Injury Mortality Following the Loss of Air Medical Support for Rural Interhospital Transport

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Abstract

Objectives: This study evaluated variation in mortality among interfacility transfers three years before and after discontinuation of a rotor-wing transport service. **Methods:** A retrospective cohort assessment was conducted among severely injured patients transferred from four rural hospitals to a single tertiary center in regions with continued versus discontinued rotor-wing service. Thirty-day mortality following discharge from the receiving tertiary facility served as the primary outcome measure. **Results:** Discontinuation of rotor-wing transport decreased interfacility transfers and increased transfer time. Transferred patients were four times more likely to die after (compared with before) rotor-wing service was discontinued ($p = 0.05$). No difference was noted in the region with continued rotor-wing service [odds ratio (OR) = 0.53, $p = 0.47$]. **Conclusions:** Injury mortality increased with loss of air transport for interfacility transfer in a rural area. **Key words:** air medical; patient transfer; injury; trauma centers; trauma systems; rural; mortality. ACADEMIC EMERGENCY MEDICINE 2002; 9:694–698.

The introduction of routine air transport for critically injured patients began in the 1950s during the Korean War and was advanced during the Vietnam War.[1] Since that time, debate has continued regarding the optimal method of transport for critically injured civilian patients to definitive care. Air medical transport of severely injured patients from rural hospitals to definitive care appears intuitively advantageous when compared with ground transport. Rural hospitals may be located in rugged and remote locales, requiring long ground transport times to navigate from the rural hospital to a tertiary center. Studies indicate that long transport times negatively impact survival among the severely injured[2,3] and that advanced therapeutic interventions provided by flight crews (compared with ground crews) may benefit patients during prolonged interfacility transfers.[4] However, studies assessing the overall efficacy of rotor-wing transport demonstrate either a survival advantage[5,6] or disadvantage[7] for seriously injured patients when assessing this resource-intensive method of providing interfacility transport.

Given these conflicting findings, we monitored outcomes following a helicopter crash in a rural area to further elucidate the effect of rotor-wing availability on the survival of severely injured patients requiring interfacility transfer from a rural hospital. We examined temporal changes in long-term mortality occurring in two adjacent rural regions in a single state. One region suddenly lost rotor-wing transport capabilities due to a crash and did not reinstate flight service, while a geographically and demographically similar comparison region had no interruption in helicopter service for interfacility transport. Our hypothesis was that risk-adjusted injury mortality would increase after discontinuation of flight service in the affected region, compared with the comparison region.

METHODS

Study Design. We used a retrospective cohort design to assess injury survival before and after discontinuation of rotor-wing transport in the test region compared with the comparison region (i.e., with continued rotor-wing support) during the same time period. Hospital data were collected for severely injured patients initially presenting to one of four rural hospitals in the test region, or one of

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four rural hospitals in the comparison region, who were subsequently transferred to one tertiary trauma center in each region. This study was deemed exempt from patient consent requirements by the Oregon Health & Science University Institutional Review Board.

Study Setting and Population. All study hospitals represent the primary triage/stabilization centers for severe trauma in their respective rural regions. The two participating tertiary centers (one in each region) receive the vast majority of interfacility transfers for definitive care from the study hospitals. Rural geographic comparability was ensured since all enlisting study hospitals are located outside metropolitan statistical areas, are more than 20 miles from an adjacent hospital, and maintain fewer than 50 staffed beds.

Included in the study were inter-facility transfer patients <80 years of age with ≥1 confirmed "serious injury" upon arrival at a rural study hospital. Serious injuries were confirmed by medical record review, and represent one of the following ICD-9-CM[8] coded injuries:

Head injury: 800, 801, 803, 804, 851, 852, 853, 854.
Chest injury: 807.03–807.09, 807.13–807.19, 807.4, 860, 861.20–861.22, 861.30–861.32, 862.00–862.10, 862.80–862.90.
Femur/open tibia fractures: 821, 823.30–823.32, 823.90–823.92.
Spleen/liver: 864, 865.

Patients were identified by examination of study hospital emergency department (ED) logs for the years of interest. The medical records of potential patients were reviewed to confirm the presence of an index injury. A second abstraction of medical record data was completed at the receiving tertiary center for confirmed study patients. Study data were abstracted for two time periods at each hospital in both regions: 1) three years prior to the crash date and 2) three years following the first anniversary of the crash date.

Measurements. Study variables were abstracted from medical charts at the rural hospitals (and two tertiary trauma centers) by trained medical records administrators. Variables abstracted include patient demographics, vital signs upon ED presentation, transfer time, and severity of injury coded according to Abbreviated Injury Scale (AIS) criteria.[9]

The level of presenting neurologic function was documented in the medical chart as either an AVPU scale[10] (i.e., Alert, responsive to Verbal commands, responsive to Painful stimuli, or Unresponsive) or a Glasgow Coma Scale (GCS) score.[11] For the purpose of statistical modeling, a single measure of global neurologic functioning was constructed by converting GCS scores to the AVPU scale: GCS 15–14 = Alert; GCS 13–10 = Verbal; GCS 9–4 = Pain; and GCS 3 = Unresponsive. Missing systolic blood pressure (SBP) values for 12.3% (33/269) of the study patients were approximated using sample means for SBP stratified by neurologic function (AVP versus U) and age deciles.[12]

An assessment of overall injury severity was based upon an Injury Severity Score (ISS).[13] Patient transfer time was calculated as the time interval from arrival at the rural study hospital to arrival at the receiving tertiary trauma center. Mortality was monitored for 30 days following discharge from the receiving tertiary trauma center using the National Death Index (NDI).[14]

Data Analysis. Primary analyses compared injury and transport characteristics in test and comparison regions for the two time periods. Comparisons were made using either a chi-square test of independence or one-way analysis of variance (ANOVA). Multivariate logistic modeling was used to measure variance in mortality associated with discontinuation of rotor-wing service in the test region (pre versus post), controlling for potential covariates. A one-step, "forced-entry" method of variable inclusion was used to estimate the unique contribution of each independent variable to the model.[15] The appropriateness of the resulting model was assessed using the Hosmer–Lemeshow (H/L) goodness-of-fit statistic.[16] Contributions to the model are reported as risk-adjusted odds ratios (ORs). All analyses were conducted using SPSS 10.0.7.[17]

RESULTS

Sample Characteristics. Thirty-eight percent (n = 148) versus 20% (n = 121) of the patients presenting to rural study hospitals received an interfacility transfer over the entire six-year period in the comparison and test regions, respectively. Among the transferred patients, head injuries were more prevalent in the test region, while chest injuries were more prevalent in the comparison region (Table 1). Patients transferred in the test region before loss of rotor-wing transport were younger and more likely male. The 30-day post-discharge death rate was significantly higher among interfacility transfer patients in the test region after loss of rotor-wing transport (26%) compared with either the compar-

TABLE 1. Demographic Characteristics for Transferred Patients in the Test and Comparison Regions

	Comparison (before)	Comparison (after)	Test (before)	Test (after)	p-value*
Total sample	46	102	75	46	—
Gender—male	70%	67%	80%	57%	<0.001
Age—mean ± SD (yr)	30.5 ± 18.1	32.3 ± 19.8	25.1 ± 16.5	34.9 ± 22.6	<0.001
Preexisting†	4%	17%	7%	11%	0.313
30-day mortality‡	13%	9%	7%	26%	<0.001
Systolic blood pressure—mean ± SD (mm Hg)	110 ± 19	113 ± 12	114 ± 12	112 ± 13	0.717
Index injuries§					
Head	34 (3.3 ± 1.0)	63 (2.9 ± 1.4)	72 (3.1 ± 1.3)	44 (3.6 ± 1.2)	<0.001
Chest	15 (3.4 ± 0.9)	29 (3.2 ± 1.2)	8 (2.6 ± 1.2)	8 (3.3 ± 1.5)	0.016
Liver/spleen	4 (2.2 ± 1.7)	20 (2.3 ± 1.7)	4 (1.5 ± 2.4)	2 (0.0 ± 0.0)	0.070
Tibia/femur	8 (2.9 ± 0.4)	21 (3.0 ± 0.3)	3 (3.0 ± 0.0)	6 (3.0 ± 0.0)	0.098
AVPU/GCS‖					
Alert	60%	64%	44%	49%	<0.001
Verbal	13%	21%	25%	18%	
Pain	13%	11%	18%	20%	
Unresponsive	13%	4%	14%	13%	
ISS¶—mean ± SD	20.6 ± 11.0	17.2 ± 11.5	15.9 ± 10.9	21.7 ± 12.2	0.863

*Significance level compares delta changes (before vs. after) between regions.
†Preexisting or associated medical conditions.
‡Death within 30 days of discharge from receiving hospital.
§Index injury categories provide number of patients with injury and mean ± SD of the Abbreviated Injury Scale (AIS) score.
‖AVPU scale = alert, responsive to verbal commands, responsive to painful stimuli, or unresponsive; GCS = Glasgow Coma Scale score.
¶Injury Severity Scale.

ison region during the same time period (9%) or the test region before loss of rotor-wing transport (7%). There was no difference in the death rate among patients *not* receiving an interfacility transfer in either the control [pre: 9.4% vs. post: 7.0%, p = 0.752 (n = 237)] or test [pre: 7.5% vs. post: 7.4%, p = 0.897 (n = 492)] region.

Transfer Characteristics. During the pre-crash time interval, the two regions demonstrated similar proportions of overall interfacility transfer use: 24% versus 25% among presenting patients for the test and comparison regions, respectively (Table 2). However, in the three years following discontinuation of rotor-wing service in the test region, interfacility transfers significantly decreased in the test region (15%) compared with the comparison region (51%). During the post-crash time interval, ground transports (and transfer times) increased in the test region.

Multivariate Analysis. Using multivariable logistic regression modeling, we examined the association between 30-day mortality and rotor-wing availability (i.e., pre- and post-crash time intervals), controlling for injury severity, age, and sex. Separate models were constructed for each study region.

The overall fit of both logistic models was good (H/L > 0.10), correctly classifying 91% and 95% of all cases in the study and comparison regions, respectively. Covariate factors significantly contributing to the odds of death included AIS scores in the head and chest regions (Table 3). Controlling for covariates, patients in the test region transferred for definitive care were four times more likely to die after discontinuation of rotor-wing service than

TABLE 2. Interfacility Transfer Characteristics among Patients in the Test and Comparison Regions

Variable	Comparison (before)	Comparison (after)	Test (before)	Test (after)	p-value*
Total presenting patients	184	201	313	300	—
Interfacility transfers†	46 (25%)	102 (51%)	75 (24%)	46 (15%)	<0.001
Ground transports‡	27 (59%)	34 (33%)	22 (29%)	42 (91%)	<0.001
Rotor-wing transports	19 (41%)	68 (67%)	53 (71%)	4 (9%)	<0.001
Median transport time (hr:min)	2:15	2:10	2:07	3:10	<0.001

*Significance level compares delta change (before vs. after) between regions.
†A small proportion of additional transports were conducted using private or law enforcement vehicles, or a distant fixed-wing service, and are not included here.
‡Values are given as percentage of interfacility transfers.

TABLE 3. Logistic Models Assessing the Effect of Rotor-wing Transport Discontinuation (pre vs post) on Probability of Transfer Death by Study Region, Controlling for Covariates

	Test Region			Comparison Region		
Variable	β	adj. OR	p-value	β	adj. OR	p-value
Age	−0.005	0.17	0.761	−0.017	0.98	0.526
Gender (male)	−0.607	0.54	0.387	−1.551	0.21	0.196
AIS* head	0.184	1.20	<0.001	0.355	1.42	<0.001
AIS chest	0.098	1.10	0.112	0.155	1.17	0.031
AIS abdomen	−0.010	0.99	0.902	−0.073	0.93	0.495
AIS extremity	0.098	1.10	0.336	0.154	1.16	0.238
AIS face	0.163	1.17	0.309	0.061	1.06	0.640
Pre/post (post)	1.386	4.00	0.050	−0.624	0.53	0.474

*Abbreviated Injury Scale score by body region.

were patients transferred while the service was still active. No difference was noted in the region with continued air service over the same time period.

DISCUSSION

Our results suggest that interfacility transfer patients demonstrated a fourfold increase in risk-adjusted odds of death after local rotor-wing service was discontinued compared with when such service was available. A temporal comparison in an adjacent region with continued rotor-wing service over the same time frame found no statistical difference in survival. After the loss of air medical support in the test region, local physicians took a more conservative approach when considering an interfacility transfer for a severely injured patient. Nevertheless, injury mortality increased among transferred patients and remained constant among patients admitted locally.

One might surmise that loss of air medical support in the test region may have also affected survivability for severely injured patients during scene treatment and transport. However, air medical transport from the scene was rarely used in the test region before discontinuation of the service.

Temporal increases in interfacility transfers to trauma centers and expanded air service usage in our control region mirror findings in other rural areas of the state under study. It is our supposition that similar increases would have been observed in the test region if the rotor-wing crash had not occurred.

Most published observational studies of air medical transport are limited by an inability to adequately control for the multiple aspects of clinical judgment that govern whether air or ground transport is requested.[5,7,18] The current study minimizes biases associated with the selection of a transport mode since an "air transport" option was not available after discontinuation of flight service. However, biases due to clinical judgment may still exist. That is, our data suggest that more patients were admitted locally rather than transferred to the tertiary center after discontinuation of the local air medical service.

LIMITATIONS

The interpretation of our findings should be tempered by limitations inherent to this observational study. First, the unexpected loss of rotor-wing service may not represent an ideal model to assess the value of interfacility rotor-wing transport. One would expect fluctuations in patient outcomes as providers attempt to compensate for the sudden loss of rotor-wing service and revise transfer protocols based upon available resources. The assumption underlying our analysis was that such modifications could be accomplished in a year's time. Thus, a one-year transitional period was built into the study design.

A second potential limitation relates to our finding that patients consistently presented with more frequently depressed vital signs and more severe head injuries in the test region compared with the comparison region (during pre and post time intervals). To compensate for this potential bias, we developed separate logistic models for each region and included demographic data and injury severity measures to capture the overall variance in the models explained by these covariates. The resulting models demonstrated good fits to the data and are assumed to have isolated the effect of rotor-wing availability on injury mortality.

Thirdly, it is possible that variations in the health care delivery system over the seven-year study period may bias our findings. A primary reason for including a control group in an adjacent rural region to the test region was to minimize bias caused by permutations in state health care funding and other legislative mandates. However, it is still possible that specific hospital-level changes in care delivery (e.g., cutbacks in ED staffing) may bias our findings. However, by combining the common experience of four hospitals in each area (both treatment and control regions), we hope to minimize the potential for bias due to individual hospital experience.

It should also be noted that presenting SBP was not documented in the medical chart for more than 12% of the study patients. Individual approximate values were generated using the mean of existing blood pressures stratified by neurologic function and age deciles. Since estimated values may have weakened the integrity of the modeling, the variable SBP was not included in the multivariate logistic models.

Finally, fixed-wing support was available in the test region from a distant, existing flight service [4 flights (pre), 7 flights (post)]. Fixed-wing transport was locally available in the comparison region, but rarely used for emergency transport [1 flight (pre), 3 flights (post)]. Because of the small number of flights and differences in fixed-wing use between the two regions, these transports were excluded from the analysis.

Based upon our data sources, it is difficult to speculate regarding the specific reasons for the observed increased mortality among transferred patients after loss of air medical support. Fewer advanced therapeutic interventions available to ground crews or prolonged transfer times are potential areas for further investigation.

CONCLUSIONS

Tempered by the stated limitations, this study suggests that when rotor-wing transport was no longer available, the odds of death increased among patients severely injured in rural areas and receiving an interfacility transport by ground ambulance. In addition, the study indicates that the availability of interfacility rotor-wing transport in rural areas appears to reduce transport times and promote the transfer of severely injured patients to tertiary care facilities.

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