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Declining trend in the use of repeat computed tomography for trauma patients admitted to a level I trauma center for traffic-related injuries

Kevin J. Psoter, MPA,

Department of Epidemiology, University of Washington, Box 357236, Seattle, WA 98195, Phone: 1-206-465-5459, Fax: 1-206-543-8525

Bahman S. Roudsari, MD, PhD,

Department of Radiology, Comparative Effectiveness, Cost and Outcomes Research Center, University of Washington, 325 Ninth Avenue, Box 359960, Seattle, WA 98104, Phone: 1-206-744-9437

Janessa M. Graves, PhD, MPH,

Department of Pediatrics, Harborview Injury Prevention and Research Center, University of Washington, 325 Ninth Avenue, Box 359960, Phone: 1-206-744-9861

Christopher Mack, MS, and

Harborview Injury Prevention and Research Center, University of Washington, 325 Ninth Avenue, Box 359960, Seattle, WA 98104, Phone: 1-206-744-9430

Jeffrey G. Jarvik, MD, MPH

Department of Radiology and Department of Neurological Surgery, Comparative Effectiveness, Cost and Outcomes Research Center, University of Washington, 325 Ninth Avenue, Box 359960, Seattle, WA 98104, Phone: 1-206-744-3561

Kevin J. Psoter: kevinp2@u.washington.edu; Bahman S. Roudsari: roudsari@u.washington.edu; Janessa M. Graves: janessa@u.washington.edu; Christopher Mack: cdmack@uw.edu; Jeffrey G. Jarvik: jarvikj@u.washington.edu

Abstract

Objective—To evaluate the trend in utilization of repeat (i.e. 2) computed tomography (CT) and to compare utilization patterns across body regions for trauma patients admitted to a level I trauma center for traffic-related injuries (TRI).

Materials and Methods—We linked the Harborview Medical Center trauma registry (1996–2010) to the billing department data. We extracted the following variables: type and frequency of CTs performed, age, gender, race/ethnicity, insurance status, injury mechanism and severity, length of hospitalization, intensive care unit (ICU) admission and final disposition. TRIs were defined as motor vehicle collisions, motorcycle, bicycle and pedestrian-related injuries. Logistic regression was used to evaluate the association between utilization of different body region repeat

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Correspondence to: Kevin J. Psoter, kevinp2@u.washington.edu.

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(i.e. 2) CTs and year of admission, adjusting for patient and injury-related characteristics that could influence utilization patterns.

Results—A total of 28,431 patients were admitted for TRIs over the study period and 9,499 (33%) received repeat CTs. From 1996 to 2010, the proportion of patients receiving repeat CTs decreased by 33%. Relative to 2000 and adjusting for other covariates, patients with TRIs admitted in 2010 had significantly lower odds of undergoing repeat head (OR: 0.61, 95%CI: 0.49–0.76), pelvis (OR= 0.37; 95% CI: 0.27–0.52), cervical spine (OR= 0.23; 95%CI: 0.12–0.43), and maxillofacial CTs (OR=0.24; 95% CI: 0.10–0.57). However, they had higher odds of receiving repeat thoracic CTs (OR= 1.86; 95% CI: 1.02–3.38).

Conclusion—A significant decrease in the utilization of repeat CTs was observed in trauma patients presenting with traffic-related injuries over a 15-year period.

Keywords

Trauma; CT; trend analysis; utilization rates; traffic-related injuries

INTRODUCTION

Traffic-related injuries (TRI) are the leading cause of morbidity and mortality in children and young adults in the United States [1]. Even among older individuals, TRIs are among the top 10 leading causes of death. The total direct and indirect burden of these injuries in the United States has been estimated to exceed \$230.6 billion in 2000 [2].

Computed tomography (CT) is the imaging modality of choice for the management of trauma in emergency departments and during hospitalization [3]. Since its introduction in 1970, CT has revolutionized diagnostic radiology by providing precise images that could not be obtained through other non-invasive modalities [4–7]. Studies have demonstrated substantial increases in CT utilization, particularly among patients treated in emergency departments [6, 8–11]. Multiple factors have been suggested to be involved in the escalating trend in utilization, including availability and affordability of this modality [12], patient demands [13], defensive medicine [14], financial incentives [15] and aging of the population.

The increase in the utilization rate of CT raises two major concerns. First, CT emits ionizing radiation that has potential carcinogenic effects for individuals exposed to repeat scans [7, 16, 17]. This issue is particularly important when considering CT utilization in the pediatric population [18]. Second, advanced imaging technologies have contributed to increasing the cost of care because of the high cost per study as well as the high frequency of use [7].

This study evaluated the trend in utilization of repeat (i.e. 2) CT for trauma patients admitted to a level I trauma center for TRIs after adjustment for potential confounding variables.

MATERIALS AND METHODS

We linked the trauma registry and billing department data from Harborview Medical Center (HMC), the only level I trauma utilization in the Northwest United States covering Washington, Idaho, Montana and Alaska. From the linked databases, we extracted the following variables: age, gender, race/ethnicity, insurance status, mechanism of injury, injury severity score (ISS), length of hospitalization, intensive care unit (ICU) admission, final disposition (dead vs. alive), year of admission and type and frequency of CTs performed during hospitalization. The study population consisted of those patients admitted for TRIs, including motor vehicle collisions, motorcycle, bicycle and pedestrian-related

injuries. This study was approved by the University of Washington institutional review board.

We evaluated the utilization of the most commonly performed CTs: head, pelvis, abdomen, cervical spine, thorax, and maxillofacial. Repeat CT was defined as two or more CTs of the same body region performed during the patient's hospitalization period following admission. As a result, follow-up CTs after discharge from hospital and those performed on referred patients prior to transfer are not included in our analyses. In addition, reconstructed images were not included as separate CT investigations, since patients were not billed for these services.

The outcome variable was the proportion of patients receiving repeat CTs for each body region. Year of admission was the primary exposure of interest. To evaluate the unadjusted trend in repeat CT utilization from 1996 to 2010, the mean proportion of patients receiving repeat CTs was plotted against year of admission for each body region.

We used multivariate logistic regression to evaluate the trend in utilization of repeat CTs during the 15-year study period, considering 2000 as the baseline for comparison. For each body region we used a separate logistic regression model, adjusted for demographic and injury-related characteristics that could influence utilization rates including age, gender, race/ethnicity, insurance status, injury severity, length of hospitalization, ICU admission and final disposition (dead vs. alive). Results are presented as odds ratios (ORs) with corresponding 95% confidence intervals (CI). All analyses were conducted using Stata 11.1 (Stata Corporation, College Station, TX).

For the multivariable analyses, year of admission was considered a dichotomous (dummy) variable for the following reasons. First, previous studies have demonstrated that the change in utilization does not follow a linear pattern over time [19]. Second, the binary classification of year of admission in the model allowed us to compare the change in utilization rate between any two years of the study period. However, including year of admission as a continuous variable did not change our conclusions (results not presented).

RESULTS

A total of 28,431 trauma patients were admitted to HMC for TRIs from 1996–2010 (average of 1,895 patients per year) and 20,748 (73%) of these patients received at least one CT during hospitalization, while 9,207 (32%) received at least one repeat CT. The majority of TRIs involved motor vehicle injuries (63%), followed by motorcycle (15%), pedestrian (13%), and bicycle-related injuries (8%). The distributions of age, gender, race/ethnicity, insurance status, ISS, length of hospitalization, ICU admission and fatality rate for the patients who received repeat CTs are summarized in Table 1.

Demographic characteristics of the study population were relatively stable during the study period. For example, the proportion of males ranged from 65–69% and the mean age of patients varied between 34–37 years. However, the proportion of uninsured patients increased steadily to a peak of 21% in 2007 and has remained at approximately 16% since. Similar to demographics, injury characteristics of the study population showed minimal variability over the 15 year period. The mean length of hospitalization ranged from 7 to 9 days and the mean ISS from 13–19, while the proportion of patients who were admitted to the ICU and died ranged from 30–50% and 4–7%, respectively. However, there were no temporal trends observed for any of these characteristics.

The most commonly performed repeat CTs in this patient population were as follows: head (n=6,411), pelvis (n=3,085), abdomen (n=990), cervical spine (n=731), thorax (n=681), and

maxillofacial (n=400). From 1996 to 2010, the proportion of patients who received a repeat head CT decreased by 29%, from 28% to 20% for all patients (Figure 1). The proportion of patients receiving repeat exams also decreased for pelvis (52%), cervical spine (51%), and maxillofacial (43%); while increased repeat CTs was observed for abdomen (41%) and a 200% increase was observed for repeat thorax exams (from 1% in 1996 to 3% in 2010).

Compared to 2000, patients with TRIs in 2010 had significantly lower odds of receiving a repeat head (OR= 0.61; 95% CI: 0.49–0.76), pelvis (OR= 0.37; 95% CI: 0.27–0.52), cervical spine (OR= 0.23; 95% CI: 0.12–0.43), and maxillofacial (OR=0.24; 95% CI: 0.10–0.57) CTs, after adjusting for previously described covariates (Figure 2). Patients had higher odds of receiving a repeat thorax (OR= 1.86; 95% CI: 1.02–3.38) CT, while no differences were observed for repeat abdomen (OR= 0.62; 95% CI: 0.37–1.06) CTs.

Repeat head CTs demonstrated a significant decline in utilization beginning in 2006 and persisting to 2010 (Figure 2). A similar pattern to repeat head CTs was observed for repeat pelvis CTs, with decreased utilization from 2006 to 2010. Compared to 2000, significant decreased utilization of repeat cervical spine CTs was observed from 2001–2010, while decreased utilization of repeat maxillofacial CTs began in 2003 and remained throughout the study period. For repeat abdomen CTs, slightly increased or unchanged utilization rates occurred from 2001–2007; however, in more recent years (2008–2010) decreased utilization was observed. Significant increased utilization for repeat thoracic CTs was observed beginning in 2001 and generally persisted over the study period, with a maximum utilization rate observed in 2005.

DISCUSSION

In this study, we described long-term utilization trends (1996–2010) in the use of repeat CTs for trauma patients admitted to a single level I trauma utilization for TRIs. We observed significant decreases in utilization of repeat head, pelvis, abdomen, and cervical spine CTs and increased use of repeat thorax CTs in this patient population.

Utilization of advanced imaging technologies, including CT, is of a special concern at level I trauma utilizations for a number of reasons. First, these hospitals are responsible for providing care to the most seriously injured patients, 30–50% of which may be under the influence of alcohol [20]. Since patient history and physical examinations are less reliable for intoxicated patients, clinicians rely on CT examinations significantly more often, compared to equally injured patients not under the influence of alcohol [20]. Second, a large proportion of patients in level I trauma utilizations are uninsured, resulting in largely uncompensated care. Therefore, any strategy that could potentially limit unnecessary CT utilization without affecting quality of care may be of substantial importance for these hospitals.

The decreasing utilization of repeat CTs in our study differs from previous reports of increased use of CT. For instance, a review of electronic records from 2001 to 2007 at an inner-city academic emergency department (ED) showed a 6-fold increase in chest CT and a 5-fold increase in neck CT [11]. Head, abdomen, and facial CT utilization also showed a significant (150%) increase [11]. Nationally representative studies provide additional evidence of substantial increases in general CT use [6, 8–11]. However, these studies often have included all medical and surgical causes of ED visits, did not differentiate between disease or injury mechanisms, or consider repeat examinations.

Few studies have evaluated utilization of repeat CTs. Using data from a large integrated health system, Smith-Bindman and colleagues reported an approximate 30% increase in the

use of repeat CT of the abdomen and central nervous system between 1997 and 2006, but a decreasing trend in the later years between 2005 and 2006 [21].

In our study, head CTs were the most commonly performed repeat investigations (52%). Repeat head CT is a standard practice in many trauma utilizations in the evaluation of the progression of head injuries, yet the effects on patient outcomes have not been fully investigated [22, 23]. Wang and colleagues, in a review of published literature, concluded that there might be subset(s) of trauma patients who benefit from repeat head CTs [24].

Our study adds to the current literature by demonstrating that the use of repeat head, pelvis, abdomen, and cervical spine CT has decreased in recent years in our institution. Unfortunately our existing data does not allow us to evaluate the factors that have been associated with this temporal utilization pattern. Smith-Bindman, et al [17] and Hendee and colleagues [25] have proposed the following approaches to address the escalating use of CT: 1) Use of evidence-based guidelines for CT examination protocols and techniques, 2) Reduction in the number of CT exams, including multiple scans, achieved by weighing diagnostic benefit with radiation costs, 3) Recording and monitoring radiation doses as a component of risk assessment, and 4) Decision support for physicians, education of physicians, patients, and the public, and payment reform. Future studies should evaluate the potential influence of these strategies on resource utilization.

Our study has several limitations. First, the data are from a single level 1 trauma utilization, which may limit the generalizability of our study findings. Second, data was obtained from the trauma registry and we therefore were unable to evaluate the appropriateness of the performed procedures. Any investigation into the overutilization of performed CTs would require further in-depth medical record review. Finally, our study was limited to CTs performed during hospitalization at our institution and does not capture CTs performed prior to admission at other institutions or in outpatient setting after discharge from hospital institution.

CONCLUSION

In conclusion, in spite of most other studies that have demonstrated an increasing trend in CT use, we observed a declining trend in the use of repeat CTs. Our future studies will focus on identifying factors that have contributed to this utilization pattern.

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Figure 1.

Trends in utilization of repeat (2) CTs for various body regions for trauma patients admitted to Harborview Medical Center for traffic-related injuries (1996–2010).

Figure 2.

Adjusted logistic regression analysis, evaluating the association between year of admission and repeat (2) use of different body region CTs for trauma patients admitted to Harborview Medical Center for traffic-related injuries from 1996–2010, considering 2000 as the baseline for comparison.

NOTE—change in scale for each figure. All analyses were adjusted for age, gender, race/ethnicity, insurance status, injury severity score, length of hospitalization, ICU admission, final disposition (dead vs. alive), and year of admission

Table 1

Demographic and injury-related characteristics of trauma patients who received different types of repeat (2) CTs admitted to Harborview Medical Center for traffic-related injuries, 1996–2010

	Body region					
	Repeat head CT (N=6,411)	Repeat pelvic CT (N=3,085)	Repeat abdomen CT (N=990)	Repeat cervical spine CT (N=731)	Repeat Thorax CT (N=681)	Repeat Maxillofacial CT (N=400)
<i>Demographic Characteristics</i>						
Age (%)						
0–14	11	7	7	4	7	8
15–18	11	10	10	8	9	10
19–54	62	67	66	66	65	72
55+	17	16	17	22	19	11
Male (%)	68	66	70	65	72	73
Race/ethnicity (%)						
White	82	84	83	87	79	81
Black	7	6	6	7	6	6
Asian	7	6	6	5	8	8
Other	4	4	5	2	6	4
Insurance status (%)						
None	8	7	8	5	7	7
Medicaid	27	28	30	29	29	35
Medicare	15	10	11	15	15	5
Other	51	55	51	51	49	54
<i>Injury Characteristics</i>						
ISS (%)						
0–8	15	18	15	12	14	10
9–15	23	26	20	23	23	20
16–75	62	55	65	66	63	70
Mean length of hospitalization (days)	11	13	16	14	17	14
ICU admission (%)	63	55	66	66	62	68
Died (%)	7.4	4.8	7.9	7.4	7.8	2.8

NOTE–Percentages may not add up to 100% because of rounding.