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Effect of Prehospital Advanced Life Support on Outcomes of Major Trauma Patients

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Objective: **Determine whether prehospital advanced life support (ALS) improves the survival of major trauma patients and whether it is associated with longer on-scene times.**

Methods: **A 36-month retrospective study of all major trauma patients who received either prehospital bag-valve-mask (BVM) or endotracheal intubation (ETI) and were transported by paramedics to our Level I trauma center. Logistic regression analysis determined the association of prehospital ALS with patient survival.**

Results: **Of 9,451 major trauma patients, 496 (5.3%) had either BVM or ETI. Eighty-one percent received BVM, with a mean Injury Severity Score of 29 and a mortality rate of 67%; 93 patients (19%) underwent successful ETI, with a mean Injury Severity Score of 35 and a mortality rate of 93%. Adjusted survival for patients who had BVM was 5.3 times more likely than for patients who had ETI (95% confidence interval, 2.3–14.2, $p = 0.00$). Survival among patients who received intravenous fluids was 3.9 times more likely than those who did not (p = not significant). Average on-scene times for patients who had ETI or intravenous fluids were not significantly longer than those who had BVM or no intravenous fluids.**

Conclusion: **ALS procedures can be performed by paramedics on major trauma patients without prolonging on-scene time, but they do not seem to improve survival.**

Key Words: **Prehospital, Advanced life support, Paramedics, Major trauma.**

The role of prehospital Advanced Life Support (ALS) for major trauma patients remains a highly controversial issue. Although several studies have concluded that prehospital intravenous fluid (IVF) administration provides no benefit in an urban system[1–4] and may even be harmful, [5,6] the effect of prehospital airway intervention is less clear.

Paramedics are capable of assisting respirations through bag-valve-mask ventilation (BVM), endotracheal intubation (ETI), or with other airway adjuncts such as an esophageal obturator airway or an esophageal tracheal combination tube, with high degrees of success and few complications.[7–9] Each of these modalities offer different benefits, but all are measured against ETI as the "gold standard." One of the concerns of prehospital ETI for trauma patients is the additional time that may be required to perform this procedure, which may delay definitive surgical care.[10] Prehospital ETI poses several challenges that may not exist in the more controlled setting of an emergency department or an operating room, including inadequate suction, combative patients, poor lighting, a hostile environment, inability to use induction agents, and often a lack of tools to confirm correct tube placement. In addition, concern over potential cervical injury often necessitates additional personnel to assist with ETI or warrants the use of medications to facilitate the procedure.

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There is a paucity of literature that has examined the role of ETI on major trauma patients.[11–13] The purpose of this study was to determine the impact of prehospital ETI versus BVM on the outcomes of major trauma patients. In addition, the effect of other ALS procedures on patient survival and paramedic on-scene times was examined.

PATIENTS AND METHODS

Records were reviewed over a 36-month period from January 1, 1993, to December 31, 1995, for all patients who met trauma center criteria, had airway intervention performed by paramedics in the prehospital setting, and were transported to the Los Angeles County/University of Southern California (LAC/USC) Medical Center. Trauma center criteria were those established by the American College of Surgeons, which have been adopted by the Los Angeles County Emergency Medical Services Agency.[14]

LAC/USC Medical Center is a large, urban, Level I trauma center which admits approximately 3,000 major trauma patients per year. Emergency medical services is provided by several fire department-based provider agencies, all of which have ALS units staffed by two paramedics who respond to major trauma incidents.

Airway intervention was defined as the performance of prehospital ETI or BVM. Patients who received prehospital BVM ventilation were only included in the study if BVM ventilation was continued throughout their prehospital course and they subsequently received ETI or cricothyrotomy in the emergency department, or went directly to the operating room from the emergency department. This protocol was established to eliminate those patients who had a brief decline in respiratory status, which quickly responded to noxious stimuli or supplemental oxygen. An ETI attempt was based on paramedic documentation, which reflects an attempt at inserting the laryngoscope in the patient's mouth. Patient resistance, anatomic abnormality, or blood or vomitus in the airway are reasons given for unsuccessful ETI.

Indications for BVM or ETI were in accordance with local prehospital care policy. Patients with head injuries who are unresponsive are hyperventilated by means of BVM for cerebral resuscitation or intubated if paramedics are able. All other trauma patients have respirations assisted by means of BVM or ETI, if they are in respiratory arrest or respiratory failure, have no gag reflex, or are in cardiopulmonary arrest. Paramedics in Los Angeles County do not carry neuromuscular paralytic agents to facilitate ETI, are not permitted to perform nasal ETI, nor can they administer sedative agents to facilitate ETI.[15]

The performance of other ALS procedures was recorded, including placement of intravenous lines, administration of medications, and electrocardiogram monitoring, along with the resultant on-scene times and transport times. On-scene time was defined as the documented times from arrival of paramedics at the patient's side until transport was initiated. Transport time was defined as the documented time that transport was initiated until arrival at the trauma center.

Patients were grouped according to Injury Severity Score (ISS) and mechanism of injury (blunt vs. penetrating). Patients with an ISS between 1 and 15 were considered to have minor injuries; those with an ISS between 16 and 30 sustained moderate injuries; and patients with an ISS greater than 30 had severe injuries.[16,17] Medical records of all patients were reviewed, including their prehospital course, in-hospital course, and outcomes.

Relationships between on-scene times and paramedic interventions were examined by *t* test and analysis of variance testing. Multiple logistic regression analysis was done to examine the relationship between survival and paramedic intervention, controlling for age, sex, mechanism of injury, and ISS. Human subjects approval was obtained from the Institutional Review Board of the University of Southern California.

RESULTS

Airway Intervention

During the study period, there were 496 major trauma patients who had prehospital BVM or ETI and were transported to LAC/USC Medical Center; 426 patients (86%) were male, and 70 patients (14%) were female. The mean age of the patients in the study population was 29.4 years (range, 0 to 91 years). The number of patients who had airway support by means of BVM was 403 patients (81%), and 93 patients (19%) underwent successful ETI. There were 148 cases with at least 1 documented attempt at ETI, with 93 attempts (63%) resulting in success. One patient arrived in the emergency department with an unrecognized esophageal intubation.

The mean ISS of all patients in the study population was 29.9. Table 1 shows the number of patients who had respirations assisted by means of BVM versus ETI according to age, sex, mechanism of injury, whether or not paramedics established an intravenous line, the ISS, and resultant mortality. As shown in Table 1, patients in the BVM and ETI groups were similar in age and sex, but the ETI patients had a significantly higher percentage of patients with ISS > 30.

There were 95 patients with isolated head injuries, of which 85 (89%) sustained a gunshot wound (GSW). Of these head-injured patients, 76 (80%) had a Glasgow Coma Scale score ≤ 5. Overall, 266 patients had a Glasgow Coma Scale score of 3; of these 79 (30%) had ETI performed in the field. The mean Glasgow Coma Scale score for patients in the ETI group was 3.3 (range, 3–8), and for the BVM group was 4.9 (range, 3–14).

Mechanism of Injury

Of the total study population, 266 patients (54%) sustained penetrating trauma. There were 229 patients (86%) who sustained GSWs, and 37 patients (14%) who sustained stab wounds (SWs). Of penetrating trauma patients, 83 (31%) sustained an isolated GSW to the head.

During the study period, there were 227 patients (46%) who sustained blunt trauma, of whom 88 patients (39%) were involved in motor vehicle crashes, 77 patients (34%) were pedestrians struck by automobiles, and 52 patients (23%) sustained falls or other blunt trauma injuries. Ten patients sustained isolated blunt head trauma.

On-Scene Time

Scene time was documented in 354 of the cases reviewed (70%). The mean on-scene time for these documented cases was 11.1 minutes (Fig. 1). Scene time was 20 minutes or less in 328 patients (93% of the cases for which scene time was documented). Of the 21 cases for which scene time exceeded 20 minutes, 17 patients (80%) were blunt trauma patients, of whom 5 required extrication. There were four cases for which scene time exceeded 20 minutes with patients who had sustained GSWs or SWs; all of these patients died.

Application of the logistic regression model compared the mean on-scene times for the BVM and the ETI groups, adjusting for differences in sex, mechanism of injury, and ISS. The mean on-scene time for the BVM group (11.0 minutes) was shorter than that for the ETI group (12.8 minutes), although the difference was not significant. ($p = 0.09$)

When on-scene times were compared between the patients who had one or more intravenous lines placed versus those who received no intravenous lines, only ISS was found to be a significant covariate through analysis of variance testing. Mean on-scene times of patients who received one or more intravenous lines compared with those who had no intravenous lines established also failed to show any difference in mean scene time, even after adjusting for different ISS scores ($p = 0.71$).

Factors Influencing Survival

There were 355 patients (72%) who did not survive. Of the 403 patients who had respiration assisted by means of BVM, the mortality rate was 67%. Of the 93 patients who underwent ETI, 87 patients (93%) died. The factors found to be significantly associated with lower mortality rates in the study

TABLE 1. Prehospital airway intervention[a]

Characteristics	BVM	ETT	Total
Age			
n	403	93	496
Mean	29.4	31.0	29.7
Median	28	29	28.5
Range	0–91	12–74	N/A
Sex	# %	# %	# %
Male	342 (85)	84 (90)	426 (86)
Female	61 (15)	9 (10)	70 (14)
On-scene time			
n	281	68	349
Mean	11.0	11.3	11.1
Median	10	10	10
Range	2–49	2–27	N/A
	# %	# %	# %
0–10 min	164 (59)	35 (52)	199 (57)
11–20 min	99 (35)	30 (44)	129 (37)
21+ min	18 (6)	3 (4)	21 (6)
Mech. of injury	# %	# %	# %
Penetrating	202 (51)	64 (68)	269 (54)
Blunt	197 (49)	30 (32)	227 (46)
Isolated head trauma	82 (16)	13 (3)	95 (19)
IV	# %	# %	# %
With IV	385 (96)	88 (94)	473 (95)
Without IV	17 (4)	6 (6)	23 (5)
Outcome	# %	# %	# %
Lived	134 (33)	7 (7)	141 (28)
Died	268 (67)	87 (93)	355 (72)
ISS			
n	377	86	463
Mean	29	35	30
Median	25	26	26
Range	1–75	1–75	1–75
	# %	# %	#<%
1–15	66 (18)	9 (11)	75 (16)
16–30	203 (54)	42 (49)	245 (53)
30+	108 (28)	35 (40)	143 (31)

[a] Mech., mechanism.

population were blunt trauma as the mechanism of injury, ISS $\leq$ 30, and BVM as the type of airway control (Table 2).

Adjusting for sex, mechanism of injury, and ISS, the patients in the BVM group were 5.3 times more likely to survive than the patients in the ETI group (95% confidence interval, 2.3–14.2; $p = 0.0$). When comparing adjusted survival rates between groups who received IVF with those who did not, the likelihood of survival for patients who received IVF was 3.9 times higher than that for patients who did not, although the difference was not significant (95% confidence interval, 1.0–26.7; $p = 0.09$). The only subgroup of patients for which survivors had significantly shorter on-scene times were patients 55 years and older.

Advanced Life Support Intervention

Each case was analyzed to determine which ALS interventions were performed in addition to airway control. Four hundred seventy-five (96%) patients had at least one or more intravenous lines started in the field. The actual volumes of IVF infused in the field were not recorded. The mean on-scene time for patients who had one or more intravenous lines placed by paramedics, adjusted for ISS, was similar to that for patients who did not have intravenous lines established (11.1 vs. 11.6 minutes, p = not significant)

Of the patients who had one or more intravenous lines placed, 39 patients (10%) received medications intravenously. All patients who received epinephrine or atropine

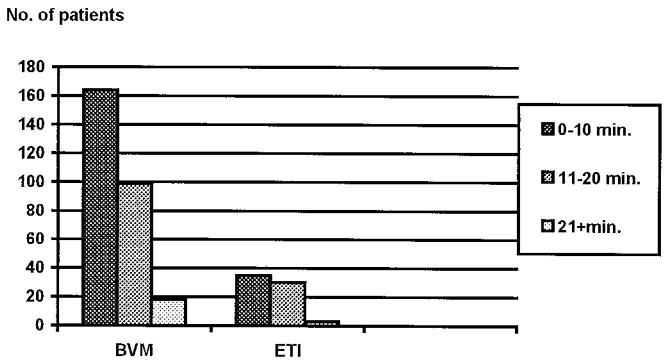

FIG 1. **Scene times.**

were either pulseless upon paramedic arrival or arrested en route. None of these patients survived.

Emergency Department Thoracotomy

There were 110 patients (22%) who had emergency department thoracotomy (EDT) performed. Ninety-eighty (89%) of these patients sustained GSWs or SWs. There were five survivors from this group (4.5%), three of whom were victims of SWs and two sustained GSWs. All five survivors were in the BVM group. Mean on-scene time for the EDT survivors was 4.3 minutes (range, 2 to 8 minutes), and mean transport time was 8.7 minutes (range, 6 to 10 minutes). Two patients who survived EDT were found to be in cardiac arrest upon paramedic arrival. Both had sustained SWs, had very short scene times (2 and 3 minutes), and short transport times (6 and 8 minutes). The other three patients who survived EDT initially had vital signs upon paramedic arrival but arrested en route or shortly after arrival in the emergency department. The mean ISS score for EDT survivors was 39.

TABLE 2. **Association between survival and patient characteristics**

Patient Characteristics	Total #	% Survived	*p* Value
Age			
<55 yr	470	28.9	
≥55 yr	33	18.2	0.185
Gender			
Female	72	36.1	
Male	431	27.2	0.119
MOI[a]			
Penetrating	269	16.7	
Blunt	230	41.7	0.000
IV			
With IV	482	29.1	
Without IV	23	13.0	0.096
ISS			
≤15	75	62.7	
16–30	247	28.3	
≥30	146	8.9	0.000
Airway			
BVM	404	33.7	
ETI	94	7.4	0.000
On-scene time			
≤10 min	200	21.0	
11–20 min	131	29.0	
≥20 min	21	52.4	0.004

[a] MOI, mechanism of injury.

DISCUSSION

The impact of prehospital ETI on the survival of trauma patients has not been studied in depth. Winchell and Hoyt compared the impact of intubation by ground-based paramedics on patients with severe head injuries versus those patients intubated by aeromedical crews, which consisted of at least one flight nurse who carried neuromuscular blocking agents to facilitate intubation. This study concluded that although the success rate of ETI without the aid of paralytic agents was only between 50 and 60%, ETI did decrease mortality.[13] Two other studies have directly examined the effect of prehospital ETI and concluded that it decreased mortality.[11,12] Both of these studies focused only on patients presenting in traumatic cardiopulmonary arrest. The former study found that prehospital ETI lengthened the time of successful cardiopulmonary resuscitation for the moribund trauma patient, and the latter study found that all but one of the survivors had ETI.

Prehospital ETI is usually thought to benefit patients who have sustained severe closed head injury through “therapeutic” hyperventilation, which has been thought to protect against secondary brain injury by decreasing intracranial pressure.[18–20] Recent studies have questioned the role of hyperventilation,[21,22] whereas other studies suggest that the primary rationale for ETI is related to reversal or prevention of hypoxemia.[23,24]

Paramedics in Los Angeles do not administer paralytic neuromuscular agents; thus, the patient with head injuries must be unable to protect their airway and not have a clenched jaw to allow passage of an endotracheal tube. The patient with head injuries who tolerates ETI without the use of paralytic agents will predictably have a very high mortality rate.[25] It is likely that paramedics unsuccessfully attempted many intubations on such patients with head injuries, which might explain the relatively low success rate for ETI in our series. However, the success rate of ETI in our series is similar to that in other published studies of trauma patients with prehospital ETI.[13,26]

The training and quality of paramedics play an important role when evaluating the impact of prehospital interventions.[27,28] The finding that there was no significant difference between on-scene times for BVM patients and ETI patients, nor between patients who had intravenous lines versus no intravenous lines, suggests that paramedics in Los Angeles are capable of rapidly performing ALS procedures. Prospective studies are required to determine which of these procedures, if any, should be done in the prehospital setting.

This study has several limitations. The data were obtained from the paramedic field reports, for which documentation of intubation attempts or attempts at intravenous access may be incomplete. Also, because it was a retrospective study, groups were compared by covariates and not true controls.

The finding that trauma patients with airway support by means of BVM were significantly more likely to survive is contrary to the findings of previous studies.[11–13] One possible explanation for this finding is that, although ETI may be of value in reversing the intrapulmonary shunting occurring in inadequately inflated lungs, the rate of subsequent assisted ventilation is paramount. Once ETI is successfully performed, paramedics are trained to hyperventilate the patient. Mechanical ventilation with positive pressure increases intrathoracic pressure, which may cause a decrease in venous return to the heart and subsequently decrease cardiac output.[29,30] Therefore, this method may increase mortality. In addition, the critically injured patient actually has lower oxygen demands, because they have little oxygen transport and, thus, little oxygen consumption. Eventually, there is also little carbon dioxide production along with compromised circulation; thus, markedly decreased carbon dioxide return to the lungs. The result of these processes is a much lower ventilatory requirement than normal.[31] Markedly increased airway pressures throughout the respiratory cycle may exacerbate hemodynamic compromise. Thus, the increased mortality found in our group of patients who received prehospital ETI may be related to the subsequent hyperventilation with which it is often associated.

Further study is needed to examine the effect of hyperventilation on critically injured patients. Intensive training of paramedics by physicians will help not only to improve the success rate of ETI but to ensure that proper minute ventilation is provided after ETI is accomplished. The performance of ETI on a major trauma patient may also preclude the paramedic from performing other prehospital interventions, such as direct control of ongoing sites of hemorrhage or initiation of IVF. This diversion may result in potentially correctable problems to continue unchecked.

Other reasons for the increased mortality of the ETI group versus the BVM group are that there were a large number of patients with head injuries and a greater number of patients in the ETI group who had ISS $>$ 30 compared with those patients who had BVM. Thus, even though ISS was controlled for through logistic regression analysis, the ETI group will predictably have a very high mortality based on their ISS. In addition, although the additional on-scene time was not statistically significant, there was an average of 1.8 additional minutes spent on-scene with patients who had ETI performed.

ISS, although widely accepted as a statistical tool for comparing injured patients, also has several limitations.[32,33] Thus, without a true control population, ETI patients with the same ISS as BVM patients still might have had more severe injuries. This possibility is particularly true of patients with head injuries. In our study population, 102 patients (21%) suffered isolated blunt or penetrating head trauma.

Under an expanded scope of practice, basic emergency medical technicians can defibrillate and perform ETI, whereas paramedics offer continuous electrocardiogram monitoring and intavenous access for fluid and drug administration. Our results do not show lower mortality rates from any of these additional procedures, but paramedics were performing all of the procedures evaluated in the study. The quality with which BVM is performed and the rapidity of patient assessment, packaging, and transport may be higher with well-trained paramedics than with basic level emergency medical technicians. In addition, paramedics, by virtue of their advanced training, possess better patient assessment skills, which may result in more trauma patients being transported to trauma centers even though they did not formally meet trauma center criteria.[34]

Shorter paramedic on-scene times for major trauma patients seemed to be a contributor toward survival in those patients over age 55 years. These patients are more likely to have co-morbid conditions, less cardiopulmonary reserve, and are more susceptible to the effects of hypovolemia and hypothermia than their younger cohorts.[35,36]

Evidence that supports the need to minimize the time spent in the prehospital setting is also found in analysis of EDT survivors, all of whom had extraordinarily short scene times and transport times. These patients were likely able to benefit from this lifesaving procedure because the duration of circulatory arrest was kept at a minimum.

This study suggests that prolonging on-scene time to perform ALS procedures, even ETI, is not warranted. Paramedics should quickly establish scene safety, perform a primary survey with basic airway support as needed, package the patient for transport while protecting the cervical spine, and provide rapid transport to the nearest trauma center. ALS procedures, including ETI and IVF administration, should only be performed during transport. When additional personnel are on scene to assist with the above procedures, (e.g., emergency medical technicians on an engine company in addition to the paramedics on an ambulance), ETI can be performed while the patient is being prepared for transport as long as it does not delay time on-scene. Although prospective study is needed to directly compare the effect of BVM versus ETI, medical control efforts to minimize the time from injury to definitive care at a trauma center should be paramount.

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