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Use of a Statewide Trauma Image Repository Decreases the Rate of Unnecessary Transfers to a Level 1 Trauma Center

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Abstract

Background: We hypothesized that implementation of a statewide Trauma Image Repository (TIR) would lead to increased efficiency of care.

Methods: The state of Arkansas instituted TIR in July 2013. In this retrospective cohort study, we analyzed patients in the Arkansas trauma registry from December 2013 through May 2017, and compared patients with images loaded to the TIR with those without images in TIR.

Results: Altogether 2,354 patients were included in the study, and the utilization of the TIR increased from 44% to 74% of all transfers during the study period. The patients in the TIR group were more likely to be admitted to the ICU from the ED (25.84% *vs.* 18.09%, p<0.01). TIR patients had longer LOS (5.3 + 6.7 *vs.* 4.6 + 6.2 days, p<0.01) and a longer ICU LOS (1.8 + 4.1 *vs.*1.3 + 3.4 days, p<0.01). Patients in the TIR group also had a higher mean ISS (11.7 + 9.8 *vs.* 9.1 + 8.8, p<0.01. There was no difference in mortality between the two groups.

Conclusion: The implementation of a state-wide TIR led to a lower proportion of patients being transferred with an injury severity score less than 15. Patients with images in the TIR had more severe injuries and a higher predicted mortality. While they were shown to have longer hospital and ICU length of stay, there was no difference in mortality between the two groups. We can speculate that the increased efficiency potentially led to more seriously injured people surviving at the same rate as the less severely injured patients.

Keywords: Trauma; Imaging; Transfer Image Repository; Tertiary center

Abbreviations

CT: Computer Tomography; ED: Emergency Department; GCS: Glasgow Coma Scale; ICU: Intensive Care Unit; ISS: Injury Severity Score; LOS: Length of Stay; NISS: New Injury Severity Score; OR: Operating Room; SBP: Systolic Blood Pressure; TRI: Trauma Imaging Repository; TRISS: Trauma and Injury Severity Score; UAMS: University of Arkansas for Medical Sciences

Introduction

Trauma care is expensive, with a majority of patients undergoing financially catastrophic expenditures at the time of injury [1]. One contributor to the overall cost of care is secondary over-triage of patients to tertiary care centers. In addition to the monetary costs associated with unnecessary transfer and repeat imaging, there is the issue of wasted time in a patient population in which time to definitive treatment is of crucial importance. Previous data indicates that in rural trauma system with a single level I trauma center, up to 25% of trauma transfers are unnecessary, as patients are discharged without major procedure within 24 hrs of arrival [2,3].

The University of Arkansas for Medical Sciences (UAMS) is the only adult American College of Surgeons verified Level I Trauma Center in the state of Arkansas. UAMS serves as a large tertiary referral center with 509 beds, of which 52 are ICU beds. The catchment area includes the state of Arkansas as well as areas of surrounding states including Louisiana, Texas and Oklahoma. In 2017, UAMS received an average of 81 trauma transfers per month from 75 different hospitals, in addition to handling 1,688 from scene traumas.

The state of Arkansas instituted a state-wide Trauma Image Repository (TIR) in July 2013. We know from previous studies that uploading images prior to transfer within an integrated healthcare delivery network improves costs and efficiency [4]. It has already been shown that the institution of

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TIR in Arkansas has led to fewer duplicate Computer Tomography (CT) scans, improving patient care and reducing costs compared to neighboring Missouri [5]. We hypothesized that the implementation of TIR would furthermore lead to decreased in time in the emergency department, decreased unnecessary transfers, and potentially a decrease in overall mortality. This study compared transferred trauma patients with images uploaded to the TIR, to those patients transferred without TIR images.

Methods

In this retrospective cohort study, we analyzed patients in the Arkansas trauma registry from December 16th, 2013 through May 21st, 2017. We extracted the following variables from the database: age, gender, race, mode of transport, Emergency Department (ED) disposition, mortality, admission status (admitted or discharged), mechanism of injury (blunt *vs.* penetrating), use of TIR, prehospital Systolic Blood Pressure (SBP), pre-hospital pulse, Glasgow Coma Scale (GCS), total hospital days, Total Intensive Care Unit (ICU) days, total days on ventilator, Injury Severity Score (ISS), New Injury Severity Score (NISS), Trauma and Injury Severity Score (TRISS), and whether or not they had a severe injury to the head/neck, chest or abdomen. The study was approved by the institutional review board of the University of Arkansas for Medical Sciences.

During the roughly forty-two month study period, 2,412 traumas were transferred from other hospitals and 4,625 arrived from scene. We re-coded the chief complaint to group the mechanisms of injury by penetrating, blunt, or burn. We decided to look at only those with blunt or penetrating injuries, excluding 33 patients with burn or unknown mechanisms of injury. We excluded 18 people who died before assessed in the ED, and 7 people due to no recorded GCS. After these exclusions our study population was 2,354.

Statistical Methods

Descriptive statistics were used to summarize the data. Bivariate analysis was used to test for differences between the subgroup means and proportions for patients with blunt versus penetrating injuries transported by air. The differences between the group means on each measure were analyzed for direction and statistical significance using t-tests for continuous variables and chi-square tests for categorical variables.

To addresses the differences between the TIR group and the non-TIR group, propensity score analysis was used to create a study sample of matched TIR patients and non-TIR patients. A 4:1 matching algorithm was used to match TIR patients and non-TIR patients. Standardized differences were used to measure covariate balance between the TIR patients and non-TIR patients. The post-matched standardized differences were <10% for all covariates, which confirm balance was successfully achieves between the two groups. The matched sample consisted of 2,009 patients.

The matched sample was then used in a logistic regression to assess the relationship between the covariates and inpatient mortality. The regression model control for patient and injury characteristics. Statistical significance was set at $\alpha=0.05$ for all analyses. Odds ratios and 95% confidence intervals were reported. The analysis was conducted using Stata 14.0.

Results

During the study, utilization of the TIR increased from 44% to 74% of all transfers. Data collected on 2,354 patients were used in this analysis, and (Table 1) shows the study population characteristics. Of these 2,354 patients transferred, 2,255 (96%) were discharged alive. Mean age was 47.9 years, 69% were men, and the majorities were white. The most common mode of transportation was ambulance. There were 1,973 patients admitted and the majority of patients were admitted to the general wards. The majority of patients in this study (63%) had uploaded images in TIR. The mean hospital Systolic Blood Pressure (SBP) of patients arriving was 135, the mean hospital pulse

Table 1: Study population characteristics (n=2,354).

Characteristics	n (%)/mean [SD]
Mean Age (years) [SD]	48 [20]
Gender (male)	1626 (69)
Race	
White	1841 (78)
Black or African American	408 (17)
Other	105 (5)
Mode of Transport	
Ground	1868 (79)
Air	485 (21)
Unknown	1 (0.04)
ED Disposition	
Discharge	404 (17)
Floor	843 (36)
ICU	541 (23)
Observation	107 (5)
OR	409 (17)
Other	50 (2)
Mortality (alive)	2,255 (96)
Admitted	1,973 (84)
Mechanism	
Blunt	2,062 (88)
Penetrating	292 (12)
Images uploaded to TIR	1,486 (63)
Mean Pre-Hospital SBP (mmHg) [SD]	135 [31]
Mean Pre-Hospital Pulse [SD]	92 [21]
GCS	
Mild (>12)	2,052 (87)
Moderate (>8, <13)	58 (2)
Severe (<9)	244 (10)
Mean Total Hospital Days [SD]	5 [7]
Mean Total ICU Days [SD]	2 [4]
Mean Total Vent Days [SD]	1 [3]
Mean ISS [SD]	11 [10]
ISS >15	555 (24)
Mean NISS [SD]	14 [12]
Mean TRISS [SD]	1 [0.1]
Severe Head/Neck, n	574
Severe Chest, n	336
Severe Abdominal, n	133

Table 2: TIR versus Non-TIR (n=2,354).

Characteristic	TIR (n=1,486)	Non-TIR(n=868)	p-value
Mean Age (years) [SD]	48 [21]	48 [20]	0.78
Gender (male), n (%)	1,018 (69)	608 (70)	0.44
Race			0.48
White, n (%)	1,171 (79)	670 (77)	
Black/African American, n (%)	254 (17)	154 (18)	
Other, n (%)	61 (4)	44 (5)	
Mode of Transport			<0.01*
Ground, n (%)	1,135 (76)	733 (85)	
Air, n (%)	350 (24)	135 (16)	
Unknown, n (%)	1 (0.1)	0 (0)	
ED Disposition			<0.01*
Discharge, n (%)	219 (15)	185 (21)	
Floor, n (%)	558 (38)	285 (33)	
ICU, n (%)	384 (26)	157 (18)	
Observation, n (%)	72 (5)	35 (4)	
OR, n (%)	245 (17)	164 (19)	
Other, n (%)	8 (1)	42 (5)	
Mortality (alive), n (%)	1,422 (96)	833 (96)	0.75
Admitted, n (%)	1,280 (86)	693 (80)	<0.01*
Mechanism			<0.01*
Blunt, n (%)	1,347 (91)	715 (82)	
Penetrating, n (%)	139 (9)	153 (18)	
Mean Pre-Hospital SBP [SD]	135.0 [31]	136.4 [30]	0.44
Mean Pre-Hospital Pulse [SD]	91.1 [21]	92.7 [21]	0.22
GCS			0.02*
Mild (>12), n (%)	1,281 (86)	771 (89)	0.07
Moderate (>8, <13), n (%)	34 (2)	24 (3)	0.47
Severe (<9), n (%)	171 (12)	73 (8)	0.02*
Mean Total Hospital Days [SD]	5.3 [7]	4.6 [6]	0.01*
Mean Total ICU Days [SD]	1.8 [4]	1.3 [3]	<0.01*
Mean Total Vent Days [SD]	0.9 [3]	0.7 [3]	0.05*
Mean ISS [SD]	12 [9]	9 [9]	<0.01*
ISS >15, n (%)	391 (26)	164 (19)	<0.01*
Mean NISS [SD]	15 [12]	12 [12]	<0.01*
Mean TRISS [SD]	1 [0.1]	1 [0.1]	0.55
Severe Head/Neck, n	400	174	
Severe Chest, n	243	93	
Severe Abdominal, n	98	35	

was 92, the majority had a Glasgow Coma Scale (GCS) greater than 12, and the mean hospital stay was 5.05 days. The mean ISS was 10.76, the median ISS was 9, and 23% of patients had an ISS greater than 15. Of the patients in this study, the mean NISS was 14.16 and the mean TRISS was 0.96. Almost half of the patients (44%) had a severe injury with the most common being a severe head/neck injury (55% of severe injuries).

Table 2 compares the patients transferred with images uploaded to the TIR with those without images uploaded. Of the 2,354 patients included in our study, 1,486 had images uploaded into the Trauma Image Repository. There was no statistically significant difference in age, gender, or race between the two groups. The majority of patients in both groups was men, transported via ambulance, and was admitted to the general inpatient floors. However, the patients in the TIR group were more likely to be transported via air transport (23.55% *vs.* 15.55%) and be admitted to the ICU from the ED (25.84% *vs.* 18.09%). Between the groups, a higher percentage of TIR patients were admitted (86.1% TIR, 79.8% non-TIR, p<0.01). There was no difference in mortality between the two groups, and the most common mechanism of injury for both groups was blunt trauma. There was no significant difference in average pre-hospital systolic blood pressure or pulse between the groups. There was a greater percentage of patients with a GCS of <9 in the TIR group. TIR patients had longer Length of Stay (LOS) and ICU LOS (Table 2). Patients in the TIR group also had a higher mean ISS, a higher mean NISS, and more patients with an Injury Severity Score (ISS) greater than 15. The TRISS was not significantly different between the two groups.

In comparing groups with ISS <15, those with images in TIR were discharged home from the ED 19.6% of the time while 25.9% those without images were discharged (p<0.01). Looking at patients with ISS >15, there was no difference in the rate of discharges home from the ER. In comparing the two groups, a similar percentage went to the OR from the ED.

Of the 2,354 patients transferred, 409 (17.4%) required an operation upon arrival. Table 3 compares patients that went to the OR after being transferred with images uploaded to the TIR with those going to the OR without images uploaded. When compared with trauma patients using TIR, the non-TIR group was similar in age, gender, race, pre-hospital SBP, and pre-hospital pulse. There was no significant difference in mortality between the two groups. Patient in the TIR group were significantly more likely to have suffered blunt trauma. Non-TIR patients were more likely to have a GCS >12, while patients in the TIR group were more likely to have a GCS <9. TIR patients had longer LOS and ICU LOS. The TIR group also had a higher mean ISS, more patients with an ISS >15 and higher NISS. The mean TRISS was also lower for the TIR group (Table 3).

To explore whether TIR had any direct impact on mortality, we adjusted the study groups for age, gender, mode of transport, trauma mechanism (blunt *vs.* penetrating), and ISS, and performed a logistic regression analysis.

When adjusted for variables that differed between study groups at admission, TRI did not significantly impact patient mortality.

Discussion

The results of this retrospective observational study indicate that patients who were transferred with images uploaded to the TIR were more likely to have an ISS greater than 15, had more severe injuries, as well as longer hospital and ICU length of stay. Additionally, those with images uploaded to the TIR that required surgery upon arrival had a higher predicted mortality as predicted by their TRISS. However, there was no difference in actual mortality between the two groups, nor did TIR have an impact on mortality in an adjusted analysis. We can speculate that the efficiency provided by having images uploaded to a TIR prior to transfer gives the team time to plan for operations, time to prepare operating rooms, and the ability to bypass repeat imaging, however we were not able to show this clearly with the data available. This increased efficiency potentially led to more seriously injured people surviving at the same rate as the less

Table 3: TIR versus Non-TIR for Patients going to OR (n=409).

Characteristic	TIR (n=245)	Non-TIR (n=164)	p-value
Mean Age (years) [SD]	42 [18]	41 [17]	0.56
Gender (male), n (%)	187 (76)	131 (80)	0.4
Race			0.87
White, n (%)	185 (76)	126 (77)	
Black/African American, n (%)	48 (20)	29 (18)	
Other, n (%)	12 (5)	9 (6)	
Mode of Transport			0.05*
Air, n (%)	79 (32)	36 (22)	
Ground, n (%)	165 (67)	128 (78)	
Unknown, n (%)	1 (0.4)	0 (0)	
Mortality (alive), n (%)	232 (95)	160 (98)	0.15
Mechanism			<0.01*
Blunt, n (%)	201 (82)	109 (67)	
Penetrating	44 (18)	55 (34)	
Mean Pre-Hospital SBP [SD]	125 [31]	127 [32]	0.75
Mean Pre-Hospital Pulse [SD]	95 [23]	100 [23]	0.19
GCS			
Mild (>12), n (%)	194 (79)	146 (89)	0.01*
Moderate (>8, <13), n (%)	6 (3)	3 (2)	0.67
Severe (<9), n (%)	45 (18)	15 (9)	0.01*
Mean Total Hospital Days [SD]	7.5 [8]	5.0 [7]	<0.01*
Mean Total ICU Days [SD]	2.9 [6]	1.4 [4]	<0.01*
Mean Total Vent Days [SD]	1.6 [4]	0.9 [4]	0.09
Mean ISS [SD]	13.6 [12]	8.5 [9]	<0.01*
ISS >15, n (%)	82 (34)	26 (16)	<0.01*
Mean NISS [SD]	18 [15]	11.7 [12]	<0.01*
Mean TRISS [SD]	0.94 [0.16]	0.97 [0.11]	0.04*
Severe Head/Neck, n	42	16	
Severe Chest, n	44	15	
Severe Abdominal, n	30	10	

severely injured patients.

Additionally, the data demonstrated that the implementation of a state-wide Trauma Image Repository (TIR) seemed to reduce the relative portion of patients transferred to a level 1 trauma center with an ISS <15. While the causality was not explored within this study, we can speculate that this reduced volume of secondary over-triage is likely to save time, money and resources, which can be in turn used by tertiary care centers to focus on providing care to the more severely injured trauma victims that other hospitals are ill-equipped to care for.

Most trauma transfers in the United States occur from smaller, rural community hospitals to larger regional medical centers for advanced interventional and supportive care [6]. It has been shown that 60% of trauma deaths occur in remote areas, despite the fact that they account for only 25% of the overall population [7]. Arkansas is a largely rural state, with UAMS receiving an average of 81 trauma transfers per month from 75 different hospitals, in addition to annually handling 1,688 transfers from scene traumas. Thus the effectiveness and accuracy of triage is of significant interest to our unit. Previously, a similarly rural state of Oregon has shown that the implementation of a statewide tele-radiology network resulted in fewer repeat CT scans, significant cost savings, decrease in radiation exposure, and a theoretical cancer risk reduction [8].

Table 4: Multiple logistic regression assessing the impact of TIR on inpatient mortality (n = 1,753, adjusted cohort).

Characteristic	Odds Ratio	95% Confidence Interval	p-value
TIR	0.72	.29, 1.80	0.481
Age	0.94	.92, .97	<0.01*
Male[1]	1.23	.55, 2.75	0.616
Race: Black/African American[2]	0.7	.22 2.27	0.553
Race: Other[2]	0.3	.04, 2.63	0.279
Mode of Transport: Air[3]	5.19	.51, 53.25	0.165
Mode of Transport: Ground[3]	5.51	.58, 52.02	0.137
ED Disposition: Floor[4]	1.2	.26, 5.47	0.811
ED Disposition: Intensive Care Unit[4]	0.29	.07, 1.18	0.084
Mechanism: Blunt[5]	1.7	.35, 8.37	0.512
GCS: Moderate (>8, <13)[6]	2.02	.13, 32.27	0.62
GCS: Severe (<9)[6]	18.1	.76, 433.34	0.074
ISS	0.98	.91, 1.06	0.655
TRISS	46166.33	168.33, 1.27e+07	<0.01*
Severe Head/Neck	0.93	.32, 2.76	0.9
Severe Chest	1.59	.47, 5.38	0.452
Severe Abdominal	1.87	.27, 12.88	0.523
Constant	0.02	.00, 13.94	0.247

[1]Referrent is female; [2]Referrent is Race: White; [3]Referrent is Mode of Transport: Private; [4]Referrent is ED Disposition: Operating Room; [5]Referrent is Mechanism: Penetrating; [6]Referrent is GCS: Mild (>12)

The Arkansas TIR was instituted in 2013, and the current study is the second to be published assessing its performance. Dr. Sheppard and colleagues from Missouri have recently shown that the implementation of the Arkansas TIR led to fewer patients receiving duplicate scans within Arkansas compared to Missouri, where no state-wide TIR exists [5]. The current study complements their work, continuing the encouraging findings of states such as Oregon – a decrease in patients transferred with lesser injuries, and good outcomes for trauma patients in general, regardless of arrival trauma scores. Overall our results seem to indicate that the resources of a Level 1 trauma center are being appropriately utilized when pre-transfer imaging tips the scale towards bringing in the patients that are truly in dire need of the specialized services of a tertiary unit – and reducing the number of those who can be successfully treated in the primary hospital.

As with any retrospective study, a limitation comes from assuming that data is correctly input and subjective scoring systems are accurately performed. Also, the fact that more severely injured patients had images uploaded to the TIR could introduce bias to the study, and it is worth noting that the study cohorts were inherently different at admission, although we believe this to be at least partially due to the implementation of TIR. Confounding factors come from making the assumption that referring hospitals, especially the more rural ones, have the resources to manage a trauma patient of any severity. These resources that may possibly be lacking include not just manpower and imaging capability, but also training of the staff to feel confident that they can adequately care for the patient. Furthermore, this was a single-institution study and the results may not be generalizable to all institutions that receive transfer patients, as there can be significant institutional or regional differences in patient populations and imaging utilization, as well as differences in referral patterns and network accessibility to images [9].

Moving forward, this study, in conjunction with other studies conducted over this topic, can be used as an impetus to mandate the use of a TIR, or at least strongly encourage it as best practice. It would also be prudent to consider implementing a telemedicine triage system for distant and rural sites to help physicians and other providers who feel that they are inadequately equipped or trained to properly triage a trauma patient.

Conclusion

The results of this retrospective observational study indicate that patients who were transferred with images uploaded to the TIR were more likely to have an ISS greater than 15, had more severe injuries, as well as longer hospital and ICU length of stay. Additionally, those with images uploaded to the TIR that required surgery upon arrival had a higher predicted mortality as predicted by their TRISS. However, there was no difference in actual mortality between the two groups, nor did TIR have an impact on mortality in an adjusted analysis. We can speculate that the efficiency provided by having images uploaded to a TIR prior to transfer gives the team time to plan for operations, time to prepare operating rooms, and the ability to bypass repeat imaging. This increased efficiency potentially led to more seriously injured people surviving at the same rate as the less severely injured patients. These data should be utilized as an impetus to mandate the use of a TIR, or at least strongly encourage it as best practice. Further work needs to be done to determine the financial and life-saving impact of implementation of a state-wide imaging system.

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Contributor Statements

KWS, RDR, and TLI conceived the idea. KWS, SK, and WCB developed the study design. AB, BD, MKK, TJH and LCF organized the data from the Trauma Image Repository and merged the data with the existing UAMS trauma registry. The analysis was performed by KWS, SK, and HKJ. The manuscript was primarily drafted by TJH, LCF, and HKJ. All authors discussed the results and contributed to the final manuscript.

References

1. Scott JW, Raykar NP, Rose JA, Tsai TC, Zogg CK, Haider AH, et al. Cured into Destitution: Catastrophic Health Expenditure Risk Among Uninsured Trauma Patients in the United States. Ann Surg. 2018;267(6):1093-9.
2. Tang A, Hashmi A, Pandit V, Joseph B, Kulvatunyou N, Vercruysse G, et al. A critical analysis of secondary overtriage to a Level I trauma center. J Trauma Acute Care Surg. 2014;77(6):969-73.
3. Sorensen MJ, von Recklinghausen FM, Fulton G, Burchard KW. Secondary overtriage: the burden of unnecessary interfacility transfers in a rural trauma system. JAMA surgery. 2013;148(8):763-8.
4. Bledsoe J, Liepert AE, Allen TL, Dong L, Hemingway J, Majercik S, et al. The salutary effect of an integrated system on the rate of repeat CT scanning in transferred trauma patients: Improved costs and efficiencies. Am J Surg. 2017;214(2):198-200.
5. Sheppard CW, Groll AL, Austin CL, Thompson SJ. Impact of duplicate CT scan rate after implementation of transfer image repository system at a level 1 trauma center. Emerg Radiol. 2018;25(3):275-80.
6. Pitts SR, Niska RW, Xu J, Burt CW. National Hospital Ambulatory Medical Care Survey: 2006 emergency department summary. Natl Health Stat Report. 2008(7):1-38.
7. Kappel DA, Rossi DC, Polack EP, Avtgis TA, Martin MM. Does the rural trauma team development course shorten the interval from trauma patient arrival to decision to transfer? J Trauma. 2011;70(2):315-9.
8. Watson JJ, Moren A, Diggs B, Houser B, Eastes L, Brand D, et al. A statewide teleradiology system reduces radiation exposure and charges in transferred trauma patients. Am J Surg. 2016;211(5):908-912.
9. Sodickson A, Opraseuth J, Ledbetter S. Outside imaging in emergency department transfer patients: CD import reduces rates of subsequent imaging utilization. Radiology. 2011;260(2):408-13.