Prehospital Spinal Immobilization Does Not Appear to Be Beneficial and May Complicate Care Following Gunshot Injury to the Torso

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Background: Prehospital spinal immobilization (PHSI) is routinely applied to patients sustaining torso gunshot wounds (GSW). Our objective was to evaluate the potential benefit of PHSI after torso GSW versus the potential to interfere with other critical aspects of care.

Methods: A retrospective analysis of all patients with torso GSW in the Strong Memorial Hospital (SMH) trauma registry during a 41-month period and all patients with GSW in the National Trauma Data Bank (NTDB) during a 60-month period was conducted. PHSI was considered potentially beneficial in patients with spine fractures requiring surgical stabilization in the absence of spinal cord injury (SCI).

Results: Three hundred fifty-seven subjects from SMH and 75,210 from NTDB were included. A total of 9.2% of SMH subjects and 4.3% of NTDB subjects had spine injury, with 51.5% of SMH subjects and 32.3% of NTDB subjects having SCI. No SMH subject had an unstable spine fracture requiring surgical stabilization without complete neurologic injury. No subjects with SCI improved or worsened, and none developed a new deficit. Twenty-six NTDB subjects (0.03%) had spine fractures requiring stabilization in the absence of SCI. Emergent intubation was required in 40.6% of SMH subjects and 33.8% of NTDB subjects. Emergent surgical intervention was required in 54.5% of SMH subjects and 43% of NTDB subjects.

Conclusions: Our data suggest that the benefit of PHSI in patients with torso GSW remains unproven, despite a potential to interfere with emergent care in this patient population. Large prospective studies are needed to clarify the role of PHSI after torso GSW.

Key Words: Spinal cord injury, Gunshot wound, Spinal immobilization, Prehospital care.

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Gunshot injury remains a significant public health problem, accounting for almost 20% of all trauma deaths in the United States.[1] The management of gunshot wounds (GSW) is frequently initiated at the scene of injury, with the routine application of prehospital spinal immobilization (PHSI). Although commonly used, the role of the cervical collar, rigid backboard, and spinal precautions after GSW to the torso is not clear and may, in fact, interfere with other treatment modalities.

The role of PHSI is not controversial after blunt trauma, where patients felt to be at risk for spinal cord injury (SCI) are immobilized to prevent the manipulation of a potentially unstable vertebral column during subsequent transport and treatment. The literature, however, reports the occurrence of unstable spine fractures after GSW to be extremely rare, and some have questioned the role of spinal immobilization in this patient population.[2–6] The purpose of this study was to evaluate whether PHSI afforded any benefit after torso GSW and, furthermore, whether its application in this patient population complicated or delayed early treatment efforts.

MATERIALS AND METHODS

Two data sets were examined during this analysis (Fig. 1). First, the trauma registry at Strong Memorial Hospital (SMH), a New York State designated level I trauma center, was retrospectively reviewed to identify all subjects sustaining a torso GSW during a 41-month period from January 1, 2003, to June 1, 2007. Subjects were excluded if they were noted to have concurrent blunt mechanism of injury or isolated GSW to the head, neck, or extremities. Data regarding prehospital times, immobilization, airway management, emergency department (ED) disposition, and need for non–spine-related emergent surgical intervention (ESI) were collected. Medical records were further reviewed to identify all subjects in this group who sustained injury to the spine. Specific characteristics related to spine injury were further collected, including presence or absence of neurologic deficits, indication for decision to proceed with surgical stabilization of the spine, and any changes in neurologic status during hospitalization. The theoretic benefit of PHSI is to prevent secondary SCI caused by excessive manipulation of an unstable spinal column. Thus, PHSI was regarded as potentially beneficial in subjects without complete SCI who went on to require surgical stabilization of an unstable vertebral fracture.

Second, to assess similar variables in a larger national sample, the National Trauma Data Bank (NTDB) version 6.2 was queried using International Classification of Diseases (ICD)-9 E-codes to identify all subjects who sustained a GSW between the years 2001 and 2005 (Table 1). Any subject with a primary injury type of "blunt" was excluded. From this group, the following variables were collected—age, sex, injury severity score (ISS), ED disposition, and intubation type. The need for ESI was defined as an ED

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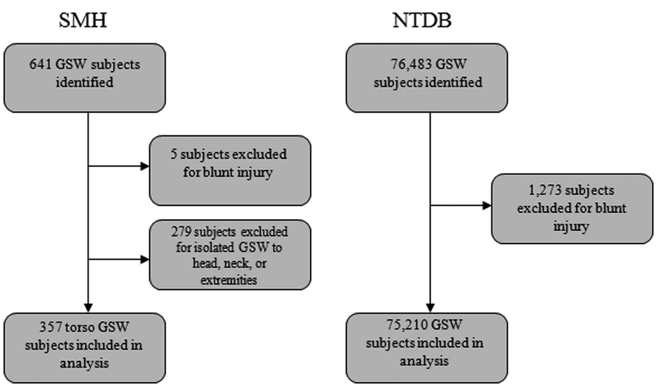

Figure 1. Study samples included from the Strong Memorial Hospital trauma registry (SMH) (January 1, 2003, to June 1, 2007) and the National Trauma Databank (NTDB) (2001–2005).

TABLE 1. ICD-9 E Codes, Diagnosis Codes, and Procedure Codes Used to Identify Groups

Identification of gunshot wounds	
E922.0–E922.3	Accident caused by firearm
E922.8–E922.9	
E955.0–E955.4	Suicide and self-inflected injury by firearms
E965.0–E965.4	Assault by firearms
E970	Injury due to legal intervention by firearm
E985.0–E985.4	Injury by firearms, undetermined whether accidentally or purposely inflicted
Identification of spine injury	
805	Fracture of vertebral column without mention of spinal cord injury
806	Fracture of vertebral column with spinal cord injury
Identification of surgical spine stabilization	
03.53	Repair of vertebral fracture
81.0	Spinal fusion
81.62–81.64	Fusion or refusion of 2–9+ vertebrae

disposition to the operating room or death in the ED in this sample. Of subjects who sustained a spine injury, presence of SCI and those undergoing operative spinal stabilization were also identified using ICD-9 codes (Table 1). The NTDB does not allow reliable identification of the anatomic location of GSW, therefore, this sample contained all subjects with isolated GSW. In addition, immobilization status and surgical specifics regarding decision for spinal stabilization were not reliably available in the NTDB data. Thus, the potential benefit of PHSI could not be directly assessed from the NTDB sample. We instead identified subjects coded as sustaining a vertebral fracture without SCI who also underwent operative spinal stabilization surgery during that admission.

Missing data for each field of the NTDB sample were assessed within the final group of study subjects. All variables were missing <4% of entries, with the exception of intubation type where 48.3% of subjects were missing these data and adjusted results are reported.

Data were analyzed using SAS JMP version 6.0 (Cary, NC) and GraphPad Prism version 4.0 (San Diego, CA). Means are reported as ±SD. Means were compared using a Mann-Whitney test. Proportions were compared using the χ^2 test, with calculation of odds ratios. A p value ≤0.05 was considered significant.

This study was approved by the University of Rochester Research Subjects Review Board. The American College of Surgeons granted approval for the use of the NTDB v6.2 data.

RESULTS

From the SMH trauma registry, 641 subjects with GSW were initially identified during the study period. Of these, five subjects were excluded because of concomitant blunt injury and 279 subjects were excluded for nontorso GSW, leaving 357 subjects with torso GSW for analysis (Fig. 1). This sample had an average age of 28 years ± 11 years, average ISS of 15 ± 13, and 90.4% were male. All subjects with available prehospital records (54%) underwent PHSI. There were 33 (9.2%) subjects who had gunshot injury to the spine. Within this group, 51.5% were found to have neurologic deficits consistent with SCI, in addition to a vertebral fracture, whereas 39.4% had isolated spinal fractures with no evidence of SCI, and 9.1% died before the neurologic status could be determined. Subjects with any spinal injury were 9.4 times more likely to be shot in the back (confidence interval, 4.2–21.1, $p < 0.01$).

All SMH subjects with SCI who went on to require surgical stabilization of the spine had evidence of complete neurologic injury on presentation. No subject who presented with neurologic deficits improved or worsened by hospital discharge, and no subject developed a new deficit during hospitalization. Intubation was required in 40.6% of SMH subjects and 54.5% required ESI (Fig. 2). The average prehospital scene time was 13.1 minutes ± 8 minutes, whereas the average transport time was 9.4 minutes ± 7 minutes. The average ratio of time on scene to time in transit calculated for each patient is 1.71.

The NTDB was used to identify 76,483 patients who suffered GSW during the study period. Of these, 1,273 subjects were excluded because of concurrent blunt injury, leaving 75,210 subjects for analysis. This sample had an average age of 30 years ± 13 years, average ISS of 13 ± 13, and 89.7% were male. There were 3,216 (4.3%) subjects coded as having a spine injury after GSW. Within this group, 32.3% were coded as spinal fracture with SCI, and 67.7% were coded as spinal fractures alone with no evidence of SCI. The most common area of combined spinal injury with SCI was the thoracic spine, whereas the most common area of isolated spinal fracture was the lumbar spine (Table 2).

The NTDB data included 26 subjects (0.03%) who were found to have spinal fractures requiring operative stabilization in the absence of SCI. Specifics regarding immobilization techniques used as well as surgical indications were not available for these cases. Intubation was required in

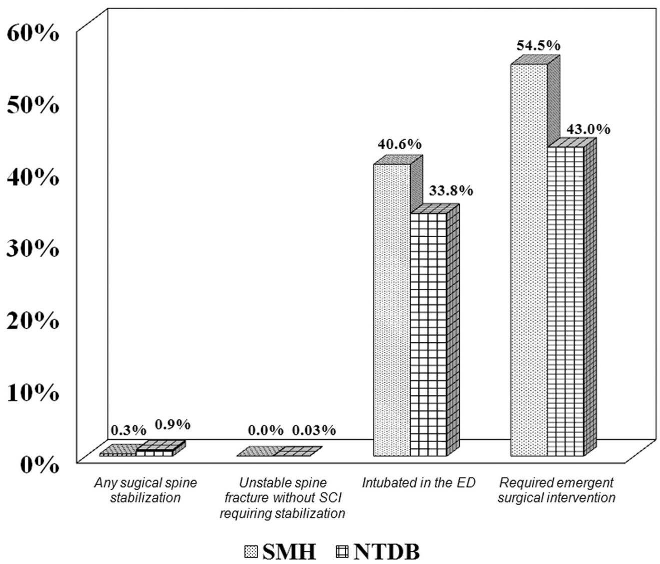

Figure 2. Percent of subjects requiring spine stabilization, intubation, and emergent surgical intervention in patients with GSW from both study samples. SMH, N = 357; NTDB intubation, N = 38,892; overall NTDB intubation rate was 17.5% (N = 75,210); NTDB emergent surgical intervention, N = 72,472.

TABLE 2. Distribution of Spine Injuries After GSW

	SMH*		NTDB†	
	Isolated Fracture, n (%)	Fracture With SCI, n (%)	Isolated Fracture, n (%)	Fracture With SCI, n (%)
Cervical	0 (0)	0 (0)	525 (24.1)	253 (24.3)
Thoracic	7 (43.8)	8 (47.1)	676 (31.1)	500 (48.1)
Lumbar	7 (43.8)	8 (47.1)	716 (32.9)	244 (23.5)
Sacral	2 (12.4)	1 (5.8)	220 (10.1)	22 (2.1)
Unspecified	0 (0)	0 (0)	39 (1.8)	21 (2)
Total	16 (100)	17 (100)	2176 (100)	1040 (100)

* Torso GSW patients.
† All GSW patients.

33.8% of NTDB subjects and 43% required ESI (Fig. 2). NTDB subjects who were missing intubation data had lower ISS and were less likely to require ESI than subjects with intubation data ($p < 0.01$). The overall rate of intubation for all NTDB subjects was 17.5%.

DISCUSSION

On the basis of our analysis, PHSI seems to be of little or no benefit to those with GSW to the torso. No subject in the SMH sample potentially benefited from PHSI as defined above. Because the presence of an unstable spine fracture in the absence of a SCI is extremely rare after a gunshot injury, it is unlikely that manipulation during early treatment would cause further SCI. In addition, patients who present with complete SCI or those with stable vertebral fractures without evidence of SCI would also not seem to benefit from PHSI. Our findings support those of similar studies, which have found that SCI caused by GSW is more likely the result of direct injury to the cord itself, as opposed to blunt force fracture of the supporting vertebral column. Waters and Sie[7] have found that patients with spinal injury after GSW have complete SCI 50% to 70% of the time, with a lack of neurologic progress at 1 year postinjury. Other reports have similarly demonstrated lack of neurologic recovery in patients sustaining SCI after a GSW.[4,8] Although PHSI may prevent further neurologic injury in patients with unstable spinal fractures after blunt trauma, it seems likely that the damage to the cord after penetrating trauma is not related to manipulation of the spine but rather the direct damage done by the projectile.[9]

Early studies that argued for spinal immobilization after trauma did not include patients with penetrating trauma and concluded that improper handling led to neurologic deterioration that was observed after initial injury[10,11]; however, the role of ischemia and edema in secondary SCI[12,13] was not recognized at that time. Data from our institution indicated that no patient with SCI after GSW had any change in neurologic status by time of discharge, further suggesting an immediate and permanent injury caused by the missile resulting in a lasting deficit. It is unlikely that these patients would benefit from PHSI, even if an unstable fracture was present.

The NTDB sample revealed only 26 patients with vertebral fracture and no SCI who subsequently underwent surgical spine fixation. Although indications for surgery in these cases were not clear, they represent 0.03% of all patients with GSW in this national sample. Similarly, no patient in the SMH registry was found to require surgical stabilization of the spine to prevent SCI after GSW. Only one subject with torso GSW in the SMH sample required surgical stabilization of the spine, but that was done to facilitate wheelchair use.

Our results are consistent with previous studies that examined the prevalence of spinal injuries after GSW. Cornwell et al.[2,3] reviewed two large populations of >4,000 patients with GSW, and they found only two patients without complete neurologic deficit who required surgical spinal stabilization, concluding that PHSI was of almost no benefit. Rhee et al.[4] reported 4 of 12,559 patients with GSW without SCI who required stabilization for an unstable fracture. Klein et al.[14] found only three patients with GSW over 10 years with an incomplete SCI, requiring spinal stabilization. In a review of Vietnam Conflict casualties, Arishita et al.[6] found that only 1.4% of immobilized patients may have potentially benefited from spinal immobilization.

Airway management is technically more challenging with PHSI in place.[10,15–17] The SMH data showed that a significant proportion of those with torso GSW were intubated in the ED. Similarly, a considerable number of subjects from the NTDB sample required intubation, even when adjustments are made for missing data. Spinal immobilization has been significantly associated with more attempts at intubation[15] and failure to properly place an endotracheal tube.[18] Failed airway management was reported as the second leading error resulting in the death of trauma patients, accounting for 16% of mortality in one study.[19]

The potential need for emergent operative intervention is also significant among patients with torso GSW.[12,20] This emphasizes the need to minimize delay in transporting patients with GSW to a trauma center capable of providing definitive surgical care. Both the NTDB and the SMH subjects demonstrated a high need for ESI. Furthermore, SMH data imply that nearly twice as much time is spent at the scene with these subjects, which includes time to apply PHSI, compared with actual transport time to the trauma center. Proper PHSI is a labor-intensive intervention that increases prehospital times. PHSI is estimated to take at least 5.5 minutes when applied by two experienced prehospital care providers under optimal conditions.[6] For trauma centers in urban settings, GSW often occur in close proximity to the hospital, allowing very short prehospital times if rapid transport is initiated. Several studies have demonstrated the value of a "scoop and run" approach to the prehospital care of critically injured trauma patients, with increases in mortality for each prehospital procedure, including cervical collar application, as well as each additional minute of prehospital time.[21–23]

It should be noted that the sample from SMH included only torso GSW because these patients are at highest risk for a spine injury.[14] The NTDB sample, however, included all subjects coded for GSW because of the inability to reliably determine the location of a GSW from available data. For this reason, patients with nontorso wounds who are less likely to suffer a potential spine injury are included in this group. This is likely responsible for the lower ISS, the lower rate of spine injury, the decreased need for surgical intervention, and the decreased rate of intubation in the NTDB group compared with the SMH population. Furthermore, few details were available about the spinal injuries and surgical indications. Thus, to indirectly evaluate the theoretical benefit of PHSI in this sample, we had to rely on ICD-9 coding that could only identify subjects sustaining spinal fracture without SCI who underwent surgical fixation of the spine during admission. Despite this, the absolute number of subjects in the NTDB who would theoretically benefit from PHSI remains negligible, although the need for ESI and intubation in this sample is significant.

Currently, there are two different national prehospital trauma curricula: Prehospital Trauma Life Support (PHTLS), which calls for PHSI in penetrating trauma patients only if a neurologic deficit is present,[24] and Basic Trauma Life Support in which the indication for PHSI is a bullet wound in or near the spinal canal.[25] Because patients with neurologic deficits after GSW to the torso seem to have a permanent injury, it would seem that PHSI would be unnecessary in this setting. Similarly, an algorithm mandating PHSI based purely on anatomic location of GSW would require that 12% of the SMH population be immobilized, although none of these patients seem to benefit from this effort.

There are several limitations to this study. First is the retrospective nature of the study. The numbers contained in the SMH data are small and limit the conclusions that can be drawn, especially when outcomes of interest are exceedingly rare. Use of registry data relies on accurate and complete imputation of data for each record. The NTDB is a large registry containing nearly 1.5 million records from 640 contributing hospitals during the period of 2001–2005. The nature of the NTDB precludes it from containing a high level of detail; however, this is a trade-off for the large sample that can be obtained. Contributing hospitals may have variation in the quality of data acquisition. Prompted by the large volume of missing intubation data, analysis demonstrated that those subjects without data were less injured. Thus, we believe it is reasonable to assume that many of these subjects were not intubated in the ED and an adjusted rate is reported accordingly. It is also possible that these subjects represent less serious GSW, such as those to the extremities, and the intubation rate of 33.8% may be a better reflection of torso GSW, such as the sample represented in the SMH data. Finally, ICD-9 coding was used for identification of patient groups, which creates the possibility for improper or missed coding. However, we believe that the rates in both samples are reasonably similar and are likely a reliable representation, especially when considering the NTDB data includes subjects with lesser injuries and a decreased risk for spine injury.

Although injury to the spine after a GSW to the torso is not uncommon, the benefit of PHSI in these patients remains unproven. It seems clear, however, that patients sustaining GSW to the torso are more likely to require some form of emergent intervention that may be affected by the process of PHSI. The potential to delay definitive surgical treatment, the potential to complicate airway management, and the overall lack of neurologic improvement after gunshot injury to the spinal cord suggest that PHSI in this patient population may by unjustified. A prospective multicenter study would be beneficial to adequately define the role of PHSI after torso GSW and to help with the development of an evidence-based approach to this problem.

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