with rates that are near the floor (10–15%) of those reported in prior studies.[11,15,16] Our findings may be explained by the distinctives of our care delivery model, including comparably lower degrees of financial incentives and medicolegal risk to image very low-risk patients, as well the presence of an integrated system that allows for close patient follow-up. Such dynamics may reassure physicians and parents who choose observation or expectant management rather than immediate CT.[17] This use pattern is similar to those seen in New Zealand and Australia, where the retrospective review of Wilson et al.[18] of 31 EDs (a mix of tertiary, urban/suburban, and rural EDs) revealed head CT use to be less than 10% on average. Our findings may also be explained by the natural diffusion of the PECARN prediction rules into clinical practice, as the evidence mounts for their effectiveness in reducing CT imaging in children with minor blunt head trauma without compromising safety.[4–8] The implementation of these rules into a EHR-based decision support tool in a subset of our study cohort may have spurred more rapid diffusion at other sites in the system.

Limitations

Our study is limited by its observational nature, and thus we were unable to control for specific factors associated with interfacility variation. In

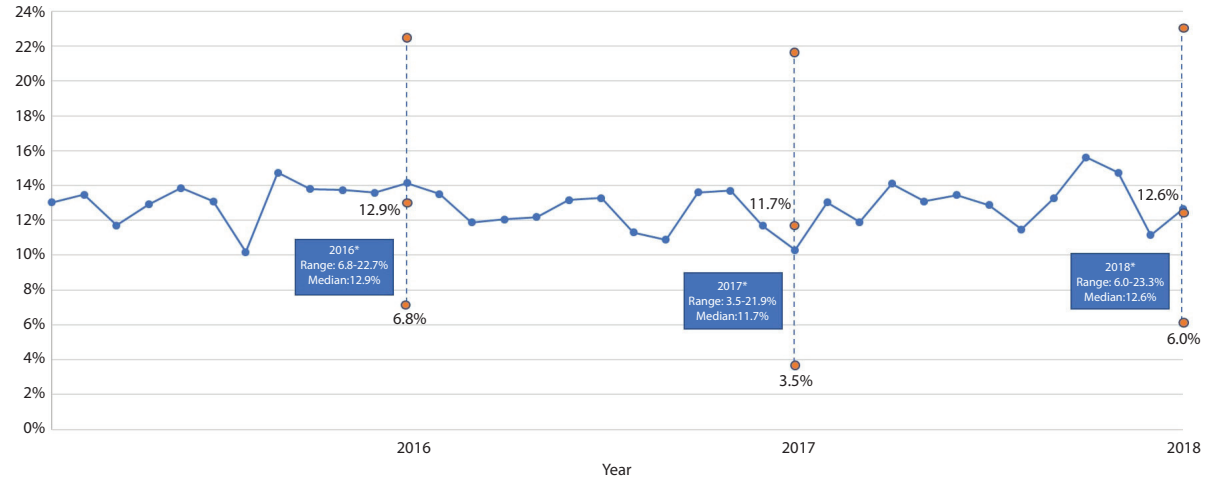

Figure 2: Cranial computed tomography (CT) use in children with head trauma in 21 community emergency departments (EDs), 2016 through 2018. * = yearly maximum, minimum, and median facility CT use rates among the 21 EDs.

addition, we did not assess potentially missed TBI, although a review of medicolegal cases for our health system did not suggest this to be an issue. We were also unable to exclude all populations (such as known or suspected abusive head trauma) that might be excluded in a prospective study. However, the volume of such patients in our system is small and we have no reason to believe there was variation in such patients over time or medical facility. Lastly, our study sites are part of an integrated health-care system, and thus our observed CT practice patterns may not be generalizable to other community EDs.

Conclusion

Cranial CT use rates for children with minor blunt head trauma were low and stable at 21 community EDs in this integrated health system between 2016 and 2018. This may be indicative of the safe stewardship of resources in the system, including the absence of financial or medicolegal incentives to image very low-risk patients, as well the availability of resources for close patient follow-up. Because a large proportion of pediatric emergency care is provided by community hospitals, it remains important to generate high-quality imaging use data that can inform future quality improvement studies and interventions.

Supplementary Materials

Supplemental Material is available at: www.thepermanentejournal.org/files/2021/21.096supp.pdf.

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