Chapter 10: Ballistic injuries

Types of firearms

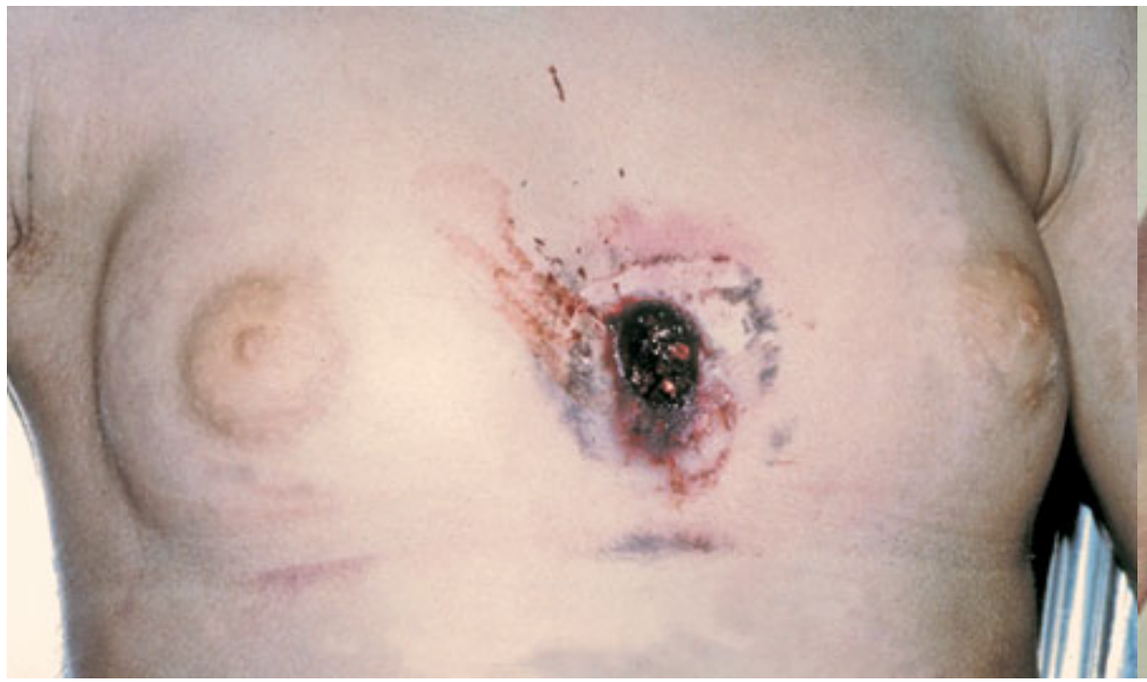
- There are two main types of firearm: those with **smooth barrels**, which fire groups of pellets or shot, and those with **grooved or rifled barrels**, which fire single projectiles or bullets.
- The speed with which the projectile leaves the end of the barrel (the muzzle velocity) varies from a few hundred meters per second
- Higher muzzle velocities are considerably more effective at delivering energy

Gunshot injuries

- Discharging a firearm will result in the formation of smoke, flame and gases of combustion.
- These exit the barrel, together with portions of unburned, burning and burnt propellant and other items such as wadding and plastic containers for the pellets. These '**contaminants**' will usually follow the projectile(s), but in some guns they may also precede them. The distance they will travel from the end of the muzzle is extremely variable, depending mainly on the type of weapon and the type of propellant. They can also escape from small gaps around the breech and will soil hands or clothing close to the breech at the time of discharge.
- The presence, location and distribution of such contaminants may have great importance in the forensic Investigation of a shooting incident

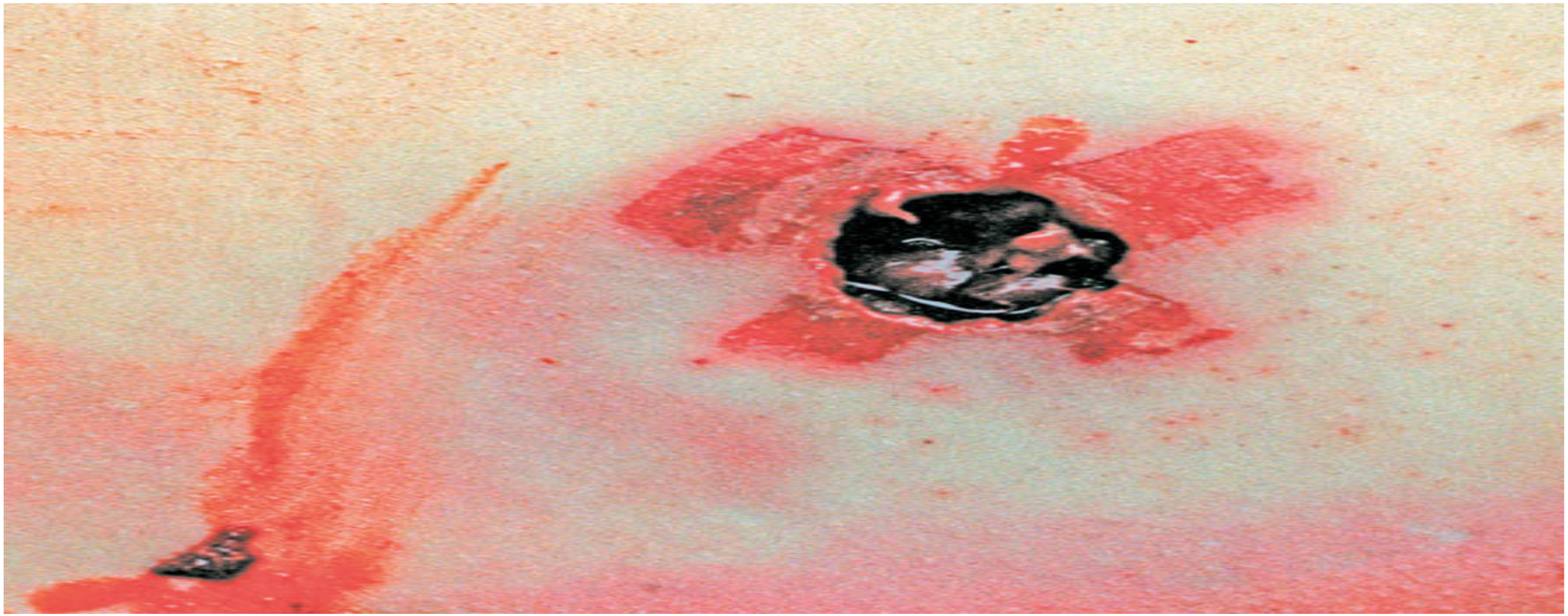
Injuries from smooth-bore guns

- Discharge from a cartridge forces pellets along the barrel by the gases of detonation.
- The pellets will leave the muzzle in a compact mass, the components of which spread out as it travels away from the gun.
- The shot pattern expands as a long, shallow cone with its apex close to the muzzle of the shotgun. The further away from the gun that the victim is situated, the larger the pellet spread, and the larger the area of potential damage.
- Contact wounds are created when the gun muzzle abuts the skin and usually results in a circular entrance wound that approximates the size of the muzzle. (The wound edge will be regular and often has a clean-cut appearance with no individual pellet marks apparent).

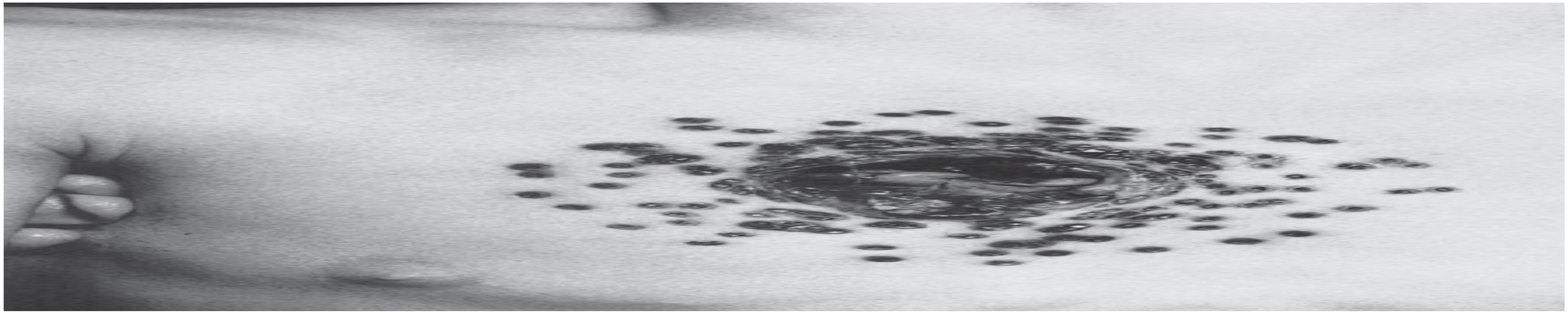


- If the **discharge** was over an area **supported by bone,** the gases cannot disperse as readily as they would in soft.
- A **close** discharge, within a few centimeters of the surface, will also produce a wound with a similar appearance, but as there is now room for muzzle gases to escape, there will be no muzzle mark.
- More smoke soiling can occur, and burning of skin, with singeing and clubbing of melted hairs, can be seen around the wound.
- There is also, very commonly, **powder 'tattooing' of the skin around the wound entry**.
- This tattooing results from burnt and burning flakes of propellant causing tiny burns on the skin and cannot be washed off.
- As with contact discharges, wads will generally be found in the wound track.

- At **intermediate** ranges, diminishing smoke soiling and burning of the skin, but powder tattooing may persist.
- The spread of shot will begin, first causing an irregular rim to the wound, This is often called a **‘rat-hole’** because of the appearance of the wound edge; the term **‘scalloping’** may also be used.
- Separate injuries caused by the wads or plastic shot containers may be seen.



- At a **range** of over 1 m, smoke damage and tattooing generally **do not** occur and injuries caused at longer ranges will depend upon the spread of the shot, which in turn is dependent upon the construction of the barrel.



- It is important to measure the spread of the shot so that if the weapon is recovered, test firings using identical ammunition can be performed to establish the range at which a particular spread of shot will occur.
- At **long** ranges, such as 20–50 m, there is a uniform peppering of shot, and this is rarely fatal.

- **Shotguns** rarely produce an exit wound when fired into the chest or abdomen, although single pellet exit wounds can occasionally be seen.
- Exit wounds can be seen when a shotgun is fired into the head, neck or mouth.
- cases may be a huge ragged aperture, especially in the head, where the skull may virtually explode with the gas pressure from a contact wound, ejecting part or even all of the brain from the cranial cavity

Wounds from rifled weapons

- Bullets fired from rifled weapons, generally at a **higher velocity than pellets from a smooth-bore weapon**, will commonly cause both an entry and an exit wound. However, many bullets are retained within the body because they did not possess enough energy to complete the passage through it, or energy was expended on contact with other structures (e.g. bone).

Entrance and exit wounds

- Contact wounds from a rifled weapon are generally circular, unless over a bony area such as the head, where splitting caused by the propellant gas is common. There may be a muzzle mark on the skin surface if the gun is pressed hard against the skin, and a pattern may be imprinted from a fore-sight or self-loading mechanism. There may be slight escape of smoke, with some local burning of skin and hair, if the gun is not pressed tightly. Bruising around the entry wound is not uncommon

- At close range, up to about 20 cm, there will be some smoke soiling and powder burns, and skin and hair may be burnt, although this is very variable and depends upon both the gun and the ammunition used.
- The shape of the entry wound gives a guide to the angle that the gun made with that area of skin: a **circular hole** indicates that the discharge was at right angles to the skin, whereas an **oval hole**, perhaps with visible undercutting, indicates a more acute angle.
- Examination of the entry wound will show that the skin is inverted; the defect is commonly slightly smaller than the diameter of the missile because of the elasticity of the skin.
- Very commonly, there is an '**abrasion collar**' or 'abrasion rim' around the hole, which is caused by the friction, heating and dirt effect of the missile when it indents the skin during penetration.
- Bruising may or may not be associated with the wound
- Over 1 meter or so, there can be no smoke soiling, burning or powder tattooing.
- At longer ranges (which may be up to several kilo meters with a high powered rifle), the entrance hole will have the same features of a round or oval defect with an abrasion collar.

- The exit wound of a bullet is usually everted with split flaps, often resulting in a stellate appearance .
- No burning, smoke or powder soiling will be evident.
- If the bullet has been distorted or fragmented, or if it has fractured bone, the exit wound **may be considerably larger and more irregular**, and those fragments of bullet or bone may cause multiple exit wounds, potentially leading to difficulties in interpretation.

- Where skin is firmly supported, as by a belt, tight clothing or even a person leaning against a partition wall, the exit wound may be as small as the entrance and may fail to show the typical eversion. To increase the confusion, it may also show a rim of abrasion, although this is commonly broader than that of an entry wound.

- The internal effects of bullets depend upon their kinetic energy. Low-velocity, low-energy missiles, such as shotgun pellets and some revolver bullets, cause simple mechanical disruption of the tissues in their path. High-velocity bullets, however, cause

- far more damage to the tissues as they transfer large amounts of energy, which results in the formation of a temporary cavity in the tissues. This cavitation effect is especially pronounced in dense organs, such as liver and brain, but occurs in all tissues if the energy transfer is large enough and can result in extensive tissue destruction away from the wound track itself.

Air weapons, unusual projectiles and other weapons:

Air guns and rifles:

Air weapons rely upon the force of compressed air to propel the projectile.

There are 3 ways in which the gas is compressed:

1. **Compression of a spring → The simplest method**
2. **Repeated movement of a lever**
3. **Internal cylinder which is charged by connecting it to external source**

The energy of the projectile will depend mainly on the way in which the gas is compressed.
Simple spring driven is low powered, whereas the more complex systems can propel projectile with the same energy and approximately the same speed of handguns.

The injuries caused by air weapons projectiles depend on their design.

Miscellaneous firearms and weapons

- **Plastic round:**
  - Law enforcement and security forces may use plastic rounds that may be fired from special guns to control the crowd.
  - The purpose of such weapon is to disable or discourage rioters, but NOT to kill or seriously injure them.
  - Should only be fired at the lower part of the body.
  - Some deaths, and many serious injuries including: fractures of skull, ribs and limbs, eye damage have occurred and these are usually associated with improper use.
  - The marks left on the skin by a plastic round is usually distinctive.
- **Stud guns:**
  - Stud guns are devices used in the building industry to fire steel pins.
  - Deaths and injuries from stud guns are well recorded.
  - They have been used in suicide and homicide, but accidental injuries are more common.
  - The skin mark will usually appear similar to small-calibre entry wounds. But finding a nail will solve the diagnostic problem.
- **Humane killers:**
  - Are devices used by veterinary surgeons to stun animals before slaughter.
  - It may fire a small-calibare bullet or a captive blot.
  - It is used for suicide and homicide but accidental discharges are also recorde.
  - Skin mark will depend on the weapon used.

Miscellaneous firearms and weapons

- **Bows and cross bows:**
  - Are used recreationally but may also be used as weapons of assault.
  - They fire arrows or bolts, which are shafts of wood or metal.
  - The tips of these projectile may have many shapes, often triangular.
  - The energy produced is extremely variable, depending on the construction of the weapon.
  - The injuries caused depend on the energy as well as the construction.
  - Is a projectile has a simple pointed tip, and was removed from the body the entry wounds can appear similar to those caused by standard bullets with a central defect and surrounding abrasion rim.

Determination of accident, suicide or murder

- Death investigators, including pathologists, must be aware of the potential fro “staging” of homicide in order to give the appearance of death having occurred as a result of accident or suicide.
- **The weapon must be present at the scene if it was suicide attempt.**
- **Weapon maybe at a distance from the body because it may have been thrown away from the body by recoil.**
- **It may be expected that the deceased’s DNA or fingerprints will be present on the weapon (unless gloved were on)**
- Most commonly suicidal shot injuries sites are:
  - **In the mouth**
  - **Below the chin**
  - **On the front of the neck**
  - **The centre of the forehead**
- **And rarely, on the front of the chest over the heart.**
- **Almost never shoot themselves in the eye, the abdomen or the back.**
- Both long-barelled and short-barelled weapons can be used.
- It is unusual for females to commit suicide with guns.
- **Multiple firearm wounds strongly suggest homicide.**
- **The distinction between homicide, suicide and accident can sometimes be extremely difficult unless a full medico-legal investigation was done.**
- It is unwise to state that a gunshot wound must have been immediately fatal.
- Most likely the severe damage to the brain, heart, aorta and any number of other vital internal organs will lead to rapid collapse and death.

Evidence recovery

- **The emergency medicine specialist, and surgeon**, should make good notes of the original appearances of the injuries and preferably take images before any surgical cleaning or operative procedures are performed .
- Any foreign objects such as wads, bullets or shot ,and any skin removed from the margin of a fire-arm wound during treatment, should be carefully preserved for the police.
- Those arrested for possible involvement in fire-arms offences will need detailed examination and taking of samples. The same general rules apply to the post-mortem recovery of exhibits.
- **Swabs of the hands of the victim should be taken .**
- The pathologist must ensure that accurate drawings and measurements of the site, size and appearance of the wound are obtained and that distant and close-up photographs are taken of each injury with an appropriate scale in view.

Explosives

- There is increase in the experience of medical personnel in the assessment and treatment of explosive injuries, because **terrorist activity is now present in many countries**

- When an explosion occurs, a chemical interaction results in the generation of huge volumes of gas, which are further expanded by the great heat that is also generated. This sudden generation of gas causes a **compression wave to sweep outwards at the origin, this is at many times the speed of sound.**

- The pure blast effects can cause either physical fragmentation or disruption of the victim or bomber solely from the effects of the wave of high pressure and hot gases striking the body.
- **A minimum pressure of about 700 kPa (100 lb/inch2) is needed for tissue damage in humans**.
- There will also be pressure effects upon the viscera and these effects are far more damaging where there is an air fluid interface, such as in the air passages and gut.

- **Rupture and hemorrhage** of these areas represent the classical blast lesion although the primary effect of blast is fatal.

- These **secondary** effects include:

1. Burns
2. Missile injuries
3. Peppering by small fragments of debris and dust propelled by the explosion.
4. Injuries and death from vehicular damage.

Mass disasters and the doctor

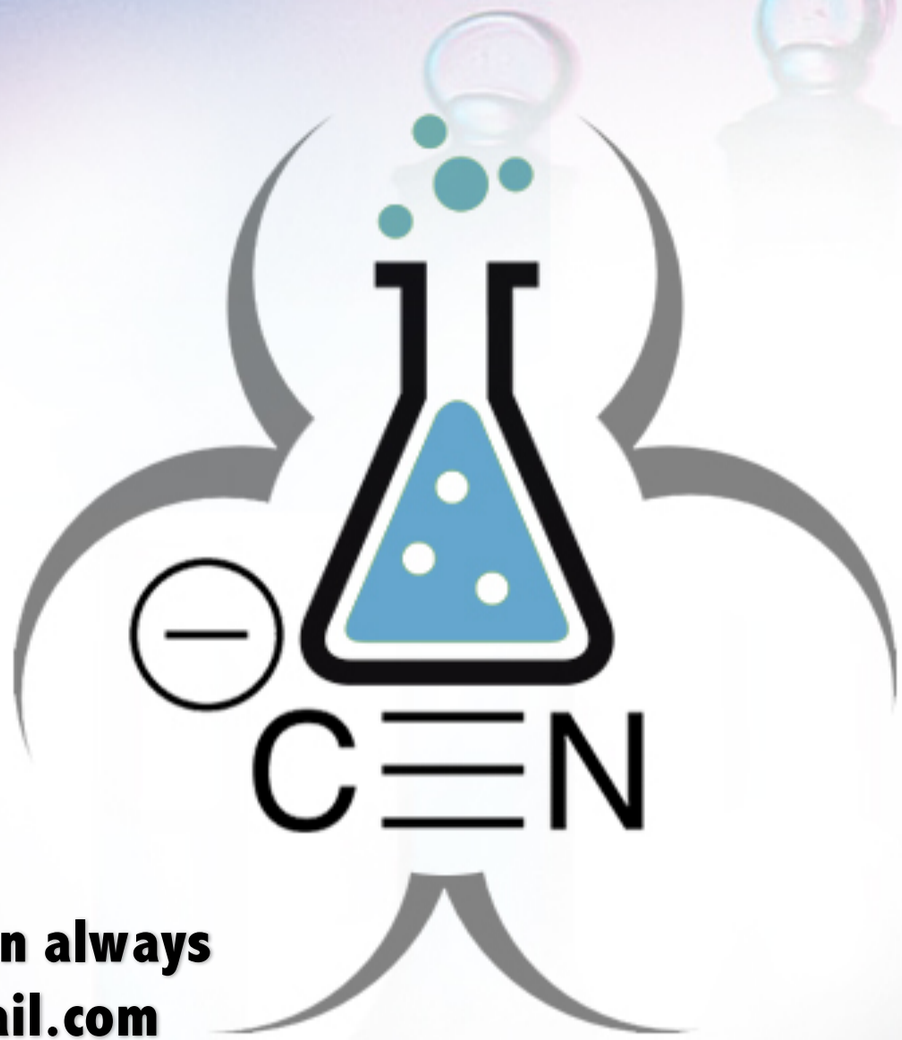
- Previously, transport incidents probably represented the most frequent setting for mass casualties and death. Increasingly, such a situation is just as likely to involve a terrorist incident.
- For the non-specialist doctor at the scene of a mass disaster of any kind, the first consideration is, of course, the **treatment of casualties, which may involve taking difficult ethical decisions about triage.**

Box 10.1 Recommended ethical principles and procedures with regard to the physician's role in disaster situations, from WMA statement 2006

1. Triage is a medical action of prioritizing treatment and management based on a rapid diagnosis and prognosis for each patient. Triage must be carried out systematically, taking into account the medical needs, medical intervention capabilities and available resources. Vital acts of reanimation may have to be carried out at the same time as triage. Triage may pose an ethical problem owing to the limited treatment resources immediately available in relation to the large number of injured persons in varying states of health.
2. Ideally, triage should be entrusted to authorized, experienced physicians or to physician teams, assisted by a competent staff.
3. The physician should separate patients into categories and then treat them in the following order, subject to national guidelines:
   a. Patients who can be saved but whose lives are in immediate danger should be given treatment straight away or as a matter of priority within the next few hours.
   b. Patients whose lives are not in immediate danger and who are in need of urgent but not immediate medical care should be treated next.
   c. Injured persons requiring only minor treatment can be treated later or by relief workers.
   d. Psychologically traumatized individuals who do not require treatment for bodily harm might need reassurance or sedation if acutely disturbed.
   e. Patients whose condition exceeds the available therapeutic resources, who suffer from extremely severe injuries such as irradiation or burns to such an extent and degree that they cannot be saved in the specific circumstances of time and place, or complex surgical cases requiring a particularly delicate operation which would take too long, thereby obliging the physician to make a choice between them and other patients may be classified as 'beyond emergency care'.
   f. As cases may evolve and thus change category, it is essential that the situation be regularly reassessed by the official in charge of the triage.

The following statements apply to treatment beyond emergency care:

   g. It is ethical for a physician not to persist, at all costs, in treating individuals 'beyond emergency care', thereby wasting scarce resources needed elsewhere. The decision not to treat an injured person on account of priorities dictated by the disaster situation cannot be considered a failure to come to the assistance of a person in mortal danger. It is justified when it is intended to save the maximum number of individuals. However, the physician must show such patients compassion and respect for their dignity, for example by separating them from others and administering appropriate pain relief and sedatives.
   h. The physician must act according to the needs of patients and the resources available. He/she should attempt to set an order of priorities for treatment that will save the greatest number of lives and restrict morbidity to a minimum.



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