Prehospital Endotracheal Intubation for Trauma Does Not Improve Survival over Bag-Valve-Mask Ventilation

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Background: Few data exist supporting a survival benefit to prehospital endotracheal intubation (ETI) over bag-valve-mask ventilation (BVM) in trauma patients.

Methods: Data were reviewed from all trauma patients transported to our Level I trauma center receiving prehospital ETI or BVM. Mortality was adjusted by age, Revised Trauma Score, Injury Severity Score, and mechanism of injury (penetrating vs. blunt).

Results: Of 5,773 patients, 316 (5.5%) had ETI and 217 (3.8%) had BVM. Patients receiving ETI were significantly more like to die (88.9% vs. 30.9%, $p < 0.0001$). When corrected for Injury Severity Score, Revised Trauma Score, and mechanism of injury, ETI was associated with similar or greater mortality than BVM. ETI patients had longer prehospital times (22.0 vs. 20.1 minutes, $p = 0.0241$).

Conclusion: In our trauma system, when corrected for mechanism and severity of anatomic and physiologic injury, ETI confers no survival advantage over BVM and slightly increases prehospital time.

Key Words: Endotracheal intubation, Bag-valve-mask ventilation, Advanced life support, Prehospital, Trauma.

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There has been considerable debate in the trauma literature for two decades on the role of basic life support (BLS) versus advanced life support (ALS) procedures in the prehospital setting.[1] Indeed, the definitions of the terms themselves are not standardized.[2] Some studies have demonstrated improved survival (either out-of-hospital or out-of-emergency department) in ALS over BLS transportation;[3–5] others have shown no advantage.[6–9] The contribution of specific ALS therapies is similarly unclear. In the trauma population, endotracheal intubation has been shown to increase survival or improve outcome in some studies,[10–14] although this finding is not universal.[15–18] However, we know of only two studies that have directly studied bag-valve-mask ventilation (BVM) versus endotracheal intubation (ETI) in trauma patients. In one, BVM patients had a 5.3 times higher adjusted survival rate;[7] in the other, no improvements were found in either survival or neurologic outcome.[18]

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To evaluate the efficacy of ETI versus BVM in our trauma system, a retrospective review of trauma patients was performed. All ALS interventions were provided by Emergency Medical Technician-Paramedics (EMT-Ps) without a physician present at the scene.

PATIENTS AND METHODS

Records were reviewed retrospectively for a 34-month period—December 1, 1999, to September 30, 2002—for all patients who met Level I trauma center criteria, had prehospital ETI or BVM, and were transported to the Medical Center of Louisiana at New Orleans–Charity Hospital (MCLNO). All patients in four parishes (counties) meeting anatomic and physiologic criteria as established by the American College of Surgeons were by law transported to MCLNO. MCLNO is a large, urban, Level I trauma center that serves a population of 3.4 million and sees approximately 4,000 trauma patients per year, of whom approximately 2,800 meet trauma center criteria as defined by the American College of Surgeons.[19] Emergency medical services are provided by various municipal, hospital-based, or private ambulance services that provide ALS response to major trauma incidents. EMT-Ps in the greater New Orleans area do not carry neuromuscular blocking agents or use rapid-sequence intubation protocols. Patients were identified by the Trauma Registry of the Medical Center of Louisiana database, which captures data from all trauma admissions to MCLNO.

Patients were analyzed on the basis of Injury Severity Score (ISS), mechanism of injury (blunt vs. penetrating), and Revised Trauma Score (RTS), when these data were available. Actual survival was compared with survival predicted by TRISS methodology[20] and by RTS.[21] Outcome was defined as death or as discharge alive from the hospital. Prehospital time was defined as the time from arrival on scene by EMT-Ps to the time of arrival at the trauma center. Means are

Table 1 Mortality by Airway Intervention and Mechanism of Injury[a]

	ETI (%)	BVM (%)	*p* Value	Total (%)
Penetrating	183/191 (95.8)	46/86 (53.5)	<0.0001	229/277 (83.0)
Blunt	98/125 (78.4)	21/131 (16.0)	<0.0001	119/256 (46.5)
p value	<0.0001	<0.0001		<0.0001
Total	281/316 (88.9)	67/217 (30.9)	<0.0001	348/533 (65.3)

ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] The p values were calculated between groups after overall χ^2 with $p < 0.0001$.

reported ± SD. The decision to intubate was made on the basis of the clinical judgment of the EMT-Ps providing prehospital care; in our system, prehospital protocols mandate ETI only for a Glasgow Coma Scale score of 8 or less. No attempt was made to ascertain the rate of successful ETI in the prehospital setting.

The χ^2 test or Fisher's exact test was used to test for differences in mortality between groups. Comparisons between group means for ISS, RTS, and prehospital time were made using parametric (analysis of variance) or nonparametric (Mann-Whitney *U* test) techniques with post hoc tests where indicated. Comparisons of actual survival versus survival predicted by TRISS were made using the *z* statistic as described by Boyd et al.[22] Values of $p < 0.05$ were considered to be significant. Research protocols, data review, and human subjects approval were obtained from the Institutional Review Board of Tulane University Health Sciences Center and from the Trauma Registry of the Medical Center of Louisiana.

RESULTS

During the 33-month study period, there were 5,773 trauma patients transported to MCLNO who met Level I trauma center criteria. Of these, 533 received either ETI or BVM; this was the study population. Study population demographics included the following: mean age, 31.8 ± 15.6 years (range, 2–97 years); male patients, 82.2%; and female patients, 17.8%. There was no significant difference in age between those receiving ETI and BVM (32.6 ± 15.7 years vs. 30.6 ± 15.4 years, $p = 0.1446$) or between survivors and nonsurvivors (31.6 ± 16.5 years vs. 31.9 ± 15.2 years, $p = 0.8375$). Those with penetrating injuries were younger than those with blunt injuries (28.1 ± 10.8 years vs. 35.8 ± 18.8 years, $p < 0.0001$).

Mortality and Mechanism of Injury

Overall mortality for the study population was 65.3%. Table 1 subdivides these patients on the basis of airway intervention (ETI vs. BVM) and mechanism of injury (blunt vs. penetrating). Penetrating injuries showed a higher overall mortality than blunt injuries (83.0% vs. 46.5%; relative risk, 1.78; 95% confidence interval, 1.54–2.05; $p < 0.0001$), and patients receiving ETI had a higher overall mortality than those receiving BVM (88.9% vs. 30.9%; relative risk, 2.88; 95% confidence interval, 2.36–3.54; $p < 0.0001$). Not surprisingly, the subgroup with penetrating injury and ETI had the highest mortality (95.8%), significantly worse than ETI with blunt injury (78.4%, $p < 0.0001$) and BVM with penetrating injury (53.5%, $p < 0.0001$).

Injury Severity Score

Patients with ETI had a higher ISS than those with BVM (19.2 ± 16.3 vs. 14.8 ± 13.3, $p = 0.0018$). Because of this, ISS was stratified into three ranges for comparison (<13, 13–24, and >24). Table 2 compares mortalities on the basis of mechanism of injury and ISS. Overall, increasing ISS was associated with higher mortality across groups ($p < 0.0001$). For each group of ISSs, patients receiving ETI fared signif-

Table 2 Mortality by Airway Intervention, Mechanism of Injury, and ISS[a]

	ETI (%)	BVM (%)	*p* Value	Total (%)
ISS < 13				
Penetrating	88/92 (95.7)	14/36 (38.9)	<0.0001	102/128 (79.7)
Blunt	36/45 (80.0)	6/80 (7.5)	<0.0001	42/125 (33.6)
p value	0.0096	<0.0001		<0.0001
ISS 13–24				
Penetrating	24/26 (92.3)	6/19 (31.6)	<0.0001	30/45 (66.7)
Blunt	11/21 (52.4)	3/25 (12.0)	0.0042	14/46 (30.4)
p value	0.0026	0.1440		0.0008
ISS > 24				
Penetrating	70/72 (97.2)	26/31 (83.9)	0.0247	96/103 (93.2)
Blunt	49/57 (86.0)	12/25 (48.0)	0.0007	61/82 (74.4)
p value	0.0222	0.0086		0.0007

ISS, Injury Severity Score; ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] The p values were calculated between groups after overall χ^2 with $p < 0.0001$.

Table 3 Mortality by Airway Intervention and RTS[a]

	Predicted (%)[b]	ETI (%)	BVM (%)	p Value	Total (%)
RTS 0–2.00	82.8–97.3	175/179 (97.8)	22/22 (100.0)	1.000	197/201 (98.0)
RTS 2.01–5.99	19.3–63.9	10/22 (45.5)	13/32 (40.6)	0.7841	23/54 (42.6)
RTS 6.00–7.84	1.2–8.1	4/12 (33.3)	3/77 (3.9)	0.0056	7/89 (7.9)

RTS, Revised Trauma Score; ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] The p values were calculated between groups after overall χ^2 with $p < 0.0001$.
[b] According to Champion et al. (1989).[21]

icantly worse than those receiving BVM for both penetrating and blunt injuries. Within each intervention (ETI or BVM), patients with penetrating injuries did worse than those with blunt injuries. Patient groups with penetrating injuries receiving ETI had uniformly poor survival.

Revised Trauma Score

Patients with penetrating injuries had a lower RTS than those with blunt injuries (1.52 ± 2.70 vs. 3.93 ± 3.43, $p < 0.0001$). Survivors had higher RTS than nonsurvivors (6.58 ± 1.93 vs. 0.68 ± 1.64, $p < 0.0001$). Patients receiving ETI had a significantly lower mean RTS than those receiving BVM (0.89 ± 2.00 vs. 5.59 ± 2.88, $p < 0.0001$). Because of this, RTS was stratified into three ranges for comparison (0–2.00, 2.01–5.99, and 6.00–7.84). When compared with mortalities predicted by RTS,[21] ETI patients with an RTS > 6 had a higher mortality than expected and significantly worse than those with BVM (Table 3).

Table 4 subdivides patients by airway intervention, mechanism of injury, and RTS range. All groups with RTS < 2.01 fared poorly, with penetrating injuries being uniformly fatal. Overall, patients with penetrating injuries trended toward a higher mortality, although this was not always statistically significant. Patients with ETI never had a significantly lower mortality than the comparable BVM group.

TRISS-Predicted Survival

Table 5 lists observed versus predicted outcomes for patients with complete TRISS data (n = 344). Overall mortality was 68.0%, worse than the 57.7% predicted by TRISS ($z = +5.48$, $p < 0.001$). Patients with blunt injuries had mortality similar to that predicted, whether they received ETI (72.9% vs. 70.1%, $z = +0.96$, $p > 0.100$) or BVM (15.0% vs. 13.5%, $z = +0.57$, $p > 0.100$). However, patients with penetrating injuries had significantly higher than predicted mortality, whether they received ETI (95.5% vs. 82.1%, $z = +4.89$, $p < 0.001$) or BVM (56.5% vs. 41.2%, $z = +4.06$, $p < 0.001$).

Prehospital Time

The average prehospital time for all patients was 21.2 ± 8.9 minutes. Patients receiving ETI had statistically significantly longer prehospital times than those receiving BVM, although this difference was only 1.9 minutes (22.0 ± 9.0 vs. 20.1 ± 8.6 minutes, $p = 0.0256$). Patients with blunt injuries had significantly longer prehospital times than those with penetrating injuries (22.6 ± 9.7 vs. 20.0 ± 7.9 minutes, $p = 0.0018$). When comparing survivors and nonsurvivors, there was no significant difference either overall or in any subcategory (Table 6); however, because of the small number of ETI survivors (n = 6 for penetrating, n = 23 for blunt), the statistical power to detect a 3-minute difference was less than 40%.

DISCUSSION

The efficacy of prehospital ETI remains poorly studied and controversial. Lockey et al.[15] reviewed 492 patients who were intubated in the field without neuromuscular blockade

Table 4 Mortality by Airway Intervention, Mechanism of Injury, and RTS[a]

	ETI (%)	BVM (%)	p Value	Total (%)
RTS 0–2.00				
Penetrating	116/116 (100.0)	17/17 (100.0)	1.000	133/133 (100.0)
Blunt	59/63 (93.7)	5/5 (100.0)	1.000	64/68 (94.1)
p value	0.0144	1.000		0.0123
RTS 2.01–6.00				
Penetrating	7/11 (63.6)	7/9 (77.8)	0.6424	14/20 (70.0)
Blunt	3/11 (27.3)	6/23 (26.1)	1.000	9/34 (26.5)
p value	0.1984	0.0147		0.0038
RTS 6.01–7.84				
Penetrating	3/5 (60.0)	2/20 (10.0)	0.0377	5/25 (20.0)
Blunt	1/7 (14.3)	1/57 (1.8)	0.2083	2/64 (3.1)
p value	0.2222	0.1636		0.0173

RTS, Revised Trauma Score; ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] The p values were calculated between groups after overall χ^2 with $p < 0.0001$.

Table 5 Actual Deaths vs. Deaths Predicted by TRISS

	Actual (%)	Predicted (%)	z Score[a]	p Value
All patients	227/344 (68.0)	198 (57.7)	+5.48	<0.001
Penetrating BVM	26/46 (56.5)	18 (41.2)	+4.06	<0.001
Penetrating ETI	127/133 (95.5)	109 (82.1)	+4.89	<0.001
Blunt BVM	12/80 (15.0)	10 (13.5)	+0.57	>0.100
Blunt ETI	62/85 (72.9)	59 (70.1)	+0.96	>0.100

ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] According to Champion et al. (1981).[20]

and found one survivor (0.2%) who underwent thoracotomy at the scene. Durham et al.[12] showed that ETI prolonged successful cardiopulmonary resuscitation for survivors of emergency room thoracotomy. Copass et al.[11] showed that survivors of traumatic cardiac arrest were more likely to have been intubated in the field than nonsurvivors. That study contained 131 patients, only 24 of whom had penetrating injuries. Karch et al.,[23] however, did not show a statistically different intubation rate between survivors and nonsurvivors, although not all of their patients had cardiac arrest.

Winchell and Hoyt[14] suggested that ETI could improve outcomes in patients with severe head injuries, although in their study population aeromedical crews had access to neuromuscular blocking agents. This was not confirmed by Murray,[16] whose intubated patients actually had a higher relative risk of mortality when matched to nonintubated patients.

Gausche et al.[18] reported a prospective study in 830 pediatric patients, specifically comparing BVM versus ETI. Although only 296 of their patients were victims of trauma, no improvement in survival or neurologic outcome was found with ETI in any subgroup including the trauma subgroups (immersion, multiple trauma, head injury, or child maltreatment).

Rhee et al.[24] reviewed 42 traumatized patients with respiratory compromise in the field, 6 of whom were intubated. The remainder were given BVM or supplemental oxygen. They identified five patients who might have benefited from ETI in the field, but found no preventable deaths. They concluded that BVM is an effective means of ventilation in transport but did not report how many of the nonintubated patients received BVM versus supplemental oxygen.

Eckstein et al.[7] performed a retrospective study similar to ours. In their analysis, BVM was associated with a 5.3 times higher relative survival than ETI; blunt mechanism of injury was also associated with higher survival. ISS was higher in ETI than in BVM patients, as was the case in our study; this is why we also compared mortalities on the basis of ISS ranges. However, ISS alone may not be an accurate predictor of survival in the subset of patients requiring airway control: in our population, intubated patients with low a ISS (<13) still had a mortality in excess of 90%. ISS was designed to assess the severity of injury in blunt trauma from motor vehicle collisions, not penetrating trauma.[22]

RTS, in contrast, is a reflection of prehospital physiologic status that correlates with mortality.[21] In our study population, increasing RTS was associated with increasing survival in all patient groups, as expected. However, despite correcting for RTS and mechanism of injury, ETI patients still had a surprisingly high mortality (33%) for a higher RTS range where a survival of greater than 90% would be expected. Although this may be attributable to a relatively small number of patients in this subset (only 12 intubated patients with an RTS > 6), it does not alter the observation that, in our study population, in no comparison did patients receiving ETI have a significantly higher survival than those receiving BVM. Perhaps the need for intubation represents a separate factor for mortality, much as mechanism and age do in the TRISS model.

Most studies on trauma outcomes suffer from the shortcomings of being neither controlled nor prospective; our study is no exception to this. A recent analysis of the ALS literature found only one controlled study of 2,034 studies identified, and this contained only 16 patients.[25] This clearly underscores the difficulties inherent to this field of endeavor, both methodologic and ethical. A marked limitation of our study is that the two groups (ETI and BVM) may be different patient populations. The clinical decision to intubate may itself be a selection bias; because the ETI group was significantly more seriously injured, as measured by both ISS and RTS, we subgrouped patients by mechanism of injury, ISS, and RTS scores in an attempt to make groups of equivalently injured patients. However, ETI and BVM patients all still had some degree of respiratory failure in that they required assisted ventilation by either ETI or BVM. Furthermore, those receiving BVM may have failed attempts at intubation or not required intubation, or not had time to be intubated.

TRISS methodology[20,22] allows for the calculation of survival probability using RTS, ISS, age (< or > 55 years), and mechanism of injury (blunt or penetrating) on the basis of coefficients derived from the Major Trauma Outcome Study. Using these survival probabilities, the *z* statistic can be used to compare outcomes between the study population and the predicted norm (the Major Trauma Outcome Study popula-

Table 6 Prehospital Time by Intervention, Mechanism of Injury, and Survival[a]

	Survivors	Nonsurvivors	p Value
ETI			
Penetrating	23.8 ± 9.9	20.5 ± 8.2	0.3334
Blunt	26.7 ± 13.5	23.3 ± 8.4	0.1382
BVM			
Penetrating	17.0 ± 6.0	19.8 ± 7.3	0.0752
Blunt	21.1 ± 9.8	21.1 ± 7.3	0.9988
Total	21.2 ± 10.2	21.2 ± 8.2	0.9275

ETI, endotracheal intubation; BVM, bag-valve-mask ventilation.
[a] Mean ± SD in minutes; *p* values of post hoc *t* tests after analysis of variance with $p = 0.0008$.

tion). This has been suggested as an ideal means for comparing different subsets of trauma patients.[22] One would expect interventions that improve outcome to produce higher survivals than those predicted by TRISS. Applying TRISS analysis to our study population, ETI did not improve survival.

Using this methodology, Frankel et al.[13] compared outcomes for trauma patients intubated outside versus inside the hospital and found higher than predicted survivals for patients intubated in the field. That study did not specifically compare ETI to BVM. Of note, though, was that the predicted survival for those patients intubated in the field was only 2%, compared with a survival of 11% in our field-intubated patient population. This suggests a difference in EMS practices between New Orleans and the District of Columbia, possibly that D.C. paramedics intubate only the most moribund patients. Furthermore, in that study, ETI was performed in only 1.6% (58 of 3,574) of patients transported, compared with 5.4% in our population, suggesting that New Orleans paramedics are more likely to intubate in general. This might predispose toward a higher survival rate for ETI in that patients not needing airway control would receive it anyway. Despite this possibly more aggressive approach with a higher survival compared with the study by Frankel et al., ETI did not appear to improve survival compared with BVM in our patients when corrected for ISS and RTS.

There has also been debate over whether ALS for trauma increases prehospital times.[1,26,27] In our study, ETI was associated with longer prehospital times than BVM, although this added only 1.9 minutes on average and may not therefore be clinically significant. There was no difference in times between survivors and nonsurvivors in any group, although statistical power to detect a difference was low because of the small number of survivors. In our population, patients with blunt injuries had longer transportation times; this may have been caused by the need to extricate patients from motor vehicles, but this is mere speculation.

In summary, the efficacy of ALS versus BLS interventions in the prehospital setting remains contentious. Because of the limitations inherent in our study, it would be premature to state that ETI is harmful when compared with BVM. However, using TRISS methodology to compare observed versus predicted outcomes, and correcting for differences in ISS and RTS between ETI and BVM patients, prehospital endotracheal intubation in trauma patients does not appear to confer any survival advantage over bag-valve-mask ventilation in our trauma system.

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Book Review

***Color Atlas of Emergency Trauma*, by Diku P. Mandavia MD, Edward J. Newton MD, and Demitrios Demetriades MD, PhD, Cambridge University Press, New York, 2003, 295 pp., $150.00, ISBN: 0-521-78148-5.**

This text is a very exciting tour of trauma through a colorful lens. Popular trauma texts are replete with many black and white drawings and photographs while this book presents a unique colorful survey of excellent trauma photographs from head to toe. Surgical pearls that are not found in standard texts are also interspersed throughout the text. These key insights and specific procedures used in trauma care are further effectively illustrated with drawings. Classic X-rays and CT scans are utilized to elucidate physical examination findings demonstrated in the color photographs.

While the experienced trauma surgeon may gain little by reading this book, the medical student, paramedic, young trauma nurse, surgical resident, and trauma fellow will benefit from seeing lifelike color representations of injuries. The general surgeon who finds orthopedic trauma labyrinthine may also benefit greatly from the excellent illustration with corresponding radiographs.

In the age of evidence-based surgery, one criticism of this book is that many treatment options are stated without the benefit of a single reference. Certainly, the value of this text to individuals who teach trauma care would be greatly enhanced if it contained an accompanying CD of the illustrations found in the book, for use in slide presentations.

In summary, this book brings to "life" many trauma conditions that might otherwise take a lifetime of experience to encounter. It offers an enthusiastic, unique survey of the lesions found in trauma patients and will be an excellent introduction for many individuals attracted to the trauma field. Thus, this book may interest the readers of the *The Journal of Trauma* as a means to whet the appetite of young individuals interested in the care of the trauma patient.

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