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Barriers to incident notification in a regional prehospital setting

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ABSTRACT

Background The identification and monitoring of critical incidents or adverse events and error reporting is a relatively new area of study in the prehospital setting. In 2005, we commenced a prospective descriptive study of the implementation of a Critical Incident Monitoring process in a rural/regional pre-hospital setting. The objective of the project was to describe the nature and incidence of errors detected in the management of prehospital trauma with the ultimate aim of identifying processes to reduce or mitigate such incidents. This paper describes the barriers to reporting critical incidents identified during the 3-year study.

Method This study used a qualitative approach involving the triangulation of a number of ethnographic methodologies, including unscripted focus groups, informal interviews and qualitative aspects of surveys utilised in a broader research project. Prevailing themes were fed back to participants in an iterative process to further explore perceptions and beliefs regarding these concepts. The final analysis of themes is descriptively presented.

Results A number of barriers were identified and categorised into seven themes. These themes were; Burden of reporting, fear of disciplinary action, fear of potential litigation, fear of breaches of confidentiality and fear of embarrassment, concern that 'nothing would change' even if the incident was reported, lack of familiarity with process and impact of 'blame culture'.

Conclusion There are numerous barriers to reporting critical incidents. One of the key approaches which may alleviate many of the barriers to reporting is shifting to a systems based focus rather than an individual 'shame and blame' approach. The underlying barriers lie in the culture of the profession, and appear consistent across other health care disciplines.

BACKGROUND

The systematic identification, monitoring and reporting of critical incidents is a relatively new area of study in the prehospital setting. There is considerable literature examining incident monitoring and adverse event tracking within the hospital environment[1]; in such areas as surgery,[2] anaesthesia,[3] intensive care[4] and emergency departments.[5] Unfortunately, literature pertaining to the prehospital environment has been limited[6 7] until fairly recently.[8 9] The Consultative Committee on Road Traffic Fatalities (CCRTF) published a number of reports covering the years 1992–2003.[10] Boyle recently synthesised the prehospital data from these reports, concluding that there was a large number of incidents and that there had been a recent increase since the creation of a local trauma system and introduction of Advanced Life Support training.[11]

One of the earliest papers on error reporting in the prehospital setting dates back to 1987 and examined the impact and utilisation of a computer based reporting system.[12] Whilst many of the features of a 'blame and shame' culture as opposed to a more systems focused processes are still seen in its methodology, it incorporated many features of modern incident monitoring processes.

Boyle and Archer examined the evidence surrounding error reporting and the feasibility of an incident monitoring system within the Victorian prehospital environment.[6] The authors confirmed that current incident reporting practice is 'haphazard at best', and that improved methods for identification of errors in clinical practice will improve patient care. They suggested the implementation of a model that identifies errors that would otherwise go undetected, and support an option of anonymous reporting by clinicians. Furthermore, they found unanimous agreement that the Emergency Medical Services are ready to implement incident monitoring methodology, and "[n]o barriers were envisaged to impede the early implementation, provided the essential feature of confidentiality and privacy, and feedback to staff were maintained, and the organisational culture change from 'blame' to safety and reporting".[6]

In 2005, the then Barwon region of Rural Ambulance Victoria commenced a prospective descriptive study of the implementation of a critical incident monitoring (CIM) process in a rural/regional pre-hospital setting, the methodology of which has been previously described.[13] The objective of the project was to describe the nature and incidence (the number of new cases identified during the study period) of errors detected in the management of prehospital trauma with the ultimate aim of identifying processes to reduce or mitigate such incidents.

This paper describes the barriers to reporting critical incidents identified during a 3-year CIM study.[13]

METHODS

Study design

A qualitative approach involving the triangulation of a number of ethnographic methodologies was employed. These included unscripted focus groups, informal interviews and qualitative aspects of surveys utilised in the CIM Project described above. Institutional ethics approval was obtained for the life of the project and all participants in the research provided written consent.

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Study setting and population

Prehospital ambulance personnel and management staff were the subjects of this methodology, which was part of the larger CIM project. The project was the result of collaboration between RAV and Barwon Health through the Geelong Hospital Emergency Department. The project ran from July 1st 2005 to June 30 2008. The population was derived from the then Rural Ambulance Victoria (RAV, now a part of Ambulance Victoria) in the Barwon region. This area covers approximately 10 600 square kilometres in South Western Victoria serving a population over 240 000. There are between 18 000–20 000 ambulance cases per year with 112 operational personnel serving the region, All operational staff were eligible for inclusion in this study. The Geelong Hospital is a tertiary regional centre with an adult and paediatric case mix. It is the only public tertiary hospital in the region and provides all specialities except neurosurgery (cases are transferred to metropolitan neurosurgical centres). The Emergency Department (ED) manages more than 45 000 patients per annum.

Study methods and analysis

A purposive sample was employed to distil perceptions and data regarding perceived barriers to incident reporting in the prehospital setting. Prevailing themes were then crystallised and definitive categories were identified. Prevailing themes were fed back to participants in an iterative process at subsequent focus groups. This allowed the groups to further explore perceptions and beliefs regarding these concepts and to validate the themes as being central to reducing the likelihood of incident reporting. To further maximise validity, triangulation of three main complimentary methodologies was utilised:

- Unstructured discursive focus groups utilising senior, management and operational RAV personnel and senior ED staff. These were conducted both in the inception phase of the CIMS project, during the pilot phase and at a variety of junctures throughout the 3-year project. The management and oversight committees of the CIMS project often functioned as focus groups facilitators with examination of ongoing barriers to incident reporting part of the agenda.
- Informal interviews with operational RAV personnel conducted by the authors and other researchers of the CIMS project. Key clinical leaders and those held in high esteem amongst operational personnel were identified and informally interviewed regarding perceived barriers to reporting. These occurred through the life of the project and were seen as an essential part of the project to encourage awareness and interest in the project as well as elicit perceptions regarding barriers.
- Qualitative portions of surveys utilised in the CIMS project (which were offered to all operational personnel) examined to elucidate interest, knowledge and free commentary on incident reporting and any perceived barriers.

The final analysis of themes is descriptively presented and where appropriate simple qualitative descriptive statistics are employed.

RESULTS AND DISCUSSION

A number of barriers were identified and were categorised into the following seven themes:

- Burden of reporting
- Fear of disciplinary action
- Fear of potential litigation
- Fear of breaches of confidentiality and fear of embarrassment
- Concern that 'nothing would change' even if the incident was reported
- Lack of familiarity with process
- Impact of 'blame culture'

Burden of reporting

The burden of reporting incidents was seen by many as an important issue. The need for a mechanism that allowed reporting of incidents in a timely fashion was seen as critically important. A mechanism which is quick and simple to complete, and is readily available in a range of locations (ie, ambulance branches and hospital emergency department) is of value. Paramedics felt that they would be less likely to report an incident if they were not able to easily access a mechanism to report the incident, or if a period of time had elapsed following the incident.

> 'I'll happily report incidents as they occur so long as there is a quick and easy to use system in place. I don't want to be wasting time finding and filling out complex forms when I have little downtime between jobs anyway'.

Another participant said, '…we have too many other issues to cope with than to worry about filling out reports'. When participants were asked why they failed to report a critical incident following an occurrence, many reported they 'hadn't got around to it', 'forgot' or stated, 'no reason'. A study of 139 primary care providers identified four factors which they believed to be central to making error reports. The burden of making a report was the most commonly mentioned barrier.[14]

Fear of disciplinary action/fear of potential litigation

The project team delivered significant education prior to the introduction of the CIM project to try to address this fear. Despite participants being informed that the aim of the project was to identify systematic shortfalls rather than focussing on individual performance, and promoting the philosophy of a 'blame free' culture, staff cited fear of disciplinary action as a significant barrier to reporting. When participants were asked how the rate of participation could be improved, several suggested that issues surrounding indemnity from prosecution needed to be clarified. Previous research has identified similar fears amongst medical[15 16]and nursing disciplines.[17] To a lesser extent, participants were concerned about their own liability if they admitted to an incident which may have contributed to an adverse outcome for a patient in their care. Concerns around responsibility and liability are common amongst health care providers more broadly.[18] Interestingly, despite fear of disciplinary action, Emergency Medical Services (EMS) staff were found to be more likely to report severe errors compared to minor errors.[19] In this project the problem of potential for litigation was resolved by the systematic de-identification of all retained data for the project so no possible link to a specific patient or specific paramedic was possible. Statutory Immunity for the project was explored as an option, but was not feasible.

Fear of breaches of confidentiality/fear of embarrassment

Participants described some anxiety around their ability to remain anonymous. Several paramedics were sceptical regarding the ability of the 'system' to maintain their confidentiality and some participant's cited this concern as a potential barrier to reporting incidents. Participant's felt that being linked to certain types of critical incidents could be embarrassing within their peer group and may impact on their likelihood of being considered for promotion.

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Concern that 'nothing would change' even if the incident was reported

Participants described a lack of faith that even though they may report an incident, the problem may not be dealt with by those responsible. Again, during the education program, participants were reassured that one of the important objectives of the project was to identify, and then implement changes to reduce the likelihood of the same incident from occurring again. One participant, whose opinions were extremely well respected amongst the regional staff, was far from supportive of the process initially. He commented,

> "I really don't think this system will work. All it does is provides ammunition for the managers to come down on you. … The times I have reported something, they have always said, they'll look into it but nothing ever comes of it."

This senior paramedic was invited to participate as a debrief facilitator at several focus groups and following this exposure, his opinion regarding the utility of the project change completely. He acknowledged,

> "At first I was a little sceptical of this project, including it's motives, however now having seen the number of incidents it identifies, which otherwise would have gone unnoticed, I can see its value…I'm sold on it!…It is far more supportive of our guys than I had thought it was going to be".

Waring believes that the medical culture itself has deeply ingrained values and this in itself diminishes the perceived significance of incident reporting. His study revealed that many doctors regard incident reporting as 'pointless' or a 'waste of time' since many of the incidents are unavoidable and therefore see little benefit.[18] Repeated reporting to higher authorities to no avail would seem to reinforce this belief. Attempts were made during the CIM project to report incidents which could be potentially resolved or mitigated to relevant authorities as identified, to enable timely resolution.

Lack of familiarity with the process

Over the course of the project several new staff commenced working within the study setting. Whilst project staff tried to catch up with new staff during their induction phase to explain the project, it appears that some were missed. Some participants stated they had not reported a critical incident as they, "…only started recently and didn't know I could". An anonymous survey which was administered two thirds of the way through the project identified 6.3% of respondents who stated they were not aware of the project. This was despite project posters being displayed around the workplace, group email feedback and updates being provided at compulsory professional development days (two per year). Other projects have reported high levels of lack of awareness (up to 90%) and difficulty understanding who to report to in the early stages of implementing reporting processes.[8]

Impact of 'blame culture'

Reporting of critical incidents was encouraged by both EMS and nursing/medical staff from the participating ED. Several participating paramedics were frustrated that hospital staff were encouraged to submit reports on critical incidents involving paramedics, however paramedics were not encouraged to report on in-hospital incidents as this was not within the scope of the project. One participant stated, "It's not all us you know…we should be able to report on them!" Other pathways were available for such issues and in a number of instances there was direct feedback to the hospital regarding issues perceived to be relating to medical or nursing management via the project. Whilst not frequently cited as a barrier to notification, this 'cross-disciplinary sensitivity' could potentially reduce the likelihood of some to report critical incidents on the basis that they feel the process is not equally balanced. A focus on the errors of others (within EMS systems, or doctors and nurses particularly in Emergency Departments) has been identified in other papers as a major barrier to incident reporting within EMS systems.[9]

CONCLUSION

Improvement of patient safety is a clear priority in the health-care system. There are numerous barriers to reporting critical incidents. The fear of punishment is a natural human feeling, but in the interest of patient safety this fear or perception of risk must be alleviated. One of the key approaches which may alleviate many of the barriers to reporting is shifting to a systems based focus rather than an individual 'shame and blame' approach. The underlying barriers lie in the culture of the profession, and appear consistent across other health care disciplines.

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Competing interests None.

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REFERENCES

1. **Brennan TA,** Leape LL, Laird NM, *et al*. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 1991;**324**:370–6.
2. **Semmens JB,** Aitken RJ, Sanfilippo FM, *et al*. The Western Australian Audit of Surgical Mortality: advancing surgical accountability. *Med J Aust* 2005;**183**:504–8.
3. **Aders A,** Aders H. Anaesthetic adverse incident reports: an Australian study of 1,231 outcomes. *Anaesth Intensive Care* 2005;**33**:336–44.
4. **Beckmann U,** Bohringer C, Carless R, *et al*. Evaluation of two methods for quality improvement in intensive care: facilitated incident monitoring and retrospective medical chart review. *Crit Care Med* 2003;**31**:1006–11.
5. **Wolff AM,** Bourke J. Detecting and reducing adverse events in an Australian rural base hospital emergency department using medical record screening and review. *Emerg Med J* 2002;**19**:35–40.
6. **Boyle M,** Archer F, Macdonald R. *Incident monitoring: a review of the literature and development of a pre-hospital model*. Melbourne: Monash University, 2002.
7. **O'Connor RE,** Slovis CM, Hunt RC, *et al*. Eliminating errors in emergency medical services: realities and recommendations. *Prehosp Emerg Care* 2002;**6**:107–13.
8. **Donald M,** Paterson B. Introduction of an electronic debrief and governance tool in prehospital care. *Emerg Med J* 2007;**24**:363–6.
9. **Fairbanks RJ,** Crittenden CN, O'Gara KG, *et al*. Emergency medical services provider perceptions of the nature of adverse events and near-misses in out-of-hospital care: an ethnographic view. *Acad Emerg Med* 2008;**15**:633–40.
10. **McDermott FT,** Cordner SM, Tremayne AB. *A "before and after" assessment of the influence of the new Victorian trauma care system (1997-1998 vs 2001-2003) on the emergency and clinical management of road traffic fatalities in Victoria. Report of the consultative committee on road traffic fatalities in Victoria*. Melbourne: CCRTF, 2003.
11. **Boyle MJ.** An overview of prehospital erros involving road traffic fatalities in victoria, Australia. *Prehosp Disaster Med* 2009;**24**:254–61.
12. **Pointer JE,** Osur MA. EMS quality assurance: a computerized incident reporting system. *J Emerg Med* 1987;**5**:513–17.
13. **Stella J,** Davis A, Jennings P, *et al*. Introduction of a prehospital critical incident monitoring system—pilot project results. *Prehosp Disaster Med* 2008;**23**:154–60.
14. **Elder NC,** Graham D, Brandt E, *et al*. Barriers and motivators for making error reports from family medicine offices: a report from the American Academy of Family

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Physicians National Research Network (AAFP NRN). *J Am Board Fam Med* 2007;**20**:115—23.
15. **Nuckols TK,** Bell DS, Liu H, *et al*. Rates and types of events reported to established incident reporting systems in two US hospitals. *Qual Saf Health Care* 2007;**16**:164—8.
16. **Schmidt CE,** Bottoni T. Improving medication safety and patient care in the emergency department. *J Emerg Nurs* 2003;**29**:12—16.
17. **Potylycki MJ,** Kimmel SR, Ritter M, *et al*. Nonpunitive medication error reporting: 3-year findings from one hospital's Primum Non Nocere initiative. *J Nurs Adm* 2006;**36**:370—6.
18. **Waring JJ.** Beyond blame: cultural barriers to medical incident reporting. *Soc Sci Med* 2005;**60**:1927—35.
19. **Hobgood C,** Bowen JB, Brice JH, *et al*. Do EMS personnel identify, report, and disclose medical errors? *Prehosp Emerg Care* 2006;**10**:21—7.

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Prehospital Intravenous Fluid Administration Is Associated With Higher Mortality in Trauma Patients: A National Trauma Data Bank Analysis

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Objective: Prehospital intravenous (IV) fluid administration is common in trauma patients, although little evidence supports this practice. We hypothesized that trauma patients who received prehospital IV fluids have higher mortality than trauma patients who did not receive IV fluids in the prehospital setting.

Methods: We performed a retrospective cohort study of patients from the National Trauma Data Bank. Multiple logistic regression was used with mortality as the primary outcome measure. We compared patients with versus without prehospital IV fluid administration, using patient demographics, mechanism, physiologic and anatomic injury severity, and other prehospital procedures as covariates. Subset analysis was performed based on mechanism (blunt/penetrating), hypotension, immediate surgery, severe head injury, and injury severity score.

Results: A total of 776,734 patients were studied. Approximately half (49.3%) received prehospital IV. Overall mortality was 4.6%. Unadjusted mortality was significantly higher in patients receiving prehospital IV fluids (4.8% vs. 4.5%, $P < 0.001$). Multivariable analysis demonstrated that patients receiving IV fluids were significantly more likely to die (odds ratio [OR] 1.11, 95% confidence interval [CI] 1.05–1.17). The association was identified in nearly all subsets of trauma patients. It is especially marked in patients with penetrating mechanism (OR 1.25, 95% CI 1.08–1.45), hypotension (OR 1.44, 95% CI 1.29–1.59), severe head injury (OR 1.34, 95% CI 1.17–1.54), and patients undergoing immediate surgery (OR 1.35, 95% CI 1.22–1.50).

Conclusions: The harm associated with prehospital IV fluid administration is significant for victims of trauma. The routine use of prehospital IV fluid administration for all trauma patients should be discouraged.

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The administration of intravenous (IV) fluids has been a key component of the prehospital treatment of trauma patients since the advent of paramedic emergency medical systems (EMS). Prehospital IV fluid resuscitation is intended to hemodynamically stabilize trauma patients by replacing intravascular volume and maintaining vital organ perfusion.[1] Since its inception, the American College of Surgeons Advanced Trauma Life Support course has emphasized immediate treatment of trauma patients with IV fluids, although in the newest eighth edition, the course now emphasizes a more "balanced" approach.[2] The routine practice of IV fluid administration in the prehospital arena is touted with great enthusiasm but little data exist to support its use.[3,4]

An increasing body of evidence has demonstrated that IV fluid administration does not improve survival in trauma and may actually be of harm in certain subsets of trauma patients.[5–9] One theory for the possibility of harm is based upon the delay of transport to definitive care. Scene placement of venous access is not only associated with increased scene time but also increased overall time to hospital, in some cases the time to place an IV exceeds that of the actual transport itself.[10] In hypotensive patients and those with primary torso injuries, scene placement times exceed that of en route IV line placement.[11,12] Many trauma providers believe that the "scoop and run" approach, which minimizes prehospital procedures in favor of rapid transport to definitive care, is preferable to the "stay and play" model of prehospital trauma care.[13,14]

The second main theory regarding the potential harm of IV fluids is based upon the idea of "popping the clot." This theory suggests that in patients, who have stopped bleeding temporarily from vasoconstriction and hypotension, IV fluids will raise systolic blood pressure and cause patients to rebleed if their bleeding source is not yet surgically controlled. This theory is supported by one of the few prospective randomized studies of prehospital IV fluid resuscitation in trauma patients. Bickell et al[15] showed that delaying aggressive fluid resuscitation until surgery significantly improved outcome in hypotensive patients with penetrating torso injuries. On the basis of these data, a new Eastern Association for the Surgery of Trauma practice management guideline advocates limited prehospital IV fluid resuscitation.[16]

Given the previous data, we chose to examine the impact of prehospital IV catheter placement and fluid administration on survival following traumatic injury using the National Trauma Data Bank (NTDB), which is the largest dataset of trauma patients ever created. We hypothesize that trauma patients receiving prehospital IV catheter placement (with or without IV fluids) have higher mortality than trauma patients who did not receive an IV or fluids.

METHODS

This retrospective study used 5 years (2001–2005) worth of data from the American College of Surgeons NTDB (Version 6.2). The NTDB is the largest collection of trauma data, with approximately 1.5 million records from more than 600 US trauma centers. Data from the NTDB are deidentified to comply with The Health Insurance Portability and Accountability Act (HIPAA) regulations. Institutional review board exemption was obtained from the Johns Hopkins institutional review board. All trauma patients who suffered

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a penetrating or a blunt injury were included in the analysis. Patients without complete prehospital procedure information were excluded. Statistical analysis was performed in Stata/Multi-Processor 10.0 (StataCorp, College Station, TX).

The objective of the analysis was to determine the influence of prehospital IV fluid administration on patient outcome. The primary outcome variable was in-hospital mortality. The primary independent variable was defined as prehospital IV. The majority of patients with the word "intravenous" or "IV" in the prehospital procedure file of the NTDB were coded as having received "intravenous fluids." However, there were many different terms reported along the "intravenous" continuum and we could not definitively differentiate IV fluid administration versus IV catheter placement alone. Therefore, we grouped both all patients under the heading of "pre-hospital IV". We performed a descriptive analysis of our dependent and independent variables, and we conducted an unadjusted analysis that included a comparison of mortality rates among all patients with versus without prehospital IV fluids. Because there were significant differences in the groups based upon known risk factors for death, we then performed multiple logistic regression, adjusting for potential confounders. We adjusted for the performance of the 5 most common prehospital procedures: endotracheal intubation, military antishock trousers , spine immobilization, splinting, and chest decompression. We did not adjust for cardiopulmonary resuscitation because the data on cardiopulmonary resuscitation appeared to be biologically implausible: the mean systolic blood pressure of penetrating trauma patients who received cardiopulmonary resuscitation was 118 mmHg. Other variables included in the multiple logistic regression analysis were age, gender, race, insurance status, mechanism (penetrating vs. blunt), injury severity score (ISS), hypotension (defined as systolic blood pressure < 90 mmHg), and Glasgow Coma Scale [GCS] Score < 9. We repeated this multiple logistic regression after excluding patients who were dead on arrival (DOA).

Subgroup analyses were performed to examine the consistency of the association between prehospital IV fluid administration and trauma patient outcomes based on mechanism, presence of hypotension (systolic blood pressure < 90 mmHg), head injury status, and the need for immediate surgery. This approach of stratification is another reliable method to examine the impact of IV placement on mortality when the groups are different in regards to known confounders. The same multiple logistic regression analysis was rerun on the following subgroups of trauma patients: (1) blunt patients, (2) penetrating patients, (3) gunshot wound patients, (4) normotensive patients, (5) hypotensive patients, (6) hypotensive blunt patients, (7) hypotensive penetrating patients, (8) hypotensive gunshot wound patients, (9) patients with GCS < 9, (10) patients with severe head injury (GCS$<$9 and head Abbreviated Injury Score 3–5), and (11) need for immediate surgery (disposition from emergency department directly to the operating room).

The same multivariable regression analysis was then performed on subsets of patients based upon ISS category. In the analysis of patients with an ISS < 9, patients who were dead on arrival were excluded from the analysis because of the potential for undercoding of ISS in trauma patients with early death. Trauma patients who are DOA, but are assigned an ISS < 9 frequently have unidentified injuries, not captured in the trauma registry. If all their injuries were definitively known (ie, by autopsy), they often have significantly higher injury severity scores.[17,18]

RESULTS

A total of 776,734 patients with complete prehospital procedure files were identified from the 1,466,887 total patients in the National Trauma Data Bank. The patient population was predominantly young (median age 36) and male (64.7%). The highest proportion of patients were white (67.8%), followed by black (17.1%) and Hispanic (10.9%). Upon arrival in the emergency department, 9.9% of patients had penetrating trauma and 4.4% of patients were hypotensive. Approximately half (49.3%) of patients were in the prehospital IV group. The overall unadjusted death rate was 4.6% (Table 1).

TABLE 1. Descriptive Analysis of Trauma Patients in Study

	Percent (%)
Race	
Whites	67.8
Blacks	17.1
Hispanics	10.9
Other race	4.3
Age, y (mean ± SD)	38.8 ± 22.4 y
Age, y (median-years)	36 y
Male	64.7
Female	35.3
Blunt	90.1
Penetrating	9.9
Gunshot wound	4.0
Injury severity score	
<9	47.1
9–15	29.9
16–25	12.1
>25	10.9
Insurance	
Private insurance	42.3
Medicaid or no insurance	33.2
Medicare	15.8
Other insurance	8.8
Prehospital procedures	
IV fluids	49.3
Spine immobilization	8.1
Intubation	2.8
MAST	28.6
Chest decompression	8.1
Splint	1.2
GCS < 9	9.1
Hypotensive (systolic blood pressure < 90 mmHg)	4.4
Severe head injury (GCS < 9 and Head AIS 3–5)	2.5
Immediate surgery	16.1
Death	4.6
Dead on arrival	1.8

MAST indicates military anti-shock trousers.

On bivariate analysis, patients who received IV fluids were more likely to be intubated, have military antishock trousers, and be splinted, while they were less likely to undergo chest decompression ($P < 0.001$). Patients were more likely to receive an IV if they had penetrating trauma, but less likely if they had blunt trauma ($P < 0.001$). Patients who received an IV were also more likely to have a severe brain injury and be more severely injured overall based upon ISS category. Patients who received IV fluids were significantly more likely to die than patients who did not receive an IV (4.8% vs. 4.5%, $P < 0.001$) (Table 2).

Multivariable logistic regression was used to examine the relationship between prehospital IV and mortality in the 311,071 patients

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TABLE 2. Bivariate (Unadjusted) Comparison of Demographics of Trauma Patients With Versus Without Prehospital IV Catheter and/or IV Fluid Administration

	No IV (%)	IV (%)	*P*
Race			<0.001
White	68.7	66.8	
Black	17.2	16.9	
Hispanic	9.7	12.1	
Other race	4.5	4.1	
Age, y			<0.001
<18	17.4	15.1	
18−24	15.3	17.8	
25−34	14.5	16.8	
35−44	14.1	15.8	
45−54	12.5	13.0	
55−64	8.2	7.8	
65−74	6.4	5.4	
75−84	8.3	6.1	
85 & above	3.4	2.3	
Gender			<0.001
Male	63.2	66.3	
Female	36.8	33.8	
Blunt	90.7	89.8	<0.001
Penetrating	9.6	10.3	<0.001
Gun shot wound	3.8	4.2	<0.001
ISS			<0.001
<9	48.2	46.0	
9−15	29.3	30.4	
16−25	11.6	12.7	
>25	10.9	10.9	
Insurance			<0.001
Private insurance	38.5	46.0	
Medicaid or none	32.4	34.0	
Medicare	18.1	13.5	
Other insurance	11.1	6.5	
Prehospital procedures			
Spine immobilization	4.2	11.5	<0.001
Intubation	1.5	3.8	<0.001
MAST	0.19	53.4	<0.001
Chest decompression	10.1	6.3	<0.001
Splint	0.70	1.6	<0.001
GCS < 9	9.0	9.2	0.002
Hypotension (systolic blood pressure < 90 mmHg)	4.4	4.3	0.02
Severe head injury	1.9	3.1	<0.001
Immediate surgery	16.2	16.0	0.038
Dead on arrival	1.9	1.7	<0.001
Death	4.5	4.8	<0.001

MAST indicates military anti-shock trousers.

with complete data. After adjustment, prehospital IV patients had significantly higher mortality than those without a prehospital IV. The odds ratio of death associated with prehospital IV placement was 1.11 (95% CI 1.06–1.17). (Table 3) When DOA patients were excluded from the group as a whole, the association persisted (OR 1.17, 95% CI 1.11–1.23)

On subgroup analyses, the association between IV placement and excess mortality was maintained in nearly all-patient subsets. (Table 4 and Fig. 1) The harm associated with prehospital IV placement was seen in both blunt and penetrating trauma, although it is more exaggerated in penetrating trauma victims. When patients were stratified by blood pressure, the negative association was more exaggerated in hypotensive patients (OR 1.44, 95% CI 1.29–1.59) but no effect was seen in normotensive patients (OR 1.05, 95% CI 0.99–1.11). When patients were grouped by the combination of mechanism and hypotension, the effect was the same in every subset. In patients with severe head injury (n = 10,909), IV placement was associated

TABLE 3. Multiple Logistic Regression Showing Odds Ratio of Death for Trauma Patients With Versus Patients Without Prehospital IV Catheter and/or IV Fluid Administration

	Odds Ratio of Death	95% CI
Prehospital procedures		
Prehospital IV fluids	1.11	1.06–1.17
Spine immobilization	1.42	1.29–1.57
Intubation	1.57	1.47–1.67
MAST	0.95	0.90–1.00
Chest decompression	1.03	0.98–1.08
Splint	0.88	0.57–1.36
Blunt	Reference	
Penetrating	2.02	1.89–2.15
Race		
Whites	Reference	
Blacks	1.14	1.08–1.21
Hispanics	1.30	1.21–1.40
Other race	1.00	0.89–1.12
Age, y		
<18	0.92	0.85–1.00
18–24	Reference	
25–34	1.04	0.97–1.12
35–44	1.13	1.05–1.22
45–54	1.61	1.50–1.74
55–64	2.58	2.38–2.81
65–74	4.29	3.91–4.71
75–84	8.46	7.73–9.26
85 and above	11.26	10.07–12.59
Male	Reference	
Female	0.84	0.80–0.88
ISS < 9	Reference	
ISS 9–15	2.05	1.89–2.22
ISS 16–25	4.78	4.40–5.18
ISS > 25	16.51	15.31–17.81
GCS < 9	7.82	7.46–8.20
Shock (systolic blood pressure < 90 mmHg)	3.75	3.57–3.95
Insurance		
Private insurance	Reference	
Medicaid or no insurance	1.44	1.37–1.51
Medicare	1.39	1.30–1.49
Other insurance	0.96	0.88–1.03

MAST indicates military anti-shock trousers.

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TABLE 4. Multiple Logistic Regression Showing Odds Ratio of Death for Trauma Patients With Versus Patients Without Prehospital IV Catheter and/or IV Fluid Administration–Subset Analyses

	n	Odds Ratio of Death for Patients With Vs. Without Prehospital IV Catheter and/or IV Fluids	95% CI
All trauma patients	311,071	1.11	1.06–1.17
Blunt	280,811	1.09	1.03–1.16
Penetrating	30,256	1.25	1.08–1.45
Gunshot wound	12,286	1.23	1.04–1.45
Normotensive	296,474	1.05	0.99–1.11
Hypotensive	14,597	1.44	1.29–1.59
Hypotensive blunt	11,406	1.37	1.22–1.54
Hypotensive penetrating	3,191	1.67	1.34–2.09
Hypotensive gunshot wound	2,015	1.71	1.32–2.20
GCS < 9	35,466	1.11	1.04–1.19
Severe head injury	10,909	1.34	1.17–1.54
Immediate surgery	57,294	1.35	1.22–1.50
ISS < 9	128,250	0.89	0.70–1.12
ISS ≥ 9	122,388	1.14	1.08–1.21
ISS >15	83,010	1.17	1.11–1.24
ISS ≥ 25	41,031	1.21	1.13–1.29

with a 34% increase in risk of death (OR 1.34, 95% CI 1.17–1.54). In the 57,294 patients who required immediate surgery, there was a 35% increased odds of death with prehospital IV fluids (OR 1.35, 95% CI 1.22–1.50) (Table 4 and Fig. 1).

Patients suffering moderate and severe injuries (ISS > 8, ISS > 15, and ISS > 24) showed significantly higher mortality with IV fluid administration (OR 1.14, 95% CI 1.08–1.21, OR 1.17, 95% CI 1.11–1.24, and OR 1.21, 95% CI 1.13–1.29 respectively). (Table 4 and Fig. 1) Patients with an ISS < 9 (excluding those DOA) showed no difference in mortality (OR 0.89, 95% CI 0.70–1.12).

DISCUSSION

The results of this study support the hypothesis that prehospital IV placement and/or fluid resuscitation is associated with higher mortality in trauma patients. The association is robust across nearly all subsets of trauma patients and is especially marked in more severely injured patients. In no subset of trauma patients is there a survival advantage for prehospital IV placement. The findings of this study support the opinions of many trauma providers that the routine use of IV catheter placement and fluid administration for all trauma patients should be discouraged.

Several mechanisms for these worse outcomes associated with IV fluid administration have been suggested, including dislodgement of clot formation, dilution of clotting factors, and acceleration of hemorrhage caused by elevated blood pressure.[19–22] The concept of "hypotensive resuscitation" is based upon the idea that patients with uncontrollable sources of bleeding such as solid organ injury (ie, liver, spleen) or other internal bleeding vessels (ie, pelvic vessels) may "pop the clot" that has been formed if the blood pressure is raised before sites of hemorrhage have been controlled (ie, using surgery or angiography). The first prospective study of this strategy showed that "delay of aggressive fluid resuscitation until operative intervention improves the outcome" in hypotensive patients with penetrating torso injuries.[15] Our current study agrees with these findings with over 3000 hypotensive penetrating trauma patients.

Many trauma practitioners agree that not every trauma patient should be treated with early aggressive fluid resuscitation. The variation in opinions is well-established based on a survey of practicing trauma surgeons regarding prehospital care trauma. For a patient with a gunshot to epigastrium, "the majority of trauma practitioners believed that a relatively hypotensive state should be maintained, regardless of transport time."[14] Our study supports the majority opinion with data showing higher mortality in patients such as these receiving IV fluids. The effect is more pronounced in patients with penetrating trauma, hypotension, and those requiring immediate surgery-–the exact patient scenario which was used in the survey of trauma surgeons.

Restrictions on IV fluid administration have been suggested by some to protect trauma patients from preventable death. The Eastern Association for the Surgery of Trauma practice management guidelines committee has recently published new evidence-based guidelines regarding the use of prehospital IV fluids in trauma patients suggesting that IV catheters need not be placed in the prehospital setting. They also advocate that IV fluids should be withheld in patients with penetrating torso trauma and in all trauma patients until active bleeding is addressed.[16] Another consensus paper asserts that IV fluids should not be administered in penetrating trauma patients if a central pulse is present, and that under no circumstances should IV administration delay transport.[23] Current military teaching often recommends the hypotensive resuscitation strategy, suggesting fluid administration based on physiologic signs rather than using IV fluids in all patients.[24,25] The Israeli Defense Force guidelines for patients with uncontrolled hemorrhagic shock suggest withholding IV fluids until the 1 of 3 parameters is documented: altered sensorium, radial pulse cannot be palpated, or systolic blood pressure below 80 mmHg.[26] Advanced Trauma Life Support still currently recommends IV fluid administration for many patients, but suggests that small fluid boluses should be given to "maintain life until definitive care is possible" and suggesting that "a less than normal blood pressure is acceptable" in the austere or hostile environments.[2]

In blunt trauma patients, there is no proven benefit nor has there been suggestion of harm with IV fluid administration. Though prehospital fluid resuscitation in these patients has been shown to increase systolic blood pressure, it does not change patient survival or hospital length of stay.[8] The original success of Advanced Life Support in caring for patients with cardiac arrest fueled the translation of interventions—specifically IV fluid resuscitation and intubation—into the care of trauma patients. However, there may be fundamental differences in what prehospital providers can do to improve outcomes for trauma versus medical patients. Prehospital trauma care often provides temporary care, unlike the prehospital care of cardiac arrest patients in whom defibrillation can be the definitive treatment.[10] A large Canadian study showed that system-wide implementation of full advanced life support programs did not improve overall trauma patient outcomes and worsened outcomes significantly for severely brain injured patients.[27]

In patients with traumatic brain injury (TBI), the primary brain injury has already occurred; management should be focused be on prevention of secondary brain injury. Treatment often includes maneuvers to elevate blood pressure because even a single episode of hypotension is associated with significantly worse outcomes in patients with TBI.[28] There have been some concerns that withholding IV fluids may worsen outcomes.[25] It is likely that a certain group of patients in this group (perhaps those with hypotension and a long transport time to definitive care) may benefit from IV fluid administration. However, even in the TBI population, our study showed

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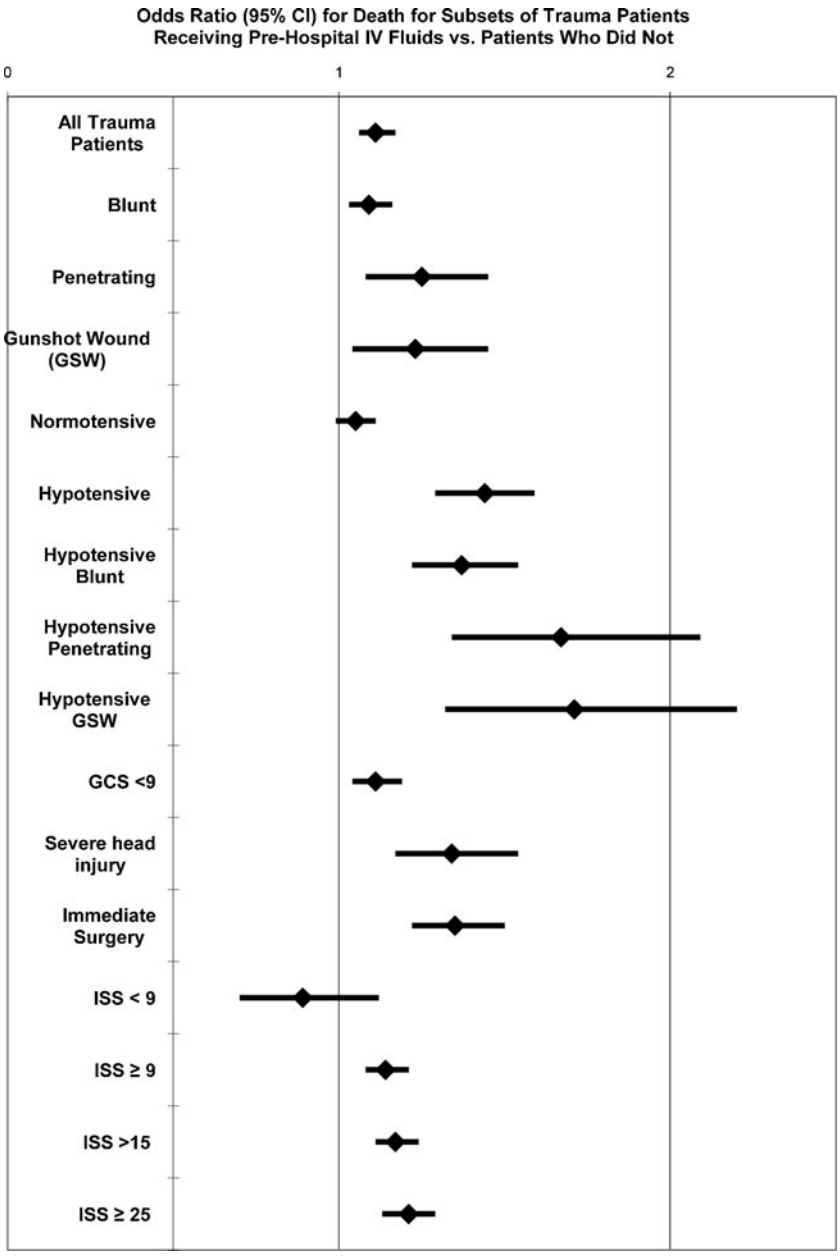

FIGURE 1. Multiple logistic regression showing odds ratio of death for trauma patients with prehospital IV fluid administration—subset analyses. GSW indicates gunshot wound.

worse overall outcomes with IV fluid administration in patients with GCS <9 and in the most severely brain injured patients (GCS <9 and head AIS 3–5). This data are consistent with a prospective study evaluating the use of prehospital hypersonic saline administration on patients with severe TBI that showed no benefit in the fluid treated group.[29]

Data supporting the "scoop and run" approach to prehospital care suggest that performing more prehospital procedures on trauma patients may be detrimental. In an urban setting, the time necessary to establish IV access may be greater than the time of transport and prehospital procedures may delay necessary surgical intervention for patients with potentially survivable injuries.[10] Seamon et al[13] reported that prehospital procedures were associated with lower survival in patients undergoing emergency department thoracotomy in an urban level 1 trauma center. Prehospital spine immobilization is associated with higher mortality in patients with penetrating trauma in the NTDB.[30] In Los Angeles, trauma patients had improved survival if they were transported by private vehicles rather than being treated and transported by EMS providers after sustaining severe trauma.[31] Another study from the same institution used a case control methodology to identify similarly injured patients in EMS and non-EMS transported groups. They found that in the more critically injured (ISS $\geq$ 13) group, "non-EMS patients got themselves to the trauma center in less time than their EMS counterparts (15 minutes vs. 28 minutes; $P < 0.05$)."[32] As a compromise between time and supposed benefit, some authors suggest that prehospital providers should start IVs en route rather than in the field. The success rates for initiating IV therapy en route to the hospital are high—92% for trauma patients—indicating that IV fluid administration is no justification for delaying the transport of unstable trauma patients.[12]

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This retrospective study suffers from some inherent limitations, largely due to potential residual confounders, which are not available within the dataset used. The NTDB did not report prehospital transport times or differentiate urban versus rural care. Thus, we could not examine whether excess mortality in patients treated with IVs was directly associated with delays in transport to definitive care. We were also not able to control for transport time within the multiple regression model or perform a stratified analysis by urban versus rural patients. Perhaps this analysis would have identified a subset of patients who may benefit from IV placement. The NTDB database also does not differentiate between patients who received only an IV catheter placement and patients who received IV fluids. In addition, we could not study any possible dose-response relationship based upon the amount of fluids administered (as these data are also not included). Due to these limitations, we could not determine the potential causal pathway of the higher mortality. Was it a consequence of time delay to definitive care caused by placing the IV or was it due to the fluid administration and physiologically inappropriate targets of resuscitation causing more hemorrhage? Inaccuracy in IV catheter insertion recording is likely to go one direction—not recording it when an IV was actually placed. It is unlikely that an IV will be documented if none was placed. Therefore, this measurement error problem will likely move patients from the IV to the non-IV group and dilute the difference identified. Because trauma centers submitted data voluntarily to the NTDB and were not required to report data in all fields, many patients had no data regarding the presence or absence of prehospital procedures. We assume that data are missing completely at random, and thus does not affect the direction of the observed associations.

However, the overall advantages of using the large NTDB probably outweigh these potential limitations. The NTDB is the largest collection of trauma registry data ever assembled, allowing this study to examine data from a sizeable national sample of trauma patients. As the NTDB improves over time, more prehospital data (including transport time, mode, and treatments) will become available for analysis. Perhaps the current study will be redone in the future on a new NTDB cohort with more robust and reliable data to help overcome some of the limitations of the current study.

Prehospital fluid resuscitation has been considered to be standard of care in trauma patients despite a lack of evidence demonstrating any benefit. The role of prehospital interventions in trauma victims remains controversial and new evidence has done more to raise questions than to give definitive answers. Proponents of the "scoop-and-run" philosophy argue for a rapid transfer to definitive care and avoidance of many prehospitals procedures. Simultaneously, advocates of the "stay-and-play" approach suggest that more patients may reach the hospital alive and perhaps have better neurologic outcomes after brain injury with appropriately chosen prehospital interventions. Some important clinical questions (such as those raised by this debate) are not amenable to a randomized clinical trial and therefore must often be answered by other approaches such as observational studies. We believe our current study adds an important piece of evidence to the complex literature in this field.

CONCLUSIONS

In summary, this study demonstrates that the harm associated with prehospital IV placement is significant for victims of trauma. In no subset of trauma patients is there any survival advantage for prehospital IV placement and/or IV fluid administration. The association is especially marked in patients with penetrating mechanism, hypotension, severe head injury, and patients undergoing immediate surgery. The routine use of IV placement and fluid administration for all trauma patients should be discouraged.

REFERENCES

1. Soudry E, Stein M. Prehospital management of uncontrolled bleeding in trauma patients: nearing the light at the end of the tunnel. *Isr Med Assoc J*. 2004;6(8):485–489.
2. American College of Surgeons. *Advanced Trauma Life Support (ATLS) Student Chicago,IL Course Manual*. 8th ed. Chicago, IL: American College of Surgeons Committee on Trauma.
3. Liberman M, Mulder D, Lavoie A, et al. Multicenter Canadian study of prehospital trauma care. *Ann Surg*. 2003;237(2):153–160.
4. Dretzke J, Sandercock J, Bayliss S, et al. Clinical effectiveness and cost-effectiveness of prehospital intravenous fluids in trauma patients. *Health Technol Assess*. 2004;8(23):iii,1–103.
5. Branas CC, Sing RF, Davidson SJ. Urban trauma transport of assaulted patients using nonmedical personnel. *Acad Emerg Med*. 1995;2(6):486–493.
6. Dalton AM. Prehospital intravenous fluid replacement in trauma: an outmoded concept? *J R Soc Med*. 1995;88(4):213P–216P.
7. Kaweski SM, Sise MJ, Virgilio RW. The effect of prehospital fluids on survival in trauma patients. *J Trauma*. 1990;30(10):1215–1218.
8. Dula DJ, Wood GC, Rejmer AR, et al. Use of prehospital fluids in hypotensive blunt trauma patients. *Prehosp Emerg Care*. 2002;6(4):417–420.
9. Talving P, Palstedt J, Riddez L. Prehospital management and fluid resuscitation in hypotensive trauma patients admitted to Karolinska University Hospital in Stockholm. *Prehosp Disaster Med*. 2005;20(4):228–234.
10. Smith JP, Bodai BI, Hill AS, et al. Prehospital Stabilization of critically injured patients: a failed concept. *J Trauma*. 1985;25(1):65–70.
11. O'Gorman M, Trabulsy P, Pilcher DB. Zero-time prehospital i.v. *J Trauma.* 1989;29(1):84–86.
12. Slovis CM, Herr EW, Londorf D, et al. Success rates for initiation of intravenous therapy en route by prehospital care providers. *Am J Emerg Med*. 1990;8(4):305–307.
13. Seamon MJ, Fisher CA, Gaughan J, et al. Prehospital procedures before emergency department thoracotomy: "scoop and run" saves lives. *J Trauma*. 2007;63(1):113–120.
14. Salomone JP, Ustin JS, McSwain NE Jr, et al. Opinions of trauma practitioners regarding prehospital interventions for critically injured patients. *J Trauma*. 2005;58(3):509–515; discussion 515–517.
15. Bickell WH, Wall MJ, Pepe PE, et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med*. 1994;331(17):1105–1109.
16. Cotton BA, Jerome R, Collier BR, et. al. Guidelines for prehospital fluid resuscitation in the injured patient. Eastern Association for the Surgery of Trauma (EAST) practice management guideline. *J Trauma*. 2009;67(2):389–402. Accessed December 12, 2010.
17. Martin BT, Fallon WF Jr, Palmieri PA, et al. Autopsy data in the peer review process improves outcomes analysis. *J Trauma*. 2007;62(1):69–73.
18. Marx WH, Simon HM, Jumbelic M, et al. Severity of injury is underestimated in the absence of autopsy verification. *J Trauma*. 2004;57:46–49.
19. Pepe PE, Mosesso VN, Falk JL. Prehospital fluid resuscitation of the patient with major trauma. *Prehosp Emerg Care*. 2002;6(1):81–91.
20. Kowalenko T, Stern S, Dronen S, et al. Improved outcome with hypotensive resuscitation of uncontrolled hemorrhagic shock in a swine model. *J Trauma.* 1992;33:349(Y 353).
21. Bickell WH, Bruttig SP, Millnamow GA, et al. The detrimental effects of intravenous crystalloid after aortotomy in swine. *Surgery*. 1991;110:529–536.
22. Riddez L, Johnson L, Hahn RG. Central and regional hemodynamics during crystalloid fluid therapy after uncontrolled intra-abdominal bleeding. *J Trauma*. 1998;44:433(Y 439).
23. Revell M, Porter K, Greaves I. Fluid resuscitation in prehospital trauma care: a consensus view. *Emerg Med J*. 2002;19:494–498.
24. Greaves I, Porter KM, Revell MP. Fluid resuzscitation in pre-hospital trauma care: a consensus view. *J R Coll Surg Edinb*. 2002;47(2):451–457.
25. Holcomb JB. Fluid resuscitation in modern combat casualty care: lessons learned from Somalia. *J Trauma.* 2003;54(suppl 5):S46–S51.
26. Krausz MM. Initial resuscitation of hemorrhagic shock. *World J Emerg Surg.* 2006;27(1):14.
27. Stiell IG, Nesbitt LP, Pickett W, et al. OPALS study group. The OPALS major trauma study: impact of advanced life-support on survival and morbidity. *CMAJ*. 2008;178(9):1141–1152.
28. "Guidelines for the management of severe traumatic brain injury". Brain Trauma Foundation; American Association of Neurological Surgeons; Congress of Neurological Surgeons; Joint Section on Neurotrauma and Critical Care, AANS/CNS, Bratton SL, Chestnut RM, Ghajar J, McConnell Hammond

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FF, Harris OA, Hartl R, Manley GT, Nemecek A, Newell DW, Rosenthal G, Schouten J, Shutter L, Timmons SD, Ullman JS, Videtta W, Wilberger JE, Wright DW. *J Neurotrauma*. 2007;24(Suppl 1):S7–S13. https://www.braintrauma.org/pdf/protected/Guidelines_Management_2007w_bookmarks.pdf. Accessed December 12, 2010.

29. Cooper DJ, Myles PS, McDermott FT, et al. HTS Study Investigators. Prehospital hypertonic saline resuscitation of patients with hypotension and severe traumatic brain injury: a randomized controlled trial. *JAMA*. 2004;17,291(11):1350–1357.
30. Haut ER, Kalish BT, Efron DT, et al. Spine immobilization in penetrating trauma: more harm than good? *J Trauma*. 2010;68(1):115–121.
31. Demetriades D, Chan L, Cornwell E, et al. Paramedic vs private transportation of trauma patients: effect on outcome. *Arch Surg*. 1996;131(2):133–138.
32. Cornwell EE 3rd, Belzberg H, Hennigan K, et al. Emergency medical services (EMS) vs non-EMS transport of critically injured patients: a prospective evaluation. *Arch Surg*. 2000;135(3):315–319.

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