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The efficacy of advanced life support versus basic life support in the pre-hospital care of trauma victims

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A Thesis Submitted to the Yale University
School of Medicine in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Medicine

by
Craig Elfmon Fleishman
1989

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Finally, I would like to thank my family and friends, especially my parents, Sandy, and Peter. Their never ending support was a source of energy that helped me complete this undertaking. I know I can always count on them, and I hope they know they can always count on me.

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ABSTRACT

THE EFFICACY OF ADVANCED LIFE SUPPORT VERSUS BASIC LIFE SUPPORT IN THE PRE-HOSPITAL CARE OF TRAUMA VICTIMS. Craig E. Fleishman, Linda Degutis, Kathleen Shea, and Christopher C. Baker. Section of General Surgery, Department of Surgery, Yale University, School of Medicine, New Haven, CT.

We studied pre-hospital and in-hospital data of 185 trauma victims admitted to Yale-New Haven Hospital from June through December, 1986. We attempted to determine if Advanced Life Support (ALS) procedures (artificial airway, Military Anti-shock Trousers (MAST), IV placement) decreased morbidity and mortality of trauma over Basic Life Support alone.

Thirty-nine (21.1%) of the patients received BLS care while 146 (78.9%) received ALS care with IV placement being the most common (126 patients, 68%). Mean total pre-hospital time did not differ between the BLS group [26.3 minutes(S.E.±1.7)] and the ALS group [28.1 minutes (S.E.±1.4)].

The ALS patients were more severely injured than the BLS patients. The mean on-scene trauma score (TS) for ALS patients was 12.6 (S.E.±0.4). The mean on-scene TS for BLS patients was 14.7 (S.E.±0.6). Thirty-four (18%) of the patients died. Of these 34, 17 died at the scene of the incident or in the emergency department. There was no

significant difference in mortality between the BLS group (4/39, 10%) and the ALS group (30/146, 21%, p>0.1). Through use of the TRISS methodology, we showed that the BLS group did not have significantly more deaths than would have been expected (3.27 deaths, p>0.1). The ALS group did have significantly more deaths than expected (21.6 deaths, p<0.001).

Use of multiple regression showed that the MAST was the only pre-hospital procedure that was associated with improvement in the TS during transport. Placement of a pre-hospital IV was associated with a decreased total length of stay.

We concluded that although the use of ALS procedures did not increase on-scene time, we could show no significant improvement in mortality or morbidity associated with the use of ALS procedures except for an association between placement of an IV and a decreased total length of stay.

INTRODUCTION

Trauma-The Scope

As public health measures and medical advances such as antibiotics have led to a lengthening of the human life span, injuries are now the leading cause of death for the first four decades of life (from 1-43). In 1985, there were 45,600 deaths due to motor vehicles and 33,000 deaths due to firearms (6, 57). Of all causes of death, unintentional injuries have caused the most years of potential life lost per year: 2,371,024 (31). In comparison, the years of potential life lost to heart disease per year has been estimated to be 1,534,607. This has occurred although the mortality rate due to unintentional injuries, 39.7/100,000, is much less than the mortality rate due to heart disease 318.7/100,000.

These figures show that those affected by trauma are the young, productive people of our society. Fife showed that the 14- to 34-year old age cohort has the highest rate of major injury. Correspondingly, they have had the highest rate of injury from motor vehicle accidents and assaults (32).

With the loss of this productive segment of the population, the cost to society has been large. Baker estimated the total annual cost to society, both direct (hospitalization and rehabilitation) and indirect (loss of

earnings and productivity) at $75-100 billion. This amount is in excess of the costs associated with any disease process (6, 9).

Trauma has been noted as a problem since earliest recorded history, but other diseases have had higher death rates until recently. In 1910, tuberculosis and GI disorders were among the major causes of death. The death rates from these two sub-groups had dropped 99% by 1980. Over the same period, the death rate due to injuries remained relatively stable leading to an increase in the percentage of deaths due to injury (9).

Although injuries are the leading cause of death for the young, the highest injury death rates are found in the elderly population-300/100,000 for those 85 and older (9). This compares to a peak injury death rate of 100/100,000 for those between 15 and 24 years of age. Those with lower incomes also have high injury rates (9). For people with an annual income of less than $3,000, the death rate due to injuries is 71/100,000. For those with an annual income of greater than $6,000, the injury death rate is put at 34/100,000.

There have been reductions in the mortality from trauma. These reductions have come about through advances in prevention such as: household fuses, energy absorbing steering columns, and mandatory seat belt laws. Advances have also been made in the way injured people receive

medical care through the development of trauma systems. This study examines the effectiveness of the pre-hospital components of these trauma systems.

REVIEW OF RELEVANT LITERATURE

I. Origins of Trauma Systems

The National Research Council showed in 1966 that improvement was needed in the care of critically injured trauma victims (1). Eiseman pointed out in 1967 that an injured American soldier in Vietnam had a better chance for fast, definitive, surgical care by a board certified specialist than if that same person was injured in a motor vehicle crash in the Continental United States (29). Indeed, the progression of wars has shown steady improvement in survival from injury. In World War I, the mortality rate was 18%. In World War II the rate dropped to 4.7%. The Korean and Vietnam conflicts saw further mortality rate reductions to 2.5% and 1.8% respectively (29, 70). The decrease in mortality corresponded to reduction in the time from injury to delivery of definitive care. Evacuation times dropped from 18 hours in World War I to one to two hours in the Vietnam conflict (70).

In the civilian world of the mid- to late-1960′s, Pantridge and Geddes in Belfast showed their favorable experience with a mobile coronary care unit in the care of victims of myocardial infarction. This led to the development of the paramedic trained in airway control, intravenous (IV) line placement, and management of cardiac

REVIEW OF RELEVANT LITERATURE

I. [illegible]

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In the [illegible] Participants [illegible] experience [illegible] victims of myocardial [illegible] development of the [illegible] intravenous (IV) line placement and [illegible] arrhythmias (60). The combination of these trained medical personnel in the field and the knowledge of the improvements needed in the pre-hospital care of trauma victims led to the utilization of these paramedics in the care of the injured. But these early paramedics did not have specific training in trauma care.

What became apparent was that time was a key element in the care of the injured. Brill, et al., showed that survival was inversely related to length of time to definitive care (17). These observations confirmed in the civilian arena what had already been known from military conflicts.

Throughout the 1970´s and ´80´s, this country has seen the development of regional trauma systems to care for injured patients. These systems center around regional trauma centers which have the following resources: fully staffed emergency rooms with personnel trained in the care of trauma victims; 24-hour in-house availability of general surgeons and the sub-specialties; 24-hour availability of operating theaters and anesthesiologists; 24-hour availability of needed radiological services and radiologists; 24-hour availability of all necessary ancillary services (27). The trauma center also provides medical control over Emergency Medical Technicians (EMT) and paramedics in the field. This medical control involves:

training; formulation of policies, procedures and protocols; communication with personnel in the field; and evaluation of the pre-hospital care given.

Pre-hospital care, then, is an integral part of a trauma system. While there is much controversy over what procedures are appropriate in the pre-hospital care of the injured, there is a general consensus that a primary goal is to expedite transport to a definitive care location, such as a trauma center, while preventing as much as possible the deterioration of the patient (15). Medical control has become crucial in defining what is appropriate to prevent deterioration and in determining what should be the priorities of treatment.

Medical control is especially important when there may be a conflict between rapid transport of the patient and resuscitation of the patient. Any resuscitative procedure performed in the field takes a finite amount of time. When evaluating the effectiveness of a given procedure, one must take into account the time it takes for that procedure to be performed and determine if the benefits of the procedure outweigh the delay in transport to definitive care. If after analysis, a given procedure does not add to pre-hospital time (e.g., a procedure is performed at the same time another procedure is performed) (44), it is still important to examine the efficacy of the procedure to

determine that it is beneficial to the patient, and more importantly, does not harm the patient.

Of particular interest in the pre-hospital care of trauma victims are what are known as the Advanced Life Support Procedures. These procedures are: use of endotracheal intubation or of an Esophageal Obturator Airway (EOA) to provide an airway; application of the Military Anti-Shock Trousers (MAST) to provide external counterpressure to compensate for hypovolemia; and placement of an intravenous catheter to provide access for fluid resuscitation therapy. These procedures are provided by paramedics or advanced level EMT´s (68).

In contrast to the advanced procedures noted above, the beneficial effects of which are controversial, are the Basic Life Support Procedures which can be administered by paramedics or EMT´s of all levels. These procedures include: extrication of the patient; maintenance of an airway by positioning the patient and/or use of an oral or nasal airway; ventilation with a bag and mask and supplemental oxygen; control of the cervical spine with manual traction, cervical collar, sandbags, and a backboard; control of hemorrhage by direct pressure, pressure points, and or tourniquets; assisted circulation with CPR; treatment of shock with position of the patient (Trendelenburg), supplemental oxygen, blankets; splinting of fractures; and psychological support (73).

II. Development of Injury Indices

Given the controversy surrounding some of the pre-hospital procedures mentioned, methods of studying their effectiveness have been developed. Various instruments have been developed to qualify and quantify the injuries people sustain. These instruments allow the degree of injury to be controlled when evaluating the efficacy of a procedure. Theses instruments also provide a way to compare data from different regions of the country. One of the earliest of these measures was Baker′s Injury Severity Score (ISS) (7, 8). The ISS is determined by first rating the severity of each injury from one to five with the Abbreviated Injury Scale (AIS). Then, the squares of the highest AIS score for each of the three most severely injured body areas are added together. The ISS can range from 0-75 and is inversely related to survival.

The ISS uses anatomic criteria and cannot be scored until the patient has been evaluated completely. Other indices use physiologic criteria. One such index is the Trauma Score (TS) (Table 1) developed by Champion, et al., which utilizes the Glasgow Coma Scale, systolic blood pressure, respiratory rate, respiratory effort and capillary refill. The weights for each of these variables were selected by consensus and the range of the scale is from one (worst prognosis) to sixteen (best prognosis) (22).

TABLE I

TRAUMA SCORE DETERMINATION

Measure	Value	Trauma Score Number
Glasgow Coma Scale	14-15	5
	11-13	4
	8-10	3
	5-7	2
	3-4	1
Respiratory Rate	10-24/min	4
	25-35/min	3
	36/min or greater	2
	1-9/min	1
Respiratory Expansion	Normal	1
	Retractive/None	0
Systolic Blood Pressure	90 mmHg or greater	4
	70-89 mmHg	3
	50-69 mmHg	2
	0-49 mmHg	1
	No Pulse	0
Capillary Refill	Normal	2
	Delayed	1
	None	0
Total Trauma Score		1-16

Ref-Champion, H.R., Sacco, W.J., Carnazzo A.J., et al.: Trauma Score. Crit Care Med, 9:672-676, 1981.

Both the ISS and TS have been widely applied and validated since their introductions. Other instruments have also been developed such as the CRAMS (circulation, respiration, abdomen, motor, speech) Scale (40). This scale utilizes a simplified TS and then adds an assessment of thoracic and abdominal wall tenderness as a measure of anatomic injury. Newer instruments have also been introduced, but they require further validation. (43, 48).

Anatomic scales cannot be used in the pre-hospital setting because they cannot be calculated until the patient has been completely evaluated. The physiologic scales can be used as triage instruments in the pre-hospital phase (25). As a triage instrument, they can help identify those patients who might benefit most from a given pre-hospital procedure and can also help identify those patients who could benefit from the care a trauma center could provide. By identifying those patients most at risk from their injuries, more appropriate care can be provided.

To be of the most benefit, an injury index: should be predictive of outcome of the patient (e.g. survival, length of stay); should have components of the score that are considered credible by clinicians; should have mathematical consistency (e.g., patients with the same scores have the same probability of having the same outcome); should be practical, that is, it should be easily applied in the field; and should have good interrater and intrarater reliability (25, 18).

The Trauma Score has been evaluated as meeting these criteria (22, 25). It can be applied quickly in the field, essentially from evaluating a patient´s vital signs. The degree of injury that it indicates can be used in making decisions on what procedures should be performed by pre-hospital personnel and on where a patient should be transported.

In the ideal Trauma System, those patients with the most severe injuries should be transported to the Trauma Center. Those with less severe injuries may need to be transported to another facility in order to make the best use of the resources of the Trauma Center. Like any index though, the Trauma Score is not 100% accurate at indicating those who should go to a Trauma Center (sensitivity) and those who do not need the services of a Trauma Center (specificity). Estimates show that the Trauma Score may have a sensitivity of 60 to 90% in identifying those patients with moderate to severe injuries (25, 40) and have a specificity of 75 to 99% (16, 25, 48). Neither the TS or ISS takes into account mechanism of injury. Such an assessment could provide useful information to clinicians and researchers on the amount of energy transferred to the patient from the injury (25).

As a tool for evaluating the effectiveness of care, the Trauma Score has been combined with the Injury Severity Score and the age of the patient in the development of the

TRISS Methodology (24). With this methodology, a patient´s physiologic and anatomic information are combined with the patient´s age to predict the probability of patient survival. Data from the Major Trauma Outcome Study has been used in conjunction with the TRISS Methodology to provide a yardstick against which the actual survival of a given set of trauma patients can be compared (20). If the set´s patient survival rate was worse than would have been expected, then reevaluation of the Trauma System may be indicated.

III. Efficacy of Advanced Life Support to Date

With the development of injury indices, more accurate studies have been conducted to look at the effectiveness of pre-hospital care of trauma victims. Some of these studies have looked at all trauma victims while others have concentrated on various sub-groups classified by mechanism of injury. It should be pointed out that given the nature of Emergency Medical Services (EMS) training and the controls over then (medical, governmental, and political), it is very difficult to conduct randomized, prospective studies to investigate various modalities of care.

Jacobs, et al., looked at the Boston EMS system, specifically looking for any benefits Advanced Life Support (ALS) procedures (endotracheal intubation, IV line placement, and/or application of the MAST) had over Basic Life Support (BLS) procedures (e.g., control of the cervical

spine, immobilization/splinting of fractures, control of hemorrhage) alone (44). Their study looked at 178 patients, 45% of whom received pre-hospital ALS care, 55% of whom received BLS care only. In those patients who received ALS care, Jacobs, et al., found a significantly greater improvement in the Trauma Score from that at the scene to that on-arrival at the hospital than in those patients treated with BLS procedures only. They also concluded that ALS care had the most influence on those patients with middle level trauma scores (TS=4-13). Their study, however, did not address the efficacy of individual ALS procedures; rather, all of the patients who received any single procedure or combination of procedures were grouped together in their analysis. The study showed that in the Boston EMS system, there was not a significant difference in pre-hospital times for those who received ALS intervention and those who received BLS intervention. The authors noted an average of 31 minutes of pre-hospital time per patient and concluded that paramedics were able to perform ALS procedures at the same time BLS procedures were being performed. The authors failed to note how much time was spent at the scene on average and how much time was spent in the actual transport of the patient which makes it difficult to analyze these differences.

But Jacobs was not the first to advocate pre-hospital intervention in the care of trauma patients. Frey, et al.,

in their study of 150 motor vehicle fatalities from 1962-1967, suggested that deaths due to motor vehicle crashes could be prevented if there was appropriate pre-hospital care such as endotracheal intubation, IV fluid therapy, and aspiration of tension of pneumothorax (35). West and Trunkey suggested, in their study of two trauma systems, that the pre-hospital ALS care received by 20% of the surviving patients in San Francisco in their study might have contributed to their lower potentially preventable death rate over those victims in Orange County, CA where 12% received ALS care (75).

In a different setting, Gervin and Fischer looked at the data of 23 victims of penetrating wounds to the heart (37). These injuries occurred from 1979 to 1987 in Tuscon, Arizona. Thirteen of the 23 were considered potentially salvageable and were further analyzed. Of those 13 who had in-field times of less than nine minutes, six (67%) survived. Not one of the seven with an in-field time of greater than 25 minutes survived. Paramedics performed extensive in-field procedures on all those patients who spent greater than 25 minutes in the field. Of the six survivors, though, three received endotracheal intubation and IV placement during transport. The benefits of rapid transport ("scoop and run") that were put forth in their study should therefore be weighed against the fact that ALS care was provided, albeit not at the scene. Although the

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study had a small number of patients, the data suggest that ALS care for critical trauma patients should be provided <u>during transport</u> rather than <u>at the scene</u> whenever possible.

Deichert, et al., also looked at penetrating heart wounds (70). Their study of 16 patients took place in Fresno, California. The median in-field time for the patients in this study was 33 minutes. Nine (56%) of their patients received ALS care consisting of the MAST and/or IV placement. No endotracheal intubation was performed. All of them survived, suggesting that, unlike Gervin's series, the pre-hospital time taken to give ALS care did not contribute to mortality.

More recently, Ivatury, et al. (42), reported on 100 victims of penetrating thoracic injuries who underwent Emergency Room thoracotomy in New York. Fifty-one of those patients received ALS care in the field with a mean on-scene time of 5.5 minutes. Their survival was 1/51. This was a lower survival rate than in the group of 49 who were transported without ALS care. In that group survival was 9/49. The difference between the two groups was not significant at the p=0.05 level. They reported that the mean on-scene time for the non-ALS group was three minutes, but this was based on data from only 15 of the 49 patients. The other 34 patients in that group were transported by police car or private vehicle. No data were presented on study had a small [illegible]

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police car or private vehicle. No data were presented on whether the survivors in the non-ALS group were transported by ambulance or by private vehicle.

Pons, et al. (62), concluded from their study of 203 patients with penetrating wounds of the thorax or abdomen that the provision of ALS care can be of benefit. In the presentation of the salvage rates of the patients in their study, however, they failed to differentiate those who received ALS procedures and those who did not.

Aprahamian looked at the data gathered from 1970-1981 on 112 patients in the Milwaukee area suffering from major intra-abdominal vascular trauma (3). His study looked at victims before and after the institution of a paramedic system. Of those 21 patients who received BLS care and who had in-field systolic blood pressures of less than 60mm Hg, three (14.3%) survived. Those 22 who received ALS care and who had in-field systolic blood pressures of less than 60mm Hg had a 50% survival rate (11/22). The ALS patients did have longer in-field times, but one cannot necessarily say that the ALS care improved the survival rate because it is difficult to factor out other aspects in the development of a trauma system (e.g. better in-hospital care) that might have also contributed to survival. Fortner, et al. (34), also failed to take into account advances made in in-hospital care when they concluded from their study of 180 bridge jumpers over a 49 year period that the use of ALS contributed to increased survival.

Hedges and Sacco noted in their study of 36 blunt trauma victims that average paramedic on-scene time was 24.9±11.1 min (41). They noted that only one patient had a decrease in trauma score of more than one from that taken at the scene to that scored on hospital arrival. Thirty had the same trauma score or differed by not more than one in either direction. Five had an increase in their TS by more than one. The authors showed no data to compare ALS care to BLS care as a means of control. When looking at the ISS of these patients, there was a significant difference between the expected mortality (as predicted by the ISS) which was 3.77 of the 36 patients, and the actual mortality which was one of the 36. Although the TS expected mortality of 1.86 of the 36 was not significantly greater than observed, greater numbers in their study might have shown a more significant difference.

Attempts have been made to identify sub-groups of trauma victims for whom ALS care would be more appropriate than for other sub-groups. Baker, et al. (5), presented data that showed that the majority of early non-neurologic trauma deaths resulted from respiratory compromise or hemorrhage. These are the two problems that ALS procedures are designed to treat.

Baxt and Moody (11) compared mortality of 545 trauma victims with and without severe head injuries. They showed a significantly higher mortality rate among those major

blunt trauma patients with severe head injury (32/104, 30.8%) than for those without severe brain injury (4/44, 0.9%), after controlling for degree of injury. They were unable to draw any conclusions about the appropriate pre-hospital care for these patients; rather, they postulated that those with severe brain injury sustained irreversible fatal injuries that would not have responded to any treatment. In an earlier study in 1987 (12), Baxt and Moody showed a significantly lower mortality rate for 128 severely brain injured patients treated by an advanced care rotorcraft aeromedical emergency service than those treated by a land advanced life support system (31% vs. 40%). No comparison was made with those treated by Basic Life Support.

As discussion of the efficacy of ALS care of trauma victims has continued, attention has been paid to the individual ALS procedures in an attempt to determine when and where each procedure might best be used.

IV. Review of Advanced Life Support Procedures

A. Airway Control

Of the ALS procedures now performed, the one that seems to be the most favored by clinicians has been endotracheal intubation (15, 44, 70, 71). Intubation requires a high degree of training for the paramedics and the necessity of maintaining proficiency in technique. To place an ET tube, the intubator must first visualize a patient's vocal cords

using a blade and a laryngoscope to raise the epiglottis, and then place the tube just past the vocal cords. Some have raised the question of whether intubation may result in manipulation of the cervical spine with untoward results (70). No data have been shown to substantiate this concern.

The major ALS alternative to endotracheal intubation has been the Esophageal Obturator Airway (EOA) which is a 34cm long tube with a distal balloon. The EOA is inserted blindly into the esophagus where the balloon is inflated to obstruct the esophagus. A face mask and ventilator bag attached to the proximal end of the tube allows air to be forced down the tube, out of holes in the tube positioned above the trachea, and into the lungs. Theoretically, obstruction of the esophagus should prevent aspiration of gastric contents and should allow the ventilation provided by the bag and mask to go exclusively to the lungs instead of the stomach and lungs (66, 67).

Although a higher level of training is necessary to place an endotracheal (ET) tube than an EOA, many now feel that it is worth the extra training (36, 66, 67). Initially, the EOA was thought to give nearly as good a control of the airway as an ET tube. Studies have shown that this probably is not the case (4, 57, 64, 65, 66, 67). In addition, there have been complications related to use of the EOA including: esophageal aspiration, rupture, and laceration; unrecognized tracheal intubation; gastric

rupture; and tracheal occlusion (36). When control of the airway is desired, most agree that health care personnel should perform endotracheal intubation. If that is not possible, then an oral airway should be used with ventilation being provided by a bag and mask device.

B. Medical Anti-Shock Trousers

Medical (or military or pneumatic) Anti-Shock Trousers (MAST) have been advocated for use in the pre-hospital setting in the management of post-traumatic hypotension (54, 62). The device works by applying pressure to the lower extremities and abdomen of the patient. Initially, this was thought to provide the patient with an "autotransfusion" of up to 1000cc from the patient´s lower body to the patient´s upper body and brain. Subsequent studies have tended to discredit this theory of autotransfusion (14). Instead, its therapeutic effects on blood pressure are thought to derive from its ability to tamponade the bleeding and to increase peripheral vascular resistance. While the MAST is easy to apply and inflate in the field, there has been a concern as to its efficacy.

Mackersie, et al., reported retrospectively on 226 patients in the San Francisco area (52). They showed that although the use of the MAST did not increase on-scene time, its use was not associated with any significant improvement in blood pressure, trauma score, or survival.

Bickell, et al., reported on a series of trauma patients with hypotension who were randomly assigned to either a MAST group or control group (13). The MAST group had the MAST device applied in the field and inflated. Both groups were similar in terms of demographics, initial blood pressure, initial TS, amount of IV crystalloid infused, and in-field times. They showed no significant difference between the two groups in their presenting ER TS´s. The key question, however, is: is the trauma score a sensitive enough instrument to detect any improvement the MAST might have provided or should outcome be the end-point? Bickell, et al., did not report on whether there was any difference in outcome between the two groups.

A follow-up study done by Mattox, et al. (55), looked at 352 patients with pre-hospital systolic blood pressures of less than 90mm Hg who were randomized into two groups: 1) those who received the MAST and 2) those who did not receive the MAST. They concluded that for those patients who suffered from penetrating trauma and who had pre-hospital times of 30 minutes or less, use of the MAST did not lead to improvement in survival, decreased length of stay or decreased hospital costs. They also reported on problems associated with use of the MAST such as: difficulty in performing abdominal, rectal, and pelvic examinations; difficulty in performing cutdowns in the groin; and difficulty in evaluating complex groin wounds. Three cases

of lower extremity compartment syndrome were also encountered.

A later study by Mattox in 1988 (56) has expanded the randomization to 900 patients. Analysis of patient data has continued to show no advantage in survival, length of stay, or costs from use of the MAST.

One of the issues brought up by Mattox´s studies, the incidence of lower extremity compartment syndrome, was also addressed in a study of 12 normotensive subjects in Denmark by Christensen. His study showed that external counter-pressures of 30mm Hg decreased transcutaneous oxygen tension to zero mm Hg. Without the external counter-pressure, transcutaneous oxygen tension was measured at 70.6mm Hg. A decrease in oxygen tension was correlated to a decrease in capillary blood flow. Low pressures of the MAST, therefore, could stop microcirculation in the lower extremities and result in tissue anoxia, bringing the risk of precipitating compartment syndrome.

In a different study involving normotensive men, Pricolo, et al., compared the physiologic effects of the MAST with the effects produced by patient position, specifically, Trendelenburg (63). They showed that with the MAST, there was a significant elevation of central venous pressure (CVP) and mean arterial pressure (MAP), but no increase in cardiac index. With Trendelenburg, they showed no elevation in CVP or MAP, but did show an increase in

cardiac index. They concluded that the increase in cardiac output from Trendelenburg may be more beneficial than the increase in MAP that was produced by the MAST. They did not give data to show that hypotensive patients would respond the same way as normotensive subjects.

C. Intravenous Line Placement

Probably the most controversial of the ALS procedures performed in the field by paramedics has been the placement of intravenous (IV) lines for fluid replacement. Many believe that conditions in the field make it very difficult to adequately replace fluid deficits, especially if the patient is continuing to lose volume secondary to trauma (15, 71).

Can a paramedic replace intravascular volume fast enough to compensate for the blood being lost by a patient who is losing volume rapidly (greater than 150cc/min)? Dula, et al., studied obtainable flow rates through IV infusion with a 14-gauge cannula (28). The highest gravity assisted rate obtainable was 125cc/min. Since only about one-third of the crystalloid volume will remain in the intravascular space (42cc/min), a patient who is bleeding enough to risk hypovolemic shock will not be able to maintain intravascular volume with crystalloid infusion.

Lewis used computer modeling to investigate the benefits of pre-hospital IV therapy (50). He ran the model using various combinations of bleeding rates, IV infusion

rates, and pre-hospital care times. His results suggested that pre-hospital IV therapy would be of benefit only when the following combination of conditions occurred: 1) the bleeding rate was initially 25-100 ml/min; 2) the pre-hospital time exceeded 30 minutes; and 3) the IV infusion rate was equal to the bleeding rate.

With conditions other than these, Lewis concluded that the bleeding either: 1) was not severe enough to require pre-hospital IV infusion or 2) was too fast for the amount infused to compensate for the additional time required to start the IV. Lewis used the estimate that it took approximately 10 minutes to start an IV in the field. One would assume that if personnel in an EMS system could start an IV more rapidly, or if the IV could be started while other procedures were being performed, Lewis´s model would have to be adjusted. Another factor to take into account is that many advanced level technicians now place IV´s during prolonged extrication or during transport (rather than at the scene) in which case the placement of the IV should not add to the total time from injury to arrival of the patient at the hospital.

McSwain, et al., showed that on-scene time was 12 min greater in cardiac arrest patients when paramedics attempted to place an IV line (53). If the extra time was due to the IV line attempt, then in the case of a patient with severe hemorrhage, those 12 min might be better used in traveling

to a trauma center where the bleeding could be more definitively controlled.

Modifications of the normal gravity flow system might make IV crystalloid infusion more effective. Milliken, et al., showed that with wider-bore IV tubing and a pressure infuser, they could achieve IV flow rates approaching 600cc/min (58). One could ask if pre-hospital personnel would feel comfortable infusing at such high rates. One could also ask if the higher infusion rate would adequately compensate for the additional time needed to start the IV.

V. Areas Unexplored and Future Concerns

Many of the studies produced to date have centered around relatively large urban areas with short transport times to the hospital. The studies have tended to look at either the efficacy of ALS pre-hospital care in general, or the efficacy of one ALS procedure in particular. Studies in less populated, rural regions with longer transport times would be desirable. It would also be desirable to have more studies that provided data on all of the ALS procedures performed within a given region. The data produced would be beneficial in evaluating the efficacy of the care provided within a region.

To date, debate has remained over what is the appropriate form of pre-hospital care for trauma patients (15). Obviously each patient should have an individualized form of treatment, but a consensus has been reached that

in a severe manner [illegible]
quantitatively [illegible]

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To date, [illegible] has [illegible] questioned the [illegible] appropriate form of [illegible] to [illegible] (115). Obviously each patient should have an individualized course of treatment, but a consensus has been reached that good medical control is essential (15, 44, 51). Medical control should include periodic evaluations of the type of care given and continued research on the effectiveness of care provided.

Plans should be made for the future of trauma care as well. By 1995, Fischer has predicted that there will be a decrease in the size of the high-injury-risk age cohort (14-34 years of age) by 8.2% (33). There will also be an increase by 18.5% of those 65 years and older. Since trauma systems need a minimum number of patients to maintain proficiency, will these demographic changes have an impact on the care of trauma victims? Fischer predicted that the number of penetrating and blunt trauma victims will decrease through 1995 even though the total population of the country will increase by 21 million. He concluded that there will be a need to decrease the number of trauma centers in the country.

Ramenofsky (33) argued against decreasing the number of trauma centers pointing out there would be an increase through 1995 of what he described as the very high-risk inner city population. He stated that this population would increase by three times its current population. Adequate studies will need to be made to determine how trauma systems might need to be modified in the future.

Introduction to Study

Connecticut´s Emergency Medical Services system is divided into five regions. The South Central Region (SCC) consists of 21 towns in an area of 600 square miles with an approximate population of 600,000 people. Within the SCC region, there are six hospitals (the West Haven VA Hospital also accepts some patients from the EMS system, but it is not included as one of the six hospitals active in the region). Yale-New Haven Hospital in New Haven, Connecticut meets the American College of Surgeons criteria for a Level I Trauma Center. Each town in the region is responsible for its own provision of pre-hospital care. There is no middle level of county government management in the EMS system.

The South Central Connecticut Regional Emergency Medical Communications System (C-MED) is the link between the pre-hospital phase and the hospital phase of emergency care for the 21 towns in the region. C-MED provides either radio or telephone links between pre-hospital care personnel and hospitals. The rescue services operate under protocols developed by the Regional Medical Advisory Council but come under the medical control of the particular receiving hospital to which they are going.

The region has several types of provider services giving pre-hospital care and transport: volunteer rescue services, commercial rescue services, and fire departments. Depending on the provider service, a patient may receive

care from an EMT-A (basic EMT), an EMT-I (intermediate EMT), a paramedic, or any combination of them. Within the region, there are 914 EMT-A´s, 100 EMT-I´s, and 120 paramedics.

During the time of this study, paramedics were not evenly distributed around the region. There were also variations in the degree of training of these paramedics with some having been trained in endotracheal intubation and others awaiting training, certified to use the EOA. EMT-I´s can only use the EOA. Both EMT-I´s and paramedics can start IV´s in the field. EMT-A´s can provide BLS care only. The effect of the variations in distribution of EMT-A´s, EMT-I´s, and paramedics was that patients of equal degree of injury may have received ALS care or BLS care, providing some relatively controlled data to examine.

For this study, a patient was considered to have received ALS care if he or she had one or more of the following procedures performed: 1) placement of an EOA or endotracheal tube (ETT); 2) application and inflation of the MAST; 3) placement of an IV line. Control of bleeding, immobilization of fractures, providing oxygen, and protection of the cervical spine were considered BLS procedures.

C-MED maintains data on all aspects of pre-hospital care including location of incident, mechanism of injury, response times, on-scene times, transport times, and procedures performed. Such a centralized system provided

consistent data for this study on in-field and transport times and activities.

In this region, personnel capable of providing BLS care responded to all emergency calls. In many cases, units with ALS capability were also dispatched. Protocols were in place that rescue personnel could follow based upon patient presentation.

Routine ALS care included all BLS procedures plus: maintaining an airway (using an EOA or ETT if necessary); and the initiation of an IV line in the field except in the case of a patient suffering from multi-system trauma (68). In the case of multiple system trauma, if the estimated total pre-hospital time was less than 10 minutes, then rapid transport was recommended with inflation of the MAST if systolic BP was less than 90 mmHg, but the initiation of an IV was not required. If total pre-hospital time was estimated to be greater than 10 minutes, an IV was to be initiated en route. In the case of shock or multi-system trauma, the protocols stated it was preferable that an IV be initiated with a #14-16 gauge intracath. The IV should be titrated to maintain systolic BP>90 mmHg. Indications for use of the MAST were systolic BP<90 mmHg or cases of an unstable pelvic fracture.

Crews were also able to communicate directly with a surgical resident in the Yale-New Haven Emergency Department so that these protocols were subject to

modification depending on patient presentation.

Upon arrival to the Emergency Department, the patient was assessed and resuscitated in a fully staffed and equipped trauma room. A paramedic coordinator reviewed and evaluated all ALS transports. The Trauma Coordinator also reviewed the trauma cases and pertinent data was recorded in the Department of Surgery's Trauma Registry.

In this study, we were interested in the effectiveness of ALS care versus BLS care of trauma patients in a region such as the SCC where there are several types of provider services. Yale-New Haven Hospital receives the majority of major trauma cases in the region. We were particularly interested in seeing if there would be any differences in outcome, types and quantity of complications, lengths of stay, or changes in Trauma Score. Since paramedics were being trained in ET intubation during the time of this study, we also wanted to look at the efficacy of ETT use versus EOA use. We specifically set out to answer the following questions:

1) Does the use of ALS improve the outcome (as measured by mortality) of trauma victims?

2) Does the use of ALS lead to improvement of a patient's condition on arrival to the hospital?

3) Does the use of ALS lead to longer time spent in the pre-hospital phase?

4) Does the use of ALS lead to a shorter length of stay in the hospital or the Intensive Care Unit?

5) Does the use of ALS affect the number of complications a patient might experience?

6) Do any of the individual ALS procedures have more effect than other procedures on the above variables?

Methods

Yale-New Haven Hospital adult trauma admissions and Emergency department deaths were prospectively studied between June and December, 1986. A total of 5,302 admissions from the Emergency Department to all departments of the hospital were screened to obtain the 185 patients that were used in this study. Data was gathered from EMT and paramedic reports, emergency department notes, progress notes from the intensive care unit and the general ward, laboratory data, and radiology reports. Patients were selected for this study if they were transported by ambulance and met at least one of the following criteria: penetrating injuries, injuries to more than one body system, injury to any one body system with an AIS of three or more, falls of 10 feet or greater, systolic blood pressure of less than 90mm Hg upon arrival to the Emergency Department, or head injuries with alteration in consciousness. Patients were specifically excluded from this study if they: did not arrive by ambulance; were less than 16 year of age; or were transferred to Yale-New Haven Hospital from another institution.

Those patients entered in the study were followed during their stay by the investigator, and data on their progress was recorded. Data collected included: demographic data; mechanism of injury; in-field Glasgow Coma Scale (GCS) and Trauma Score (TS); procedures performed in

the field; GCS and TS on-arrival at the hospital; amount of time, if any, on a ventilator; radiologic studies performed during the hospital stay and results; diagnostic studies performed during the hospital stay; operative procedures performed; any complications during the hospital stay; outcome (mortality); length of stay (both total and, if any, ICU). Complications were classified by the organ system affected. If patients had any of the previously mentioned ALS procedures performed on them, they were classified into the ALS group; otherwise, they were classified into the BLS group.

The investigator reviewed records at C-MED to determine response times, on-scene times, and transport times for each patient. The patients′ records were then reviewed at a later time to look for any long-term complications related to the trauma they suffered that may have developed (e.g. a patient who suffers injury to his head, and at a later time develops neurological impairment). Each patient had a data form on which the above data was entered. Using the above data, the Injury Severity Score (ISS) was calculated for each patient using The Abbreviated Injury Scale 1985 Revision to code each injury.

The data was transferred onto an IBM PS/2 Model 60 computer using the Dbase III Plus software package. The data was analyzed using the Crunch statistical package. Chi-Square analysis and Student t-tests were used as

appropriate to determine if there were any significant differences between the ALS group and the BLS group in: on-scene times; transport times; total pre-hospital times; on-scene systolic BP, GCS, TS; on-arrival to the hospital systolic BP, GCS, TS; ISS; length of time on a ventilator; mortality; length of stay in the Intensive Care Unit (ICULOS); total length of stay (TOTLOS); and number of complications. These analyses were repeated for each group of patients that received an individual ALS procedure vs. those who did not receive that procedure. Also analyzed was the above data for those patients who received an EOA in the field vs. those who received an ETT.

Patient data was then analyzed to compare the actual number of deaths vs. the predicted number of deaths as calculated using the TRISS methodology summarized by Champion and Sacco (20, 24). The predicted number of deaths was determined using coefficients derived from data gathered in the 23,000 patient Major Trauma Outcome Study. Using the mechanism of injury, on-arrival TS (or on-scene TS if the on-arrival TS was not determined), ISS, and age of the patients in this study along with coefficients derived from regression analysis performed on data analyzed from the MTOS, the predicted probability of survival (P) for each patient in this study was determined using the following equation:

$$P=1/(1+e^{-b})$$

where $b=b_0+b_1(TS)+b_2(ISS)+b3(A)$. After P was determined, the predicted probability of death (Q) and the product P*Q was determined for each patient. The actual number of deaths (D) was then compared to the predicted number of deaths by calculating a Z statistic in the following equation:

$$Z=(D-\Sigma Q_i)/\surd(\Sigma P_i Q_i)$$

where Z has a mean value of 0 and a standard deviation of 1. If Z was negative, then the actual number of deaths was less than the predicted number of deaths. If the absolute value of Z exceeded 1.96 then it was likely that there was a significant difference ($p<0.05$) between the actual number of deaths and the predicted number of deaths.

Then, an M statistic was calculated to determine how the study group matched in terms of distribution of severity of injury compared to the MTOS group. The fraction of patients falling into each of six different P groups in this study was compared to the fraction falling into the same P groups from the MTOS study. Then s_i was the smaller of the two fractions and entered into the equation:

$$M=s_1+s_2+s_3+s_4+s_5+s_6.$$

M ranges from 0 to 1. If $M\geq0.88$, the study group was considered to match up well with the MTOS group. Z and M values were calculated for the following groups: the total study population, those that had BLS care only, those that

had ALS care, those that had an airway, those that had the MAST, and those that received an IV.

Because of the inaccuracy that can exist by simply comparing two variables without controlling for the confounding affects of other variables, stepped multiple regression analysis was performed on the data.

Regression was used to see if pre-hospital procedures and parameters [age, pre-hospital time, BP, GCS, degree of physiologic injury (as measured by the TS), degree of anatomic injury (as measured by the ISS)] had any predictive significance on: on-arrival TS, change in TS, total length of stay, length of stay in the ICU, total pre-hospital time, number of complications, and incidence of renal failure. The last, incidence of renal failure, was investigated because of the thought that prolonged time in shock (even if prolonged secondary to performing ALS procedures) may increase the incidence of renal failure as well as sepsis and, later, multiple organ failure as complications.

Results

I. General Results

A. Demographics

A total of 5,302 admissions through the Emergency Department to all departments of Yale-New Haven Hospital were examined. Of these, 185 met the criteria for this study. Table II shows demographic characteristics of those in the study. The mean age was 36.4 years (S.E.±1.3, range 16-74). There were 127 men and 58 women. A majority (140, 75.7%) of the people were white. There were 29 (15.7%) Black´s and 12 (6.5%) Hispanics.

The most common mechanism of injury (Table III) was a motor vehicle crash/motorcycle crash [81 (44.5%) were injured in MVC´s, 20 (11%) in MCC´s)]. Falls accounted for 26 (14.3%) of the injuries. Pedestrian injuries accounted for 25 (13.7%) of the injuries. In decreasing order after these were: firearm wounds (11, 6.0%), stab wounds (10, 5.5%), and other causes (9, 4.9%) (e.g. one person had a house fall on her). A total of 126 (69.2%) of the patients in this study had their injury due in some way to a motor vehicle (car, truck, motorcycle crash, or an injured pedestrian).

B. ALS Procedure Distribution

A majority of victims [146(78.9%)] received Advanced Life Support (ALS) care at the scene of the incident or

TABLE II

Demographics

Average Age (years) 36.4 (S.E.±1.3, range 16-74)

	Total (%)
Number of Patients	185 (100.0)
Males	127 (68.6)
Females	58 (31.4)
White	140 (75.7)
Black	29 (15.7)
Hispanic	12 (6.5)

Average Age (years)

Number of Patients
Males
Females

White
Black
Hispanic

TABLE III

Mechanism of Injury

	Number (%)
Motor Vehicle Crash	81 (44.5)
Fall	26 (14.3)
Struck Pedestrian	25 (13.7)
Motorcycle Crash	20 (11.0)
Gunshot Wound	11 (6.0)
Stab Wound	10 (5.5)
Assault	5 (2.8)
Other	4 (2.2)

TABLE IV

Pre-hospital Care

	Number (% overall, % ALS)
Basic Life Support	39 (21.1, N.A.)
Advanced Life Support	146 (78.9,100.0)
IV (attempts)	131 (70.8, 89.7)
MAST	60 (32.4, 42.8)
Airway	23 (12.4, 15.8)
EOA (attempts)	12 (6.5, 8.2)
ETT (attempts)	11 (5.9, 7.5)

N.A. - Not Applicable
IV - Intravenous Catheter placement
MAST - Medical Anti-shock Trousers
EOA - Esophageal Obturator Airway
ETT - Endotracheal Tube intubation

during transport to the hospital (Table IV). The most common ALS procedure used was placement of an IV line. This was attempted in 131 (89.7%) of the 146 patients who received ALS care. Only five attempts were unsuccessful. The next most frequent ALS procedure was application of the MAST. Sixty people (41.1% of ALS patients) had the MAST applied and inflated. In the area of airway control, 23 (15.7% of the ALS group) patients had either an EOA or an ETT placement attempted. Of 11 endotracheal intubations attempted, nine were successful. Of the 12 EOA placements attempted, 10 were successful. When ETT or EOA placement failed, the patient was ventilated with a bag and mask. There was no significant difference in the success rate between the ETT and the EOA.

C. Data-All Patients

For all patients (Table V), the mean on-scene systolic blood pressure (BP) was 107.5 mmHg (S.E.±3.9). Of those patients who had a measurable BP at the scene, the mean systolic BP was 120±4 mmHg. The mean on-scene Glasgow Coma Scale (GCS) score was 11.1 (S.E.±0.4). The mean on-scene Trauma Score (TS) was 13.0 (S.E.±0.4).

Overall, the average time on the scene was 16.0±0.6 minutes (range 1-51 min), while the mean transport time was 12.1±1.0 minutes (range 1-105). The mean total pre-hospital time for all patients was 27.8±1.2 minutes (range 6-126).

Upon arrival to the hospital, the mean GCS and TS

TABLE V

Injury Data - All Patients

	Value ± SE
On-scene SBP	107.5 ± 3.9
On-scene GCS	11.1 ± 0.4
On-scene TS	13.0 ± 0.4
On-scene time (min)	16.0 ± 0.6
Transport time (min	12.1 ± 1.0
Total pre-hospital time (min)	27.8 ± 1.2
On-arrival SBP	96.4 ± 3.1
On-arrival GCS	12.5 ± 0.3
On-arrival TS	13.7 ± 0.3
ISS	19.5 ± 1.3
Number of complications	0.5 ± 0.1
ICULOS	13.3 ± 1.4
TOTLOS	2.2 ± 0.4
Mortality (%)	34/185 (18%)

On-scene - measured at scene of incident
On-arrival - measured on arrival at emergency department
SBP - systolic blood pressure in mm Hg
GCS - Glasgow Coma Scale score
TS - Trauma Score
ISS - Injury Severity Score
ICULOS - Length of Stay in the Intensive Care Unit
TOTLOS - Total length of stay in the hospital

increased to 12.5±0.3 and 13.7±0.3 respectively ($p<0.01$ for each). The mean BP decreased to 96.4±3.1 mmHg ($p<0.01$). The mean Injury Severity Score (ISS) for all patients in the study was 19.5±1.3 (range 1-75).

Mortality was used as a measure of outcome. The overall mortality was 34 (18%). Seventeen of the 34 people who died had an on-scene TS of one. Only one of those patients survived past the Emergency Department (ED), and that patient died in the ICU. Seven of the 17 died from hypovolemic shock, seven from central nervous system (CNS) injuries, two from multiple trauma, and one from penetrating cardiac trauma. For those 17 fatalities with an on-scene TS>1, one died in the ED, three died in the operating room (OR), ten died in the ICU, and three died on the ward. Eight of these patients died from CNS injuries. Two died from hypovolemia, four from respiratory failure, and three from multiple organ failure.

The mean number of complications was 0.5±0.1 (range 1-4). The most common site of complication was in the pulmonary system (27 cases). Table VI shows a breakdown of complications by system. There were three cases of multiple organ failure; all of these patients died.

The mean total length of stay (TOTLOS) for all patients was 13.3±1.4 days (range 0-140). The mean length of stay in the Intensive Care Unit (ICULOS) was 2.2±0.4 days (0-50).

increased to 12 [illegible]
each). The mean of [illegible]
The mean injury severity [illegible]
study was [illegible]

Mortality [illegible]
overall mortality [illegible]
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hypovolemic [illegible]
injuries. [illegible]
penetrating [illegible]
or some [illegible]
operated [illegible]
the early [illegible]
Two died [illegible]
and three from [illegible]

The most common [illegible]
The most common site [illegible]
system (21 cases). [illegible]
complications by system. [illegible]
organ failure, all [illegible]

The mean total length [illegible]
was 13.3±11.4 days (range [illegible]
the Intensive Care Unit (ICU) was [illegible]

TABLE VI

Complications

	Number of Cases
Pulmonary	27
Fever (cause not determined)	20
Hematologic	13
Renal	10
Renal Failure	2
Wound Infection	6
GI	5
Neurologic	4
Sepsis	4
Multiple Organ Failure	3
Cardiac	2
TOTAL	94

Looking at survivors only, the mean TOTLOS was 15.1±1.5 days (range 1-140) and the mean ICULOS was 2.1±0.4 days (range 0-25). For non-survivors, the mean TOTLOS was 13.1±7.0 days (range 0-95) and the mean ICULOS was 6.7±3.7 days (range 0-50).

As would be expected, there was a significant difference in the mean ISS between survivors and non-survivors (survivor mean ISS was 14.3±0.8, non-survivor mean ISS was 42.8±4.5; $p<0.0001$). There was a also a significant difference in on-scene TS (survivor mean TS was 14.7±0.2, non-survivor mean TS was 6.2±1.1; $p<0.0001$) and on-arrival TS (survivor mean TS was 15.3±0.1, non-survivor mean TS was 6.3±1.0; $p<0.0001$) between survivors and non-survivors.

II. Advanced Life Support vs. Basic Life Support

A. Severity of Trauma

For those 39 patients who received Basic Life Support (BLS) care only, the mean on-scene systolic BP was 119.8±6.9 mmHg (range 0-180). The mean on-scene GCS and TS were 13.6±0.6 and 14.7±0.6 respectively. During transport to the hospital there was a significant drop in BP to 104±6.0 mmHg (range 0-170) ($p<0.01$). There was no significant change in the GCS or TS for BLS patients (Tables VII, VIIa, VIIb, VIIc).

For those patients who received ALS care, the mean on-scene BP was 104.5±4.5 mmHg (range 0-200). The mean on-scene GCS was 10.4±0.5 and the mean on-scene TS was

12.6±0.4. For the ALS patients, there was, as with the BLS patients, a significant drop in BP during transport with a mean emergency department BP of 94.3±3.5 mmHg (range 0-160) ($p<0.05$). Both the ALS and BLS patients had significant drops in blood pressure, but the difference in BP decrease between the two groups was not statistically significant ($p>0.05$). For ALS patients the emergency department mean GCS and TS (12.0±0.4 and 13.4±0.4 respectively) were higher than the mean on-scene scores ($p<0.05$ for each). These GCS and TS changes were not significantly greater than the score changes for the BLS patients ($p>0.05$ for each).

Looking at the presentations of the ALS patients and BLS patients, it can be seen that there was no significant difference in on-scene or in-hospital BP between the two groups. There was a significant difference in on-scene GCS and TS ($p<0.0001$ and $p<0.01$ respectively) and in-hospital GCS and TS between the two groups ($p<0.001$ and $p<0.05$ respectively). It would appear that a lower trauma score made it more likely that a person received ALS care. The Injury Severity Score was significantly higher for the ALS group (21.0±1.5 compared to 13.5±2.8 for the BLS group, $p<0.05$)(Table VII).

When controlled for degree of injury based on the on-scene TS (Table VIIa), the difference in systolic BP´s disappeared. Two groupings of TS were examined: 1) those with TS´s from 2-11; and 2) those with TS´s from 12-15.

TABLE VII

ALS vs BLS - Severity of Trauma, all patients

	BLS (mean±SE)	ALS (mean±SE)	p
On-scene SBP	119.8 ± 6.9	104.5 ± 4.5	>0.05
On-scene GCS	13.6 ± 0.6	10.4 ± 0.5	<0.0001*
On-scene TS	14.7 ± 0.6	12.6 ± 0.4	<0.01*
On-arrival SBP	104.4 ± 6.0	94.3 ± 3.5	>0.1
On-arrival GCS	14.2 ± 0.5	12.0 ± 0.4	<0.001*
On-arrival TS	15.0 ± 0.6	13.4 ± 0.4	<0.05*
ISS	13.5 ± 2.8	21.0 ± 1.5	<0.05*

TABLE VIIa

ALS vs BLS - Severity of Trauma, TS from 12 to 15

	BLS (mean±SE)	ALS (mean±SE)	p
On-scene SBP	130.7 ± 15.1	122.2 ± 7.1	>0.5
On-scene TS	14.7 ± 0.3	13.4 ± 0.3	>0.1
On-arrival SBP	106.7 ± 32.8	110.3 ± 3.9	>0.5
On-arrival TS	14.3 ± 0.3	14.0 ± 0.2	>0.1
ISS	14.3 ± 5.5	20.7 ± 2.0	>0.1

TABLE VIIb

ALS vs BLS - Average Changes, all patients

	BLS	p	ALS	p
Change in SBP	-15.4	<0.01	-10.2	<0.05*
Change in GCS	+0.6	>0.05	+1.6	<0.05*
Change in TS	+0.3	>0.1	+0.8	<0.05*

TABLE VIIc

ALS vs BLS - Average Changes, TS from 12-15

	BLS	p	ALS	p
Change in SBP	-24.0	<0.01	-11.9	<0.05*
Change in TS	+0.3	>0.1	+0.6	>0.1

Where: * indicates $p<0.05$

Those patients with a TS=1 were not subgrouped because of their 100% mortality rate and their early location of death. Those with a TS=16 were not included because of their 100% survival rate. All those with a TS from two to 11 received ALS care, so no ALS/BLS comparison was made for patients with these scores. For those with a TS from 12-15, as Table VIIa shows, the BLS group had a mean on-scene systolic BP of 130.7±15.1 vs. a mean on-scene systolic BP of 122.2±7.1 for the ALS group ($p>0.5$). On-arrival to the hospital, the mean BP for the BLS group was 106.7±32.8 vs. a mean BP for the ALS group of 110.3±3.9 ($p>0.5$).

II. B. <u>Results</u>

The outcomes of the patients did not differ significantly between the ALS group and the BLS group (Table VIII). In the BLS group, 4/39 (10%) died. In the ALS group, 30/146 (21%) died ($p>0.1$). Neither was there a significant difference in length of stay between the two groups (BLS=11.1±1.9 days, ALS=13.9±1.6 days, $p>0.1$). There was a significant difference in the length of time spent in the ICU between the two groups. For BLS patients, the mean was 0.6±0.3 days compared to 2.6±0.5 days for ALS patients ($p<0.01$). The number of complications did not differ significantly between the ALS group and the BLS group.

When controlled for TS (Table VIIIa), there was no significant difference in mortality, ICU length of stay, total length of stay, or number of complications between the

TABLE VIII

ALS vs BLS - results

	BLS (mean±SE)	ALS (mean±SE)	p
Mortality (%)	4/39 (10)	30/146 (21)	>0.1
Number of Complications	0.4 ± 0.1	0.6 ± 0.1	>0.1
ICULOS (days)	0.6 ± 0.3	2.6 ± 0.5	<0.01*
TOTLOS (days)	11.1 ± 1.9	13.9 ± 1.6	>0.1

TABLE VIIIa

ALS vs BLS - results, TS from 12-15

	BLS (mean±SE)	ALS (mean±SE)	p
Mortality (%)	2/12 (17)	6/60 (10)	>0.5
Number of Complications	0.0 ± 0.0	0.8 ± 0.2	>0.1
ICULOS (days)	0.0 ± 0.0	4.7 ± 1.3	>0.1
TOTLOS (days)	8.7 ± 4.7	15.5 ± 5.8	>0.1

two groups for those with a TS from 12-15.

Table IX shows in-field times for groupings of patients. There was no significant difference in mean on-scene time, transport time, or total pre-hospital time between the ALS and BLS groups ($p>0.1$). When broken down into individual ALS procedures, there were no significant differences in on-scene or transport times. Table XIII shows that even when multiple procedures were performed, there were still no significant differences in mean on-scene, or total pre-hospital times. In this study, therefore, pre-hospital time did not have a significant association with outcome.

II. C. Airway

As noted earlier, there were nine successful endotracheal intubations performed and ten successful EOA placements. There was not a significant difference in on-scene time between those patients who did not receive an artificial airway in the field and those who had an EOA placed (Tables X, Xa, Xb, and Xc), but there was a significant difference in on-scene time between those who did not receive an airway and those who received an ETT, with those patients requiring an ETT spending less time on-scene. For those who did not receive an airway in the pre-hospital period, the mean on-scene time was 16.6±0.7 minutes (range 0-51). The mean total pre-hospital time was 28.1±1.2 minutes (range 9-126). For those who received an EOA, the

TABLE IX

Pre-hospital times - minutes (mean±SE)

	On-scene	Transport	Total
BLS	14.9 ± 1.3	11.7 ± 1.2	26.3 ± 1.7
ALS	16.3 ± 0.7	12.2 ± 1.2	28.1 ± 1.4
EOA	13.0 ± 1.7	11.2 ± 3.0	24.2 ± 4.0
ETT	12.0 ± 1.7	14.5 ± 9.1	26.5 ± 8.7
MAST	14.5 ± 1.1	10.1 ± 1.0	24.6 ± 1.4
IV	16.6 ± 0.7	11.8 ± 0.9	28.0 ± 1.3

$p>0.1$ for differences in on-scene, transport, or total pre-hospital times between BLS group and ALS group and between BLS group and ALS subgroups.

TABLE X

Artificial Airway (mean±SE), all patients

	No-airway	Airway	p
On-scene time (min)	16.6 ± 0.7	12.3 ± 1.2	<0.01*
Total pre-hospital time (min)	28.1 ± 1.2	25.9 ± 5.2	>0.5
On-scene TS	14.2 ± 0.2	4.6 ± 1.1	<0.0001*
On-arrival TS	14.8 ± 0.2	5.0 ± 1.1	<0.0001*
ISS	16.5 ± 1.1	43.3 ± 5.9	<0.001*
Ventilator time (survivors) (days)	17.4 ± 7.7	5.3 ± 1.3	>0.1
Mortality (%)	19/166 (11)	15/19 (79)	<0.0001*
Number of complications	0.6 ± 0.1	0.3 ± 0.2	>0.1
ICULOS	2.2 ± 0.5	2.3 ± 1.0	>0.5
TOTLOS	13.8 ± 1.4	9.4 ± 4.1	>0.1

TABLE Xa

Artificial Airway (mean±SE), for TS from 2-11

	No-airway	Airway	p
On-scene time (min)	10.3 ± 1.6	13.1 ± 2.2	>0.1
Total pre-hospital time (min)	22.8 ± 3.2	35.6 ± 11.5	>0.1
On-scene TS	10.3 ± 0.6	8.7 ± 1.4	>0.1
On-arrival TS	10.6 ± 0.8	9.0 ± 1.1	>0.5
ISS	32.7 ± 5.3	33.5 ± 8.7	>0.5
Mortality (%)	3/16 (19)	6/10 (60)	>0.05
Number of complications	1.3 ± 0.4	1.0 ± 0.4	>0.1
ICULOS	5.5 ± 2.6	4.6 ± 2.1	>0.5
TOTLOS	18.6 ± 7.2	18.9 ± 11.8	>0.5

TABLE Xb

EOA and ETT (mean±SE), all patients

	EOA	p vs no airway	ETT	p vs no airway	p- EOA vs ETT
On-scene time	13.0±1.7	>0.1	12.0±1.7	<0.05	>0.5
Total pre-hospital time	24.2±4.0	>0.5	26.5±8.7	>0.5	>0.5
On-scene TS	3.6±1.5	<0.001	5.0±1.5	<0.01	>0.5
Vent time (survivors)			5.3±1.3	>0.1	
On-arrival TS	4.4±1.4	<0.001	5.0±1.5	<0.01	>0.1
ISS	44.8±8.8	<0.001	47.5±7.6	<0.001	>0.5
Number of complications	0.2±1.3	>0.05	0.4±0.3	>0.5	>0.1
Mortality (%)	9/10 (90)	<0.001	6/9 (67)	<0.01	>0.5
ICULOS	1.6±1.3	>0.05	2.6±1.4	>0.5	>0.1
TOTLOS	2.7±1.8	<0.05	14.9±9.8	>0.01	>0.1

TABLE Xc

EOA and ETT (mean±SE), for TS from 2-11

	EOA	p vs no airway	ETT	p vs no airway	p- EOA vs ETT
On-scene time	17.8±2.8	>0.1	11.2±1.9	<0.05	>0.1
Total pre-hospital time	34.0±6.4	>0.5	41.2±11.6	>0.05	>0.5
On-scene TS	8.0±2.1	>0.1	9.0±0.7	>0.5	>0.5
On-arrival TS	9.0±1.4	>0.5	9.0±0.6	>0.5	>0.5
ISS	21.0±2.8	>0.1	38.7±6.4	>0.1	>0.1
Number of complications	1.0±0.7	>0.5	1.0±0.4	>0.5	>0.5
Mortality (%)	2/3 (67)	>0.05	4/7 (57)	>0.1	>0.1
ICULOS	8.5±5.3	>0.1	4.0±1.5	>0.5	>0.1
TOTLOS	10.5±6.7	>0.1	37.2±7.3	>0.1	>0.1

mean on-scene time was 13.0±1.7 minutes (range 5-22)($p>0.1$) while the mean total pre-hospital time was 24.2±4.0 minutes (range 6-43)($p>0.5$). For those who received an endotracheal tube, the mean on-scene time was 12.0±1.7 minutes (range 5-20)($p<0.05$) while the mean total pre-hospital time was 26.5±8.7 minutes (range 9-52)($p>0.5$).

Those who had an airway placed had a higher severity of injury than those who did not receive an airway. The mean on-scene TS and ISS for the EOA patients were 3.6±1.5 (range 1-11) and 44.8±8.8 (range 10-75) respectively. The mean on-scene TS and ISS for the ET tube patients were 5.0±1.5 (range 1-11) and 47.5±7.6 range (16-75) respectively. For those who did not receive an airway, the mean on-scene TS was 14.2±0.2 (range 1-16) and the mean ISS was 16.5±1.1 (range 1-75). Both the EOA patients and ETT patients had a significantly greater ($p<0.01$) degree of injury as measured by the TS and ISS compared to those who did not receive an airway. There was not a significant difference in on-scene TS, on-arrival TS or ISS between the EOA and ETT group.

Those who had an EOA placed had a significantly higher mortality rate (9/10, 90%) than those who did not receive an airway (19/166, 11%, $p<0.001$). The same was true of those who received an ETT (6/9, 67%) vs. those who did not receive an airway ($p<0.01$). Between the EOA group and the ETT group, there was no significant difference in mortality ($p>0.5$).

The differences in mortality between those who received an artificial airway and those who did not receive an airway disappeared when the data were controlled for TS. Since all those who received an airway had a TS less than 12, the group of patients with a TS from 2-11 was examined. Those with a TS of one were not examined because it was assumed that no treatment would have influenced their outcome. In this subgroup, those who did not have an airway had a mortality rate of 3/16 (19%). Those who received an airway had a mortality rate of 6/10 (60%) ($p>0.05$). There was no significant difference because of the small numbers in each group.

Of those who received an ET tube in the field and survived, the mean time spent on a ventilator (5.3±1.3 days) was not significantly different from those who did not receive an airway in the field but later required ventilator support (17.4±7.7 days)($p>0.1$). Of the ten patients who received an EOA, the one survivor did not require ventilator support.

The number of complications did not vary significantly between the EOA group (0.2±1.3) and the non-airway group (0.6±0.1, $p>0.05$) or the ET tube group (0.4±0.3) and the non-airway group (0.6±0.1, $p>0.05$). Between the EOA and ETT groups, there was no significant difference in the number of complications ($p>0.1$). The distribution of complications was not different between the airway group and the non-

airway group. Of the 11 cases of pneumonia noted in all patients, only one case was observed in an ETT patient. Two of the eight cases of UTI occurred in the ETT group. Of the four cases of Adult Respiratory Distress Syndrome, one case occurred in a patient who received the EOA.

The mean total length of stay for the EOA group (2.7±1.8 days) was significantly shorter than the non-airway group (13.8±1.4 days, $p<0.05$), but all but one from the EOA group died. Seven of the 10 in this group died at the scene or in the Emergency Department. For the three with a TS from 2-11, the mean TOTLOS was 10.5±6.7 days for the EOA group. The mean TOTLOS for those in the non-airway group who had a TS from 2-11 was 18.6±7.2 days ($p>0.1$). The mean TOTLOS of the ETT group (14.9±9.8 days) was not significantly different from the non-airway group (13.8±1.4 days)($p>0.1$). When looking at just those patients who had a TS from 2-11, the mean TOTLOS´s between the ETT group (37.2±15.3 days) and the non-airway group (18.6±7.2 days) were not significantly different ($p>0.1$).

The mean ICULOS´s for the EOA group (1.6±1.3 days) or the ETT group (2.6±1.4 days) were not significantly different from the non-airway group (2.2±0.5 days)($p>0.1$). In the subgroup of those patients who had a TS from 2-11, the mean ICULOS´s were still not significantly different between those who received an airway and those who did not.

II. D. MAST

As mentioned in the methods section, protocols allow application of the MAST in the field when the systolic BP is less than 90 mmHg or if an unstable pelvic fracture is suspected. There was a significant difference in systolic BP at the scene (Table XI) between those who did not receive the MAST (123.5±3.8 mmHg) and those who did (75.9±6.8 mmHg, $p<0.0001$). The on-scene TS´s were also significantly lower for those who received the MAST (10.3±0.8) than for those who did not (14.3±0.3, $p<0.0001$). Use of the MAST resulted in a mean increase in BP of 0.2 mmHg between the scene and arrival to the emergency department ($p>0.1$). In comparison, the non-MAST group had a mean decrease in BP of 17.6 mmHg ($p<0.0001$). The changes in BP during transport between the MAST group and the non-MAST group were significantly different ($p<0.001$). There was also a significantly larger increase in Trauma Score during transport for the MAST group (mean increase was 1.4) compared to the 0.4 increase in the non-MAST group ($p<0.01$). These statistical differences were probably not clinically significant. The ISS´s were significantly higher in the MAST group (26.2±27) than the non-MAST group (16.2±1.4, $p<0.001$) indicating that the MAST group suffered from more severe anatomic injuries.

The differences in on-scene and on-arrival BP´s between the MAST group and the non-MAST group decreased when patients were grouped by severity of injury (Table XIa and

XIb). For those patients who had a TS from 2-11, the mean on-scene BP of the non-MAST group (110±29.4 mmHg) was not significantly different from that of the MAST group (90.2±12.1 mmHg, $p>0.1$). The mean on-arrival BP of the non-MAST group (99.3±10.3 mmHg) was not significantly different from the mean on-arrival BP of the MAST group (74.4±7.1 mmHg, $p>0.05$). The changes in BP were not significantly different between the two groups. ($p>0.1$).

For those patients who had an on-scene TS from 12-15, the mean on-scene BP of the non-MAST group was 136.9±5.5 mmHg. This was significantly different from the mean on-scene BP of the MAST group (101.3±11.2 mmHg, $p<0.05$). On arrival to the hospital, the mean BP′s of the non-MAST group (110.8±7.1 mmHg) and the MAST group (108.2±6.7 mmHg) had become not significantly different ($p>0.1$). The 26.1 mmHg decrease between the scene and arrival to the emergency department seen in the non-MAST group was significantly different from the 6.9 mmHg increase found in the MAST group ($p<0.05$).

Those patients who had the MAST applied had a shorter mean on-scene time (14.5±1.1 minutes) than the non-MAST group (16.8±0.8 minutes), but this was not a significant difference. At any rate, on-scene time was not greater in MAST patients. The mean total pre-hospital times in the MAST group (24.6±1.4 minutes) and the non-MAST group (29.4±1.7 minutes) were not significantly different. When

TABLE XI

MAST (mean±SE), for all patients

	non-MAST	MAST	p
On-scene time	16.8 ± 0.8	14.5 ± 1.1	>0.05
Total pre-hospital time	29.4 ± 1.7	24.6 ± 1.4	>0.05
On-scene SBP	123.5 ± 3.8	75.9 ± 6.8	<0.0001*
On-arrival SBP	105.9 ± 2.9	76.1 ± 6.5	<0.0001*
Change in SBP	-17.6	+0.2	<0.0001*
On-scene TS	14.3 ± 0.3	10.3 ± 0.8	<0.0001*
On-arrival TS	14.7 ± 0.3	11.7 ± 0.8	<0.0001*
Change in TS	+0.4	+1.4	<0.01*
ISS	16.2 ± 1.4	26.2 ± 2.7	<0.01*
Number of complications	0.5 ± 0.1	0.7 ± 0.1	>0.1
Mortality (%)	15/125 (12)	19/60 (32)	<0.01*
ICULOS	2.1 ± 0.5	2.4 ± 0.7	>0.5
TOTLOS	13.0 ± 1.5	13.9 ± 2.8	>0.5

TABLE XIa

MAST (mean±SE), for TS from 2-11

	non-MAST	MAST	p
On-scene time	13.4 ± 3.0	10.5 ± 1.7	>0.1
Total pre-hospital time	36.8 ± 15.4	24.0 ± 3.0	>0.1
On-scene SBP	110.0 ± 29.4	90.2 ± 12.1	>0.1
On-arrival SBP	99.3 ± 10.3	74.4 ± 7.1	>0.05
Change in SBP	-10.7	-15.8	>0.5
On-scene TS	9.8 ± 1.0	9.6 ± 0.7	>0.5
On-arrival TS	8.8 ± 0.9	11.3 ± 0.8	>0.05
Change in TS	-1.0	+1.7	>0.1
ISS	34.8 ± 8.5	31.7 ± 5.5	>0.1
Number of complications	1.2 ± 0.6	1.2 ± 0.4	>0.5
Mortality (%)	2/12 (17)	7/14 (50)	>0.1
ICULOS	8.2 ± 3.8	4.8 ± 2.1	>0.1
TOTLOS	37.7 ± 18.3	13.9 ± 4.4	>0.1

TABLE XIb

MAST (mean±SE), for TS from 12-15

	non-MAST	MAST	p
On-scene time	14.4 ± 1.9	14.2 ± 1.9	>0.5
Total pre-hospital time	25.0 ± 2.2	23.8 ± 1.6	>0.5
On-scene SBP	136.9 ± 5.5	101.3 ± 11.2	<0.05*
On-arrival SBP	110.8 ± 7.1	108.2 ± 6.7	>0.5
Change in SBP	-26.1	+6.9	<0.05*
On-scene TS	13.8 ± 0.3	13.2 ± 0.4	>0.1
On-arrival TS	14.0 ± 0.3	14.1 ± 0.2	>0.5
Change in TS	+0.2	+0.9	>0.05
ISS	18.2 ± 2.1	22.6 ± 3.8	>0.1
Number of complications	0.4 ± 0.2	1.1 ± 0.3	>0.05
Mortality (%)	5/46 (11)	3/26 (12)	>0.5
ICULOS	3.4 ± 1.2	5.5 ± 2.7	>0.1
TOTLOS	13.9 ± 2.3	25.2 ± 8.1	>0.1

controlling for TS there was still no significant difference in pre-hospital times between the non-MAST group and the MAST group.

Mortality of the MAST group was significantly higher (19/60) than the non-MAST group (15/125, p<0.01). For those who had a TS from 2-11, the mortality rate between the MAST group (7/14, 50%) and the non-MAST group (2/12) was not significant (p>0.05). This was also true for those who had a TS from 12-15 where the mortality rate for the MAST group was 3/26 (11.5%) and the mortality rate for the non-MAST group was 5/46 (10.9%, p>0.1).

Use of the MAST did not result in a significant difference in total length of stay for the survivors. The mean length of stay for the non-MAST group was 13.0±1.5 days. The mean for the MAST group was 13.9±2.8 days (p>0.1). For the low TS subgroup (TS from 2-11) the mean TOTLOS for the MAST group was 13.9±4.4 days, the mean TOTLOS for the non-MAST group was 37.7±18.3 days (p>0.1). For the high TS subgroup (TS from 12-15), the mean TOTLOS for the MAST group was 25.2±8.1 days vs. a mean TOTLOS for the non-MAST group of 13.9±2.3 days (p>0.1).

The length of stay in the ICU was not significantly different between the two groups (MAST=2.4±0.7 days, non-MAST=2.1±0.5 days; p>0.1). The low TS subgroup had a mean ICULOS of 4.8±2.1 days for the MAST group vs. 8.2±3.8 days for the non-MAST group(p>0.1). The high TS subgroup had a

mean ICULOS of 25.2±8.1 days for the MAST group vs. 13.9±2.3 days for the non-MAST group.

The mean number of complications did not differ significantly between the two groups (MAST=0.7±0.1, non-MAST=0.5±0.1; $p>0.1$). Nor did they differ significantly when TS subgroups were examined individually. Of note in the distribution of complications, of the four cases of thrombosis noted in the entire patient population of this study, three of the cases occurred in the MAST group ($p>0.1$). Of the six cases of wound infection noted overall, all six patients were in the MAST group ($p<0.05$).

II. E. IV Placement

As Table XII shows, for the patients in this study, there was no significant difference in mean on-scene BP between those who received an IV (108.1±4.2 mmHg) and those who did not (105.7±9.1 mmHg, $p>0.1$). There was also no significant difference in the physiologic response to injury as measured by the on-scene Trauma Score (no-IV=13.0±0.4, IV=13.2±0.9; $p>0.1$). Although initiation of an IV resulted in a smaller decrease in BP during transport (-10.2 mmHg) compared to the non-IV group (-10.8 mmHg), the difference was not significant. The changes in TS that occurred during transport were not significantly different (no-IV=+0.4, IV=+0.8; $p>0.05$) between the two groups. There was no significant difference in initial emergency department TS´s between the two groups (no-IV=13.8±0.4, 13.6±0.8; $p>0.5$).

The ISS´s were not significantly different between the two groups (no-IV=19.2±3.5, IV=19.6±1.4; p>0.5).

Since TS´s and ISS´s were not significantly different between the IV group and the no-IV group, it was not necessary to break the analysis down into TS subgroups in order to compare results between the two groups, but in case there were different responses to an IV between the TS subgroups, the subgroups were examined (Table XIIa). All of those patients who had an on-scene TS from 2-11, received an IV in the field, so no comparison could be made with a no-IV group. For those with an on-scene TS from 12-15, there was no significant difference in on-scene BP between the IV group (112.5±3.9 mmHg) and the no-IV group (124.7±5.7 mmHg, p>0.1). On arrival to the Emergency Department, there was still no significant difference between the IV group (109.6±2.8 mmHg) and the no-IV group (105.1±10.3 mmHg, p>0.1). As in the overall IV analysis, the IV group in this TS subgroup had a smaller decrease in BP during transport (-2.9 mmHg) than the no-IV group (-19.6 mmHg), but again the difference was not statistically significant.

Time at the scene was longer for the IV group than the no-IV group (16.6±0.7 min vs. 14.2±1.2 min), but this difference was not significant (p>0.05). Total pre-hospital times did not differ significantly either (no-IV=27.2±2.9 min, IV=28.0±1.3; p>0.5). For the subgroup of patients with a TS from 12-15, the pre-hospital times

TABLE XII

IV placement (mean±SE), for all patients

	no-IV	IV	p
On-scene time	14.2 ± 1.2	16.6 ± 0.7	>0.05
Total pre-hospital time	27.2 ± 2.9	28.0 ± 1.3	>0.5
On-scene SBP	105.7 ± 9.1	108.1 ± 4.2	>0.5
On-arrival SBP	94.9 ± 7.0	97.9 ± 3.4	>0.5
Change in SBP	-10.8	-10.2	>0.5
On-scene TS	13.2 ± 0.9	13.0 ± 0.4	>0.5
On-arrival TS	13.6 ± 0.8	13.8 ± 0.4	>0.5
Change in TS	+0.4	+0.8	>0.5
ISS	19.2 ± 3.5	19.6 ± 1.4	>0.5
Crystalloid in first 24 hours (ml´s)	3950 ± 668	5931 ± 406	<0.05*
Number of complications	0.4 ± 0.1	0.6 ± 0.1	>0.1
Mortality (%)	11/59 (19)	23/126 (18)	>0.5
ICULOS	0.8 ± 0.4	2.7 ± 0.6	<0.01*
TOTLOS	10.5 ± 1.9	14.2 ± 1.8	>0.1

TABLE XIIa

IV placement (mean±SE), for TS from 12-15

	no-IV	IV	p
On-scene time	17.8 ± 2.8	17.6 ± 1.1	>0.5
Total pre-hospital time	26.6 ± 2.9	29.9 ± 2.1	>0.1
On-scene SBP	124.7 ± 5.7	112.5 ± 3.9	>0.1
On-arrival SBP	105.1 ± 10.3	109.6 ± 2.8	>0.5
Change in SBP	-19.6	-2.9	>0.05
On-scene TS	14.1 ± 0.3	13.6 ± 0.2	>0.5
On-arrival TS	14.3 ± 0.3	14.0 ± 0.2	>0.5
Change in TS	+0.2	+0.4	>0.5
ISS	14.3 ± 5.5	20.7 ± 2.0	>0.1
Crystalloid in first 24 hours (ml´s)	3940 ± 1010	6140 ± 544	>0.1
Number of complications	0.3 ± 0.1	0.8 ± 0.2	>0.1
Mortality (%)	2/12 (20)	6/60 (10)	>0.1
ICULOS	0.6 ± 0.4	4.7 ± 1.3	>0.1
TOTLOS	8.7 ± 4.7	19.5 ± 3.8	>0.1

remained without statistical significance between the IV group and the no-IV group.

As might be expected, those patients on whom an IV was started in the field had a larger volume of crystalloid infused (5931±406.2 ml´s) in the first 24 hours than the no-IV group (3950±667.8 ml´s, $p<0.05$). For the high TS subgroup, the difference in crystalloid infusion was no longer statistically significant. The IV group received 6140±544 ml´s vs. 3940±1010 ml´s for the no-IV group ($p>0.1$).

Outcome, as measured by mortality, was not significantly different between the two groups ($p>0.5$). The mortality rate of the IV group was 23/126 (18%). The mortality rate for the no-IV group was 11/59 (19%). For the high TS subgroup, the IV group mortality was 6/60 (10%) while the no-IV group mortality was 2/12 (17%, $p>0.1$).

Although total length of stay was not significantly longer for the IV group (14.2±1.8 days) than the non-IV group (10.5±1.9 days, $p>0.1$), the length of time spent in the ICU was significantly longer for the IV group (no-IV=0.8±0.4 days, IV=2.7±0.6 days; $p<0.01$). The difference in ICULOS was not statistically significant for the high TS subgroup where those who had an IV had a mean ICULOS of 4.7±1.3 days vs. 0.6±0.4 days for those who did not have an IV.

The mean number of complications for the no-IV group was 0.4±0.1. For the IV group, the mean number of complications was 0.6±0.1. This difference was not significant. Of the six cases of wound infection, all six patients received a pre-hospital IV ($p>0.1$)(as noted above, they also had the MAST applied). Twelve of the 13 cases of fever without a cause being found occurred in those who had a pre-hospital IV ($p>0.1$). Of the 27 cases of pulmonary complications (atelectasis, pneumonia, embolus, ARDS, pneumothorax, pleural effusion), 22 (81%) occurred in patients who were in the IV group. Both patients who later suffered renal failure had an IV placed in the field. The three patients who eventually suffered multiple organ failure all received a pre-hospital IV.

II. F. Multiple Procedures

Many of the patients had more than one procedure performed in the pre-hospital setting (Table XIII). All but two patients who had a TS from 2-11 received an IV. Those two received an artificial airway. There were two patients who had a TS from 2-11 who received an airway, an IV, and the MAST. Twelve patients (all of the MAST patients in this subgroup) had a combination of MAST and an IV. Five patients had a combination of an airway and an IV. As can be seen in Table XIII, there was no significant difference in pre-hospital on-scene times, total pre-hospital times, mortality, number of complications, intensive care unit length of stay, or total length of stay.

TABLE XIII

Multiple Procedures (mean±SE), for TS from 2-11

	Airway+ MAST+IV	MAST+IV	AIRWAY+IV
On-scene time	13.2 ± 5.1	10.2 ± 1.8	15.5 ± 3.8
Total pre-hospital time	25.6 ± 6.5	23.9 ± 3.4	24.5 ± 7.0
On-scene SBP	59.5 ± 54.6	93.6 ± 13.0	105.0 ± 41.1
On-arrival SBP	51.0 ± 50.9	70.5 ± 6.3	91.5 ± 14.1
Change in SBP	-8.5	-23.1	-13.5
On-scene TS	6.5 ± 2.2	10.1 ± 0.6	9.5 ± 1.5
On-arrival TS	9.0 ± 1.9	10.7 ± 1.0	8.5 ± 1.3
Change in TS	+2.5	+0.6	-1.0
Number of complications	1.0 ± 1.0	1.4 ± 0.4	0.3 ± 0.2
Mortality (%)	2/2 (100)	5/12 (42)	2/5 (40)
ICULOS	8.0 ± 8.0	4.9 ± 2.0	3.0 ± 2.0
TOTLOS	10.0 ± 10.0	16.1 ± 4.8	27.0 ± 2.6

For those in the high TS subgroup, the only combination of procedures that was noted was that of the MAST and an IV. As in the low TS subgroup, all those who received the MAST, had a pre-hospital IV. Compared to those who had an IV only or those who had BLS care only in this subgroup (Table XIb), the MAST+IV group had no significant difference in on-scene time, total pre-hospital time, mortality, number of complications,

ICULOS, or TOTLOS.

III. TRISS Results

A. General

As described in the methods section, an analysis of mortality of different groups in this study was performed using the TRISS methodology. Z and M values were calculated for the following groups: the total study population, those who had BLS care only, those who had ALS care, those who had an airway, those who had the MAST, and those who received an IV. Table XIV shows the coefficients used in calculating the expected probability of survival for each group analyzed. Table XV and XVa shows, for each group analyzed, the fraction of each group that fell within the indicated range of probability of survival. For the entire study group, Z=3.5976 (p<0.001) and M=0.88 indicating that more patients died (34) than would have otherwise been predicted (25.5).

TABLE XIV

TRISS Coefficients

Type of trauma	b_0 (Constant)	b_1 (TS)	b_2 (ISS)	b_3 (Age)
Blunt	-1.6465	0.518	-0.074	-1.93
Penetrating	-0.8068	0.544	-0.116	-2.48

TABLE XV

Data for M and Z statistics, fraction of patients within range

Probability of Survival Range	MTOS	BLS	ALS
0.96-1.00	0.828	0.865	0.676
0.91-0.95	0.045	0.054	0.096
0.76-0.90	0.044	0.000	0.029
0.51-0.75	0.029	0.000	0.074
0.26-0.50	0.017	0.000	0.015
0.00-0.25	0.036	0.081	0.110
Z	3.60	1.06	3.84
p value for z	$<0.001^*$	>0.1	$<0.001^*$
M	0.881	0.900	0.165

Where MTOS is from Major Trauma Outcome Survey

Ref-Boyd, C.R., Tolson, M.A., Copes, W.S.: Evaluating Trauma Care: The TRISS Method. _J Trauma_, 27:370-378, 1987.

-Champion, H.R., Frey, C.F., Sacco, W.J.: Determination of national normative outcomes for trauma (abstr.). _J Trauma_, 24:651, 1984.

TABLE XVa

Data for M and Z Statistics

Range	MTOS	EOA	ETT	MAST	IV
0.96-1.00	0.828	0.100	0.000	0.542	0.810
0.91-0.95	0.045	0.000	0.000	0.119	0.066
0.76-0.90	0.044	0.000	0.000	0.017	0.025
0.51-0.75	0.029	0.200	0.333	0.085	0.041
0.26-0.50	0.017	0.000	0.000	0.034	0.008
0.00-0.25	0.036	0.700	0.667	0.203	0.050
Z		1.49	-1.22	2.33	3.17
p value for Z		>0.1	>0.1	<0.01*	<0.005*
M		0.165	0.065	0.686	0.870

Where MTOS is from Major Trauma Outcome Survey
Ref-Boyd, C.R., Tolson, M.A., Copes, W.S.: Evaluating Trauma Care: The TRISS Method. J Trauma, 27:370-378, 1987.
-Champion, H.R., Frey, C.F., Sacco, W.J.: Determination of national normative outcomes for trauma (abstr.). J Trauma, 24:651, 1984.

III. B. ALS vs. BLS

The first sub-group analyzed was the group of patients that received BLS care only. Of the 39 patients who received BLS care only, four died. The predicted number of deaths was calculated as 3.27. The Z value came to 1.06 ($p>0.1$). The M value was 0.90. There did not appear to be a significant difference in actual outcome and predicted outcome in the BLS group.

For those patients who received ALS care, there were 30 deaths compared to a predicted number of 21.6. Z came to 3.84($p<0.001$). M was 0.83. Although there were significantly more deaths than were predicted, the distribution of degree of injury within the ALS group was significantly different from the MTOS group as shown in Table XV (16).

III. C. Airway

In the non-airway group, there 12.5 predicted deaths contrasting with 19 actual deaths. Calculations showed $Z=3.122$ ($p<0.005$) and $M=0.94$. There were significantly more deaths in the non-airway group than the 12.5 predicted.

Of those 10 patients who received an EOA, nine died. The predicted number of deaths was 7.9. The value for Z was 1.49 indicating no significant difference ($p>0.1$), but the value for M was only 0.16 indicating a poor match between the study group and the MTOS group.

Six of the nine patients who received an ETT died. The predicted number of deaths came to 7.1. Z was equal to -1.22 ($p>0.1$) and M=0.06. Although there were fewer actual deaths than predicted deaths, the difference was not significant at the $p=0.05$ level. But, there was not a good match between the study group and the baseline group.

III. D. MAST

Of the 125 people who did not receive the MAST in the field, 15 died compared to a predicted 10.1 deaths. The Z statistic had a value of 2.75 ($p<0.01$) with M=0.95 indicating that there were significantly more deaths than predicted.

There were 19 deaths out of the group of 60 patients that received the MAST. The predicted number of deaths was 15.4. After calculating, Z=2.33 ($P<0.01$) and M=0.69. As with the non-MAST group, there were significantly more actual deaths than predicted deaths. But $M<0.88$ which makes interpretation of the Z statistic more risky.

III. E. IV Placement

For the 54 patients who did not receive an IV, there were 11 actual deaths compared to 9.0 predicted deaths. Z was calculated as 1.7 ($p>0.05$). M was calculated as 0.87. The value for M was borderline significant, making the Z value less believable, but there appeared to be no significant difference between the number of actual deaths and the number of predicted deaths in the no-IV group.

Of the 126 patients in the IV group, there were 23 actual deaths as compared with 16.5 predicted deaths. Calculations showed $Z=3.1751$ ($p<0.005$) and $M=0.87$. Again M is borderline, but it appears there was a significant difference between the number of actual deaths and the number of predicted deaths in the IV group.

IV. Multiple Regression

A. General

Stepped multiple regression analysis was performed as described in the methods section. We were looking for factors, particularly in the pre-hospital setting that were predictive for: a) Trauma Score on arrival to the hospital; b) Change in Trauma Score during the pre-hospital phase; c) Total length of stay; d) length of stay in the ICU; e) time spent in the pre-hospital phase; f) complications.

The variables that appear in the following equations are those that had a significant correlation at the $p=0.05$ level for that model.

IV. B. On-Arrival Trauma Score

The first multiple regression looked at the TS on-arrival to the hospital as the dependent variable. The best predictor was on-scene TS. This was removed from the equation as was BP data (because of its value influencing the TS directly). The resulting equation gave an $R^2=0.71$ as

a fit of the data:

TS=14.9-0.13(ISS)-4.7(EOA)-2.6(ETT)+0.035(total pre-hospital time)-1.1(MAST)+0.77(IV)-0.017(age)

Where:
EOA=0 if not used, 1 if used
ETT=0 if not used, 1 if used
MAST=0 if not used, 1 if used
IV=0 if not used, 1 if used

Because use of the EOA or ETT has a direct effect on the Trauma Score (the Respiratory section), those variables were removed to see how the multiple regression line might change. The R^2 value of the equation dropped to 0.59. The resulting equation was:

TS=15.8-0.17(ISS)-1.4(MAST)+0.035(total pre-hospital time)

IV. C. Change in Trauma Score

The next regression used the change in TS [(on-arrival TS) - (on-scene TS)] as the dependent variable to see if any pre-hospital procedures had a significant influence on the physiologic parameters measured by the TS. The resulting equation had an R^2=0.37:

change in TS=4.6-0.31(on-scene TS)-2.0(ETT)+0.02(total pre-hospital time)+0.66(MAST).

This equation indicates that the higher the on-scene TS, the less chance of an increase in the TS being noted upon arrival to the hospital. This would be expected because the maximum value of the TS is 16. If the TS is already high at the scene, there is not much farther it can go up. When on-scene TS was removed from the above model, the resulting

equation lost any significant capacity to predict the change in TS with an R^2 of only 0.044.

IV. D. Pre-hospital Time

This analysis attempted to see if any of the pre-hospital factors (age, procedures performed, severity of injury) had a predictive value on time spent at the scene or total pre-hospital time. None of these factors had a significant effect on-scene time or total pre-hospital time.

IV. E. Total Length of Stay

We considered all the factors mentioned in the introduction to this section. Because of the confounding effects a death would have on total length of stay (TOTLOS)(patients with the most severe injuries and least severe injuries could have short lengths of stay), only data from those patients who survived were analyzed. The R^2 of the equation was 0.79:

TOTLOS (days)=75-3.9(on-arrival TS)+6.0(total # of complications)+0.67(# days in ICU)+3.5(lower extremity fx)+0.28(age)+0.22(time spent at scene)-4.5(IV)-0.11(on-arrival BP)-1.6(on-scene GCS)-3.0(improvement in TS during transport).

Where: lower extremity fx=0 if not present, 1 if present

Although the total number of complications had predictive value, no single type of complication did.

IV. F. Intensive Care Unit Length of Stay

For this regression, data was not analyzed for those patients who died in the pre-hospital setting, emergency department, or the operating room, for the same reasons

mentioned in the preceding section. The R^2 of the equation was high at 0.96:

ICULOS= -0.38+0.78(time on ventilator in days)+3.1(EOA) +0.059(TOTLOS)+0.27[time of death after admission (days)]+0.16(ISS)-1.0(AIS Facial score)+0.49(AIS Extremity score)-0.37(AIS Chest Score)-0.066(on-scene time)+ 0.75(# of complications).

IV. G. Complications

The final regression analyses were done to look at what factors were predictive of the number and type of complications a patient might experience. In this analysis, no data was analyzed from those patients who expired prior to reaching the ICU because it was thought they would not have had time to develop complications. As mentioned in the methods section, complications were recorded by system (ID, Pulmonary, Cardiac, GI/Liver, Hematologic, Renal, Neuro). The best fit obtainable was an R^2=0.67:

# of complications= 0.018(TOTLOS)+0.032(# of units of blood received)+0.046(ICU length of stay)+ 0.012(ISS).

Because of the thought that prolonged time in shock, especially in the pre-hospital setting, may contribute to renal failure, a regression analysis was performed with the severity of renal failure being the dependent variable where:

0=no renal complication
1=UTI
2=Renal Insufficiency
3=Renal Failure.

The resulting equation had an $R^2=0.85$:

Severity of Renal Complications= -0.14+1.7(multiple organ failure)+0.029(# of days on a ventilator)+0.014(ICULOS)+ 0.007(pre-hospital transport time)+ 0.012(number of units of blood received)+0.0048(TOTLOS)-0.0052(IV).

Where: multiple organ failure=0 if not present, 1 if present

There was no significant association between the length of time in shock (BP<90 mmHg) and severity of renal complication.

Discussion

I. Methods

Designing a randomized trial to evaluate the efficacy of a clinical procedure that has been utilized for many years is difficult to do. Of the ALS procedures investigated in this study, use of the MAST was the only one that had been studied in the past with a randomized trial (13, 55, 56). Mattox concluded that use of the MAST did not improve survival, decrease length of stay, or decrease hospital costs. Because these procedures have been in use for a long period of time, they have become established in current protocols and accepted by the EMS community. That does not mean, however, that the effectiveness of these procedures should not be established. If data suggests that a given procedure is effective, then there is documentation available supporting its continued use. If data suggests that a given procedure is not effective, or is only effective in certain circumstances, then the indications for use of that procedure can be modified.

In this study, which was prospective but not randomized, we gathered data on a series of trauma patients admitted to a well equipped trauma center. We then compared the results from those patients who received ALS procedures in the field to those who received only BLS procedures. We used the on-scene trauma score to control

for degree of injury when comparing the ALS group to the BLS group, or when comparing a group who received a given ALS procedure to a group that did not receive that procedure.

We were concerned that ALS care might lead to longer time at the scene; therefore, delaying arrival to the emergency department. This was not the case in the current study. Previous studies performed in different areas of the country revealed different on-scene time differentials between ALS patients and BLS patients (2, 15, 42, 44, 51, 52, 55). From this study, we wanted to identify areas requiring further investigation. The results from this study could be used to justify a randomized study.

Because of the variety of provider services in this area, we hoped to find patients who received ALS care and patients who received BLS care only. The results of the study could be utilized in formulating future policy for trauma care in this region. Those regions of the country that had a similar trauma system could also utilize our results.

II. Pre-hospital

A. Mechanism of Injury

Unlike other areas of the country where penetrating trauma predominates (44, 55), the vast majority (88.5%) of the trauma victims in this study suffered from blunt trauma: motor vehicle/motor cycle crash, pedestrian injuries, or falls. This predominance of blunt trauma may be

attributable to the presence of two major interstate highways and the relatively small size of any violent inner city areas. One would expect a different constellation of injuries in a blunt trauma victim than in a penetrating trauma victim.

With blunt trauma, such as a motor vehicle crash, the energy released in the crash is spread out over a wide area, increasing the potential for multi-system/multi-organ injury. In a gunshot or stabbing wound, the energy is more concentrated in and around the path taken by the bullet or knife, increasing the potential for single-system injury. One might expect that a blunt trauma victim would have a less favorable outcome. Indeed, the coefficients derived from the Major Trauma Outcome Study Table (20), show that for patients with the same TS, ISS, and age, the patients suffering from blunt trauma would have a lower probability of survival than those suffering from penetrating trauma.

II. B. Pre-hospital Procedures

Most of the patients in this study (79%) received ALS care in the pre-hospital setting with IV placement being the most common. This result would be expected given the protocols used in this region. As explained in the Introduction to Study section, just about any patient was allowed to have an IV placed as long as the expected pre-hospital time was greater than 10 minutes. Since the average transport times (the minimum pre-hospital time

obtainable) for patients in this study were greater than 10 minutes, few patients were excluded from receiving an IV under the protocols.

For those with an on-scene TS of one (17 in all), all but two received ALS care. For those with a TS from 2-11, all patients received ALS care at the scene. Further analysis comparing ALS care to BLS care in this subgroup was not possible. Instead, a group who received a given ALS procedure was compared to those who did not receive that procedure. While this was not the same as comparing ALS to BLS care, data showed that no group analyzed, be it BLS, ALS, or ALS subgroups, differed significantly in on-scene times or total pre-hospital times, suggesting that ALS procedures did not result in longer times at the scene.

Use of an artificial airway was not very common, with nine successful endotracheal intubations and ten successful EOA insertions. There was no significant difference in success rates between inserting an ETT and inserting an EOA. Of the 17 patients who had a TS of 1, nine received an artificial airway. The remaining ten recipients of an airway all had TS´s from 2-11.

While endotracheal intubation has been thought of by many as one of the few useful ALS procedures, our study showed that opportunity for its use was limited. Criteria for its use restrict the number of patients in whom it can be placed. It would be expected that it would be used most

often in patients with lower TS´s. One would think that paramedic personnel maintain their proficiency in endotracheal intubation during cardiac arrest runs.

Use of the MAST was spread more evenly, with patients of all TS´s receiving the MAST. Effectiveness of the MAST was able to be analyzed for patients of all degrees of injury.

II.C. Pre-hospital Times

While there has been continual discussion of the merits of rapid transport vs. in-field stabilization for the care of trauma victims, there have not been many studies determining how long is too long as far as time spent in the field is concerned (37, 42, 46). In our study, the data showed that use of ALS procedures did not lead to longer on-scene times or total pre-hospital times compared to those patients who received BLS procedures. The MAST group, the ETT group, and the EOA group had shorter on-scene times than the BLS group. The IV group had longer on-scene times than the BLS group overall. None of these differences were statistically significant. Using multiple regression analysis, no ALS procedure performed in the field had a significant effect on pre-hospital time.

In interpreting these numbers, one could say that medical control in this region was effective in encouraging the expeditious transport of those patients who were more severely injured. All of the patients with a TS from 2 to

11 received ALS care. Any procedure performed must take a finite amount of time. A majority of the patients in this TS range received multiple procedures, yet their pre-hospital times did not differ significantly from the times of those who did not have those procedures, or from the times of those patients who received only BLS care in the other TS group. Either these procedures were effectively carried out during transport, or the necessity of using an ALS procedure prompted the pre-hospital personnel to perform more rapidly, enabling them to perform more tasks in a given amount of time.

Another explanation might be that the ALS resources of the region were concentrated closer to the hospital, thereby leading to shorter transport times that could offset any additional time spent at the scene. We obtained data, however that refutes this explanation by showing that on-scene times and transport times did not differ significantly between any of the studied groups. The similar transport times also suggests that ALS care was available equally in all areas of the region. In addition, in the SCC region, more emphasis has been placed on performing ALS procedures (especially IV and MAST) *en route*.

Future studies may wish to send outside observers into the field with pre-hospital personnel. They could provide objective information on pre-hospital times and the time taken for each procedure performed in the pre-hospital

setting. Jurkovich, et al. (46), performed such a study with a series of 118 patients. They showed significantly longer on-scene times for ALS patients than for BLS patients. They also showed that an average of 5.0±0.147 minutes was required to start an IV.

III. Effectiveness of ALS vs. BLS

A. Effect on Trauma Score

The group of patients who received ALS care did not have a significantly greater change in TS during transport than did the group of patients who received BLS care. When examined using multiple regression analysis, the only ALS procedures that had a significant effect on the TS were: 1) placement of an endotracheal tube; 2) application of the MAST. The entire model only had an R^2 of 0.37 indicating that there was significant portion of change in the TS that the model did not explain.

Endotracheal intubation actually had a negative effect on the TS during transport while use of the MAST resulted in an increase in the TS. Note that although every patient who received the MAST also received an IV, use of an IV did not have an effect on the TS during transport. The negative effect of ETT could have been due to its direct effect on the respiratory component of the TS. Also, those patients who had an ETT placed had a more precarious clinical situation.

With t-tests of these groups, these difference were not noted when controlled for degree of injury. Since the regression model did not explain much of the change in TS, it was difficult to determine if use of any ALS procedure led to an improvement in the physiologic response to trauma.

Those in the MAST group did have a significantly greater increase in TS than did those who did not receive the MAST. But when controlled for TS, this difference was no longer present. As noted above, while the use of the MAST had a statistically significant effect on the TS during transport, the effect was small, with an average increase of +0.66 in the TS if the MAST was used.

It appeared on initial analysis that the beneficial effect on TS by the MAST was due to its effect on systolic BP, with patients in the MAST group having essentially no change in BP during transport and patients in the non-MAST group having a 17.6 mmHg drop in BP. When controlled for degree of injury, however, the BP differences lost their statistical significance for those with a TS from 2-11. In that group, the patients who received the MAST had an average BP decrease of 15.8 mmHg while the patients who did not have the MAST had a BP decrease of 10.7 mmHg. These BP decreases were not significantly different.

For those patients who had a TS from 12-15, there was a significant difference in BP changes for patients in the MAST group (+6.9 mmHg) vs. patients in the non-MAST group

(-26.1 mmHg). The mean BP´s in this TS subgroup, both at the scene, and on arrival to the hospital, for MAST and non-MAST groups, were greater than 100 mmHg, so the clinical significance of these changes in BP was questionable. It would appear, then, that the effect of the MAST on a change in TS was of statistical significance rather than clinical significance.

Use of an IV did not even produce a statistically significant change in TS as seen in the t-test analysis and the multiple regression model. In this region, IV placement was used not only for fluid replacement, but also for simply establishing IV access. Those who did receive an IV eventually received more crystalloid than those who did not, a result that would be expected.

While no ALS procedure appeared to result in significant clinical improvement during transport to the hospital, no procedure appeared to result in significant clinical deterioration (if one assumed that use of the ETT led to a decrease in TS because of its direct effect on the respiratory component of the trauma score). If one of the goals of pre-hospital care was to prevent clinical deterioration of a patient, then the use of ALS procedures met that goal, but so did the use of BLS alone.

III.B. Survival

As seen in the results, the patients in the ALS group were, statistically, more severely injured as measured by

the TS and the ISS. Were they clinically more severely injured? The mean on-arrival TS for the BLS group was 15.0±0.6. The mean on-arrival TS for the ALS group was 13.4±0.4. Data from studies of the Trauma Score (21) suggest that the probability of survival for patients in the BLS group based on their mean TS would be 98%. The predicted probability of survival for patients in the ALS group would be 93-96%. The actual survival of the BLS group was 90% while the ALS group survival rate was 79%. Neither group had as high a survival rate as would have been predicted by the TS. Using the survival data for the ISS instead of the TS (7, 8), the results are the same.

Use of the TRISS methodology showed that there was not a significant difference between the actual number of survivors in the BLS group and the predicted number of survivors. There did appear to be a higher number of deaths in the ALS group than was predicted. In the ALS group, M was equal to 0.83. Examining the distribution of probability of survival for patients in the ALS group (Table XV), that group seemed to have more people with a lower probability of survival than the MTOS group. The result was that fewer patients survived which would be expected if there was a lower probability of survival. It has to be concluded that the ALS group had a higher than expected mortality rate. Further studies should be done to validate this finding and determine if there might be a confounding

variable that has not been noticed. Perhaps more patients in the study would have provided a better match between the study group and the MTOS group.

When each ALS procedure was examined independently, the mortality results were variable. Using t-tests, the use of no individual ALS procedure resulted in a significantly different mortality rate, when controlled for on-scene TS than was encountered in the group of patients who did not receive that procedure. With the TRISS analysis, results were somewhat more variable.

For those who did not receive an artificial airway, use of the TRISS methodology showed significantly more deaths than were predicted. For the EOA group or the ETT group, such a difference between predicted and actual deaths was not present. The question is: were there patients who would have benefitted from placement of an airway but who did not receive one due to lack of ALS availability, poor clinical judgement, or some other factor?

More than for the ALS group, caution must be taken in interpreting the TRISS results for those who received an airway. In either airway group, there were more people with a lower probability of survival than in the MTOS group. As with the ALS group, more patients might bring a better distribution of survival probability.

TRISS analysis of the MAST group vs. the non-MAST group showed more deaths than predicted in both the MAST group and

the non-MAST group. When controlled for TS, t-test analysis showed that there was no significant difference in mortality between the MAST group and the non-MAST group. There were more patients in the MAST group, as in the ALS group and airway groups, who had a lower probability of survival than in the MTOS group. Even so, it is safe to assume that the data from this study did not show that use of the MAST increased survival. This was a conclusion shared by Mattox (55, 56).

Of the ALS procedure patient groups, only the IV group had a distribution of probability survival that approximated that of the MTOS group. The TRISS analysis revealed significantly more deaths than predicted in the IV group. The no-IV group did not have a significant difference between the predicted number of deaths and the actual number of deaths. T-test analysis did not show a significant difference in mortality between the IV group and the no-IV group.

It is hard to explain the higher than expected mortality rate in the IV group given that use of an IV did not add to pre-hospital time. A majority (17) of the 26 patients in the IV group who died had a TS less than 12. Perhaps the MTOS group did not have enough patients with low trauma scores to accurately predict survival. Or perhaps the trauma system in this region was not as successful in

the care of the more severely injured during the time of this study.

Another possible cause of the increased mortality of those patients with low trauma scores was the relative prevalence of CNS injury in this study group compared to the MTOS group. Of the 34 deaths in this study, 15 (44%) were due to CNS injury. Baxt reported on a series of 545 trauma patients with and without severe brain injury (11). For any given degree of injury as indicated by the TS and ISS, Baxt showed that those with severe CNS injury had a higher mortality rate than those without severe CNS injury. The incidence of CNS injury in the MTOS group was not known, but if the MTOS group had a lower proportion of CNS injuries than in this study group, that might explain the difference in predicted survival and actual survival.

With almost half of the deaths in this study taking place at the scene or in the emergency department, prevention is obviously important. Petrucelli´s study of the effect of seatbelt laws in New York (61) on motor vehicle occupant deaths showed a 16.9% decline in occupant deaths during the first year of mandatory seatbelt usage. This was in comparison to an average of the five previous years. Severe injuries decreased 14% compared to the average of the previous five years.

III.C. Complications

Multiple regression modeling showed the number of

complications to be significantly affected by length of stay in the ICU, total length of stay, number of units of blood received in the first 24 hours, and the severity of anatomic injury as measured by the ISS. Number of units of blood had a significant effect probably because of its association with a surgical procedure being performed. Because surgical procedures were recorded by type of procedure, no one procedure appeared to have an effect on the number of complications. Multiple regression is not supposed to determine cause and effect, so one could not determine from this model whether more time spent in the ICU, or in the hospital in general, contributed to more complications, or more complications led to more time spent in the ICU or in the hospital in general.

The multiple regression analysis showed no significant association between any ALS procedure performed and the number of complications. The t-tests performed on each group of patients that received a particular procedure or combination of procedures showed no significant difference in the number of complications between those who received the procedure and those who did not.

In those patients who received an artificial airway in the pre-hospital setting, there was no significant increase in the incidence of pulmonary complications. However, of the 19 patients who received an airway, only four survived. Of the 15 who died, nine were dead at the scene or

pronounced dead in the emergency department. Of the remaining six, there was one death due to Adult Respiratory Distress Syndrome (ARDS). Of the four cases of ARDS, one occurred in a patient who received an EOA. We were not able to show an association between use of an artificial airway and pulmonary complications; however, a larger study that used pre-hospital airways more frequently might show a higher survival rate among the recipients, or at least a higher survival rate past the emergency department, and therefore might provide more patients in which to look for complications.

Weigelt noted in a study of 949 trauma patients requiring operative therapy (72) that delay from the time of injury to the time of surgery led to an increase in the incidence of wound infection. In our study, all six cases of wound infections occurred in those patients who received the MAST and IV placement. This was a significant association when comparing the MAST group to the non-MAST group, but was not significant when comparing the IV group to the no-IV group.

Although the use of these procedures did not increase the pre-hospital time for these patients compared to other patients, if these ALS procedures had not been performed, could these patients have been operated on sooner? Would a decrease from a mean pre-hospital time of approximately 24 minutes have a clinical effect on the incidence of wound

infection? Further studies would have to be done to answer these questions. It is likely that the difference is related to severity rather than factors such as pre-hospital time.

In the MAST group of patients were found three of the four cases of deep vein thrombosis noted in this study. This was not statistically significant, but the occurrence of this complication in the MAST group should be noted. Other studies (39) have also reported on thrombosis associated with use of the MAST. Perhaps the change in peripheral vascular resistance produced by use of the MAST leads to increased thrombus formation.

Use of the MAST has also been associated with lower extremity compartment syndrome (10, 45). There were no cases of compartment syndrome in this study. This could suggest that on arrival to the emergency department, the MAST had been removed expeditiously; therefore, minimizing the amount of time of possible tissue anoxia in the lower extremities.

In the IV group of patients, the incidence of wound infection (6/126, 5%) and the incidence of fever without a cause being found (12/126, 10%), did not differ significantly from the incidence of these complications in the no-IV group. While there was not a statistical difference in the incidence of fever, 12 of the 13 cases occurred in patients who received a pre-hospital IV.

Perhaps the less than sterile conditions in the pre-hospital setting resulted in the IV catheter site becoming an infectious source; however, we could not conclude that an IV catheter was the infectious source.

Both patients who eventually developed renal failure and all three patients who eventually developed multiple organ failure all received a pre-hospital IV. Because of the small numbers of these cases, this association was not significant. The multiple regression model for severity of renal complication actually showed an inverse correlation between use of an IV and the severity of renal complications. This was due to the fact that the overwhelming majority of patients had no renal complication and that many of these patients received a pre-hospital IV.

III.D. Length of Stay in the ICU

When multiple regression was performed, of the ALS procedures investigated, only the use of an EOA had an association with length of stay in the ICU (ICULOS). Use of an EOA was predictive of an increased amount of time in the ICU. Because of the small numbers of patients, however, the validity of that association might be questionable. When controlled for TS, there was no significant difference in ICULOS between those patients who received an EOA or ETT and those who did not.

The number of complications had a direct relationship with the ICULOS. As noted above, however, one cannot say

if having a complication resulted in a longer stay in the ICU or if a longer stay in the ICU made a person more susceptible to complications.

III.E. Total Length of Stay

The only ALS procedure that had an effect on total length of stay (TOTLOS) was use of an IV, which, with multiple regression modeling, was inversely correlated with TOTLOS. When controlled for degree of injury, there was no significant difference between the IV group and the no-IV group in TOTLOS.

Length of stay is a difficult measure to relate to pre-hospital care because of the many factors that can affect it. As seen in the analysis, the less severe the injury, as measured by the TS, the shorter the TOTLOS. The presence of a lower extremity fracture was associated with a longer length of stay, presumably because a patient who was non-ambulatory would be less likely to be discharged.

The initiation of an IV probably did not lead to a shorter length of stay; rather, initiation of an IV was merely associated with a shorter length of stay. More than likely, there were other variables that were not used in that regression model that, if included, would result in the use of an IV no longer being independently associated with TOTLOS.

Conclusions

This study of 185 trauma victims showed that the pre-hospital use of ALS procedures did not increase the time spent at the scene of the incident or the total pre-hospital time. This observation was thought to reflect appropriate medical control in this EMS system with emphasis on the rapid transport of trauma victims such that ALS intervention did not lead to increased pre-hospital time.

Although pre-hospital times were not different, mortality was higher than expected for the ALS group of patients when controlled for degree of injury. The higher mortality may have been due to a greater number of deaths due to severe CNS injuries in our study group than in the normative group to which it was compared (MTOS). No data were available on the incidence of CNS mortality in the normative group. Of the individual ALS procedures, the use of an artificial airway was not associated with a significantly different mortality rate than was predicted. Use of the MAST or a pre-hospital IV was associated with a higher than expected mortality rate.

No ALS procedure or combination of procedures was associated with an increased number of complications. The only significant association between a particular ALS procedure combination and a particular complication was the association between the use of a MAST and an IV and the

incidence of wound infection. No explanation for this observation was immediately apparent.

Use of an EOA was associated with an increased amount of time in the ICU, but the number of patients in the EOA group may have been too small to say that this was an accurate observation. Use of an IV was inversely associated with the total length of stay, although there was no significant difference, when controlled for TS, between the length of stay of the IV group of patients and the group of patients without a pre-hospital IV. Future studies should be designed to attempt prospective randomizations of the ALS procedures or combinations of the ALS procedures.

The use of ALS procedures in the pre-hospital setting was not associated with significant improvements in patient morbidity or mortality. But since many of these procedures were performed during extrication or transport, pre-hospital times were not lengthened. The importance of good BLS care and airway control (with or without endotracheal intubation) should be emphasized. Control of the cervical spine at the scene can prevent neurologic compromise. Proper use of a bag and mask with oxygen can provide good ventilation in many circumstances. ALS procedures may prove to be beneficial in certain circumstances, but they should never be used at the expense of BLS care.

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