

CE/Gunshot Wounds: A Primer

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Objectives

After reading this article, you will be able to describe the:

1. Appearance of multiple types of gunshot wounds.
2. Patient evaluation of gunshot wounds.
3. Appropriate treatment of gunshot wounds

Case

9-1-1 receives a call from the owner of a liquor store near the county line who has just been shot in the face by a robber. The man is alert and coherent with slurred speech. He is requesting immediate assistance from police and ambulance. He warns dispatchers that he anticipates the return of the thief because, in his haste to escape with the cash, the perpetrator forgot his wallet. Shortly thereafter, the 9-1-1 operator hears shouting and two distinct sets of gunshots.

Introduction

Firearms and gunshot wounds are now common in today's society. Hot debate continues to rage regarding cause, effect and the best way to handle the ever-increasing number of deaths resulting from guns. Emergency services must also examine their response to such an environment. This article provides a brief overview of current information on the subject.

Before You Arrive

Prior to arriving on the scene of a shooting, assess the situation. Security is paramount. Has law enforcement secured and stabilized the scene? Are all the combatants and weapons accounted for? Is the firefight ongoing? Just what are you about to walk into—a family dispute, robbery, gangland style drive-by? Timely information from dispatch may assist you in making such an assessment; however, such information may be unavailable or inaccurate. Approach every scene as if your life depended upon it. Seek site information from law enforcement. Know the area, alternate routes in and out, have options for escape available and stay mobile. Approach the scene with your windows rolled down. You may be able to assess the scene from conversations, voice intonations, and sounds (like the distinctive sound of

a pump shotgun being cycled). If trouble is still brewing, back off. Ambulances make great targets and you will not be able to assist the patient if you get shot or pinned down.

Body Armor is another consideration. Unfortunately, they have to be worn to provide any protection. Too often vests are left sitting behind the seat in the unit, instead of being placed on the paramedic when needed. While most EMS services are probably not issuing armor to their medics, an increasing number are. Up to 37% of body surface area, to include most of the vital organs, can be protected from most handgun and shotgun projectiles with a vest. Rifle projectiles, on the other hand, are a different story. They have a higher velocity and are more difficult to protect against.

EVALUATION

History

A knowledge of firearms, ballistics, and a simple reconstruction of the shooting will help you properly assess the victim's potential injuries. Ask other emergency response personnel, family members, the victim, or witnesses what kind of weapon was used (handgun, rifle, or shotgun), the size of the weapon (the caliber is usually printed on the bottom of empty shell casings), type of bullet used, and distance from which the patient was shot. It is also helpful to ask how many shots were heard.

Physical Examination

General Appearance: Is the patient armed? It is imperative that you remove any threat to you, the patient, and bystanders. Look for a weapon. Turn the weapon over to the nearest law enforcement personnel. If no one is available, remove the weapon, engage the safety, and unload the remaining rounds, but only if you know how.

ABCs

Airway: Secure the airway while taking precautions to stabilize the cervical spine, if indicated.

Breathing: If the patient is not breathing, begin ventilation using bag-valve-mask while preparing to intubate. Hyperventilate patients with head wounds. If the patient has adequate spontaneous respirations, supply 100% O₂ from a non-rebreather. Be sure to check for adequate and bilateral chest expansion and breath sounds.

Circulation: Determine pulse rate and blood pressure. While there is some controversy about the proper treatment for traumatic injuries resulting in hypotension, aggressive fluid resuscitation with normal saline or lactated Ringer's solution through two large bore IVs (14 -16 gauge) is still the standard of care. Control hemorrhage with direct pressure or application of PASG, if not contraindicated. As with all treatment, be sure to consult your local protocols.

Neurological Deficits: Because the bullet path may not be easily determined without direct visualization, the assumption of possible neurologic involvement must be made. Assess the patient's level of consciousness, pupillary reflex, response to verbal and pain stimuli, as well as movement and sensation in the extremities.

Examination: Remove all clothing and perform a head-to-toe examination while looking for additional entry or exit wounds and any other unseen injuries.

Entrance and Exit Wounds

Usually, it is easy to distinguish a shotgun wound at close range — a large, devastating entrance wound with no exit wound. The entrance and exit wounds from a rifle or handgun are often more difficult to identify. The elastic properties of the skin and surrounding tissue as well as the small diameter of the single projectile make measurement misleading.

Range also plays a part in identifying entrance wounds. Close proximity shots will have gunpowder stippling or tattooing. In contact wounds, the hot gases accompanying the projectile create a larger entrance wound than expected for that caliber and carry any material the muzzle was in contact with deep into the wound.

Exit wounds, on the other hand, are generally larger and may contain debris such as bone, solid organ particles and projectile fragments. They can be distinguished approximately 60% of the time from the entrance wound.

Never assume a patient was hit by only one bullet.

There may be more than one exit wound. Depending on bullet fragmentation, bone or other fragments such as pocket contents may have been blown through the wound creating multiple exit tracts.

Head

- Examine the scalp for entrance and exit wounds.
- Look for blood, fluid or vomitus in the ears and mouth. Observe for postauricular ecchymosis (Battle sign) and periorbital ecchymosis ("raccoon eyes") which may indicate a basal skull fracture.
- Wounds to the head, face, mouth or neck suggest cervical spine injury.
- Airway compromise from maxillofacial injuries is potentially lethal due to hemorrhage, swelling and debris. Immediate stabilization of the airway is imperative.
- Airway patency should be reevaluated throughout transport.

Neck

- Distended neck veins may result from a tension pneumothorax or cardiac tamponade.
- Tracheal deviation may indicate tension pneumothorax or soft tissue swelling from a bullet.
- Crumpling cellophane sensation under the skin of the neck may indicate a pneumothorax with subcutaneous emphysema.
- Neck wounds require aggressive airway management due to the potential for rapid deterioration. Intubation should be attempted immediately in an unconscious patient.

Torso

- Trunk wounds may consist of penetrations either to the chest or abdominal cavity.
- Bullet paths are seldom linear and no assumptions can be made as to the organs damaged. Observe for pneumothorax, hemothorax, cardiac tamponade, visceral or solid organ damage.
- Don't forget to check the axillae or perineum for entrance and exit wounds.
- Internal injuries often present with a tender or rigid abdomen.

Extremities

- Evaluate extremities for any deformities, tenderness, pallor, cyanosis or pulselessness.

Legal Considerations

Remember, almost all incidents involving gunshot trauma are crime scenes. While the principal activities of EMS personnel at a shooting scene have nothing to do with crime-scene evaluation, EMS should follow law enforcement's recommendations regarding crime scenes. EMS personnel may be required to provide law enforcement with written statements describing their actions at a shooting scene.

- Do not cut through bullet holes in clothing.
- Minimize destruction to clothes.
- Don't throw away bullets or fragments.
- Document where bullets were found. Place them in a container and label it with the patient's name, your name, and where it was found.
- Document wounds with description of location, powder burns or tattooing, and size.
- Save everything.
- Be prepared to testify in court if you disarmed the patient, unloaded the gun and maintained custody of the weapon until relinquishing it to the proper authorities.

Wound Ballistics

Tissue Crush — The Permanent Cavity

As a bullet first enters the body, it crushes any tissue in its path. A round with a copper or steel jacket may stay intact as it travels through the body, creating a narrow cavity. Hollow point or soft point rounds create larger permanent cavities by mushrooming. High velocity rounds are sometimes designed to tumble (the M-16 .223 caliber round), thus enlarging the bullet tract and damaging more tissue. A shotgun offers multiple projectiles creating numerous bullet tracts and tremendous tissue damage, especially at close range.

A cross between a shotgun and a hollow point projectiles is the fragmentable (composite) round. These rounds begin with a copper hollow point outer shell, but contain shot immobilized by plastic or marine epoxy. They are designed to fragment upon hitting a surface, creating multiple projectiles once inside the body. This dramatically increases the surface area of the projectile and thus greatly magnifies the diameter of the permanent cavity.

Cavitation — The temporary cavity

The second injuring mechanism is the temporary cavity created by the kinetic energy of the bullet. The transference of this energy from the projectile to the patient causes tissue to be forcibly thrown from the bullet's path, causing stretching, tearing and concussive forces to the surrounding tissue.^{5,9} The cavity may measure 15 times the projectile diameter with wall pressures 100 times that of the atmosphere. During the first five minutes, the wall collapses and reforms (reverberates) several more times. This sheering force can damage tissue some distance from the projectile tract itself.

Ballistic Kinematics

Kinetic energy = $\frac{1}{2}mv^2$

m = weight of the bullet in grains

v = velocity in feet/second

Notice, if you double the bullet weight, it doubles the kinetic energy, but if you double the velocity, it quadruples the kinetic energy. Hand guns are considered low-velocity weapons (usually under 1,000 feet per second), while rifles are considered to be high velocity. Shotguns are considered high velocity when used at close range. Remember, however, a well placed BB (.177 caliber, 4.5 mm) from an air gun can still kill.

Increased velocity is the thought process behind magnum or hot (+P) rounds. Bullet manufacturers surmise that they can increase “stopping power”, or the ability to stop an aggressor, by increasing the powder charge in the round, thus increasing the velocity of the projectile. The relationship does not correlate completely with actual “stops” but is significant. The energy of a projectile may be incompletely transferred to the target if the round is not stopped by the tissue. Military rounds use heavier copper jackets than are found in civilian marketed rounds. This produces a projectile that is less likely to deform or fragment once it has hit a target. Overpenetration (when a projectile leaves the body intact) causes the round to exit the tissue without completely transferring its energy, thus substantially decreasing the cavity size and tissue damage. Bullet manufacturers compensate for this with mushrooming or fragmentable rounds. Civilian rounds such as the Black Talon, Hydra-Shok, or Golden Saber are designed to ensure complete transference of the kinetic energy to the target.

Combustion

When a round is fired, combusting gasses and gunpowder exit the barrel of the weapon. If the weapon is in contact with the skin, these gases, gunpowder soot, clothing and skin follow the projectile into the wound. A stellate, or star-shaped, lesion is formed at the skin with a ragged appearance to the entrance wound and occasionally, an imprint of the barrel is left in the skin. The gasses continue to expand the temporary cavity, overwhelming the elastic properties of the tissue, multiplying the sheering forces to the tissue.

The entrance wound pattern changes as the distance between the firearm and the skin increases. As the barrel is retracted away from the skin, less stippling (tattooing) from the powder and scorching around the wound edges is noted. Preserving the wound appearance, skin and clothing is imperative, as this information may be required as evidence.

Case Conclusion

Both the liquor store owner and the perpetrator were transported to the hospital with gunshot wounds. The robber received a single gunshot wound to the forehead, and despite resuscitative efforts, was pronounced dead two hours after arrival in the emergency department (ED). The ED had to be locked down because the perpetrator’s family became distraught at his death and attempted to seek revenge on the store owner. They were escorted from the premises by police. The store owner was admitted for a single gunshot wound to the left jaw requiring minor reconstructive surgery. He returned to work 10 days later.

Glossary

Bird Shot: The lead shot used in shotgun shells. Bird shot ranges from size 2 to size 9. Larger shot is called buckshot; smaller shot, dust shot.

Blank: Ammunition containing powder but no projectile. Blank ammunition may cause injury or death at close range because of the high-velocity gases (muzzle blast) and wadding released upon firing.

Caliber: The bore (internal diameter) of a firearm, given in inches (or millimeters). Standard calibers are .22 - .30 inches for rifles and .22 - .45 inches for handguns. Caliber may also refer to the diameter of a bullet.

Fragmentation: Secondary missiles that may be sent in different directions when a jacketed bullet fragments when hitting bone or when a non-jacketed, soft-point, hollow-point, or composite bullet fragments when passing through soft tissue. Fragmentation may significantly increase injury.

Grain: The unit of weight for a powder charge or bullet. There are 7,000 grains in an avoirdupois pound. Weight for some commonly used bullets are 158 grains, .38 caliber handgun; 250 grains, .45 caliber handgun; and 40 grains, .22 caliber rifle.

Handgun: A firearm designed to be fired with one hand. Handguns fire bullets with calibers ranging from .22 to .45 inches, and most are low-velocity weapons. The .38 Special, the .357 magnum, and the .44

magnum are relatively high-velocity handguns with pronounced recoil and may require the shooter to use both hands.

Hollow-point: A partially jacketed bullet whose tip is hollowed out to increase the mushrooming effect when hitting the target. Hollow-points are usually used with a Magnum load to maximize the mushrooming effect. Should the cavity at the point become plugged with clothing, wood, drywall or other matter, it may fail to expand.

Jacket: An outer layer of high-melting-point metal, typically copper or steel, covering the lead of a bullet so it maintains its shape. A completely encased bullet is said to have a full metal jacket.

Magnum Cartridge: A cartridge with extra gunpowder added to increase bullet velocity.

Mushroom: The tendency of certain bullets to expand and flatten on impact, enhancing the destructive effect. Increasing degrees of mushrooming are seen with nonjacketed, partially jacketed, and hollow-point bullets.

Muzzle Blast: The surge of hot air and gases that bursts from the muzzle of a gun as the missile leaves it (also called powder blast).

Muzzle Velocity: The speed of a bullet as it leaves the gun barrel. In general, rifles (except the .22 caliber rifle) and shotguns (depending on range) are high-velocity weapons, and handguns are low-velocity weapons. Most experts agree that high velocities are greater than 1,000 feet per second and low velocities are less than 1,000 feet per second.

Range: Distance between the muzzle of a weapon and the intended target.

Rifle: By U.S. law, a firearm with a barrel longer than 16 inches. The barrel is cut with spiral grooves to impart rotational energy to the bullet and stabilize it in flight.

Shotgun: A smooth-bore weapon (that is, a firearm with no rifling or grooves in the barrel). A shotgun may fire a single missile or multiple pellets from a single shell. The typical 12-gauge shell is loaded with 1-1/8 ounces of no. 6 lead shot, which contains 253 individual lead pellets and has a muzzle velocity of 1,255 feet per second.

Soft-Point: A bullet that is nonjacketed or partially jacketed to expand and flatten on impact.

Temporary Cavitation: Tissue stretch beyond the permanent wound cavity occurring after the missile has passed through the target. If a bullet entering tissue is like a diver entering the water, temporary cavitation is akin to the splash the diver makes. It produces localized blunt trauma and may increase the magnitude of injury.

Tumbling: Forward rotation of a bullet around the center of mass.

Yaw: Deviation of a bullet in its long axis from a straight line of flight.

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CE/GUNSHOT WOUNDS

BLS Questions

1. Up to _____% of body surface area can be protected from most handgun and shotgun projectiles with a safety vest.
 - a. 10
 - b. 28
 - c. 37
 - d. 50

2. A knowledge of firearms, ballistics, and a simple reconstruction of shooting will help you properly assess the victim's potential injuries.
 - a. True
 - b. False

3. It is imperative that you remove any threat to you, the patient, and bystanders. Look for a weapon, and:
 - a. Hide it from the victim.
 - b. Leave it; the gun is of no importance to you.
 - c. Take it to the hospital with you.
 - d. Turn the weapon over to the nearest law enforcement officer.

4. In your initial assessment of the patient, secure the airway without compromising the:
 - a. Cervical spine
 - b. Patient's LOC
 - c. Pulse rate
 - d. Wound

5. Because the path of the bullet may not easily be determined, the assumption of possible neurologic involvement must be made. Assess the patient's:

- a. LOC
- b. Pupillary reflex
- c. Response to verbal stimuli
- d. All of the above

6. During your examination, remove all clothing and perform a head-to-toe examination.

- a. True
- b. False

7. Shotgun wounds are easy to distinguish, due to devastating entrance wounds with large exit wounds.

- a. True
- b. False

8. On the examination of the head, the rescuer should pay particular attention to what signs:

- a. Airway difficulties from maxillofacial injuries
- b. Blood, fluid or vomitus in ears and mouth
- c. Postauricular ecchymosis (battle signs)
- d. All of the above

9. Distended neck veins are usually the result of what thoracic chest injuries?

- a. Cardiac tamponade
- b. Fluid overload
- c. Tension pneumothorax
- d. All of the above

10. Trunk wounds may consist of penetrations to the chest or abdominal cavity.

- a. True
- b. False

11. Extremities should be evaluated for what signs and symptoms?

- a. Burns
- b. Deformities
- c. Tenderness
- d. All of the above

12. Responders rarely need to testify in court, since all information is usually gathered and recorded by law enforcement personnel.

- a. True
- b. False

13. High velocity rounds, such as those from the M-16, stay intact as they travel through the body, creating a narrow cavity.

- a. True
- b. False

14. Handguns are considered low velocity weapons because they travel less than _____ feet per second.

- a. 1,000
- b. 2,000
- c. 5,000
- d. 10,000

15. Missile velocity and missile kinetic energy are the main factors that determine the wound produced.

- a. True
- b. False

ALS Questions

16. Since increasing a patient's bleeding is a major concern, aggressive fluid resuscitation should be avoided at all costs.

- a. True
- b. False

17. Since neck wounds have the potential for rapid deterioration, _____ should be performed immediately in an unconscious patient.

- a. Intubation
- b. Placement of an EGTA
- c. Placement of an oral airway
- d. All of the above

18. Aggressive fluid resuscitation with normal saline or lactated Ringer's solution through two IVs _____ is still the standard of care.

- a. 8-10 gauge
- b. 14-16 gauge
- c. 16-18 gauge
- d. 18-20 gauge

19. Control of hemorrhage may be possible, not only with direct pressure, but with _____.

- a. Large layers of kerlex
- b. PASG
- c. Tourniquets
- d. All of the above

20. Fluids of choice for resuscitation efforts are:

- a. D5W
- b. Normal saline
- c. Plasma
- d. None of the above