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DOES HELICOPTER EMERGENCY CARE SERVICE
IMPROVE BLUNT TRAUMA MORTALITY

BY

Major Kenneth Duane Oefinger, USAF, NC

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University of Alabama at Birmingham

Abstract

A retrospective study of a hospital-based helicopter service was studied to determine if patients transported with blunt trauma from accident scenes to a Level I trauma center experienced a reduction in predicted mortality rates. The medical records of 78 consecutive ground ambulance patients and 149 consecutive helicopter patients during the period January 1, 1988 to January 1, 1989 who met the criteria were reviewed.

A statistical analysis designed to predict mortality based on TRISS methodology and Flora's Z-statistic was utilized. An alpha level of 0.5 was used for this study.

There were no statistically significant differences in the predicted mortality of patients transported by ground ambulance or helicopter. Patients transported by helicopter demonstrated no decrease in predicted and actual mortality rates. In this group, 16 patients were predicted to die and 18 actual deaths occurred. The mean probability of survival for patients transported by helicopter was .89.

Recommendations for future studies include evaluating patients transported only from rural areas

to determine if these patients demonstrate a reduction in predicted mortality in this region. Another suggested study would be a replication of this study including patients requiring CPR after leaving the accident scene to determine whether interventions by the helicopter medical crew affect mortality outcome. A final recommended study would be implementation and evaluation of a prehospital triage tool by paramedic/EMTs to determine whether a helicopter should be dispatched. This would allow for the monitoring of effective utilization of the hospital service.

DOES HELICOPTER EMERGENCY CARE SERVICE IMPROVE BLUNT TRAUMA MORTALITY?

by

CYNTHIA LYNN SALE

MAJOR KENNETH DUANE OEFINGER

A RESEARCH PROJECT

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Introduction

Each year in our nation, over 150,000 deaths occur from injuries, making trauma one of the leading causes of death for persons under the age of 45. Deaths from trauma in the United States are surpassed only by heart disease, cancer, and stroke. Additionally, over 70 million nonfatal injuries are incurred each year. The direct and indirect cost of traumatic injuries in which death or disabling injuries occur exceeded $140 billion in 1988 (Champion & Mabee, 1990).

With the emphasis placed on reducing mortality, morbidity, and the rising cost of trauma care, several changes have been implemented in the emergency health care system in recent years. The two foundations upon which these system modifications were based are the reemphasis on improving prehospital care of the trauma victim and in the organization of regional trauma care systems (Howell, 1988).

There are many variables which may affect the mortality rate of trauma victims during the initial phase of care. These include the availability of highly trained Emergency Medical Service (EMS) providers at the scene of injury and during transport to definitive care. Another is the recent development of trauma centers specializing in the care of the critically injured. These two variables have significantly related to a decrease in trauma mortality (Law, Law, Brennan, & Cleveland, 1982).

During the Korean and Vietnam Wars, the advantages of using the helicopter for air evacuation of the seriously injured soldier was utilized extensively. Mortality rates for major injuries were significantly reduced in comparison to those of World War II experiences (Neel, 1955, 1968). This reduction in mortality and morbidity of injured soldiers encouraged the civilian community to establish hospital-based helicopter services staffed with an advanced medical crew and equipment dedicated to EMS missions. For the first time, a direct extension of the emergency department was capable of responding directly to the injury scene and providing major therapeutic interventions (Baxt & Moody, 1985). The purpose of this study was to evaluate the impact of a hospital-based helicopter service on the outcome of blunt trauma patients transferred from the scene of an accident to a Level I trauma center.

Background

A report in 1966 by the National Research Council referred to accidental injury as the "neglected disease of modern society" (National Academy of Sciences - National Research Council, 1966). This report led to the realization that medical care of the trauma victim, both at the prehospital and hospital levels, was in need of change.

The enactment of the National Highway Safety Act (P.L. 89-564) and other Federal legislation led to the eventual upgrading of prehospital care by providing government funding to the Medical Services Program. Funding from this program was utilized to train emergency medical technicians (EMTs) and paramedics. It was also utilized in the improvement of hospital trauma care by funding systemized and regionalized trauma care systems (Howell, 1988). In the ensuing years, most highly populated areas have developed paramedic or EMT prehospital care services, and many areas have developed formalized regional trauma care systems (Baxt & Moody, 1983). Trauma, however, continues to be the leading cause of death for those between the ages of 1 and 45. The death rate from trauma in older Americans is increasing yearly. It is the young, however, who are the most vulnerable. Trauma claims more lives than all other causes combined for those between the ages of 1 and 45. It has been estimated that more than $65 million per day is lost in wages as a result of trauma. In the United States, an estimated 80% of those who are severely injured never receive appropriate care and one-third of all severely traumatized victims die needlessly after they reach the hospital (Champion & Mabee, 1990). As a result of these grim statistics, there has been continued upgrading in the approach to the treatment of trauma victims. One recent development has been the use of hospital-based helicopter EMS services with advanced medical crews (Baxt & Moody, 1983).

In the United States, the concept of transporting injured patients by air from the scene of injury to definitive care centers originated with Armed Services. World War II brought the first large-scale utilization of air transport for medical evacuation. The United States Air Force airlifted by fixed-wing aircraft more than 1,360,000 patients between 1942 and 1947, with a mortality rate of less that one in 30,000 (Neel, 1955). The United States military first utilized helicopters in the transport of critically wounded soldiers during the Korean War. During this time, the helicopter gained recognition as an effective resource in the evacuation of wounded soldiers from areas inaccessible to ground ambulances. A program was developed with special communication, medical control, and medically trained personnel as members of the flight crew. Mortality rates for major injuries were dramatically reduced for injured soldiers as compared to those of World War II (Neel, 1955). As a result, the helicopter became a permanent fixture in medical evacuation in the Armed Services.

In Vietnam, the helicopter was utilized extensively and successfully to transport critically wounded soldiers directly from the battlefields to surgeons in field hospitals. This capability further established the importance of the helicopter in medical evacuation. Medical facilities capable of treating life-threatening injuries were within 35 minutes or less of a wounded soldier as a result of helicopter transport. The mortality rate in the Vietnam conflict was less than 2% (Neel, 1968). The reduction in morbidity and mortality of war casualties led Neel (1968) to suggest that the experiences gained by the Armed Medical Services use of helicopter ambulances could be utilized in the civilian setting. Using the military experience as a framework, civilian use of hospital-based and private helicopters were developed and have become an important component of prehospital care. Several have identified theoretical advantages of air transport services for the critically injured or ill patient over conventional ground transport services. First, rapid transport of the injured patient can be provided at speeds two to three times faster than ground ambulance. Helicopter services are also capable of providing access to patients who can not be reached by ground transport service or who would be forced to forego transport until a ground EMS service could respond (Baxt & Moody, 1983). Helicopter EMS services offer the availability of a highly skilled and experienced medical crew capable of evaluating, diagnosing, and performing life-threatening interventions at the scene of injury (Burney & Fischer, 1986). Lastly, helicopter EMS services provide a multidisciplinary team approach from initial resuscitation of the injured patient to definitive care (Cleveland & Miller, 1980). There are numerous papers describing the experiences of different helicopter programs. However, few studies are found that objectively evaluate whether the proposed advantages of air transport has any impact on the mortality of trauma patients. Since hospital-based helicopter programs are extremely costly to maintain, it appears appropriate to examine the effectiveness of such a service on patient mortality.

One of the first reports to objectively evaluate the impact of air transport on the outcome of trauma patients was Baxt and Moody in 1983. This study reported a 52% reduction in predicted mortality utilizing the TRISS evaluation of 150 scene flights compared to 150 ground transport of trauma patients. In 1985, a study of seven different helicopter EMS services demonstrated a decrease in predicted mortality of 21% in a sample of 1,273 patients flown from the scene of an accident to a trauma center (Baxt, Moody, Cleveland et al., 1985). The use of helicopter EMS services responding to the scene of an accident in the urban setting has been questioned. A study performed in the Phoenix area demonstrated no appreciable impact of the helicopter EMS service on mortality in the urban setting where readily available and skilled ground transport existed (Schiller & Knox, 1988). A study examining the experience of a helicopter EMS service operating in the Houston metropolitan area concluded that in a metropolitan area where advanced life support EMS and rapid transport to a trauma center are routinely feasible, there is little need for helicopter response to the scene of an injury (Fischer, Flynn, Miller, & Duke, 1984). This study did not compare outcome between the helicopter EMS service and ground EMS transport. Burney and Fischer (1986) have published guidelines that detail important considerations in the appropriate use of helicopter EMS services in scene flight response. The use of the helicopter EMS service in scene response and the impact on mortality appear to remain in question in an urban setting.

Seventy percent of fatal accidents occur in rural area, and rural mortality rates for victims of motor vehicle accidents are four times greater than in the urban setting (Waller, Curran, & Noyes, 1964). The helicopter EMS service should play a significant role in the rural trauma system where time and distance become major factors in the outcome of the trauma patient (Boyd & Corse, 1988). In 1987, utilizing a subjective panel review, Urdaneta and

Miller retrospectively reviewed 916 patients with multisystem trauma transported by a helicopter EMS service in a rural trauma care system in Iowa. The study concluded that a helicopter EMS service was essential or helpful in the survival of 27% of patients reviewed (Urdaneta & Miller, 1987).

In both the military and civilian settings, the team approach has demonstrated the most effective and efficient means in caring for the seriously injured or critically ill patient. A prerequisite to this is an excellent prehospital emergency medical system, an organized regional communication system, access to rapid air evacuation with a skilled medical team, and dedicated trauma care resources (Boyd, 1982). A trauma system should be able to effectively evaluate the adequacies of their services. Injury severity indices which correlate with patient outcome have recently been combined with advanced statistical methods. Although these indices are not perfect they do assist in controlling for case mix and provide a common language for describing trauma patient populations (Champion, Sacco, & Hunt, 1983). The results obtained enable the user to provide insights into the efficiencies of the strategies being used at the prehospital and hospital levels.

Until recently, the comparison of trauma patients outcomes at different medical centers was impossible. A severity scoring system for measuring acute head injury was developed by Teasdale and Jennett (1974). This measurement enabled medical centers to compare patients who had suffered major head trauma. A statistically sound system for evaluating trauma was not described until the development of the Trauma Score (Champion, Sacco, Carnazzo, Copes, & Fouty, 1981). The Trauma Score (TS) is a simple physiological scoring system utilizing four physiologic parameters - systolic blood pressure, respiratory rate, respiratory effort, and capillary refill - combined with the Glasgow Coma Score (GCS). The performance of the TS as a valid predictor of patient outcome was applied to a large number of patients and was shown to reliably indicate patient outcome (Champion, Sacco, & Hunt, 1983).

In 1974, the Injury Severity Score (ISS) was developed by Baker and provides a numerical description of the overall severity of injury sustained by the patient. This score has been shown to directly correlate with mortality for patients with multiple trauma. The score is easily obtained and is based on a widely utilized classification system, the Abbreviated Injury Scale. By using the ISS, the mortality experience of varied groups of trauma patients can be compared, thereby improving the ability to evaluate care of the injured patient (Baker, O'Neill, Haddon, & Long, 1974). Studies have demonstrated that by utilizing the TS, ISS, and the patients' age (TRISS method) the patients' outcome can be predicted in 94% of patients less than 54 years of age (Boyd, Tolson, & Copes, 1987).

This study utilized the TRISS methodology to compare the mortality of 78 blunt trauma patients who were treated and transported by ground EMS service to the mortality of 149 blunt trauma patients treated and transported by a helicopter EMS service staffed with a physician and a critical care nurse to the same medical center.

Methodology

This retrospective study was conducted in a private hospital in a large metropolitan area. The study center chosen was a Level I trauma center with an organized and highly structured protocol for the evaluation and resuscitation of trauma patients who are received by ground EMS services or the hospital-based helicopter service.

The hospital records of 227 consecutive patients who arrived by ground EMS or the hospital-based helicopter EMS service during the time period extending from January, 1988 through January, 1989 were reviewed. Two groups of patients were compared in this study: 78 consecutive patients who sustained blunt trauma and were treated at the scene of injury and transported by ground EMS services and 149 consecutive patients who sustained blunt trauma and were treated at the scene of injury and transported by helicopter EMS service to the same Level I trauma center. Only patients who sustained blunt trauma and who received treatment in the Shock/Trauma/Resuscitation Room (Trauma Room) were included in the study. Patients who sustained penetrating trauma or who required CPR at the scene of injury, during transport, or in the Trauma Room were excluded from this study. All patients were followed to discharge. Mortality was defined as death caused by the original injury or complications of that injury.

The ground EMS services consisted of crews staffed with an EMT and a paramedic during transport to the trauma center. The helicopter EMS service crew consisted of a physician and a highly trained critical care nurse.

The severity of injury to the patient was determined utilizing the TRISS (TS, ISS, and age) methodology. Studies have demonstrated that the TRISS methodology offers a standard approach for evaluating trauma patient outcome (Boyd et al., 1987). The TS variables for ground transported patients were developed upon the immediate arrival of the patient to the Trauma Room. The TS variables for helicopter transported patients were developed on initial flight crew contact. The ISS was developed from patient medical records at the completion of admission.

The TS was calculated using the method described by Champion, Sacco, Carnazzo et al. (1981). The Injury Severity Score (ISS) was calculated using the method described by Baker et al. (1973). The TS, ISS, patient age, and mechanism of injury were used to compute a probability of survival (Ps) for each patient based on the TRISS method of the Major Trauma Outcome Study (MTOS) as described by Champion, Frey, & Sacco, (1984) using the following calculation:

(Equation 1) $$Ps = 1/1(1=eb)$$

(Equation 2) where $b=b0+b1(TS)+b2(ISS)+b3(age)$.

The regression coefficients utilized for b0...b3 were those derived through use of the logistic regression analysis of the 3,133 patients collected in the MTOS (Champion et al., 1984). Age was coded as 0 for patients 54 years of age or less and as 1 for patients age 55 or over.

The statistical significance of an observed variation in mortality of each test group from that predicted by TRISS was evaluated using the Z-statistic first described by Flora in 1978. The Z-statistic quantitates the difference in the actual number of deaths and the predicted number of deaths based on the MTOS norm (Boyd et al., 1987). When evaluating mortality, the following formula was used:

(Equation 3) $$\frac{D-\sum Qi}{\sqrt{\sum PiQi}}$$

D equals the actual number of deaths in the study group. Pi is the probability of survival as derived from Equation 1, and Qi = 1-Pi (patients predicted to die). The significance of the observed variation in mortality between each group was determined by using the Mantel-Haenszel test. Differences in mean values of independent variables were evaluated using the two-taied Student's t-test. An alpha level of $p < 0.05$ was selected for statistical significance.

Results

There were 78 patients transported by ambulance and 149 patients transported by helicopter in this study. Table 1 summarizes the demographic data collected on these patients. Patients transported by helicopter were slightly younger than the patients transported by ambulance. The difference, however, was not statistically significant ($t = 1.43$, $p = .156$) at a significance level of .05. Table 1 also presents a breakdown of the patients by gender. There were more males transported by both ambulance and helicopter then females.

The average response time of the ambulance to the injury scene was 12 minutes. The average length of time from time of injury to arrival at the trauma center was 33 minutes. Transport time could not be

Table 1

Age and Gender of Patients Transported by Ground Ambulance and Helicopter

	Ambulance (n = 78)	Helicopter (n = 149)	p
Age in Years			
M	35.6	32.2	
SD	18.6	15.1	
10-20	16(20.5%)	41(27.5%)	.23
21-30	22(28.2%)	40(26.9%)	.19
31-40	17(21.8%)	30(20.1%)	.61
41-50	9(11.6%)	19(12.7%)	.46
51-60	5(6.4%)	9(6.1%)	.64
61-90	9(11.6%)	10(6.7%)	.07
Gender:			
Male	59(75.6%)	103(69.1%)	
Female	19(24.4%)	46(30.9%)	

calculated since time spent at the scene was not included on the ambulance run sheet.

The response time of the helicopter to the injury scene is dependent on the initial assessment by the ambulance crews and subsequent notification of the helicopter. The average response time to the accident scene after notification was 21 minutes. The average length of time from time of injury to arrival at the trauma center was 55 minutes, while the average length of time from the helicopter arrival at the scene to arrival at the trauma center was 21 minutes. The time spent on the scene by the ambulance crews before notification of the helicopter was not included on the ambulance run sheet.

Table 2 presents the cases by county from which the individuals were transported. Jefferson County (Jeffco) is primarily an urban county and the others are primarily rural. A non-metro county, for the purpose of this study, is a county that does not contain an urban population center of 50,000 or more people. The majority of patients in both groups were from Jeffco. Of the patients transported by helicopter, 35.6% came from locations outside Jeffco. In comparison, only 16.7% of the ground ambulance patients were transported from areas outside Jeffco.

Table 2

Distribution of Patients Transported by Ambulance and Helicopter According to County

County	Ambulance Number (%)	Helicopter Number (%)
Jefferson	65(83.3)	96(64.4)
St. Clair	2(2.6)	5(3.4)
Cullman	2(2.6)	11(7.4)
Walker	9(11.5)	8(5.4)
Shelby		19(12.8)
Talladega		5(3.4)
Butler		5(3.4)

When patients were transported by ambulance within Jeffco, 58 patients survived and 7 died. There were 84 patients who survived and 12 patients who died when transported by helicopter within Jeffco. An analysis of these patients by the two-tailed Student t-test found no significant differences among the survivors ($t = 1.54$, $p = .126$) or nonsurvivors ($t = .07$, $p = .946$).

A total of 11 patients lived and two patients died when transported from outside Jeffco by ambulance. There were 47 patients who lived and 6 patients who died when transported by helicopter from outside Jeffco. When analyzed by the two-tailed Student t-test, the differences were significant for the survivors ($t = 2.10$, $p = .041$) but not significant for the nonsurvivors ($t = 1.21$, $p = .271$).

These patients were further analyzed using Flora's equation (Flora, 1978) to compare the predicted number of deaths to the observed number of deaths (see Table 3). A Z-statistic is obtained and it must exceed $\pm$ 1.96 to be significant at an alpha level of .05. There were no statistically significant differences found between ambulance and helicopter patients transported within Jeffco or outside Jeffco. However, more patients died when transported from outside Jeffco by ambulance than was predicted.

Table 3

Predicted and Actual Number of Deaths of Patients by Ambulance and Helicopter Within and Outside of Jefferson County (Jeffco)

	Ambulance			Helicopter			
	Σ Qi	Died	Z	ΣQi	Died	Z	Z^d
Within Jeffco	5.430	7	.911	11.08	12	.386	.525
Outside Jeffco	.550	2	*2.130	5.05	6	.618	1.512
Total	45.980	9	1.63	16.13	18	1.004	.626

Note. ΣQi = Predicted number of deaths
Z = Flora's Z-statistic
Z^d = Difference in Z-scores
*p <.05

The patients in this study were placed into five arbitrary probability of survival (Ps) classifications based upon the distribution of their severity of injury (see Table 4). When the number of patients in both groups were analyzed by the two-tailed Student t-test, there were no statistically significant differences noted ($t = 1.254$, $p = .212$). When both groups were analyzed using the Mantel-Haenszel analysis for linear association, there was no statistical significance found ($p = .531$).

Table 4

Distribution of Patients Transported by Ambulance and Helicopter According to Their Probability of Survival (Ps)

	Ambulance	Helicopter		
M	.92	.89		
SD	.165	.297		
Ps	Number (%)	Number (%)	P	P^m
≥.90	64(82.1)	117(78.5)	.696	.623
.75-.89	8(10.2)	14(9.3)	.0005	-
.50-.74	3(3.8)	9(6.0)	.31	-
.25-.49	1(1.2)	4(2.6)	-	-
≤.24	2(2.5)	5(3.3)	.769	-
Total	78	149	.212	.531

Note. P^m = Mantel-Haenszel analysis

When the number of patients within the Ps classifications were analyzed using the two-tailed Student t-test, the only statistically significant difference found was in the Ps classification .75-.89 ($t = 4.76$, $p = .0005$). The mean Ps of the ambulance patients in this classification was .87 (SD = .024) and the mean Ps of the helicopter patients was .81 (SD = .04). Each Ps classification was also analyzed by the Mantel-Haenszel analysis. Due to the small sample sizes only the comparison of the ambulance and helicopter populations, and the Ps classification ≥.90 could be analyzed, and none were found to be statistically significant.

The Ps classifications of the patients were further analyzed using Flora's equation (Flora, 1978) to compare the predicted number of deaths to the observed number of deaths (see Table 5). There were no statistically significant differences found between the patients transported by ambulance or helicopter. When each method of transportation was analyzed within each Ps classification, the ambulance patients with a Ps of $\geq$ .90 were found to have a significantly higher mortality rate than expected. Four patients died when only 1.51 were predicted to die. No difference in mortality (obtained by subtracting the Z-statistic of the ambulance and helicopter patients) within this Ps classification was found, although the difference was significant at an alpha level of .10. This was primarily due to the fact there were no deaths in the ambulance patients in this Ps classification.

The Mantel-Haenszel analysis was used to compare the number of predicted deaths and observed deaths when transported by ambulance or helicopter. There were no significant differences found ($p = .90$).

Table 5

Predicted and Actual Number of Deaths of Patients Transported by Ambulance and Helicopter

Ps	Ambulance Σ Qi	Ambulance Died	Ambulance Z	Helicopter Σ Qi	Helicopter Died	Helicopter Z	Z^d
$\geq$.90	1.51	4	*2.054	2.60	3	.251	+1.803
.75-.89	1.04	0	-1.016	2.73	4	.862	+1.878
.50-.74	1.96	2	1.148	3.67	4	.226	.922
.25-.49	.61	1	.796	3.31	3	-.299	1.095
$\leq$.24	1.76	2	.551	3.82	4	.424	.127
Totals	5.98	9	1.629	16.12	18	.66	1.502

Note. Σ Qi = Predicted number of deaths
Z = Flora's Z-statistic
Z^d = Difference in Z-scores
*p <.05
+p <.10

Table 6 presents the means of the two groups, including survivors and nonsurvivors. The difference between the overall probability of survival means of patients transported by ambulance and helicopter was analyzed using the two-tailed Student t-test and was not statistically significant, nor was there a difference between the mean Ps of nonsurviving patients or surviving patients.

Table 6

Probability of Survival Means of Patients Transported by Ambulance and Helicopter

	Ambulance	SD	Helicopter	SD	t	p
Overall Ps	.92	.165	.89	.207	1.25	.212
Nonsurvivors	.63	.343	.54	.329	.69	.494
Survivors	.96	.064	.94	.122	1.59	.112

The MTOS found patients could be expected to die if they had a Ps $\leq .50$ and survive with a Ps $>.50$ (cited in Baxt & Moody, 1987c). Table 7 presents an analysis of patients fitting these criteria. The two-tailed Student t-test was used to determine if the frequencies of patients within the Ps classifications were different depending on the type of transportation (ambulance or helicopter) and geographic location of injury (inside or outside Jeffco).

A total of 13 patients were expected to die, of whom three were in the ambulance group and 10 were in the helicopter group. A total of 214 patients were expected to live, 75 of the ambulance patients and 139 of the helicopter patients. There were no differences between the number of ambulance patients and helicopter patients who died but were expected to

Table 7

Mortality of Patients Transported by Ambulance and Helicopter

	Ambulance			Helicopter				
Ps	No.	M(Ps)	SD	No.	M(Ps)	SD	t	p
>.5[a]	6	.842	.117	10	.776	.163	.86	.40
≤.50[b]	3	.21	.191	8	.238	.213	-2.0	.85
≤.50[c]	0	-	-	2	.235	.035	-	-

Note. [a] = Expected to live but died
[b] = Expected to die and died
[c] = Expected to die but lived

live. No differences were found between the number of ambulance patients and helicopte- ...cients who lived but were expected to d...

Table 8 preserted an analysis of patients transferred from within and outside Jeffco by ambulance and helicopter. A total of nine patients (three in the ambulance group and six in the helicopter group) were expected to die when transported by ambulance or helicopter within Jeffco. Of these nine, two survived and both were transported by helicopter. A total of 152 patients were expected to live, 62 in the ambulance group and 90 in the helicopter group. However, 12 of these patients died - 8 in the helicopter group and 4 in the ambulance group. An analysis of these patients using the two-tailed Student t-test failed to show any significant differences.

Table 8

Mortality of Patients Transported by Ambulance and Helicopter Within and Outside Jeffco

	Ambulance			Helicopter				
Ps	No.	M(Ps)	SD	No.	M(Ps)	SD	t	p
>.50[a]	4	.86	.131	8	.75	.173	1.06	.31
>.50[b]	2	.82	.120	2	.88	.042	-.72	.55
≤.50[c]	0	-	-	2	.24	.035	-	-
≤.50[d]	-	-	-	-	-	-	-	-
≤.50[e]	3	.21	.191	4	.20	.190	.05	.96
≤.50[f]	-	-	-	4	.27	.257	-	-

Note. a = Expected to live but died within Jeffco
b = Expected to live but died outside Jeffco
c = Expected to die but lived within Jeffco
d = Expected to die but lived outside Jeffco
e = Expected to die and died within Jeffco
f = Expected to die and died outside Jeffco

Among patients transported from outside Jeffco, there were four patients expected to die and these were from the helicopter group. There were no patients from either group who were expected to die but lived. A total of four patients, two from each group, died when they were expected to live.

Table 9 presents the distribution of the GCS for patients transported by helicopter and associated head injuries with each score. The EMS and medical records did not cont ain the GCS for the ambulance patients. A total of 98 patients with head injury were transported by helicopter. A total of 33 patients (22%) had a GCS ≤ 8 and 116 patients had a GCS > 8. In addition, 18 (54%) of the patients in this group survived with a GCS ≤ 8. Of 104 patients with associated head injuries, 32 (31%) had a GCS ≤ 8.

Table 9

Distribution of GSC and Associated Head Injury Patents Transported by Helicopter

GCS	No. (%)	Head Injury (No.)
3	6(4.0)	6
4	6(4.0)	6
5	5(3.4)	4
6	3(2.0)	3
7	8(5.4)	8
8	5(3.4)	5
9	2(1.3)	2
10	7(4.7)	8
11	7(4.7)	7
12	12(8.1)	10
13	20(13.4)	18
14	15(10.1)	12
15	51(34.2)	14
16	2(1.3)	1
Total	1.49	104

Discussion and Recommendations

The purpose of this study was to evaluate the impact of a hospital-based helicopter service on the outcome of major blunt trauma patients transported from the accident scene to a Level I trauma center. The predicted and actual mortality rates of the helicopter service and ground EMS systems were compared to determine if there was a significant reduction in the patients transported by helicopter.

This study failed to find any significant differences in the predicted and actual mortality of patients transported by helicopter (see Table 5). This contrasts with other studies of blunt trauma patients in which the helicopter may have had a favorable impact in reducing predicted mortality (Baxt & Moody, 1983; Baxt, Moody, & Cleveland et al., 1985). There are several possible reasons for this. It has been found in several studies that the use of a helicopter has no significant impact in urban areas where a highly organized EMS system exists, paramedics can performed Advanced Life Support (ALS), and rapid movement of the patient to a trauma center is possible (Fischer et al., 1984; Jacobs, Sinclair, Beiser, & D'Agostino, 1984; Schiller & Knox, 1988). In this study, the majority of patients transported by helicopter came from an urban area with a highly organized EMS system and where paramedics can perform

ALS interventions, including intubation. In addition, ambulances within the urban area can transport patients to a trauma center within 15 minutes of leaving the accident scene. These factors may explain the similarity in outcomes between the two transport systems.

Helicopter transport has been shown to be most beneficial in transporting patients from rural areas. In this study, only one-third of the patients transported by helicopter came from rural areas and there was no statistically significant reduction in mortality for these patients (see Table 3). In contrast, Baxt and Moody (1983) demonstrated a 52% reduction in predicted mortality when transporting patients primarily from rural areas.

This lack of reduction in predicted mortality may be due to the fact only 53 patients were transported by helicopter from rural areas and the number transported may be too small to indicate any significant impact. Helicopter services provide a more rapid response and decreases the time to definitive care at a trauma center. When time for assessment and any interventions made by the physician/critical care nurse are considered, the transport time in this study was short. Burney and

Fischer (1986) recommended helicopters be used when it would reduce the time between the accident and arrival at an appropriate hospital.

The scene time and transport time from the scene was not available fo- the ambulance or helicopter patients and may be a limitation of the study. Inclusion of these times would assist in determining distance traveled by both services and allow for an evaluation of whether more interventions were required for some of the patients. The availability of this information could also be used in determining whether the helicopter was requested when the patients may have benefited from rapid transport by the ambulance. A patient's condition may have worsened while waiting for the helicopter to arrive.

The mean Ps of patients who survived and died (see Table 6) was similar to those found in other studies (Baxt & Moody, 1983; Baxt, Moody, Cleveland et al., 1985). The mean Ps of the nonsurvivors was higher than those found in their studies but the mean Ps of the survivors was similar. The difference in mean Ps of the nonsurvivors may be due to the large number of patients transported from Jeffco, an urban area, whereas the patients transported in the Baxt and Moody study were primarily from rural areas with more severe injuries.

Several studies (Baxt & Moody, 1987a; Baxt & Moody, 1987c) have demonstrated that patients with a GCS $\leq$ 8 have significantly higher mortality rates. Of the 33 patients who were transported by helicopter with a GCS $\leq$ 8, 15 did die (see Table 9). There were two unexpected survivors with a GCS $\leq$ 8 (see Table 7). This suggests that helicopter transport was beneficial to these two patients. However, there were seven unexpected deaths. The data supports Baxt and Moody's (1987c) study suggesting TRISS methodology doesn't accurately reflect low GCS scores and thus results in higher Ps scores.

Development of a less subjective triage system for use in the study area would be helpful in determining whether a helicopter is needed to transport patients to a trauma center. Studies by Champion et al. (1988) and Jacobs et al. (1984) found improved patient outcomes when patients with TS of 4-12 are transported to a trauma center. Other studies have demonstrated improved outcomes for patients with a TS of 4-12 transported by helicopter (Moylan, 1988; Moylan et al., 1988). Currently, the helicopter is dispatched when requested by paramedics/EMTs or nonprofessionals such as law enforcement officers.

The field personnel utilize the mechanism of injury, an associated death of the driver or passenger, and their judgement of the severity of the injury as the basis for their requests. No formal triage tool is place in this region for triage of the trauma patient. This may account for the large number of patients transported by helicopter from Jeffco. The use of the TS as a basis for requesting a helicopter could result in better utilization of the helicopter service. Approximately 39 (26%) of the patients in this study would have met the criteria for transport using the TS as the prehospital triage tool in determining whether a helicopter should be requested. This would indicate that 74% of all helicopter flights are being used for patients who would benefit as well if transported by ambulance. Although these findings should be used with caution, the results suggest that a better system is needed in the prehospital setting to determine if a helicopter is required. Appropriate criteria for use of helicopter services have been recommended (Burney & Fischer, 1986; Fischer et al., 1984; Moylan, 1988). Findings of this study supports their criteria.

Several limitations were identified. The exclusion of patients who required CPR during transport or in the Trauma Room at the Level I trauma center resulted in selection bias. Including these patients would have reflected possible improvements in outcomes by the transport service, allowing for an evaluation of the interventions made and future studies should include these patients. A lack of randomization is also a limitation identified.

Another limitation is the method by which the TS is calculated on patients transported by ambulance. By having it calculated upon arrival to the trauma center by the physician, the interventions by the paramedic cannot be assessed and may result in a higher TS than was present at the accident scene.

Suggestions for future study include performing a prospective replication of this study and including travel time from the accident scene and scene time. Inclusion of these factors could assist in evaluating whether interventions were required and whether requesting a helicopter reduced transport time fore the patient to a trauma center.

Another suggestion for future study is implementation and evaluation of a triage protocol system for use by paramedics/EMTs in a particular area. This study could analyze the appropriate utilization of the helicopter in the area before and after the intervention was made. If successful, the protocol could be utilized throughout the region.

A study evaluating the patients transported only from rural areas is suggested to determine if these patients demonstrated a reduction in predicted mortality in this region. This would allow a comparison with other studies which have demonstrated a benefit to this patient population when transported by helicopter.

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