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Field Hypotension in Patients Who Arrive at the Hospital Normotensive:
A Marker of Severe Injury or Crying Wolf?

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Abstract

Introduction: *Trauma patients with hypotension in the field who arrive at a hospital with a normal blood pressure (BP) may not be recognized as significantly injured.*

Methods: *Over a 5-year period, demographic, injury severity, and disposition data were retrospectively analyzed for patients ≥16 years of age with documented hypotension in the field (systolic BP ≤ 90mmHg) and normal BP (systolic BP >90mmHg) on hospital arrival (hypotensive group). This group was compared to patients with normal BP in the field and on hospital arrival (normotensive group).*

Results: *During the study, 2207 patients with documented BP were transported directly from the scene. Of this number 44 (2%) were assigned to the hypotensive group, 2086 (94%) were assigned to the normotensive group, and 77 (4%) patients were hypotensive on hospital arrival. The hypotensive group had a systolic BP in the field of 70 ± 26 mmHg compared to 140 ± 26 mmHg in the normotensive group ($p<0.0001$). Arrival BP at the hospital was normal in both groups. Compared to the normotensive group, the hypotensive group had higher Injury Severity Scores (22.0 vs 11.1, $p<0.0001$), lower Glasgow Coma Scores (10.8 vs14.0, $p<0.0001$), lower Revised Trauma Scores (6.5 vs 7.4, $p<0.001$), more emergency department deaths (7% vs 0%, $p<0.001$), longer lengths of stay in the intensive care unit (8.6 vs 7.0 days, $p<0.0001$) and hospital (14.0 vs 7.0 days, $p<0.0001$), and increased hospital mortality (18% vs 4%, $p<0.001$).*

Limitations: *The retrospective design and exclusion of patients without documentation of BP in the field may have resulted in selection bias.*

Conclusion: *Despite these limitations, field hypotension is a marker of significant injury in patients arriving at the hospital normotensive.*

Obtaining a blood pressure (BP) is fundamental in the initial evaluation and management of traumatically injured patients and is frequently one of the few vital signs immediately available on the scene of an accident. However, multiple studies have found that BP obtained in the field may be inaccurate.[1-3] The human ear is almost deaf to the sounds needed to measure BP. The frequency of Korotkoff sounds (25-50 Hz) used in the auscultatory method of BP determination is near the limits of human sound detection (16 Hz).[4] This situation is further complicated by the out of hospital environment that may inhibit the ability to hear. As a result of this limitation, it is tempting to dismiss the significance of field hypotension in

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patients who arrive at the hospital with a normal BP. In a busy emergency department, a patient with a normal BP at time of hospital arrival is at risk for undertriage and delay in identifying significant injuries. In a hospital with limited resources, a normal arrival BP may also mislead the physician into delaying transfer to a higher level of care when early transfer is appropriate. The purpose of this study was to evaluate the significance of field hypotension in patients who arrived directly from the scene at a rural trauma center with a normal blood pressure. Our hypothesis was that hypotension in the field is a marker of severe injury in patients who arrive at the hospital normotensive.

METHODS

University Health Systems of Eastern North Carolina operates a Level I trauma center which serves 29 counties in eastern North Carolina. This region has a predominately rural landmass of 13 735 square miles and a population of 1.5 million. According to the North Carolina Office of Emergency Medical Services (EMS),[a] there are 4203 EMS providers in this region of which 2.4% are certified prehospital providers, 63.3% are basic Emergency Medical Technicians (EMTs), 15.8% are intermittent EMTs, and 18.5% are paramedics (EMT-Ps). There are 69 volunteer EMS agencies and 239 paid EMS agencies of which 50 provide only basic life support with the remainder providing advanced life support.

The trauma registry and performance improvement database of the University Health Systems of Eastern Carolina has been in place for 14 years. Data is obtained and managed as follows: a data collector abstracts raw demographic, vital signs, and injury severity data directly from the written chart and prehospital record at time of admission and hospitalization; concurrent with the patient's hospitalization, complications are identified and recorded in multiple settings including trauma morning report, clinical rounds, scheduled performance improvement meetings, and chart reviews. Using this method, data on all trauma patients admitted to the hospital by the trauma service are entered into the database. All patients evaluated by the trauma service are considered trauma activations. Validation studies on various data points are performed on a monthly basis, and the accuracy of the database is consistently between 98% to 100%.

After obtaining approval from the East Carolina University Institutional Review Board, a retrospective review of our National Trauma Registry of the American College of Surgeons (NTRACS) database from January 1, 2000 through December 31, 2005 was performed. Data were collected and analyzed for all patients aged 16 years or older who had documented field hypotension, defined as systolic BP < 90 mmHg, but arrived normotensive in the ED, defined as an initial systolic BP ≥ 90 mmHg (hypotensive group). Analyzed data included demographic, mechanism of injury, neurologic injury severity as determined by Glasgow Coma Scale[5] (GCS), anatomic injury severity as determined by Injury Severity Score[6] (ISS), altered physiology as determined by Revised Trauma Score[7] (RTS), emergency department (ED), and hospital discharge disposition information. Patients were assigned to the hypotensive group if they experienced any episodes of hypotension prior to arrival at the hospital. This group was compared to patients who were normotensive both in the field and on arrival to the ED (normotensive group). Methods used to calculate GCS, ISS, and RTS are presented in Table 1. In both the prehospital and hospital settings, BP was obtained using the auscultatory method, an automated oscillometric device, or the palpation method. Due to use of

Table 1.
Injury Severity Scoring Systems

GLASGOW COMA SCORE (GCS)	
	Score
Eyes:	
Open spontaneously	4
To verbal command	3
To pain	2
No response	1
Motor Response:	
Obeys	6
Localize to pain	5
Withdrawal to pain	4
Decorticate posturing	3
Decerebrate posturing	2
No response	1
Verbal Response:	
Oriented	5
Disoriented	4
Inappropriate	3
Incomprehensible	2
No response	1

REVISED TRAUMA SCORE[7] (RTS)
RTS = (0.7326 x systolic BP) + (0.2908 x respiratory rate) + (0.9368 x GCS)

INJURY SEVERITY SCORE[6] (ISS)
ISS is an anatomic injury scoring system based on division of the body into 6 separate regions (thorax, abdomen, head/neck, face, bony pelvis/extremities, external structures). Injures in each area are assigned an abbreviated injury score (AIS) which ranges from 1-6 with 6 being a severe injury. The highest AIS for each of the 3 most severely injured regions are squared and then added together to calculate the final score.

a The North Carolina Office of Emergency Medical Services collects and maintains data which is provided to each trauma center by way of personal communication.

the palpation method, only systolic BP was utilized in this study. Only patients transported directly from the scene with complete data were included in this study; those patients transferred from other hospitals or those with incomplete data were excluded

Statistical analysis was performed using chi square test, Student's t-test, and ANOVA, with significance set at a value of $p < 0.05$.

RESULTS

Over the 5-year study period, 7199 patients were evaluated in the prehospital setting by EMS personnel and admitted to the hospital by the trauma service. Of this number, 3493 patients were transported directly from the scene. Of these, 2207 had documented BP in the field and on arrival to the ED and were therefore included in the analysis. Forty-four patients were hypotensive in the field and normotensive on arrival in the ED and assigned to the hypotensive group. This group was compared to 2086 patients who were normotensive in both the field and on arrival in the ED (normotensive group).

The following patients were excluded from analysis: 77 patients who were hypotensive on arrival in the ED; 1286 patients transferred directly from the scene whose blood pressure was not documented; and 3706 patients who were transferred from other hospitals.

Neither age nor gender were significantly different between study groups. The mean age of the hypotensive group was 43.3 ± 18 years versus 49.7 ± 24 years in the normotensive group. Males represented 52% of the hypotensive group and 56% of the normotensive group. The mechanism of injury differed between groups with blunt trauma accounting for 84% in the hypotensive group compared to 93% in the normotensive group, a significant difference at $p = 0.02$.

Indicators of injury severity are summarized in Table 2. The mean systolic BP in the field was 70 ± 26 mmHg in the hypotensive group compared to 140 ± 26 mmHg in the normotensive group. Blood pressure on arrival at the hospital was within normal range in both groups. The mean ISS of the hypotensive group was double that of the normotensive group. Injury severity scores greater than 16 indicate severe injury and those greater than 25 indicate critical injury; both scores were significantly increased in the hypotensive group compared to the normotensive group. The mean Glasgow Coma Scores (GCS) and Revised Trauma Scores (RTS) were significantly lower in the hypotension group compared to the normotesnive group.

Data addressing ED disposition, hospital and intensive care unit length of stay (LOS), ventilator days, and hospital discharge disposition is summarized in Table 3. The ED disposition of patients was as follows: 34% of patients in the hypotensive group were admitted directly to the operating room; 27% to the intensive care unit; and 7% died in the ED. Only 18% of patients in the normotensive group went directly to the operating room from the ED, and 13% admitted directly to the intensive care unit. No patients in this group died in the ED. The intensive care unit LOS and hospital LOS were significantly longer in the hypotensive group compared to the normotensive group.

Disposition at hospital discharge was also significantly different between groups. Fifty-five percent of the hypotensive group returned home, 14% required inpatient rehabilitation, 5% required placement in a skilled nursing facility, and 18% died. In the normotensive group, 59% returned home, 17% required rehabilitation, 10% required a skilled nursing facility, and 4% died. The mortality for patients admitted to the hospital was significantly different between groups: 18% of patients in the hypotensive group died whereas only 4% of the normotensive group died after hospital admission.

Table 2.
Injury Severity Data

Parameter	Normotensive Group	Hypotensive Group	p-value
Mechanism	93% blunt	84% blunt	0.02
Systolic BP Scene	140 ± 26 mmHg	70 ± 26 mmHg	< 0.0001
Systolic BP Hospital	142 ± 26 mmHg	125 ± 22 mmHg	< 0.0001
Blood Transfusion	0.4 ± 1.7 units	2.4 ± 3.5 units	< 0.0001
Injury Severity Score	11.1 ± 9.5	22.0 ± 17.9	< 0.0001
Injury Severity Score (>16)	23% (480)	57% (25)	<0.001
Injury Severity Score (>25)	11% (229)	30% (13)	<0.0001
Glasgow Coma Score	14.0 ± 3.2	10.8 ± 5.6	< 0.0001
Revised Trauma Score	7.4 ± 1.3	6.5 ± 2.0	< 0.001

Data presented as mean ± standard deviation or percent (patients)

Table 3.
Disposition and Length of Stay Data

Parameter	Normotensive Group	Hypotensive Group	p-value
ED disposition			
OR	18% (376)	34% (15)	
ICU	13% (271)	27% (12)	<0.01
Death	0%	7% (3)	
ICU LOS	7.0 ± 10.3 days	8.6 ± 7.5 days	<0.0001
Ventilator days	7.8 ± 12.7 days	8.8 ± 9.9 days	<0.001
Hospital LOS	7.0 ± 9.7 days	14.0 ± 21.7 days	<0.0001
Hospital disposition			
Home	65% (1356)	61% (25)	
Rehab	19% (397)	14% (6)	
SNF	12% (250)	7% (3)	<0.001
Death	4% (83)	18% (7)	

ED emergency department; OR operating room; ICU intensive care unit; LOS length of stay; SNF skilled nursing facility
Data presented as mean ± standard deviation or percent (patients)

DISCUSSION

Determination of an accurate blood pressure is fundamental to the initial triage and evaluation of traumatically injured patients. Despite the importance of this measurement, determination of BP in a field environment may be difficult and inaccurate.[2-4] These inaccuracies may be the result of ambient noise, motion artifact, weak pulses, and faulty equipment.[2,4,8,9] A rural environment may further contribute to these difficulties as many EMS agencies are volunteer-based, and members may lack frequent experience with severely injured patients. Patients in rural settings also have prolonged discovery and transport times, are at greater risk for deterioration prior to evaluation at a trauma center, and have increased mortality.[10] Given these findings it is important that reports of hypotension in the field not be dismissed in those patients who arrive with a normal BP.

In this study hypotension was defined as a systolic BP of less than 90 mmHg and normotension as a systolic BP of greater or equal to 90 mmHg. While BP may vary according to the cardiovascular health of the patient and may be altered by antihypertensive medications, these values were chosen because the majority of studies[9,11-16] investigating the effects of hypotension in adult populations use a range of 90-100 mmHg. In our study the mean field BP in the hypotensive group was 70 ± 26 mmHg which increased to 125 ± 22 mmHg by the time the patient arrived at the hospital. Within our region, the majority of EMS agencies are able to provide advanced therapy in the field, and it is likely that the improvement in BP in this group was the result of resuscitative efforts such as intravenous hydration. In the normotensive group the BP was essentially unchanged from the prehospital measurement to arrival at the hospital. Differences in mean arrival blood pressure between groups, 125 ± 22 mmHg in the hypotensive group and 142 ± 26 mmHg in the normotensive group, while statically different, does not likely represent a clinically significant difference.

In comparison to patients in the normotensive group, patients who had hypotension in the field which resolved by time of arrival in the ED had significantly greater anatomic injury as demonstrated by doubling of ISS from a mean of 11.1 ± 9.5 to 22.0 ± 17.9. This data is also consistent with that of Codner and colleagues,[16] who found in a study of urban trauma patients with hypotension in the field that resolved prior to arrival at the ED that 51% of this population had a significant injury as defined by an ISS greater than 16, and 19% had a critical injury as defined by an ISS greater than 25. In our study 58% of the hypotensive group had an ISS of greater than 16, and 30% had an ISS of greater than 25. In light of our findings and that of Codner et al[16] it is reasonable to assume that field hypotension is a marker of severe injury in both urban and rural environments. In earlier work by Chan et al,[17] patients with out-of-hospital hypotension were also associated with a higher ISS and greater number of femur and pelvic fractures than were patients who were not hypotensive in the field. The difference in RTS between the groups is partially explained by the study design as hypotension was needed for inclusion to the hypotensive group, and hypotension is a variable used in calculating this score.[7] The RTS is also weighted toward GCS in order to compensate for the effect of severe head injury;[7] as a result the lower GCS in the hypotensive group compared to the normotensive group also contributes to this difference.

Brain injury is responsible for more deaths and permanent disabilities and is more costly than any other type of trauma. The association of hypotension and worse outcome following brain injury is well-documented.[13,18,19] These findings were also confirmed in the early period of resuscitation[12,20] and when hypotension was transient.[21] In our study the hypotensive group had a significantly lower GCS, and the association with hypotension may have been a contributing factor to the mortality rate.

Field and ED triage can be complex. Trauma team activation based solely on mechanism of injury has been shown to be an ineffective utilization of resources.[23] Field hypotension has been demonstrated to predict severe injury and thus has been determined to be a valid indicator of triage and trauma team activation.[14,15] In a rural trauma system with multiple EMS agencies of varying clinical abilities, prehospital hypotension may be a triage tool that is easier to use than calculation of more complex trauma scoring systems.[14] Our data support field hypotension as a marker of severe injury even in those who arrive with normotension, and therefore it may be used as a primary indicator for trauma team activation, early transfer to a higher level of care, or utilization of aeromedical resources.

Comparison of ED and hospital discharge disposition between the hypotensive and normotensive groups also supports the finding that field hypotension is a valid marker of severe injury. This data is consistent with previous work by Shapiro et al,[23] who examined isolated prehospital hypotension in patients transported by an experienced areomedical crew expected to have greater experience with critically ill patients and hence less variability in determination of BP. In that study patients with isolated hypotension in the field were 4.4 times more likely to die and 2.9 times more likely to require a chest or abdominal operation.

Our data suggest that field hypotension is a significant marker of severe injury in patients who arrive at the hospital with a normal blood pressure. However, our investigation has several limitations. While the retrospective nature of this study reduces the risk of bias associated with reporting a lower BP in predicting outcome, this method also resulted in exclusion of many patients who did not have appropriate documentation of field BP. The exclusion of these patients may have resulted in a selection bias. One potential explanation for failing to document field BPs was that EMS providers treating more critically injured patients were focused on other tasks. A related limitation is the small number of patients in the hypotensive group. Prior studies have demonstrated measurement of BP in an out-of-hospital environment[2-4,10,11] may be unreliable. In our study the accuracy of BP determination in the field is unknown.

Hypotension in the field is a significant indicator of severity of injury even in those who arrive at the trauma center with a normal BP. This data also should remind all those who care for injured patients to be ever vigilant regardless of arrival BP. **NCMJ**

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