The Time Cost of Prehospital Intubation and Intravenous Access in Trauma Patients

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Abstract

Objectives. The prehospital management of trauma patients remains controversial. Little is known about the time each procedure contributes to the on-scene duration, and this information would be helpful in prioritizing which procedures to perform in the prehospital setting. We sought to estimate the contribution of procedures to on-scene duration focusing on intubation and establishment of intravenous (IV) access. **Methods.** Data were provided by the Office of Emergency Planning and Response at the Mississippi Department of Health. Real-time prehospital patient-level data are collected by emergency medical services (EMS) providers for all 9-1-1 calls statewide. Linear regression was performed to determine the overall additional time for an average procedure and to calculate marginal increases in on-scene time associated with the establishment of IV access and with endotracheal intubation. Analyses were performed using Stata 9. **Results.** During 2001–2005, 192,055 prehospital runs were made for trauma patients. 121,495 (63%) included prehospital procedures. Average on-scene duration for those runs was 15:24 (minutes:seconds). On average, each procedure was associated with an addition of 1 minute to the on-scene duration (95% confidence interval [CI]: 58–62 seconds). A scene involving the establishment of IV access was 5:04 longer, while one involving tracheal intubation was 2:36 longer. **Conclusions.** We estimate the marginal increase in on-scene duration associated with the performance of an average procedure, establishment of IV access, and endotracheal intubation. There are policy and planning implications for the time trade-off of prehospital procedures, especially discretionary ones. **Key words:** prehospital; trauma; procedures; IV access; intubation.

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Introduction

A complex network of trauma systems exists in the United States,[1] providing timely access to definitive trauma care[2] and a substantial survival advantage.[3] Nevertheless, the prehospital management of seriously injured patients remains controversial.[4–7] Prehospital advanced life support (ALS) interventions for cardiac care have been shown to provide a survival benefit,[8,9] although the justification for corresponding ALS procedures in trauma care remains under debate.[10–24]

In the debate over the most appropriate use of prehospital ALS for trauma patients, the importance of certain prehospital procedures, particularly intravenous (IV) access and intubation, has been repeatedly questioned.[24–29] A key issue surrounding these procedures is the potentially long periods of time that they take to execute in the field, generating a difficult trade-off for prehospital planners who are forced to choose between a possibly lifesaving procedure and the threat to life imposed by an increase in the overall time to definitive, often surgical, care. However, because little is known about the amount of time that specific procedures contribute to the total prehospital time interval for trauma patients, planners are unable to effectively manage this trade-off. With this in mind, we conducted a large-scale study to determine the incremental increase in on-scene time associated with prehospital providers' performing procedures. Specifically, we sought to determine the additional on-scene time associated with prehospital intubation and IV access in trauma patients.

Methods

Population and Setting

Mississippi has a population of 2.9 million and a land mass of 48 thousand square miles. Emergency medical services (EMS) in the state are coordinated through the Bureau of Emergency Medical Services (BEMS), a component of the Mississippi Department of Health. All ambulance services and prehospital providers in Mississippi are licensed and regulated by this central agency. Mississippi uses the Department of Transportation's National Standard Curricula as the minimum training standards for all levels of EMS providers. BEMS uses a tired provider system ranging from medical first responder to a paramedic partnered with an emergency medical technician (EMT). Ninety-eight percent of the population of Mississippi has access to a paramedic first responder.

In addition, BEMS acts as the lead agency for trauma care within the state in cooperation with the Mississippi Trauma Advisory Council. The Mississippi Trauma Care System is a voluntary system designating level 1–5 trauma centers. The state has a total of 71 trauma centers, 9% of which are level 1 or 2.[30] Approximately 60.5% of the population has access to a level 1 or 2 trauma center within 60 minutes (ground and air transport).

Design

Our data were obtained by the Office of Emergency Planning and Response at the Mississippi Department of Health. The Mississippi Emergency Medical Services Information System (MEMSIS) provides statewide patient-level incident data. The data are collected through a comprehensive software system in real time by the EMS provider. MEMSIS was designed to aid the state in managing the information and processes associated with patients and providers. Quality assurance of the data is performed internally by Mississippi EMS. Details on the data system are publicly available.[31] Our data represent all prehospital calls for trauma over the five-year period between 2001 and 2005. The data were free and publicly available to researchers through the Mississippi Department of Health. The study was deemed exempt by the institutional review board (IRB) given the de-identified nature of the data.

Analytical Methods

Our cohort was identified as including any trauma-related prehospital calls over the five-year period from 2001 to 2005. Trauma calls were identified in MEMSIS by the on-scene providers in real time. We studied only trauma calls involving at least one prehospital procedure and resulting in transport to a hospital/trauma center. We excluded calls in which no procedures were performed because they may represent a systematically different scene, injury severity, and level of urgency.

We performed a retrospective cohort study of secondary data using ordinary least squares (linear) regression to determine the marginal increase in on-scene time associated with performing an average procedure. To do this, we used on-scene duration as the dependent variable while controlling for multiple potential confounders. We developed multiple models (five separate regressions) to demonstrate the stability of the estimate. In the first regression, only the number of procedures performed, a time trend, and the indication for the prehospital call were entered into the model as independent variables. In subsequent regressions, the model was expanded to include location of the run, race of the patient, month of the year, and two important prehospital intervals (first response time and transport interval). These prehospital intervals were used as surrogates to account for urban/rural differences in the performance of discretionary procedures. The variables location of the incident, race of the patient, and month of the year were included to account for unmeasured confounders. That is, differences in care that are systematically associated with month of the year, such as weather conditions, can be indirectly controlled for through this sort of modeling. The analysis was performed using Stata 9.0 (StataCorp, College Station, TX).

In a separate analysis, we categorized all available procedures by type. These procedure bundles were categorized as airway related, breathing related, circulation related, and disability related. Airway-related procedures included airway management, suctioning, and intubation. Breathing-related procedures included breathing management, oxygen therapy, end-tidal carbon dioxide (CO_2), ventilation, and pulse oximetry. Circulation-related procedures included any form of vascular access, drug administration, cardiopulmonary resuscitation, and defibrillation. Disability-related procedures included extrication, spinal immobilization, and splinting. Linear regression was again performed to demonstrate the increase in on-scene time associated with establishing IV access and endotracheal intubation. This was done by using on-scene duration as the dependent variable while controlling for procedure bundles as described above. This model allows us to demonstrate the additional time required for the interventions of interest in the presence and absence of other procedures.

Results

During 2001–2005, 192,055 prehospital runs were made for trauma patients. Of the 192,055 calls, 121,495 (63%) included prehospital procedures and were included in the analysis. In our sample, there was at least one paramedic responding to the call 98% of the time. Twenty-four percent of prehospital calls were attended to by community-based/local fire departments, 25% of calls were attended to by hospital-based agencies, and the remainder (51%) of calls were attended to by large private firms. The leading reasons for prehospital trauma calls were motor vehicle crashes (59%) and falls (28%). The average age of patients was 41 years (standard deviation [SD] 24 years). Most of the patients were white (56%) or African American (41%). The locations of trauma calls were broadly distributed to city streets (23%), county roads (10%), highways (26%), and residences and other locations (41%). Prehospital intervals measured include the response interval (8:12 [minutes:seconds]), on-scene interval (15:24), and transport interval (13:25) (Fig. 1). On average, 2.5 procedures were performed on patients included in the analysis. Summary demographics are available in Table 1.

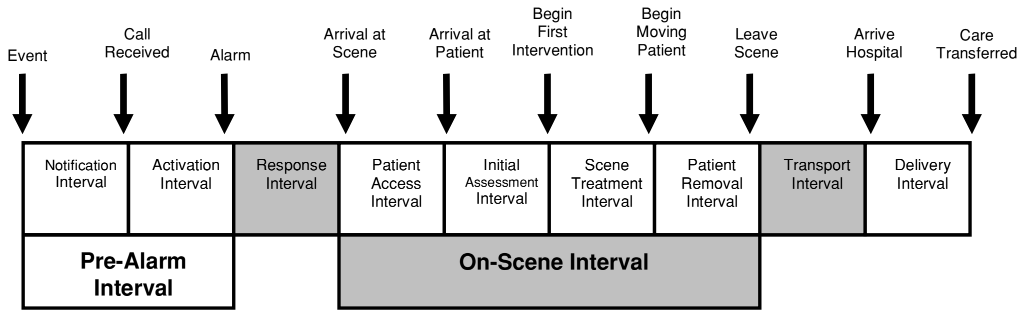

Figure 1. Specific intervals and points in time for trauma patients. The shaded intervals were included in the analysis. Reprinted with permission from: Carr BG, Caplan J, Pryor JP, Branas CC. A meta-analysis of prehospital care times for trauma. Prehosp Emerg Care. 2006;10:198–206.

Average on-scene duration was 15:24 (minutes: seconds). In our first analysis, we sought to determine the average increase in on-scene time associated with performing a procedure in the prehospital setting. The multiple regression models that were performed to demonstrate the robustness of the time estimate are demonstrated in Table 2. With the inclusion of very few variables (column 1), the average time increase per additional procedure was 1 minute. As the models were made more complex (columns 2–5), it can be seen that there was very little change in the additional time associated with the performance of a prehospital procedure. On average, each procedure was associated with an additional 1 minute in on-scene duration (95% confidence interval [CI]: 58–62 seconds). This result, and its stability across the five models, is robust to the inclusion of individual attendant fixed effects. Hence, unobserved systematic differences across EMTs potentially stemming from differences in training, experience, and talent do not account for this relationship.

In our second analysis, we sought to determine the specific additional scene time associated with performing an intubation and with establishing IV access. As is intuitive, these procedures are rarely performed in isolation. In our data, no intubations and fewer than 3% of IV placements were reported without other concomitant procedures. To account for the complex notion that the time associated with intubation cannot be separated from the time required for airway positioning, suctioning, and other procedures, we partitioned observations into mutually exclusive procedure bundles. Table 3 demonstrates the additional scene time associated with the procedures in question, intubation and IV access. We provide the additional scene time associated with performance of the procedure as an isolated event (when possible), as well as the time associated with the procedure when additional actions were performed at the scene. No intubations were performed in isolation. Intubations that had procedures included in the airway bundle and the breathing bundle were associated with an increased scene time of 3:39. Additional scene time associated with intubation varied between 2:36 and 3:39 depending on the types procedures that accompanied it (Table 3). The additional time cost associated with establishing IV access in isolation was approximately 2 minutes. When IV access was accompanied by other procedures, the associated increase in time was between 3:17 and 5:04 (Table 3).

Table 1. Summary Data Characteristics, 2001–2005

	Mean	SD
Trauma type		
Motor vehicle crash	58.5%	0.493
Assault	7.1%	0.257
Stabbing	2.4%	0.155
Fall	28.1%	0.450
Gunshot	1.9%	0.136
Pedestrian incident	1.9%	0.137
Patient characteristics		
Age, years	41.158	23.944
Race		
African American	40.9%	0.492
White	55.9%	0.497
Other race	3.2%	0.176
Gender—female	53.4%	0.499
Incident location		
City street	22.6%	0.418
County road	10.4%	0.305
Highway	26.4%	0.441
Residence	23.6%	0.425
Other location	17.1%	0.377
EMS performance		
Response interval, min	8.189	6.027
On-scene interval, min	15.419	8.565
Transport interval, min	13.425	9.456
Number of procedures	2.494	1.764

EMS = emergency medical services; SD = standard deviation.

Discussion

We demonstrate an increase in on-scene time associated with the performance of prehospital procedures. In general, each procedure performed is associated with an additional 1 minute of on-scene time. We further investigated two procedures thought to be important in managing trauma patients to determine the incremental time cost associated with performing these procedures. Intubation was associated with an increased

TABLE 2. Estimated Change in On-Scene Interval Using Linear Regression Models

	Model				
	[1]	[2]	[3]	[4]	[5]
Number of Procedures	**1 : 00**	**0 : 58**	**0 : 58**	**0 : 58**	**0 : 56**
Yearly time trend	**−0 : 08**	**−0 : 08**	**−0 : 08**	**−0 : 08**	**−0 : 09**
Incident type					
Assault	**−2 : 47**	**−3 : 09**	**−3 : 02**	**−3 : 02**	**−2 : 54**
Stabbing	**−4 : 47**	**−5 : 15**	**−5 : 06**	**−5 : 05**	**−4 : 57**
Falling	**−1 : 02**	**−1 : 34**	**−1 : 49**	**−1 : 49**	**−1 : 48**
Gunshot	**−3 : 56**	**−4 : 14**	**−3 : 59**	**−4 : 00**	**−3 : 49**
Pedestrian	**−4 : 25**	**−4 : 13**	**−4 : 06**	**−4 : 07**	**−4 : 01**
Motor vehicle crash	–	–	–	–	–
Incident location					
City street		**−1 : 27**	**−1 : 23**	**−1 : 23**	**−1 : 17**
County road		**−0 : 29**	**−0 : 24**	**−0 : 25**	**−0 : 24**
Highway		−0 : 01	0 : 02	0 : 02	0 : 06
Other location		–	–	–	–
Age			**0 : 00.5**	**0 : 00.4**	**0 : 00.5**
Race					
African American indicator			**−0 : 17**	**−0 : 17**	**−0 : 15**
White indicator			–	–	–
Other race			**0 : 17**	**0 : 17**	**0 : 22**
Female			**0 : 19**	**0 : 19**	**0 : 20**
Month of year					
January				−0 : 10	−0 : 08
February				−0 : 11	−0 : 10
March				**−0 : 22**	**−0 : 22**
April				**−0 : 31**	**−0 : 31**
May				**−0 : 41**	**−0 : 40**
June				**−0 : 35**	**−0 : 35**
July				**−0 : 31**	**−0 : 31**
August				**−0 : 41**	**−0 : 40**
September				**−0 : 35**	**−0 : 35**
October				−0 : 13	−0 : 13
November				−0 : 14	−0 : 13
December				–	–
First responce time					**−0 : 03**
Transport time					**0 : 04**
Constant	**13 : 56**	**14 : 35**	**14 : 15**	**14 : 39**	**14 : 07**

Notes: Bolded cells indicate significance at the 0.05 level.
First response and transport times are measured in minutes.
Times are shown in minutes:seconds.

TABLE 3. Incremental Increases in On-Scene Time for Intubation and Intravenous Access

	Frequency	Effect (In Mins:Secs)	Lower CI	Upper CI
Baseline On-Scene interval		13:40***	13:06	14:14
Intubation Only	–	–		
Intubation with A/B	18	3:39		
Intubation with C/D	70	3:27**	0:42	6:13
Intubation with A/B and C/D	791	2:36***	1:27	3:45
IV Access Only	1,059	1:54***	1:18	2:30
IV Access with A/B	1,072	3:17***	2:33	4:01
IV Access with C/D	6,925	4:43***	4:07	5:20
IV Access with A/B and C/D	32, 261	5:04***	4:39	5:29
Any A/B (without intubation or IV)	24, 904	0:50***	0:37	1:04
Any C (without intubation or IV)	20,319	0:50***	0:30	1:09
Any D (without intubation or IV)	64,336	1:50***	1:27	2:14

A/B = airway or breathing-related intervention (airway management, suctioning, oxygen, etc.); C = circulation-related intervention (vascular access, cardiopulmonary resuscitation [CPR], defibrillation, etc.); CI = confidence interval; D = disability-related intervention (extrication, splinting, immobilization, etc.); C/D = circulatory- or disability-related intervention; IV = intravenous.
Notes: ***indicates significance at the 0.01 level. **indicates significance at the 0.05 level, and *indicates significance at the 0.10 level.

scene time between 2:36 and 3:39, and IV access was associated with an increase in on-scene duration between 3:17 and 5:4. Our analysis used a large data set collected in real time by prehospital providers, and we employed methods developed expressly to demonstrate the stability of a point estimate.

The time associated with intubation is comparable to a recent analysis that used probability matching in 570 field intubations to demonstrate that intubation was associated with an increased unadjusted scene time between 4.35 and 7.16 minutes, and a total out-of-hospital time of between 5 and 10 minutes.[24] Although our times are somewhat shorter, we were able to account for additional procedures performed at the scene rather than solely the additional prehospital time for a scene at which an intubation was performed.

Early investigations of the prehospital time required for establishment of IV access demonstrated shorter times than what we demonstrated in our analysis. A study of 97 patients demonstrated that IV lines required 2.5 minutes in the prehospital setting,[32] a study of 58 patients reported 1.6 minutes in urban settings and 1.4 minutes in nonurban settings,[33] and a study of 125 patients reported that IV access took 2.20 ± 0.20 minutes in trauma patients and 2.71 ± 0.18 minutes in nontrauma patients.[34] The most recent analysis, however, demonstrated times more comparable to ours, with an average mean time for IV placement of 4.4 ± 2.8 minutes.[35]

Understanding how long procedures take in the prehospital setting is important only if the procedures are discretionary. Beyond a certain degree of maximizing efficiency, most prehospital intervals, including prealarm intervals, are fixed. Although drive times (response interval, transport interval) may vary according to speed of travel, distances are fixed and little can be done to decrease these times. The most effective way to decrease prehospital times is to decrease the on-scene duration. Here we face a time trade-off. If lifesaving maneuvers in the field increase the likelihood of survival, they should be performed. However, if these maneuvers increase mortality by delaying definitive care, they should be avoided. Our data cannot determine whether intubation and establishment of IV access should be performed because these decisions need to be tailored to the individual patient and the individual EMS system given the predicted transport interval. However, by providing an estimate of time cost for such prehospital procedures, our data can be used as a benchmark for EMS providers when weighing this time trade-off.

The Institute of Medicine's (IOM's) recent report, "The Future of Emergency Care," highlighted the importance of prehospital care and emphasized the need to extend evidence-based practices in the prehospital arena.[36] Providing estimates of the time costs of prehospital procedures is an important step in assessing the value of prehospital procedures, such as IV access and intubation, delivered to trauma patients. Future efforts should attempt to quantify the benefit of these interventions so that a formal cost–benefit analysis can be performed. Important factors that will need to be considered in developing this analysis include the distance to definitive care and the degree to which prehospital procedures are discretionary. There is likely not a one-size-fits-all solution to the question of which procedures should be performed in the prehospital setting. However, by quantifying the time cost of prehospital procedures, we hope to contribute to the body of literature that informs policy and future studies.

Limitations

Our study is the largest ever to estimate the time associated with performing prehospital procedures and uses a data set that is collected in real time by the paramedics responding to the call. There are, however, limitations. Most importantly, this is a retrospective analysis using a preexisting data set and, as such, we can demonstrate the association between procedures and additional time spent at the scene but cannot definitively attribute this as the reason for the longer scene times. In addition, we identified EMS calls for trauma by the categorization system preexisting in the MEMSIS data set. While this likely represents a broad definition of trauma, we included only patients who had at least one procedure performed out of hospital, which may serve as a surrogate for severity.

Further, the state of Mississippi may not be representative of the entire United States and, as such, the estimates of time to perform procedures may not be generalizable. In addition, there may be statewide factors including but not limited to highway infrastructure, prehospital regulations, and differing types of ambulance companies that may impact our data. However, most of the ambulance companies in Mississippi are national corporations with national rather than local guidelines. Although infrastructure may markedly impact travel times, there is little reason to believe that on-scene durations would be impacted or that the paramedics in our sample are systematically different than all U.S. paramedics.

It is plausible, given data limitations, that some of the invasive procedures of interest were performed en route as opposed to on scene. In that case, our results underestimate the true time cost of prehospital interventions. Our data include the number of attempts of each procedure. Hence, the additional scene time associated with a given procedure nests its typical number of attempts. For example, this allows us to estimate the additional time associated with intubation as opposed to the time cost of an intubation attempt. Unfortunately, we were not able to risk adjust using physiologic, anatomic, or injury scoring systems because these data were unavailable. Finally, any data collected in real time by providers are prone to human data-collection error.

CONCLUSIONS

Although largely unproven,[37] the ideas of the "golden hour" and the trimodal distribution of death[38] are firmly entrenched in the framework of trauma care. The degree to which definitive care at the trauma center should be delayed for prehospital procedures has been debated for decades, without clear consensus.[14–23,39] In our analysis, intubation was associated with an increased scene time between 2:36 and 3:39 (minutes:seconds), and IV access was associated with an increase in on-scene duration of 3:17 and 5:4. We believe that providing quantifiable time costs for IV access and endotracheal intubation will help EMS and trauma planners to perform cost–benefit analysis and to optimize the prehospital care of trauma patients.

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References

1. Hoff WS, Schwab CW. Trauma system development in North America. Clin Orthop Rel Res. 2004;422:17–22.
2. Branas CC, MacKenzie EJ, Williams JC, et al. Access to trauma centers in the United States. JAMA. 2005;293:2626–33.
3. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006;354(4):366–78.
4. Nathens AB, Brunet FP, Maier RV. Development of trauma systems and effect on outcomes after injury. Lancet. 2004;363:1794–801.
5. Salamone JP, Ustin JS, McSwain NE, Feliciano DV. Opinions of trauma practitioners regarding prehospital interventions for critically injured patients. J Trauma. 2005;58:509–17.
6. Liberman M, Mulder D, Sampalis J. Advanced or basic life support for trauma: meta-analysis and critical review of the literature. J Trauma. 2000;49:584–99.
7. Sukumaran S, Henry JM, Beard D, et al. Prehospital trauma management: a national study of paramedic activities. Emerg Med J. 2005;22:60–3.
8. Adgey J, Scott M, Allen J, et al. Management of VF outside hospital. Lancet. 1969;1:1169–71.
9. Pantridge J, Geddes J. Mobile intensive-care unit in the management of myocardial infarction. Lancet. 1967;2:271–5.
10. Gold CR. Prehospital advanced life support vs "scoop and run" in trauma management. Ann Emerg Med. 1987;16:271–5.
11. Keller RA, Forinash M. EMS in the United States: a survey of providers in the 200 most populous cities. J Emerg Med Serv. 1990;15(1):79–99.

12. Braun O, McCallion R, Fazackerley J. Characteristics of midsized urban EMS systems. Ann Emerg Med. 1990;19:536–46.
13. Fishman PE, Branas CC. Urban trauma transport—no need for medical personnel at all? Proceedings of the European Congress of Trauma and Emergency Surgery, 2004;7–16.
14. Sampalis JS, Lavoie A, Williams JI, Mulder DS, Kalina M. Impact of on-site care, prehospital time, and level of in-hospital care on survival in severely injured patients. J Trauma. 1993;34:252–61.
15. Feero S, Hedges JR, Simmons E, Irwin L. Does out-of-hospital EMS time affect trauma survival? Am J Emerg Med. 1995;13:133–5.
16. Branas CC, Sing RF, Davidson SJ. Urban trauma transport of assaulted patients using nonmedical personnel. Acad Emerg Med. 1995;2:486–93.
17. Gervin AS, Fischer RP. The importance of prompt transport of salvage of patients with penetrating heart wounds. J Trauma. 1982;22:443–8.
18. Jacobs LM, Sinclair A, Beiser A, D'Agostino RB. Prehospital advanced life support: benefits in trauma. J Trauma. 1984;24:8–13.
19. Cunningham P, Rutledge R, Baker CC, Clancy TV. A comparison of the association of helicopter and ground ambulance transport with the outcome of injury in trauma patients transported from the scene. J Trauma. 1997;43:940–6.
20. Petri RW, Dyer A, Lumpkin J. The effect of prehospital transport time on the mortality from traumatic injury. Prehosp Disaster Med. 1995;10(1):24–9.
21. Pepe PE, Wyatt CH, Bickell WH, Bailey ML, Mattox KL. The relationship between total prehospital time and outcome in hypotensive victims of penetrating injuries. Ann Emerg Med. 1987;16:293–7.
22. Smith JP, Bodai BI, Hill AS, Frey CF. Prehospital stabilization of critically injured patients: a failed concept. J Trauma. 1985;25:65–70.
23. Seamon MJ, Fisher CA, Gaughan J, et al. Prehospital procedures before emergency department thoracotomy: "scoop and run" saves lives. J Trauma. 2007;63:113–20.
24. Cudnik MT, Newgard CD, Wang H, Bangs C, Herrington R. Endotracheal intubation increases out-of-hospital time in trauma patients. Prehosp Emerg Care. 2007;11:224–9.
25. Bochicchio GV, Scalea TM. Is field intubation useful? Curr Opin Crit Care. 2003;9:524–9.
26. Davis DP, Vadeboncoeur TF, Ochs M, Poste JC, Vilke FM, Hoyt DB. The association between field Glasgow Coma Scale score and outcome in patients undergoing paramedic rapid sequence intubation. J Emerg Med. 2005;29:391–7.
27. Davis DP, Peay J, Sise MJ, et al. The impact of prehospital endotracheal intubation on outcome in moderate to severe traumatic brain injury. 2005;58:933–9.
28. Bulger EM, Copass MK, Sabath DR, Maier RV, Jurkovich GJ. The use of neuromuscular blocking agents to facilitate prehospital intubation does not impair outcome after traumatic brain injury. J Trauma. 2005;58:718–24.
29. Spanjersberg W, Ringburg A, Bergs B, et al. Prehospital chest tube thoracostomy: effective treatment or additional trauma? J Trauma. 2005;59:96–101.
30. EMS Annual Report FY 05, Mississippi Department of Health. Available at: http://www.ems.doh.ms.gov/pdf/annual_rpt_fy 2005.pdf. Accessed February 13, 2007.
31. National EMSC Data Analysis Resource Center. State-of-the-Art EMS Data Collection Systems: The Mississippi MEMSIS System. Available at: http://www.nedarc.org/nedarc/media /pdf/EMS_Mississippi_2003.pdf. Accessed April 13, 2008.
32. Jones SE, Nesper TP, Alcouloumre E. Prehospital intravenous line placement: a prospective study. Ann Emerg Med. 1989;18:244–6.
33. Spaite DW, Valenzuela TD, Criss EA, Meislin HW, Hinsberg P. A prospective in-field comparison of intravenous line placement by urban and nonurban emergency medical services personnel. Ann Emerg Med. 1994;24:209–14.
34. Pons PT, Moore EE, Cusick JM, Brunko M, Antuna B, Owens L. Prehospital venous access in an urban paramedic system—a prospective on-scene analysis. J Trauma. 1988;28:1460–3.
35. Minville V, Pianezza A, Asehnoune K, Cabardis S, Smail N. Prehospital intravenous line placement assessment in the French emergency system: a prospective study. Eur J Anaesthesiol. 2006;23:594–7.
36. Institute of Medicine of the National Academies. Emergency Medical Services: At the Crossroads. Washington, DC: National Academies Press, 2006.
37. Lerner EB, Moscati RM. The golden hour: scientific fact or medical "urban legend." Acad Emerg Med. 2001;8:758–60.
38. Trunkey DD. The trimodal distribution of death after injury. Sci Am. 1983;249(2):28–53.
39. Harrington DT, Connolly M, Biffl WL, Majercik SD, Cioffi WG. Transfer times to definitive care facilities are too long; a consequence of an immature trauma system. Ann Surg. 2005;241:961–8.
40. Carr BG, Caplan J, Pryor JP, Branas CC. A meta-analysis of prehospital care times for trauma. Prehospital Emergency Care 2006; 10(2): 198–206.