Factors Improving Survival in Multisystem Trauma Patients

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This report analyzes the effect of air *versus* ground interhospital transport on survival following multisystem injury. There were 136 air-transported patients *versus* 194 ground-transported patients. The groups were similar in trauma scores, ages, mechanism of injury, and organ systems injured. There was a statistically significant survival advantage for air-transported patients with trauma scores between 10 and 5 (82.8% survival *vs.* 53.5%, p = < 0.001). The time interval between accident and admission to the authors' institution was similar for both groups. Important therapeutic interventions contributing to better survival by the air-transported group included higher incidences of endotracheal intubation (50% *vs.* 25%), blood transfusions (32% *vs.* 10%), larger volumes of electrolyte fluid (3.3 L per patient *vs.* 2.1 L per patient) as well as the use of MAST trousers (60.3% *vs.* 34.9%). Transport charges for both ground and air services were similar. However, helicopter charges met only 15% of the operational budget of the aeromedical service. The remainder of the costs were generated from hospital patient revenues. Overall, total hospital charges were similar for both groups and were influenced by the variability of length of stay, particularly for orthopedic patients.

MORTALITY RATES from major trauma have been shown to be significantly improved by rapid access to definitive care, particularly during the "golden hour" following injury. Many variables affect mortality rate during the initial phase of care including the availability of highly trained emergency medical technicians (EMTs) to care for the trauma patient both at the scene and during transport, as well as the specialized health care personnel and resources available at trauma centers. During wartime the helicopter has been instrumental in improving survival by providing rapid transport of the injured soldier to medical care.[1] The role of the helicopter in civilian trauma continues to be questioned.

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There are two missions for aeromedical transport: scene response and interhospital transportation.[2] Reports from helicopter-based services show that advanced trauma life-support procedures were performed frequently at the scene of accidents with low morbidity rates.[3] However, only a single report comparing air *versus* ground transportation shows better survival for trauma patients treated and transported by helicopter from the scene of the accident.[4] In rural states, the majority of patients treated at major trauma centers have their initial medical treatment begun at an emergency department nearest to the scene of the accident and are then referred to the trauma center. In this type of trauma practice, the helicopter is most frequently used to transport critically injured patients from outlying hospitals to a tertiary trauma facility. The focus of this study is the comparison of the impact of helicopter *versus* ground ambulance on interhospital transportation of severely injured patients.

Methods

All patients with trauma scores of 12 or less, excluding local accident victims, admitted to the Duke University Medical Center Trauma Service beginning in 1985 were separated into either helicopter or ground transport groups and matched by trauma score comparing mechanisms of injury, age, systems traumatized, Glasgow scores, and mortality rate. Patients with complete referring hospital and transport records were reviewed to compare changes in physiologic status during transport and interventions prior to arriving at Duke Medical Center, which may have affected outcome in both groups. Ambulance charges, helicopter charges, and costs as well as total hospital charges were also evaluated for the air and ground groups.

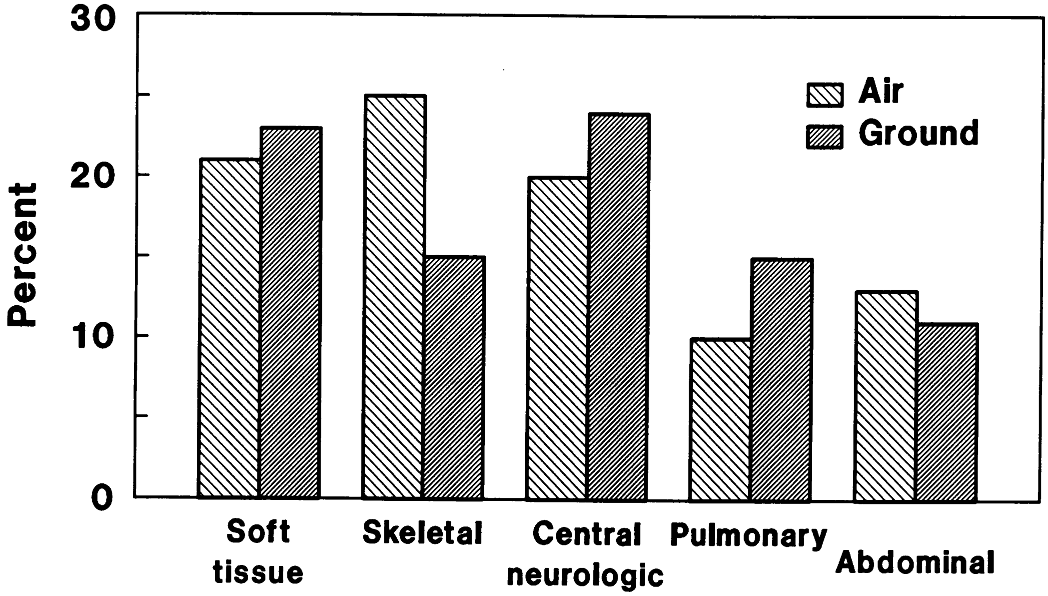

FIG. 1. Systems analysis of air- *versus* ground-transported patients.

Results

Records of 330 patients with trauma scores of 12 or less admitted to the Duke Trauma Service were reviewed. One hundred thirty-six patients were transported by helicopter while 194 patients were transported by ground ambulance. The air group had a mean age of 31.4 years and a mean trauma score of 8.7, while the ground group had a mean age of 33.4 years and a mean trauma score of 9.2. Glasgow coma scores were 8.6 for the air group *versus* 10.6 for the ground group. In the ground group 76% were injured in motor vehicle or industrial accidents and the remainder were assault victims. Of patients transported by helicopter, 85% incurred motor vehicle or industrial trauma while 15% were assault victims. The frequency of organ systems injured are shown in Figure 1. The average number of organs injured per patient was 1.9 for the ground group and 2.1 for the air group. Overall survival rates by trauma score are shown in Table 1. A statistically significant survival advantage for air transport was documented for patients with trauma scores between 10 and 5. In this group, there were 101 ambulance transport and 64 helicopter transport patients with a survival rate of 53.5% (54 of 101) and 82.8% (53 of 64), respectively ($p = <0.001$). Mean trauma scores for nonsurvivors was 4.1 for the air group and 7 for the ground group.

TABLE 1. *Overall Survival*

Trauma Score	Air	Ground
12–10	78 (97.4)	92 (92.3)
9–7	16 (81.3)	46 (47)
6–4	19 (63)	36 (27)
3–0	23 (15)	20 (5)
Total	136 (89)	194 (61)

Percentages are given in parentheses.

Ninety-six patients of 194 transported by ground had complete referring hospital and ambulance records, which were compared to the records of 136 air-transported patients to define important parameters affecting improved survival in the helicopter group. In this subset, 23% of the ground group were assault victims *versus* 15% in the helicopter group. Mean ages and trauma scores were comparable (13.4 air *vs.* 30.6 ground and 8.7 air *vs.* 9.2 ground). Systems injured analyses are shown in Figure 2. The average number of systems injured per patient were 2.1 for the air group and 2.2 for the ground group. Survival rates for each trauma score grouping were similar to the overall group (Table 2).

Therapeutic interventions prior to arrival at the hospital for each type of interhospital transport are shown in Table 3. Of the 46 patients aerovacuated to the hospital requiring urgent blood transfusions, 40 had their units started by the flight team at the referring hospital or during transport. Only ten (10.5%) of the ambulance group transported from outlying hospitals received blood prior to arrival at the hospital, although 26% of the ground group required blood urgently upon arrival at the Duke Emergency Department. Sixty of 68 patients (88%) in the helicopter transport group requiring airway intubation had their endotracheal tubes placed under the direction of the flight team at the referring hospital or in transport. Only 11 of 24 ground transport patients (47%) requiring urgent endotracheal intubation were intubated prior to arriving at the hospital. The remaining 13 patients required emergency endotracheal intubation by the hospital's trauma service due to airway complications. No patient in the air transport group had deterioration in their vital signs during the transport

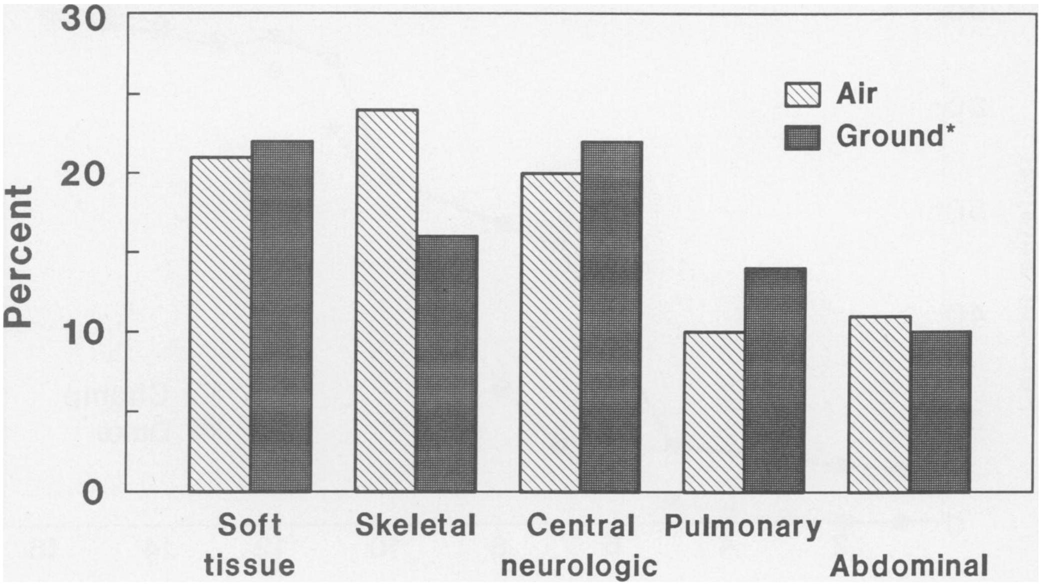

FIG. 2. Systems analysis of multisystem trauma patients.

phase between the referring hospital and Duke while 43% of the ground transport group became hemodynamically unstable. The average total time from occurrence of injury to arrival at the hospital was slightly longer for the air group (182 minutes *vs.* 175 minutes).

Transport charges for both types of services included a base charge plus a per mileage fee, which were billed to the patients. Life Flight helicopter charges averaged 15% more than the ground ambulance; however, the charges for helicopter service covers only 15% of the operational cost. Ground ambulance organizations were able to operate with a balanced budget or are dependent on local charitable donations. Total hospital charges were similar for both groups ($26,000 ground *vs.* $23,858 air). Separation of charges by trauma scores were also similar: trauma scores of 1–4 ($23,717 air *vs.* $30,965 ground); trauma scores 5–8 ($22,828 air *vs.* $24,863 ground); trauma scores 9–12 ($21,525 air *vs.* $19,603 ground).

Discussion

Survival following multisystem injury has improved over the past decade with the development of organized emergency medical service systems. Many factors of this system including designation of trauma centers, advanced prehospital care, communications systems, and better technology in the treatment of multisystem injury influence these improved statistics. Prehospital services vary from urban areas where paramedic level EMTs provide care to more rural areas which vary from basic EMT to EMT-intermediate level care. The impact of EMT prehospital care on survival is still being evaluated. Alexander et al.[5] showed improved survival from care provided by paramedic level EMTs in motor vehicle trauma patients while Boyd et al.[6] demonstrated no difference in survival between care given by basic or advanced EMTs. The utilization of ground ambulances during wartime was associated with delayed access to initial surgical treatment for the injured soldier. Military experience with helicopters has demonstrated progressively lower mortality rates with serious injury supporting the concept of shorter time intervals between injury and effective surgical care as the important factor in this improved survival.[7] Additional benefits of rapid air transport on the battlefield were lower morbidity rates, improved limb salvage, and shortened hospitalization. Civilian experience with helicopter transport for scene response has not been able to demonstrate survival differences. While many reports attest to the improved level of care provided by flight teams who are trained in Advanced Trauma Life Support and Advanced Cardiac Life Support procedures, the value of this alternate

TABLE 2. *Survival of Patients with Complete Prehospital Records*

Trauma Score	Air	Ground
12–10	78 (97.4)	48 (97.9)
9–7	16 (81.3)	18 (62.5)
6–4	19 (63)	15 (40)
3–0	23 (15)	15 (12)
Total	136 (89)	96 (74)

Percentages are given in parentheses.

TABLE 3. *Interventions*

	Air	Ground
Blood transfusions	32%	10.5%
Intubation	50%	25%
MAST	60.3%	34.9%
Fluid volume prior to arrival	3.34 L/pt	2.1 L/pt

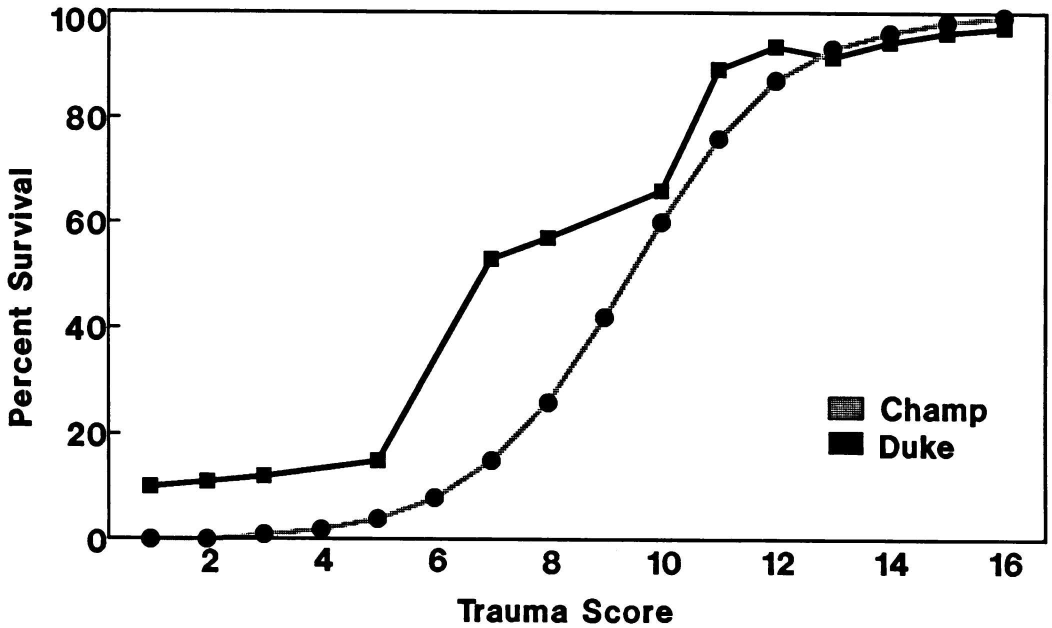

FIG. 3. Duke *versus* Champion[8] predicted survival by trauma score.

method of prehospital transport has been seriously challenged. Only a single report comparing transportation of a large volume of trauma patients from the scene of the injury has shown an improved survival over predicted mortality rate for the air *vs.* ground transportation.[4]

Trauma centers with organized trauma services, outreach educational programs, and trauma registries for outcome analysis provide a multifactorial approach to better trauma care. Level I trauma centers such as Duke University Medical Center, which has a trauma registry containing over 2000 patients, have shown favorable survival statistics compared to the national experience such as shown by Champion[8] (Fig. 3). While the basic principle of triage is to transport the patients with serious multisystem injury to a trauma center, rural states with extensive distances between trauma centers are not suited to this approach. Patients are most commonly taken to the nearest hospital where their initial treatment is provided. Those needing specialized trauma care in a Level I trauma center then require a second transport to the tertiary care center. The rural practice of trauma care is different from that of urban trauma centers with a twofold increase in mortality rates for specific motor vehicle injuries.[9] In this setting the helicopter is utilized primarily for interhospital transportation of critically injured patients rather than scene response.

Duke Trauma Center, centrally located in North Carolina, receives over 75% of multisystem-injured patients shortly after having their treatment begun at other outlying hospitals. With the initiation of the helicopter program, it was possible to compare the impact of air *versus* ground transportation on survival for referred trauma patients. A trauma score of 12 or less was selected for this study because these lower trauma scores reflect serious injuries associated with increased mortality rates. The study group included over 300 air- or ground-transported patients who were similar in age, trauma scores, mechanism of injury, and systems injured. There was significantly better survival advantage for severely injured patients with trauma scores between 10 and 5 who were transported by helicopter. The survival in the midrange trauma scores (10–5) was 82% for the air transport group and 53% for the ground transport group. While there were more survivors with trauma scores of 4 or less in the aerovacuation group, no statistical advantage could be attributed to helicopter transportation because of the small numbers of patients.

Survival for injured patients with trauma scores of 11 or higher was excellent for both groups. There was no advantage for aeromedical transport for these patients. This points out the need for careful triage prior to dispatching the helicopter, especially for busy helicopter programs where availability of the helicopter may be limited.

Lower mean trauma scores for nonsurvivors in the air *versus* the ground transport group is another indicator of the impact of care provided during transport. In order to define the factors influencing improved survival for patients with midrange trauma scores, the hospital records of those ground transport patients with complete documentation to compare to the air transport group were utilized. Approximately one-half of the ground transport group arrived at the Duke emergency department with complete documentation of the accident and treatment received at the referring hospital. The remaining records of the ground ambulance group lacked key information on the treatment prior to admission to the Duke Hospital. This subset of ground-transported patients were similar in terms of types, numbers of organ systems injured per patient, mechanism of trauma, ages, and trauma scores.

The time interval from scene of accident to admission to the hospital was similar for both ground and air transport groups, indicating that other factors are important in improved survival for the aeromedical group. Therapeutic interventions including blood transfusions, endotracheal intubation, and the use of Medical Antishock Trousers were significantly more frequent in the air-transported group. Of patients requiring intubation because of significant head and neck or chest trauma, 88% of the intubations were placed under the direction of the flight team prior to arrival at the hospital. Only 47% of the ground ambulance patients requiring intubation had their endotracheal tubes placed prior to arrival at the hospital. Significantly higher percentages of the air-transported group had blood administered prior to arrival at the hospital under the direction of the flight team. In addition, Medical Antishock trousers were more frequently employed in the air-transported group. The aerovacuated patients received a larger electrolyte resuscitation during transport and prior to arriving at the hospital.

The impact of utilization of the Life Flight personnel with critical care training under direct medical supervision had a beneficial effect in that no patients in the air-transported group had deterioration of their vital signs during the transport phase from the referring hospital compared to 43% of the ground group, which did become more hemodynamically unstable. The Life Flight helicopter program carries O− blood on interhospital transports as well as utilizes any blood that is crossmatched at the referring hospital. The flight personnel are skilled in endotracheal intubation as well as other advanced cardiac and trauma life-support techniques. Ventilatory support including the capability of providing PEEP and continuous suction for chest tubes can be provided during air transport. The availability of constant medical supervision via radio and telemetry made other pharmacologic interventions possible during aeromedical transport including treatment of hemorrhagic or cardiogenic shock, dysrhythmias, or increased intracranial pressure from head injuries.

The charges for the helicopter service billed to the patients were similar to ground charges in the area. The establishment of the charges for the helicopter were determined by many internal factors in the medical center. These charges, however, only met 15% of the operational expenses of the helicopter service. The remainder of the operational costs were generated by revenue from inpatient hospital charges and represents an institutional commitment to trauma care. No difference in hospital charges including breakdown by trauma scores could be found between the two groups. These results may be influenced by variables in length of stay, especially in patients with long bone fractures. A larger series of patients may show a favorable financial impact of the helicopter service on patient care.

In summary, analysis of the Duke experience in the helicopter transport of multisystem trauma patients demonstrates that an organized systems approach to trauma care improves survival. In the rural setting, interhospital helicopter transportation provides a lower mortality rate by the prompt extension of Level I trauma center resources and expertise to the primary care hospital rather than by shortened intervals between injury and admission to the trauma center. Aeromedical transportation provided hemodynamic stability and physiologic support in the resuscitation phase of trauma care. Interhospital helicopter transportation was most beneficial to trauma patients with midrange trauma scores between 10 and 5. While charges generated by helicopter transport do not meet operational expenses, these operational deficits were met from hospital patient revenues associated with improved survival.

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Discussion

Dr. Basil A. Pruitt, Jr. (Fort Sam Houston, Texas): Dr. Moylan, Dr. Georgiade, and their colleagues have demonstrated the importance of stratifying patients by injury severity when assessing outcome, and have presented data indicating that a significantly higher percentage of injured patients with trauma scores between 10 and 5 survived when their interhospital transfer to a Level I trauma center was by helicopter as compared to ground ambulance.

These authors have found that time between the injury and the admission to the trauma center was not influenced by the means of transfer, but that the means of transportation influenced the level of prehospital care applied to the patient. That is, endotracheal intubation, application of MAST trousers, infusion of blood, and the rapid