EANS/UEMS European examination in neurosurgery

Variants of questions with answers (compilation - Vyacheslav S. Botev, Department of Neurosurgery, M.Gorky Donetsk National Medical University)

GUNSHOT WOUNDS (GSW)

Questions

1. Distinguish between high-velocity and low-velocity injuries.
2. Is there a difference in prognosis between high- and low-velocity injuries?
3. Why are high-velocity injuries more destructive?
4. Injury to which part of the brain carries the highest mortality?
5. What are some major determinants of injury in gunshot wounds (GSW)?
6. What is the primary factor that determines prognosis in low-velocity injuries?
7. What is the initial management for a protruding object in the head such as knife or arrow?
8. What are criteria for removal of intracranial fragment?
9. What is Matson's classification?
10. What are the military levels of care for gunshot wounds?
11. What is the most important prognostic factor for gunshot wounds?
12. What is classification of gunshot injuries in the spine?
13. What is the distinguishing feature between spinal shock and neurogenic shock?
14. What is keyhole fracture in gunshot wounds?
15. What is concentric heaving fracture in gunshot wounds?
16. What is typical gunshot wound exit size?
17. What is common imaging checklist for gunshot injuries to the head?
18. What are two types of cavitation in penetrating injury?
19. How large is the cavitation area that results from a medium-energy object?
20. How large is the cavitation area that results from a high-energy object?
21. What produces a temporary cavity?
22. What produces a permanent cavity?
23. What is the evolution of neurosurgical approach to wartime penetrating brain injury?
24. What are common vectors of penetrating TBI?
25. Does spinal decompression improve neurologic recovery after gunshot wound to the spine?

26. Do spine fractures from gunshot wounds require surgical stabilization?

27. Is surgical debridement warranted after transcolonic gunshot wounds to the spine?

28. Should bullets be removed from the spine to prevent lead toxicity?

29. Do all cerebrospinal fluid leaks after gunshot wounds to the spine require repair?

MCQs

1. Which of the following statements regarding wound ballistics is TRUE?

A. A bullet’s caliber is an indicator of wound potential.
B. Lead bullets in soft tissue should be removed because of the risk of lead poisoning.
C. Newer generation BB gun shots are not harmful.
D. Radiographic localization of a bullet requires two views at 90 degrees.
E. The emergency physician should describe wounds as entrance and exit wounds in the medical record.

2. Regarding ballistics, which of the following is true?
A. Secondary missiles are bone and metal fragments created from the impact of the projectile on the skull.
B. Higher-velocity projectiles have less cavitation effect than bigger projectiles with less velocity.
C. The projectile creates a temporary track of injury.
D. Primary injury to the brain is determined by the ballistic properties: kinetic energy, mass, and velocity, but not shape of the projectile.

3. Management of survivable penetrating brain injury should include:
A. Removal of all bullet fragments because of the risk of infection
B. Withholding antibiotics until a brain abscess has developed and the bacterium cultured
C. Aggressive management of CSF leaks because they have a high risk of leading to infections
D. Bilateral decompressive hemicraniectomy in all patients with bihemispheric lesions because they have a specially poor prognosis

4. True or False. Regarding gunshot wounds (GSWs):

A. GSWs represent 35% of all deaths from brain injury in the older population (> 45).
false (GSWs represent 35% of deaths by head injury in the population aged < 45.)
B. GSWs are the most lethal type of head injury; one fourth die at the scene.
false (It is lethal and two thirds of patients die at the scene.)
C. 90% of victims die.

true (Ultimately 90% of patients will die directly or from complications related to GSW regardless of their expression of APO E4 allele.)
D. Poor outcome in GSWs is related to APO E4 allele.
false (APO E4 allele relates well to the poor closed head injury outcome and Alzheimer disease but not to GSW.)

5. For GSWs to the head the mechanisms of injury include
A. c________ cavitation, coup-contrecoup
B. g________ gas
C. s________ shock waves
D. l________ low pressure
E. i________ impact
F. e________ explosive
G. r________ ricochet

6. Complete the following:
A. Higher impact velocity is correlated with ICP that is ________. higher
B. The size of the entrance wound is ________ compared with the exit wound. smaller
C. Edges of entrance wound show a beveled ________ table. inner
D. Edges of exit wound show a beveled ________ table. outer

7. Angiography in penetrating injury to the brain should be considered if there is
A. a trajectory near major ________ or arteries
B. ________ and sinuses
C. a large ________. hematomas

8. Complete the following:
A. What is the most important prognostic factor after a gunshot wound to the head (GSWH)? level of consciousness on admission
B. What is the mortality/morbidity in GSWH if the patient is unconscious?
94% of patients comatose on admission die; 3% are severely disabled
C. The prognosis is worse if the path of the bullet
i. c________ the m________ crosses the midline
ii. passes through the g________ c________ geographic center of the brain
iii. t________ the v________ traverses the ventricle
iv. passes through m_______ l_______ multiple lobes

Non-missile penetrating trauma

9. Complete the following:
A. Because of low velocity only l________ d________ is needed. local debridement
B. These are more or less contaminated than gunshot wounds? more
C. Prophylactic antibiotics are or are not advised? are
D.
i. Would you consider an angiogram? yes
ii. If so why? To rule out a t________ a________ traumatic aneurysm

Answers

1. High velocity: bullets; Low velocity: arrows and knives.
2. Yes: high-velocity projectiles carry a very high mortality.
3. Kinetic energy of the projectile destroys surrounding tissues.
4. Basal ganglia, brainstem, and posterior fossa.
5. Mass of projectile; Muzzle velocity; Location and trajectory of projectile.
6. Location of the brain injury.
7. Leave it alone! The risk of hemorrhage mandates removal in the OR.
8. Criteria for removal of intracranial fragment:

- Movement of fragment
- Abscess formation
- Vessel compression or contact
- Porous material in contact with cerebrospinal fluid (i.e., rock, wood)

9. Matson's classification:

Grade	Matson description
I	Scalp wound
II	Skull fracture, dura intact
III	Skull fracture with dural/brain penetration (a) Gutter-type (grazing) – in-driven bone with no missile fragments (b) Penetrating – missile fragments in brain (c) Perforating – through and through
IV	Complicating factors: (a) Ventricular penetration (b) Fractures of orbit or sinus (c) Injury of dural sinus

10.

1. Casualty evacuation (CASEVAC) is transport from battlefield to military medical facility;

2. Medical evacuation (MEDEVAC) is rotary-wing patient movement between medical facilities;

3. Aeromedical evacuation (AEROVAC) is fixed-wing patient movement between medical facilities;

4. Tactical refers to in-theater missions; and

5. Strategic refers to intertheater missions.

11.

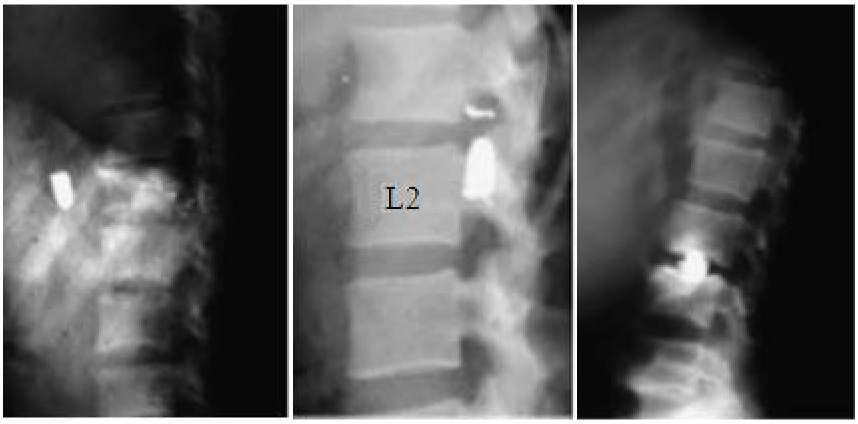
1. Level of consciousness is the most important prognostic factor: 94% of patients who are comatose on admission die, and 3% are severely disabled.
2. The path of the bullet is also an important prognosticator. Especially poor prognosis is associated with:

A. Bullets that cross the midline.
B. Bullets that pass through the geographic center of the brain.
C. Bullets that enter or traverse the ventricles.
D. The more lobes traversed by the bullet.

3. Hematomas seen on CT are poor prognostic findings.
4. Suicide attempts are more likely to be fatal.

12. The spinal injuries caused by GSW may be classified as type I: transfixing (when small fragments are found inside the canal); type II: intracanal (when the whole projectile is inside the canal); or type III: intervertebral lesions (when the bullet is inside the intervertebral disc space).

Type III injuries are subdivided into (A) spinal lesion not associated with perforation of abdominal viscera or (B) injury with perforation of abdominal organs. In most cases of GSW, the injury is transfixing, and only little fragments (altogether <50% of the projectile) remain in the spinal canal. In the second place come cases in which the projectile is lodged inside the canal, comprising 20.4% of cases.



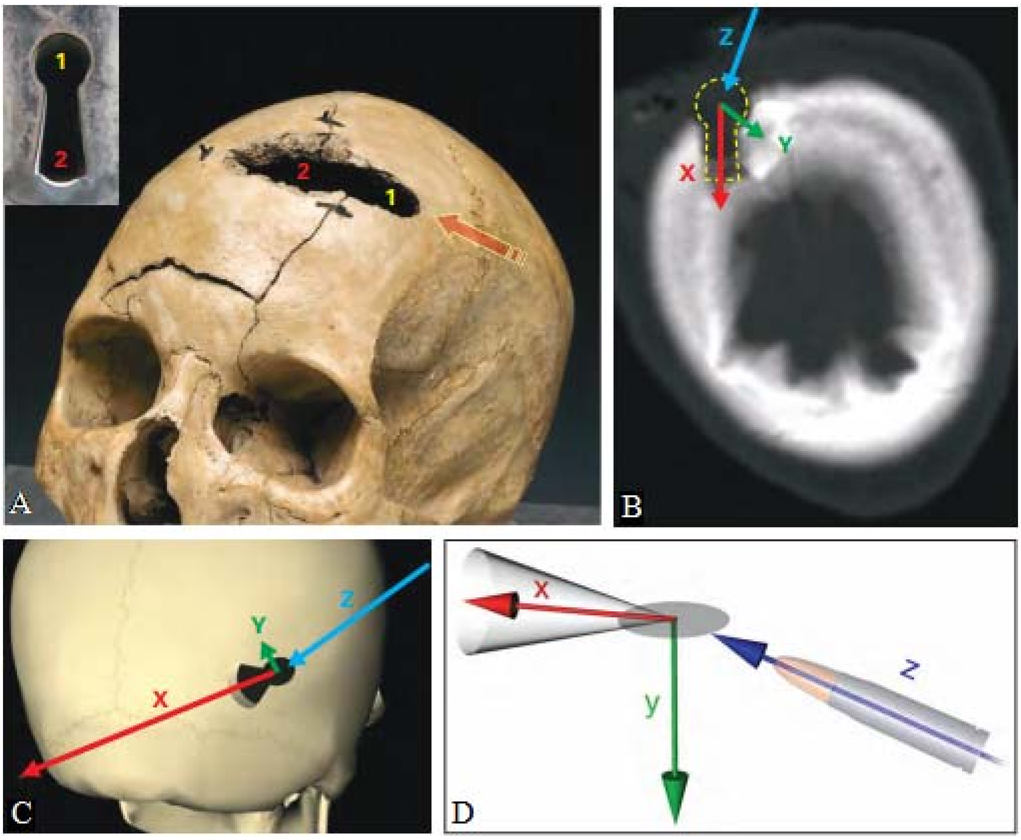
Radiographs showing different types of gunshot wounds in the spine: type I (left), type II (center) and type III (right).

13. Spinal shock versus neurogenic shock

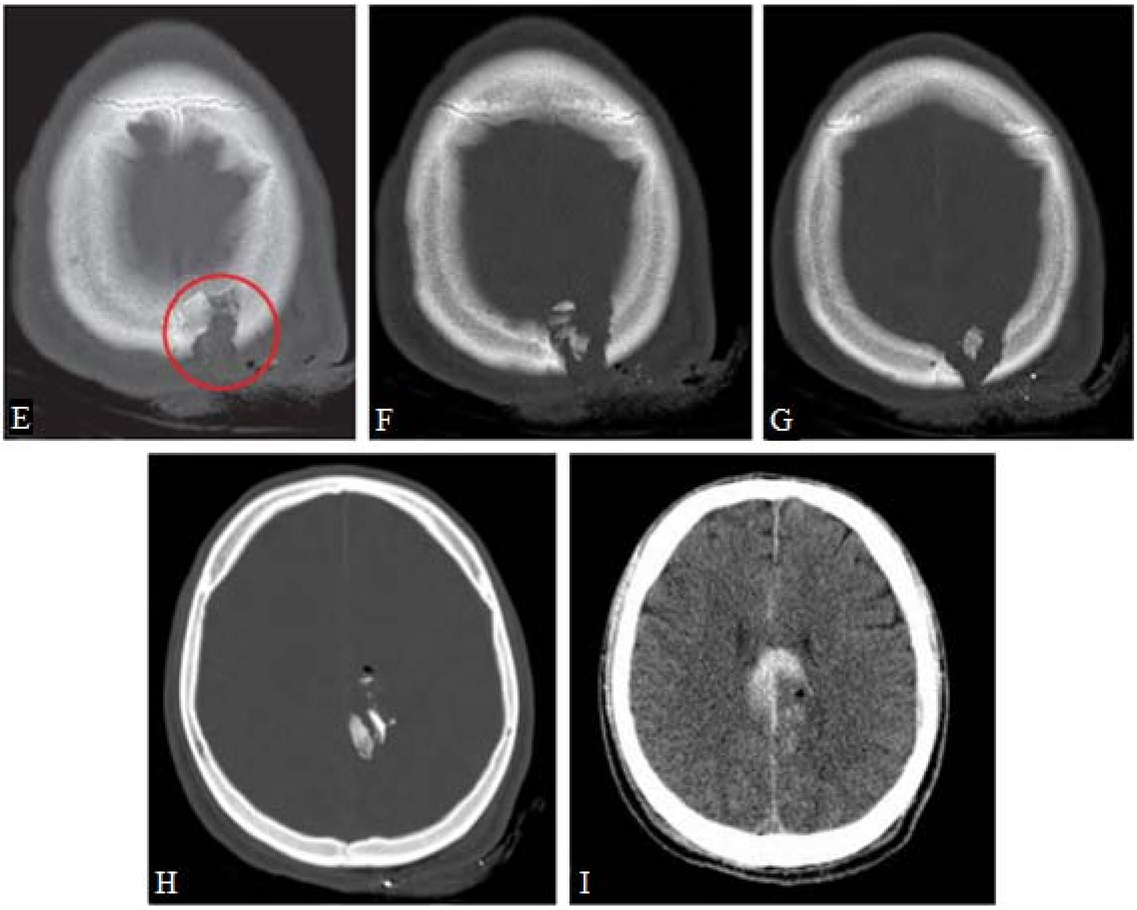
This is a favorite board exam question, but it is surprising how many physician continue to confuse or misunderstand these concepts. Neurogenic shock is the hemodynamic consequence of the spinal cord injury, classically characterized by bradycardia and hypotension. Cervical spine and high thoracic spine injuries are the usual culprits due to loss of sympathetic cardiac stimulation (bradycardia) and vasomotor tone in the lower body (hypotension). This is one situation in trauma where immediate pressor ase is warranted, and the mean arterial pressure should be restored as soon as possible.

Spinal shock is the complete loss of reflexes below the level of injury, including the monosynaptic pathways. If spinal shock is present, this means that you don't yet know what the ultimate amount of recovery of function will be. You will have to lait until the spinal shock period is over. If spinal shock is not present, or it has resolved, then whatever neurologic deficits you have at that time are likely to be permanent.
So for someone with paralysis, being in spinal shock is actually preferable since it leaves hope for some recovery of function. To diagnose spinal shock check the bulbocavernosus and/or cremasteric reflexes. If they are absent, then the patient is in spinal shock, and when they return the shock period has ended.

14. Gunshot wound fracture pattern. Keyhole fracture:



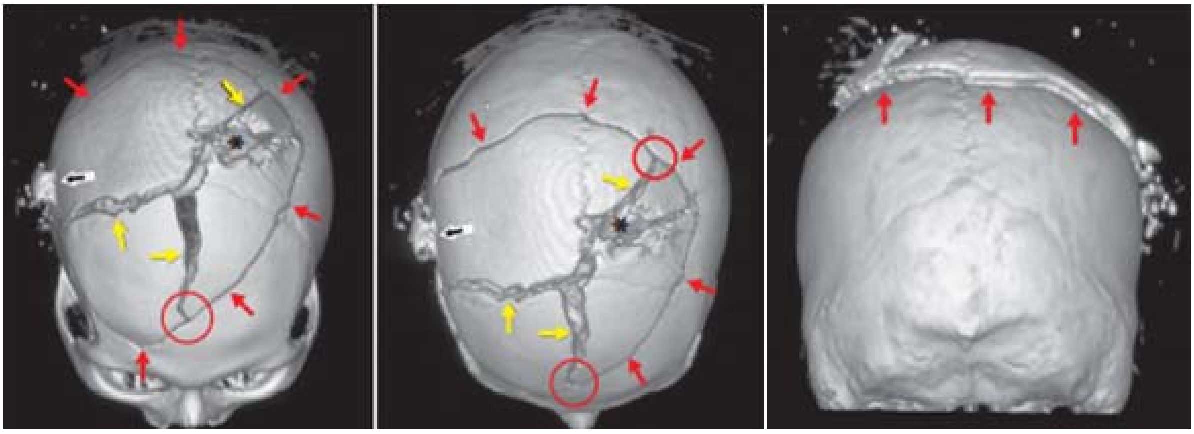
A. Photograph of a skull showing the characteristic combination of both entry and exit features at the site of impact. Note the sharp margin at the entry site (*1*) and irregular beveling of the outer table of the skull at the distal end of the wound (*2*). Both the size of the exit hole and the size of the sloped bevel are larger at the exit site than at the entry site. Photograph of a typical door keyhole symbolizing the circular entrance defect and a triangular exit defect. B. CT example of a keyhole fracture with the trajectory forces outlined. C. Drawing of the keyhole mechanism in the skull. Note that the projectile does *not* enter the skull, but the force of the tangential impact causes significant intracranial injury. D. Mechanism of the keyhole fracture. Note that the projectile impacts the skull tangentially (*Z*), but the projectile itself does not enter the brain. The impact with the skull does, however, displace bone fragments perpendicularly into the brain (*Y*). As the projectile continues its course, it grazes the surface of the skull and causes beveling of the outer table of the skull (*X*).



E–H. Contiguous axial images viewed with bone windowing shows inward displacement of bone fragments. Note the upside-down keyhole fracture shape illustrated in (E) (*circle*). I. Brain windowing shows intracranial hemorrhage extending to the depth of the corpus callosum.

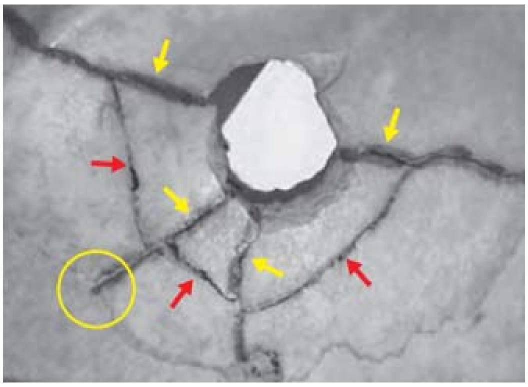
KEY POINT The keyhole fracture, sometimes referred to as a gutter fracture, occurs when the projectile strikes the surface of the skull in a tangential manner. The shearing force of the volume-restricted cavitating energy, coupled with bone fragments serving as secondary missiles, makes brain injuries subsequent to keyhole fractures often devastating and in excess of what is erroneously predicted from visualization of the entrance wound.

15. Gunshot wound fracture pattern. Concentric heaving fracture:



Concentric heaving fracture. Three dimensional reformatted CT images in a patient statuspost a lethal GSW to the head. The entry site is located at the left parietal convexity (*asterisk*). The exit site is located at the right inferior parietal calvarium (*black arrow*). Note the large concentric heaving fracture in which the cranial vault appears lifted off the top of the head (*red arrows*). There are several radiating fractures (*yellow arrows*) originating from the entry site. Unlike skull fractures caused by blunt (i.e., closed) head trauma, fractures caused by GSWs may occasionally cross suture lines. In this example, the concentric heaving fracture crosses the sagittal and coronal sutures. Note that this case is atypical in that the formation of the concentric fracture must have preceded the formation of the radial fractures, as evidenced by the fact that the radial fractures stop where they intersect the concentric fracture (*circles*). This may be due to the relative delay in formation of the radial fractures when they traverse or merge with calvarial sutures.

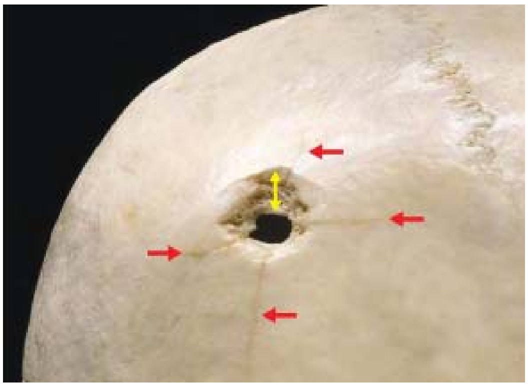
KEY POINT In most cases, fractures do not cross fracture lines and do not cross sutures. The pattern of intersecting fracture lines is thereby used in forensics to assess the sequence and direction of fire in multiple GSWs to the head.



Autopsy specimen illustrates the characteristic concentric heaving fracture lines (*red arrows*) around an exit wound. Note how the concentric heaving fractures develop perpendicular to the radiating fractures (*yellow lines*). Note also how they abruptly terminale at their intersection with the radiating fractures. One of the radiating fractures terminates at a suture line (*circle*).

KEY POINT The concentric heaving fracture is produced indirectly by the sudden massive increase in ICP, whereas the radial fracture lines are caused directly by impact of the projectile. Radial fractures may occur alone, but concentric heaving fractures are never seen without radial fractures.

16. Typical gunshot wound exit size:



This autopsy specimen demonstrates the characteristic crater defect found at the exit site of a perforating GSW. This appearance is due to beveling of the outer table of the skull, which always occurs at the exit site of a GSW (*yellow arrow*). Multiple linear fractures are seen radiating away from the wound defect (*red arrows*).

17. Imaging checklist for gunshot injuries to the head:

What is the location of the missile fragment(s)? Use the CT scout view.
Is it a superficial, penetrating, or perforating injury?
If perforating, what are the locations of the entry and exit sites?
Is the projectile intact or fragmented?
Are there retained fragments (bone, bullet, glass, other)?
Is the injury unihemispheric or bihemispheric? Multilobar? Transventricular?
Does the missile tract traverse the paranasal sinuses and/or mastoid air cells?
Describe the trajectory of the bullet in three dimensions (i.e., is the path anterior or posterior, left or right, and superior or inferior?); the scout view can be helpful.
Does the bullet path have a ricochet component?
Are the basal cisterns preserved effaced? Is there midline shift?
Is there hemorrhage remote from the primary injury?
Is there a fracture remote from the primary entry and exit sites (e.g., orbital roof)?

Describe the skull fracture(s): linear, comminuted, depressed, keyhole, or heaving?

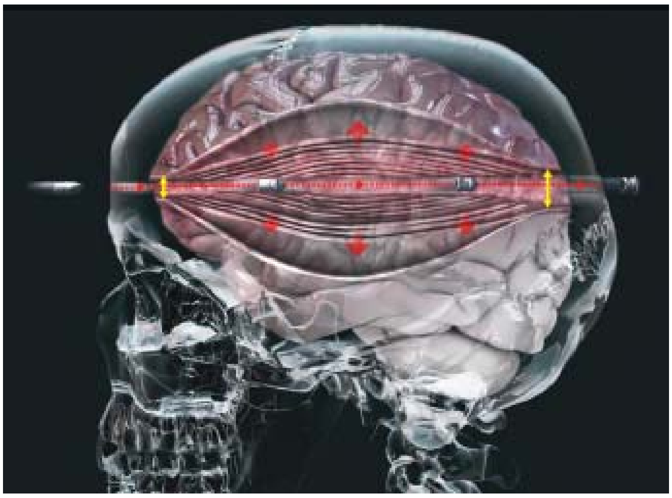
Does the fracture traverse the carotid canal or a dural venous sinus?

Is CTA or catheter angiography indicated?

On follow-up imaging, is there a change in position of bone and/or ballistic fragments?

On follow-up imaging, is there new intracranial hemorrhage or enhancement to suggest interval development of a traumatic pseudoaneurysm?

18. Temporary cavities and permanent cavities.



Idealized behavior of a bullet through the brain.

As the bullet moves through the brain, it crushes and shreds tissue in its path, forming the so-called permanent cavity. At the same time, it transiently displaces outward the surrounding tissue from its path, forming the temporary cavity. In reality, the temporary cavitation is more asymmetric, spreading out in different tissue planes. The size of the final wound track is a combination of these two mechanisms. The energy loss along the wound track is not uniform, and the entry site is always smaller than the exit site (*yellow arrows*). This is partially due to deformation, expansion, and yaw of the projectile as it traverses the tissue. Also note that the temporary cavity is always larger than the permanent cavity. This is particularly the case in high-velocity injuries. As the wound cavity expands within the tissue, a negative pressure gradient arises, and there is aspiration of foreign material into the cavity. In this way, contaminated dead tissue comes to line the final wound tract.

19. It is 6 to 10 times the frontal area of a bullet.

20. It is 20 to 30 times the frontal area of a bullet.

21. Stretching.

22. Compression and decompression.

23. Evolution of neurosurgical approach to wartime penetrating brain injury.

The current treatment of penetrating brain injury in miliary conflict has evolved from the principles established at the end of World War I (WWI) by Dr. Harvey Cushing. Since that time, the strategy of radical debridement utilized in World Wars I and II, the Korean War, the Vietnam War, and the Iran–Iraq War has been followed by an approach of conservative debridement during the Israeli-Lebanon conflict of the 1980s. During Operation Iraqi Freedom (OIF), a method of early radical decompression through the use of hemicraniectomy with conservative debridement and duraplasty has been applied to blastinduced penetrating brain injuries. Although a normal analysis of all casualties is not complete, the immediate impression is that early decompression results in increase survivability and neurological improvement. Ultimately, long-term follow-up will be necessary to determine if early decompression actually improves functional outcome.

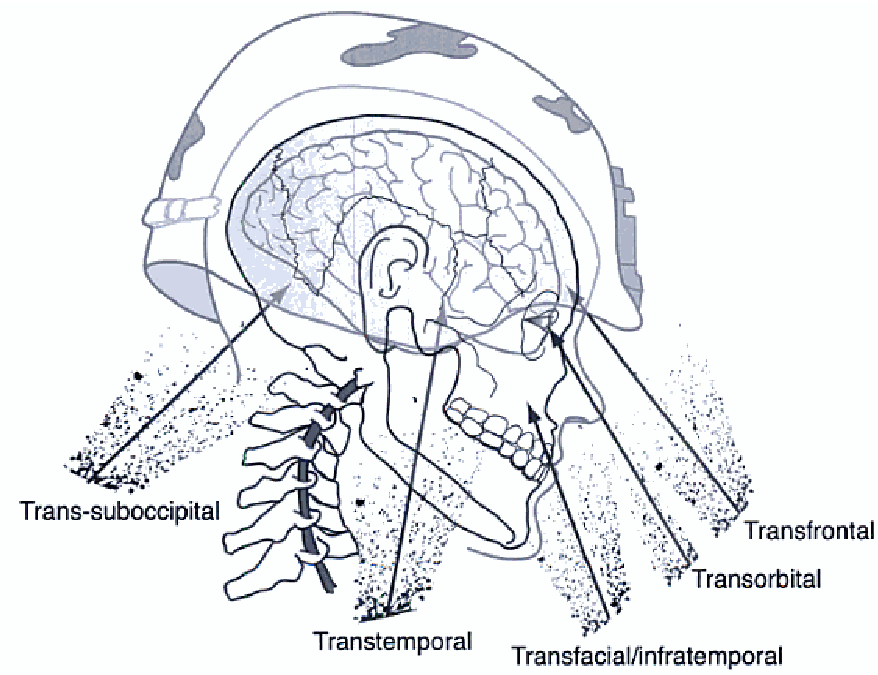
Evolution of neurosurgical approach to wartime penetrating brain injury.

The multitude of head injuries associated with trench warfare in WWI challenged early neurosurgeons unlike any prior civil-military conflict. The field of neurosurgery was in its infancy and was unprepared for the complexities of these injuries. Cushing's observations and reports were instrumental during this time in establishing guidelines for treatments. He noted that decreased infection rates limited the major cause of mortality at the time.

However, due to the lack of axial imaging and delays in the evacuation process, few operations were actually performed for immediate "life-saving" interventions. Despite these obstacles, Dr. Cushing developed a process of radical debridement of the scalp and skull and irrigation of the track with a catheter, attempting to remove all foreign bodies. This was then followed by a watertight scale closure without drains. The application of these techniques in a

well-equipped center, usually remote from the front, was preferable in his mind to the "frontline" surgery that risked overwhelming infectious morbidity. His classification of penetrating injuries provided the foundation for the concept of limiting secondary injury and promoting eventual reconstruction.
These concepts evolved with improved training and technology during WWII. In a summary of procedures from WWII, Dr. Donald Matson clearly outlined the purpose of far-forward neurosurgery. The tenets of those lessons still hold true in today's interventions and are summarized as follows: (1) the immediate saving of life (hematoma evacuation, brain stem decompression), (2) the prevention of infection, (3) the preservation of the nervous function, and (4) the restoration of anatomic structure. He also attributed the success of medical care in WWII to forward neurosurgical care with specialized equipment, rapid evacuation of casualties to these hospitals permitting early surgery, availability of blood in larger amounts in the forward area, and the universal application of antibiotics.

24. The majority of military penetrating TBI occurs from penetrating fragment injuries and not from fired bullets. Historically, penetrating fragment-related TBI had a significantly lower overall mortality than military gunshot wound TBI. In the past, the clinical management of penetrating TBI involved complete neurosurgical removal and debridement of wounds, to include retrieval of any bone and metal fragments in the brain. This approach was subsequently altered following a detailed analysis of the Israeli-Lebanese conflict. This study confirmed that aggressive surgical debridement was unnecessary and may have worsened outcomes.



Common vectors of penetrating TBI

25. Does spinal decompression improve neurologic recovery after gunshot wound to the spine?
Brief answer

The role of surgery in the management of a gunshot wound to the spine (GSWS) is limited. In general, surgical decompression does not improve neurologic recovery after spinal cord injury (SCI) from a GSWS, but evidence suggests better motor recovery with operative decompression than with Nonoperative treatment of gunshot wounds of the lumbar spine when the bullet is lodged in the spinal canal. At all levels, a progressive neurologic deficit associated with an intracanalicular bullet, bony fragment, or expanding hematoma is an indication for urgent surgical intervention. Surgery is rarely required for stabilization of fractures from gunshot wounds because the majority are stable injuries. If clinical suspicion warrants, dynamic flexion–extension views can be used to assess mechanical instability, which may require instrumentation and fusion. Surgical debridement is not indicated after transcolonic GSWSs because the lowest infection rates have been documented with 7 to 14 days of antibiotics without operative intervention. For persistent cutaneous cerebrospinal fluid (CSF) leak through bullet entry or exit sites, surgery should be considered to reduce the risk of meningitis.

Background
GSWSs often result in SCI. More than half of these cases result in paraplegia or tetraplegia. Compared with blunt trauma, gunshot injuries to the spine are more likely to produce complete injuries and are usually associated with stable fracture patterns that do not require surgical stabilization.

Controversy
Although the beneficial effect of neural decompression for canal compromise after blunt spinal trauma is becoming increasingly accepted, the effectiveness of decompression after gunshot wounds is less clear. Both class II (prospective, nonrandomized) and class III (retrospective) evidence suggests that surgical decompression of cervical and thoracic gunshot wounds has no beneficial effect on the likelihood of neurologic recovery. However, class II evidence supports operative decompression for gunshot wounds at the T12 to L4 levels when a bullet remains in the spinal canal. No class I studies have investigated the surgical treatment of gunshot wounds to the spine.

Pearl

Surgical decompression of intracanalicular bullets between T12 and L4 has been reported to produce statistically significant motor improvement.

Recommendations

For low-energy civilian GSWSs to the spine, most authors agree that surgical decompression of the cervical and thoracic spinal canal has little utility. Substantial rates of postoperative complications with no demonstrable improvement in neurologic outcome lead to the general conclusion that surgery is not indicated in these regions. However, in the specific situation in which a neurologic deficit is associated with an intracanalicular bullet at the conus medullaris or cauda equina level, surgical decompression may be beneficial.

26. Do spine fractures from gunshot wounds require surgical stabilization?

Background

In the terminology of the three-column spine model of Denis, disruption of two or more columns of the spine may indicate spinal instability. In contrast to blunt trauma, two- or even three-column disruption from a GSWS is less likely to result in instability. In Denis's original work, the proposed mechanisms of injury implied an abrupt acceleration/deceleration of the body/spine in space. In the case of gunshot wounds, the body/spine can be considered stationary, and the bullet is the directional force. In the best-case scenario, a through-and-through bullet wound will only damage those structures that lie directly in its effective path. Low-energy gunshots have a narrower circumference of damage than high-energy wounds. These factors influence the amount of spinal instability after GSWSs.

These concepts can be likened to a magician pulling a tablecloth from underneath a table that has been set with glasses and plates. The bullet acts as the tablecloth. If the tablecloth is pulled very quickly, the glasses and plates (i.e., the spinal elements) stay in place. If the table is pushed abruptly (i.e., motor vehicle accident), the contents will surely fall and break.

Controversy

Most spine fractures after gunshot wounds are stable injuries. Interestingly, most cases of spinal instability after gunshot wounds may be associated with overly aggressive decompression.

Recommendations

In general, the majority of gunshot wounds are stable injuries and do not require surgical stabilization. If stability is questionable, careful flexion and extension radiographs of the spine can demonstrate pathologic mobility of adjacent spinal segments in an awake, cooperative, neurologically intact patient. For the cervical spine, commonly used criteria for radiographic instability are angulatory change exceeding 11 degrees or translation exceeding 3.5mm between flexion and extension views. In cases of instability, the affected segments can be stabilized with a variety of instrumentation and fusion constructs, detailed discussion of which is beyond the scope of this chapter.

Surgical decompression of spinal gunshot injuries can lead to vertebral instability. Aggressive laminectomy with substantial removal of the facet joints and posterior elements can destabilize the spine. Laboratory studies suggest that instrumentation and fusion should be contemplated if total facetectomy has occurred, even if only unilateral.

Pearl

The majority of spinal gunshot wounds are stable injuries that do not require surgical stabilization. Surgical decompression of these injuries can lead to spinal instability.

27. Is surgical debridement warranted after transcolonic gunshot wounds to the spine?

Background

Viscus perforations from gunshot wounds carry a high risk of spinal infection. The highest rates of infection (up to 88%) have been reported with colonic perforations that occur prior to the bullet entering the spine, but not all authors agree with these results. It is thought that the stomach and small bowel are sterile, but spinal infection has been associated with gunshot paths that violate these organs.

Controversy

Because of high rates of infection, initial recommendations for transcolonic GSWSs called for careful observation and a low threshold for surgical debridement.

At the time of these studies, however, the role of proper antibiotic therapy was not appreciated. Subsequent authors examined the influence of the duration of broad-spectrum antibiotic administration on infection rates after transcolonic gunshot injuries. The lowest spinal infection rates after colonic perforation by GSWSs have been reported after antibiotics have been continued for at least several days; a reasonable average duration would seem to be at least 7 to 14 days after injury. Bullet removal and surgical debridement have been associated with higher rates of infection. Barring other indications, such as neurologic deterioration or lead toxicity, bullet extraction is not advocated as a means to decrease infection risk. As far as the authors are aware, no class I or II studies have investigated this issue.

Recommendations

The role of surgical debridement after transcolonic injury seems to be limited after low-velocity civilian GSWSs. The lowest documented infection rates have been demonstrated after approximately 7 to 14 days (at least) of broad-spectrum antibiotics. The authors prefer a nonoperative approach to gunshot wounds that pierce a hollow viscus prior to lodging in the spine. To the authors' knowledge, there are no prospective investigations comparing the effects of antibiotic prophylaxis with or without surgical debridement. Because of the substantially greater rate of infection in surgically versus nonsurgically managed patients after gunshot wounds in general, as well as the relatively low risk associated with leaving retained bullets in situ, it would be difficult to justify such a study. Nonetheless, a prospective investigation of a standardized antibiotic protocol for transabdominal gunshot wounds to the spine could be informative. Importantly, these recommendations are applicable only to low-energy injuries because high-energy wounds (AK-47, M-16, military assault weapons, etc.) may more often require surgical intervention for extensive soft tissue loss and for life-threatening systemic injuries.

Pearl

Surgical debridement of the spine has only a limited role in transcolonic injuries from low-velocity civilian gunshot wounds. The lowest infection rates have been associated with approximately 1 to 2 weeks of broad-spectrum antibiotics.

28. Should bullets be removed from the spine to prevent lead toxicity?

Background

Lead intoxication is a recognized complication that may arise from retained bullets. Among other complications, lead toxicity may cause anemia and progressive motor neuropathy. Because synovial fluid appears to be an effective solvent, bullet removal from appendicular joints has been recommended. On the other hand, lead elution from bullets bathed in CSF seems to be rare. Accordingly, bullets in close proximity to facet joints (i.e., synovial joints) may be more likely to cause lead intoxication. Of interest, plumbism has also been reported in association with a bullet lodged in an intervertebral disc.

Controversy

Lead intoxication is a rarely reported complication of spinal gunshot wounds. If it occurs, however, removal of the bullet should be considered in addition to appropriate drug therapy.

Recommendations

Because the diagnosis of lead intoxication requires a high level of suspicion, it may often be missed. Blood testing can reveal abnormally high levels. When documented lead intoxication occurs, treatment with chelating agents is initiated immediately. If pharmacologic treatment alone is insufficient, it should be followed by carefully planned bullet removal. Delaying surgery until a patient has received pharmacologic therapy for a sufficient period of time, for example, until blood levels of lead have decreased to less dangerous or even normal levels, may help prevent a sudden and potentially disastrous flush of lead into the bloodstream during operative manipulation.

For the majority of cases, however, most authors would agree that bullet removal to prevent plumbism after GSWSs is not necessary, regardless of the location of the bullet fragments. Some authors recommend removal of copper-containing bullets from the spinal canal to prevent progressive damage to neural tissue. A major clinical challenge is determining the composition of the bullet, which in many instances is not known preoperatively.

29. Do all cerebrospinal fluid leaks after gunshot wounds to the spine require repair?

Background

CSF leak may occur after GSWS. Persistence of a leak can predispose to meningitis or to formation of a cutaneous CSF fistula. Accurate diagnosis of a CSF leak is crucial to making treatment decisions. CSF must be differentiated from other sources of clear wound drainage. Assay of a sample of the collected fluid for β_2-transferrin has been recommended because β_2 -transferrin immunofixation is a very specific test for confirming the presence of CSF.

Controversy

Surgical intervention to repair dural injuries resulting in CSF leaks after GSWSs may seem intuitively appealing. Other clinicians, however, might consider more conservative management, such as the placement of a subarachnoid drain, as a first course of treatment, reserving open dural repair for refractory cases.

Recommendations

In the initial treatment of gunshot wound patients, the bullet entry site should be treated with debridement of any devitalized skin and superficial soft tissues. If a CSF leak appears to be present, a lumbar subarachnoid drain should be placed. When a persistent CSF leak is present through the bullet entry or exit sites at the level of the skin, open surgery should be considered. Because of the risk of meningitis from a persistent CSF leak, the treatment would involve a laminectomy with repair of the dural violation either primarily or by use of a dural graft. In these relatively rare instances, placement of a temporary lumbar subarachnoid drain after the laminectomy may help protect the dural repair.

Pearl

A lumbar subarachnoid drain should be considered as the first option for treating a CSF leak after a GSWS. Persistent CSF leakage through bullet entry or exit sites may require open surgery.

For cranial gunshot wounds, no study has reported a functional outcome in patients of any age in whom a bullet has penetrated the brainstem or basal ganglia. In a meta-analysis of the effects of bullet traversal of the midsagittal plane, Polin et al 6 reviewed the results of six series (totaling 343 patients) and noted that the mortality rate was 87% if the bullet track crossed the mid-sagittal plane, i.e., was bihemispheric.

MCQs answers

1. D. Radiographic location of a bullet requires two views at 90 degrees or a tomographic image.

A bullet's mass, structure, and striking velocity are indicators of wound potential. The caliber of a bullet does not predict wound potential. Emergency physicians should be aware that newer generation BB guns and air guns fire small bullets with high muzzle velocity, which can cause significant injury or be fatal. Lead bullets in soft tissue usually become encapsulated and do not cause leadpoisoning.Lead bullets in synovial fluid, intra-articular space, and disc space should be removed because of the risk of leadpoisoning. In the medical record, emergency physicians should avoid describing the wound as an entrance or exit wound but should describe the shape, location, and size of the gunshot wound including any evidence of soot powder or subcutaneous tissue tattooing with gunpowder.

2. A. Secondary missiles are bone and metal fragments created from the impact of the projectile on the skull.

3. C. Aggressive management of CSF leaks because they have a high risk of leading to infections

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