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Neurosurgery

Surgical Management of Missile Trauma to Thoraco -Lumbar Spine

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ABSTRACT

Objectives: To evaluate the optimum treatment for Spinal Missile Injury with respect to Missile trajectory, Functional outcome, surgical indications, and timing of surgical intervention.

Study Design: Analysis of the patients with spinal missile injury.

Place and Duration of Study: This study was conducted in the Emergency Department of Assir Central Hospital Abha Kingdom of Saudi Arabia over a period of three years from June 2001 - May 2004.

Material and Methods: A prospective series of Nineteen Missile trauma patients to the Thoraco-lumbar spine is presented . A total of 20 patients (13 in the surgical group A , 7 in the conservative group B) were monitored for functional recovery. One female patient died preoperatively. Twelve were treated surgically, of whom 9 (75%) had incomplete injuries (Frankel scores B, C, and D) ,6 (66.66%) showed improvement, 2 (22.22%) showed no change, and 1 (11.11%) worsened(Table3) . In the conservative group , five (71.42%) had incomplete injuries, 3(60%) improved, one (20.0%) remained unchanged and one (20%) worsened. Five patients (including both groups) were with complete injury (Frankel scores A). Mean postoperative hospital stay was 18 days. The wounds were caused by splinters in 12 (71.4%) and bullets in 7 (28.7%). Eight patients received more than one shrapnel. Associated injuries were present in eleven patients.

Results: The best results were obtained by the patients who received operations because of rapid neurologic deterioration cauda equina compression. If spinal cord is not injured by the trajectory, the best approach is conservative.

Conclusion: It was concluded that surgical intervention is essential for spinal gunshot injury patients with instability or rapid neurological deterioration and beneficial for patients with CSF fistula, infections and compressing foreign bodies in the injury site. The initial neurological grade was found to be the best prognostic indicator**.** Most of the management revolves around consequences of the neurological deficit.

Key Words: Missile injury, Thoracolumbar Spine, Functional recovery, Surgical management

INTRODUCTION

Gunshot wounds (GSW) are the 3rd most common cause of traumatic spinal cord injuries in the U.S. civilian population[18]. In 2009, according to the United Nations Office on Drugs and Crime, 66.9% of all homicides in the United States were perpetrated using a firearm[1]. There were 52,447 deliberate and 23,237 accidental non-fatal gunshot injuries in the United States during 2000[2]. Just over half of all gun-related deaths in the United States are suicides[3]. Of the 30,470 firearm-related deaths in the United States in 2010, 19,392 (63.6%) were suicide deaths, and 11,078 (36.4%) homicide deaths[4]. Inspite of these figures, the efficacy and appropriateness of surgical management of missile injuries of the spine and the subsequent functional recovery remain controversial (14,24,26). In addition, surgical exploration may not offer significant improvement in the final recovery of function of patients with low velocity injuries. To remove this ambiguity we planned this prospective study.

Our aim was to choose the optimum treatment for SMI with respect to bullet trajectory, evaluation of surgical indications, and timing of surgical intervention.

MATERIALS AND METHODS

This is a prospective study of 20 cases of missile trauma to Thoraco-Lumbar Spine where functional outcome based surgical management was performed .Twenty consecutive patients (Seventeen male, Three female), with spinal missile injury were admitted to Neurosurgical Department from June 2001 to May 2004 at Assir Central hospital, Abha KSA. One female patient died preoperatively. Patients with Cervical and Sacral Spine missile trauma were excluded. The mean follow-up period was 8.3 months (range:3-15 months).

RESULTS

Age Incidence: Age range was 18-49 years (mean age 34+-7.5) yrs.

Sex Incidence: There were seventeen (17) males and three (3) female with male to female ratio 8.5:1 as

Level of Injury: Level of Injury was D5:1, D8:2, D10:2, D11:3, D12:4, L1:3, L2:2 , L4:2 (Table 1).

Neurologic Grading: The injuries were classified with respect to the presence or absence of neurological deficits based on Frankel Grading (Table 2). Fourteen patients had incomplete deficit while five have complete neurological deficit.

Clinical Features: All patients underwent a complete clinical and hemodynamic evaluation on arrival, and were neurologically examined once they were hemodynamically stable and the airway was intact . One female patient died preoperatively. Five patients had wounds of exit, the rest had metallic fragments retained in the spine/surrounding soft tissues/spinal canal. All these patients were observed to have neurological deficit upon admission. There were 11 thoracic and 8 lumbar region injuries. Thirteen patients had metallic fragment in the spine/surrounding soft tissues/spinal canal. These patients underwent a standard medical management protocol in their workup which included intravenous fluids, antibiotics, steroids, bladder catheterization, care of the skin and pressure points. Inj. Methylprednisolone was administered to only 2 patients who were received within 24 hours of the injury.

Investigations: Dominant radiological modalities used were X-ray and CT or Reformatted CT, CT/ Myelo and Myelography once routine laboratory work-up was done.

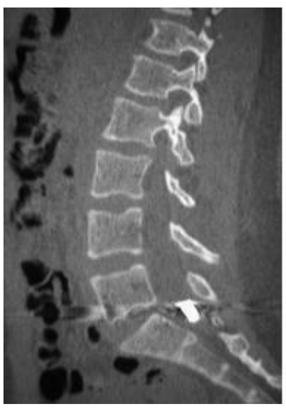

Fig No.1: Reformated CT of Lumboscral Spine shows a Bullet residing in the spinal card at the level L5/S1 and its break

Fig No.2: X-ray Lumbo scral Spine shows Bullet in spinal card

Fig No.3: X-ray AP view LS Spine showing bullet at the level of L4 vertebra

Patient Groups: Patients were divided into 2 groups based on their management (Table 1): -

Group A: Surgically treated patients : 12 patients

Group B: Conservative treatment group: 7 patients

Associated Injuries: Associated Injuries were haemothorax, haemoperitoneum or visceral injuries and are mentioned(Table-1).

Neurosurgical procedure: Thirteen patients were admitted but one patient(thoracic injury D11) died preoperatively. Hence twelve patients were treated surgically (as shown in Table 1), of whom 9 (81%) had incomplete injuries. Four patients whose vertebral column was injured with side-to-side trajectory were operated on because of instability. Visceral injuries were operated by the surgeon concerned to begin with. The spinal cord was explored by midline incision in 10 patients. Lateral extracavitory decompression of the dorsal cord was done in 2, debridement and fusion were done in 2 patients. Laminectomy was done to open dura to visualize the cord which was seen lacerated in 3, contused in 4 and transected in 3 patient. Three patients had lacerations of cauda equina rootlets. After debridement, irrigation and hemostasis, the dura was closed primarily or by duroplasty using lumbodorsal fascia. In the lateral extracavitory approach, cord could not be visualized completely and only a patch of fascia was placed over the part and wound closed after hemostasis. Postoperatively, these cases had continuous lumbar drainage of CSF for 72 hours. All patients received broad spectrum antibiotics that cross the blood-CSF barrier, for a period of four weeks. The average stay in the acute unit was 18 days(Mean 7-29 ± 9).

Outcome: Functional recovery and complications in surgical and conservative treatment groups (12 patients and 7 Patients respectively) were evaluated in a total of 19 patients (Table 1) .Of those treated surgically, 9 (75%) had incomplete injuries , 6 (66.66%) showed improvement, 2 (22.22%) showed no change, and 1 (11.11%) worsened (Table 3) . In the conservative group, five (71.42%) had incomplete injuries, 3(60%) improved, one (20.0%) remained unchanged and one (20%) worsened. The best results were obtained by the patients who received operations because of rapid neurologic deterioration, compression, and instability in the spinal canal. Seven associated multi-organ injuries were seen in the surgically treated patients and 5 were seen in the conservatively treated patients.

Two Cerebrospinal fluid fistulae and one case of meningitis were the dominant complications seen in the surgically treated group. In addition, two patients developed pneumonia, 4 developed pressure sores and one deep-vein thrombosis.

No patient in the surgical or the conservative groups with a complete cord injury made a meaningful recovery after removal of the bullet and decompression of the canal. Whereas Patients with bladder dysfunction were also very slow to progress towards recovery.

Table No.1: Summary of Surgical and Conservative Groups – All Patients Data

No./ Sex	Site of injury	Mode	Imaging	Associated Injuries	Surgery	Frankel Grading
A.	Surgical Group					
1/M	Dorsal 8 (D8)	Shrapnel	CT	Haemothorax	Lateral Decompression	B
2/M	Dorsal 8 (D8)	Shrapnel	CT	Hemothorax	Lateral Decompression	A
3/M	Dorsal 11 (D11)	Shrapnel/Pellet	X-ray	-	Laminectomy	B
4/M	Dorsal 11(D11)	Bullet	Myelo	Hemoperitoneum/ Spleen	Laminectomy/Posterior Instrumentation	C
5/F	Dorsal 12(D11)	Shrapnel	CT	Liver	Laminectomy	A
6/M	Dorsal 12 (D12	Bullet	CT	-	Laminectomy	D
7/M	Dorsal 12 (D12	Bullet	X-ray	Small Intestine	Laminectomy	D
8/M	Lumbar1 (L1)	Shrapnel	CT	Renal	Laminectomy/Posterior Instrumentation	B
9/M	Lumbar 1 (L1)	Shrapnel	CT	Colon	Debridgement	A
10/M	Lumbar 2 (L2))	Shrapnel/Pellet	X-ray	-	Laminectomy	C
11/M	Lumbar 2 (L2)	Shrapnel	CT	-	Laminectomy/Posterior Instrumentation	B
12/M	Lumbar 4 (L4)	Bullet	CT	-	Laminectomy	B
B	Conservative Group					
1/M	Dorsal 5 (D5)	Shrapnel	CT	Spleen	-	C
2/M	Dorsal 10 (D10)	Shrapnel	CT	-	-	B
3/M	Dorsal 10 (D10)	Bullet	CT	Hemoperitoneum	-	D
4/M	Dorsal 12 (D12)	Shrapnel	CT/MRI	-	Debridgement	A
5/M	Lumbar 1 (L1)	Shrapnel/Pellet	Myelo	Renal	-	C
6/F	Lumbar 1 (L1)	Bullet	CT	Colon	Debridgement	A
7/M	Lumbar 4 (L4)	Bullet	CT	-	-	B
8/F	Dorsal 10 (D10)	Shrapnel/Pellet	CT/Myelo	-	Died before Surgery	B

Table No.2: Frankel Grading

Grade A	Complete neurological injury-no motor or sensory function.
Grade B	Preserved sensation only-no motor function sensory function only partial function.
Grade C	Preserved motor non-functional-of no practical use to the patient.
Grade D	Preserved motor function-useful motor function below the level of the injury.
Grade E	Normal motor.

Table No.3: Neurological status per anatomical level and per group with percentage

Neurological status per anatomical level			
	Thoracic	Lumber	Total
Incomplete	8(6)*	5(3)*	14(9)
Complete	3(0)*	2(1)*	5(1)*
Total			
Improved	6	4	10
*Parenthesis indicate number of patients with neurological improvement			

Neurological status per group				
Incomplete	9(6)*	5(3)*	14(9)	64.2%
Complete	3(0)*	2(1)*	5(1)*	20.0%
Total				
Improved	6	4	10	52.63%
*Parenthesis indicate number of patients with neurological improvement				

DISCUSSION

Because of the high incidence of associated injuries and permanent neurological deficit, gunshot injuries of the spine place a huge burden on our society. Gunshot wounds (GSW) are the 3rd most common cause of traumatic spinal cord injuries in the U.S. civilian population[19]. In civilian life upto 13.6% of all spinal cord injuries and up to one-half of spinal injures in young patients has resulted from low-velocity gunshot wounds[7,11,15]. Thus, long-term functional disability as a consequence of spinal cord injuries resulting from GSWs is an important problem that needs to be addressed in our society.

Civilian low-velocity gunshot injuries are vastly different from the military experience which provided much of the earlier experience. As one would expect, survival is far likelier in the low-velocity group.

Projectile characteristics have significant impact on wounding capacity:

(1) **Deformation**: Encased (jacketed) bullets used in higher velocity firearms tend to deform (“mushroom”) on impact increasing local tissue damage.

(2) **Tumbling**: On hitting target, bullet loses its directional stability and is able to rotate around its short axis.

(3) **Fragmentation**: Fragmentation often leads to a typical distribution: fragments spreading along the bullet course. Fragmentation gives important information about the mechanism and direction of injury.

Mechanism of Injury: The injury from a gunshot wound results from shock waves or secondary fragments damaging the neural elements[15]. Directly it is a consequence of the projectile crossing the spinal cord and/or canal causing compression, contusion, or laceration of the spinal cord/ nerve roots, with or without laceration of the dura[6,9,15]. Lipid peroxidation is unlikely an important mechanism of further damage in penetrating cord injuries[19].

Tissue characteristics: Bullet injury is more severe in friable organs such as brain due to temporary cavitation at a distance from the bullet path. Both bone and subcutaneous fat are more resistant to damage. Bone can significantly alter behaviour of the projectile and its wounding capacity by slowing it down and changing its path.

Indications for Surgery: The efficacy and appropriateness of surgical management of missile injuries of the spine and the subsequent functional recovery remain controversial[16,28,30]. Our series was an attempts to clear concepts and promote evidence based management. The definite indications for surgical intervention are usually progressive neurological deficits, persistent cerebrospinal (CSF) leaks, incomplete neurological deficits with radiographic evidence of neural compression (especially in cauda equina).

Surgical exploration has been advocated for GSW injuries of the cauda equine[6,9,16,28]. All patients in our series with an incomplete cauda equina injury improved in their functional capacity after surgical decompression and bullet removal. Surgery enhances functional recovery from GSWs to the cauda equina by decompressing the neural elements by laminating bony, bullet and disc fragments may be beneficial[6,16,28] and to prevent subsequent spinal infections[14,24]. Waters and Adkins reported that bullet removal did not alter infection rates or sensory recovery[32]. However, in the cauda equina region they found that removal may increase the neurological recovery. Same was reported in our series.

Transperitoneal fragments injuring the spinal cord and hollow organs, e.g., colon, cause local septic complications, which needs visceral debridement and extended antibiotic treatment without removing apparently contaminated bullet fragments[12,17,20,22,23,24,26,27]. GSWs to the spine used to be treated in order to prevent potential complications such as plumbism and reactions to copper or brass in cases of copper-jacket bullets[11,21], CSF fistulas[5,24], and central nervous system/ local infections [17,23,24,26]. But, metal intoxication has usually not been encountered in follow-up studies.[5]

Cerebrospinal fistulae have been encountered in only small percentage of patients with bullet wounds.[5,29] There were no cases of CSF fistula in our patients. Cerebrospinal fluid fistula was observed more in the surgically treated group. Same was the case of Meningitides .

Overall most studies in the literature recommend a conservative (non-surgical) approach to GSWs to the spine[5,12,27]. Surgical exploration may not offer significant improvement in the final recovery of function of patients with low velocity GSWs to the spinal cord.[5,16,18,25] Conversely, reasons cited for surgical management of GSWs to the spine is prevention of subsequent spinal infections[14,24]. Aggressive and meticulous surgical principles were applied in Vietnam, which included debridement, dural exploration and repair, which resulted in improvement in mortality.

Injury restricted to the posterior elements would warrant a posterior midline approach; laminectomy, debridement, dural reapir are carried out. Intraspinal fragments can be extricated if visible or if the patient is completely paralyzed below the injury.

Some authors question the efficacy of spinal debridement of transperitoneal wounds (including colonic injuries) to prevent spinal infections [17,20,23,24,26].

Surgical Management: Way Forward?

Much greater degree of wound contamination and tissue destruction occurs in the high-velocity injury (30),which will result in high rate of infections. Hence the treatment of military wounds may be very different from civilian injuries (more surgically-oriented). In addition to direct damage, high-velocity bullets may injure the spinal cord by transmitting shock waves without actually penetrating the spinal cord[10].

Surgeons have evolved their strategies accordingly over times starting from conservative management of complete injuries in WWI[23], to a nonurgent and surgically oriented view, taking advantage of antibiotics, in WWII[12], to swifter and more aggressive surgical management and effective use of antibiotics in the Korean and Vietnam Conflicts[8,13]. The civilian situation, however, is more confusing and efficacy of surgical management is often questioned. [5,6,12,17,18,21,27,28,29]

It is thus imperative that the treating surgeon understands the exact role and scope of surgical intervention, so that neurological function can be preserved and further deterioration recognized and treated.

CONCLUSION

Lumbar trajectories of Spinal Missile Injury (SMI) which are antero-posterior or oblique must be recognized as highly infective in the lumbar region. A side-to-side trajectory missile with spinal cord injury was deemed to be unstable and needs further stabilization. If spinal cord is not injured by the trajectory, the best approach is conservative. The best results from neurosurgical interventions was achieved after rapid neurologic deteriorations because of spinal compression and/or instability. All patients with an incomplete cauda equina injury showed significant improvement in the motor and sensory assessment after bullet removal/ decompression.

Most of the management revolves around the consequences of the neurological deficit. Surgical intervention is essential for spinal gunshot injuries resulting in instability, rapid neurological deterioration and may be beneficial for patients with compressing foreign bodies in the injury site, CSF fistula and infections .

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