SPEED ISN'T EVERYTHING: IDENTIFYING PATIENTS WHO MAY BENEFIT FROM HELICOPTER TRANSPORT DESPITE FASTER GROUND TRANSPORT

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Introduction: Helicopter emergency medical services (HEMS) have shown survival benefits over ground emergency medical services (GEMS). Most conceptualize the benefit of HEMS as bringing the patient to the trauma center quickly, citing the time and speed advantage over GEMS. However, HEMS may offer benefits in selected patients by bringing the trauma center to the patient. Some severely injured patients may benefit from immediate critical interventions such as advanced airway management or transfusion, as well as more experienced providers regardless of time savings and even when GEMS transport may be faster. Our objective was to determine if any existing triage criteria identify patients at the scene of injury that benefit from HEMS even when prehospital time is shorter for GEMS transport.

Methods: Adults undergoing scene ALS transport by HEMS or GEMS between 2000-2013 in the Pennsylvania State Trauma Registry were included. Propensity score matching was used to match HEMS and GEMS patients for likelihood of HEMS transport based on demographics, prehospital physiology, mechanism, and anatomic injuries. Patients were matched within county to approximate similar distances. Iterative nearest neighbor 1:1 matching was performed, keeping only pairs at each iteration where HEMS patients had longer total prehospital time than the matched GEMS patient. Mixed-effects logistic regression then evaluated the effect of transport mode on survival while controlling for demographics, admission physiology, ISS, transfusions, and procedures, with a random-effect to account for matched pairs. Models were then stratified based on the presence/abscence of triage criteria from national guidelines that had a significant interaction with transport mode to determine which triage criteria when present identify patients with a significant survival benefit when transported by HEMS despite being slower than GEMS.

Results: From 153,729 eligible patients, 8,307 pairs were matched. After matching, all propensity score variables were balanced with no absolute standardized difference between groups >0.1. HEMS total prehospital time was a median of 13minutes (IQR 6, 22) longer than GEMS. Overall, regression revealed HEMS transport was associated with a 22% increase in the odds of survival (OR 1.22; 95%CI 1.03-1.45, p=0.02) among matched pairs. A significant interaction with transport mode was seen for respiratory rate <10 or >29bpm, GCS<14, and hemo/pneumothorax (p<0.05). Patients presenting in the field with one of these criteria had a significant survival advantage when transported by HEMS despite longer prehospital time than GEMS, while there was no association between transport mode and survival in patients without these criteria (TABLE 1).

TABLE 1	AOR HEMS vs. GEMS	95%CI	p value
Respiratory rate <10 or >29bpm	2.39	1.26—4.55	0.01
Normal respiratory rate	1.16	0.93—1.44	0.20
GCS<14	1.47	1.12—1.92	0.01
GCS≥14	1.07	0.68—1.68	0.76
Hemothorax or pneumothorax	2.25	1.06—4.78	0.03
No hemothorax or pneumothorax	1.16	0.93—1.45	0.19

Conclusion: Patients with abnormal respiratory rate, GCS<14, and hemo/pneumothorax benefit from HEMS transport even when GEMS transport was faster. This suggests these patients benefit primarily from HEMS care, such as airway management, rather than simply faster transport to a trauma center. These criteria may help inform air medical triage protocols, and additional study should further elucidate which patients may benefit from HEMS care even if GEMS transport may be faster.

Cardiac Complications and Failure to Rescue after Injury in a Mature Statewide Trauma System: Identifying Opportunities for Improvement

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Introduction:

Cardiac complications after injury are rare but contribute disproportionately to mortality. Variability in rates of cardiac complications (CC) and failure to rescue after cardiac complications (FTR-C) within trauma systems may suggest opportunities of improvement, but little is currently known. We examined center-level rates of CC and FTR-C in a mature trauma system with the hypothesis that high-performing centers for each of these outcomes could be identified.

Methods:

Using a statewide trauma registry from 2007-2015 (inclusion criteria: age >16 years, minimum Abbreviated Injury Score ≥2, and non-burn mechanism), we developed multivariable logistic regression models on CC and FTR-C including patient demographics, physiology, comorbidity, and injury data. Predicted probabilities of each outcome were summed to generate expected event rates, which were compared to observed event rates to generate center-level observed-to-expected (O:E) ratios. We measured internal consistency between CC and FTR-C for centers using Cronbach's alpha.

Results:

Cardiac complications occurred in 5,079/278,042 (1.8%; center-level range: 0.9-3.8%) of included patients (median age 55 (IQR 34-76), 84% Caucasian, 60% male, 92% blunt, median ISS 9 (IQR5-16)). Death after CC occurred in 982/5,097 patients for an FTR-C rate of 19.3% (center-level range: 7.8-30.4%). For CC, 10/27 centers were high-performers (95% CI for O:E ratio <1) and 8/27 were low performers (Figure 1A). For FTR-C, 2/27 centers were high-performers and 3/27 were low performers (Figure 1B). Internal consistency between these metrics was poor (alpha = 0.31).

Conclusion:

Rates of CC and FTR-C vary significantly by center in mature trauma systems but high-performing centers can be identified. Inconsistent performance between metrics suggests different institutional factors underlie performance for CC and FTR.

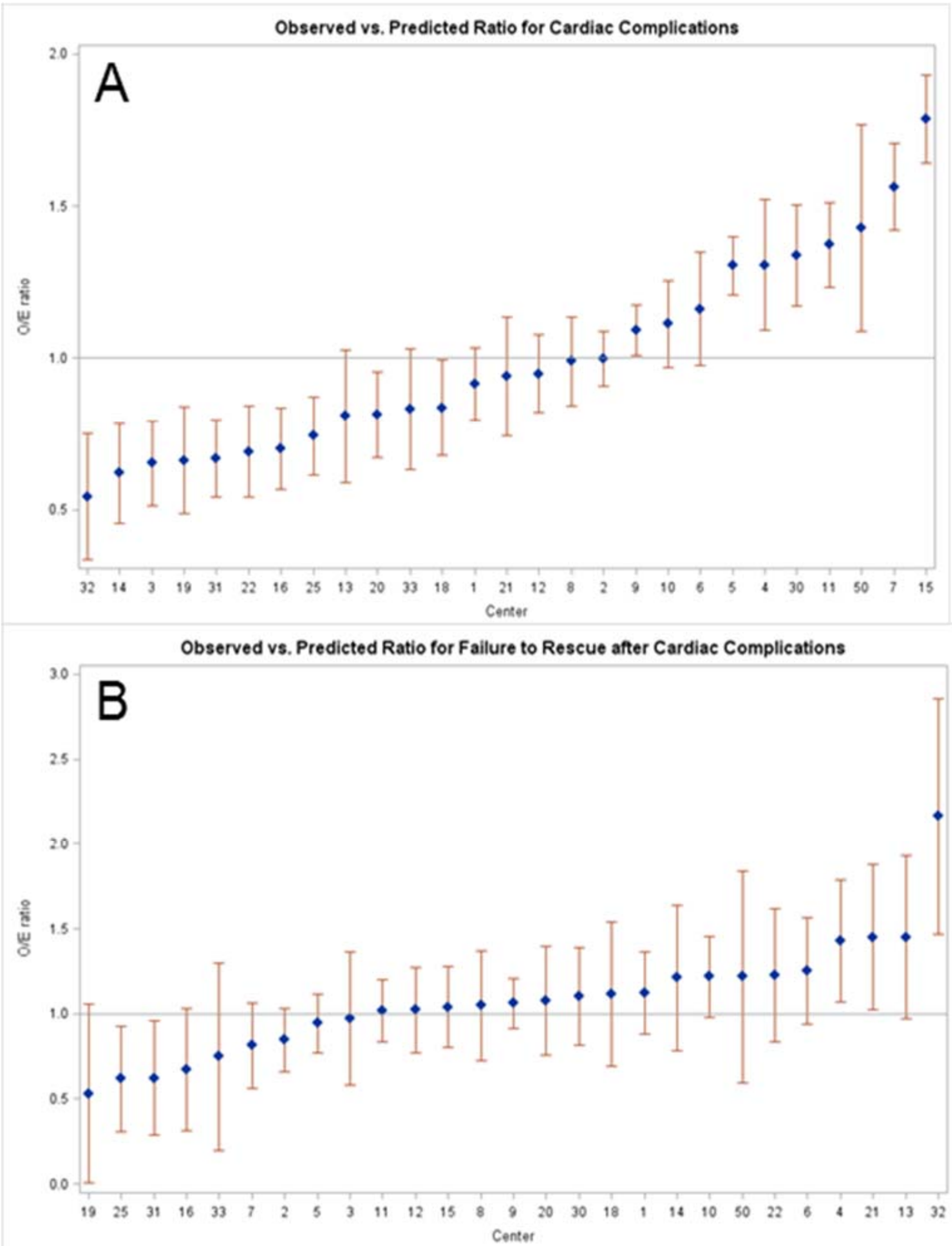

Figure 1 – Observed-to-expected ratios with 95% confidence intervals of rates of cardiac complications (A) and Failure to Rescue after cardiac complications (B) at trauma centers in Pennsylvania. Centers with 95% of confidence intervals that do not cross 1 are significant outliers.

DEVELOPMENT OF A TRAUMA SYSTEM AND OPTIMAL PLACEMENT OF TRAUMA CENTERS USING GEOSPATIAL MAPPING

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BACKGROUND: The care of patients at individual trauma *centers* (TCs) has been carefully optimized, but not the placement of TCs within the trauma *systems*. We sought to objectively determine the optimal placement of trauma centers in Pennsylvania using geospatial mapping.

METHODS: We used the Pennsylvania Trauma Systems Foundation (PTSF) and Pennsylvania Health Care Cost Containment Council (PHC4) registries for adult (age ≥15) trauma between 2003-2015 (n=377,540 and n=255,263). TCs and zip codes outside of PA were included to account for edge effects with trauma cases aggregated to the Zip Code Tabulation Area centroid of residence. Model assumptions included no prior TCs (clean slate), travel time intervals of 45, 60, 90 and 120 minutes, TC capacity based on trauma cases per bed size and candidate hospitals ≥200 beds. We used Network Analyst Location-Allocation function in ArcGIS Desktop to generate models optimally placing 1 to 27 TCs (27 current PA TCs) and assessed model outcomes.

RESULTS: At a travel time of 60 minutes and 27 sites, optimally placed models for PTSF and PHC4 covered 95.6% and 96.8% of trauma cases and 81.9% and 84.9% of ZCTA respectively in comparison with the existing network reaching 92.3% or 90.6% of trauma cases based on PTSF or PHC4 inclusion and 72.4% of ZCTAs. When controlled for existing coverage, the optimal number of TCs for PTSF and PHC4 were determined to be 22 and 16 or 22 and 17 when considering trauma volume and ZCTA.

CONCLUSIONS: Our algorithm selected a set of TCs that differs from the current set and varies with the database used to generate models. Because it examines the entire trauma system, it is likely that our algorithm, or one similar, may be better suited to guide trauma system development as opposed to the customary practice of permitting individual TCs to dictate expansion.

KEY WORDS: Trauma center; Non-trauma center; Geospatial mapping; Geospatial analysis

LEVEL OF EVIDENCE: Level III epidemiological study

UNDER-TRIAGE IN TRAUMA: DOES AN ORGANIZED TRAUMA NETWORK CAPTURE THE MAJOR TRAUMA VICTIM? A STATEWIDE ANALYSIS

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BACKGROUND: Proper triage of critically injured trauma patients to accredited trauma centers (TCs) is essential for survival and patient outcomes. We sought to determine the percentage of patients meeting trauma criteria who received care at non-trauma centers (NTCs) within the statewide trauma system that exists in the state of Pennsylvania. We hypothesized that a substantial proportion of the trauma population would be undertriaged to NTCs with undertriage rates (UTR) decreasing with increasing severity of injury.

METHODS: All adult (age ≥15) hospital admissions meeting trauma criteria (ICD-9: 800-959; Injury Severity Score [ISS]>9 or ISS>15) from 2003-2015 were extracted from the Pennsylvania Health Care Cost Containment Council (PHC4) database, and compared with the corresponding trauma population within the Pennsylvania Trauma Systems Foundation (PTSF) registry. PHC4 contains all hospital admissions within PA while PTSF collects data on all trauma cases managed at designated TCs (Level I-IV). The percentage of patients meeting trauma criteria who are undertriaged to NTCs was determined and Network Analyst Location-Allocation function in ArcGIS Desktop was used to generate geospatial representations of undertriage based on injury severity scores throughout the state.

RESULTS: For ISS>9, 173,022 cases were identified from 2003-2015 in PTSF, while 255,263 cases meeting trauma criteria were found in the PHC4 database over the same timeframe suggesting UTR of 32.2%. For ISS>15, UTR was determined to be 33.6%. Visual geospatial analysis suggests regions with limited access to trauma centers comprise the highest proportion of undertriaged trauma patients.

CONCLUSIONS: Despite the existence of a statewide trauma framework for over 30 years, approximately, a third of severely-injured trauma patients are managed at hospitals outside of the trauma system in PA. Intelligent trauma system design should include an objective process like geospatial mapping rather than the current system which is driven by competitive models of financial and healthcare system imperatives.

KEY WORDS: Undertriage; Trauma center; Non-trauma center; Geospatial mapping; Geospatial analysis

LEVEL OF EVIDENCE: Level III epidemiological study