Gunshot Injuries

Gunshot injuries occur when someone is shot by a bullet or other sort of projectile from a firearm. Peace time gunshot injuries occur in a variety of different situations - criminal and terrorist incidents (including shots fired by law enforcement agents), attempted suicides as well as unintended firearm 'accidents' (both civilian and amongst the armed forces). Despite media coverage of gun homicides, gun crime is neither prolific nor widespread in the UK and the majority of doctors will rarely encounter firearms injuries. Expertise usually resides with military surgical services or pooled within regional trauma centres.

Mechanism of injury

There are many different types of bullets but the most common type is composed of a lead core with some type of casing. On striking, the projectile element may travel at speeds of up to 1,500 metres/second, dependent on the ammunition and type of gun. The most important factors in causing significant injury or death are their placement and projectile path. The head and torso are the most vulnerable areas, with incapacitation due to CNS disruption or massive organ destruction and haemorrhage. The extent of tissue and organ trauma will depend on terminal ballistics, which are influenced by the type of bullet, its velocity and mass as well as the physical characteristics of the penetrated tissue.

Injury is inflicted in a number of ways:

- Firstly, the projectile crushes structures along its track, similar to other forms of penetrating injury. Temporary cavitation causes shearing and compression, sometimes tearing structures (as with solid abdominal viscera) or stretching inelastic tissue (the brain is particularly susceptible), analogous to blunt trauma. As tissues recoil and hot gases dissipate, soft tissue collapses inwards with the permanent cavity being the resultant defect. Bullets which display greater yaw will be associated with increased temporary cavitation.
- Secondly, kinetic energy transfer occurs during retardation of the bullet and this may cause damage outside the tract. Factors influencing the efficiency of kinetic energy transfer include:
  - Kinetic energy of a body which is proportional to mass and velocity.
  - Projectile's deformation and fragmentation.
  - Entrance profile and path travelled through the body.
  - Biological characteristics of the transit tissues.

Projectiles tend to be classified as low-velocity (<300 hm/second) or high-velocity (>300 hm/second). Those with higher velocity may be expected, on this basis, to dissipate more energy into surrounding tissue as they slow and cause more tissue damage but this is only a very approximate guide. This 'kinetic energy dump' theory is controversial, since high-velocity injuries are frequently less extensive than would be predicted and fragmentation appears to be the most effective mechanism for wounding rather than yawing or other mechanisms for slowing high-velocity rounds quickly.
- Secondary contamination.

Interpretation of fatal gunshot wounds in post-mortem is fraught and requires expert attention.

Epidemiology

Deaths from firearms reflect their availability in various countries. Other factors must play some part - Switzerland has relatively high gun ownership and a low homicide rate (but a high gun suicide rate) compared with the USA.

<table>
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<tr>
<th>Country</th>
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<th>Accident</th>
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<tr>
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<td>0.24</td>
<td>1.34</td>
<td>0.09</td>
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</table>

In 2008-2009, there were 11,227 firearm offences (most where no firearm was discharged) in England and Wales with 58 homicides and 330 serious injuries. Firearms are used in 0.3% of recorded crimes and fired in a third of these offences.
Based on media coverage there is a general belief that firearm injury and death is common in England and Wales. Based on data from 1998 - 2007 collected by the Trauma Audit and Research Network, only 0.53% of cases of recorded trauma was related to firearm injury.[7] Similar results have been reported by other smaller studies. [8, 9]

Airguns and air rifles are potentially lethal low-velocity weapons firing lead pellet or ball bearings. They are frequently regarded more as toys than as weapons and are thought to be owned by up to 4 million households in the UK. They generate a large number of firearm injuries in England and Wales due to their frequent use. They are usually accidental injuries to boys caused by themselves or other children. Most injuries are relatively minor but fatal injuries do occur. Eye, neck and abdominal injuries are most common but there is also potential for serious brain and chest trauma.[10] The Violent Crime Reduction Act of 2006 restricted the sale of air weapons to licensed firearm dealers and increased the minimum age for ownership from 14 to 18 years.

Presentation

See also separate article Trauma Assessment.

- As with any emergency situation, first assess SAFETY - of yourself and other emergency staff - before approaching. Is the shooter still in the vicinity? Are others (including the patient) armed? Routinely, paramedics and prehospital emergency medics wear body armour for all assault, stabbing or shooting incidents and require police back-up before entering a potentially dangerous situation.
- Employ standard trauma life support protocols for the initial assessment (Airway, Breathing, Circulation) and resuscitation - principles are the same for gunshot injuries as for any major trauma.
- When faced with gunshot wounds, there are further useful questions a doctor can ask:
  - What type of weapon was used? For example, a small handgun, a shotgun or a high-powered rifle (if it’s a sniper attack). The victim or witnesses may be able to answer.
  - Where is the entry wound and where is the exit wound? Over-concern with the entry wound may mean that the exit wound is ignored.
  - What structures may have been damaged between the two? Lungs, major vessels, vascular organs like liver and kidneys or bones may be involved. If the trajectory was at an unusual angle there may be an unusual combination.

The primary survey

Airway
Use basic manoeuvres (suction, chin lift, oropharyngeal airway) to open an airway and apply high flow oxygen by face mask. Avoid tilting the head or moving the neck if there are concerns of cervical spine injury.

Breathing
Respiratory distress following gunshot injury can be due to pain, flail chest, or diaphragmatic injury. Patients who are apnoeic or hypoventilating require bag and mask ventilation prior to tracheal intubation and ventilation. Insert a chest drain if there is suspected damage to the lung, bronchus, or chest wall.

Circulation
Make an assessment of the general state of the patient. Considerable bleeding can occur internally and hence be occult. Patients are frequently young and fit so compensate well until in extremis - tachycardia may be delayed and hypotension suggests very marked blood loss. Obtain good intravenous access as soon as possible. If possible, secure bleeding vessels. If not, compression is permissible to stem bleeding. The use of tourniquets is controversial. In a hospital environment, ensure blood is grouped and cross-matched fast. Rapid haemorrhage may necessitate operation before adequate resuscitation but anaesthesia may induce collapse of a compromised circulation and an experienced anaesthetist is essential.

Disability
Perform a rapid assessment of neurological status.

Exposure
Clothes should be removed and the entire body surface examined for exit and entry wounds. NB: it is easy to miss these in hairy parts of the body such as the scalp, axilla and perineum.

Management
All patients with non-trivial gunshot injuries need:

- Cross-matching of six units of blood.
- At least one and, preferably, two large-bore IV cannulae: required for vigorous fluid replacement. However, avoid hypertension which may exacerbate blood loss - aim for a systolic BP of 100-110 mm Hg.
- Investigation: X-ray (AP and lateral) one body region above and one below any wound, as well as the one directly involved, to search for further embedded shot/bullets.
- Monitoring: vital signs, blood gases, CXR, ECG monitoring.
- High-dependency or intensive care.

Chest injuries
Penetration of the chest may damage pleura, lung, great vessels, heart, mediastinum, diaphragm and abdominal contents. The most common injury is a haemopneumothorax from damage to the lung and chest wall. This requires a large (adult: 32G) chest drain. Any deterioration or cardiac arrest demands prompt thoracotomy. Wounds of the intercostal vessels or heart can cause massive haemorrhage. If drainage is initially >1500 ml, or >300 ml/hour, thoracotomy is needed.

- Sucking chest wounds must be closed immediately. Vaseline® gauze pads sealed on only three sides can act as a flutter valve. The seal is completed when the chest drain is inserted.
- Relieve any tension pneumothorax by needling the chest on the side of the suspected lesion before inserting a 32G chest drain or doing X-rays. Delay may be fatal. A tension pneumothorax gives hyper-resonance on that side and the trachea is deviated away from it.
- Infection is a major problem. Risk is reduced by early drainage of haemothorax, wide debridement of damaged tissue, delayed closure of wounds, and use of prolonged antibiotics.

**Cardiac tamponade**

- 15% of deep chest injuries involve the heart.
- Diagnosis is difficult so have a high index of suspicion following penetrating trauma:
  - Beck's triad is rising venous pressure, falling systemic pressure and a small, quiet heart but often these are not observed. Picking up muffled heart sounds at a noisy trauma scene may be impossible.
  - Pulsus paradoxus may be noted as with constrictive pericarditis.
  - The JVP may not be visible if there is hypovolaemia.
  - Pericardial aspiration is a useful diagnostic tool and may be a life-saving treatment. It also buys time before definitive anterolateral thoracotomy.
  - If the equipment is available and time permits, echocardiography is the diagnostic investigation of choice.
- To relieve a tamponade, insert an 18G needle to the left of the xiphoid. Aim at the left shoulder, but with the needle angled downwards at 45° to the horizontal.
- Penetrating injuries to the heart can also occur without initial haemodynamic compromise.[11]

**Abdominal injuries**

Abdominal injuries are associated with a high incidence of internal injury. All but the most superficial penetrating wound of the abdomen require full exploratory laparotomy. This applies as much to knife as to bullet wounds. Observation is inadequate as there may be occult bleeding or perforation of bowel. This is challenged by some who feel that non-operative management of penetrating abdominal injuries of solid organs (ie liver, spleen or kidneys) is safe in Level 1 trauma centres, in patients who are haemodynamically stable, without signs of peritonitis, following a CT scan to rule out damage to hollow viscous organs with serial monitoring by clinical examination, haemoglobin and white cell counts.[12, 13] Broad-spectrum antibiotics should be administered early with any abdominal injury.

**Limb injuries**

Nerves, tendons and vessels are endangered, so examine the limb in a good light. Test for pulses but their presence does not exclude arterial injury. Note sensation and sweating. Any damage identified will need formal surgical repair.

**Wound closure**

Significant tissue damage can occur with both low- or high-velocity bullets. Some high-velocity bullets (particularly those from military rifles) are designed to stay intact after impact, limiting wound severity and the need for massive wound debridement.[14, 15] However, many low-velocity gunshot wounds can be safely managed with local wound care and outpatient review, dependent on the absence of any bony or vascular injuries.[16, 17] High-velocity bullets suck foreign material (normally clothing) through both entry and exit wounds and it can be spread along dissected tissue planes. Wide excision or fasciectomy may be required to clear foreign material and dead tissue. Primary suture is frequently delayed for high-velocity injuries with grafting and suture at 3-5 days.

Gunshot wounds are particularly prone to anaerobic infection, especially tetanus and gas gangrene. Ensure tetanus cover is up-to-date, and intravenous antibiotic prophylaxis of 24-48 hours’ duration is usual following fractures caused by high-velocity weapons or shotguns.[18]

**Legal and forensic aspects**

**Reporting gunshot injuries**

The General Medical Council (GMC) has issued supplementary guidance concerning the reporting of gun- and knife-related injuries.[19] These state that:

- The police should quickly be informed whenever an individual arrives in a healthcare setting (usually hospital) with a gunshot wound, as they are responsible for the risk assessment (both of risk to the patient and others) and to ensure that important statistical information about gun crime is not lost.
- A professional judgement should be made regarding the disclosure of personal information about the patient (including their identity). Disclosure of personal information without consent may be justified in the public interest where failure to do so may expose others to a risk of death or serious harm, and, where this is the case, should happen promptly. However, medical staff should actively seek the patient’s consent to disclose wherever possible and must consider any reasons given for refusal. Ideally, the patient should be informed prior to the disclosure of information without their consent, provided this does not compromise safety.
- The patient should remain the medical team’s prime concern at all times and the police’s arrival should not be allowed to delay or hamper treatment or to compromise the patient’s recovery. If the patient’s condition and treatment would allow them to speak to the police, they should be asked whether they are willing to do so, and the consequences of deciding not to speak to the police should be explained to them. The healthcare team and the police must abide by this decision.
Forensic evidence
Healthcare professionals also have a duty to preserve potential forensic evidence when dealing with the victims and perpetrators of violence. To this end, ensure that all the patient’s clothes, belongings and any missile fragments are retained, bagged, labelled and kept secure until passed on to the police, ensuring the ‘chain of custody’.

Firearm and shotgun licensing
Doctors are not required to act as cosignatories or referees for firearm or shotgun licences. British Medical Association (BMA) guidance suggests:[20]

- You may act as a person of ‘good standing’ where the person has never been a patient.
- Where the person is a patient, only support the application where you are sure that you have sufficient knowledge about the individual to justify a judgement on the individual’s safety in possessing and controlling a firearm.
- In general, make it clear that you are not in a position to judge ‘future dangerousness’.
- GPs may be approached by the police requesting additional information pertaining to licensing - only provide information with consent and which is relevant to the application.
- Where you believe an individual has access to a firearm and is a danger, encourage them to return their licence and surrender the firearm. Confidence should be breached where the risk of death or serious harm to third parties outweighs the patient’s privacy interest. Again the patient should be informed prior to disclosing the information, where practicable. An appropriate person or authority (Chief Constable or the Commissioner of the Metropolitan Police Authority) should be informed of the concerns. Any breach of confidentiality may have to be justified to the GMC or a court.

Prevention
Body armour
Body armour offers some protection against injury from high-velocity weapons but has considerable limitations.[21] The protection offered is graded I to IV. By and large, I and II will protect against handguns but assault rifles and other high-power weapons require ceramic tiles to give grade III or IV. Like mediaeval armour they are rather heavy and cumbersome.

Gun control
Moderating the injury and death caused by the violent use of guns is a very valid public health issue. The right to bear arms in the USA is enshrined in its constitution and has been ardently and effectively protected by the National Rifle Association, whilst the UK has some of the strictest gun control laws in the world. The massacre of school children and their teachers in Dunblane caused public outcry and subsequent legislation to impose even tougher restrictions on the legal owners of handguns, although there is little evidence that this has saved any lives. Amnesties allowing people to hand in illegal firearms often produce impressive responses but those who hand weapons in are unlikely to use them. During the month-long firearms amnesty in April 2003, over 43,000 guns were surrendered in England and Wales and 3,393 in Scotland.

Further reading & references
- Gun Control Network

4. World report on violence and health; World Health Organization, 2002
5. Karp A; Chapter 2 'Civilian firearms' from Geneva Graduate Institute of International Studies, Small Arms Survey 2007
19. Confidentiality: reporting gunshot and knife wounds; General Medical Council, 2009
20. What is a doctor’s involvement in the firearms licensing process; British Medical Association

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