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Utilization of head CT during injury visits to United States emergency departments: 2012–2015

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Abstract

Introduction: Studies have shown increasing utilization of head computed tomography (CT) imaging of emergency department (ED) patients presenting with an injury-related visit. Multiple initiatives, including the *Choosing Wisely*TM campaign and evidence-based clinical decision support based on validated decision rules, have targeted head CT use in patients with injuries. Therefore, we investigated national trends in the use of head CT during injury-related ED visits from 2012 to 2015.

Methods: This was a secondary analysis of data from the annual United States (U.S.) National Hospital Ambulatory Medical Care Survey from 2012 to 2015. The study population was defined as injury-related ED visits, and we sought to determine the percentage in which a head CT was ordered and, secondarily, to determine both the diagnostic yield of clinically significant intracranial findings and hospital characteristics associated with increased head CT utilization.

Results: Between 2012 and 2015, 12.25% (95% confidence interval [CI] 11.48–13.02%) of injury-related visits received at least one head CT. Overall head CT utilization showed an increased trend during the study period (2012: 11.7%, 2015: 13.23%, $p = 0.09$), but the results were not statistically significant. The diagnostic yield of head CT for a significant intracranial injury over the period of four years was 7.4% (9.68% in 2012 vs. 7.67% in 2015, $p = 0.23$).

Conclusions: Head CT use along with diagnostic yield has remained stable from 2012 to 2015 among patients presenting to the ED for an injury-related visit.

Keywords

CT scan; Head trauma; Intracranial hemorrhages; Traumatic brain hemorrhage; Traumatic subdural hematoma; Traumatic brain injuries; Traumatic subarachnoid hemorrhage; Brain concussion; Traumatic cerebral hemorrhage; Neurosurgery

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1. Introduction

Head computed tomography (CT) is highly sensitive for intracranial injury, and is thus the recommended initial imaging modality to evaluate traumatic head injuries. A number of well-validated clinical decision rules, including the Canadian Head CT Rule and New Orleans Criteria, are available to improve the efficiency of head CT utilization for the evaluation of patients with traumatic head injury in the emergency department (ED) [1].

Several prior studies have shown an increasing trend in CT usage [2,3]. Hussein et al. found that head CT use for injury-related visits significantly increased from 9.6% in 2007 to 11.6% in 2010 ($p < 0.001$), a relative increase of 20.8% [3]. Since the publication of these studies, awareness of the potential risks of radiation exposure secondary to CT scans has increased [4]. In addition in 2012, the *Choosing Wisely™* campaign kicked off an effort to avoid unnecessary tests or treatments on patients, including head CT [5]. In 2013, the American College of Emergency Physicians joined *Choosing Wisely™* with its collection of evidence-based recommendations, two of which aimed to avoid unnecessary head CTs [5].

We investigated national trends in the use of head CT during injury related visits to the ED during a 4-year period (2012–2015). We hypothesized that the prevalence of head CT use in injury-related ED visits would decrease or plateau. Secondly, we aimed to determine the change in diagnostic yield over the same period, and to examine patient and hospital characteristics associated with increased head CT utilization.

2. Methods

2.1. Study setting and population

This secondary analysis used data collected from the National Hospital Ambulatory Medical Care Survey (NHAMCS) and met criteria for exemption by the Institutional Review Board. NHAMCS is an annual, national probability sample of ambulatory visits to non-federal, general, and short-stay hospitals in the United States (U.S.) [6]. NHAMCS uses a four-stage probability sampling design, collecting a nationally representative sample of ED visits [6]. At each sampled hospital, NHAMCS data are abstracted from patient records by trained hospital staff members monitored by the U.S. Census Bureau's agents during a randomly assigned 4-week reporting period.

2.2. Study protocol

We restricted our analyses to visits from 2012 to 2015 that were related to an injury due to trauma. Variables of interest included patient age (<18, 18–64, and >64 years), region of the country, sex, race, insurance status, and provider type. Insured was defined as having Medicare, Medicaid, worker's compensation, or private insurance; uninsured was defined as charity, self-pay, no charge, other, or unknown. Providers were categorized as having primarily been seen by an attending physician, resident (defined as intern or resident), or advanced practice provider (nurse practitioners and physician assistants).

We calculated diagnostic yield based on the proportion of injury related visits in which patients receiving a head CT received a significant intracranial injury diagnosis. For the

purposes of this study, we operationally defined “significant diagnosis” as International Classification of Diseases, 9th Revision (ICD-9), code: Fracture of the vault of skull (800.xx), fracture of base of skull (801.xx), fracture of face bones (802.xx), other skull fractures (803.xx), multiple fractures involving skull or face with other bones (804.xx), cerebral laceration and contusion (851.xx), subarachnoid, subdural, and extradural hemorrhage following injury (852.xx), other intracranial hemorrhage following injury (853.xx), intracranial injury of other or unspecified nature (854.xx), injury to blood vessels of head and neck (900.xx), crushing injury of face, scalp, and neck (925.xx), injury to optic nerve and pathways (950.xx), and injury to other cranial nerve(s) (951.xx) [2,3].

2.3. Outcome measures

Our primary outcome was the use of head CT during injury-related visits to the ED. As secondary outcomes, we determined diagnostic yield, defined as the proportion of injury-related visits in which patients receiving a head CT received a significant head injury diagnosis, and patient and visit characteristics associated with head CT use.

2.4. Data analysis

We reported frequencies of unweighted raw ED visits and weighted for national representativeness. We reported yearly trends of head CT utilization for injury-related visits. We used survey-weighted chi square tests to assess for differences in the proportion of visits receiving head CT across categories. In addition, we used a survey-weighted multivariable logistic regression to assess the whether certain patient or visit characteristic variables were independently associated with head CT use.

We incorporated NHAMCS complex survey design features including cluster, strata, and probability weights to produce nationally representative estimates. As recommended, we included only variables where cell sizes were ≥ 30 samples per cell [7]. We did not consider or analyze any items with a nonresponse rate of $>10\%$. A p -value < 0.05 was considered significant. All analyses were conducted using SAS 9.4 (Cary, NC).

3. Results

From 2012 to 2015, the NHAMCS included an unweighted total of 99,135 ED visits, 30,158 of which were injury-related. This represented a weighted sample of 135 million total and 40 million yearly injury related ED visits. Patient and visit characteristics are reported in Table 1.

3.1. Head CT utilization and yield

Between 2012 and 2015, 12.25% (95% confidence interval [CI] 11.48–13.02%) of injury-related visits received at least one head CT. Overall head CT utilization showed an increased trend during the study period (2012: 11.7%, 2015: 13.23%, $p = 0.09$), but the results were not statistically significant (Fig. 1). These findings held when stratified by age. Among patients <18 years, head CT use went from 7.17% (CI 5.31%–9.03%) in 2012 to 8.20% (CI 6.24%–10.16%) in 2015 ($p = 0.46$). Among patients 18–64 years of age, head CT use went from 10.31% (CI 8.94%–11.68%) in 2012 to 11.64% (CI 9.97%–13.32%) in 2015 ($p = 0.21$).

Among patients 65 years and older, head CT use went from 26.90% (CI 22.74%–31.07%) in 2012 to 29.23% (CI 25.53%–32.94%) in 2015 ($p = 0.39$).

The diagnostic yield of head CT for a significant intracranial injury diagnosis over the four-year period was 7.4% and did not significantly change over the study period (2012: 9.68% and 2015: 7.67%, $p = 0.23$) (Fig. 1).

3.2. Characteristics associated with head CT

After adjusting for sex, race, insurance status, provider level, and region, several factors were significantly associated with increased odds of head CT performance. Patients were more likely to receive a head CT with increasing age, when seen by a resident rather than primarily by an attending, and if the ED visit occurred in the South (Table 1). In contrast, patients seen by an advanced practice provider had a lower adjusted odds ratio of receiving a head CT compared to patients seen primarily by an attending (Table 1).

4. Discussion

In this analysis of national survey data, we found no significant increase in head CT utilization among ED patients with injury-related visits from 2012 to 2015. This finding held among all age groups. Our findings contrast with prior studies which showed a significant trend towards increased head CT use with no change in diagnostic yield from 2007 to 2010 [2,3]. We also found that diagnostic yield remained unchanged over the four years.

Head CT use may be plateauing due to several factors. Through the various campaigns and education initiatives, clinicians may be more aware of the potential risks of head CT imaging, related to costs and radiation exposure [4,5]. Clinicians also may be incorporating decision rules through the adoption of clinical decision support (CDS) into the electronic health record. While CDS has not been fully adopted [8], evidence has shown that that CDS can reduce low-utility imaging for mild traumatic brain injury [9].

It is not surprising that we found an increased odds ratio of head CT utilization among patients 65 and older relative to patients <18 years of age, as various decision rules consider patients 60 years and older at higher risk for developing a clinically significant intracranial hemorrhage [1]. However, it is unclear why there was an increased odds ratio of head CT utilization among patients cared for in the Southern region of the US and this deserves further study. Consistent with other studies [2,3], there was no relationship among gender, race, and insurance status for head CT use for injury-related visits.

Interestingly, we also found that likelihood of head CT utilization varied by clinician type. When compared to patients seen primarily by an attending, patients seen by a resident had a higher adjusted odds ratio and patients seen by an advanced practice provider had a lower adjusted odds ratio of receiving a head CT. One potential explanation for this finding may be related to differences in practice settings. As we were unable to adjust for severity of illness or trauma severity, it is possible that residents are more often than advanced practice providers working in the ED of teaching hospitals, which see more critically ill patients [10].

This study had several limitations. As it was a secondary analysis of a nationally representative database, which provided visit-level data, it lacks specific clinical data and therefore we were unable to select a patient sample that had known definitive head strike. However we do not have any reason to believe that the frequency of head strike would have changed over our study period, or that it would have varied by any of our variables of interest. In addition, we were unable to adjust for severity of illness or trauma severity, nor were we able to consider clinical appropriateness of CT imaging at the patient level. Finally, while adding the years before 2012 would have provided a richer data set, starting in 2012, NHAMCS created a separate injury/trauma category variable, which we used to capture our population. Due to difference in data collection, we were unable to accurately compare pre and post-2012 data.

5. Conclusions

After a period of increased utilization of head CT from 2007 to 2010, we found that from 2012 to 2015, head CT use among injury-related ED visits did not significantly increase and diagnostic yield of head CT for finding clinically significant intracranial injuries has been stable. Additional studies should assess how these findings affect cost and quality of emergency care.

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Fig. 1. Changes in head CT utilization and diagnostic yield for injury-related visits to Emergency Departments from 2012 through 2015. CT = computed tomography.

Table 1

Relationship between patient and visit characteristics and head CT use during injury-related Emergency Department (ED) visits

	Unweighted ED visits	Weighted ED visits (Thousands)	Adjusted odds ratio [*] for likelihood of CT use (95% CI)
Age (years)			
<18	7072	9591	Reference
18–64	18,934	25,187	1.75 (1.46–2.10)
>65	4152	5462	5.19 (4.34–6.20)
Sex			
Male	15,881	20,775	Reference
Female	14,277	19,467	0.95 (0.84–1.07)
Race			
Non-Hispanic	18,900	25,245	Reference
White			
Non-Hispanic Black	5726	7722	0.97 (0.83–1.12)
Other	5532	7274	0.98 (0.84–1.14)
Insurance			
Uninsured	7759	10,459	Reference
Insured	22,399	29,782	1.03 (0.90–1.17)
Provider			
Attending	20,302	27,433	Reference
Resident/Intern	2619	2990	1.35 (1.08–1.70)
PA/NP	6479	8842	0.72 (0.62–0.85)
Region			
Northeast	6403	7402	Reference
Midwest	7365	9526	1.18 (0.95–1.46)
South	9986	14,244	1.31 (1.09–1.59)
West	6404	9069	1.053 (0.84–1.32)
Total	30,158	40,242	

* Adjusted for age, sex, race, insurance status, provider level, and region.