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THE IMPACT OF AN EMERGENCY DEPARTMENT UPGRADE TO LEVEL I TRAUMA STATUS ON THE TIMELINESS OF NONTRAUMA COMPUTED TOMOGRAPHY SCANS

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☐ **Abstract—Background: Resources such as computed tomography (CT) scanners are sometimes shared when separate adult and pediatric emergency departments (EDs) exist in proximity. Objectives: To assess the impact of American College of Surgeons Level I trauma verification of an adult ED on the timeliness of nontrauma CT scans in a pediatric and adult ED that share a CT scanner. Methods: ED patient records were retrospectively reviewed to determine the time from order to completion of nontrauma CT scans. We compared the timeliness of CT scan completion between the year leading up to the adult ED being verified as a Level I Trauma Center (2015), and the 2 subsequent years (2016–2017). Results: The median time for nontrauma CT completion in the adult ED prior to Level I verification was 39 min, compared with 50 min and 49 min for the subsequent 2 years ($p < 0.001$). Similarly, the median time for completion of nontrauma CT scans in the pediatric ED increased from 33 min to 41 min and 39 min ($p < 0.001$). The proportion of patients who received CT scans within 30 min from order decreased after adult ED trauma upgrade, from 40% in 2015 to 30% and 32% ($p < 0.001$) in the 2 subsequent years. The pediatric ED showed similar results, with 48% of patients receiving CT scans within 30 min in 2015, compared with 34% in 2016 and 35% in 2017 ($p < 0.001$). Conclusions: Level I trauma verification of the adult ED adversely affected the timeliness of nontrauma CT scans in the EDs.**

☐ **Keywords—computed tomography; timeliness; ACS trauma level**

INTRODUCTION

Medical facilities that provide trauma services in the United States may be designated as one of five trauma center levels (I–V) by local or state regulatory bodies, with Level I Trauma Centers providing the highest level of surgical care and serving as a referral center for the most critically injured patients. The American College of Surgeons (ACS) then verifies these designated facilities as trauma centers based on the attainment of certain established criteria (1). Studies have demonstrated improved patient outcomes associated with ACS verification, including reduced patient mortality, length of hospital stay, and costs (2–7). Challenges resulting from trauma center level upgrades have been documented, including increased operational costs such as hiring personnel to meet ACS requirements (4). Prompt availability of radiology services is among the requirements for trauma verification, leading to the prioritization of trauma computed tomography (CT) scans over nontrauma CT scans (1).

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Timeliness is one of the six domains of health care quality and is crucial in the delivery of medical care (8). This is especially important in the emergency department (ED), where medical care must be provided to every single patient that presents for treatment, while tackling other constraints like overcrowding. The unpredictability of the ED, with its inherent variations in patient census and disease acuity, makes prompt data gathering needed for medical decision-making and patient disposition even more critical.

Various quality measures of timeliness in the ED are usually tracked by relevant stakeholders, from hospital leadership to policymakers (9). Imaging interval, the time from order of an imaging test to the availability of results, is one of the metrics used as an operational benchmark in EDs (10). When separate adult and pediatric EDs exist in proximity, some resources are shared, as is the case with the CT scanners in our Center for Emergency Medicine. To our knowledge, the effect of ACS trauma status upgrade on the timeliness of imaging studies in the ED has not been studied. We conducted this study to assess the impact of a new American College of Surgeons Level I trauma verification of the adult ED on the timeliness of nontrauma CT scans across both our adult and pediatric EDs.

MATERIALS AND METHODS

This study was conducted in an urban tertiary academic medical center. The Center for Emergency Medicine at this institution is composed of an adult and a pediatric ED, adjacent to each other but operating as separate entities. Whereas the pediatric center has been a Level I Pediatric Trauma Center verified by the ACS since 1991, the adult ED was initially verified by the ACS as a Level I Trauma Center in December 2015.

A single dedicated CT scanner located in the Center for Emergency Medicine is utilized by both the adult and pediatric EDs. With an anticipated increase in the adult ED patient volume after its new status, we sought to preliminarily assess the impact of adult Level I trauma designation on the timeliness of nontrauma CT scans in both EDs. We hypothesized that the new verification of the adult ED as a Level I Trauma Center, and its attendant increase in case volume and complexity, would adversely affect the timeliness of CT scans for nontrauma.

With approval from the institutional review board, we conducted a retrospective review of the electronic medical records (EMR) of patients who underwent CT scans during the course of treatment in our adult and pediatric EDs in the period prior to (2015) and after (2016 plus 2017) verification of the adult ED as a Level I Trauma Center. We compared CT scan orders over the same 6-month period (May to October), which are the months with the historically highest trauma volumes. We excluded scans performed during EMR downtime, as the time stamps could not be reliably tracked.

The primary outcome measure was time from CT scan order to completion. For this study we define completion as the time CT images were uploaded into the electronic imaging viewing system and therefore accessible in the EMR to the caregivers.

We described patient demographic and clinical characteristics using mean and standard deviation or median and interquartile range (25^{th} percentile, 75^{th} percentile) for continuous variables, and frequency and percentages for categorical variables, as appropriate. The comparison among three groups (2015, 2016, and 2017) was performed using either one-way analysis of variance or Kruskal-Wallis test for continuous variables, and chi-squared test for categorical variables. Statistical analysis was performed using SAS software, version 9.4 (SAS Institute, Cary, NC), and a p-value of < 0.05 was considered as statistically significant.

RESULTS

Pediatric ED

There were 780 nontrauma CT scans performed in the pediatric ED between 2015 and 2017 (Table 1). Of those, 218 CT scans were performed in 2015, 193 in 2016, and 369 in 2017. Most patients receiving CT scans were male (61%, n = 478). The mean subject age was 9.27 years (SD 6.1), and there was no significant difference in mean age across the 3 years ($p = 0.23$). The most common CT performed was of the head (48%, n = 378). The median time from CT scan order to completion in 2015 was 33 min, which increased to 41 min in 2016 and 39 min in 2017; the median difference between the three groups was statistically significant ($p < 0.001$).

The proportion of patients whose CT scans were completed within 30 min of being ordered decreased from 48% in 2015 to 34% in 2016 and 35% in 2017. Additionally, more patients had CT scans performed after 90 min in 2016 (17%) and 2017 (15%), compared with 2015 (5%) ($\chi^2 = 25.28$, df = 6, $p = 0.0003$).

Adult ED

There were 5613, 5180, and 5952 nontrauma CT scans performed in 2015, 2016, and 2017, respectively (Table 2). The mean age was 51.92 years (20.79 SD). Most CT scans were of the head (40%, n = 6749), followed by the abdomen and pelvis (23%, n = 3825).

The median time for CT scan completion prior to ED Level I trauma verification in 2015 was 39 min, which increased to 50 min in 2016 and 49 min in 2017 ($p < 0.001$). A greater proportion of patients received

Table 1. Pediatric Patients Who had CT Scans in the ED From 2015–2017

Pediatrics N = Total Number of CT Scans	Overall N = 780	Year			*p*-Value
		2015 n = 218	2016 n = 193	2017 n = 369	
Age in years, mean ± SD	9.27 ± 6.10	9.79 ± 6.28	9.37 ± 5.93	8.91 ± 6.08	0.2301*
Time from CT order to completion in minutes, median (IQR)	38.0 (22, 68)	32.5 (19, 53)	41.0 (26, 74)	39.0 (21, 76)	< 0.0001†
Time from CT order to completion categories, n (%)					0.0003‡
< 30 min	299 (38.33)	105 (48.17)	65 (33.68)	129 (34.96)	
30–60 min	248 (31.79)	72 (33.03)	60 (31.09)	116 (31.44)	
60–90 min	136 (17.44)	31 (14.22)	35 (18.13)	70 (18.97)	
> 90 min	97 (12.44)	10 (4.59)	33 (17.10)	54 (14.63)	
Gender, n (%)					0.1808‡
Female	302 (38.72)	84 (38.53)	85 (44.04)	133 (36.04)	
Male	478 (61.28)	134 (61.47)	108 (55.96)	236 (63.96)	
Type of CT scan, n (%)					0.3282‡
CT head without contrast	378 (48.46)	115 (52.75)	97 (50.26)	166 (44.99)	
CT facial bones	92 (11.79)	25 (11.47)	22 (11.40)	45 (12.20)	
CT C-spine without contrast	64 (8.21)	17 (7.80)	20 (10.36)	27 (7.32)	
CT abdomen and pelvis	70 (8.97)	16 (7.34)	14 (7.25)	40 (10.84)	
CT orbit without contrast	33 (4.23)	11 (5.05)	10 (5.18)	12 (3.25)	
Others	143 (18.33)	34 (15.60)	193 (24.74)	79 (21.41)	

CT = computed tomography; ED = emergency department; SD = standard deviation; IQR = interquartile range (25th percentile, 75th percentile); C-spine = cervical spine.
* One-way analysis of variance.
† Kruskal-Wallis test.
‡ Chi-squared test.

CT scans within 30 min in 2015 (40%), compared with 2016 (29%) and 2017 (32%). The percentage of patients whose CT scans occurred after 90 min from order increased in 2016 (27%) and 2017 (26%), compared with 2015 (16%) ($\chi^2 = 261.86$, df = 6, $p = 0.001$).

DISCUSSION

We observed a significant time delay in nontrauma CT scans for both adult and pediatric patients after the adult ED became an ACS Level I Trauma Center. To our

Table 2. Adult Patients Who had CT Scans in the ED From 2015–2017

Adults N = Total Number of CT Scans	Overall N = 16,745	Year			*p*-Value
		2015 n = 5613	2016 n = 5180	2017 n = 5952	
Age in years, mean ± SD	51.92 ± 20.79	51.27 ± 20.63	51.61 ± 20.83	52.80 ± 20.92	< 0.0002*
Time from CT order to completion in minutes, median (IQR)	46.0 (24, 86)	39.0 (21, 71)	50.0 (27, 95)	49.0 (25, 93)	< 0.0001†
Time from CT order to completion categories, n (%)					< 0.0001‡
< 30 min	5648 (33.73)	2223 (39.60)	1534 (29.61)	1891 (31.77)	
30–60 min	4689 (28.00)	1646 (29.32)	1477 (28.51)	1566 (26.31)	
60–90 min	2532 (15.12)	814 (14.50)	779 (15.04)	939 (15.78)	
> 90 min	3876 (23.15)	930 (16.57)	1390 (26.83)	1556 (26.14)	
Gender, n (%)					< 0.0001‡
Female	8606 (51.39)	3117 (55.53)	2455 (47.39)	3034 (50.97)	
Male	8139 (48.61)	2496 (44.47)	2725 (52.61)	2918 (49.03)	
Types of CT scan, n (%)					
CT head without contrast	6749 (40.30)	2486 (44.29)	2074 (40.04)	2189 (36.78)	< 0.0001‡
CT facial bones	848 (05.06)	287 (05.11)	274 (05.29)	287 (04.82)	
CT C-spine without contrast	2179 (13.01)	626 (11.15)	749 (14.46)	804 (13.51)	
CT abdomen and pelvis	3825 (22.84)	1404 (25.01)	1063 (20.52)	1358 (22.82)	
CT orbit without contrast	71 (0.42)	25 (00.45)	21 (00.41)	25 (00.42)	
Others	3073 (18.35)	785 (13.99)	999 (19.29)	1289 (21.66)	

CT = computed tomography; ED = emergency department; SD = standard deviation; IQR = interquartile range (25th percentile, 75th percentile); C-spine = cervical spine.
* One-way analysis of variance.
† Kruskal-Wallis test.
‡ Chi-squared test.

knowledge, this is the first study examining the relationship between a trauma status upgrade and timeliness of CT scans in the ED.

The total volume in our adult ED remained relatively stable in 2015 (68,602 patients) and 2016 (68,250 patients), but increased by 5% (71,687) in 2017, and has continued to increase after ACS trauma verification. In the pediatric ED, total annual volume remained relatively stable during the 3 years (33,587 in 2015, 34,328 in 2016, and 33,482 in 2017). However, the delays in obtaining timely CT scans persisted for at least 2 years after ACS verification.

Performing advanced imaging like CT scans adds to the ED length of stay, and delays in obtaining CT scans are associated with longer hospital lengths of stay (11–13). Timeliness is one of the core aspects of quality measures, therefore, delays present a concern in the delivery of optimal patient care. As far as we know, there are no established national benchmarks for an acceptable timeframe to obtain a CT scan. There needs to be more research and benchmarks established so that EDs can have goals for maintaining timeliness when anticipating large volumes or changes in services provided, such as when an institution becomes a trauma center. Some EDs have successfully addressed delays in radiology turnaround by employing systems engineering science, especially using Lean methodology (14,15). Improvements that could be made in our institution would require multidisciplinary collaborative efforts to identify bottlenecks to streamline patient flow.

Limitations

The study has several limitations, including its single-center retrospective design, and the fact that sharing of a CT scanner between the adult and pediatric EDs might not be generalizable to many other centers. Additionally, we did not account for any other possible changes during our study period, such as staffing, transportation, or the availability of CT technologists and nurses. Although we observed a correlation between Adult Level I trauma verification and CT delays across both EDs, direct causality was not definitively established.

CONCLUSION

We observed a decrease in the timeliness of nontrauma CT scans across our ED after an upgrade of the adult ED to an ACS-verified Level I Trauma Center. The radiology issues identified here are important for similar institutions, considering the implications of becoming an ACS Level I Trauma Center. Organizations considering such a change should take proactive steps to prevent delays for nontrauma CT scans.

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ARTICLE SUMMARY

1. Why is this topic important?

An upgrade in American College of Surgeons (ACS) trauma status involves a strategic commitment from hospitals. It is important to be cognizant about certain challenges that might arise, such as the effects on performance of ancillary services. Timeliness in the provision of health care is an essential aspect of quality that can influence patient outcome.

2. What does this study attempt to show?

This study attempts to show the effect of an ACS trauma status upgrade on the timeliness of nontrauma computed tomography scans in an emergency department.

3. What are the key findings?

Timeliness in the completion of nontrauma computed tomography scans was negatively affected when an emergency department upgraded its trauma status.

4. How is patient care impacted?

Delays in completing imaging studies can result in delayed diagnosis and decision-making. Increased length of stay and poor patient experience are also undesirable effects.