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December 23, 2019

Mr. Richard J. Hertel
Prosecuting Attorney
Eightieth Judicial Circuit
P.O. Box 102
Versailles, IN. 47042

Re: South Bend Police Department, Officer-Involved Shooting Incident: Mr. Eric Logan

Dear Mr. Hertel:

The above-referenced incident involved the shooting of Mr. Eric Logan on June 16th, 2019 by Sgt. Ryan O'Neill of the South Bend Police Department. Mr. Logan was a 53-year-old African American male, who sustained a single penetrating gunshot wound to his right upper abdomen in the parking lot of the Central High Apartments, 110 North William Avenue, in South Bend, Indiana. Mr. Logan was emergently transported in a South Bend Police Department vehicle to Memorial Hospital of South Bend. At your request I have performed the following in regard to this incident:

1. Reviewed the medical records of Mr. Eric Logan from the Memorial Hospital of South Bend
2. Reviewed the radiographs of Mr. Eric Logan from the Memorial Hospital of South Bend
3. Reviewed the autopsy report of Mr. Eric Logan, A19-340 performed on 6/17/19
4. Reviewed the color photographs from the autopsy of Mr. Eric Logan, A19-340 performed on 6/17/19
5. Reviewed the color photographs of the scene and from the Memorial Hospital of South Bend
6. Reviewed the 911 call tape from 6/16/19 at 0323
7. Reviewed the radio traffic tape from 6/19/19
8. Reviewed the video obtained during the scene walk through with Sgt. Ryan O'Neill
9. Reviewed the video of Sgt. Ryan O'Neill's statement to St. Joe Homicide
10. Reviewed various videos of the scene and surveillance tapes
11. Reviewed the medical records of Sgt. Ryan O'Neill
12. Reviewed the color photographs of Sgt. Ryan O'Neill
13. Reviewed components of the investigative file from the South Bend Police Department related to this incident

14. ShotSpotter information
15. Reviewed the results from the Certificates of Analysis from the Indiana State Police Laboratory Division (DNA/Range-of-Fire/Fingerprint), Case #'s: 19L-01617 and 19X-00464
16. Reviewed color photographs from the phone of Mr. Chris Poppel
17. Reviewed portions of the interview conducted with Mr. Evan Fisher related to his stolen Gerber knife

The purpose of my review was to examine the forensic and medical issues in order to develop opinions in this case. My opinions will be based upon my education, training in the fields of emergency medicine, forensic medicine, the evaluation of fatal and non-fatal gunshot wounds and my experience with the investigation and reconstruction of officer-involved shooting incidents. My education, experience and training in these fields date back more than 30 years.

History:

At approximately 03:23 AM a 911 call was received regarding an individual, in a dark rain jacket with a flashlight possibly breaking out car windows in the parking lot of the Central High Apartments. At approximately 3:27 A.M. on June 16th, 2019 Sgt. Ryan O'Neill of the South Bend Police Department was dispatched to a call of a suspicious person and possible car break-ins in the area of the Central High Apartments, 110 North William Avenue. At approximately 03:30 Sgt. O'Neill pulled his marked patrol vehicle into the parking lot and reportedly observed an African American male leaning into a black Honda Civic, IN VTK152, through the open driver's door (Photo 1). Sgt. O'Neill reportedly asked Mr. Logan if the Honda was his vehicle and he replied it was. Sgt. O'Neill noticed, as Mr. Logan turned around, a beige purse stuffed into his sweatshirt and a bloody napkin around his right hand. Sgt. O'Neill then noticed Mr. Logan to draw a knife in his right hand and then raise his right arm. Sgt. O'Neill estimates he was about 8 feet from Mr. Logan when Mr. Logan initially raised his right arm and hand while holding a Gerber knife (Photo 2). Sgt. O'Neill states that upon seeing the knife raised in Mr. Logan's hand he drew his weapon, commanded Mr. Logan to "drop the knife, drop the knife". Mr. Logan failed to drop the knife and advanced toward the officer as Sgt. O'Neill backed pedaled toward his patrol car. As Mr. Logan advanced Sgt. O'Neill felt that Mr. Logan was close enough to stab him. Moments later Sgt. O'Neill discharged two rounds from his Smith and Wesson M&P duty weapon as Mr. Logan threw the knife at Sgt. O'Neill. The thrown knife struck Sgt. O'Neill's left forearm, leaving a pattern abrasion (Photo 3), and landed behind Sgt. O'Neill (Photo 2). Sgt. O'Neill at approximately 03:31 reported "shots fired" and immediately requested an ambulance. After securing Mr. Logan, at approximately 03:35 the on-scene officers wisely decided to "load and go" and expedited his transport to the Memorial Hospital of South Bend which was only approximately 0.8 miles from the incident scene.

Memorial Hospital of South Bend-Mr. Eric Logan:

Minutes after being shot Mr. Eric Logan arrived at the emergency department of Memorial Hospital of South Bend after being rapidly transported by an officer of the South Bend Police Department. He was seen in the emergency department's resuscitation room at 03:40. On arrival Mr. Logan had a GCS (Glasgow Coma Scale) of 15. After initial resuscitative efforts in the emergency department, Mr. Logan was taken emergently to the operating room at 0401. After massive transfusions, operative and therapeutic efforts to control the arterial and venous bleeding to the liver and other organs, Mr. Logan succumbed to his injuries. He was pronounced deceased at 0950 in the intensive care unit.

Photo 1: Open driver's door of Honda Civic where Sgt. O'Neill observed Mr. Eric Logan leaning into the vehicle.

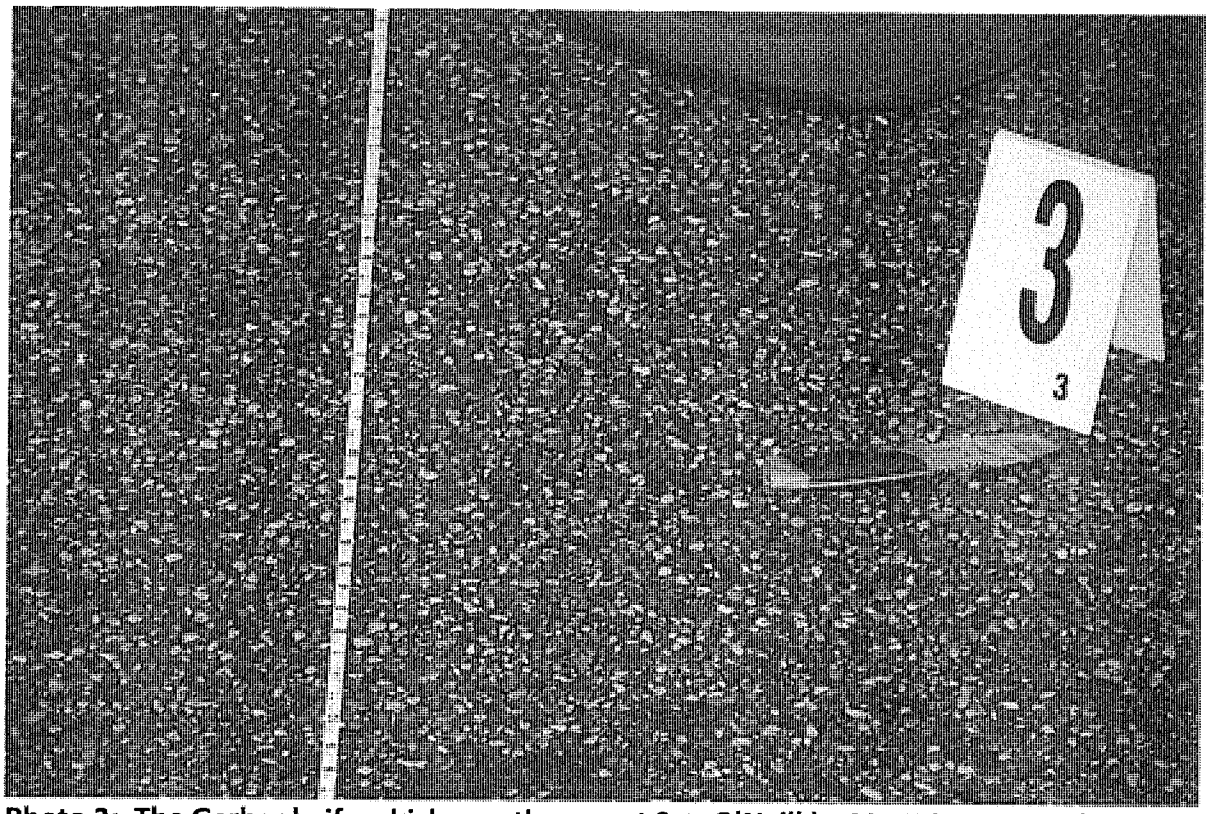


Photo 2: The Gerber knife which was thrown at Sgt. O'Neill by Mr. Eric Logan. The knife came to rest approximately 17" to the right of the right rear wheel of Sgt. O'Neill's patrol car.

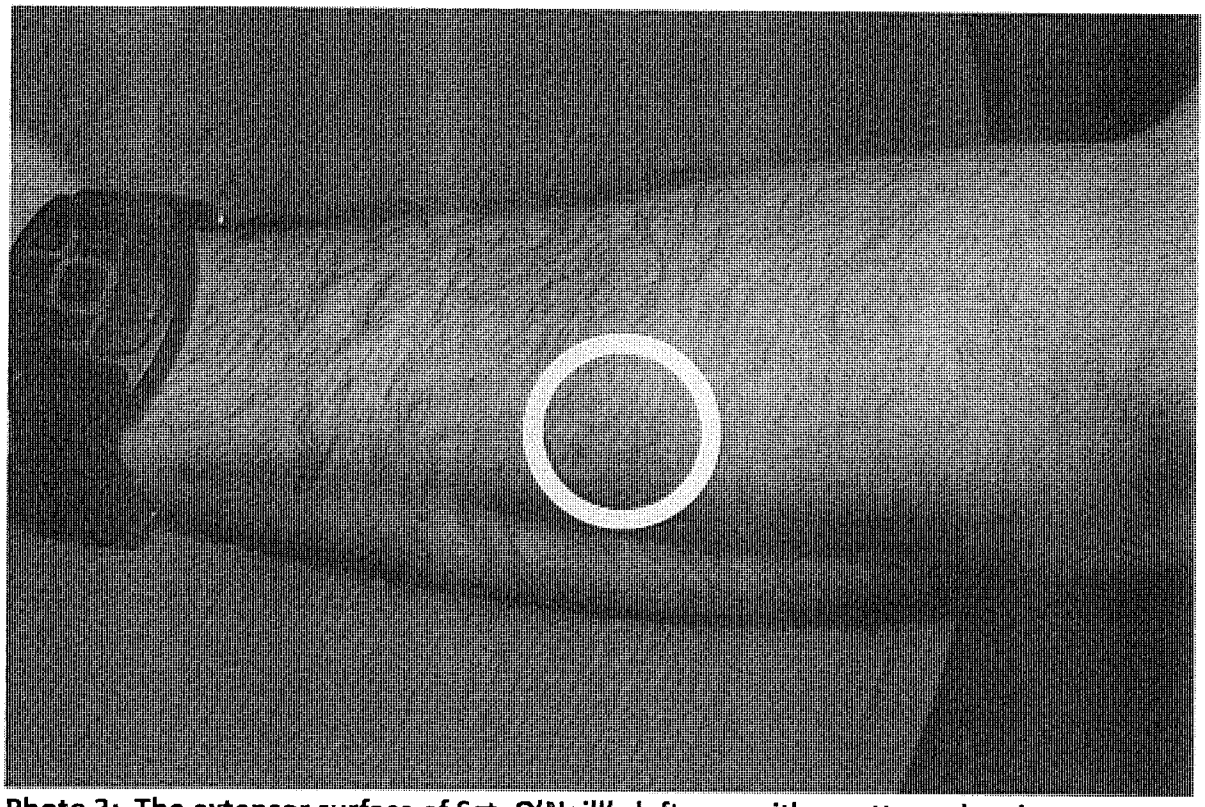


Photo 3: The extensor surface of Sgt. O'Neill's left arm with a pattern abrasion.

Autopsy Report, A19-340-Mr. Eric Logan:

A forensic autopsy was performed on Mr. Eric Logan by Dr. D.L. Wolfe on June 17, 2019. Dr. Wolfe documented a penetrating gunshot wound to the right upper abdomen with an abrasion collar (Photo 4). No soot, tattooing or muzzle abrasion was present. The wound path of the bullet was anterior to posterior, superior to inferior and right to left (Diagrams 1 - 3). The bullet entered the right lobe of the liver, struck the gall bladder, the right adrenal gland and lodged in the subcutaneous tissues adjacent to L2 (Photo 5). Two 1 cm abrasions were also noted on the dorsum of his proximal right hand.

Dr. Wolfe rendered the following anatomical findings and opinions:

A. Gunshot wound of abdomen (Photo 4)
1. Indeterminate range
2. Front to back, downward, slight right to left (Diagrams 1 - 3)
3. Bullet recovered from deep subcutaneous tissue or right paraspinal tissues (Photos 6A & 6B)
4. Injuries to liver, right adrenal, right anterior and posterior abdominal walls
5. Status post-surgical intervention

Cause of Death: Gunshot Wound of Abdomen

Manner of Death: Homicide

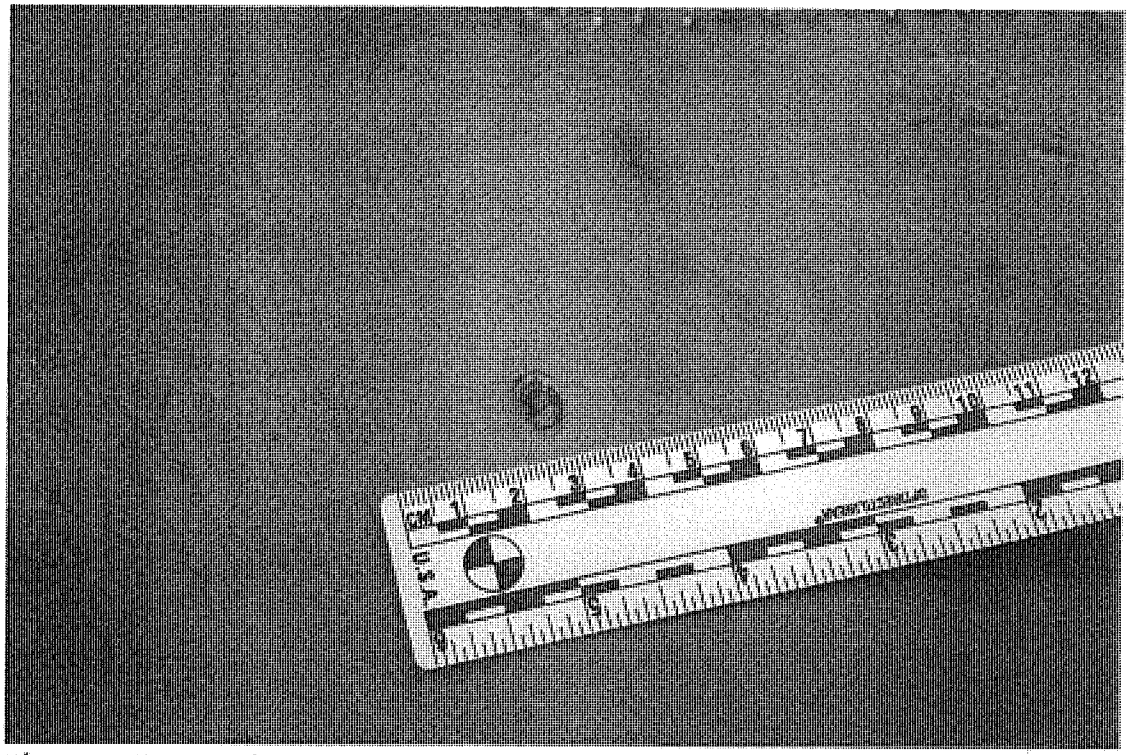


Photo 4: Penetrating entrance wound in the right upper abdomen with an abrasion collar.

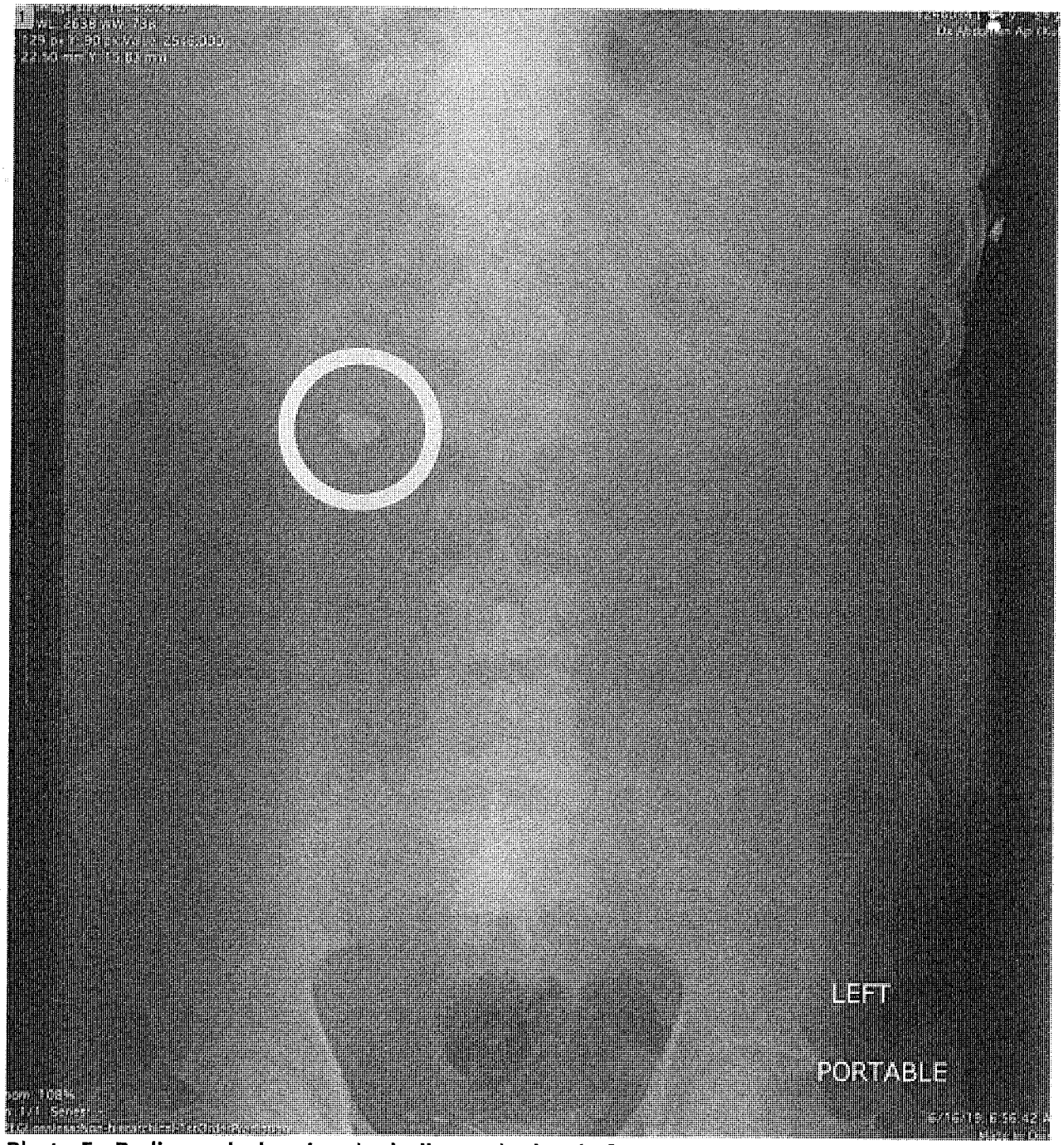


Photo 5: Radiograph showing the bullet at the level of L2.

Logan Toxicology:

Mr. Logan's blood from the hospital was tested for the presence of intoxicants. His blood ethanol level was found to be 0.143 g/100ml. Mr. Logan's blood also revealed evidence of levels of THC and THC metabolites. Mr. Logan's urine revealed the presence of cocaine/metabolite and cannabinoids.

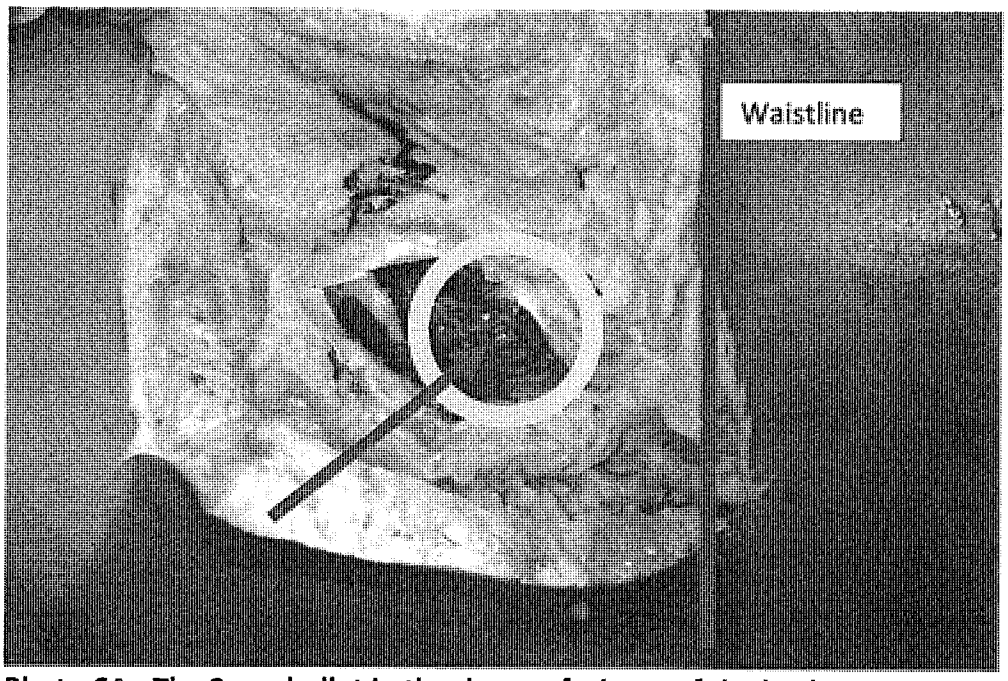


Photo 6A: The 9mm bullet in the deep soft tissue of the back.

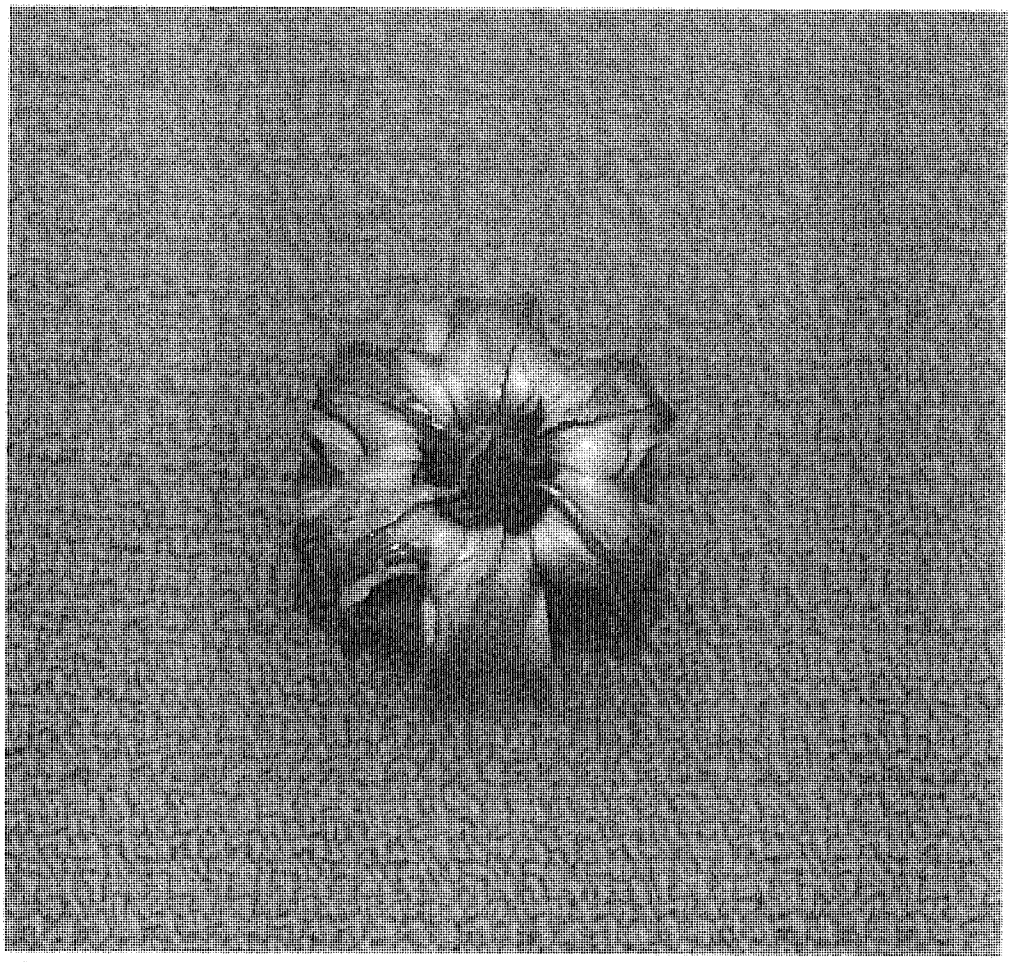


Photo 6B: The 9mm bullet removed from the deep subcutaneous tissue in the back.

Sharped-edged Weapon:

The Gerber knife (Photo 7) was identified by Mr. Evan Fisher as the knife stolen from the driver's door of his girlfriend's vehicle the morning Mr. Logan was shot. The single-edged blade knife thrown by Mr. Logan at Sgt. Ryan O'Neill is a deadly weapon. I have treated and evaluated multiple patients, both surviving and deceased, who have sustained serious and fatal injuries from similar weapons. A stab wound or incision from this knife can be fatal. The blade of this knife can easily puncture or incise vital organs including: the brain, the carotid and other major arteries, the trachea, the aorta, the heart, the lungs, the liver, the spleen, the intestines and their associated vasculature. A sharp-edged weapon, such as the one brandished and thrown by Mr. Logan is also capable of penetrating an officer's Kevlar body armor.

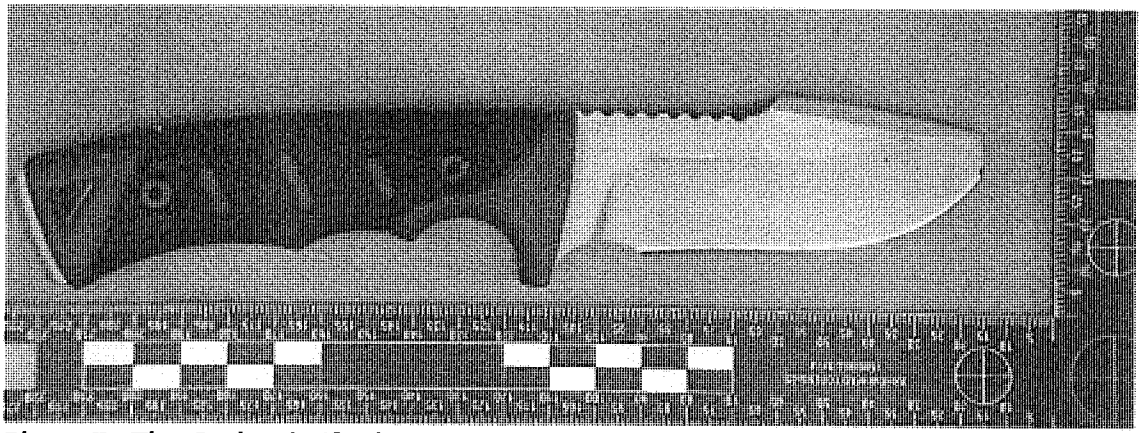


Photo 7: The Gerber knife thrown by Mr. Logan which struck Sgt. O'Neill's left forearm.

Memorial Hospital South Bend-Ryan O'Neill:

Sgt. Ryan O'Neill was seen in the emergency department of Memorial Hospital South Bend. Sgt. O'Neill is a 43-year-old Caucasian male who present at 04:13 for "ringing in his ears and an abrasion to the left arm". He stated, "he had a knife thrown at him". Review of photographs of the abrasion on his left arm reveals a pattern abrasion present on the extensor surface of the forearm (Photo 3). The periodicity of the pattern abrasion is consistent with the periodicity with the serrated edge of the Gerber knife found at the scene and reportedly thrown at Sgt. O'Neill (Photos 8 and 9). The pattern abrasion is consistent with Sgt. O'Neill's statement that he was struck by the knife thrown by Mr. Logan.

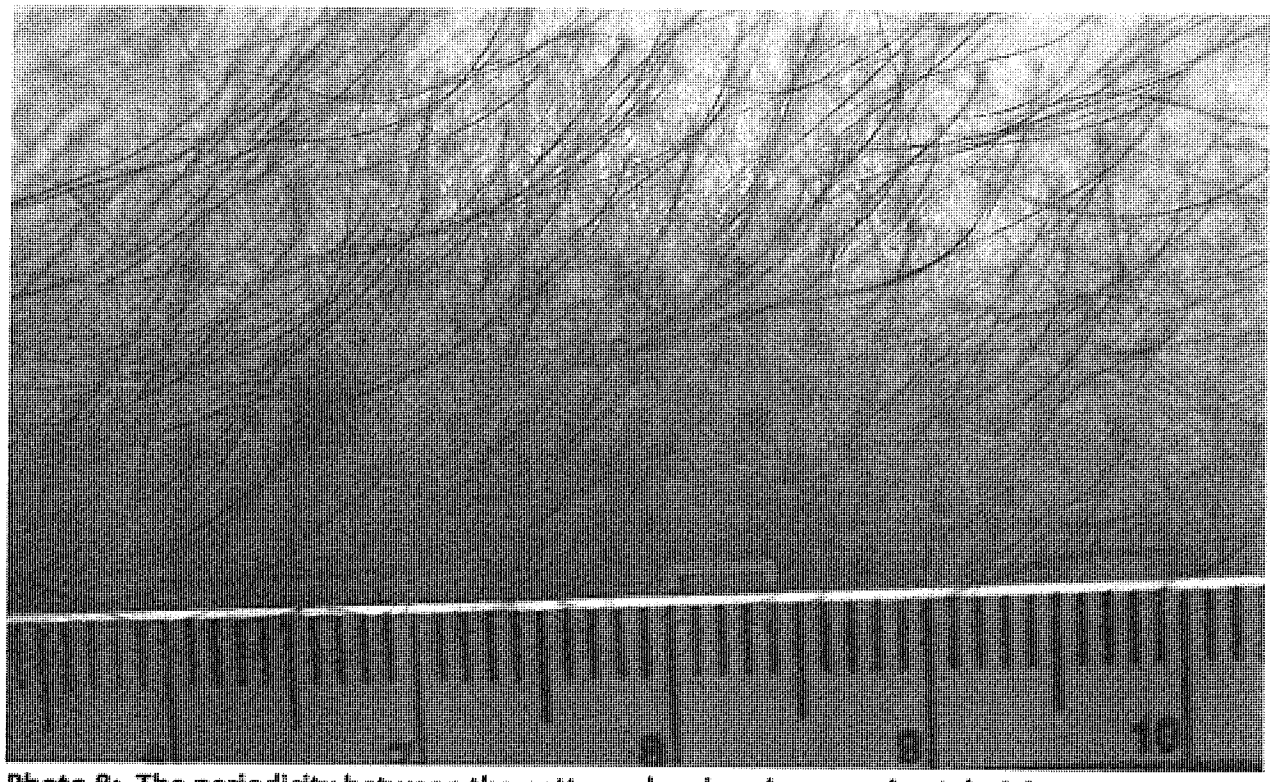


Photo 8: The periodicity between the pattern abrasions is approximately 4.0 mm.

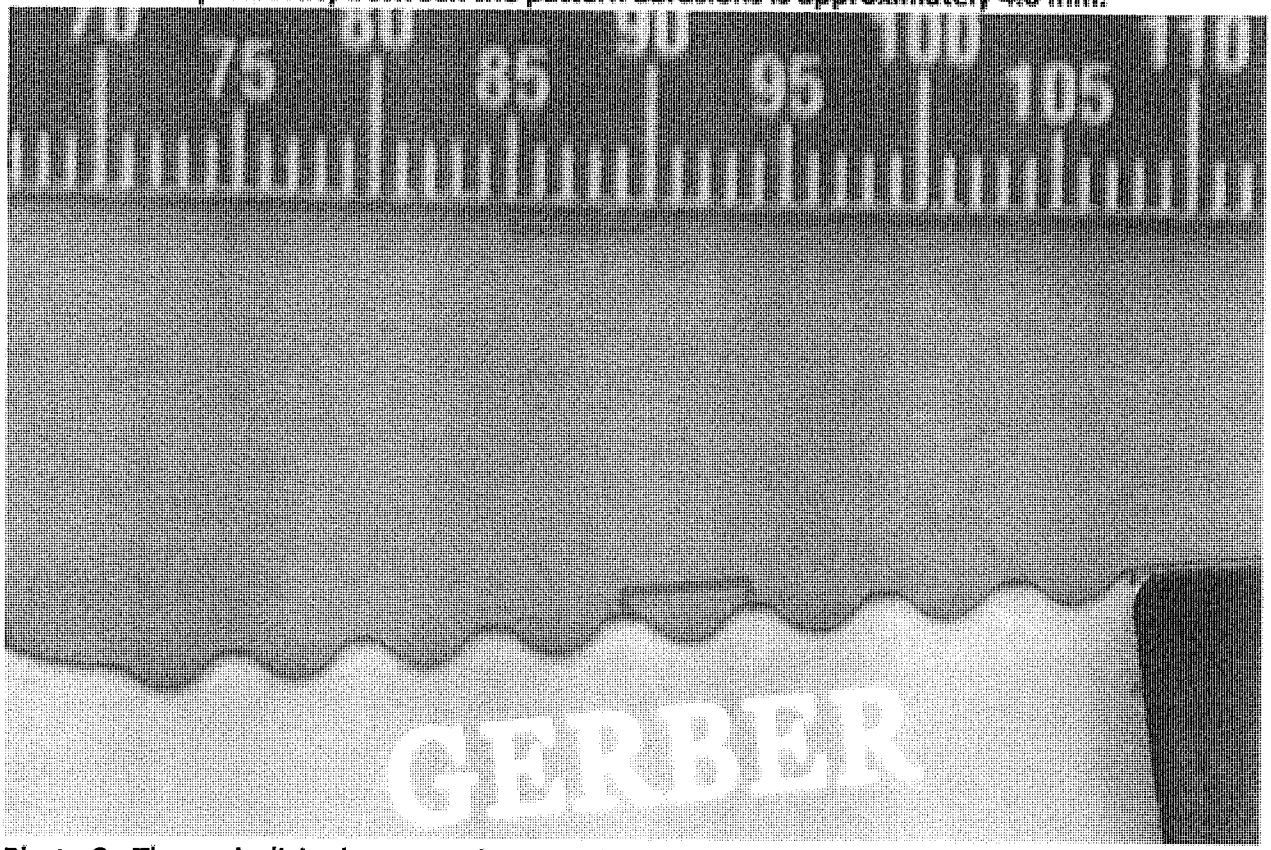


Photo 9: The periodicity between the serrations on the blade is approximately 4.5 mm.

Forensic Evidence Processed by the Indiana State Police Laboratory Division (Range-of-Fire):

Laboratory Case Number: 19X-00464

Examination of the coat in 001 and the t-shirt in item 002 revealed corresponding defects in the right chest area of the garments. The areas around the defects were visually, microscopically, and chemically examined for the presence of gunshot residues. No gunshot residues were detected in the areas around the defects. Due to the lack of such residues a muzzle-to-garment distance could not be determined.

"Load and Go" Transport by the South Bend Police Department:

The decision by the South Bend Police Department to rapidly transport Mr. Logan is to be commended. The medical literature is replete with multiple articles which document the benefits of rapid police transport in cases of penetrating trauma (Exhibits 1-5). Because of the clear benefits of "load and go" police transport of penetrating trauma, including gunshot wounds, many police agencies have official policies regarding the benefits of police transport.

Opinions:

Mr. Hertel, I am an emergency medicine and forensic fellowship trained physician with more than 30 years of experience in the forensic evaluation of injuries and the analysis of injury causation. My training, experience and position as a Police Surgeon, a Professor of Emergency Medicine, Medical Advisor to the FBI and an Assistant Medical Examiner with the Kentucky Medical Examiner's Office includes the emergency treatment, investigation and reconstruction of injuries sustained in traumatic incidents, including the investigation of officer-involved shootings. I have treated and evaluated thousands of patients, both fatally and not-fatally injured, who have experienced the physiological consequences of penetrating trauma, including gunshot wounds. I have been previously accepted in the United States in both federal and state courts as an expert in the areas of forensic medicine and emergency medicine. I have written and lectured extensively on the forensic evaluation and interpretation of gunshot wounds and the reconstruction of officer-involved shootings (see attached CV, Exhibit 6). Based upon my education, experience, including my experience as a consultant to local, state and federal law enforcement agencies, my training and my review of the above-referenced material I can render the following opinions within a reasonable degree of medical and scientific certainty:

1. Mr. Eric Logan sustained a penetrating gunshot wound to the right upper abdomen (Photo 4 and Diagrams 1-3) on 6/16/19 when he was shot by Sgt. Ryan O'Neill of the South Bend Police Department.
2. The range-of-fire associated with Mr. Eric Logan's penetrating gunshot wound to the right upper abdomen is distant/indeterminant (greater than 4 feet).

3. Mr. Eric Logan was struck by one of the two 9mm rounds discharged by Sgt. Ryan O'Neill of the South Bend Police Department. I am unable to determine if Mr. Logan was struck by the first or second round discharged by Sgt. O'Neil.
4. Mr. Eric Logan was struck by a 9mm round discharged by Sgt. Ryan O'Neill as Mr. Logan advanced toward him armed with a deadly weapon, a sharp-edged knife.
5. The wound path of the bullet which entered Mr. Logan's right upper quadrant traveled from anterior to posterior, right to left and superior to inferior (Diagrams 1 - 3). After perforating the liver, the bullet came to rest in the soft tissues of the back at the T2 level (Photo 5). The wound path is consistent with Sgt. Ryan O'Neill's statement that Mr. Eric Logan was advancing toward him.
6. The bullet trajectory is downward at approximately 30 degrees (Diagram 3). The trajectory is consistent with Mr. Logan being slightly bent forward, toward Sgt. O'Neill.
7. The Gerber knife brandished and thrown by Mr. Eric Logan is a dangerous sharp-edged weapon capable of causing serious physical injuries and death.
8. The Gerber knife brandished and thrown by Mr. Eric Logan is capable of penetrating Kevlar body armor (Photo 7).
9. Sgt. Ryan O'Neil sustained a pattern abrasion to his left forearm (Photos 3 & 8). The abrasion is consistent with being stuck by the serrated edge of the Gerber knife thrown by Mr. Eric Logan (Photos 8 & 9).
10. The Gerber knife thrown by Mr. Logan at Sgt. Ryan O'Neill was reportedly stolen from within a vehicle in the area of the shooting.
11. Mr. Eric Logan was impaired and under the influence of alcohol when he was shot by Sgt. Ryan O'Neill on 6/16/19.
12. The decision by the South Bend Police Department Officers to "load and go" and transport Mr. Eric Logan in a police vehicle to the Memorial Hospital of South Bend provided Mr. Logan with the optimal chances for survival. The shorter the time period from injury to the operating room, the lower the associated mortality from penetrating trauma (Exhibits 1-5).
13. The use of deadly force by Sgt. Ryan O'Neill was justified based upon the threat and imminent danger presented by the sharp-edged knife in the right hand of Mr. Eric Logan.
14. I agree with the findings and opinions of Dr. D.L. Wolfe's forensic autopsy.

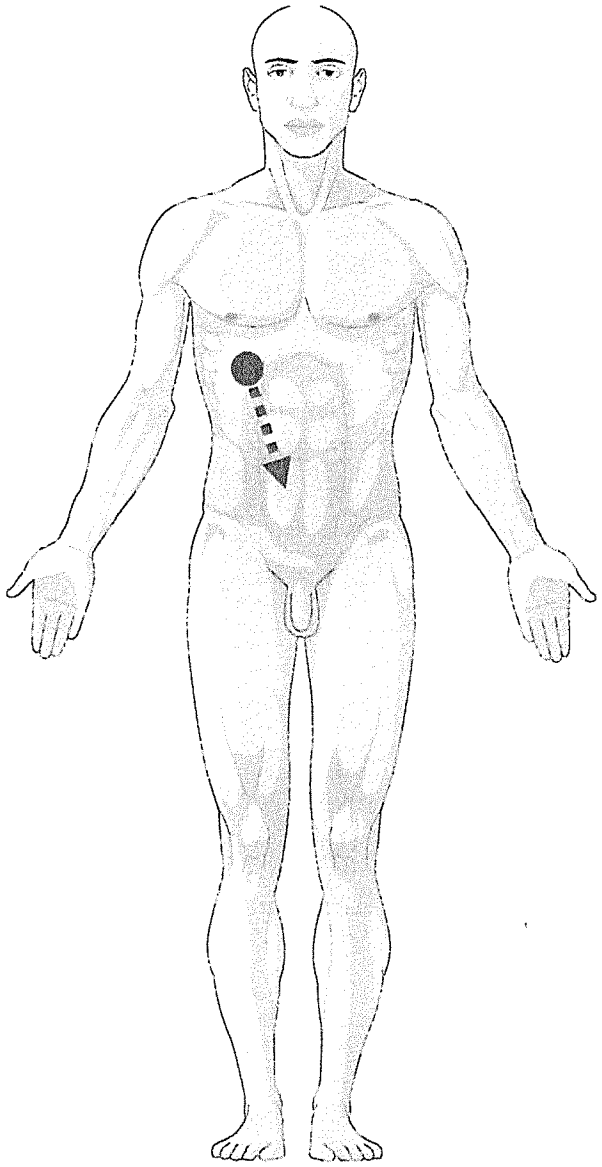
Mr. Hertel, please contact me if you have any questions or if I can be of additional assistance to you.

Yours sincerely,

William S. Smock, M.S., M.D.

Eric Logan
12-26-65

Diagram 1



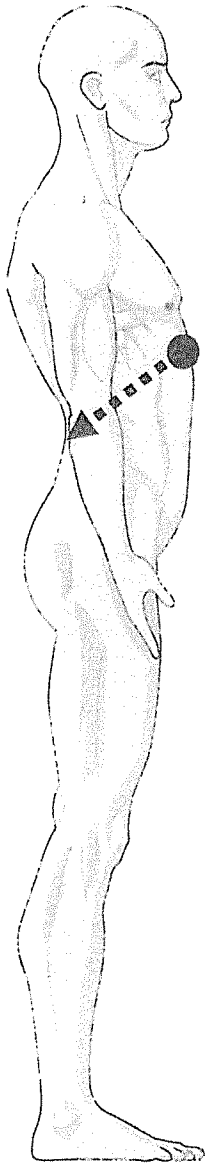
◀▪▪▪ = Bullet Path

● = Entrance Wound

Bill Smock, MD

Eric Logan
12-26-65

Diagram 2



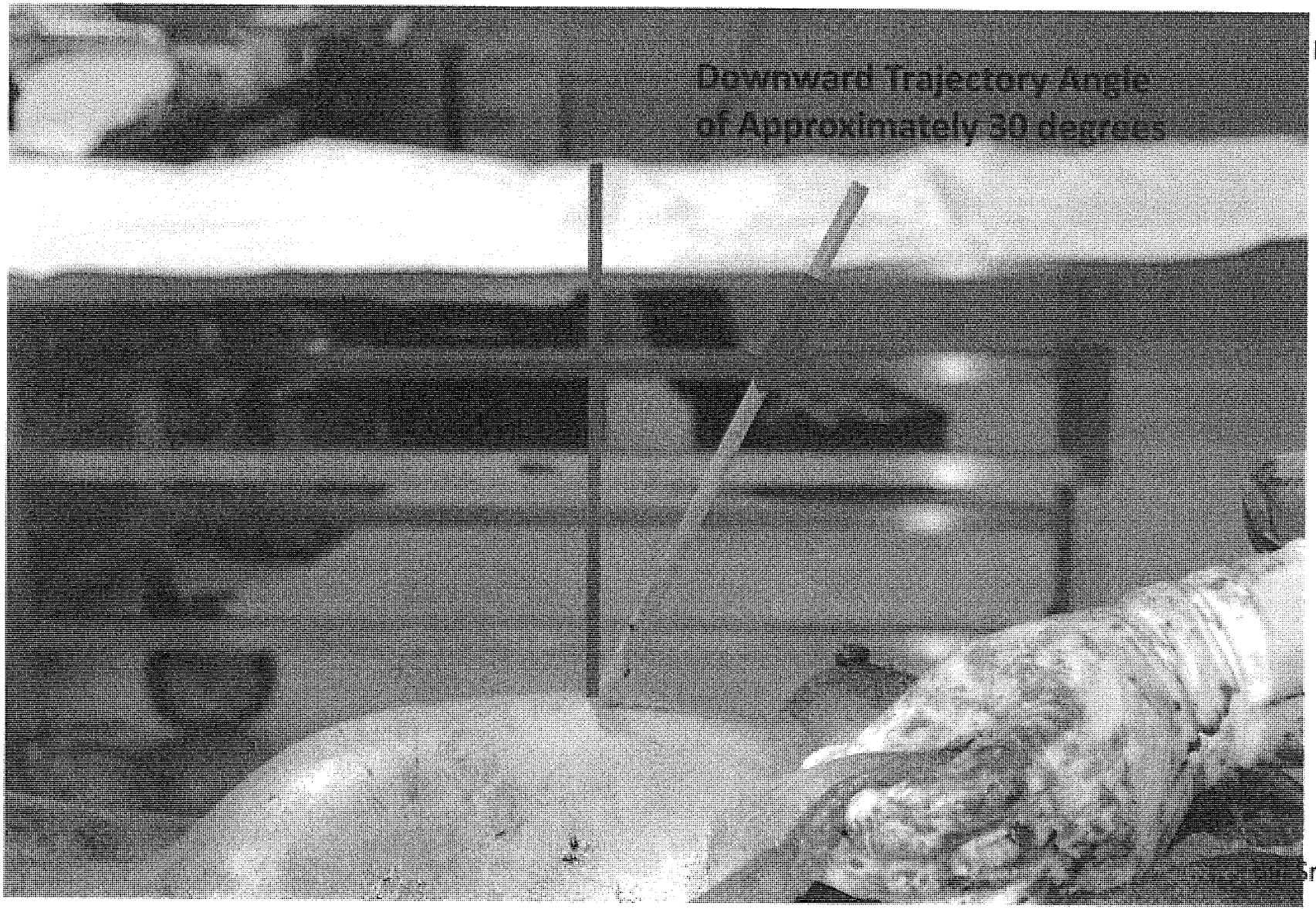
◀▪▪▪ = Bullet Path

● = Entrance Wound

Bill Smock, MD

Eric Logan
12-26-65

Diagram 3



Smock, MD

JAMA Surgery | Original Investigation

Association of Prehospital Mode of Transport With Mortality in Penetrating Trauma

A Trauma System–Level Assessment of Private Vehicle Transportation vs Ground Emergency Medical Services

Michael W. Wandling, MD, MS; Avery B. Nathens, MD, PhD; Michael B. Shapiro, MD; Elliott R. Haut, MD, PhD

IMPORTANCE Time to definitive care following injury is important to the outcomes of trauma patients. Prehospital trauma care is provided based on policies developed by individual trauma systems and is an important component of the care of injured patients. Given a paucity of systems-level trauma research, considerable variability exists in prehospital care policies across trauma systems, potentially affecting patient outcomes.

OBJECTIVE To evaluate whether private vehicle prehospital transport confers a survival advantage vs ground emergency medical services (EMS) transport following penetrating injuries in urban trauma systems.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study of data included in the National Trauma Data Bank from January 1, 2010, through December 31, 2012, comprising 298 level 1 and level 2 trauma centers that contribute data to the National Trauma Data Bank that are located within the 100 most populous metropolitan areas in the United States. Of 2 329 446 patients assessed for eligibility, 103 029 were included in this study. All patients were 16 years or older, had a gunshot wound or stab wound, and were transported by ground EMS or private vehicle.

MAIN OUTCOME AND MEASURE In-hospital mortality.

RESULTS Of the 2 329 446 records assessed for eligibility, 103 029 individuals at 298 urban level 1 and level 2 trauma centers were included in the analysis. The study population was predominantly male (87.6%), with a mean age of 32.3 years. Among those included, 47.9% were black, 26.3% were white, and 18.4% were Hispanic. Following risk adjustment, individuals with penetrating injuries transported by private vehicle were less likely to die than patients transported by ground EMS (odds ratio [OR], 0.38; 95% CI, 0.31-0.47). This association remained statistically significant on stratified analysis of the gunshot wound (OR, 0.45; 95% CI, 0.36-0.56) and stab wound (OR, 0.32; 95% CI, 0.20-0.52) subgroups.

CONCLUSIONS AND RELEVANCE Private vehicle transport is associated with a significantly lower likelihood of death when compared with ground EMS transport for individuals with gunshot wounds and stab wounds in urban US trauma systems. System-level evidence such as this can be a valuable tool for those responsible for developing and implementing policies at the trauma system level.

Supplemental content

CME Quiz at jamanetwork.com/learning

Author Affiliations: Author affiliations are listed at the end of this article.

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JAMA Surg. 2018;153(2):107-113. doi:10.1001/jamasurg.2017.3601
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The time immediately following injury can be vitally important to the clinical outcomes of severely injured trauma patients.[1-3] The term the golden hour is commonly used to emphasize the importance of time in trauma care. Trauma systems are developed at the local, state, or regional level to optimize the delivery of care to seriously injured patients and are associated with increased survival after injury.[4-6] Although the focal points of trauma systems are specialized trauma centers, the prehospital care provided to injured patients prior to arriving at trauma centers is important because this care has implications on clinical outcomes.[7,8] Prehospital care policies are typically established at the trauma system level. In accordance with these policies, first responders must determine what, if any, interventions should be performed prior to and during transport to the hospital. To our knowledge, most of the previous research into optimal prehospital trauma care policies has not evaluated their effects at a system level, limiting the generalizability of their findings and resulting in persistent variability in prehospital protocols and procedures across trauma systems.[9-12]

The spectrum of prehospital care provided to injured patients ranges from no intervention to advanced life support, fluid resuscitation, and endotracheal intubation with mechanical ventilation. Although optimal prehospital care strategies following injury remain undefined, within the last 2 years, several major national initiatives have aimed to improve early bystander and first responder response to injury, including the Stop the Bleed campaign based primarily on the Hartford Consensus.[13,14] Training of the lay public in hemorrhage control has also become increasingly common in urban areas with high levels of violence.[15]

Private vehicle transportation to a trauma center represents perhaps the most basic form of prehospital care, where no intervention is performed and only transportation is provided. In essence, private vehicle transport is a pure example of the "scoop and run" approach to prehospital trauma care. In patients with penetrating injures where time to definitive treatment is paramount, private vehicle transportation has been shown to be associated with improved survival when compared with transportation via ground emergency medical services (EMS).[12] Although compelling, the results of this study are at the patient level and thus have been difficult to translate into trauma system-level policy. The objective of our study was to evaluate the association between the mode of transportation and mortality among individuals with penetrating injuries within urban trauma systems. We hypothesized that private vehicle transport is associated with a decreased mortality for penetrating injuries when compared with ground EMS transport.

Key Points

Question Does ground emergency medical services transport confer a survival advantage vs private vehicle transport for patients with penetrating injuries?

Findings In this cohort study of 103 029 patients included in the National Trauma Data Bank, individuals transported by private vehicle were significantly less likely to die than similarly injured patients transported by ground emergency medical services, even when controlling for injury severity.

Meaning Ground emergency medical services transport is not associated with improved survival compared with private vehicle transport among patients with penetrating injuries in urban trauma systems, suggesting prehospital trauma care may have a limited role in this subset of patients.

Methods

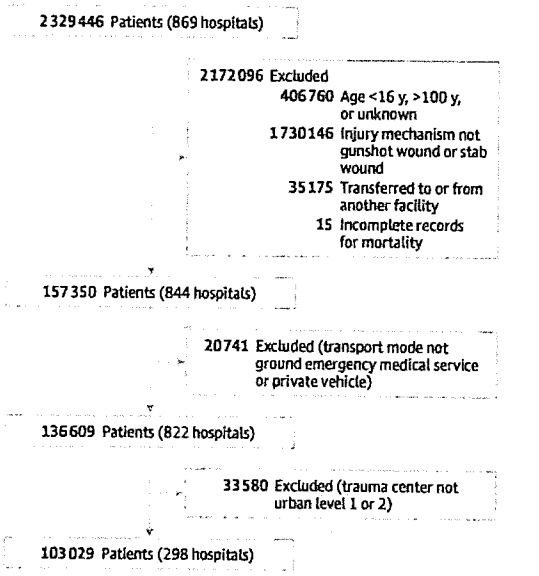
The data source for this study was the American College of Surgeons National Trauma Databank (NTDB); the largest aggregation of US trauma registry data assembled.[16] Data are entered into the NTDB by trained data abstractors, and the quality of the data is maintained through extensive statistical analyses and hospital audits performed by the American College of Surgeons Committee on Trauma. For this study, data from January 1, 2010, through December 31, 2012, were analyzed. Patients were included if they were aged 16 years or older, had a gunshot wound (GSW) or stab wound, were transported to the hospital by ground EMS or private vehicle, and were treated at a level 1 or level 2 trauma center. The design of this study is similar to previously published work comparing ground EMS and police department prehospital transport.[17] Analyses were restricted to patients treated at trauma centers located within the 100 most populous US trauma systems to generate results capable of driving prehospital policy changes within large urban trauma systems. Cities were not used to define trauma systems because doing so would exclude trauma centers located outside a city's limits that still provide trauma care to the city's population. Patients were excluded if they had incomplete records for the primary outcome of in-hospital mortality or were transferred to or from another hospital.

Study participants were limited to individuals with GSWs or stab wounds because they represent a unique subpopulation of trauma patients most likely to benefit from timely surgical intervention and least likely to derive significant benefit from prehospital interventions.[18-20] These mechanisms of injury were identified by *International Classification of Diseases, Ninth Revision* external causes of injury codes that are provided for each record in the NTDB. The 100 most populous US trauma systems were defined using 2010 US census information that ranks metropolitan areas based on Metropolitan Statistical Areas, an approach previously used in aggregating trauma centers into defined trauma systems.[21] Metropolitan Statistical Areas are geographic areas containing a large population nucleus and adjacent communities with a high degree of integration with the population nucleus.[22] Adult level 1 and level 2 trauma centers located within the most populous metropolitan areas were assigned to their respective trauma system. Institutional review board exemption was obtained from the Northwestern University Feinberg School of Medicine institutional review board. Individual patient consent was waived because all data used in this study were deidentified in the NTDB dataset prior to this study being conducted.

Baseline characteristics and unadjusted mortality rates between patients transported by ground EMS and those transported by private vehicle were compared using χ^2 and t tests. Unadjusted mortality rates by mode of transport were compared between GSW and stab wound subgroups of the patient sample. The primary outcome of in-hospital mortality included deaths in the emergency department (ED) and all deaths occurring prior to hospital discharge. We considered excluding ED deaths from our analysis to determine the correlation of transport mode with survival of only salvageable patients. However, this approach could introduce selection bias. For example, it cannot be determined whether ED deaths within the private vehicle cohort were owing to lack of prehospital intervention or rapid transport of patients with nonsurvivable injuries who EMS may have pronounced dead at the scene. Excluding these patients could bias important mortality data among these patients to favor a lower mortality rate, when prehospital cardiac arrest may in fact occur at higher rates and result in more deaths among these patients. Similarly, ED deaths could potentially have occurred in EMS-transported patients who might have survived if they had been transported by private vehicle with a shorter delay to definitive care. Patients with a documented discharge disposition of hospice were also defined as in-hospital deaths, as has been previously described for risk-adjusted mortality calculations in trauma.[23]

To evaluate the independent association between mode of prehospital transport and mortality, a general linear mixed-effects model accounting for hospital-level clustering was created. Consideration was given to using propensity score-matched cohorts, but this did not confer an advantage over multivariate modeling.[24,25] Variables included in the risk adjustment for mortality were presenting heart rate, presenting systolic blood pressure, presenting Glasgow Coma Scale Motor Score, Injury Severity Score (ISS), age, sex, race/ethnicity, insurance status, and year of admission.[26] Heart rate, systolic blood pressure, ISS, and age were treated as continuous variables, while sex, race/ethnicity, insurance status, and year of admission were categorical. Insurance status was categorized as private, governmental, self-pay, or other.[26,27] Missing data for heart rate (n = 1624; 1.6%), systolic blood pressure (n = 2065; 2.0%), Glasgow Coma Scale Motor Score (n = 2119; 2.1%), ISS (n = 411; 0.4%), and sex (n = 18; 0.02%) were addressed using multiple imputation.[28] Risk-adjusted mortality was assessed for all penetrating injuries as well as for the GSW and stab wound subgroups. Risk-adjusted mortality was also evaluated after stratifying by injury severity. Two stratified analyses were performed, 1 stratifying patients into ISS 15 or less and ISS greater than 15 categories and the other stratifying into mild (ISS ≤9), moderate (ISS, 9-15), severe (ISS, 16-24), and very severe (ISS ≥25) injury severity categories. To confirm the applicability of results to the top 100 most populous US trauma systems, sensitivity analyses were performed to evaluate risk-adjusted mortality across population strata. These strata included the most populous 10, 25, 50, and 75 systems, as well as the least populous 10, 25, 50, and 75 trauma systems within the 100 most populous US trauma systems (eTable in the Supplement). The results of this study were 2-sided and considered to be statistically significant at an α level of $P < .05$.

Figure 1. Consort Diagram Illustrating the Selection of Patients From the National Trauma Data Bank Between January 1, 2010, and December 31, 2012



SAS, version 9.4 (SAS Institute Inc), was used to perform all statistical analyses for this study.

Results

Of the 2 329 446 patients at 869 hospitals included in the NTDB from January 1, 2010, to December 31, 2012, a total of 103 029 patients at 298 hospitals were included in the study sample after applying the inclusion and exclusion criteria (Figure 1). Of the included patients, black and Hispanic patients were more frequently transported by private vehicle than by ground EMS (8545 [50.5%] vs 40 775 [47.4%] and 3472 [20.5%] vs 15 430 [17.9%], respectively), while white patients were more frequently transported by ground EMS than by private vehicle (23 420 [27.2%] vs 3663 [21.6%]). Patients with stab wounds were more likely to be transported by private vehicle than those with GSWs (9462 [55.9%] vs 7470 [44.1%], $P < .001$). The mean ISS was significantly lower for patients transported by private vehicle than those transported by ground EMS (5.5 vs 10.1, $P < .001$). Full demographic and injury information is provided in Table 1.

Overall, unadjusted mortality was lower for private vehicle transport than for ground EMS (378 [2.2%] vs 9986 [11.6%], $P < .001$). Among patients with GSWs, unadjusted mortality was significantly lower for those transported by private vehicle when compared with ground EMS (339 [4.5%] vs 18 807 [9.3%], $P < .001$). This difference was also found for the stab wound subgroup (39 [0.2%] vs 1179 [2.9%], $P < .001$). Private vehicle transport was associated with a lower unadjusted rate of death in the ED compared with ground EMS transport (1.2% vs 6.8%, $P < .001$). Unadjusted mortality rates are provided in Table 2.

Table 1. Sample Population Characteristics by Mode of Prehospital Transportation

Characteristic	No. (%)			P Value
	All Patients	Ground EMS	Private Vehicle	
Population size	103 029 (100)	86 097 (83.6)	16 932 (16.4)	
Sex				
Male	90 259 (87.6)	75 141 (87.3)	15 118 (89.3)	<.001
Female	12 770 (12.4)	10 956 (12.7)	1814 (10.7)	
Age, y				
Mean (SD)	32.3 (13.2)	32.7 (13.4)	30.4 (12.2)	<.001
Median	29.0	29.0	27.0	<.001
Race/ethnicity				
Black	49 320 (47.9)	40 775 (47.4)	8545 (50.5)	<.001
White	27 083 (26.3)	23 420 (27.2)	3663 (21.6)	
Hispanic	18 902 (18.4)	15 430 (17.9)	3472 (20.5)	
Asian	1458 (1.4)	1232 (1.4)	226 (1.3)	
Other	4437 (4.3)	3725 (4.3)	712 (4.2)	
Unknown	1829 (1.8)	1515 (1.8)	314 (1.9)	
Insurance				
Private	18 480 (17.9)	15 111 (17.6)	3369 (19.9)	<.001
Governmental	29 783 (28.9)	25 496 (29.6)	4287 (25.3)	
Self-pay	37 765 (36.7)	31 015 (36.0)	6750 (39.9)	
Other	8941 (8.7)	7700 (8.9)	1241 (7.3)	
Unknown	8060 (7.8)	6775 (7.9)	1285 (7.6)	
Admission year				
2010	34 259 (33.3)	28 651 (33.3)	5608 (33.1)	.85
2011	34 340 (33.3)	28 665 (33.3)	5675 (33.5)	
2012	34 430 (33.4)	28 781 (33.4)	5649 (33.4)	
Injury mechanism				
GSW	53 052 (51.5)	45 582 (52.9)	7470 (44.1)	<.001
Stab wound	49 977 (48.5)	40 515 (47.1)	9462 (55.9)	
HR, bpm				
Mean (SD)	91.5 (30.2)	90.6 (31.1)	96.3 (24.6)	<.001
Median	94.0	94.0	96.0	<.001
SBP, mm Hg				
Mean (SD)	125.3 (39.7)	123.6 (41.2)	134.0 (29.3)	<.001
Median	132.0	131.0	136.0	<.001
GCS motor score[a]				<.001
Mean (SD)	5.4 (1.5)	5.4 (1.6)	5.9 (0.8)	<.001
% GCS motor <6	14.1	15.9	5.9	<.001
ISS[b]				
Mean (SD)	9.3 (12.0)	10.1 (12.5)	5.5 (7.8)	<.001
Median	5.0	8.0	2.0	<.001

Abbreviations: EMS, emergency medical service; GCS, Glasgow Coma Scale; GSW, gunshot wound; HR, heart rate; ISS, Injury Severity Score; SBP, systolic blood pressure.

[a] GCS motor scores range from 1 to 6, with 6 being normal.

[b] ISS ranges from 0 to 75, with 75 being an injury resulting in death.

Table 2. Unadjusted Overall Mortality for All Penetrating Injuries, GSWs, and Stab Wounds by Mode of Prehospital Transportation

Overall Mortality	No. (%)			P Value
	All Patients	Ground EMS	Private Vehicle	
All GSWs and stab wounds (n = 103 029)	10 364 (10.1)	9986 (11.6)	378 (2.2)	<.001
GSWs only (n = 53 052)	9146 (17.2)	8807 (19.3)	339 (4.5)	<.001
Stab wounds only (n = 49 977)	1218 (2.4)	1179 (2.9)	39 (0.2)	<.001

Abbreviations: EMS, emergency medical service; GSW, gunshot wound.

After risk adjustment, patients with penetrating injuries transported by private vehicle were significantly less likely to die than patients transported by ground EMS (OR, 0.38; 95% CI, 0.31-0.47) (Figure 2). This association remained statistically significant on stratified analysis of the GSW (OR, 0.45; 95% CI, 0.36-0.56) and stab wound (OR, 0.32; 95% CI, 0.20-0.52) subgroups (Figure 2). Stratified injury severity analyses demonstrated a qualitatively similar survival benefit associ-

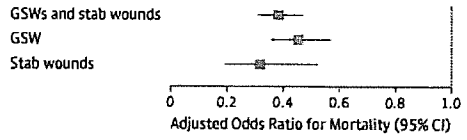
ated with private vehicle transport when compared with ground EMS transport for all but the lowest injury severity strata. Sensitivity analyses revealed statistically significant mortality benefits for patients with penetrating injures transported by private vehicle when compared with ground EMS in 8 of 9 trauma system cohorts. Sensitivity analyses revealed the only group of trauma systems failing to demonstrate statistically significant risk-adjusted mortality differences was the 91 to 100 most populous trauma systems, where the sample size was too small to detect a significant difference (OR, 0.26; 95% CI, 0.06-1.15) (Figure 3).

Discussion

This study demonstrates that for individuals with penetrating injuries in urban trauma systems, private vehicle transport to a level 1 or level 2 trauma center is associated with significantly lower mortality when compared with similarly injured individuals who are transported by ground EMS. This mortality benefit holds true on subgroup analyses of the 100 most populous US trauma systems, making these findings generalizable at the trauma system level for the large urban trauma systems included in this study. These results are important because they identify a component of prehospital trauma care that is associated with significant differences in mortality and may present an opportunity to improve trauma care at the system level.

Previous research has demonstrated that variations in prehospital care can affect mortality among seriously injured pa-

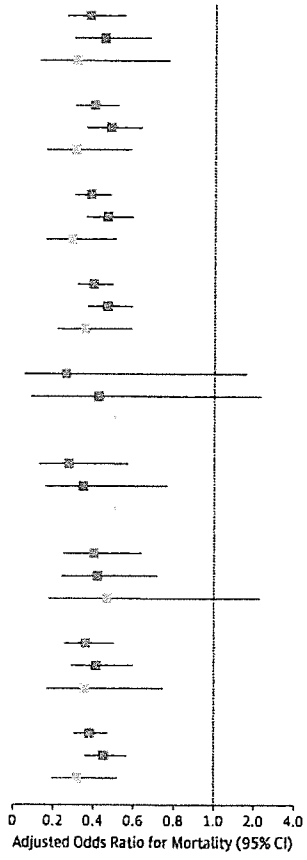
Figure 2. Risk-Adjusted Odds Ratios for Mortality for Private Vehicle Transport When Compared With Ground Emergency Medical Services Transport



GSW indicates gunshot wound.

Figure 3. Trauma System Subgroup Analyses of Risk-Adjusted Odds Ratios (ORs) for Mortality for Private Vehicle Transport When Compared With Ground Emergency Medical Services Transport

	No. of Events	No. of Participants	OR (95% CI)
Most populous 10			
All penetrating	3324	32584	0.38 (0.26-0.55)
GSWs	2915	16706	0.45 (0.30-0.68)
Stab wounds	409	15878	0.31 (0.13-0.77)
Most populous 25			
All penetrating	5517	55138	0.40 (0.31-0.52)
GSWs	4868	28258	0.48 (0.36-0.63)
Stab wounds	649	26880	0.30 (0.16-0.58)
Most populous 50			
All penetrating	7552	76908	0.38 (0.31-0.48)
GSWs	6706	40165	0.46 (0.36-0.59)
Stab wounds	846	36743	0.29 (0.16-0.51)
Most populous 75			
All penetrating	8500	86605	0.40 (0.32-0.49)
GSWs	7523	44765	0.47 (0.37-0.59)
Stab wounds	977	41840	0.35 (0.22-0.58)
Least populous 10			
All penetrating	243	2315	0.26 (0.06-1.15)
GSWs	222	1357	0.42 (0.09-2.07)
Stab wounds	21	958	NA
Least populous 25			
All penetrating	685	6987	0.28 (0.14-0.56)
GSWs	604	3549	0.35 (0.16-0.76)
Stab wounds	81	3438	NA
Least populous 50			
All penetrating	1633	16684	0.40 (0.25-0.63)
GSWs	1421	8149	0.42 (0.25-0.72)
Stab wounds	212	8535	0.47 (0.18-1.23)
Least populous 75			
All penetrating	3668	38454	0.36 (0.26-0.49)
GSWs	3259	20056	0.42 (0.29-0.60)
Stab wounds	409	18398	0.36 (0.17-0.75)
Overall			
All penetrating	9185	93592	0.38 (0.31-0.47)
GSWs	8127	48314	0.45 (0.36-0.56)
Stab wounds	1058	45278	0.32 (0.20-0.52)



GSW indicates gunshot wound; NA, not applicable.

Odds ratios cannot be derived due to small sample size.

tients, often in ways that may not be expected. For example, prehospital advanced life support care has been shown in multiple studies to be associated with higher mortality rates than basic life support when similarly injured patients are compared.[7,8] Additionally, prehospital interventions, including endotracheal intubation, intravenous fluid administration, and spine immobilization, have been found to be associated with higher rates of mortality in certain groups of trauma patients.[9-11] Previous work has also demonstrated outcome differences, or an absence of differences, based on mode of prehospital transportation including helicopter,[24] ground EMS, police department transport,[29,30] and private vehicle.[12,31] These studies highlight the significance of prehospital trauma care and the effect that trauma system-level first responder policies can have on patient outcomes. However, these studies examine outcomes within single centers or aggregated at a national level, rather than the trauma system level, which has limited the ability to use the results to drive system-level policy change.

The results of this study confirm those that have been previously reported on mortality differences between ground EMS and private vehicle transport, but represent, to our knowledge, the first time the results have been analyzed on a trauma system level. Additionally, the results of this study were obtained through a larger patient sample that contained data through 2012, which is more recent than previous studies. The ability to use unblinded NTDB hospital identifiers to conduct system-level analyses that can inform trauma system policy is a major strength of this study and, to our knowledge, has never been published. Because trauma system policies are developed and implemented at the system level, it is important to provide system-level evidence to support the implementation of policies and protocols within each system. For example, consideration could be given to educating those at high risk for penetrating injury that individuals with these injuries may benefit from rapid private vehicle transport to the nearest level 1 trauma center instead of waiting for first responders to arrive. Furthermore, although EMS "scoop and run" policy was unable to be compared with EMS "stay and stabilize" policy in this analysis, these results suggest that a "scoop and run" policy for EMS may be beneficial given the similarities between private vehicle transport and "scoop and run" by EMS. Other strengths of this study include the large sample size and the consistently statistically significant results in nearly all strata, subgroups, and sensitivity analyses.

Limitations

This study is not without limitations. As with all large, multicenter database analyses, data quality is dependent on the accuracy of the data abstraction process and the amount of missing data. Although there are auditing mechanisms in place to identify errors in abstraction, errors cannot be entirely eliminated. Missing data were not a major factor in this analysis, but where they were present, the missing data were imputed. Another limitation of this study was the risk adjustment for mortality calculations, which was limited to the data available in the NTDB. As a result, it is likely that potential confounding risk factors for mortality were unable to be included in the risk-adjustment process. Specifically, prehospital transport time is one of the major confounders we were unable to include owing to the large amount of missing data. However, because patients transported by private vehicle do not wait for EMS to arrive and do not undergo any prehospital interventions, their prehospital times are unlikely to be longer than those transported by ground EMS. Differences in baseline characteristics between modes of transport, most notably mechanism of injury and injury severity, are also a limitation. Although patient randomization would optimally eliminate these differences, this was not (and realistically, will never be) feasible, and we accounted for these differences by adjusting for them in our mortality models. Furthermore, the results of this study only reflect the data from trauma centers that contribute to the NTDB. Although more than 800 centers contribute data to the NTDB each year, it is not a requirement for all US trauma centers, and thus, not all centers participate. Lastly, although the results of this study demonstrate a mortality benefit associated with private vehicle transport, such approaches may be associated with unintended consequences unable to be assessed by this study. Consequently, further study is necessary before private vehicle transport initiatives or "scoop and run" EMS transport policies can be definitively recommended for all urban gunshot and stab wound patients.

Conclusions

Private vehicle transport is associated with a significantly lower likelihood of death when compared with ground EMS transport for individuals with GSWs and stab wounds in urban US trauma systems. System-level data such as these can be a valuable tool for use in the development and implementation of policies at the trauma system level. The goal of trauma systems is to deliver optimal care to injured patients. An important part of accomplishing this is determining what constitutes optimal care in each trauma system because it may be different. The results of this study highlight the importance of system-level research and the need for additional such work to be conducted in the future.

ARTICLE INFORMATION

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Author Contributions: Dr Wandling had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Wandling, Nathens, Haut.
Acquisition, analysis, or interpretation of data: Wandling, Shapiro, Haut.
Drafting of the manuscript: Wandling.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Wandling.
Obtained funding: Wandling.
Administrative, technical, or material support: Wandling.
Supervision: Nathens, Shapiro, Haut.

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Special Delivery:

The Pros and Cons of Police Transport

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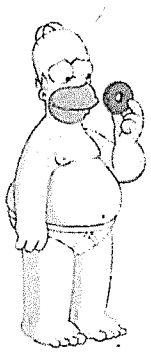
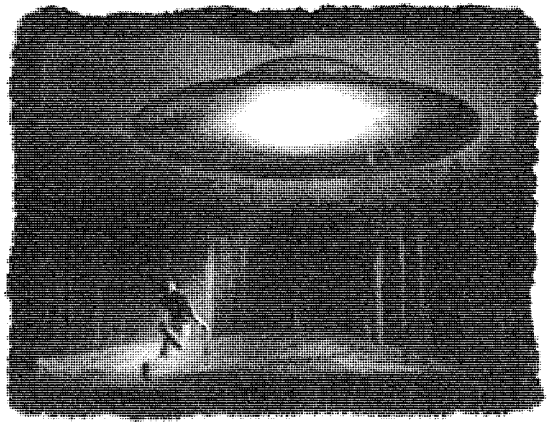
The Evolution of Patient Transport





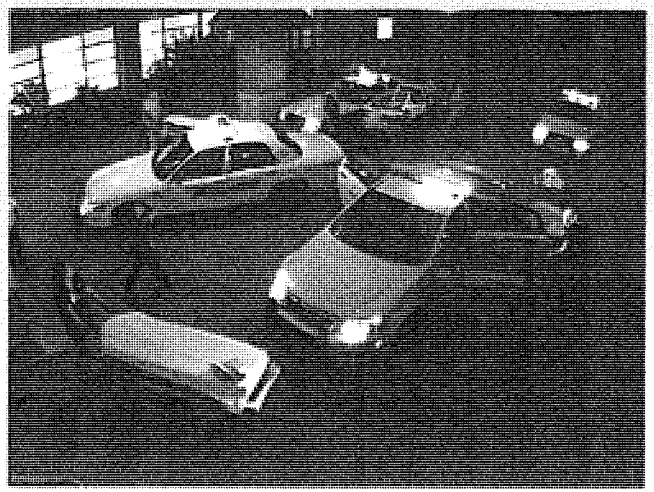
But When 9-1-1 is Called…

Police Transport of Patients

- Mumbai, India
- Tanzania
- Nigeria
- Malaysia
- Kampala, Uganda
- Louisville until 1972
- Psychiatric or violent pts/fellow LEOs

University of CO ED

- Aurora, CO, shooting, July 20, 2012
- Of 23 pts, 12 by police, 8 by PMV, 3 by EMS
  - Within 45 min., 9 police cars and 1 ambulance arrived with victims

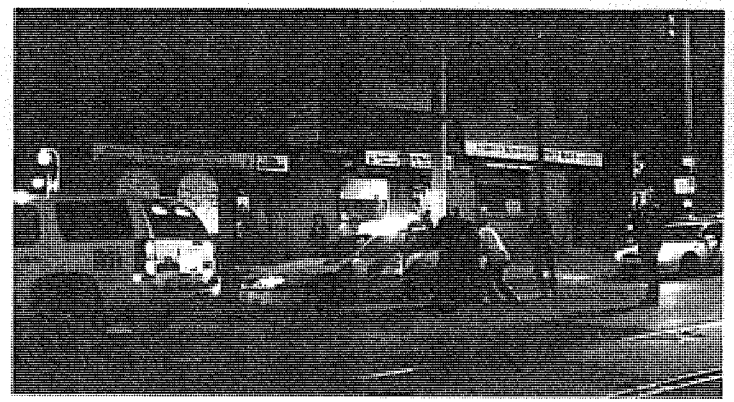


Philadelphia Fire Department

- Sole 9-1-1 EMS response agency for City of Philadelphia
- 50 ambulances during peak hours
- Transport pts to 23 receiving hospitals
  - 8 trauma centers (2 are peds hospitals)
- 2012 EMS call volume 280,877
  - 5 ambulances went on > 8000 runs
  - At times, no ambulances available

Violence in Philadelphia

- 331 homicides in 2012 (82% due to firearms)
- If arrive shooting scene and no ambulance there, police often load and go
  - At times as ambulance arrives



The Literature

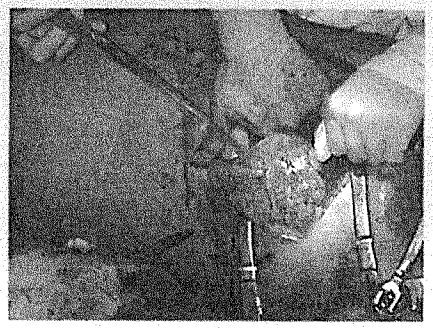
- Impact of police transport on outcome of assault pts (blunt and penetrating)
  - 6 yrs of trauma registry data
  - PFD transported 2,108; PPD transported 1,356
  - Outcomes compared
- PFD pts had lower probability of survival
- After controlling for severity, outcomes of PPD pts equivalent to PFD pts

UNIVERSITY OF PENNSYLVANIA HEALTH SYSTEM

Acad Emerg Med 1995; 2:486-93

The Literature

- Outcome of 94 pts with penetrating cardiac injuries requiring EDT (87% GSW)
- Predictors of survival:
  - Stab wound
  - Higher GCS
  - Sinus tach on ED arrival
  - Measurable ED vital signs
  - **Transport by police**



Temple University Hospital
Temple University Health System

Interact Cardiovasc Thorac Surg 2008;7:844-9

The Literature

- Compared mortality for penetrating trauma pts transported by PPD, PFD over 5 yrs
  - 1558 by PFD, 569 by PPD (most were GSWs)
- PPD pts sicker
- After adjusting for injury severity, no difference in survival between groups
  - Practice of PPD transporting penetrating trauma pts should be continued

UNIVERSITY OF PENNSYLVANIA HEALTH SYSTEM

Acad Emerg Med 2011;18:32-7

Media Attention

- "Philadelphia's unusual but effective policy: Police can transport trauma victims"
  - "This innovative program takes advantage of the existing law enforcement infrastructure to extend the EMS system and shorten time to definitive emergency medical care"

The Philadelphia Inquirer

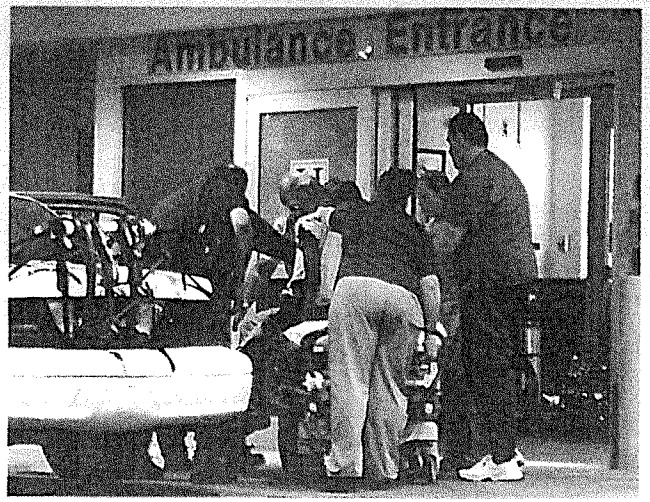
Philadelphia Inquirer, June 4, 2011

EMSWORLD

www.emsworld.com/article/

Media Attention

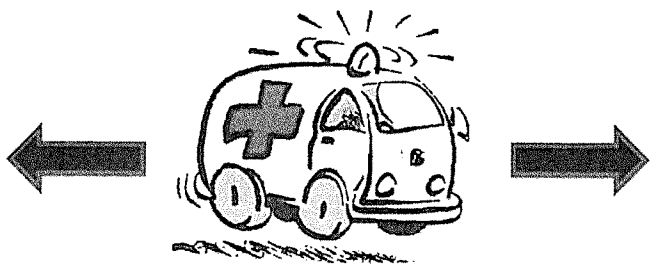
- "Philadelphia Police Begin Transporting Trauma Victims. New directive has police taking patients with penetrating injuries to nearest trauma center."

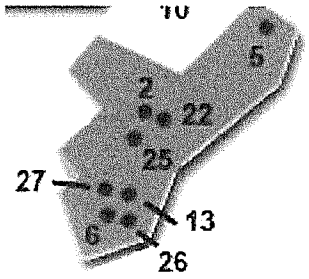


http://www.jems.com/article/news/philadelphia-police-begin-transporting-t

Pros

- Outcomes at least equal to EMS transport
  - Trauma is a BLS disease
- Gets police off of emotionally charged scene
- Police can be at trauma center in minutes
  - Often half of time of ambulance dispatch and pt transport



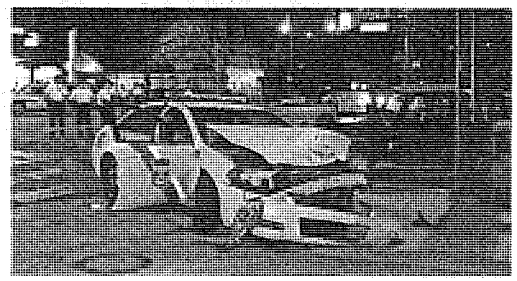


Cons

- Philadelphia Fire Department is sole 9-1-1 provider of EMS for City of Philadelphia
  - (Mayor Goode's 1988 Executive Order 7-88)
- Police vehicles not licensed ambulances
  - Function outside of EMS system
- Minimal medical training/equipment
- No medical oversight

Cons

- No medical care en route
  - Pt not secured in vehicle
- Police sometimes go to non-trauma center
- May have been police-related shooting
- Fosters resentment among EMS
- Lessens incentive for City to give more resources to EMS
- Transports not reimbursed



Thank You

Speed Does Matter: Police "Scoop and Run" Transport of Critical Trauma Victims

Answers to the May 2014 Journal Club Questions

Guest Contributors
Samuel J. Stratton, MD, MPH; Atilla Uner, MD, MPH

0196-0644/$-see front matter

http://dx.doi.org/10.1016/j.annemergmed.2014.06.021

Editor's Note: *You are reading the 39th installment of* Annals of Emergency Medicine *Journal Club. This Journal Club refers to the Band et al[1] article titled "Severity-Adjusted Mortality in Trauma Patients Transported by Police," published in the May 2014 edition. Information about Journal Club can be found at http://www.annemergmed.com/content/journalclub. Readers should recognize that these are suggested answers. We hope they are accurate; we know that they are not comprehensive. There are many other points that could be made about these questions or about the article in general. Questions are rated "novice" (NOV), "intermediate" (INT), and "advanced" (ADV) so that individuals planning a journal club can assign the right question to the right student. The "novice" rating does not imply that a novice should be able to spontaneously answer the question. "Novice" means we expect that someone with little background should be able to do a bit of reading, formulate an answer, and teach the material to others. Intermediate and advanced questions also will likely require some reading and research, and that reading will be sufficiently difficult that some background in clinical epidemiology will be helpful in understanding the reading and concepts. We are interested in receiving feedback about this feature. Please e-mail journalclub@acep.org with your comments.*

DISCUSSION POINTS

1. (NOV) Describe the study goal and researchers' conclusions. What is the difference between nonmedical police transport and emergency medical services (EMS) transport?
2. (NOV) A. For this retrospective study, patients with penetrating trauma were divided into 2 groups: those transported by police and those transported by EMS. How might selection bias affect study results?
   (INT) B. What are the characteristics of the emergency management of penetrating trauma of the thorax that support the study results? What aspects of the emergency management for penetrating trauma of the thorax contradict the logic of the study results? Which characteristics of police transport could EMS emulate and which cannot be emulated?
3. (INT) A. The outcome measure for this study was inhospital mortality. Is this outcome measure optimal? Are there other outcome measures that would be of interest? What would be the obstacles to studying them?
   (INT) B. The authors report that 4.7% of the initial study population could not be included in the study because of missing information about transport mode (police versus EMS). How could the data have been analyzed to determine whether this 4.7% missing data biased study results?
   (ADV) C. Are there other acute emergency conditions that may benefit from incorporating rapid nonmedical transport into a community emergency response system?
4. (ADV) An adjustment of case mix among study subjects was made with the Charlson comorbidity index. Was this an appropriate adjustment technique for victims of penetrating trauma? The Charlson index was modified to conduct the study; how may this affect the validity of the results?

ANSWER 1

Q1. Describe the study goal and researchers' conclusions. What is the difference between nonmedical police transport and emergency medical services (EMS) transport?

The study goal was to evaluate the association between mode of transport (police versus EMS) to the emergency department (ED) and survival among patients with proximal penetrating trauma.[1] In effect, the study compares mortality outcome for rapid transport of a trauma victim without medical intervention (police transport) versus standard out-of-hospital EMS on-scene care before transport (EMS transport).

The difference between nonmedical police transport and EMS transport is best described in the following quote from the recently published article by Band et al[1]: "Although EMS follows citywide out-of-hospital protocols, no formal policy outlines how care should be provided...by police." It is further stated that victims transported by police "...are rendered no care...."

Police provided immediate transport, presumably without basic medical care and without obtaining clearance for transport to a trauma center. Police officers apparently had no formal medical training, but during law enforcement training are taught how to best incapacitate an aggressor with their firearms and may infer that a victim hit in vulnerable body areas will be severely injured. Many police officers have a military background and would have a soldier's understanding of penetrating trauma

severity. Band et al[1] reported that patients transported by police were on average more severely injured, suggesting that officers might have some expertise in triaging more critical patients to immediate police transport rather than waiting for EMS.

By contrast, paramedics have extensive formal medical training and mandatory continuing medical education. There is no mention in the study by Band et al[1] about what the local EMS protocols for proximal penetrating trauma required. EMS standard practice usually includes airway management, assisting with ventilations as needed, aggressive hemorrhage control, and other field and transport procedures, as illustrated in Table 1. For the study by Band et al,[1] EMS-transported patients were also likely placed in complete spine immobilization because this was still recommended practice during the 2003 to 2007 enrollment period. Although some interventions can be conducted en route, others must be conducted at the scene and require considerable time. It is also not known whether there were on-scene delays for a decision about which trauma center to transport victims to who were managed by EMS.

The overall assumption is that police transport was more rapid than EMS transport both because the police did less and perhaps because they reached some victims more quickly than EMS, who would have had to wait until the police declared the scene safe. These assumptions are not validated and it is not reported to what extent EMS performed on-scene medical interventions. Scene times are not reported for either group.

The unadjusted data suggested that individuals transported by police were more severely injured and had a higher mortality rate. However, when adjusted for injury severity and patient demographics, no important difference in mortality was observed. Post hoc subgroup analyses identified improved survival for victims transported by police with gunshot wounds, with stab wounds, and when severely injured (defined as Injury Severity Score [ISS] >15). These subgroup findings should be interpreted with caution and the authors do not discuss why these subgroups show a potential survival benefit while other subgroups (presumably of same age and sex, according to information provided) show the opposite (given that the overall effect is neutral). Further study would be required to confirm these subgroup effects.

ANSWER 2

Q2.a For this retrospective study, patients with penetrating trauma were divided into 2 groups: those transported by police and those transported by EMS. How might selection bias affect study results?

Bias is an error in the design or conduct of a study that produces a spurious value for the association between exposure and outcome. Causal inference is possible only when an association is not confounded, meaning that both groups would have had the same outcome had they received the same treatment. In other words, in an unconfounded study both police-transported and EMS-transported groups would have had the same outcomes if they had both been managed on scene and transported by the same methods.

The study is confounded (biased) if the 2 groups would have had different outcomes had they received identical on-scene treatment and transport. Selection bias occurs when the placement of the patient into a study group is associated with the outcome.[2] For example, in its extreme, if the most injured 50% of patients are transported by police and the least injured 50% by EMS, then results would be highly confounded favoring EMS transport, assuming that injury correlates with outcome. Although we cannot absolutely determine the degree of selection bias (because we can't have patients transported one way, measure an outcome, roll back time, and have them transported the other way), we can look for signs of confounding such as between-group differences in variables known to affect outcome and, if necessary, attempt to adjust for confounding factors with

Table 1. Scene activities: police versus EMS.*

Police Transport	EMS Transport
1. Intuitive assessment with decision to transport	1. Airway assessment: assisted ventilation as indicated
2. Possible control of external hemorrhage	2. Control of external hemorrhage
3. Place in police vehicle and transport to hospital	3. Assess and cover "sucking" chest wounds
	4. Primary trauma assessment, including:
	a. Level of consciousness
	b. Circulation: blood pressure, oximetry
	c. Disability assessment: spinal stabilization
	5. Oxygen therapy as indicated
	6. Needle decompression of tension pneumothorax as indicated
	7. Definitive airway management (supraglottic airway, intubation, cricothyroidotomy) as indicated
	8. Contact medical control for destination
	9. Document data for encounter (ongoing)
	10. Package, load, and transport to trauma center
	11. Intravenous access with crystalloid infusion during transport as indicated
	12. Secondary survey during transport

*Illustration of typical on-scene actions for police and EMS.

EMS patient management in the field is regulated by protocols and procedures. Extensive scrutiny is applied by agencies to each case, and paramedics face professional consequences if they do not comply with all applicable rules and regulations. This includes recording medical response data, which is required for state and national databases. In most EMS systems, individual paramedic judgment such as omitting spinal precautions to decrease transport delays is discouraged regardless of patient outcomes. Following protocols takes significant time, and scrutiny is also applied to EMS by receiving hospitals ("What, no IV?"), leading to complaints to EMS superiors, whereas police officers likely face fewer such pressures. It appears that Philadelphia police officers were not restricted by protocols and regulations and were free to load a victim into a police vehicle and transport immediately.

EMS can learn from the police transport model described in the study by Band et al[1] by hastening EMS procedures. For example, omitting routine spinal precautions for patients without neurologic deficit is being implemented in many EMS systems. Emphasizing short on-scene time (5 minutes or less) and performing interventions and communicating with the receiving trauma center while en route are other ways for EMS to emulate police procedures that may have been effective in this study. Receiving hospitals and regulatory agencies can help by being less critical of omitted actions that do not directly affect patient outcome.

Although police officers have the training and equipment to enter hostile areas, EMS providers are not equipped to safely enter areas of ongoing violence and will not always be able to extricate victims as quickly as the police. One way to bridge this gap is to form tactical EMS teams that can extricate patients from a tactical environment and hand them off to EMS transport crews in a safe zone. Police can learn from EMS by providing simple and quick medical procedures such as hemorrhage control, and the fact that Philadelphia is issuing tourniquets to all police officers supports this concept.

ANSWER 3

Q3.a The outcome measure for this study was in-hospital mortality. Is this outcome measure optimal? Are there other outcome measures that would be of interest? What would be the obstacles to studying them?

Mortality is a common outcome measure in many studies that evaluate serious acute trauma. It is a binary outcome measure that is easily understood and measured. As a dichotomous variable, mortality lends itself to unambiguous accounting and straightforward statistical analysis and interpretation. On the other hand, mortality alone provides an incomplete picture of the health status of a population and fails to provide information about nonfatal aspects of trauma outcomes such as chronic mental and physical disabilities. Although mortality was not infrequent in the study by Band et al,[1] disability is likely even more prevalent and, consequently, may produce a greater overall health burden. For example, there may have been considerable variation in the level of neurologic survival characteristics among the 2 study groups that was unaccounted for in this study. Anoxic brain injury caused by prolonged lack of ventilation could have been a significant clinical outcome for either group: for police-transported patients because of lack of airway control or for EMS-transported patients because of prolonged "down time" before arrival and institution of airway management. Short- and long-term disability may be as important to measure as mortality when trauma outcome is considered.

Measuring disability is more difficult than counting deaths. In cardiac resuscitation research, a 4-level scale of function, the Cerebral Performance Category, is commonly used.[3] This score provides a gross assessment of an individual's ability to return to daily, self-sustained living activity. A more sophisticated measure is Years Lived with Disability, which is commonly used in health impact assessment research.[4] Disability outcomes are usually based on validated scoring systems. Analysis of this type of data requires more advanced study methods and statistical techniques than are required for analysis of mortality data. These measures are typically conducted at some time distant from the injury and hospitalization and therefore require a substantially more expensive study, given that patients have to be followed, located, and reassessed.

Q3.b The authors report that 4.7% of the initial study population could not be included in the study because of missing information about transport mode (police versus EMS). How could the data have been analyzed to determine whether this 4.7% missing data biased study results?

The authors were required to exclude 4.7% of the initial study population because there was no record on how the patient was transported to the trauma center. It is customary that patients transported by EMS come with EMS field records, which are made part of the medical record. It can be assumed that when patients are transported by police, such field care documentation is less likely to exist in the patient's medical record and thus the trauma registry, and therefore it is assumed that a greater proportion of the 4.7% without a record on mode of transport were transported by police rather than by EMS.

If the transport mode were primarily by police for the missing 4.7% of the study population, the outcome results could have been more or less favorable, depending on mortality rates for this portion of the population. These missing cases present risk for selection bias because they represent lost data related to exposure (mode of transport) and outcome (mortality) that could have changed the statistics for one or both study groups. The handling of missing data is a critical study design component, especially in retrospective cohort studies. Readers are directed to the November 2008 and March 2010 *Annals of Emergency Medicine* Journal Clubs Answers for a detailed discussion on these topics.[5,6]

Given that the between-group difference in this study is small, if the mortality rate in the 4.7% of patients with unknown transport type differed greatly from that observed in the 95.3% who were analyzed, then inclusion of these patients could change the study results. In a study that shows slight or no difference in

outcomes, this number could bias the results. Ideally, the authors could have performed and reported a sensitivity analysis to determine how much results could be skewed by the missing data. This could be accomplished by reanalysis of study results under the 2 extreme situations that (1) all 4.7% of patients lived, and (2) that they died and by assuming that every patient in the 4.7% with unknown transport status was transported by police, and, conversely, all of these patients were transported by EMS. This would put boundaries on the results that are more meaningful than confidence intervals (CIs) because they take into consideration nonrandom error, whereas CIs assume that there is only random error (aka bias).

Q3.c Are there other acute emergency conditions that may benefit from incorporating rapid nonmedical transport into a community emergency response system?

A common practice in some US EMS systems is for police, when first on scene, to transport small children who are victims of near drowning with continuing basic pediatric cardiopulmonary resuscitation (CPR) while in transit. There are insufficient data to derermine whether this practice is associated with improved outcomes because of infrequency of occurrence and need for organized multicenter study design. Although most will accept that EMS transport of pediatric near-drowning victims is preferred because of ability to apply oxygen and likely better CPR performance and airway management, there is logic for immediate transport from the scene by police with CPR in progress so that the child is more quickly delivered to the advanced care available in an ED.

Although not rapid transport by police, use of automatic external defibrillators is an analogous situation to rapid police transport of victims with penetrating trauma.[7] Police use of automatic external defibrillators when they are first to arrive to a scene of cardiac arrest has support throughout most US EMS systems.

ANSWER 4

Q4. An adjustment of case mix among study subjects was made with the Charlson comorbidity index. Was this an appropriate adjustment technique for victims of penetrating trauma? The Charlson index was modified to conduct the study; how may this affect the validity of the results?

The Charlson comorbidity index is a method to adjust data for 19 comorbid conditions according to their association with mortality. The index can be calculated from *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) data and is therefore commonly used to adjust studies of medical conditions.[8] To apply the Charlson index, *ICD-9-CM* coded data (in the study by Band et al,[1] presumably *ICD-9-CM* coded data in the Trauma Registry) are used to estimate and rank underlying risk of mortality related to medical comorbidities. The Charlson index includes medical conditions such as myocardial infarction, congestive heart failure, and peripheral vascular disease and was derived with an index population of medical parients.[9] A potential concern for use of the Charlson index to adjust for case mix in the study by Band et al[1] is that the study population was young (average range 27.7 to 30.6 years) and likely did not have the comorbidities that are included in the Charlson index.

The Charlson index has been validated for medical patients.[8] The use of the index for adjusting trauma-related data has been questioned, and it has been suggested that a similar trauma-focused scoring system, the Mortality Risk Score for Trauma (MoRT), is more appropriate for trauma case-mix adjustment.[9,10] Although the MoRT case-mix adjustment index has been validated for trauma victims, it relies on chronic conditions such as severe liver disease, myocardial infarction, and dementia that would be of low prevalence in the population with penetrating trauma described for the study by Band et al.[1] Furthermore, it has not been shown that the MoRT method is a better predictive tool than the Charlson method for trauma case-mix adjustment.[10] In summary, the Charlson index and MoRT method for mortality case-mix adjustment of a relatively young population with penetrating trauma likely have little adjustment effect because the factors used by either method would infrequently be present.

The Charlson comorbidity index has been evaluated in comparison with the Trauma and Injury Severity Score for blunt trauma outcomes, and both scoring systems were found to have equal predictability for inhospital death.[9] Similar studies for the use of the Charlson index and penetrating trauma have not been published, to our knowledge.

A further concern about the use of the Charlson Index as a risk-adjustment tool in the study by Band et al[1] is the authors' decision to use a modification of the index that excluded 4 of 19 conditions present in the complete index. Excluding these 4 conditions might have affected the validity of the index. The article does not report how frequently the 4 excluded conditions occurred within the study group, so it is difficult to tell whether bias was introduced.

The validity of case-mix adjustment methods for this study is important because the unadjusted data showed that police transported more severely injured victims and that those victims had a higher mortality (odds ratio [OR] 1.18; 95% CI 1.00 to 1.39). However, the multivariable analysis that adjusted for Trauma and Injury Severity Score, modified Charlson index, age, and sex produced an OR of 0.78 (95% CI 0.6 to 1.0). As discussed in question 2a, it is impossible to know whether this OR represents a true association of transport method and inhospital death or whether it is a biased estimate.

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Police transport versus ground EMS: A trauma system-level evaluation of prehospital care policies and their effect on clinical outcomes

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BACKGROUND:	Rapid transport to definitive care ("scoop and run") versus field stabilization in trauma remains a topic of debate and has resulted in variability in prehospital policy. We aimed to identify trauma systems frequently using a true "scoop and run" police transport approach and to compare mortality rates between police and ground emergency medical services (EMS) transport.
METHODS:	Using the National Trauma Databank (NTDB), we identified adult gunshot and stab wound patients presenting to Level I or 2 trauma centers from 2010 to 2012. Hospitals were grouped into their respective cities and regional trauma systems. Patients directly transported by police or ground EMS to trauma centers in the 100 most populous US trauma systems were included. Frequency of police transport was evaluated, identifying trauma systems with high utilization. Mortality rates and risk-adjusted odds ratio for mortality for police versus EMS transport were derived.
RESULTS:	Of 88,564 total patients, 86,097 (97.2%) were transported by EMS and 2,467 (2.8%) by police. Unadjusted mortality was 17.7% for police transport and 11.6% for ground EMS. After risk adjustment, patients transported by police were no more likely to die than those transported by EMS (OR = 1.00, 95% CI: 0.69–1.45). Among all police transports, 87.8% occurred in three locations (Philadelphia, Sacramento, and Detroit). Within these trauma systems, unadjusted mortality was 19.9% for police transport and 13.5% for ground EMS. Risk-adjusted mortality was no different (OR = 1.01, 95% CI: 0.68–1.50).
CONCLUSIONS:	Using trauma system-level analyses, patients with penetrating injuries in urban trauma systems were found to have similar mortality for police and EMS transport. The majority of prehospital police transport in penetrating trauma occurs in three trauma systems. These cities represent ideal sites for additional system-level evaluation of prehospital transport policies. (*J Trauma Acute Care Surg.* 2016;81: 931–935. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)
LEVEL OF EVIDENCE:	Prognostic/epidemiologic study, level III.
KEY WORDS:	Prehospital transport; trauma systems; penetrating trauma.

The development of trauma systems in the United States has helped improve the care of injured patients.[1] Trauma systems are typically designed and developed at the local, state, or regional level based on resource availability, geography, and need. However, in many settings, local history and culture of rescue personnel and trauma providers continue to shape practices. As a result, trauma systems have developed significant variability with respect to system-wide policies and protocols, including those for prehospital care. Prehospital trauma care protocols range from no intervention ("scoop and run") in some locations to fluid resuscitation, advanced life support, or rapid sequence intubation with mechanical ventilation in others.

To identify optimal prehospital management strategies, it is important to study the clinical implications of different prehospital policies. One example of a unique prehospital policy that could be of benefit to other urban trauma systems is the routine use of police transport for individuals with penetrating injuries. In Philadelphia, Pennsylvania, patients with penetrating injuries have been transported to the nearest trauma center by police officers for over 25 years.[2,3] Under the current policy that was implemented in 1996, "Police personnel will transport: Persons suffering from a serious penetrating wound, e.g., gunshot, stab wound and similar injuries of the head, neck, chest, abdomen and groin to the nearest accredited trauma center. Transportation will not be delayed to wait the arrival of the Fire Department paramedics."[4]

Major current initiatives of the American College of Surgeons Committee on Trauma (ACS COT), such as the Hartford Consensus, emphasize the importance of expanding the roles of police officers in providing basic trauma care, particularly in the arena of hemorrhage control.[5] Given these new recommendations, it is important to systematically evaluate the role that the police department currently plays in prehospital trauma care. Because of the current paucity of data regarding the implications of police department prehospital trauma care on clinical outcomes, we aimed to compare mortality rates for police transport (a true

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"scoop and run" approach) to ground emergency medical services (EMS) transport. Additionally, we sought to identify cities and trauma systems that frequently utilize police transport for penetrating trauma and determine the implications of routine police transport at the trauma system level.

METHODS

Using the National Trauma Databank (NTDB), all patients admitted with penetrating injuries (gunshot wounds (GSW) and stab wounds) from January 1, 2010 to December 31, 2012 were identified. These mechanisms of injury were determined by ICD-9 external causes of injury codes (E-codes) that are included in the NTDB. Patients were included if they were ≥16 years old or ≤100 years old, were transported to the hospital by ground EMS or the police department, and were treated at a Level 1 or Level 2 trauma center in one of the 100 most populous trauma systems in the United States. Trauma systems were defined by the central counties of 2010 U.S. Census Metropolitan Statistical Areas, which are geographic areas consisting of a large population nucleus and adjacent communities with a high degree of integration with the population nucleus.[6] Cities were not used to define trauma systems because doing so would exclude trauma centers that are not located within the boundaries of a city yet still serve the city's population. Patients were excluded if they were transferred to or from another hospital or had incomplete records with respect to the primary outcome of in-hospital mortality. Study participants were limited to individuals with penetrating injury because they represent a unique subpopulation of trauma patients most likely to benefit from timely surgical intervention and least likely to derive significant benefit from out-of-hospital interventions.

Baseline characteristics for ground EMS and police transport were compared using χ^2 or Student's *t*-tests. The primary outcome was in-hospital mortality, which included deaths in the emergency department (ED), deaths before hospital discharge, and discharge disposition to hospice. Unadjusted mortality rates for ground EMS and police transport were compared for all included patients, and stratified for GSW and stab wound cohorts.

Using a general linear mixed effects model, risk-adjusted odds ratios for mortality for police versus ground EMS transport were calculated. Clustering by trauma center was performed to account for hospital-level variability when calculating risk-adjusted odds ratios for mortality. Models were derived for all penetrating injuries and for the GSW and stab wound cohorts. Models were adjusted heart rate (HR), presenting systolic blood pressure (SBP), Glasgow Coma Scale Motor Score (GCS-Motor), Injury Severity Score (ISS), age, gender, race/ethnicity, insurance status, and year of admission.[7,8] Multiple imputation was used to address missing data for HR, SBP, GCS-Motor, ISS, and gender.

All included patients were assigned to their respective trauma systems. System-level analyses were conducted to evaluate the proportion of patients in each city who were transported by ground EMS versus the police department. The utilization of police transport for penetrating trauma

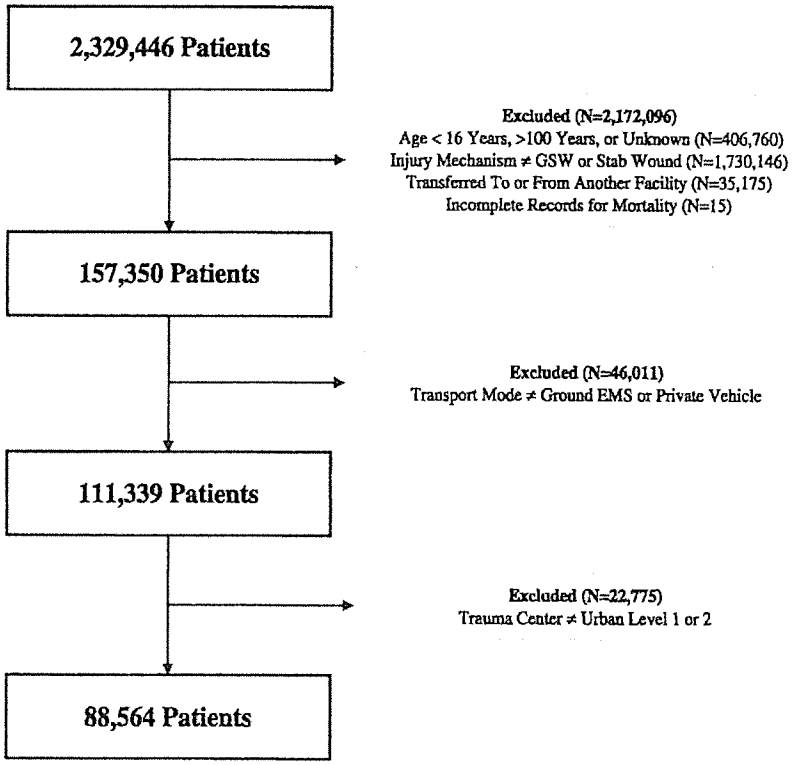

Figure 1. Flow diagram illustrating the selection of patients for this study from the NTDB between January 1, 2010 and December 31, 2012.

TABLE 1. Baseline Characteristics of Sample Population by Mode of Prehospital Transportation

	All Patients n or Mean ± SD	Ground EMS n or Mean ± SD	Police n or Mean ± SD	p
Population size	88,564	86,097	2,467	—
Age	32.6 ± 13.4	32.7 ± 13.4	30.4 ± 11.3	<0.001†
Heart rate*	90.5 ± 31.3	90.6 ± 31.1	88.1 ± 37.2	<0.001†
Systolic blood pressure*	123.3 ± 41.5	123.6 ± 41.2	113.1 ± 48.8	<0.001†
GCS Motor Score*	5.4 ± 1.6	5.4 ± 1.6	5.1 ± 1.9	<0.001†
Injury Severity Score	10.2 ± 12.6	10.1 ± 12.5	14.2 ± 16.0	<0.001†
Gender	—	—	—	<0.001‡
Male	77,379 (87.4%)	75,141 (87.3%)	2,238 (90.7%)	
Female	11,185 (12.6%)	10,956 (12.7%)	229 (9.3%)	
Race/ethnicity	—	—	—	<0.001‡
Black	42,201 (47.7%)	40,775 (47.4%)	1,426 (57.8%)	
White	23,663 (26.7%)	23,420 (27.2%)	243 (9.9%)	
Hispanic	15,690 (17.7%)	15,430 (17.9%)	260 (10.5%)	
Asian	1,254 (1.4%)	1,232 (1.4%)	22 (0.9%)	
Other	5,756 (6.5%)	5,240 (6.1%)	516 (20.9%)	
Insurance	—	—	—	<0.001‡
Private	15,409 (17.4%)	15,111 (17.6%)	298 (12.1%)	
Governmental	26,270 (29.7%)	25,496 (29.6%)	774 (31.4%)	
Self-pay	31,931 (36.1%)	31,015 (36.0%)	916 (37.1%)	
Other	14,954 (16.9%)	14,475 (16.8%)	479 (19.4%)	
Injury mechanism	—	—	—	<0.001‡
GSW	47,224 (53.3%)	45,582 (52.9%)	1,642 (66.6%)	
Stab wound	41,340 (46.7%)	40,515 (47.1%)	825 (33.4%)	

*First documented value after arrival to the hospital.
†Student's *t*-test.
‡X^2 test.

was evaluated and compared for each of the included trauma systems. The cities most frequently utilizing police transport were identified and used to create a subgroup for more focused analysis. Unadjusted mortality rates for ground EMS and police transport were compared for all patients and the GSW and stab wound cohorts within these trauma systems. Risk-adjusted odds ratios for mortality were also calculated for this subset of trauma systems.

The results of this study were two-sided and considered to be statistically significant at an alpha level of 0.05. SAS version 9.4 (SAS Institute Inc., Cary, NC) was used to perform all statistical analyses for this study. IRB exemption was obtained from the Northwestern University Feinberg School of Medicine Institutional Review Board.

RESULTS

Of the 2,329,446 patients included in the NTDB from January 1, 2010 to December 31, 2012, 88,564 total patients at 297 trauma centers met inclusion criteria for the study (Fig. 1). A total of 86,097 patients (97.2%) were transported directly to a trauma center by ground EMS and 2,467 (2.8%) were transported by the police department. Baseline characteristics of patients transported by ground EMS and the police department are provided in Table 1. Patients transported by police were, in general, more physiologically deranged (lower SBP and lower GCS motor score). Mean ISS was significantly higher among patients transported by the police department when compared to those transported by ground EMS (14.2 vs. 10.1, respectively, $p < 0.001$).

The unadjusted overall mortality was 11.8% for all penetrating wounds, and 19.5% and 2.9% for GSWs and stab wounds, respectively. Patients with GSWs had an unadjusted mortality of 19.5%, whereas those with stab wounds had a mortality of 2.9%. Overall unadjusted mortality rates were higher for police transport than ground EMS for GSWs (25.2% vs. 19.3%, $p < 0.001$). No significant differences in mortality between police and ground EMS transport were found for stab wounds (2.7% vs. 2.9%, $p = 0.68$). After adjusting for age, gender, race, ISS, HR, SBP, GCS-Motor, and insurance status, patients with penetrating injuries transported by the police department were no more likely to die than those transported by ground EMS (OR = 1.00, 95% CI: 0.69–1.45). This held true when stratified for GSWs (OR = 0.92, 95% CI: 0.62–1.37) and stab wounds (0.55, 95% CI: 0.19–1.55) (Table 2).

City-level analyses revealed that 87.8% of all police transports occurred in only three cities' trauma systems: Philadelphia, PA; Sacramento, CA; and Detroit, MI. In Philadelphia 1,494 patients were transported by the police department, accounting for 60.6% of all police transports in the NTDB study cohort. In Sacramento, there were 520 patients transported by police and in Detroit there were 153, representing 21.1% and 6.2% of all NTDB police transports, respectively.

When limiting analyses to the three trauma systems most frequently utilizing police transport for penetrating trauma (Philadelphia, Sacramento, and Detroit), the overall unadjusted mortality rate was 19.9% for police transport and 13.5% for ground EMS. Unadjusted mortality rates were higher for police transport than ground EMS for GSWs (26.4% vs. 20.8%, $p < 0.001$) and not significantly different for stab wounds (3.5% vs. 3.3%, $p = 0.89$). After risk adjustment, patients transported by the police department were no more likely to die than those transported by ground EMS (OR = 1.01, 95% CI: 0.68–1.50). This held true for GSWs (OR = 0.93, 95% CI: 0.62–1.41) and stab wounds (OR = 0.32, 95% CI: 0.09–1.14). All

TABLE 2. Unadjusted Mortality Rates and Risk-Adjusted Odds Ratios for Mortality for Aggregate Study Population

	Unadjusted Mortality Rates				OR for Mortality
	All Patients n (%)	Ground EMS n (%)	Police n (%)	p	OR (95% CI)
All GSWs and stab wounds	10,422 (11.8%)	9,986 (11.6%)	436 (17.7%)	<0.001	1.00 (0.69–1.45)
GSWs only	9,221 (19.5%)	8,807 (19.3%)	414 (25.2%)	<0.001	0.92 (0.62–1.37)
Stab wounds only	1,201 (2.9%)	8,807 (19.3%)	22 (2.7%)	0.68	0.55 (0.19–1.55)

TABLE 3. Unadjusted Mortality Rates and Risk-Adjusted Odds Ratios for Mortality Among Trauma Systems With High Utilization of Police Transport in Penetrating Trauma (Philadelphia, Sacramento, and Detroit)

		Unadjusted Mortality Rates			OR for Mortality
	All Patients n (%)	Ground EMS n (%)	Police n (%)	p	OR (95% CI)
All GSWs and stab wounds	1,345 (15.1%)	913 (13.5%)	432 (19.9%)	<0.001	1.01 (0.68–1.50)
GSWs only	1,230 (22.4%)	819 (20.8%)	411 (26.4%)	<0.001	0.93 (0.62–1.41)
Stab wounds only	115 (3.4%)	94 (3.3%)	21 (3.5%)	0.89	0.32 (0.09–1.14)

unadjusted and risk-adjusted mortality data for the high police transport utilization subgroup are provided in Table 3.

DISCUSSION

This study demonstrates that for individuals with penetrating injuries in urban trauma systems, police transport is not associated with significant mortality differences when compared to similarly injured individuals transported by ground EMS. This study also identifies the three urban, U.S. trauma systems that most frequently utilize police transport and account for nearly 90% of police transports in penetrating trauma included in the NTDB. The results of this study are important because they focus on data from major urban trauma systems and can be used to support the implementation of policies to incorporate police transport into the prehospital management protocols of similar urban trauma systems. Additionally, the results of this study reveal trauma systems where police transport is currently used and further research efforts into their benefit could be focused.

Previous research has evaluated the implications of prehospital care on clinical outcomes after trauma. Numerous studies have shown equal or higher mortality with EMS compared to private vehicle transport.[9,10] In Philadelphia, studies have found that ground EMS confers no survival benefit to police transport, though among the most severely injured, police transport was associated with a survival advantage.[2,11] Other studies have demonstrated that prehospital intravenous fluid administration, endotracheal intubation, spine immobilization, and advanced life support are associated with higher mortality rates among certain subsets of trauma patients.[12–15] Work in Philadelphia has shown that the use of prehospital procedures in patients who ultimately undergo ED thoracotomy is also associated with higher mortality.[16] Additionally, research has demonstrated the importance of transport time in penetrating trauma, with shorter transport times being associated with improved survival.[17–19]

The results of this study reinforce previous findings from Philadelphia regarding the mortality implications of routine police transport, but represent the first time police transport has been compared to ground EMS nationally on a trauma system level. Additionally, this study represents the first time prehospital transport practices in trauma have been evaluated at the system level. The ability to derive trauma system-level data from the NTDB is a major strength of this study, as it facilitates system-level analyses for use in comparative effectiveness research.

Although prehospital police transport of the injured is not associated with different mortality rates than ground EMS transport, this trauma system-level analysis does support the viability of police transport as an alternative mode of prehospital transport in urban trauma systems. For example, in Chicago, IL individuals who are shot on the city's south side experience longer prehospital transport times and higher mortality than those similarly injured in other portions of the city because of the lack of a trauma center in close proximity to that part of the city.[20] As one example, Chicago could consider allowing police to transport these patients to the hospital to address this specific problem. Based on the results of this study, these patients would be unlikely to experience any worse outcomes than waiting for ground EMS transport and may actually end up having improved outcomes. Additionally, by identifying trauma systems that frequently utilize police transport, the results of this study can help trauma system leaders in cities like Chicago know where they can seek guidance if they are interested in instituting their own police transport protocol.

This study is not without limitations. As with all large, multicenter database analyses, there may be issues with data quality and missing data. Although there are auditing mechanism in place to identify errors in abstraction, errors may still occur. Missing data was not a major factor in this analysis, but where it occurred, it was handled with imputation. Patients were not randomly assigned to police or EMS transport; therefore, some selection bias may have occurred. We have attempted to overcome this with our risk-adjustment model. Risk adjustment is another potential limitation, as risk adjustment is limited to the variables collected by the NTDB. As a result, there may be potential confounders that were unable to be identified. Specifically, prehospital transport time is likely a significant confounder, but was unable to be utilized in the risk adjustment model due to inconsistent reporting of this information in the NTDB. Additionally, the results of this study are reflective of the data from the trauma centers that contribute to the NTDB. Although more than 800 centers contribute data, it is not mandatory and not all U.S. trauma centers participate. However, our ability to group all patients within a single city's trauma system is a novel approach, which has never been done before using the NTDB.

Police transport is not associated with significant mortality differences than ground EMS transport for individuals with penetrating injuries in urban trauma systems. Three urban trauma systems are responsible for the vast majority of police transports nationwide. System-level analyses like those performed in this study can improve the generalizability of results and identify trauma systems that can provide valuable insight into unique policies and protocols. The goal of any trauma system is to deliver optimal care to injured patients. An important part of accomplishing this is determining what system-level policies are beneficial in individual trauma systems and using that knowledge to drive policy change in trauma systems likely to derive similar benefits.

AUTHORSHIP

M.W.W. participated in the study design, data analysis, and manuscript preparation. A.B.N. participated in the study design and manuscript preparation. M.B.S. participated in the study design and manuscript preparation. E.R.H. participated in the study design, data analysis, and manuscript preparation.

DISCLOSURES

The authors declare no conflicts of interest.

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Increased mortality associated with EMS transport of gunshot wound victims when compared to private vehicle transport☆

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ABSTRACT

Background: Recent studies suggest that mode of transport affects survival in penetrating trauma patients. We hypothesised that there is wide variation in transport mode for patients with gunshot wounds (GSW) and there may be a mortality difference for GSW patients transported by emergency medical services (EMS) vs. private vehicle (PV).

Study design: We studied adult (≥16 years) GSW patients in the National Trauma Data Bank (2007–2010). Level 1 and 2 trauma centres (TC) receiving ≥50 GSW patients per year were included. Proportions of patients arriving by each transport mode for each TC were examined. In-hospital mortality was compared between the two groups, PV and EMS, using multivariable regression analyses. Models were adjusted for patient demographics, injury severity, and were adjusted for clustering by facility.

Results: 74,187 GSW patients were treated at 182 TCs. The majority (76%) were transported by EMS while 12.6% were transported by PV. By individual TC, the proportion of patients transported by each category varied widely: EMS (median 78%, interquartile range (IQR) 66–85%), PV (median 11%, IQR 7–17%), or others (median 7%, IQR 2–18%). Unadjusted mortality was significantly different between PV and EMS (2.1% vs. 9.7%, $p < 0.001$). Multivariable analysis demonstrated that EMS transported patients had a greater than twofold odds of dying when compared to PV (OR = 2.0, 95% CI 1.73–2.35).

Conclusions: Wide variation exists in transport mode for GSW patients across the United States. Mortality may be higher for GSW patients transported by EMS when compared to private vehicle transport. Further studies should be performed to examine this question.

Introduction

Recent studies have questioned the benefit of emergency medical services (EMS) and prehospital procedures especially for trauma patients [1,2]. Procedures such as spine immobilization, intravenous fluid administration, endotracheal intubation and use of pneumatic antishock garments have not been shown to be definitively beneficial, and may even be associated with increased mortality [3–8]. In 1996, Demetriades et al. [9] published the results of a retrospective observational study that included 5782 patients, demonstrating that severely injured trauma patients

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transported by EMS to a large urban trauma centre had a 1.6 times higher mortality than those transported by private means. Cornwell et al. [10] later published a prospective study including 103 patients and found no difference in outcomes of death, hospital stay and complications, but found a decreased interval between time of injury to hospital arrival time among severely injured patients in the non-EMS group. A meta-analysis of observational studies showed that trauma patients receiving advanced life support (ALS) had 2.59 times the odds of dying when compared with those receiving basic life support (BLS) alone [11].

Although the term "golden hour" is intuitively appealing, this paradigm has recently come under scrutiny [2,12]. Most trauma care providers agree upon the importance of minimizing time to definitive care, since delays in management could worsen prognosis for patients with major trauma. The decades long debate on whether 'scoop and run' or 'stay and stabilise' is superior for trauma patients has yet to be resolved. A definitive answer could be sought through well-constructed randomised controlled trials, but due to ethical and logistic reasons, this is currently not feasible [13]. Comparative effectiveness research (CER) on this topic can employ observational research methodologies that make use of the natural variation in modes of transport. Liberman et al. [14] utilised the variation in prehospital trauma care systems in different cities of Canada to compare outcomes between three approaches: BLS alone (Quebec city), physician based ALS (Montreal) and paramedic based ALS (Toronto). They found no difference in outcomes. Similarly, a retrospective study from the city of Philadelphia compared differences in outcomes for two modes of prehospital transport – Police vs. EMS among victims of penetrating trauma – and found no difference in outcomes [15].

As of admission year 2007, the American College of Surgeons National Trauma Data Bank (NTDB) contains information on 'mode of transport'. The NTDB is the largest currently available trauma patient data registry and contains information from hundreds of trauma centres across the United States [16]. Employing a CER approach with robust statistical analyses to study outcome differences by mode of transport in this enormous database has the potential to provide valuable insight regarding the optimal mode of transportation for patients with GSW. We hypothesised that there is wide variation in transport mode for patients with gunshot injuries at different trauma centres (TCs) across the United States. We also hypothesised that there is differential mortality and morbidity for GSW patients brought to trauma centres (TCs) by emergency medical services (EMS) vs. private vehicle (PV) transport.

Methods

We analysed the American College of Surgeons National Trauma Databank (NTDB) for admission years 2007 through 2010. The NTDB is the largest repository of trauma incidents ever created, containing clinical and injury related information for over three million trauma incidents reported from over 900 trauma centres across the United States [16]. IRB exemption was obtained from the Johns Hopkins School of Medicine Institutional Review Board.

We selected all adult (age $\geq$ 16) patients with gunshot wound (GSW) injuries who presented at level 1 or level 2 trauma centres (TCs). We included only centres that reported 'mode of transport' and received an average of $\geq$50 gunshot injuries patients per year during 2007–2010 [17]. Centres with lower volumes of GSW were excluded to allow for a more homogenous sample and to limit bias due to volume–outcome relationships. In a previous analysis we found improved outcomes at centres that treat higher volumes of penetrating trauma [18]. We excluded patients who were transferred to the TC from another facility or who were transferred out to another acute care facility. To assess the variation in mode of transport across TCs, we categorised transport mode as ground ambulance (EMS), private vehicle (PV), or 'others'. 'Others' included patients transported by police, air ambulance or other unspecified transport modes. To determine the difference in trauma outcomes between patients transported by EMS and PV we included only those patients that were transported by either of these transport modes and had complete information with regards to the primary outcome of in-hospital mortality.

To examine the variation in mode of transport we performed a hospital level analysis. We constructed a histogram demonstrating the proportion of patients arriving to each TC by different transport modes. We calculated medians with interquartile ranges to quantitatively describe this variation. Medians and interquartile ranges were used to describe skewed data. Means (with standard deviations) and proportions were calculated and tabulated for normally distributed demographic and injury characteristics by mode of transport. The Chi square test and Student's T test was used to determine differences between the EMS and PV groups.

The primary outcome was in-hospital mortality (dichotomous). Bivariate logistic regression analyses were performed to determine the crude association between mode of transport (PV vs. EMS) and the primary outcome (mortality) for all adult patients with gunshot wounds at included TCs.

To determine the independent effect of mode of transport on mortality we performed multivariable logistic regression analyses [19]. We included age, gender, race, insurance status, new injury severity score (NISS), emergency department presenting systolic blood pressure (SBP), Glasgow coma scale (GCS) score motor component, heart rate, need for ventilatory support, year of admission and level of trauma centre. Co-variates in the model included those previously identified from the NTDB to provide the best mortality risk adjustment model [20]. In the multivariable model SBP was defined as zero, low (<90 mm Hg), normal (90–140 mm Hg), or high (>140 mm Hg). Heart rate was defined similarly as zero, low (<60 beats per minute), normal (60–100 beats per minute), or high (>100 beats per minute). Insurance status was coded as 'insured', 'uninsured', 'medicaid' or 'not documented' [21]. NISS accounts for multiple injuries in the same body region and is considered to be a better method to control for anatomic severity, especially for penetrating injuries [22]. A single "fatal" GSW to any body region (AIS = 6) automatically receives an NISS score of 75. NISS was categorised as 0–8, 9–15, 16–24 and 25–75. In addition we accounted for clustering by facility within the regression models by calculating robust (Huber–White) standard errors. All statistical analyses were performed using STATA version 12 (STATA Corporation, College Station, TX).

Results

Out of a total of 2,539,818 incidents in the NTDB (2007–2010) there were 116,357 (4.6%) adults with firearm injuries at 710 centres. After including only patients from level 1 or 2 trauma centres that received $\geq$50 GSW patients per year, 74,187 patients from 182 trauma centres were included.

By individual TC, the proportion of patients transported by each category varied widely. Fig. 1 shows the proportion of patients transported by each mode of transport at each trauma centre included in the analysis. EMS transport ranged from 0% to 100% with a median proportion of 78% (interquartile range (IQR) 66–85%). Private vehicle ranged from 0% to 92% with a median proportion of 11% (IQR; 7–17%) while 'other' modes of transport ranged from 0% to 88% with a median of 7% (IQR; 2–18%). Included in 'other' modes of transport were 6168 (8.3%) patients transported by Helicopter, and 2190 (3%) patients transported by police.

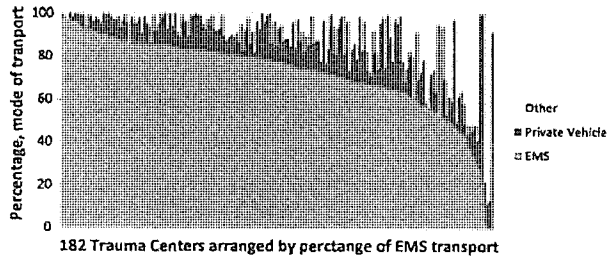

Fig. 1. Variation in mode of transport for adult patients with gunshot injuries at each trauma centre ($n = 74,187$ patients at 182 trauma centres).

Helicopter transport ranged from 0% to 55.6% with a median proportion of 5.1% (IQR; 0.65–15.4%). Police mode of transport ranged from 0% to 88.8% with a median proportion of 0% (IQR; 0–0.23%); only five trauma centres had greater than 10% of GSW patients transported by police. In the 46 centres belonging to the lowest quartile of EMS transport mode (i.e. centres with less than 66% GSW patients transported by EMS), 20% of patients were transported by helicopter, 15% by police and 17% by private vehicle. There was less than 3% missing data in all variables and this was not associated with mode of transport or mortality.

There were 55,773 patients with GSWs that were transported by EMS (76%) and 9290 patients (12.6%) transported by private vehicle. Table 1 summarises a univariate comparison between these two groups of patients. Patients transported by EMS were older, proportionally more likely to be of white race, have insurance, and were more likely to present at level 1 trauma centres than patients transported by PV (all p values <0.001). EMS patients also had higher injury severity scores, lower GCS scores and were more likely to be hypotensive upon arrival (all $p < 0.001$). Patients transported by private vehicle were more likely to be tachycardic (heart rate >100 beats per minute) on arrival ($p < 0.001$). Unadjusted analysis showed that patients transported by EMS were more likely to be admitted to the ICU, require ventilator support and have longer hospital stays. EMS patients had a higher unadjusted mortality (9.7%), which was nearly five

Table 1
Demographic and injury related characteristics by mode of transport.

Variable	Categories	EMS $n = 55,773$ n (%)	Private Vehicle $n = 9290$ n (%)	P value
Age	Mean (s.d.)	30.0 (12.8)	26.4 (9.4)	<0.001†
Age	16–25	26,621 (47.7)	5487 (59.1)	<0.001
	26–35	14,757 (26.5)	2490 (26.8)	
	36–45	7515 (13.5)	868 (9.3)	
	46–55	4240 (7.6)	304 (3.2)	
	56–65	1580 (2.8)	95 (1.0)	
	66–75	584 (1.1)	25 (0.3)	
	76–85	283 (0.5)	9 (0.1)	
	85+	193 (0.4)	12 (0.1)	
Race	White	9914 (18.1)	836 (9.1)	<0.001
	African American	32,426 (59.3)	6446 (70.4)	
	Hispanic	9706 (17.7)	1444 (15.8)	
	Others	2661 (4.9)	426 (4.7)	
Gender	Male	50,256 (90.1)	8637 (93.0)	<0.001
Year of admission	2007	10,959 (19.7)	1919 (20.7)	0.138
	2008	14,073 (25.2)	2287 (24.6)	
	2009	15,415 (27.6)	2553 (27.5)	
	2010	15,326 (27.5)	2531 (27.2)	
NISS	0–8	21,328 (39.2)	5455 (59.5)	<0.001
	9–15	14,894 (27.3)	2271 (24.8)	
	16–25	11,433 (21.0)	992 (10.9)	
	25–75	6833 (12.5)	437 (4.8)	
Insured	Uninsured	21,561 (38.7)	4024 (43.3)	<0.001
	Insured	16,139 (28.9)	2063 (22.2)	
	Medicaid	8891 (15.9)	1466 (15.8)	
	Not documented	9182 (16.5)	1737 (18.7)	
Trauma level	1	42,804 (76.8)	6093 (65.6)	<0.001
	2	12,969 (23.3)	3197 (34.4)	
Hypotensive at presentation	Yes	8731 (16.1)	706 (7.8)	<0.001
Tachycardia at presentation	Yes	18,393 (33.6)	3967 (43.5)	<0.001
GCS at presentation	3–5	8514 (17.9)	367 (4.1)	<0.001
	6–8	764 (1.4)	48 (0.5)	
	9–11	885 (1.6)	63 (0.7)	
	12–15	43,167 (19.2)	8514 (94.7)	
Mortality	Yes	5426 (9.7)	197 (2.1)	<0.001
Admission ro ICU	Yes	18,956 (34.0)	1808 (19.5)	<0.001
Ventilator	Yes	11,476 (20.6)	879 (9.5)	<0.001
Hospital stay	Median (IQR)	3 (1–7)	2 (1–5)	<0.001*

s.d. = standard deviation, *Chi square test, †Students T test, *Wilcoxon rank-sum test.

Table 2
Univariate associations with mortality, stratified by mode of transport.

Variable	Category	EMS n = 55,773			Private vehicle n = 9290		
		Live discharge n (%)	Hospital death n (%)	p-Value	Live discharge n (%)	Hospital death n (%)	p-Value
Age	16–25	24,310 (48.3)	2311 (42.6)	<0.001	5376 (59.1)	111 (56.4)	0.361
	26–35	13,406 (26.6)	1351 (24.9)		2424 (26.7)	66 (33.6)	
	36–45	6759 (13.4)	756 (13.9)		855 (9.4)	13 (6.7)	
	46–55	3745 (7.4)	495 (9.1)		300 (3.3)	4 (2.0)	
	56–65	1322 (2.6)	258 (4.8)		92 (1.0)	3 (1.5)	
	66–75	462 (0.9)	122 (2.2)		25 (0.3)	0 (0)	
	76–85	204 (0.4)	79 (1.5)		9 (0.1)	0 (0)	
	85+	139 (0.3)	54 (1.0)		12 (0.1)	0 (0)	
Race	White	8504 (17.2)	1410 (26.8)	<0.001	828 (9.2)	8 (4.2)	0.046
	African American	29,774 (60.2)	2652 (50.4)		6311 (70.4)	135 (70.3)	
	Hispanic	8781 (17.7)	925 (17.6)		1405 (15.7)	39 (20.3)	
	Others	2390 (4.8)	271 (5.2)		416 (4.6)	10 (5.20)	
Gender	Male	45,357 (90.1)	4899 (90.3)	0.640	8453 (93.0)	184 (93.4)	0.820
Year	2007	9000 (17.9)	1959 (36.1)	<0.001	1842 (20.3)	77 (39.0)	<0.001
	2008	12,971 (25.8)	1102 (22.1)		2248 (24.7)	39 (19.8)	
	2009	14,214 (28.2)	1201 (22.1)		2512 (27.6)	41 (20.8)	
	2010	14,162 (28.1)	1164 (21.5)		2491 (27.4)	40 (20.3)	
NISS	0–8	20,926 (42.4)	402 (7.8)	<0.001	5428 (60.6)	16 (8.7)	<0.001
	9–15	14,248 (28.9)	646 (12.5)		2238 (25.0)	33 (17.8)	
	16–24	8968 (18.2)	2465 (47.7)		909 (10.2)	83 (44.9)	
	25–75	5176 (10.5)	1657 (32.1)		384 (4.3)	53 (28.7)	
Insured	Uninsured	19,204 (38.1)	2357 (43.4)	<0.001	3930 (43.2)	94 (47.7)	0.047
	Insured	14,674 (29.2)	1465 (27.0)		2027 (22.3)	36 (18.3)	
	Medicaid	8293 (16.5)	598 (11.0)		1445 (15.9)	21 (10.7)	
	Not reported	8176 (16.2)	1006 (18.5)		1691 (18.6)	46 (23.4)	
Trauma level	1	38,631 (76.7)	4173 (76.9)	0.768	5965 (65.6)	128 (65.0)	0.855
	2	11,716 (23.3)	1253 (23.1)		3128 (34.4)	69 (35.0)	
Hypotensive	Yes	6370 (13.0)	2361 (46.8)	<0.001	603 (6.8)	103 (56.6)	<0.001
Tachycardia	Yes	16,234 (32.9)	2011 (38.8)	<0.001	3878 (43.6)	65 (35.3)	<0.001
GCS	3–5	5766 (11.7)	3954 (75.0)	<0.001	237 (2.7)	130 (67.7)	<0.001
	6–8	515 (1.1)	249 (4.7)		39 (0.4)	9 (4.7)	
	9–11	713 (1.5)	172 (3.3)		56 (0.6)	7 (3.7)	
	12–15	42,269 (85.8)	898 (17.0)		8468 (96.2)	46 (24.0)	
ICU	Yes	16,165 (32.1)	2791 (51.4)	<0.001	1733 (19.1)	75 (38.1)	<0.001
Ventilator	Yes	8699 (17.3)	2777 (51.2)	<0.001	795 (8.7)	84 (43.6)	<0.001

times greater than patients transported by PV (2.1%, $p < 0.001$). Table 2 demonstrates univariate associations with mortality for all variables stratified by mode of transport. Variables associated with death are qualitatively similar in the EMS and PV groups, with the exception of age. There was no significant association of age with mortality in the PV groups, although this is probably related to statistical power since there were few deaths ($n = 20$) of PV patients over 35 years of age.

After adjusting for patient demographic and injury characteristics GSW patients transported by EMS were two times more likely to die than those transported by PV (95% confidence interval (CI) = 1.71, 2.36).

A sensitivity analysis that included only level 1 TC also demonstrated that patients transported by EMS had a twofold greater odds of death compared to those transported by PV (OR = 2.0, 95% CI = 1.68, 2.36).

Discussion

A wide variation in mode of transport was observed in this large sample that included 74,187 GSW patients treated at 182 TCs. Our results demonstrate a higher mortality for patients with gunshot wound injuries transported by EMS when compared to similar patients transported by private vehicle. Although the majority of gunshot wound victims are transported by EMS (76%), some trauma centres receive very high proportions of patients transported by non-EMS modes. Although this is not due to assignment as in a randomised controlled study, this natural variation may allow for further comparative effectiveness research studies to be performed.

The proportion of non-EMS transported patients in the NTDB is congruent with data from previous single-centre studies. A retrospective study on 5782 trauma patients in Los Angeles also found that 16% of patients arrived by non-EMS means including friends, relatives or by-standers [9]. Band et al. found that 26.8% of 2127 patients with penetrating trauma in Philadelphia were transported by police [15]. A report from Northern Ireland demonstrated that 16% of seriously injured patients arrived at a hospital by private means even when ambulance services were offered free of charge [23]. In our study, 12.6% of patients used private means of transport. However, the wide variations in proportions of patients arriving by different modes has been suggested, but not demonstrated on a national scale with such magnitude.

There is growing evidence relating mode of transport to outcomes. An early study comparing outcomes between EMS and non-EMS transport was a retrospective review comparing 2108 trauma patients transported by medical personnel to 1356 patients transported by the police [24]. The study demonstrated better survival in the police group for patients with penetrating injury but not for blunt injury. Likewise, a retrospective review of 5782 patients published by Demetriades et al. [9] in 1996 found severely injured patients who were transported by non-EMS had lower adjusted mortality (17.9%) than those transported by EMS (28.2%) ($p < 0.001$). Cornwell et al. [10] in a subsequent prospective study that matched patients transported by non-EMS with patients transported by EMS, found no significant difference in outcomes between the groups. However, this study had a relatively small number of patients ($n = 103$) and limited power. A study that evaluated patients with penetrating chest injuries from Cape Town, South Africa showed that patients with lower socioeconomic status had approximately a ninefold greater odds of survival compared to their injury-adjusted affluent counterparts [25]. The authors attributed this finding to a higher proportion of poor patients utilizing non-EMS modes of transport. However, Band et al. [15], in a more recent retrospective review of 2127 penetrating trauma patients (combined stab and GSW), found no significant difference in injury severity adjusted mortality for patients transported by police or EMS.

The study by Liberman et al. comparing three types of pre-hospital trauma systems in Canada is an important one [14]. Comparisons were made between pre-hospital trauma care provided by physicians, paramedics and emergency medical technicians (EMT). The first two being examples of 'advanced pre-hospital care' while the third being closest to 'scoop and run' where only basic support was provided. They found overall mortality rates to be 35% for physician attended units, 24% for paramedics and 18% for EMTs. After risk adjustment trauma patients receiving advanced pre-hospital care were 21% more likely to die than those receiving BLS alone. However, these results may not be directly applicable to our study as there are very few GSW injuries in Canada relative to the United States. Penetrating injury ranged from 2% to 9% in the three states compared with at least 10% in the United States on average.

Our study is the largest to date with data from 74,187 GSW patients from 182 trauma centres across the country. When adjusting for multiple demographic and physiologic patient-level covariates, transport mode was found to be independently associated with mortality. Crude mortality in the EMS group was 9.7% compared to 2.1% in those transported by private vehicle, a finding similar to other published studies. The very large number of patients included in our sample allowed us to perform a robust adjusted analysis which has not been possible previously when using smaller datasets. Our data demonstrate that there are differences in injury severity for patients transported by different modes. The mortality difference between groups persisted after controlling for demographic and injury characteristics. Patients transported by EMS were twice as likely to die compared to those transported by private vehicle. In trauma patients with gunshot wounds, advanced pre-hospital care may not always be beneficial and in many cases, may be harmful [7].

Patients travelling by private means are the purest example of the 'scoop and run' approach. This study provides evidence in support of the 'scoop and run' concept for patients with gunshot wounds. There are multiple possible explanatory mechanisms for this observation. First, EMS transport may increase the overall prehospital time interval as compared to private vehicle transport [9,10]. Penetrating trauma has a high potential for life threatening exsanguination and early definitive surgical care is crucial [26]. In our analysis we found that patients transported by private vehicle were more likely to be tachycardic on arrival than those transported by EMS. This may provide some evidence that these patients arrive at an earlier stage of shock and thus have more favourable outcomes. Second, the benefit of pre-hospital procedures for victims of penetrating trauma has yet to be proven, and remains controversial. Many studies have demonstrated certain pre-hospital procedures, including intravenous fluids administration, endotracheal intubation and use of antishock garments to be independently associated with higher mortality [3–7]. In a recent analysis using the NTDB we found patients receiving pre-hospital intravenous fluids to be 1.1 times (95% CI, 1.05–1.17) more likely to die than those who did not receive any [6]. Pre-hospital spine immobilization in gunshot wound victims has not been shown to be of benefit [27] and may be associated with higher mortality [7] A previous analysis demonstrates on-scene times and the number of pre-hospital procedures to be associated with higher 30-day mortality [26]. Seamon et al. [8] analysed survivability of penetrating trauma patients undergoing an emergency department thoracotomy and found each pre-hospital procedure to independently increase mortality (OR = 2.63; 95% CI 1.26–5.56). A recent analysis of trauma victims utilizing 146 EMS agencies in North America demonstrated no association between EMS transport times and mortality [2]. It is possible that harmful 'pre-hospital procedures' is the stronger of the two mechanisms; however, this hypothesis deserves further analysis.

The NTDB provides valuable data to compare outcomes between subsets of trauma patients. Over 120 papers have been published in peer-reviewed journals in which multivariable adjusted analyses have been used. High quality research projects with appropriate risk adjustment and robust statistical methods is imperative [19,28]. A continuous effort is made to control the quality of data entered in the NTDB using the National Trauma Data Standard (NTDS). Even though every important variable for a particular analysis cannot be expected to be available in a large database, the NTDB likely has enough information to provide for meaningful analysis of many (although not all) trauma research questions. The large number of trauma incidents from trauma centres spread across the country makes it one of the best currently available resource for comparative effectiveness research in trauma. Considering the inherent difficulty in performing randomised controlled trials in the pre-hospital and emergency settings, the variability of care between centres participating in the NTDB allows for "natural experiments" to examine outcomes of different types of pre-hospital care. For clinical questions in which randomised clinical trials will likely never be performed, observational studies may provide excellent evidence to change clinical practice. Evidence based medicine experts agree that strong recommendations can be made based on high quality observational studies, especially if the relative risk is high [29,30]. Such evidence from a large database analysis, especially when combined with other types of research, can be used to guide policy. For example, the Pre-Hospital Trauma Life Support (PHTLS) Executive Committee no longer recommends spinal immobilization for all GSW patients based on a systematic review of published observational studies [31]. We have used this data in a similar fashion to change EMS policy for the state of Maryland which will affect spinal immobilization protocols for penetrating trauma patients (which began July 2013).

Analysis from the NTDB has several limitations worth mentioning. Residual confounding and selection bias are inherent problems in many large multi-centre database studies. Not every variable that may play a role in the outcome of trauma patients are included in the NTDB. For example, data regarding pre-hospital time and procedures were not available in our regression analysis, as these data are not reported consistently in the NTDB. Additionally important variables that define injury severity such

as base deficit, lactate levels, massive transfusions, etc. are not available and thus we were unable to account for these in our analysis. We do, however, use the standard set of variables for risk adjustment that is frequently used for NTDB outcomes research.

In the NTDB, TCs participate voluntarily, and any results obtained with these data cannot be considered truly population-based. Additionally, our analysis was based only on data from only level 1 and Level 2 centres that reported greater than 50 gunshot wound incidents per year. This may have caused some selection bias and makes the results difficult to generalise. However, by selecting patients based on trauma centre characteristics, we removed many unmeasured confounders and attempted to analyse a more homogenous population.

The variation in mode of transport may have been affected by inconsistent reporting mode of transport at individual trauma centres. An information bias might have also occurred; however, such effects are expected be non-differential with respect to the mode of transport used. Additionally we selected only those centres that did report mode of transport. Many centres did not report this data element and were thus excluded. This removal of centres is not 'at random' and therefore may be another source of selection bias. However, since this is not a probability sample of trauma centres and we study the differences in outcomes related to mode of transport at select trauma centres, the effects of this bias on our conclusions are minimal, if any. It is likely that non-EMS modes of transport are clustered within certain cities or counties, although since trauma centres are not identified within the NTDB, we were unable to cluster by city, state, or region.

Another limitation of the study is that we are unable ascertain whether this difference in mortality is due to delays in management, over-treatment or some other cause. Prospective studies focusing on pre-hospital care and transport of patients may be able to provide conclusive data in this regard and should be performed to corroborate and further explain these findings.

In conclusion this study demonstrated wide variation in transport mode for patients with gunshot wounds at different trauma centres across the United States. For patients with GSW injuries, transport by private vehicle was associated with a significant survival and advantage over EMS transport, even after controlling for differences in patient demographics, anatomic, and physiologic parameters. However given the limitations of analysis from the NTDB definite conclusions cannot be made. Our analysis demonstrates a need to perform further research on this topic and reconsider policies and procedures pertaining to pre-hospital trauma care and EMS transport for patients with gunshot wounds.

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Conflict of interest statement

The authors declare that there is no conflict of interest.

Disclosures

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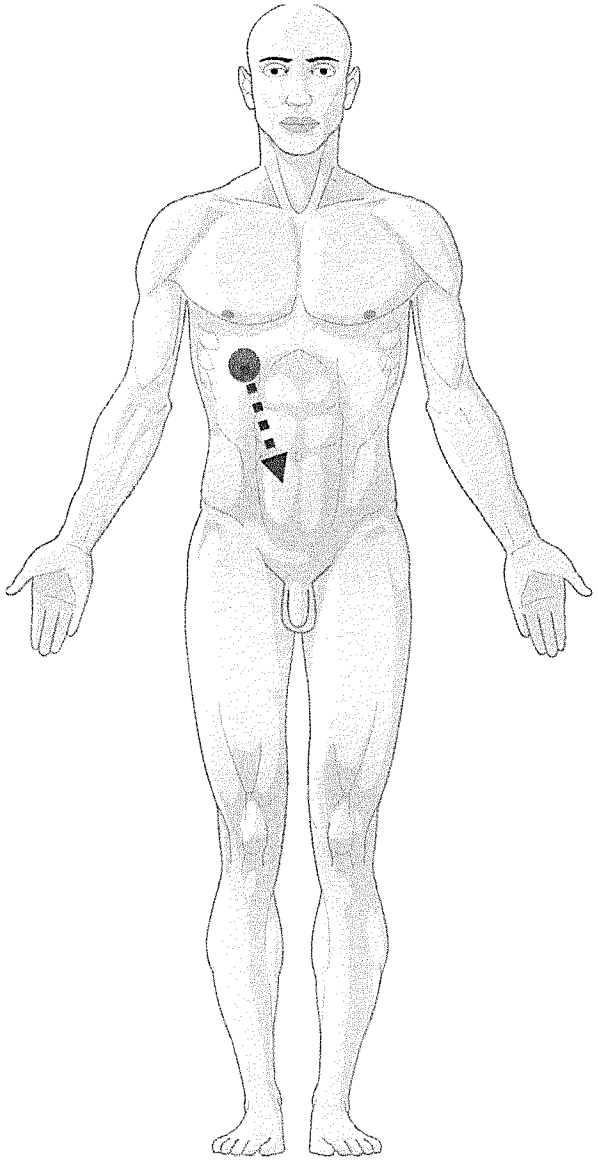
Eric Logan
12-26-65

Diagram 1



◀▪▪▪ = Bullet Path

● = Entrance Wound

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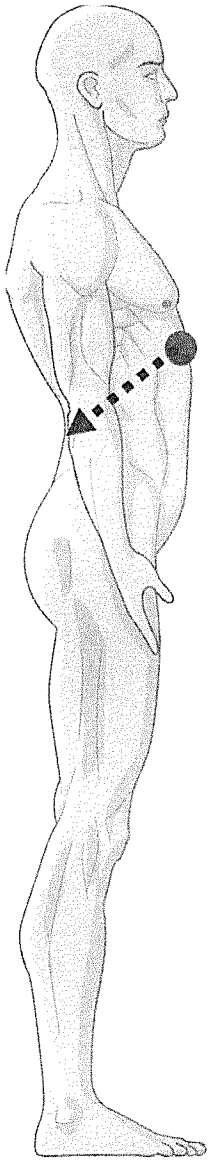
12-26-65

Diagram 2



◀▪▪▪ = Bullet Path

● = Entrance Wound

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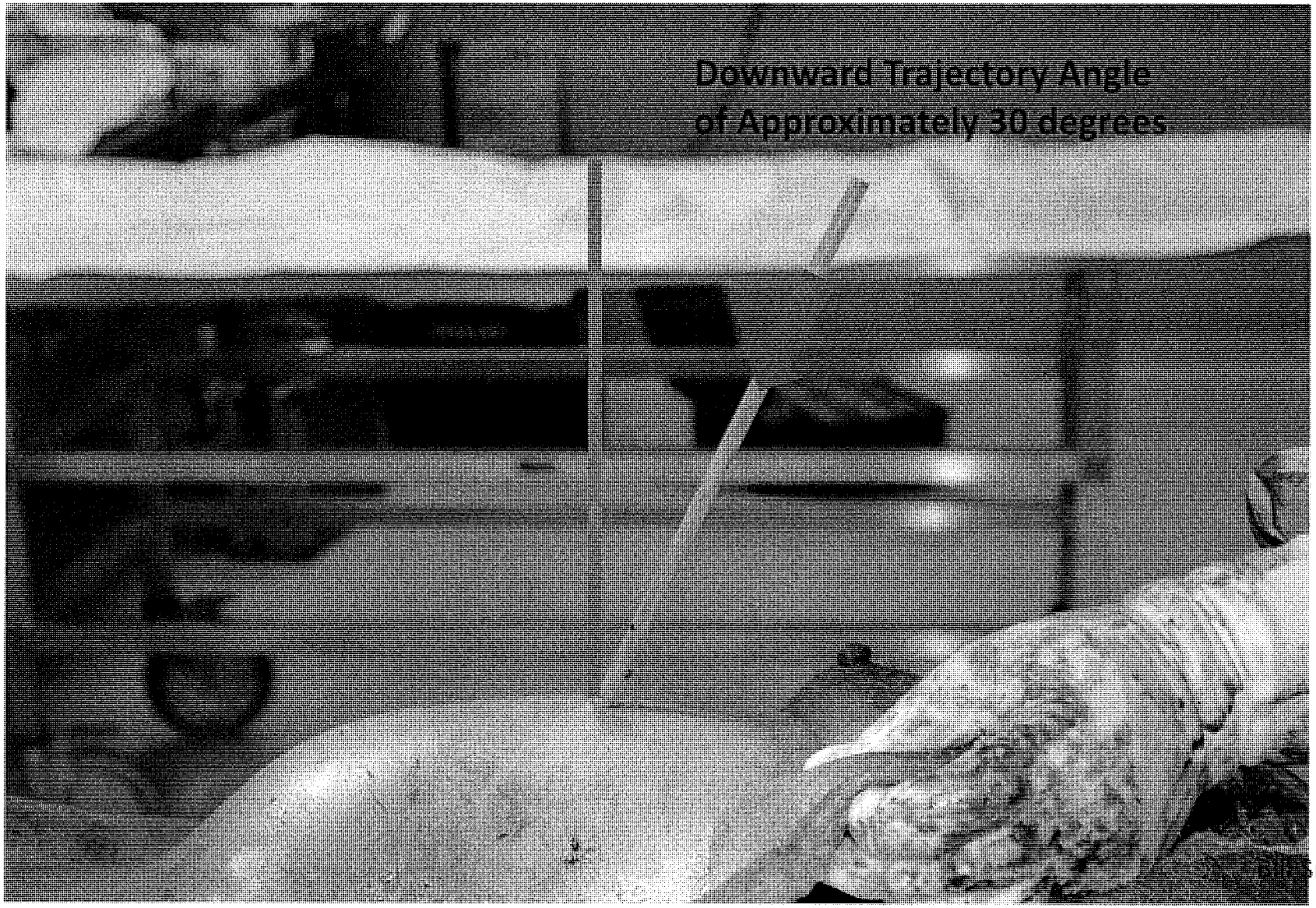
12-26-65

Diagram 3



Smock, MD