Differences in hospital outcomes following traumatic injury for patients experiencing immediate transfer to a level I trauma facility versus resuscitation at a critical access hospital (CAH)✩

Jered Windorski [a], Jared Reyes [a], Stephen D. Helmer [a, b], Jeanette G. Ward [c], James M. Haan [a, d], *

[a] Department of Surgery, The University of Kansas School of Medicine — Wichita, Wichita, KS, USA
[b] Department of Medical Education, Via Christi Hospital Saint Francis, Wichita, KS, USA
[c] Department of Trauma Services, Chandler Regional Medical Center, Phoenix, AZ, USA
[d] Trauma Services, Via Christi Hospital Saint Francis, Wichita, KS, USA

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ABSTRACT

Background: Critical access hospitals (CAH) serve a key role in providing medical care to rural patients. The purpose of this study was to assess effectiveness of CAHs in initial care of trauma patients.
Methods: A 5-year retrospective review was conducted of all adult trauma patients who were transported directly to a level I trauma facility or were transported to a CAH then transferred to a level I trauma facility after initial resuscitation.
Results: Of 1478 patients studied, 1084 were transferred from a CAH with 394 transported directly to the level I facility. Patients transported directly to the level I hospital were younger and more severely injured. After controlling for injury severity score, age, GCS, and shock, the odds of mortality did not differ between CAH transfer patients and patients transported directly to a level I facility (OR 0.70, $P = 0.20$). Transfer from CAH was associated with decreased ICU and hospital days, but not associated with increased ventilator days.
Conclusion: This study demonstrates that use of a CAH for initial trauma care in rural areas is effective.
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Introduction

Trauma patients are most effectively treated when dedicated trauma systems coordinate care between tertiary trauma facilities and less specialized medical facilities.[1–3] Intuitively, geographic, economic, and population trends determine the location of specialized tertiary facilities that can deliver state of the art trauma care. Trauma systems that include a large rural area often have tertiary-care centers that are confined to one part of the system with large rural expanse in between, leaving non-tertiary centers to fill the gap. Among these non-tertiary centers are Critical Access Hospitals (CAHs). Critical Access Hospitals are part of the Medicare Rural Hospital Flexibility (FLEX) Program, a federal initiative to develop rural health networks and strengthen the rural health infrastructure. The CAH designation was created to reduce the financial vulnerability of rural hospitals and improve access to healthcare in rural communities.[4] While CAHs carry no official trauma designation, the literature would indicate that approximately 38.4 million rural patients do not live within 1 h of organized trauma care.[5] Thus, CAHs are potentially the initial point of care for rural trauma patients, and as such, their effectiveness in rendering trauma care to patients injured in the rural setting should be evaluated.

Multiple studies using mortality as an outcome have shown decreased mortality for trauma patients that are transferred from the scene directly to a level I trauma facility versus trauma patients that are initially managed, or definitively managed, at a non-tertiary care facility.[1–3,6,7] For example, Haas et al.[6] studied 6341 patients who were severely injured in motor vehicle collisions, 55% of whom were triaged to a non-trauma center. Of those patients, 57% were ultimately transferred to a trauma center after initial

evaluation. Their study showed that at 24 and 48 h, there was a significant reduction in mortality in those that were transported directly to a trauma center versus those that were transported to a non-trauma center and then triaged to a trauma center.[6] Rarely, other outcomes aside from mortality have been evaluated, including hospital length of stay and intensive care unit (ICU) length of stay. One such study indicated that the hospital length of stay and ICU length of stay were significantly reduced in those that were transported directly to a level 1 center versus those that were transferred from a non-trauma center after initial evaluation.[8] While it would seem that a large portion of the literature makes a case against the use of CAHs for trauma, a study by McSwain et al.[9] contends that, "More than 90% of patients have less severe injuries and do not need the resources of the level I and II trauma centres" and that, "these patients can be managed safely and conveniently in their local community hospitals, obviating unnecessary travel and separation from family and friends." Further, a study by Rogers et al.[10] concluded that when adjusting for injury severity and age, survival was no worse for those trauma patients seen at a community hospital versus those seen at a level 1 trauma center.

We believe that CAHs play a critical role in the triage of trauma patients and thus the purpose of this study was to determine what, if any, discrepancies exist among hospital outcomes between those patients initially resuscitated at CAHs and then transferred to a level one trauma facility versus those patients who are transported to a level I trauma facility directly from the scene. The outcome of this study could validate the usefulness of, and demonstrate the continued need for funding of, CAHs throughout the State of Kansas as well as provide a model of trauma care that could be replicated in other CAHs throughout the nation.

Methods

Patients and setting

A 5-year retrospective chart review was conducted of all patients 18 years of age or older who sustained a traumatic injury and were subsequently either (1) transported directly to a level I trauma facility, or (2) were transported to a CAH and subsequently transferred to a level I trauma facility after initial resuscitation. Our trauma database was queried to produce a list of all adult trauma patients that presented to our level I trauma facility between January 1, 2009 and May 31, 2014. Patients who were transferred from level II, III, and IV facilities, as well as those transferred from out of state, or arrived by local ground ambulance, were excluded from analysis so that outcome differences as they relate to CAHs could be specifically analyzed.

Data collected

Data collected included patient demographics (age, race, and sex), initial destination (level I facility vs CAH), mechanism of injury, injury severity score (ISS), the presence of shock (defined as SBP <90 mmHg), and initial Glasgow Coma Scale (GCS) score. The primary outcomes of interest included ICU length of stay, ventilator requirement and duration, hospital length of stay, and mortality as they related to patients initially transferred to a level I facility versus those who were initially evaluated and resuscitated at a CAH.

This study was approved for implementation by the institutional review board of Via Christi Hospitals Wichita, Inc.

Statistical analysis

For univariate analyses, comparisons of continuous and categorical data were conducted using t tests and Chi-square analysis, respectively. For continuous variables that were not normally distributed, a Mann-Whitney U test was used for comparison.

Multivariable analysis was conducted using a complete case analysis. To compare the odds of mortality for those transferred from a CAH with those transported directly to a level I facility, the variables age, ISS, shock, and GCS were used in a logistic regression to obtain adjusted associations. To evaluate differences in hospital length of stay between CAH transfers and those initially treated at a level I facility, a negative binomial regression analysis was conducted to adjust for the variables age, ISS, shock, and GCS.

All statistical tests were two-sided and analyses were considered significant when the resultant P value was ≤ 0.05. All analyses were conducted using SPSS release 19.0 (IBM Corp., Armonk, New York).

Results

A search of our trauma registry generated a list of 10,132 patients who were treated at our facility for a traumatic injury during the study period. Of those patients, 5924 were excluded because they arrived to our facility by local ground transportation. Another 2730 patients were excluded because they were transferred to our facility from a non-CAH facility, leaving 1478 patients included in final analyses. Of the 1478 trauma patients studied, 1084 (73.3%) were transferred from a CAH while 394 (26.7%) were transported directly to our level I facility.

Table 1 compares the demographics of the study participants. The average age of those transferred from a CAH was significantly greater than of those in the direct transport group (52.4 vs. 42.2 years, respectively; $P < 0.001$). There was no significant difference between the two groups with regard to race and sex with the majority of patients being white males.

The majority of patients in both groups had a blunt mechanism of injury (Table 2). Of the patients studied, 106 (7.2%) were noted to have a GCS <9 on presentation to either a CAH or our level I facility. However, fewer patients transferred from a CAH had a GCS <9 as compared to those transported directly to the level 1 trauma center (3.3 vs. 17.1%, respectively; $P < 0.001$). Similarly, fewer patients transferred from a CAH had an initial SBP<90 mmHg when compared to those transported directly to the level 1 facility (1.0 vs. 6.6%, respectively; $P < 0.001$). In both the CAH and direct transport group the majority of patients had an ISS between 1 and 15; however, the direct transport group did have a higher percentage of patients who were severely injured as evidenced by an ISS of 25 or greater (23.9 vs. 10.9%, respectively; $P < 0.001$).

The hospital length of stay and ICU days were significantly different between the CAH and the direct transport group, with significantly larger ranges in the direct transport group for both hospital length of stay and ICU days (Table 3). The direct transport group was also more likely to require mechanical ventilation. The mortality rate was significantly lower in the CAH group versus the direct transport group on univariate analysis (5.7 vs. 11.0%, respectively, $P = 0.001$).

Regression models were then run to determine if CAHs were an independent predictor of mortality or hospital length of stay. With regard to mortality, logistic regression analysis identified that older age, higher ISS, and lower GCS were all associated with a higher odds ratio of death, while transfer from CAH was not (Table 4). Negative binomial regression analysis was also conducted to evaluate the effect of transfer from CAH on total hospital days (Table 5). As would be expected, older age, higher ISS, and GCS <9 were associated with increased hospital LOS. Transfer from CAH, however, was associated with a decreased length of hospital stay ($P < 0.023$).

Table 1
Comparison of demographics between patients transferred to the Level 1 trauma center from a CAH versus those transported directly to the trauma center from the injury scene.[a]

| Parameter | Study Group | | P value |
	Transfer from CAH	Direct Transport	
Number of observations	1084 (73.3)	394 (26.7)	—
Age	52.4 ± 23.0	42.2 ± 18.6	<0.001
Race			0.322[b]
White	1010 (93.2)	362 (91.9)	
Black or African American	5 (0.5)	6 (1.5)	
Native Hawaiian or Other Pacific Islander	1 (0.1)	1 (0.3)	
Asian	5 (0.5)	3 (0.8)	
Other	62 (5.7)	22 (5.6)	
Missing	1 (0.1)	0 (0.0)	
Male sex	730 (67.3)	257 (65.2)	0.445

[a] Data presented as the number of observations (%) or mean ± standard deviation.
[b] Represents a lower bound for significance since the expected cell counts are low for multiple cells.

Comments

The State of Kansas has 3 American College of Surgeons Committee on Trauma (ACSCOT) verified level I trauma centers and 2 level II trauma centers, which are located in densely populated areas of the state with large rural expanse in between. Level III and level IV facilities exist throughout the State of Kansas, but their number and geographic location is such that gaps in coverage persist. Critical Access Hospitals are part of a broader initiative to fill these gaps in coverage.[4] Currently, all CAHs are reimbursed by Medicare at 101% of their cost, but it has been suggested by the Department of Health and Human Resources that CAHs operating within 35 miles of another hospital have their designation re-evaluated and be reimbursed at the standard Medicare rate.[11] In Kansas, there are 84 CAHs serving 73 counties. Losing the CAH designation would reduce reimbursement to these rural hospitals and could potentially make operations financially unsustainable, thereby affecting rural populations' access to care.[11]

To our knowledge, this is the first study that has specifically evaluated the outcomes of trauma patients that have been treated at a CAH and subsequently transferred to a level I facility versus those that were transported directly to a level I facility. There are studies, however, that have evaluated outcomes of trauma patients who were not treated at designated level-1 trauma centers (non-trauma centers and level III and IV trauma facilities) and thus an expectation about the performance of CAHs could be inferred from these studies. It could be suggested that the quality of trauma care rendered at level III and IV facilities (and thus CAHs) is lower than

that which could be rendered at level I and II facilities owing to fewer resources, lesser expertise, and the lack of in-house trauma teams. A study by Dufresne et al.[8] evaluated mortality secondary to hemorrhagic shock and found that patients seen at a level III trauma center had an adjusted odds of dying that was 70% higher versus those patients treated at a level I center.[4] A study by Papa et al.[1] compared the case fatality rate (defined as the fatality per injury) between those patients that were injured in a county with a trauma center and those that were injured in a county with a non-trauma center. In that study, the case fatality rate was found to be 1.4% in the trauma center group, and 3.2% in the non-trauma center group (P < 0.0001).[1] In another study featured in the New England Journal of Medicine, MacKenzie et al.[2] found that in-hospital mortality and mortality at one year were increased for those patients that were treated at a non-trauma center versus those that were treated at a trauma center (9.5 vs 7.6% and 13.8 vs 10.4%, respectively).[2] These studies evaluated a group of patients in which definitive management was undertaken at non-trauma centers, rather than initial management and subsequent transfer, and set the precedent for what most of the literature would suggest: that trauma patients have better outcomes if treated at tertiary centers that carry an official trauma designation.

In contradistinction to the above studies, our study evaluated a rural trauma population that was triaged solely from CAHs and shows that when adjusting for age, ISS, GCS, and the presence of hypotension, patients did not experience an increase in mortality, nor did they experience an increase in morbidity as would be indicated by increased length of hospital stay, ICU days, or

Table 2
Comparison of mechanism of injury and severity of trauma between patients transferred to the Level 1 trauma center from a CAH versus those transported directly to the trauma center from the injury scene.[a]

| Parameter | Study Group | | P value |
	Transfer from CAH	Direct Transport	
Number of observations	1084 (73.3)	394 (26.7)	—
Type of injury			0.282[c]
Blunt	1058 (97.6)	379 (96.2)	
Penetrating	24 (2.2)	13 (3.3)	
Burn	2 (0.2)	2 (0.5)	
Glasgow Coma Scale score < 9	36 (3.3)	70 (17.8)	<0.001
Systolic blood pressure < 90 mmHg	11 (1.0)	26 (6.6)[b]	<0.001
Injury Severity Score			<0.001
1—15	778 (71.8)	216 (54.8)	
16—24	188 (17.3)	84 (21.3)	
25+	118 (10.9)	94 (23.9)	

[a] Data are presented as the number of observations (%).
[b] Includes 6 patients with SBP = 0.
[c] Represents a lower bound for significance since the expected cell counts are low for multiple cells.

Table 3
Comparison of hospital outcomes between patients transferred to the Level 1 trauma center from a CAH versus those transported directly to the trauma center from the injury scene.[a]

| Parameter | Study Group | | P value[d] |
	Transfer from CAH	Direct Transport	
Number of observations	1084 (73.3)	394 (26.7)	−
Intensive care unit admission	621 (57.3)	228 (57.9)	0.842
Intensive care unit days[b]	3.7 ± 5.2; 2 (1–4)	6.3 ± 8.5; 2 (1–7)	<0.001
Ventilator days[c]	5.5 ± 7.0; 2 (1–7)	7.8 ± 9.1; 4 (1–12)	0.082
Hospital length of stay	4.8 ± 6.4; 3 (1–5)	7.3 ± 11.8; 3 (1–8)	0.003
Mortality	62 (5.7)	43 (11.0)	0.001

[a] Data are presented as the number (%), mean ± standard deviation; or median (IQR).
[b] Individuals with zero ICU days excluded.
[c] Individuals with zero ventilator days excluded.
[d] Based on results of a Mann-Whitney test.

Table 4
Adjusted association of CAH transfer status with the likelihood of mortality.

Parameter	B	Wald chi square	Odds ratio	95% Confidence interval	P value
ISS 1-15	reference	78.06	reference		<0.001
ISS 16-24	0.72	4.68	2.06	1.07–3.97	0.031
ISS ≥25	2.43	72.92	11.34	6.49–19.80	<0.001
Age	0.04	46.02	1.04	1.03–1.05	<0.001
GCS <9	1.81	30.73	6.10	3.22–11.55	<0.001
SBP <90 mmHg	0.53	1.12	1.70	0.64–4.54	0.29
CAH transfer	−0.36	1.66	0.70	0.41–1.20	0.20
Constant	−5.81	62.78			<0.001

ventilator days. Our findings are in line with those reported by Rogers et al.[10] who also reported that survival was not different between patients treated at community hospitals versus those seen at Level 1 trauma centers when adjusting for injury severity and age. In our study, patients experienced decreased hospital days and ICU days if they were initially triaged to a CAH versus being directly transported to a level one facility. The majority of studies in this area evaluated a patient population that received definitive treatment at a non-trauma center; while our study looked at triage only before transfer, which could be a key reason that we have been able to show a benefit in terms of morbidity and no detriment in terms of mortality. To be fair, this could also be related to lesser injuries in the CAH cohort as evidenced by a lower ISS, lower GCS scores and higher proportion of patients with hypotension. A paucity of studies have evaluated the effects of non-trauma center care on morbidity, which is another key to our study as perhaps the reduction in morbidity (particularly decreased ICU and hospital days) could translate to overall cost savings for the healthcare system, justifying the continued funding of CAHs and even augmenting their income. A key benefit to keeping rural trauma patients in a rural trauma setting is that insured patients provide reimbursement to the rural hospital versus the level I facility to which they are triaged.

In addition to this, cost savings could be realized via the reduction in over triage that occurs when higher levels of care are used for less severely injured patients. A study by Newgard et al.[12] found that about 34% of low risk patients who did not meet criteria for transport to a higher level of care were transported anyway; appropriate triage would have saved an estimated 136 million dollars per year.

Several questions remain. What care are our CAHs providing that negates the mortality increase seen in other studies, and if the differences in care could be brought to light, could they be duplicated? Can the improvement in mortality as compared to other research be solely attributable to CAHs, or is the quality of pre-hospital care and triage decision making offsetting any mortality increase that would be seen by triage to CAHs? If all of the patients in the CAH group had been transported directly to our level I trauma center rather than being sent to a CAH first, would some of them have missed out on the beneficial resuscitation and stabilization provided at the CAHs and thus been harmed? While there was no benefit to triage to CAHs in regards to mortality and ventilator days, perhaps the real benefit could be a potential reduction in over-triage to higher levels of care. Answering these critical questions through further research might allow for the formation of care plans and policies that could be applied to other hospitals that are similar to CAHs.

There are several limitations to this study. The retrospective

Table 5
Association of CAH transfer status with hospital length of stay adjusted for measures of injury severity.

Parameter	β	Wald chi square	Exp β	95% Confidence interval	P value
Age	0.01	31.98	1.01	1.01–1.01	<0.001
ISS 1-15	reference		reference		
ISS 16-24	0.99	117.76	2.70	2.26–3.23	<0.001
ISS ≥25	1.47	205.94	4.37	3.57–5.34	<0.001
GCS <9	0.42	8.96	1.52	1.16–2.01	0.003
CAH transfer	−0.19	5.17	0.82	0.70–0.97	0.023
Constant	0.50	18.73			<0.001

nature of this study introduces the possibility of selection bias and information bias which could have altered the accuracy of our analysis between the direct transport and the CAH group. In addition, data for prehospital interventions including intubation at CAH versus intubation during transport, tube thoracostomy placement, and needle decompression were collected, but found to be incomplete in about 25% of patients in the study and thus was not included in our analyses. Prehospital interventions could explain the similarity in mortality between the two groups as well as the decreased morbidity experienced by the CAH group. In addition, while we were able to ascertain which patients were transported from a CAH, it is unclear exactly what took place in terms of stabilization and treatment at the CAH. Transport times from CAH versus the direct transport group could conceivably influence morbidity and mortality; however, data on transport time from the injury scene to the CAH was only available in a minority of cases and as such analysis of transport times between study groups could not be performed.

Conclusions

Critical access hospitals play a key role in serving the rural population of Kansas by providing service to those patients who would otherwise have to travel away from their home for medical care. Although they carry no official trauma designation CAHs are providing access to care for trauma patients injured in a rural setting and are facilitating transfer to tertiary-care centers for definitive management. This study shows that when adjusting for age, ISS, GCS, and the presence of hypotension, patients do not suffer increased morbidity or mortality when they are triaged to a CAH versus being taken directly to a tertiary-care facility and that hospital length of stay and ICU days are reduced for those patients taken to CAHs initially. It would seem from this study that ongoing funding of CAHs at the present level would be justified from a trauma standpoint, but further research is needed to understand the exact benefit realized from the decreased morbidity demonstrated in our study. If these benefits were substantial, then further research could be conducted to ascertain whether or not the care in our CAHs could be duplicated around the nation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2018.10.050.

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