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Research Article

Missile Injuries to The Spine Local Experience and Review of The Literature

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Abstract:

Introduction: Missile injuries of the spine particularly the high velocity projectiles are very destructive, leading to real disaster and even death. The incidence has increased recently on both civilian and military troops.

The ideas behind writing this article is to shed the light on the seriousness of this type of injury and on the consensus for the ideal treatment depending on our local experience and others experience.

Materials and Methods: We review our patient's files whom had missile injuries related to orthopaedic practice since the last 40 years in public and private hospitals and we also search the web looking for articles discussing missile injuries in orthopaedic practice. We collect complications that observed in our patients and reported in literatures to be mentioned in the results of this review.

Results: Missile injuries is the cause of 13-44% of all spinal injury. The cervical lesion is behind complete neurological deficit in 70% of cases. Almost all injuries are stable particularly in the cervical lesion provided that both facet and both pedicles remain intact. Probably pain is one of the commonest complications recorded. Bullets removed did not relieve the pain due to depression. Infection is very much expected after the dirty missile wounds. Neurogenic bladder and urinary tract infection are also possible, meningitis, bone infection, Charcot arthropathy and deformity are all possible. Lead intoxication is a late and very rare complication. The last rare but possible complication is the migration of the missile.

Conclusions: Gunshot injury to the spine is becoming more and more prevalent in both military and civilian practice. Probably the absolute indication for surgery is the progressive neurological deficit. A cover of antibiotic is mandatory. A careful search for the instability is mandatory and lastly, Steroids use in spinal missile injuries is controversial.

Keywords: missile, injury, basrah, iraq

History of missile injuries to the spine

Probably Imhotep, the Egyptian physician (1700 BC) was the first to write about missile injuries of thoracic spine (Guttmann L. 1970). (10)

Ambroise Pare (1557), A French war surgeon wrote the first description of spinal cord injury caused by firearm during the Civil U.S. war, he reported 642 cases of spinal gunshot wounds (Sonn tag VKH 1997). (11) In the ancient days, a mortality of 50% discourage many surgeons for offering any surgical intervention (Hanigan et al. 2004). (12) The bad reputation about spine surgery continued to the First World War, 1914-1918 and the mortality increase to 56%. (12) After World War I, the only indication for surgery was progressive neurological deficit (Tinsley M 1946). (13)

Again, the neglect continued to World War II, Dr. Walter Haynes was objecting this idea and started doing laminectomy, as World War II progressed and there was a real shift to more aggressive surgical debridement even with complete neurological deficit. (14)

Pools series (1945) reported 57 patients during the year 1943-1944, 35 patients out of them underwent laminectomy with 57% showed marked improvement compared to 4.5% spontaneous home improvement in the conservative group, he strongly believed that old patients with incomplete injury whether with static or progressive neurological deficit should undergo exploration and decompression (Pool J 1945). (15)

The policy of early surgery carried into to Korean and Vietnam conflict, amazing recovery more in the cervical spine even with complete injury.

To conclude, the recovery was mostly related to the initial neurological status, rather than related to performing surgery, but surgery is always required for patients with grossly contaminated wound or with progressive neurological deficit. Surgery appeared to be not effective in Heiden series of patients with gunshots of the spine (Heiden J S 1975). (16)

Initial resuscitation and first aid measures, clinical evaluation

of this emergency condition needs thorough evaluation of the whole body.

In cervical injury, examination for vascular and airway is required if any of vascular or Airway injury detected, emergency treatment is required without delay, standard basic life support is mandatory to be followed by the clinical evaluation of the injured site, details of the direction of shoots, type of weapon, the proximity of the weapon, i.e. Close proximity or far shooting, number of shoots, all vital to be counted.

Antibiotic, anti-tetanus toxoid, sedation or even minor tranquilizer may be required. The use of cervical immobilization is discouraged, moreover, some consider using halo or collar is useless and increase the mortality rate, though sadly it is to date still practiced. Rhee et al. (2006) (17) in large meta-analysis reported that cervical spine immobilization potentially benefit less than 0.05% of patients and increase the death rate.

Arishita G et al (1989) (18) reported no benefit to applying immobilization for many reasons. Alexis et al (2020) (19) reported that external bracing may be over utilized. Nima et al (20) confirm that gunshot wound to spinal column are stable injury and no need for spinal orthosis or bracing.

Ballistics

Transfer of the kinetic energy from the projectile to the tissue is the main destructive force to the tissue in contact with missile, the kinetic energy depends on its mass and velocity, low energy missiles travels at 1000- 2000 feet per second, when the speed 2000- 3000 feet per second, is a high velocity missile. Low velocity produce the damage by the impact from projectile mass, laceration and crushing (Gur A 2005). (3) The projectile velocity determines the wounding potential of the weapon.

The energy is not the only responsible factor for the damage, physical property of the projectile, design, fragmentation and the specific gravity of the tissue at impact, all play a role.

In high velocity missile, the damage is due to laceration and crushing, shockwave and cavitational effect (De Math Jr. 1996). (21) Neurological defect after gunshot wound is possible even without direct injury to the cord, this is related to shockwave and cavitation effect and even paraplegia may result (Yigal Mirovsky 2005) (22)

The trajectory effect of missiles

Direction of the missiles when it enter the body plays a significant role in the damage inflicted and the mechanism of injury.

Duz et al. (2008) (23) studied the reflection of the trajectory of missile and concluded that antero- posterior and oblique trajectories leads to vital structures injuries, in the neck, abdomen, and chest, while side to side trajectory missiles, Leads to spinal cord injury and damage spinel stability so stabilization is required.

The direction of the missiles is vital as the force that transferred can differ significantly, the effect of Kinematics result in different injury pattern. (17)

Then mechanism of injury matters in the outcome of cervical spine and spinal cord injuries. Prashant C et al. (2011) (24) concluded that the Supero- inferior trajectory affects the lumbar vertebral level involved, and may lead to instability, while the lateral trajectory lead to neurological compromise.

Diagnostic imaging

In addition to blood test to evaluate the general condition of the patients, three radiograph, AP, Lateral, oblique is required to diagnose fracture and bullet or pellets location, provided that the patient general condition is stable and fit.

The dynamic radiographs (in flexion and extension) this requires the patient to be awake and neurologically stable can assess spinal stability; this is usually possible after few days of injury.

Low velocity missile usually do not cause instability (Aryan H E et al. 2005) (25). Computed tomography is the next to be performed if required, CT scan allow better location of bullet, definition of bone damage and the location of intraspinal fragment, also CT scan help in detecting spinal instability.

MRI is very useful in detecting soft tissue damage if there is no retained ferromagnetic projectile, though numerous study did not prove this fact (Finitsis et al. 1990) (26). Probably low velocity, copper- covered is not ferromagnetic (Kafadar A M et al. 2006). (27)

Intrathecal migration of projectile in the spine

Migration of missiles inside the body was recorded through the gastrointestinal, intravascular, and in the lung, this is a rare phenomenon noticed in less than 1% of cases. Migration creates odd clinical presentation and may lead to serious consequences. Chan et al. (2015) (28) published a case of bullet injury to the spine, Intrathecal migration in the lumbar region, initially there was no neurological deficit but after migration obvious neurological deficit was noticed. Migration can be cranial or caudal.

Todnem et al. (2018) (29) published another case of bullet migration intrathecally leading to obvious neurological deficit, the bullet migrate from D2 to C6 with serious consequence so it is always better to keep missile migration in mind, and to follow the patients with retained missile, for the development of a neurological deficit.

The effect of MRI why on migration of missiles

MRI is very useful and helpful in the management of many pathological processes probably in certain occasion MRI is the only helpful imaging to achieve the definitive line of treatment. In general both surgeon and radiologist are reluctant to send patients with retained metallic fragments, this is particularly true with a stainless steel because of the ferromagnetic nature fearing the movement of the retained metal and the heat locally produced by the reaction between the magnetic field and the retained missile, Some of the retained bullets or fragments of shell are not ferromagnetic, so no bad sequels after exposing the patient to MRI, on the contrary some are very ferromagnetic such as some gun pellets and the ball bearing type of missile.

Finitsis et al (1999) (26) support the use of MRI imaging for

patients with retained missiles even in the spine but serious consideration is required to identify whose patient is safe to enter the MRI field.

The magnitude of the MRI current related to many factors, local heating of the metal might theoretically lead to thermal injury in the nearby tissue. Davis et al (1981) (30) found no obvious harmful temperature increase in small metallic implant like steel and copper clips.

Most of the studies confirm that the heating effects of radiofrequency pulses on a small metallic foreign body is insignificant. Also Manner et al. (1990) (31) confirm that no evidence of thermal injury in experimental animal (rabbit). This made us to conclude that the presence of metallic rings does not contraindicate MRI examination. Therefore, MRI can safely performed on selected patients with retained metallic foreign bodies.

Treatment

Whether to offer conservative or operative treatment, it depends on the degree of damage particularly the neurological deficit, in general if there is no neurological deficit and stable spine, the treatment is conservative which is basically supportive measures.

Soft tissue damage requires wound excision, removal of foreign bodies and dead tissue, then primary or secondary closure.

Probably the best result of surgical intervention can be achieved after rapid neurological deterioration due to instability or spinal cord compression.

Laminectomy may lead to spinal instability and subsequent deformity. For complete and incomplete neurological deficit in the cervical and dorsal spinal regions, is of little if no benefits, moreover may lead to higher complication rate than conservative treatment, better result of laminectomy and bullet removal betweenT12-L5 (Bono et al. 2004). (32)

The main determinant of recovery is the initial neurological status rather than surgery (Klimo et al. 2010). (33)

In general, the outcome of penetrating missile injury is worse than RTA and stab wound. (1) Narlin et al. (2014) (34) claims marked recovery after decompression in those with persistent compression, stabilization is mandatory if there is obvious instability, the nature of gunshot, spinal injury is generally associated with stable lesion and rarely need stabilization.

Bono et al. (2004) (32) and kupcha et al. (1990) (35) the thermal injury and associated fracture of C1, may lead to instability of the cervical spine

Fracture of upper cervical spine is rare without neurological deficit (Park et al. 2012). (36) Rachel et al. (2019) (37) published a strange and rare case of cervical spine decompression due to heterotopic ossification on a retained bullet 20 years after shooting, who respond very well to decompression.

Surgery is considered as a real indication when there is CSF fistula, neurological deficit with compression or instability, risk of migration of the missile, metal toxicity, in the presence of severe wound infection, persistent pain due to nerve compression, shifting position of bullet, and bullet in lumber canal causing cauda equina (Gede et al. 2018). (38) Otherwise, there is no reason to perform surgical interference Waters and Adkins (1991) (39) confirmed no significant difference between those who had bullet removal and those with retained bullet in the spinal cord and they did not recommend surgical decompression.

Maarouf et al (1995) (1) agreed with previous publication for the complete and incomplete neurological deficit, both shows no significant advantage of performing laminectomy after penetrating spinal injury to the cord, those with complete neurological deficit had poor prognosis whether with or without surgery and those with incomplete may show recovery even without surgery.

James et al. (1975) (16) support the idea that recovery in the incomplete injury is related to initial damage more than surgical or non-surgical and those with complete lesion did not show any recovery whether treatment was offered, also cord lesion at laminectomy did not reflect or give a clue about future recovery.

Narlin et al. (2014) (34) confirmed marked recovery of neurological deficit after decompression and internal fixation and no complications related to retained bullets and in 30% of their patients, stabilization was necessary. kupcha et al. (35) were against the beneficial effect of surgical decompression for both partial and complete neural tissue lesion, and neural recovery is not affected by retained missile, also no record of instability or death

Aarabi et al (40) concluded that surgical exploration does not contribute to satisfactory outcome, in addition to more complications and patients with cauda equina had better chance of recovery.

Although instability is rare after missile injury of the spine, still a search for the instability required particularly if there is neurological deficit. Plain x ray and CAT spine better done as a routine for all patients, instability is more expected with high velocity and with lateral trajectory, instability is expected if both facet joints damaged or both pedicles damaged in the same level, the heat of the projectile may lead to damage of the supporting ligaments. Severely comminuted fracture with anterior and posterior element damage with evidence of segmental deformity can be indicative of instability (P klimo et al. 2010) (33). Laminectomy may lead to instability (P Klimo et al 2010) (33) in the presence of anterior or middle column injury.

Instability in adolescence was not recorded after 1-year follow-up following low velocity missile injury, but nonfunctional improvement was recorded although no surgical intervention was required (Henry et al. 2005). (25) On the contrary Narlin et al (2014) (34) record confirm that 30% had instability and fixation was performed.

Thomas Lustenberger et al. (2011) (41) after analyzing 1069 patients confirm that the incidence of cervical spine injury after penetrating trauma to the neck is very low as 0.4%. Unstable cervical spine noted in less than 1%, all of them experienced extensive neurological damage and altered mental status, surgical stabilization of the spinal fracture performed to only two patients (0.2%) with no neurological recovery.

Alexis et al. (2020) (19) confirm that the indication for surgery

is narrow and only done after managing the associated serious injury in poly trauma patients that complicates the management.
Removal of intraspinal bullet is still controversial; almost no published articles supported removal. Velmahos et al (1994) (42) after studying 153 patients with missile injuries of the spine, they believe that in gunshot wounds of the spine, the presence of retained bullet do not increase the septic complications. On the contrary, Se-II Jeon (43) report chronic fistula from a long-term bullet in the vertebral body of L4 for 30 years, fistula treated by removing retained metallic fragment.
Despite the writing about bullet removal the authors feels that's better to remove the retained missile whenever possible, preferable at the time of the initial surgery to guard against delayed infection, and another complications like migration and the formation of fibrosis and adhesion, changing the direction of the retained bullet indicates collection surrounding the bullet and the risk of migration.
Infection always expected whether early or late because it is potentially dirty wound particularly with high velocity missile, and the best treatment is generous wound excision as soon as possible with broad-spectrum antibiotic for period of 7- 14 days, the duration depends on the severity of the infection.

How useful is corticosteroids for missile induced spinal injury?

One of the major controversial boy in the treatment of missile Injuries of the spine is the value of corticosteroids in the management of this injury, some advocate, some are neutral while others are totally against its use, they feel that it is useless and dangerous. The Pendulum is pointing to not using any form of steroids.
Roberts et al (1997) (44) mentioned that the second national acute spinal cord injury study confirm steroids to be a useful drug in improving the neurological deficit, but they did not advocate using steroids and more confer required. They mentioned that dexamethasone significantly increases gastrointestinal bleeding while pancreatitis was noticed more with the methylprednisolone group, moreover no neurological benefits was detected after the administration of intravenous steroids.
Bono C M et al. (2004) (32) support the idea that steroid has not improved the recovery of a neurological deficit and may lead to complications while Gregory et al. (2014) (45) were supportive of using steroids in acute spinal injury and they mentioned that number of surgeons giving high dose steroids for acute spinal injury.
Yigal et al. (2005) (22) administer steroids to all patients in their study group and concluded that the effect of steroids is not clear because steroids failed to improve patients with neurological deficit in their case series
Levy et al (1996) (46) and Roberts et al (1997) (44), both were against giving any form of steroids because it did not significantly improve the neurological recovery in patients with partial or complete neurological deficit following penetrating wounds of the spine, so the supporters of giving steroids are much less than the non supporters. Personally, we gave steroid (methylprednisolone acetate) and we noticed some benefits on basis of making use of the benefit of the doubt.

Complications

Probably pain is one of the commonest complication recorded Aarabi et al. (1996) (40) more obvious after injury to lumbar or cauda equina lesion.
Bullets removed did not relieve the pain due to depression; some antidepressant may be required particularly in the presence of paraplegia and worse with quadriplegia.
Infection is very much expected after the dirty missile wounds, hence the importance of giving broad-spectrum antibiotics if possible at the scene.
Neurogenic bladder and urinary tract infection is also possible (Sidhu et al. 2013) (47), Meningitis, bone infection, Charcot arthropathy and deformity are all possible. Lead intoxication (plumbism) is a late and very rare complication, we have seen only one case within thousands of war wounded (Grogan et al. 1981). (48)
Other minor and transient complications are also possible, the last rare but possible complication is the migration of the missile, which might be silent, and we have seen one case only within 40 years of experience.

Conclusion

Gunshot injury to the spine is becoming more and more prevalent in both military and civilian practice, clinical evaluation is very vital to assess the degree of neurological deficit, both plain X-ray and CAT scan are very useful, MRI is of limited value.
Probably the absolute indication for surgery is the progressive neurological deficit still there is wide controversial about removing a retained projectile, a cover of antibiotic is mandatory also, a careful search for the instability is mandatory. Steroids use in spinal missile injuries is controversial.

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