LOW VELOCITY CIVILIAN GUNSHOT WOUNDS OF THE SPINE IN AN URBAN SETTING

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ABSTRACT :

Civilian spinal gunshot wounds in an urban setting are assessed to determine patient demographics, neurologic deficit and outcome, prophylactic antibiotic administration, rate of infection, spine stability, and principle associated injuries.

A retrospective analysis of 37 patients with low velocity gunshot injury (LV-GSI) to the spine. All spinal injury patients admitted to our trauma center between 1989 and 1993 were reviewed, 37 patients with LV-GSIs to the spine were identified. Medical records, radiographs, computerized axial tomography (CAT) were reviewed to assess the patient demographics, neurologic deficit and outcome, prophylactic antibiotic administration, rate of infection, spine stability and principle associated injuries.

Thirty-seven patients with LV-GSI to the spine were identified and comprised 34% of all spinal injury patients. Neurologic improvement of 1 or 2 Frankel grades occurred in only seven patients. Prophylactic antibiotics were given to twenty patients, and one infection occurred and was associated with colon perforation. Spinal instability was noted in 3 patients with cervical injury, and 1 patient with lumbar injury, and neurologic deficit was variable, despite the presence of instability. The major associated injury was vascular occlusion or disruption in 8/12 (66%) of cervical LV-GSI to the spine.

Neurologic outcome of the LV-GSI to the spine depended on the level of the injury and the presenting neurologic deficit, in lumbar spine neurologic improvement of one of two Frankel grades was more frequent compared to thoracic and cervical injuries. In the absence of hollow viscus perforation, antibiotic prophylaxis did not appear beneficial. Spinal instability was observed despite variable neurologic presentation, especially patients with LV-GSIs to the cervical spine. We recommend that patients should be carefuly scrutinized for the presence of instability to prevent further deterioration in neurologic status. Vascular injuries, occlusion or disruption are common in the cervical spine and routine angiography is recommended following LV-GSIs.

***Key words :** gunshot wounds, spine, spinal cord injury*

INTRODUCTION

Gunshot injuries (GSI) are the second most common cause of injury-related death in the United States. In 1991, firearms became the leading cause of trauma deaths in California, Nevada, New York, Virginia, District of Columbia, Texas and Louisiana (18). In the urban setting, GSI to the spine have been reported to comprise 13 percent of all spinal injuries third only to falls and motor vehicle accidents (23).

The wounding capacity of a bullet is directly proportional to its mass, and to an even greater extent, its velocityl ($E_k = 1/2 \times MV^2$). Urban GSIs are predominantly low velocity injuries and differ from the high velocity military GSIs. In addition to the bullet track the greater kinetic energy of military GSIs produces a greater cavitation effect which can lead to neurologic injury without any apparent spine fracture or penetration (5, 10).

The treatment principles of high velocity wartime GSIs are surgical debridement of the missile track with visual assessment of the spinal cord injury without surgical decompression or stabilization (2, 9, 11, 14, 15, 22). Recently the treatment protocols of civilian low velocity GSI have challenged these protocols with even less emphasis on exploration, decompression, or instrumentation. Exploration of the bullet tract has been recommended only in the presence of structural damage to arterial, visceral, airway and peripheral nerve structures and hollow viscus perforations following abdominal injuries (1, 3, 4, 13, 19, 20, 21, 24).

Although antibiotics have been routinely recommended with GSIs associated with hollow viscus perforation, benefits of antibiotic prophylaxis in presence of LV-GSI is inconclusive. The issue of spine stability following LV-GSI has been rarely addressed, the common belief is that LV-GSI are stable (24).

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Therefore, the authors retrospectively reviewed patients presenting to a Level 1 urban trauma center with LV-GSI to the spine with emphasis on neurologic deficit, the benefit of prophylactic antibiotics, residual spinal instability, and major associated injuries.

PATIENTS AND METHODS

Patients with GSIs penetrating to the spine admitted to Ben Taub General Hospital between 1989 and 1993 were reviewed. Medical records and radiographic studies, to include CAT, were analyzed with respect to the level of the injury, initial and follow-up neurologic status, antibiotic prophylaxis, infection, spine stability, and associated injuries.

Neurologic injury at admission and discharge was assessed using Frankel grading (7). Only infections attributable to direct bullet injury were included as an infection. Infections related to prolonged immobilization or urinary catherization were excluded. The prophylactic antibiotic type, dose, and duration was also recorded. Clinical stability of the subaxial cervical spine was defined according to the scoring system developed by White and Panjabi, with a total of 5 points or more required for instability (25). In thoracolumbar spine, instability was defined according to Denis; in addition to the three columns theory, extensive comminution of the vertebral body documented by CAT was condidered unstable (6).

RESULTS

Among the 106 spine injuries identified in the study period, 39 patients sustained penetrating injuries. Two patients sustained stab wounds, leaving 37 patients with LV-GSI to the spine for the study. There were 34 men and 3 women, ranging in age from 13 to 56 years (mean age: 28.4) with LV-GSI to the spine.

Twelve patients had cervical spine LV-GSI. One patient sustained a C7 vertebral body fracture with right carotid artery laceration and died shortly after admission following a massive stroke. One patient sustained fractures of the C1 lateral mass, ring, odontoid and was neurologically intact (Frankel E); all other patients presented with a variety of neurologic deficits to include one Wallenberg syndrome, five Frankel A, two Frankel C, 3 Frankel D lesions. Only one patient improved from Frankel D to E following C6 posterior element fracture. Eight of the twelve patients with cervical spine injury had associated vascular injury (Table 1).

Twelve patients sustained injuries of the thoracic spine (T1-12) and all patients presented with Frankel A lesions. Nonoperative management was adhered to and only one patient improved from a Frankel A to C. All patients sustained posterior column spine injuries and were noted to be stable (Table 2).

In the lumbar spine (L1-5) 13 patients were identified and all presented with neurologic deficits. Frankel A lesions were noted in eight, Frankel B in two, and Frankel C in 3. Five patients improved one or two Frankel grades (Table 3). Decompression or bullet removal was performed in only two patients with L1 and L1-2 injuries respectively. One patient improved from a Frankel A to B, while the other patient demonstrated no change in neurologic status.

Table 1 : Cervical Spine

Level	NSA	NSD	Instability Score	Associated Injuries
C1	C	C	N/A	A-V Fistula
C1	D	D	N/A	L Vertebral Artery
C1-2	D	D	N/A	R Carotid Occlusion
C1-2	E	E	Unstable /Halo	Odontoid /C1 Ring FX
C3	C	C	2	Right Carotid
C4	A	A	4	
C4	A	A	Unstable/ Halo 6	Hemothorax
C4	A	A	4	Carotid Artery
C6	D	E	4	None
C6	C	C	6	Hemothorax Subclavian Diaphragm
C7	A	A	2	Right Carotid/ Deceased
C7	A	A	4	Cervical Trunk

NSA: Neurologic Status at Admission
NSD: Neurologic Status at Discharge

Table 2 : Thoracic Spine

Level	NSA	NSD	Instability	Associated Injuries
T1	A	A	–	Innominate Artery
T6	A	A	–	Pneumothorax
T6	A	A	–	Thoracotomy
T7	A	A	–	–
T8	A	A	–	–
T8	A	A	–	Hemothorax
T8	A	A	–	–
T8	A	A	–	Hemothorax
T10	A	A	–	Laparotomy
T12	A	A	–	Ureterostomy
T12	A	A	–	–
T12	A	C	–	Right Kidney & IVC

Table 3: Lumbar Spine

Level	NSA	NSD	Instability & Column Involvement	Associated Injuries
L2	B	B	Posterior	Castric Laceration
L2	A	A	Posterior	Colon, Kidney Diaphragm
L2	C	D	Posterior	–
L2	A	A	Posterior	Exploratory Laparotomy
L2	A	A	Posterior	–
L4	C	D	Posterior	–
L1	A	C	Posterior & Middle	Nephrectomy, Bowel Perforation
L1	A	B	Posterior	–
L1	A	C	Posterior	IVC, Liver, Hemothorax
L1	A	A	Posterior	Liver
L1	B	B	Posterior	–
L1	C	C	Posterior	Pneumothorax, Kidney, Diaphragm
L1	A	A	Posterior & Middle	– Laparotomy

Prorpylactic antibiotics were given to six patients with cervical, five patients with dorsal and nine patients with lumbar LV-GSIs. The antibiotics administered varied greatly, and the duration of antibiotic prophylaxis also varied, ranging from 3 to 14 days. However, the only infection occurred within two months of infury was in a patient with associated colon perforation.

Spinal instability was noted in four patients and localized to the cervical spine in three and lumbar spine in one patient. One neurologically intact patient with a C1 lateral mass, and ring fracture with a Type II odontoid was treated in traction followed by halo immobilization. One patient demonstrated a Frankel D, C4 level neurologic deficit with destruction of the C5 left pedicle and the body with 4 mm of displacements at C5-6 with extension-flexion views at C5-6 (Fig 1, 2). Another patient had a C6 injury with Frankel C neurologic deficit and comminution of the body with pedicle fracture (Fig 3). White-Panjabi instability scores were higher than 5 in these unstable cervical spines. All patients were treated non-operatively with traction, a halo, and finally a cervical thoracic brace. Associated vascular injuries occurred in 8 patients (66%) in the cervical spine however only two patients required neck exploration because of expanding hematoma.

All patients with thoracic spine injuries demonstrated involvement of only the posterior elements and therefore considered stable. In the lumbar spine, one patient was unstable with disruption of both pedicles and comminution of the middle column (Fig 4). This injury was not addressed surgically and patient was mobilized in 3 weeks with a thoracolumbar brace, without any complications. There were two patients with involvement of the pedicle without comminution of the vertebral body, these patients were assessed as stable injuries.

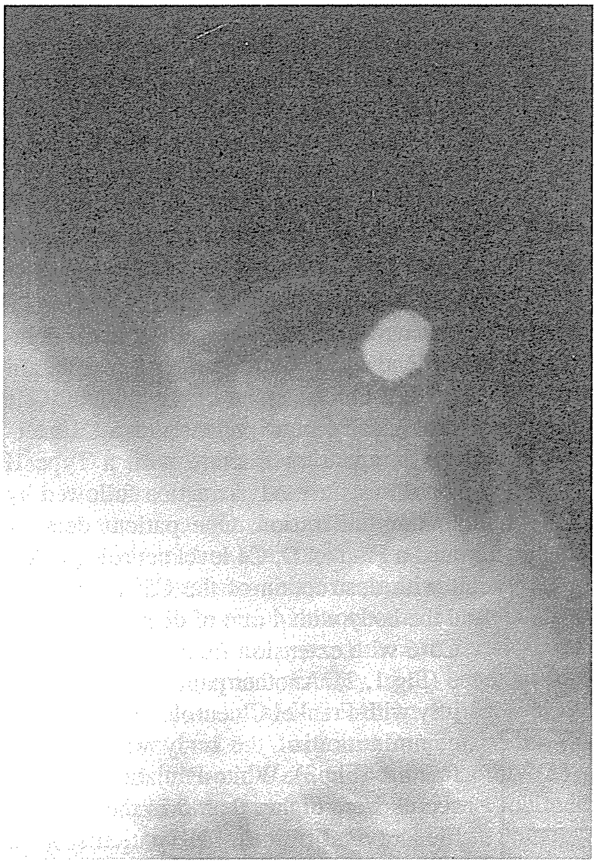

Figure 1. Lateral flexion radiograph of the patient demonstrating 4mm forward C5-6 displacement in flexion.

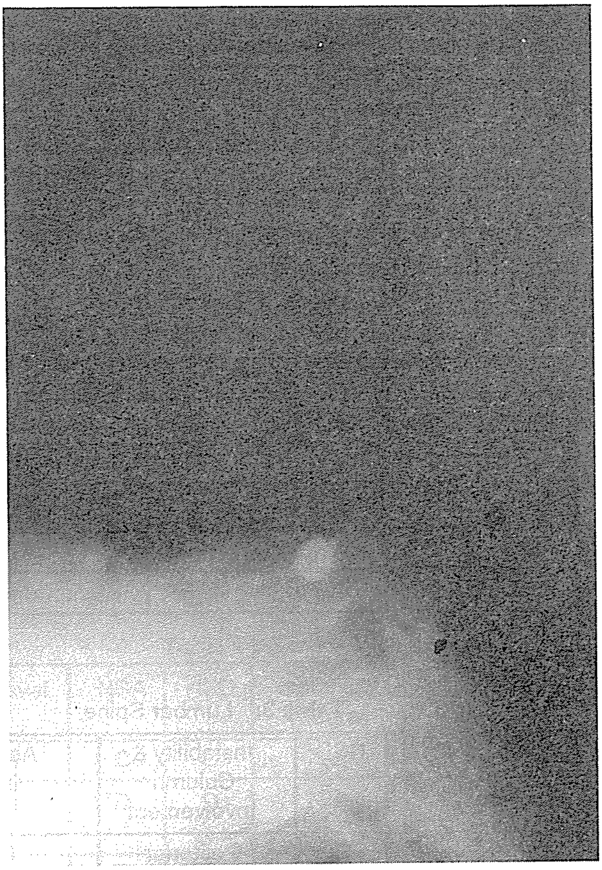

Figure 2. Lateral extension radiograph of the patient demonstrating reduction of forward displacement in extension. The patient was treated with traction followed by halo application.

DISCUSSION

In this series the most important determinant of the neurologic outcome was the extent of initial neurologic injury, and the level of the injury. In cervical and thoracic spine only 2 patients improved one Frankel grades during follow-up period. However in lumbar spine at the level of cauda equina the neurologic outcome was more favorable, 5 patients improved one or two Frankel grades. Stauffer et al. in an analysis of 185 patients with GSW to the spine were not able to demonstrate any benefit of decompression following complete lessions of the spinal cord. Incomplete lesions did not benefit significantly from multilevel decompression and decompression attempts were complicated by a higher rate of instability, infection, spinal fluid fistula (20).

Our findings are in agreement with Stauffer who reported 94 percent improvement in patients with cauda equina lesions with non-operative treatment. Furthermore, Benzel reported that nerve root function improved in all patients despite severity with or without surgery (1). Differences in regional anatomy of the spinal cord and greater susceptibility of spinal cord to injury compared to cauda equina may explain more favorable outcome in regards to functional recovery in the lumbar area. Since this is not a randomized trial we cannot make any conclusions in regards to the benefits of decompression however our finding suggests that cauda equina lesions are more favorable in regards to potential for functional recovery.

The role of administration of prophylactic antibiotics in preventing early infections following LV-GSI to the spine is not clear. There are no prospective randomized studies reported in the literature. Kupcha et al. proposed 7 days of IV antibiotic prophylaxis in

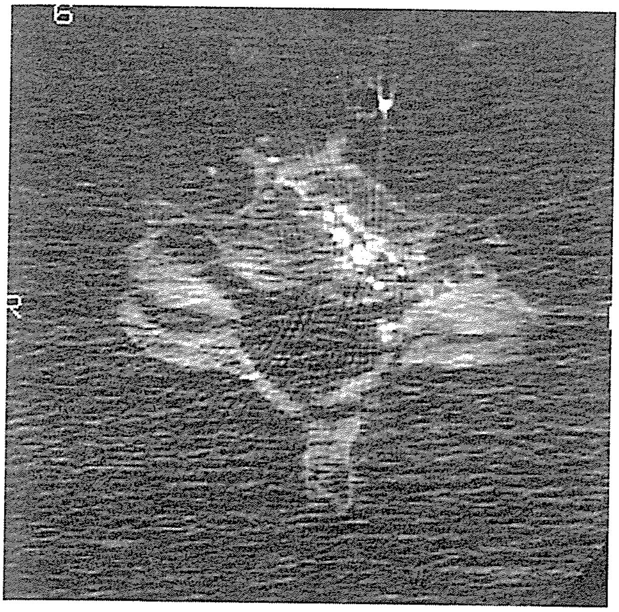

Figure 3. CAT of the same patient with C6 LV-GSI, demonstrating destruction of the posterior elements, pedicle, facet joint.

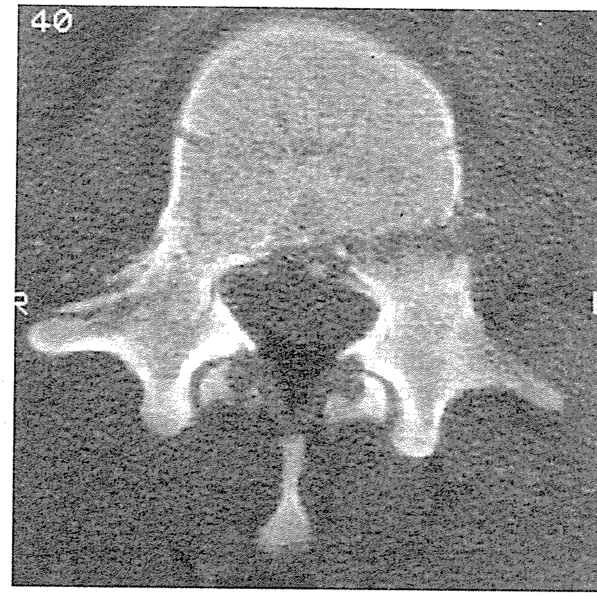

Figure 4. CAT of the patient with LV-GSI to L1 demonstrating pedicle fractures and middle column involvement. The patient was classified as an unstable injury and treated conservatively with a brace.

presence of cervical LV-GSIs because of proximity of visceral, vascular, neurologic and airway structures and recommended extension of length of administration if a transpharengeal path of the bullet is documented (13). Romanick reported 20 patients with LV-GSI to the lumbar spine of these 12 sustained perforated viscus. Of eight patients with colon perforation 7 developed infection and he recommended bullet removal following alimentary tract perforation, however patients in this series received prophylactic antibiotics only 2 to 4 days (17).

Roffi reviewed 42 patients with associated perforation of alimentary canal. Thirty-five patients had bullet lodged in the spinal structures among these 17 patients underwent bullet removal and debridement and 18 were managed without bullet removal and none of these developed infections. Nine of these 18 patients had associated colon injuries (16). The difference in management from Romanicks series was long term use of IV antibiotics lasting 7-14 days. Roffi concluded that 2 weeks of Iv antibiotic coverage was adequate to prevent spinal infection. More recently Waters supported Roffi's conclusion since none of the 19 patients who had alimentary tract perforation developed infection despite the fact that 10 of the bullets were left in place (24). In the management of transperitoneal GSIs to the spine, Kihtir et al. advocated irrigation of wound tract and administration of short term antibiotics with routine general surgical management of associated injuries (12).

In our series only 20 patients (54 percent) received intravenous prophylactic antibiotics for 3 to 14 days. One patient with colon perforation had paraspinal infection despita two weeks of prophylactic antibiotic administration. We were unable to demonstrate any differences between the group that received antibiotic prophylaxis and the group that did not, however it is logical to administer antibiotics in presence of hollow viscus, air way, or pharyngeal injuries but value of antibiotics in absence of these injuries is yet to be determined.

One of the most striking findings in this series was association of high incidence of vascular injuries with LV-GSI to the cervical spine area, 8 out of 12 (66%) patients had vascular injuries. Only two patients had neck exploration due to an expanding hematoma. Others were managed conservatively with observation. Our protocol follows guidelines reported by Golueke with aggressive angiographic evaluation of patients, observation in absence of expanding hematoma or vascular abronmalities (8).

In the reports of low velocity gunshot injury to the spine to date, the potential for subsequent instability is thought to be rare. Most reported cases of instability were iatrogenic, and occurred following operative intervention and laminectomy. Heiden et al. reviewed 38 patients with LV-GSI to the spine and observed only one unstable spine following decompressive laminectomy (10). Stauffer et al. reported six cases of iatrogenic instability among 185 GSI to the spine following laminectomy (20). Iatrogenic instability was also reported in the cervical spine however only one patient with iatrogenic cervical instability due to single level laminectomy was identified (13). In the cervical region even an impact by a low velocity gunshot injury may potentially destabilize cervical spine. This assumption was supported by identification of three unstable patients in this region in our study. One patient had C1 ring, lateral mass and non,displaced Type II odontoid fracture without any neurologic deficit. In subaxial spine we were able to demonstrate 2 patients with higher than 5 points according to White and Panjabi criteria based on CAT and lateral flexion extension radiographs and clinical presentation (25).

Since chest cavity and abdominal cavity and its contents that surrounds the thoracic and lumbar spine absorbs kinetic energy of the missile one may assume that unstable injuries other than iatrogenic instabilities would be extremely rare. To our knowledge only one case with bilateral pedicle fracture was published in lumbar area (24). We were able to identify one case with potentially unstable injury with both pedicle and middle column fracture at L1 level.

The importance of diagnosing potentially unstable spine injuries following LV-GSIs to the spine lies in preventing further neurologic compromise in neurologically incomplete or intact patients. Especially in the cervical region where kinetic energy of the bullet is not absorbed by soft tissue envelope as much as thoracolumbar region patients should be scrutinized for instability findings using contemporary imaging modalities.

CONCLUSION

In urban areas LV-GSI to the spine is becomming an important cause of morbidity and mortality in a young patient population. Our findings indicate that initial presentation of neurologic injury is the determinant of the outcome as reported previously by various authors. In our series role of routine antibiotic prophylaxis could not be demonstreated. However, porphylactic antibiotics should be administered to patients at increased risk following associated visceral perforation as indicated in previous studies. In the cervical spine vascular injury should be carefully assessed and treated conservatively in the absence of life threatening or associated injuries. Each case should be scrutinized for presence of instability especially in the cervical spine area with CAT and dynamic flexion-extension radiographs. Early identification of unstable cases may prevent further neurologic compromise.

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