

CASE REPORT

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Meningitis Following Gunshot Wound of the Neck

ABSTRACT: It is generally assumed that a missile fired from a gun is subjected to sufficient heat to render it sterilized (1,2). For this reason, retained bullets are not usually considered a source of infection. The infectious complications associated with gunshot wounds are typically attributed to perforation of a hollow viscus with leakage of gastrointestinal contents causing peritonitis or intra-abdominal abscess. There are several reports of bacterial meningitis involving the spinal cord in gunshot wounds that perforate the intestine prior to involving the thoracic or lumbar vertebral column (3–6); however, there are no published reports of cerebral meningitis resulting from a retained projectile in the spinal canal in which there was no injury to the gastrointestinal tract. This manuscript describes a woman who died as a result of unsuspected acute bacterial meningitis which developed secondary to a gunshot wound of the neck. The projectile fractured the first thoracic vertebra, lacerated the dura and contused the spinal cord at the C7-T1 junction. Meningitis developed at the C7-T1 level and ascended along the cervical spinal cord to the brain. The infection caused acute neurologic deterioration and death four days following the initial injury.

KEYWORDS: forensic science, gunshot wounds, meningitis, infection, spinal cord, brain death

Case Report

A 36-year-old black female was the victim of an apparent attempted murder-suicide. The suspect was pronounced dead at the scene and the victim was transferred to a local level I trauma center. Upon arrival at the emergency department, she was found to have a single gunshot wound to the left side of the neck at the top of the shoulder. Upon admission she was alert, somewhat confused and had a Glasgow coma score of 14; however, she was hypotensive secondary to neurogenic shock. She was unable to move her lower extremities and physical examination demonstrated sensory and motor deficits below the level of the first thoracic vertebra. A computerized tomogram of the head and neck demonstrated a fracture of the first thoracic vertebra and projectile fragments impinging into the spinal canal at the C7-T1 level. Magnetic resonance imaging demonstrated a spinal cord contusion with edema extending superiorly up to the level of C5. Over the next 48 h, the patient remained stable, however, there was no improvement in the paraplegia. On the third day after admission, the patient developed acute mental status changes, respiratory distress and bradycardia. She rapidly became unconscious and was subsequently pronounced brain dead the following day. The etiology of the acute neurologic deterioration and the cause of her death were unknown. The case was referred to the medical examiner department for autopsy.

The autopsy demonstrated acute bacterial meningitis characterized by a thick, tan-yellow, purulent exudate covering the cervical

spinal cord, cerebellar hemispheres and brainstem. Postmortem cultures of the exudate isolated *Staphylococcus aureus*. The brain had evidence of anoxic/ischemic encephalopathy characterized by diffuse brain swelling and parenchymal softening. The cerebellar tonsils were hemiated and necrotic. Two markedly distorted bullet fragments were recovered from the spinal canal adjacent to the spinal cord at the C7-T1 junction (Fig. 1). The projectile fractured the first thoracic vertebra, lacerated the spinal dura, and contused the spinal cord.

Discussion

Gunshot wounds are the third most common cause of traumatic spinal cord injury in the United States (5), but they are a rare cause of central nervous system (CNS) infection (6). A review of the recently published English literature found no cases of bacterial meningitis associated with a retained projectile in the spinal canal in which there was not an associated injury to the gastrointestinal tract.

The idea of bullet autosterilization upon discharge from a weapon has been conclusively disproven (5,7,8), making the previous belief that bullets cause antiseptic wounds inaccurate. Bullets should not be considered sterile for several reasons. The heat generated as a bullet is propelled from the muzzle of a gun is of insufficient intensity and duration to cause complete sterilization (1,9).

Despite being subjected to transient high heat as the gun is discharged, when the bullet courses through clothing, skin or hair, microorganisms including normal skin and hair flora are readily introduced into the wound (1,8–10).

Most reported cases of gunshot wounds associated with meningitis involve intra-abdominal wounds that perforate the colon or small intestine in addition to the vertebral column. As the bullet traverses the intestine, it becomes contaminated with intestinal bacteria which are then introduced into the spinal canal as the projectile

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perforates the vertebral column or spinal cord. It has been shown that the risk of infection is greatest with perforating gunshot wound of the colon, due to the high concentration of bacteria as compared with the stomach and small intestine (3,6). Romanick et al. reported 20 patients with gunshot wounds of the lumbar spine. Of the eight patients who sustained a colonic perforation, seven developed a spinal infection (3). Wilson described a case of a police officer who died of bacterial meningitis and cerebritis caused by *E. coli* following a gunshot wound to the colon, inferior vena cava and lumbar spinal cord (4). A study by Velmahos found that the incidence of septic complications in gunshot wounds of the lumbar spine was significantly higher than in thoracic and cervical spine injuries. This was found to be due to the higher likelihood of co-existing intestinal injuries with gunshot wounds of the lumbar spine (6).

Because infectious complications following gunshot wounds are typically associated with an injury to the gastrointestinal tract, it is highly unusual to have an infection of the cervical spinal cord unless the wound tract involves the pharynx or esophagus. However, perforation of a hollow viscus is not a prerequisite for infection because the projectile itself may have sufficient bacterial contamination to be a source of infection.

The victim in this case was found to have acute bacterial meningitis with a thick, tan-yellow, purulent exudate covering the cervical spinal cord and ascending over the cerebellar hemispheres and brain-

stem. The brain was swollen and diffusely softened with herniation of the cerebellar tonsils. Postmortem cultures of the purulent exudate were positive for *Staphylococcus aureus*. Within the spinal canal at the C7-T1 junction were two distorted bullet fragments (Fig. 1). The bullet fractured the spinous process of the first thoracic vertebra, lacerated the spinal dura, and contused the spinal cord.

The source of infection was the fragmented bullet which was subject to bacterial contamination as it perforated the skin. The bacteria were introduced to the leptomeninges as the bullet fractured the thoracic spine, lacerated the spinal dura and lodged in the spinal canal. The dural laceration was an important factor in that it was the dural defect that allowed the bacteria to contact the spinal cord meninges. As the infection developed, it ascended along the cervical spinal cord to the base of the brain where it spread along the cerebellum and brainstem.

In this case, the close time proximity between the gunshot wound and the death makes for an obvious direct cause and effect relationship between the meningitis and the retained bullet. However, because intracranial and spinal cord infections may develop as a remote complication of a gunshot wound, whenever an unsuspected case of meningitis is discovered at autopsy, the possibility of the infection arising from retained bullet fragments in the spinal canal should be considered. If the clinical history suggests a remote gunshot wound, radiographs of the chest and abdomen are warranted to rule out the possibility of a retained bullet or bullet fragments.

Conclusions drawn from this case include: (1) bullets are not sterile and should always be considered as a possible source of infection and (2) bullet fragments retained in the spinal canal may be a source of central nervous system infection. Furthermore, although perforation of the gastrointestinal tract increases the likelihood of infection, infectious complications including meningitis may arise in the absence of intestinal injury. The likely source of infection is the projectile which may be contaminated prior to entering the body or become contaminated upon perforating skin, hair or clothing.

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FIG. 1—Radiograph of the head and neck showing projectile fragments lodged at the C7-T1 junction.