Forensic Genetics and Legal Medicine 2019-2020

20th May 2020

Forensic Pathology

The pathophysiology of death

Death is the irreversible cessation of all vital functions especially as indicated by permanent stoppage of the heart, respiration, and brain activity.

Postmortem changes constitute the natural progression of the body's decomposition after death, beginning at the cellular level.

The process involves complex cellular and biological phenomena. The changes that commence immediately after death continue to occur over a prolonged period at different rates for different organs.

Post mortem changes

- Immediate changes (stoppage of the function of the nervous system, stoppage of circulation and respiration)
- Early changes (facial pallor, loss of elasticity of the skin, primary relaxation of muscles, changes in the eye, cooling of the body, postmortem staining, postmortem rigidity)
- Late changes (putrefaction, adepocere, mummification)

Postmortem staining- Hypostasis

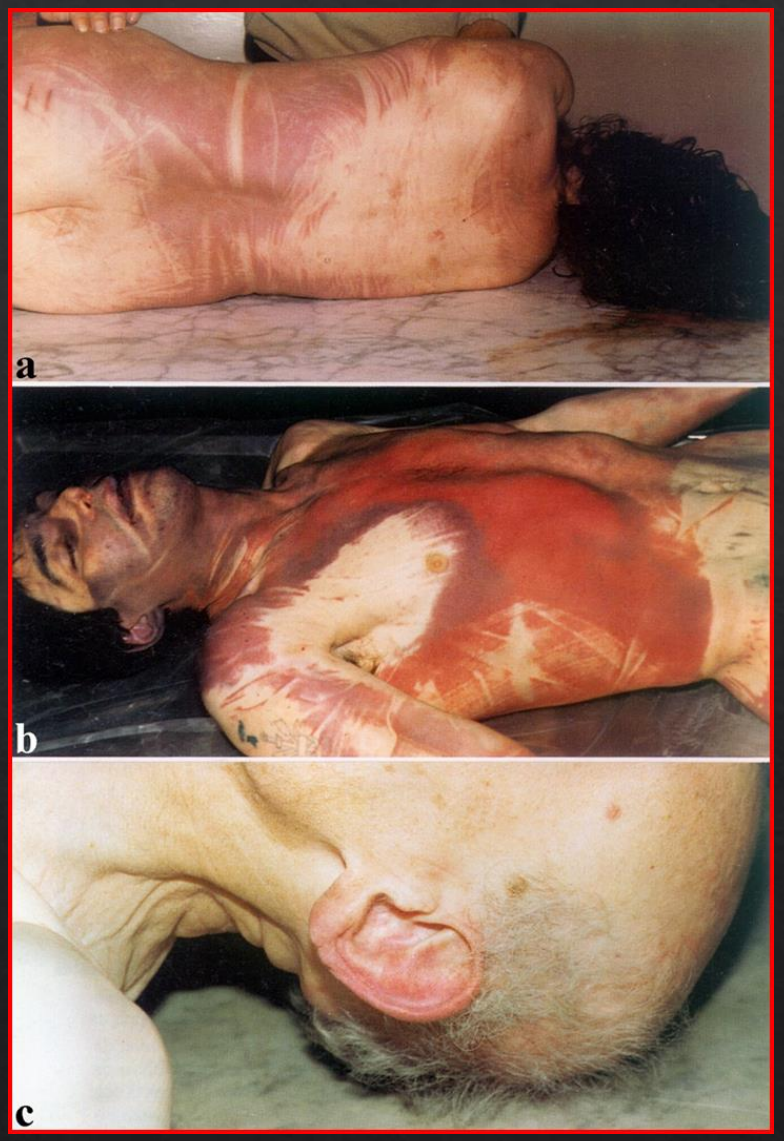
Cessation of circulation and loss of muscle tone after death allows blood within vessels to 'settle under gravity', producing a pink/ purple color in those areas of the body that are lowest, or 'dependent'.

In a body lying on its back, the back of the body show hypostatic discoloration, save for those areas compressed by direct contact with a firm surface, such as the gluteus and shoulder blade regions, for example.

Livor mortis starts in 20–30 minutes after death. The size of the patches increases in the next three to six hours, with maximum lividity occurring between eight and twelve hours after death. The intensity of the color depends upon the amount of reduced hemoglobin in the blood.

Color:

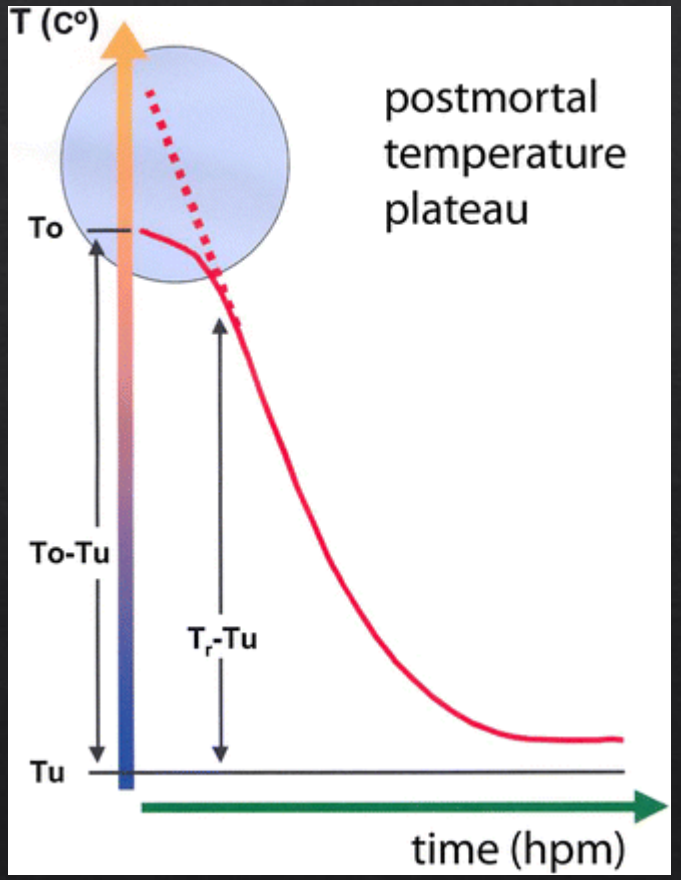
1. Bluish red (normal color)
2. Cherry red (CO poisoning)
3. Light red (corpses exposed to a damp/cold environment)
4. Dark purple (hypoxic deaths).
5. Dark blue/pink (cyanide poisoning)



Cooling of the body- Algor Mortis

Algor mortis is translated from Latin as "**cold death**" and describes the temperature change after someone has died. After death, individuals no longer produce body heat or cooling mechanisms and the decedent temperature slowly approaches room temperature.

The temperature decreases by 0.5 °C in the first 3 hours; by 1 °C/h during the next 6-12 hours; then it decreases slowly until the body reaches room temperature.



The rate at which a body cools after death depends on the following;

1. mass of the body;
2. surface area of the body;
3. body temperature at the time of death (37°C is used as the expected temperature, but this may not be correct);
4. site of reading of postmortem body temperature;
5. posture of the body;
6. clothing and coverings;
7. obesity (fat insulates);
8. environmental temperature and micro-environment (rain, humidity, etc).

postmortem rigidity- Rigor Mortis

It is one of the recognizable signs of death, characterized by stiffening of the limbs of the corpse caused by chemical changes in the muscles postmortem. Rigor develops at the same time throughout the body, but is detected most rapidly in small muscles, such as around the eyes and mouth.

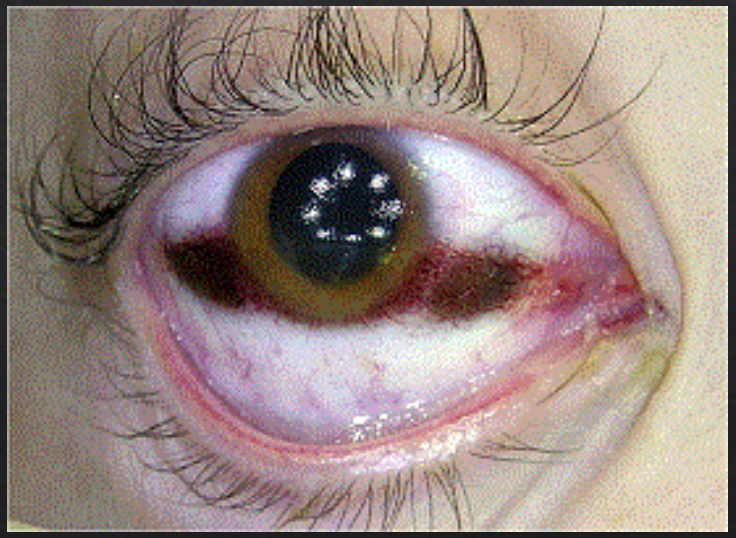
Rigor spreads to involve the whole muscle mass and it might be expected to reach a maximum within 6-12 hours in average conditions. The duration of full rigor maybe 18-36 hours, until it begins to fade in roughly the same order of muscle groups as it has appeared.

FACTORS AFFECTING RIGOR MORTIS:

1. The temperature around the body will either increase the rate of rigor (hot) or slow it down (cold).
2. Illnesses that already cause the body to have increased amounts of acid in the muscle tissue (higher concentration) will increase the rate of rigor.
3. Strenuous activity right before death will also increase the rate of rigor since activity also increases the amount (concentration) of acid in the muscles.
4. If the body is manipulated during the process of rigor, forced to move or bend despite being stiff, the rigor is broken and will not reform back to normal standards.

POST MORTEM CHANGES IN THE EYE

Numerous ocular changes are observable after death, which includes corneal opacity, loss of pupillary and corneal reflex, and loss of intra-ocular tension that leads to ocular flaccidity. The first is corneal clouding. About two hours after death, the cornea becomes hazy or cloudy, turning progressively opaquer over the next day or two. If the eyes are left open after death, there is a deposition of dust in the exposed part of the eye. This dust, along with the cellular debris and mucous manifest as a yellow triangular region on the exposed sclera which is known as 'Tache noir de la sclerotique.'



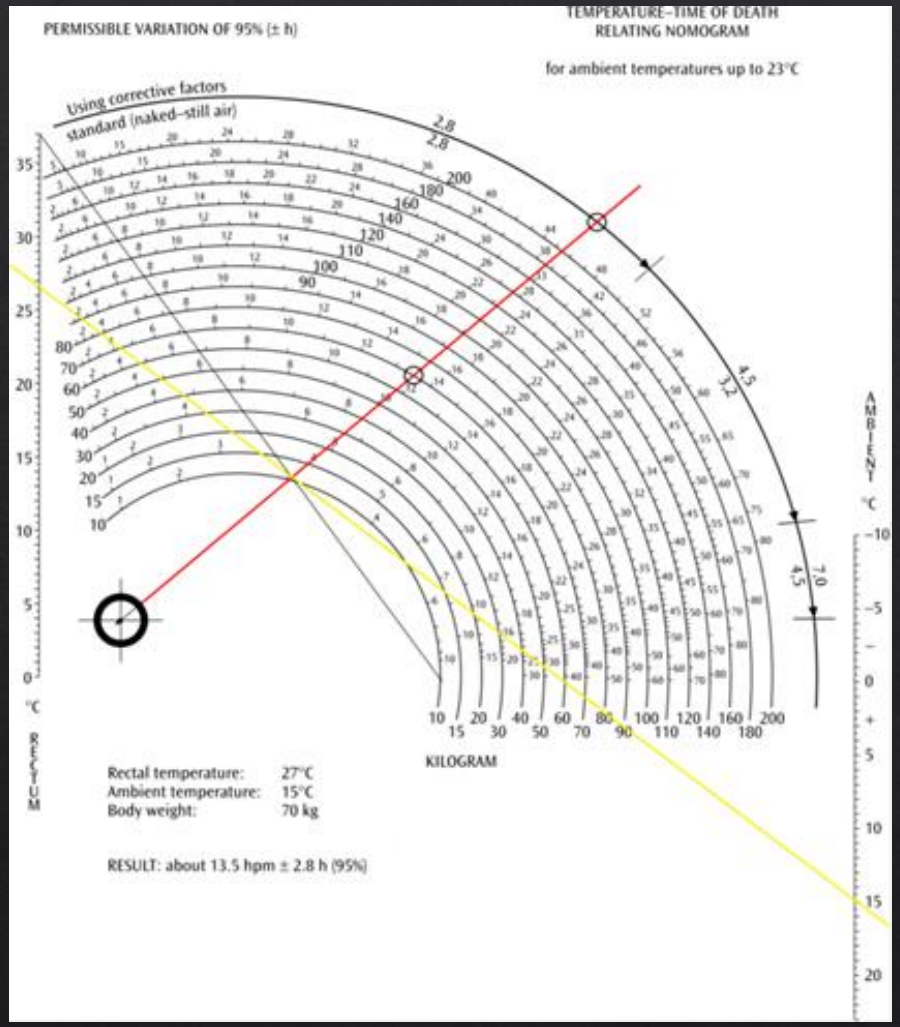
A way the eye can help determine the postmortem interval is through the measurement of **potassium levels** in the vitreous humor. After death, blood cells in the body break down and release potassium. In the eye, this process happens more slowly and at a more predictable rate than in the blood. It's also a process that's unaffected by temperature. Thus, a pathologist can sample the potassium level in the vitreous humor and use that value to calculate an approximate time of death.

DETERMINATION OF THE POST MORTEM INTERVAL: IS IT POSSIBLE?

Any determination of the post mortem interval, based on an examination of the body, must necessarily be made with extreme caution, and requires the pathologist to assess the overall appearance of changes to the body in order to give an overall assessment of the likely timeframe involved.

Various parameters are currently used to estimate the time of death including:

- Body cooling, postmortem lividity, and radiocarbon dating, which are predominantly
- Rigor mortis and supravital reagibility of skeletal muscle, which are physicochemical processes;
- Putrefaction, which is mainly based on bacterial processes;
- Chemical methods, and
- Entomology.



Nomogram Henssge

The nomogram is valid for the chosen standard conditions of cooling (naked body with dry surfaces, lying extended on a thermally indifferent base, in still air) and it can give some information about post mortem interval.

In this nomogram we evaluate:

1.Body weight

2.Rectal temperature

3.Ambient temperature

Madea, B. (2016). Methods for determining time of death. *Forensic Science, Medicine, and Pathology*, *12*(4), 451–485. https://doi.org/10.1007/s12024-016-9776-y

PUTREFACTION

- Dead bodies are eventually broken down into their constituent components. Decompositional change is important in the forensic context, not only when considering how long an individual has been dead for, but also in the recognition of natural phenomena that do not imply an unnatural death.
- Soft tissues degrade and liquefy over some time, the rate of progress of which is temperature-dependent. The warmer the environment in which the body lies, the more rapid the liquefaction occurs.
- Dead bodies degrade at different rates depending upon the medium in which they are placed; immersion in water slows the process, whilst burial slows the rate even more. Casper's law traditionally stated that 1 week in air = 2 weeks in water = 8 weeks buried in the earth.

STAGE OF PUTREFACTION

1. In temperate climates, the skin of the lower right abdomen (overlying the caecum which contains gut bacteria in abundance) turns green after 3-4 days.

2. Bacteria multiply within the vasculature, and their presence leads to hemolysis and decomposition of the blood within those vessels. This process can be seen as discoloration of the vessels ('marbling').

3. Skin breaks down, leading to blistering and skin slippage, and bacterial growth in soft tissues, with gaseous formation, leads to 'bloating' of the body. Internal pressures build-up, forcing decomposition fluids from the lungs through the mouth and nose ('purge fluid'). This purge fluid is often misinterpreted as bleeding from injuries by laypeople. In the summer this stage appears after 3-6 days (and lasts for 2 weeks), in the winter it appears after a few weeks (and lasts a few months).

4. In advanced decomposition, the flesh on the body collapses due to body gases escaping, with a caving in of the abdominal cavity, often accompanied by extensive maggot activity. The remaining flesh can be black. Usually this stage takes 3-5 years to complete.

5. During skeletonization, the tissues undergo liquefaction. Decayed tissues liquefy and penetrate the surrounding dirt matrix. Bone becomes dry, with some remaining human grease. Finally, the bone becomes a dry bone skeleton. This process takes place under the earth in 10-15 years or buried in 20 years.

PARTICULAR FORM OF PUTREFACTION

1 FORMATION OF ADIPOCERE: When the environmental conditions are moist (in earth burial for example), body fats can saponify, leading to adipocere formation. This is a pale waxy substance that becomes brittle over time and can preserve the outline of a body structure.

2 MUMMIFICATION: When a body lies in dry conditions it may desiccate instead of putrefying, a process called mummification. Mummified tissues are dry and leathery, and often brown. Mummification commonly occurs in warm and hot climates, such as in the desert, but if the micro-environment is dry enough, it can occur anywhere in the world.

3. DECOMPOSITION IN CORPSES BURIED IN ZINC COFFIN: Sort of moist mummification in which the skin remains relatively soft and elastic (such as leather).

Forensic traumatology

Study of the effects produced by the impact of moving objects against the body, or the impact of the body against any object or surface.

The purpose is to determine:

- nature of trauma and type of object
- circumstances of the event (natural or violent death, murder/suicide/accident)
- relevance according to the law (crime? In the living: severity and consequences of injury)
- timing of trauma (vital/postmortem, estimated time of the event)

Blunt force trauma

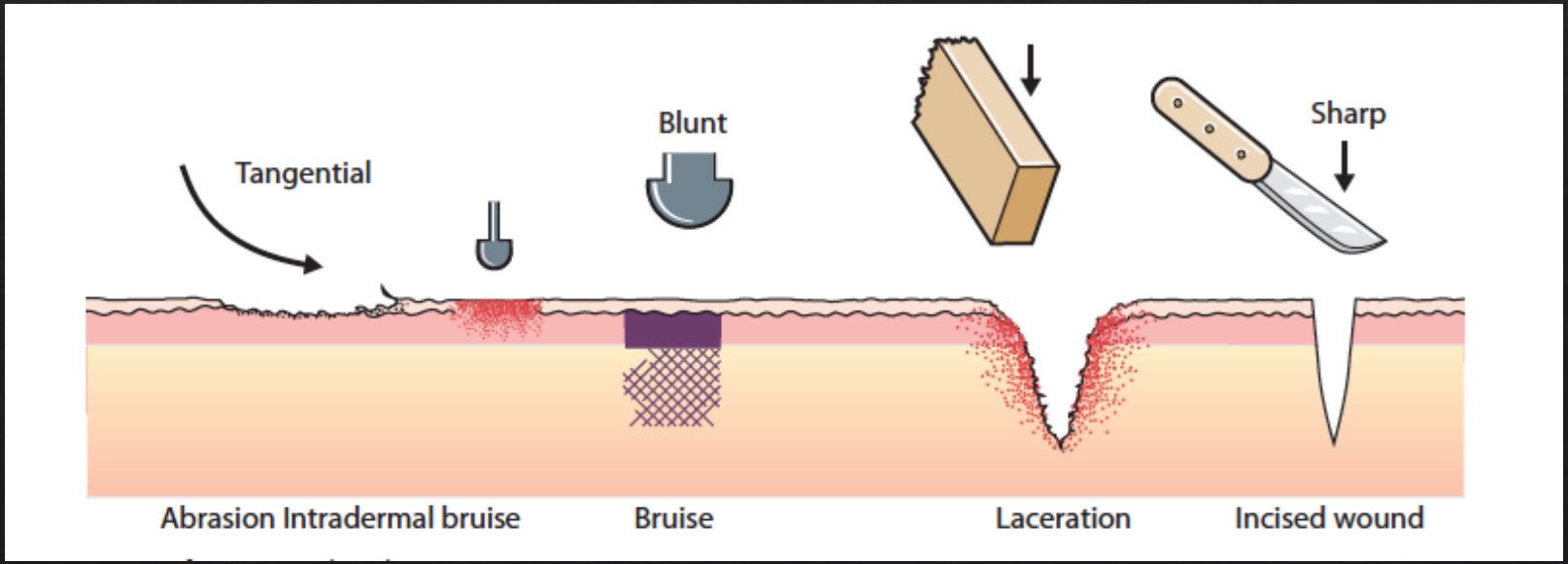
Blunt injuries are caused by a mechanical force *(contusive action)* applied on the human body by an object or by the body itself against a physical resistance.

Blunt instrument could be:

- Natural object (ex: hands, elbows, stones);
- Artificial object:
  - Various object used occasionally (book, bottle)
  - Offensive means (truncheon, iron club)
  - Work tools (hammer)

Blunt trauma Classification

- Abrasions
- Bruising
- Lacerations/ lacerated and bruised wounds
- Bone fractures



Abrasions

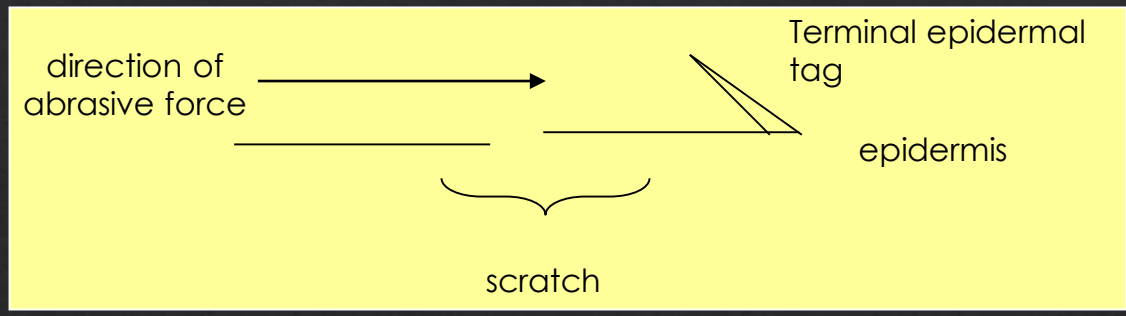
Definition: *superficial injury to the skin that does not penetrate the full thickness of the epidermis.*

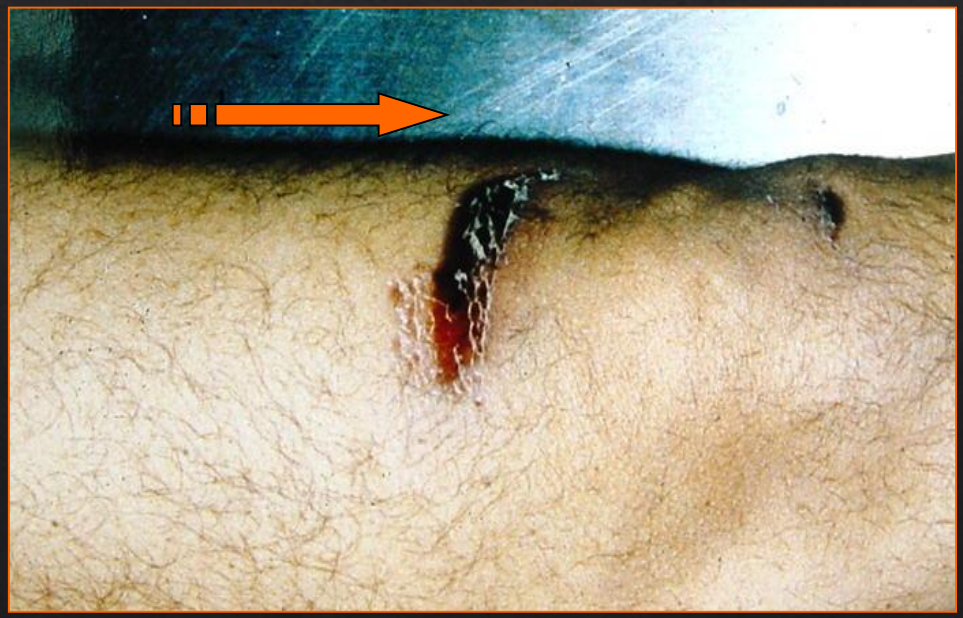
Injurious mechanism:

- *compression* (crushing abrasion: lesion can reproduce the morphology of the object involved, like fingernail abrasion)
- *sliding* (tangential friction on the surface of the skin, like scratch; lesion does not reproduce the morphology of the blunt object but its action)

Abrasions: Direction

Epidermal tags raided by the impact tend to pile up at the distal end.





Crushing Abrasions

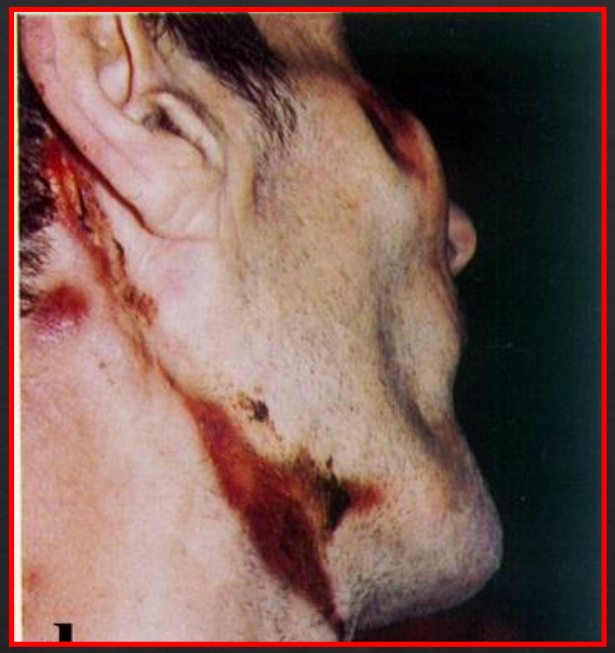
Vertical impact to the skin surface → no scrapping or tangential marks, but an imprint of the impacting object is stamped on the surface.

Small area of contact: punctured wound.

Large area of contact: crushed abrasion.

The lesion is slightly depressed below the surface unless an underlying bruise or local oedema bulges the tissues. These abrasions are the ones that most reproduce the pattern of the injuring object.

Examples: marks of a vehicle radiator on a pedestrian victim or hanging ligature mark

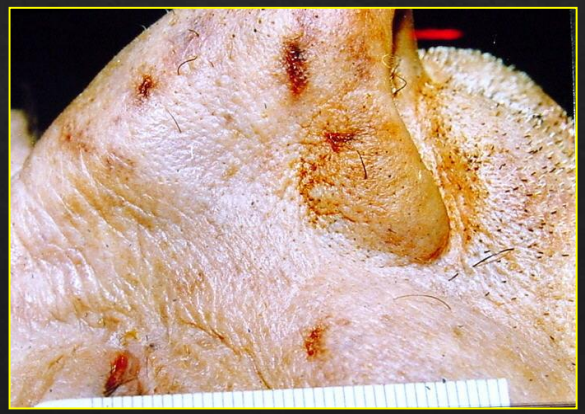


Fingernail Abrasions

Fingernail abrasions are important because of their frequency in assaults *(child abuse, sexual attacks and strangulation)*. They may be linear scratches if the fingers are drugged down the skin, or short, straight or curved marks when the skin is gripped in a static fashion.

Most common areas:

- ✓ *Neck*
- ✓ *Face*
- ✓ *Upper arms*
- ✓ *Forearms*



Bruising/Contusion

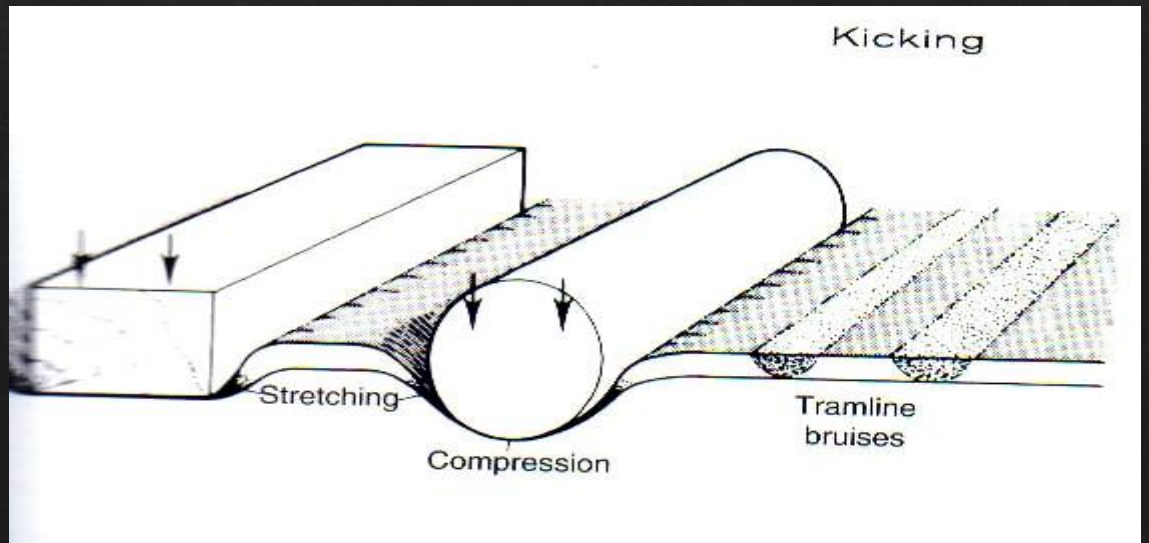
Definition: *a pure bruise/contusion lies beneath an intact epidermis and consists of an extravascular collection of blood (larger than a few millimetres in diameter) that has leaked from blood vessels damaged by mechanical impact.*

An ecchymosis is a really small bruise and the petechial haemorrhage is even smaller.

Bruising/Contusion
Injurious mechanism

Injurious mechanism:

- *compression*
- *traction*
- *pressure imbalances (sucking: local aspiration, with the consequent decrease of the atmospheric pressure on the vessels, causes the vascular walls to tear due to the blood pressure remaining unchanged; straining: produced in conditions that impede venous return with the consequent increase of venous pressure and rupture of the vessels eg. dot-like subconjunctival ecchymosis in mechanical asphyxia)*



Bruising/Contusion:
Classification

Depending on the shape, bruising can be classified as follows:

- dot-like petechiae (subconjunctival in mechanical asphyxia)
- suffusions: blood extravasation in laminar arrangement
- 'hickeys': confluence of small bruises
- 'tramline' bruises: linear spillage (a stick blow causes parallel linear "track" bruising)

Bruising/Contusion:
Classification

- mold-like: reproduce the shape of the object (e.g. tire tread)
- handprints: reproduce the action of grabbing with one or both hands (throttling)
- hematomas: massive blood collections in pre-existing (subdural hematoma) or newly formed cavities (muscle trauma)

Bruising/Contusion:
Classification

Depending on the depth, bruising can be classified into:

- superficial: in the form of flat spots, initially red-purple, with blurred margins, visible on intact skin (N.B. in some cases they are not directly visible, like on the scalp: only after skinning the skull, hemorrhagic suffusions or actual hematomas can be identified);
- deep: not visible on the surface, but identifiable only after cadaveric dissection
  - muscle (of the neck in choking)
  - brain (small 'hickeys' in the cortical gray matter)
  - extradural (rupture of the middle meningeal artery branches)
  - subdural

Bruising/Contusion:
Evolution

Bruise **appearance** is usually immediate.

In the living, bruising goes through **changes of color** as a result of hemoglobin transformation. This is important to establish the bruising timing:

- red-violet: after few hours
- greenish: 6-8 days
- yellowish: 8-12 days

The complete chromatic evolution takes about two weeks; however, variability is enormous due to size and individual features. In specific areas, color evolution is peculiar: under the *nails*, bruising remains blackish due to the absence of catalytic enzymes , at the *conjunctiva* the color is bright red due to the constant re-oxygenation of blood.

Bruising/Contusion:
Migration

Bruising can **migrate**: deep extravasation can move to the surface sometime after trauma, and towards a place far from the point of impact of the blunt object. The reason is that blood follows paths of least resistance between muscles or *fasciae*. Typical is, for example, the appearance of palpebral bruising as a result of fractures of the cranial base.

Bruising/Contusion versus Hypostasis

Bruises are typically **vital lesions** because blood circulation is necessary to produce extravasation.

Sometimes bruising may be confused with hypostatic spots. So, it is useful to incise the skin: in hypostasis, blood flows and is removable by washing; in bruising instead the blood does not flow but infiltrates the tissues and can not be washed away.

Lacerated and bruised wounds
Definition and mechanism

Definition: *injuries produced by a force that exceeds the resistance of the skin, so its full thickness is penetrated. Unless great force is used, most lacerations require a firm base: scalp, shins, shoulder, face and thorax.*

Injurious mechanism:

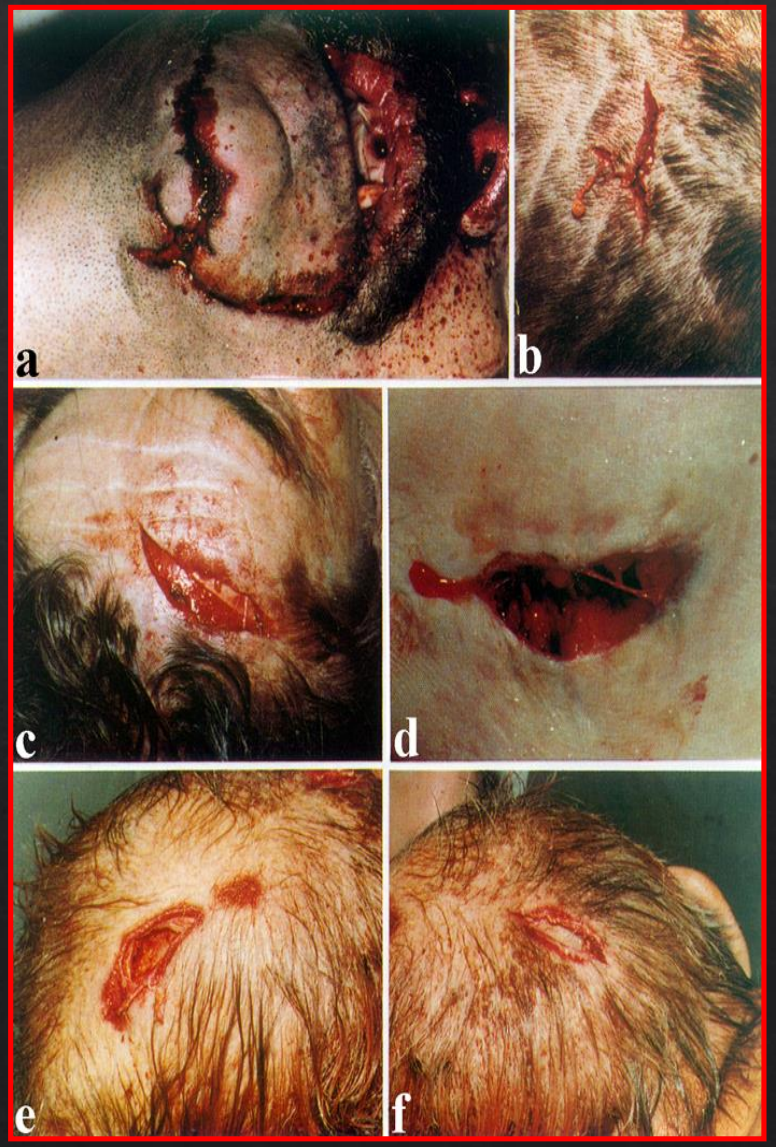
- *compression* (on the skin around bones, like the skull, caused by objects like bottles or sticks that can cause a "burst" mechanism: the interruption of the skin is not limited to the point of contact with the object, but it extends in both directions as a crack)
- *traction*

Lacerated and bruised wounds

Features

The main features are:

- irregular edges
- contusion of edges (excoriated area on the point where the force has been applied; absent in the parts of “burst" wounds not directly in contact with the blunt instrument;
- detachment of skin from the underlying layers with retracted edges)
- presence of "bridges" of fibrous connective tissue linking the opposite edges of the wound (important for differential diagnosis with cut wounds)
- shape rarely reproduces the blunt instrument, with exceptions of hammers or bites.



Lacerated and bruised wounds versus Incised wound

A **laceration** can be distinguished from an **incised wound** by:

- the bruising and crushing of the margins;
- the persistence of tissue strands across the interior of the wound, including fascial bands, vessels and nerves, in a wound from a sharp weapon these are divided;
- the absence of a sharply linear injury in the underlying bone, especially if it is the skull, a knife or ax is likely to chip or score the base of the wound;
- if the area is covered with hair intact hairs will survive to cross the wound, an incised injury would divide them.

Visceral contusion

Typical of major trauma, but also observed in local traumas such as punches, kicks or falls with or without superficial injuries.

The cause can be:

- impact (the most "fragile" organs are spleen and liver)
- crushing
- traction of organs, such in sudden decelerations (precipitation, car accident) especially in heart or liver ruptures
- burst of hollow organs (in charred corpses)

Bone fractures

The effect can be:

- direct (force directly on the bone fracture point)
- indirect (transmission/flexion/torsion)

Depending on the morphological features, fractures can be classified in:

- closed/exposed
- complete/incomplete/fragmented/comminuted
- oblique, spiral

Skull Fracture

Particularly relevant in forensic medicine

Skull fracture: an indicator of the severity of the force applied, if it is sufficient to produce fracture rarely doesn't cause intracranial damage

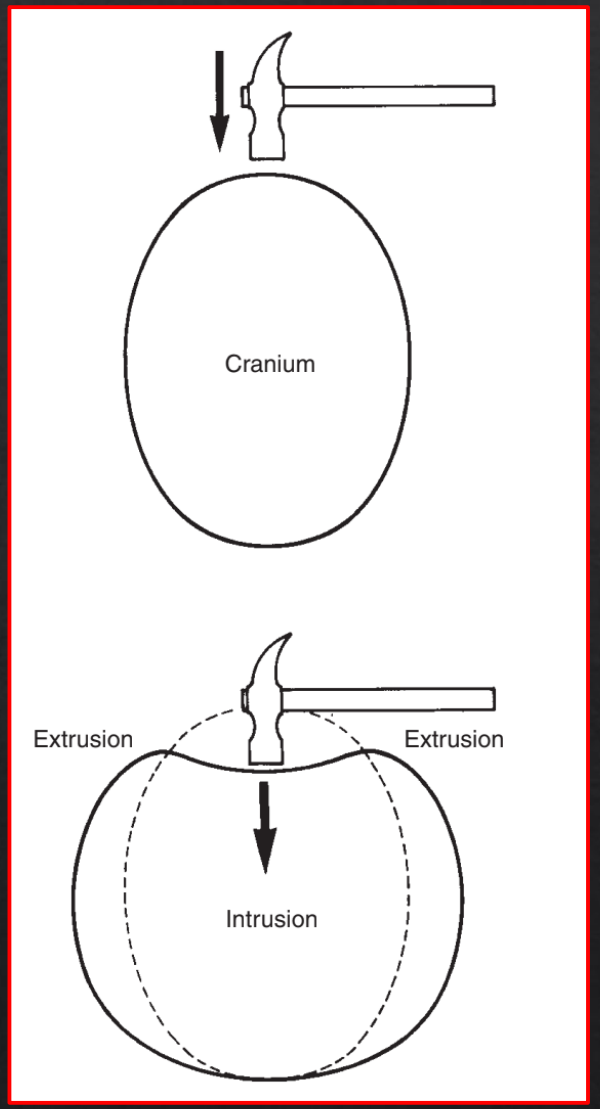
More vulnerable areas: thin areas (parieto-temporal, lateral frontal, lateral occipital)

Focal impact:
momentary distortion of the shape of the cranium.

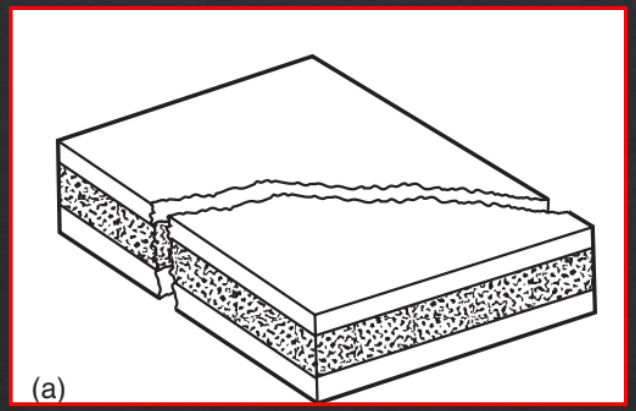
- area under the point of impact bends inwards
- compensatory bulging of other areas (contents of skull are incompressible)
- both these areas can be sites of fracture if distortion exceeds bone elasticity

Wider impact from blunt injury: a fracture may be remote from the area of impact

Blows in certain areas of the skull: fracture in specific localities (upper temporal/parieto-temporal, "hinge fracture" with heavy impact on the side or top of the head, frontal areas, occiput)

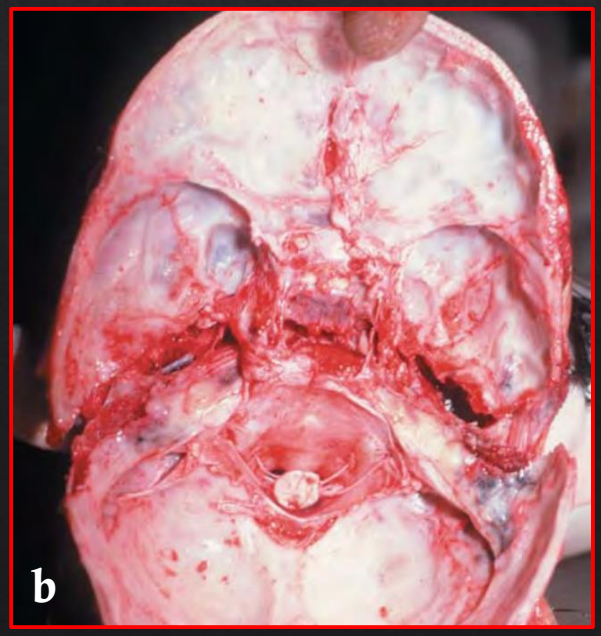


SEVERAL TYPES OF SKULL FRACTURE:



I) Linear Fracture: (Fig. a)

- straight/curved
- commonly traverse both inner and outer table
- most common caused by traffic accidents and falls
- often intracranial injuries
- may occur anywhere but especially in weak unsupported plates (frontal, temporal, parietal, occipital)
- "motorcyclist's fracture": heavy blow on the side of the head. Passes across the middle fossa separating the base in two halves (Fig. b)
- children: fracture may pass into a suture with diastasis (Fig.c)



II) Mosaic/Spider's web: (Fig. d)

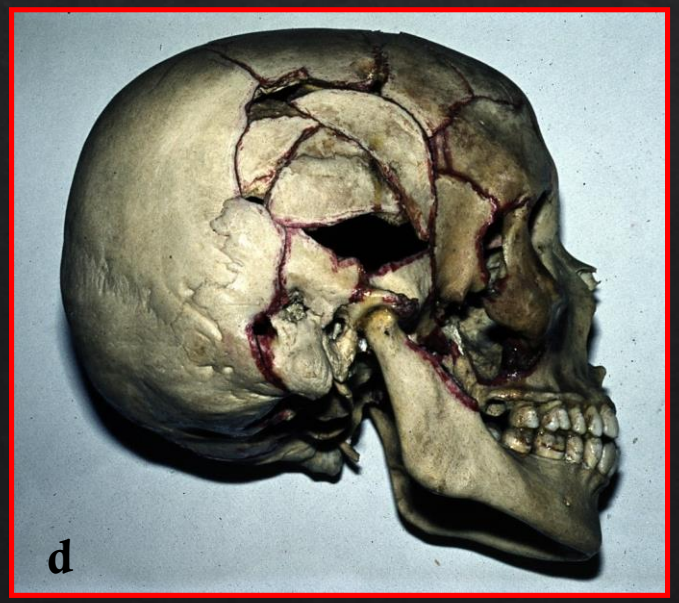
- widespread impact of the cranium against a large surface
- comminuted depressed fracture with fissures radiating from it

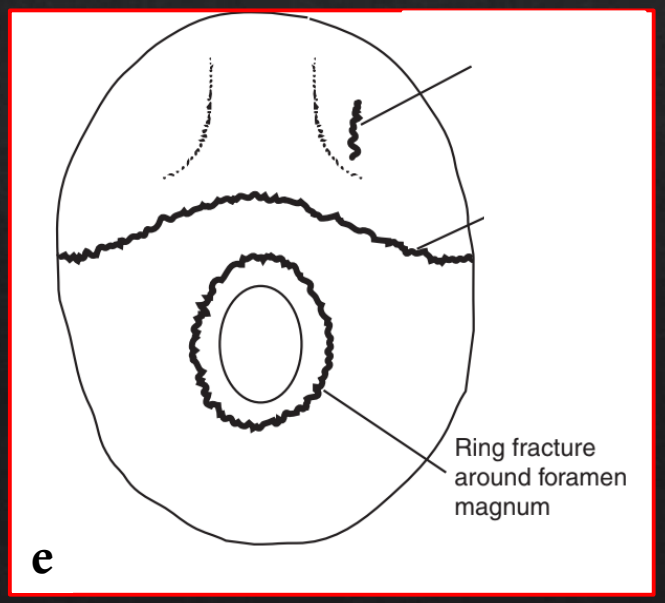
III) Ring: (Fig. e)

- in the posterior fossa around the foramen magnum
- cervical spine may be rammed into the skull carrying a circle of occipital bone
- most often caused by a fall from a height onto the feet

IV) Depressed:

- caused by focal impact
- if it is severe the depressed fracture may follow the shape of the impacting object (Fig. f)





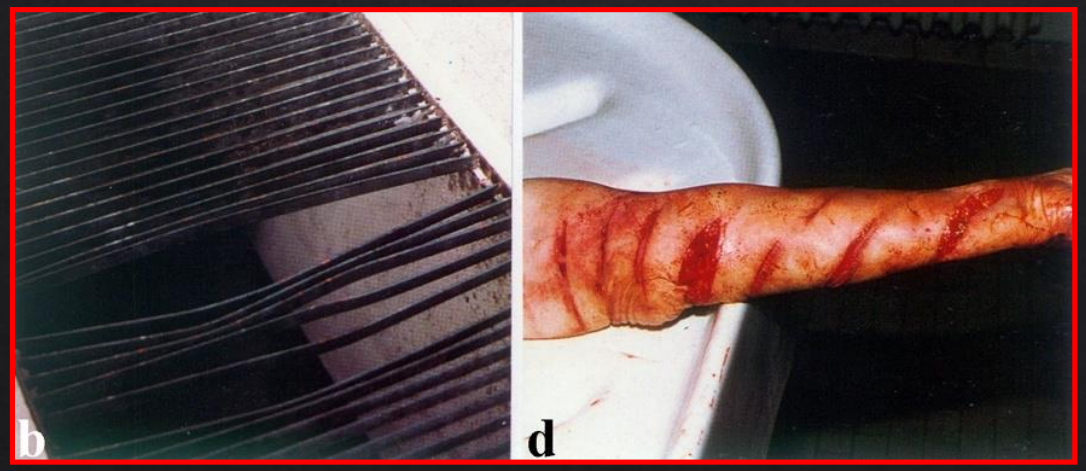
Major trauma

I) Precipitation

When the body falls from a height, so that, for a certain amount of time it is free in the air (to be distinguished from fall, in which the body is at any moment in contact with the ground).

Trajectory: the distance the body strikes the ground is variable (victim falls passively, projected themselves, movements during fall).

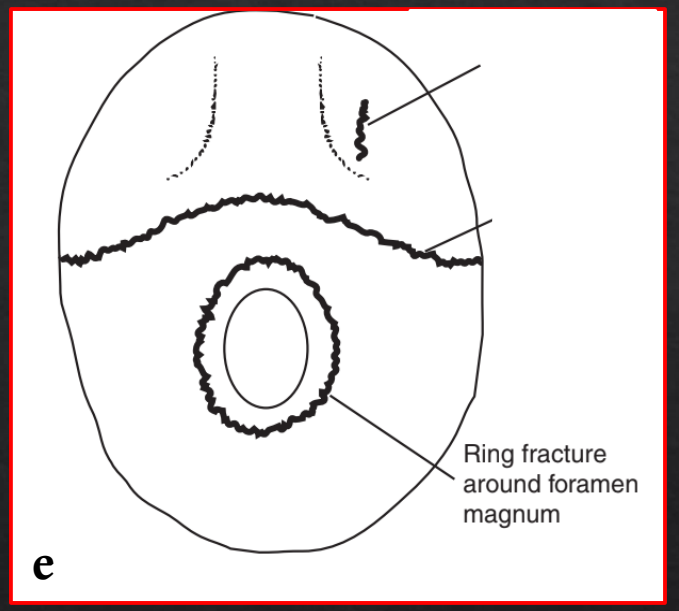
The main feature is the prevalence of internal injuries (bone fractures, ruptured parenchymal organs and tear from supporting ligaments) on the external ones (usually produced from the inside, by the action of bone stumps).



The traumatic effects depend on both the height of precipitation and the characteristics of the impact surface (smooth/rough, hard/elastic), and one impact is more damaging than a series of lesser impacts

Falls on the side of the body:

- produce different combination of injuries
- fracture (multiple of rib, shoulder, gridle, arm)
- lacerations (back, limbs)
- internal lesions (rupture of heart, lungs, liver, spleen)



Falls onto the feet:

- fracture (legs, pelvis, spine, skull).
- Upper vertebrae with a ring of bone around the foramen magnum may intrude into the skull ("ring fracture of the occipital bone", Fig. e)

II) Injuries to pedestrians (collision)

Complex of trauma directly or indirectly exercised on a person from a vehicle in motion.

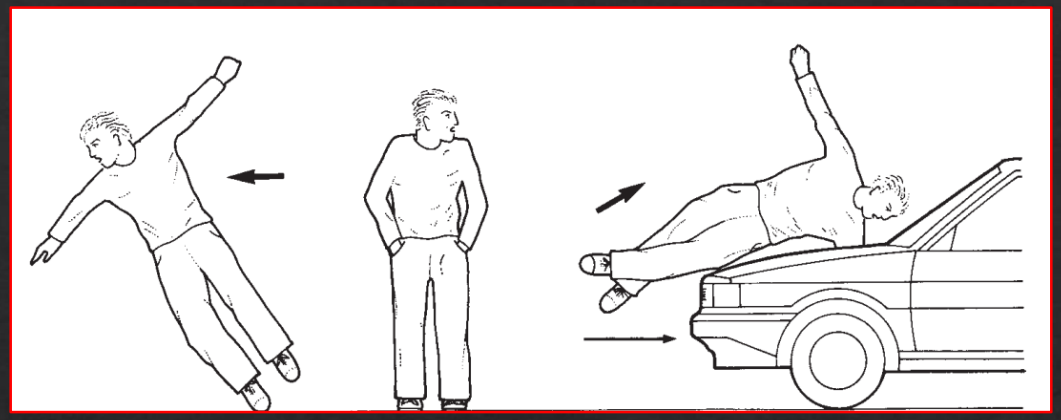
It is possible to distinguish different phases of the collision:

a) primary injuries: when the vehicle comes into contact with the body, usually with the legs ("bumper injury": LBW usually associated with symmetric bilateral fractures of tibia and fibula) (Fig. c)

b) Secondary injuries: caused by the subsequent contact with the ground or when the victim is loaded on the bonnet and receives a serious injury on the chest and skull by the impact against the windscreen, windscreen pillars

Depending on the profile and speeds of the car the pedestrian then can be:

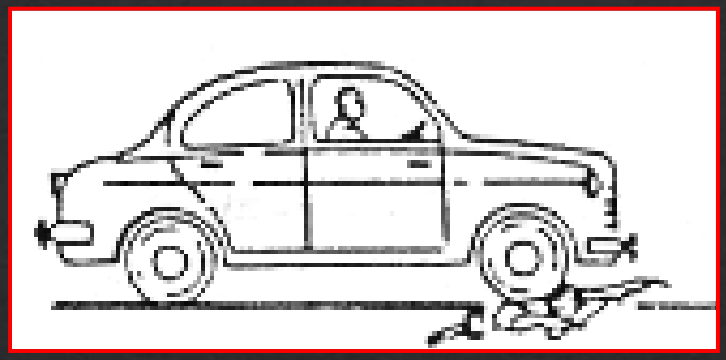
- thrown forwards (bonnet front high)
- scooped up onto the bonnet (speeds >23 km/h)



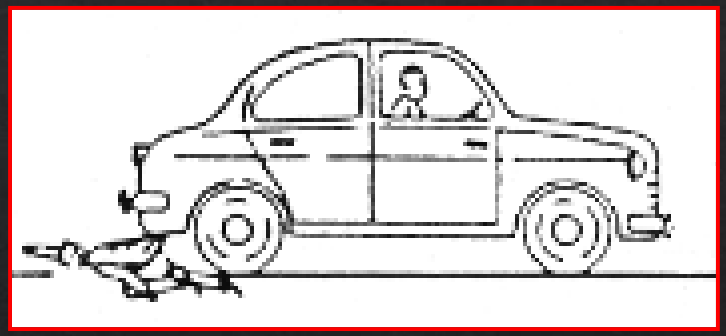
c) knocking over (directly or after scooping up, may be missing if the car is fast enough to throw the victim behind): fractures of the skull, shoulder and hip

d) propulsion: due to the forward push from the vehicle on the body knocked to the ground (typical bilateral and symmetrical bruises on the iliac crest and shoulder) (Fig. f)

e) running over: when, after the propulsion, the vehicle passes with its wheels over the body on the ground (in case of heavy and slow moving vehicles, injuries that reproduce the vehicle patterns can be observed; in the case of car tires, visceral/deep bone lesions are prevalent; if, with braking, a skin flap remains clamped below the wheel, skinning lesions can be observed)



f) dragging: when a body part or clothes remain hooked to the car in motion (superficial or deep excoriations, depending on the duration of the dragging, up to the exposure of soft tissues and bones)



High speed (>50 km/h): the body can be flung high in the air and for a considerable distance.

Although is impossible to estimate the speed of impact from the nature of injuries (these can be fatal even at slow speeds while high speeds can produce occasionally minor damage)

Legs

- The most common region of trauma (85%)
- Abrasions, lacerations, fractures (fig. c)
- Caused by the bumper contact
- Sometimes the level of injuries is too low for the bumper height (may indicate the vehicle was braking violently)

Head

- The next most frequently damaged area
- The one which leads to most causes of death

Other injuries

- Often widespread and may have no particular pattern (because of rotation)
- Fracture (ribs, chest, arms, pelvis). "Flail chest", all ribs are broken on each side on the anterior axillary line
- Internal damage
- Soft tissues (abrasions, bruises, lacerations e.g. muscle)

Patterned injuries

- maybe important in identifying the vehicle
- tyre pattern (the most common, Fig. g), the skin is forced into the grooves with the edge of the raised rubber tracing out the pattern

Heat Injuries

The extent of damage depends upon:

- the applied temperature
- time for which the heat is applied

Reddening/blistering: not always a criterion of vital infliction

A) Scalds (moist thermal damage) (Fig. b)

Caused by hot liquid

Resembles a first-degree dry burn (reddening, desquamation, blistering)

Differences from dry burn:
- doesn't cause charring or carbonization
- shape (usually sharped demarcated edge corresponding to the limits of contact of the fluid)

Water splashed: worst scald at the area of initial contact and decrease in severity as the cooling liquid runs away

B) Burns (dry heat)

More common

Severity: several classifications all indicating the depth of the tissue implicated in the injury:

- First degree: erythema and blistering (Fig. a)
- Second degree: the destruction of the full thickness of skin, epidermis coagulated or charred (Fig. c)
- Third degree: destruction of deeper tissue (subcutaneous fat, muscle, bone) (Fig. e)

The majority are due to high temperature acting for a shorter time if time is extended beyond that needed for initial burning tissues may be charred, carbonized, completely destroyed

Appearance at autopsy

- Wide range of damage (reddening to cremation)
- Surface can be blackened by soot
- Froth: at mouth/nostrils; pink stained; result of pulmonary edema (heat irritation of airways)

Burns more severe:

Skin is stiffened, yellow-brown, leathery

Hair is singed or completely burnt away

There may be involvement of deep tissues (often a post-mortem phenomenon with continuous heat):

- muscle (which becomes pale, brownish, part cooked). Muscle contractures can occur, with a position of general flexion ("boxer's attitude, Fig. f)

- all soft tissues down to bone may be consumed and the bone itself can be involved (blackened, conversion to grayish-white splinters

Spurious wounds in burns

I) Splits: (Fig.a)

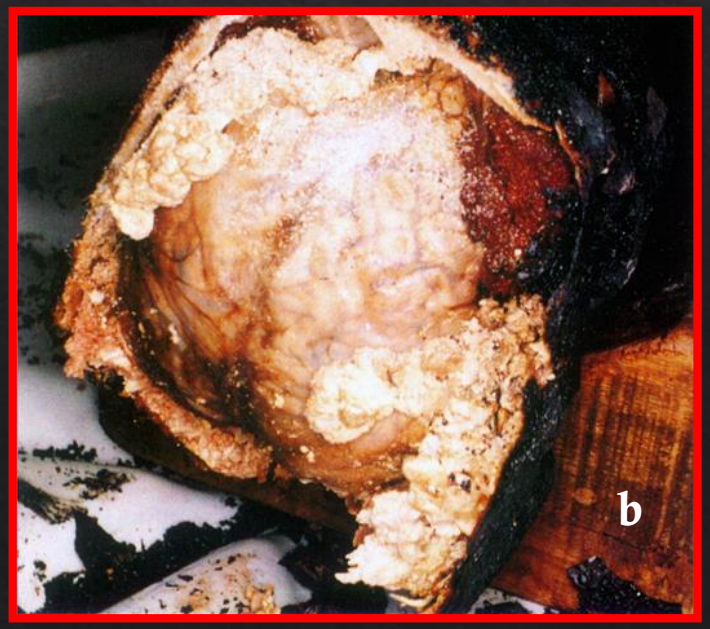
- Especially over extensor surfaces, joints, head
- Differently from true splits: show no bleeding in deeper tissues
- Suggestive position

II) Heat hematoma: (Fig.b)

- In the extradural space when severe heat is applied due to a reduction in brain volume and wrinkling of the dura madre, with a suction mechanism
- Blood spongy (from gas bubbles), tawny/chocolate brown
- Exterior of the skull charred, and scalp burnt away

III) Amputation of hands and feet:

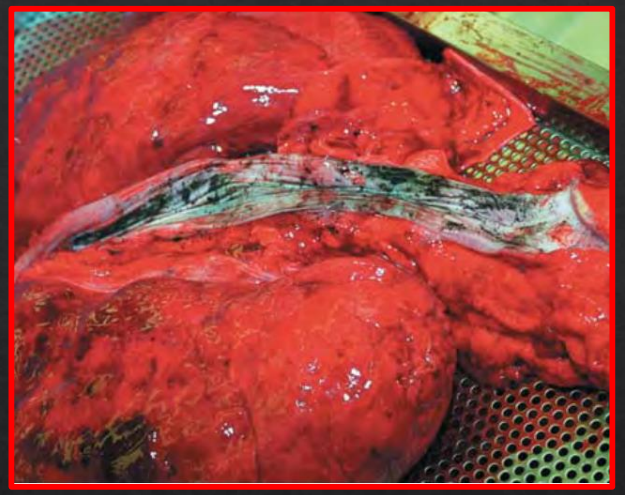
Due to bone charring where the body is less protected by soft tissue layers



Ante-mortem vs post-mortem

Many deaths occurred before the heat reaches the body (e.g. inhalation of smoke)

Reddening and blisters: may be present in both ante and post-mortem burns



Most useful:

- carbon monoxide (circulating blood, hematoma)
- carbon particles (airways in particular lower airways, lungs, stomach)

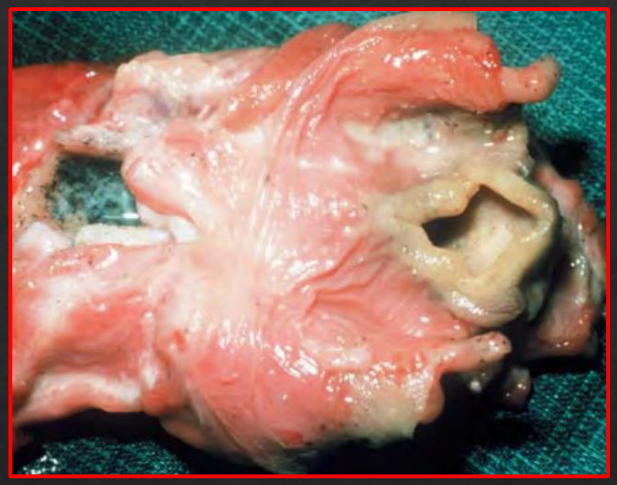
Hematoma:

- absence of HbCO (true traumatic produced before the fire began)
- presence of HbCO (heat hematoma)

However, they don't prove burns were ante-mortem but that the victim was alive when the fire was in progress. Although, if a body in a fire doesn't have HbCO in the blood this doesn't mean the victim has been dead before the fire began.

Fumes and fires

In many conflagrations in buildings death is not caused by burn but by inhalation of fumes by combustion in several ways (thermal damage, carbon monoxide poisoning, other toxic substances in fumes).



Thermal damage (airways, lungs):

- Airways: scorched, greyish-yellow, thickened, reddened
- Lungs: pulmonary edema

Carbon monoxide poisoning:

typical cherry-pink skin, blood and tissues

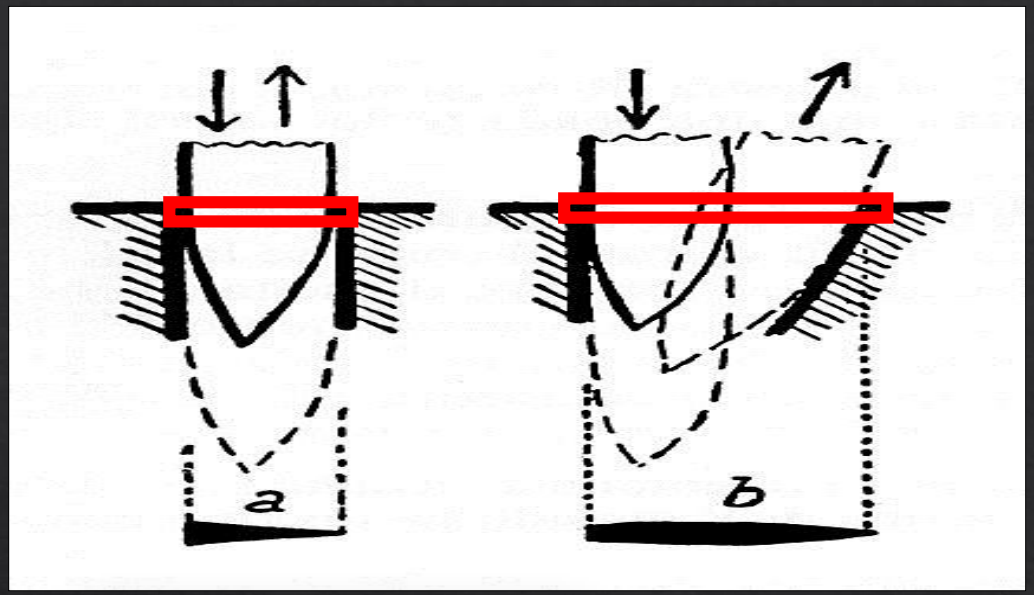
Sharp-force injuries

Tip: Cone-shaped, elongated, pointed tool.
Examples: needles, pins, awls
Mechanism of action: pressure -> penetration -> sinking
Features: more extensive depth compared to the extension on the surface
Physical aspect of the wound: The shape of the external orifice of entrance does not reproduce the section of the tip

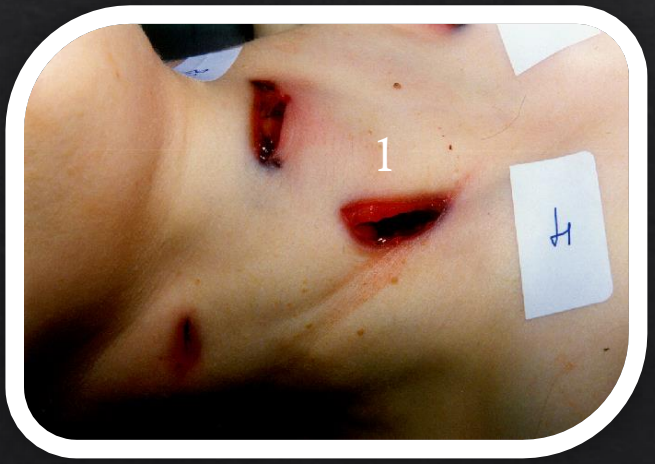
This can be explained because there is a divergence of the fibers, without a full-blown laceration of the same. For the identical reason, there is no loss of substance after pulling together the edges of the wound

Stab wounds

Stab: Knife-shaped, elongated, pointed tools. There's the possibility of changes in direction after the extraction.
Examples: knives
Mechanism of action: pressure -> penetration -> sinking -> any moves during the extraction

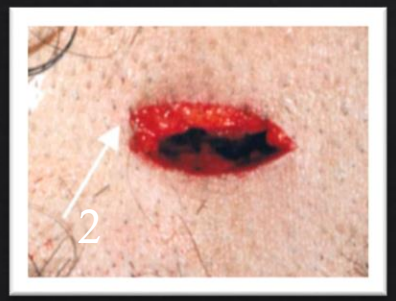


Traits: Clean cut edges, frequently shows notching or a change in direction (caused by relative movement of the knife and body). The shape depends on the extraction of the blade



Physical aspect of the wound: Knives with single cutting edges (e.g., kitchen knives) cause wounds that have a pointed edge, with the opposite edge being squared off (i.e., "boat-shaped[1]") or split (i.e., "fishtail[2]").

A double-edged bladed knife, can cause often gapes[3] (related to skin elasticity and Langer's lines).

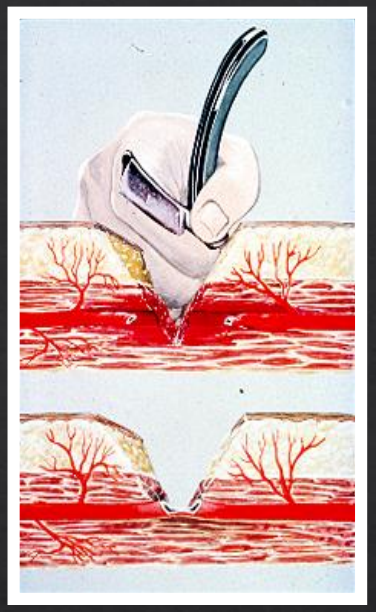


Slash wounds

Cutting edge: A sharp (usually metal) blade on one side and inserted into a handle, used as a tool or as a weapon

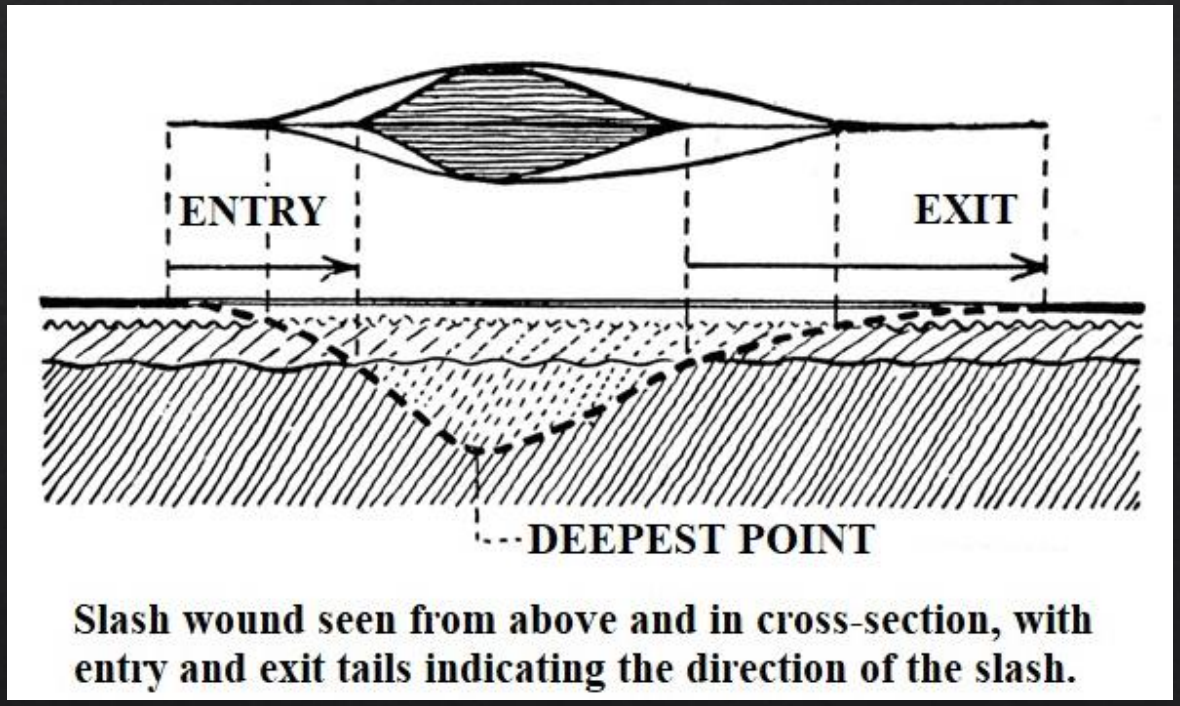
Examples: knives, scalpels, razors

Mechanism of action: pressure -> sliding



Features: more extensive on the surface, compared to the impact in the depth tissues.

Physical Aspect of the wound: The edges are clear and wide. The shape of the cut is linear and thin. The extremities of the cut present a pointed shape (are also called "tails"). No loss of substance.



Slash wound seen from above and in cross-section, with entry and exit tails indicating the direction of the slash.

A lot of variation with regards to the location, direction and depth of the wounds [1-2].

The occurrence of many lesions in the same area, with numerous wounds parallel or confluent between each other (i.e., hesitation wounds[3-4])

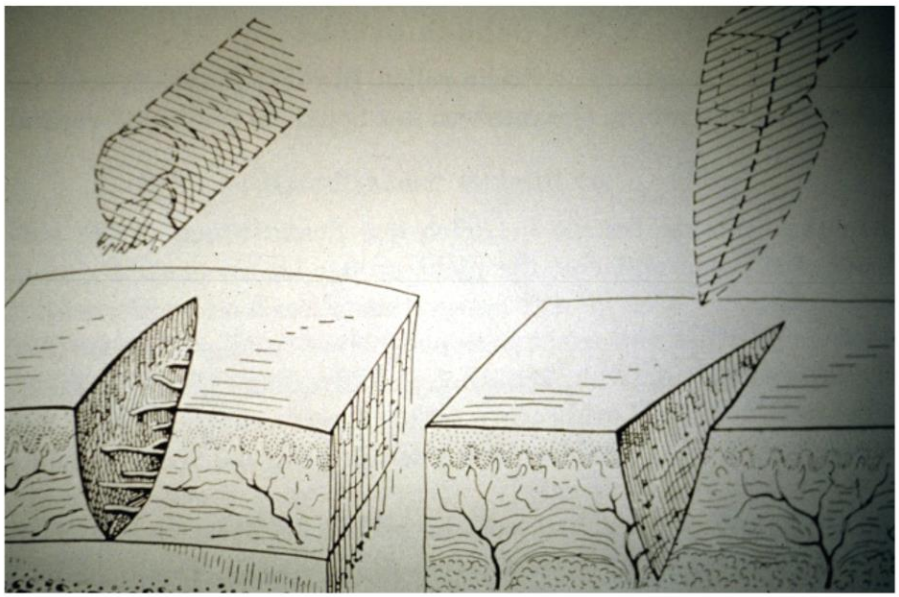
Homicide vs suicide: In the case of the former, the area most frequently hit is the neck. Also referred to as "slaughtering" or "butchering[5-6] "

Chop wounds

Chop: A tool with the combination of sharp and blunt aspects; the sharpness of the cutting-edge influences how clean the wound edges are.

Examples: machetes, meat cleavers, swords, axes, broken glass

Mechanism of action: pressure -> sliding +/- impact



Features: can include extensive soft tissue and bone damage. They represent a combination of sharp and blunt force trauma (the weapon's weight influences the force, which is exerted)

Physical aspect of the wound: The edges of the wounds are sharp, and some exhibit a rim of abrasion, which can reflect the bluntness of the object used, or the presence of rust on the object. Underlying tissue, usually, is cleanly divided, and underlying bones are notched or chipped.

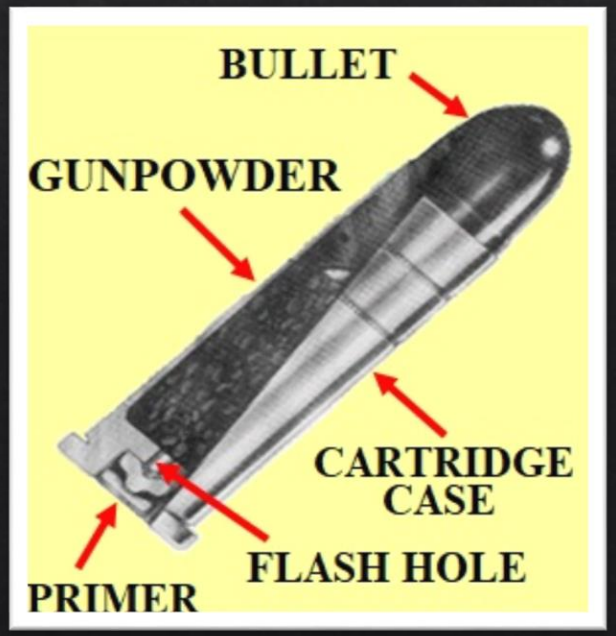
Injuries by special weapons: firearms

Gunshot wounds

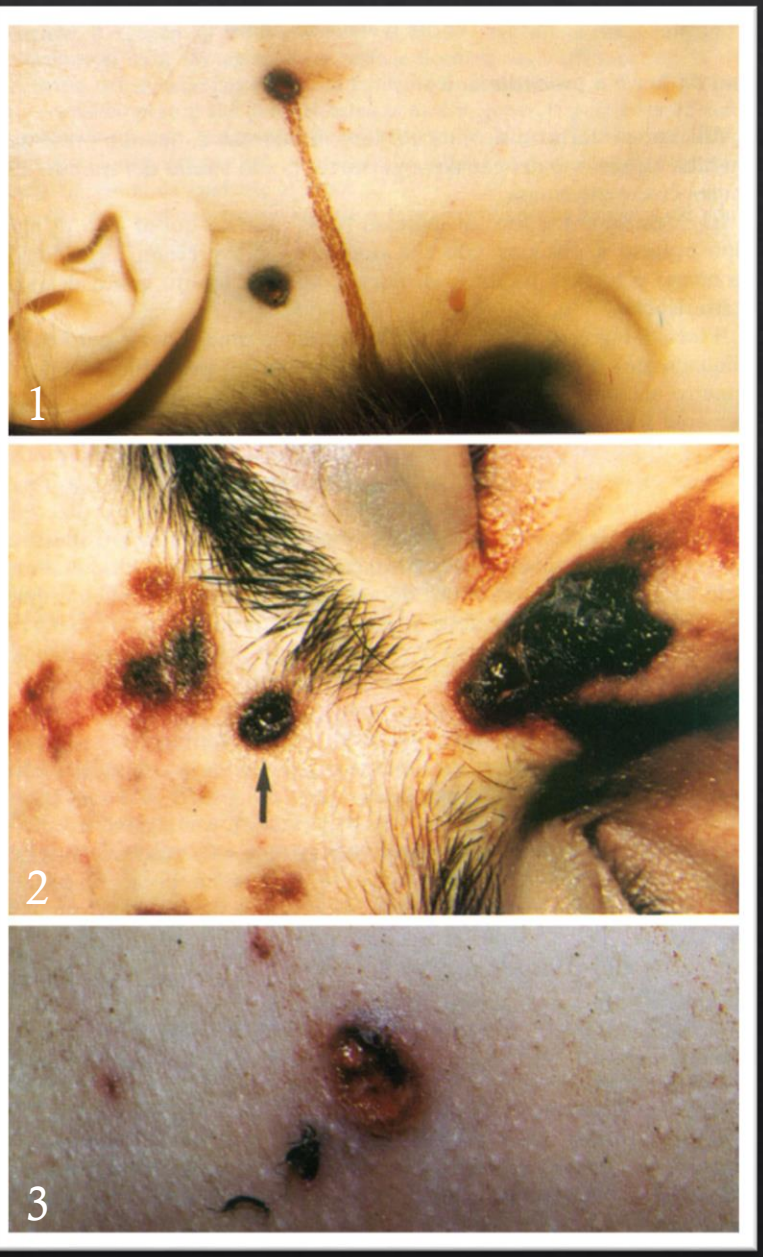
Gunshot wound: The injury is caused by the penetration of one or more bullets into the tissue. The bullet is launched at high velocity by the thrust, which, in turn, is caused by the expansion of gases that are generated from the combustion of gunpowder.
Examples: pistols, revolvers, carbines, machine guns

Composition of the <u>cartridge</u>:

- Bullet: lead core covered by an alloy (more durable)
- Cartridge case: plastic or metal chamber that holds the rear part of the bullet; it contains also the propellant charge (gunpowder) and a capsule with a substance capable of deflagrating by percussion, so that it ignites the powders (primer)



Physical aspect: Signs of a shot fired from > 50 cm – Entry wound



The hole: diameter smaller than that of the bullet; margins finely jagged

Shape:

- Round[1] (if the bullet hits the skin surface with a right angle)
- Oval (if the bullet hits the skin surface diagonally)

Surface of the wound:

Abrasion collar/contusion ring[2]: round/oval excoriated crown, more extended on the side where the shot arrives (caused by the contusive action of the projectile)

Grease ring/ring of dirt[3]**:** may be present on the edge of the hole (if it has not crossed objects capable of wiping it up) and consists of a blackish deposit resulting from material collected during the passing of the bullet through the gun barrel.

Physical aspect: Signs of a contact gunshot wound (range of fire <50 cm)

Effect of the expanding gasses[1]: when the muzzle of the gun is pressed onto the skin, high-pressure gas insinuates between the skin and the bone and then tears the skin ('stellate' configuration). If the shot is fired 5-10 cm near the skin, an excoriation margin with burnt hair can be observed around the entrance hole

The action of the smoke produced by the combustion of the gunpowder (range of fire < 10-15 cm): gray/black soiling[2] surrounding the entrance hole (round or oval), can be washed off

Action of unburnt particles of gunpowder (range of fire < 30-50 cm): dissemination of red-blackish punctate lesions[3] (shape round or oval depending on the orientation of the barrel), cannot be washed off (the particles are stuck in the dermis, like a tattoo)

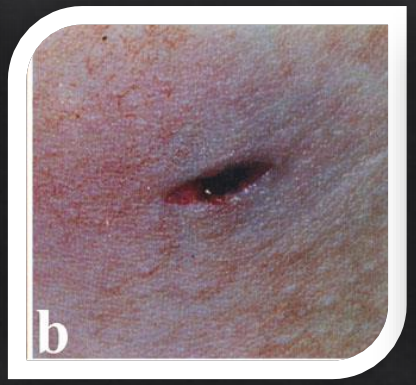
Exit wound

It could be circular, but typically it is torn apart, linear or stellate[a-b-c-d] (because the projectile loses its penetration force when crossing the body), with eversion of the margins and protrusion of connective tissue and fat

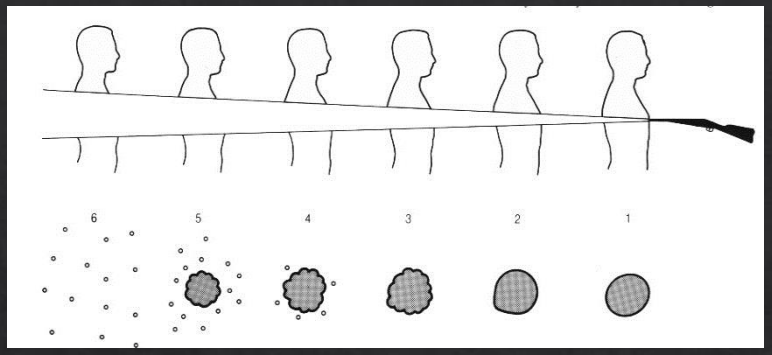
The diameter of the exit is bigger than the entrance hole[a].

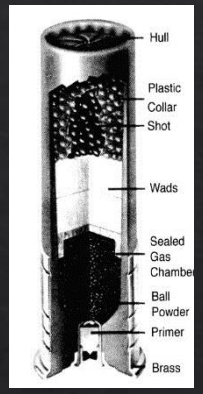
There is no the abrasion collar, but excoriations may be observed if the body lies on a solid surface[e]

In the case of a gunshot to the head, an explosion-like effect from the inside of the cranial vault, with large tissue debris, can be observed[g].



Firearm With Multiple Bullets (Shotgun)



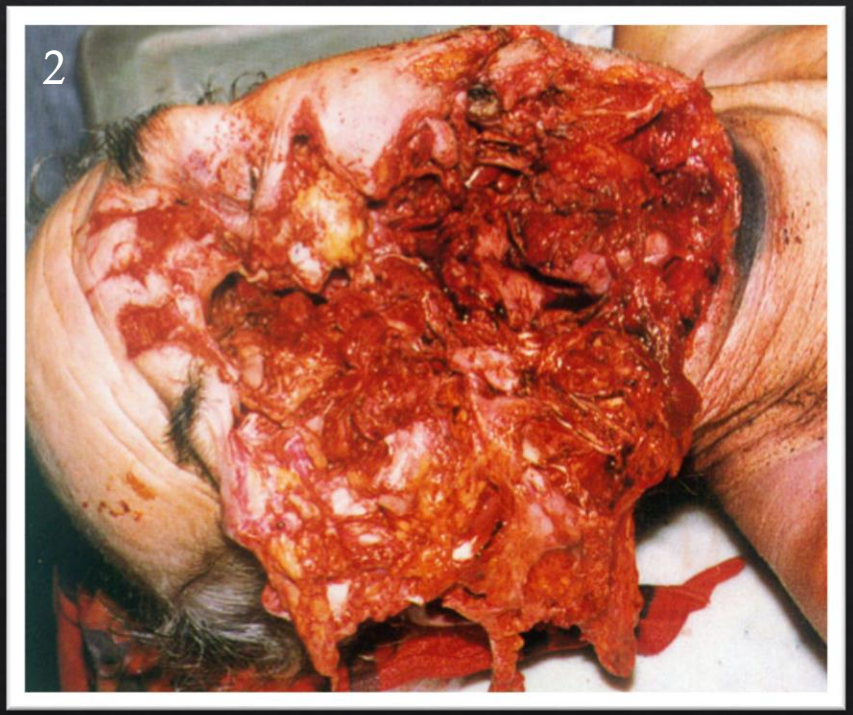


One or more entry wounds, depending on the firing distance; exit wounds are rarely present, due to the poor penetration force of the bullets.

The extent of the surface of the entry holes of the individual pellets is inversely proportional to the firing distance.

For distances > 3 m[1], a spread outshot pattern is visible, composed of individual entry holes (little round blackish areas)

For distances between 3 m and 1.5 m[2], pellets do not have time to spread and so the compacted mass of shots travels as a unit; the lesion is round and surrounded by individual entry holes of peripheral pellets.



At closer distances, a destructive effect[1] with a large loss of substance (especially the head[2]) can occur so that the wound becomes hardly distinguishable from other kinds of major trauma. This is typical of shotgun suicide, in which the shotgun muzzle is applied under the chin.

Pellets or the shot wad (felt or plastic disks that separate the pellets from the powder), which is discharged with the pellets, can sometimes be found inside the wound[3].

ASPHYXIA

Cessation of breathing due to mechanic causes which acts directly on the respiratory system in a violent way.

Different stages of asphyxia

- **Inspiratory Dyspnoea**: reduction of [O2] in the blood causes stimulation of aortic and carotid chemoreceptors. The result is a forced breathing to increase O2 levels in the blood. (Cyanosis, tachycardia, hypertension).
- **Expiration Dyspnoea**: increase of [CO2]. The body tries to remove the CO2 in excess with a forced expiration.
- **Apparent death**: there is a respiratory break (apnoea) caused by lesions of the nervous centres that lead to loss of consciousness
- **Terminal stage**: irregular, afinalistic respiratory activity caused by the residual activity of the respiratory centre damaged by hypoxia, hypotension, bradycardia, cardiocirculatory arrest

Types of asphyxia

- Occlusion of the air passages (mouth, nostrils): SMOTHERING.
- External compression of the respiratory tract: HANGING, STRANGULATION, THROTTLING.
- Respiratory tract internally filled: DROWNING, CHOKING (ASPIRATION OF FOOD, VOMIT, BLOOD)
- Immobilization of the chest: BURIAL, CRASHING IN CROWDS

Signs of asphyxia

- Dissemination and early appearance of hypostatic spots
- Rapid putrefaction
- Pinpoint subconjunctival haemorrhages (eyelids and bulbs)
- Cyanosis of the face
- Slow cooling of the body
- Subpleural spots of ecchymosis, subpericardial petechiae
- Polivisceral congestion

Cyanosis: it depends upon the absolute quantity of oxyhaemoglobin and reduced haemoglobin in the erythrocytes. Any type of congestive death, including primary heart failure, leads to engorgement of the right ventricle and atrium as part of the generalized rise in venous and intracardiac pressure.

Petechial haemorrhages: pinpoint collections of blood (0.1mm – 2mm) lying in the skin, sclera, conjunctive, pleura, pericardium. Petechiae are caused by an acute rise in venous pressure that in turn causes overdistension and rupture of the thin-walled peripheral venules, especially in lax tissues, such as the eyelid, and in serous membranes such as pleura and epicardium.

Congestion and oedema: engorgement of the veins causes swelling of the tissues when the neck is compressed, the face, lips, and tongue become swollen and reddened. The true colour change of congestion is usually darkened by the onset of cyanosis. Internal organs also become congested above the obstruction (tongue, pharynx, larynx).

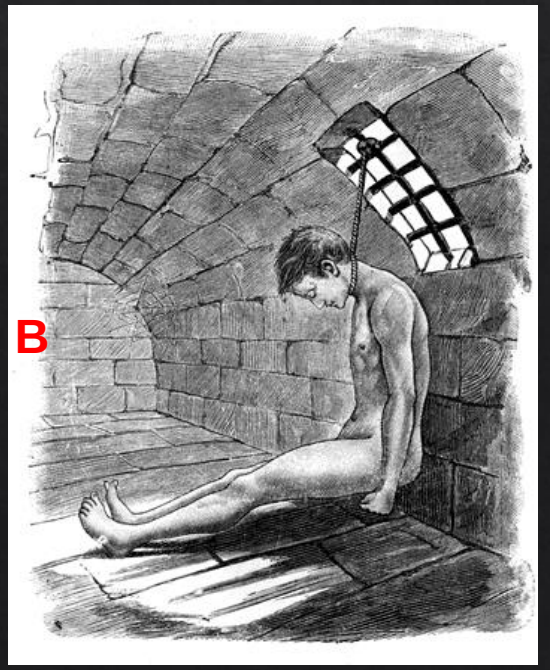
SMOTHERING

Caused by simultaneous occlusion of the air passages through hands, soft materials (pillow, towels), plastic bags. If hands are used there will be ecchymotic and excoriated round-shaped lesions (reproducing the fingertips) near the mouth and the nouse and sometimes nail print. Small bruising or even lacerations on the inner face of the lips, caused by compression against teeth edges, especially in elderly people, dislocations or fractures of the front teeth.

HANGING

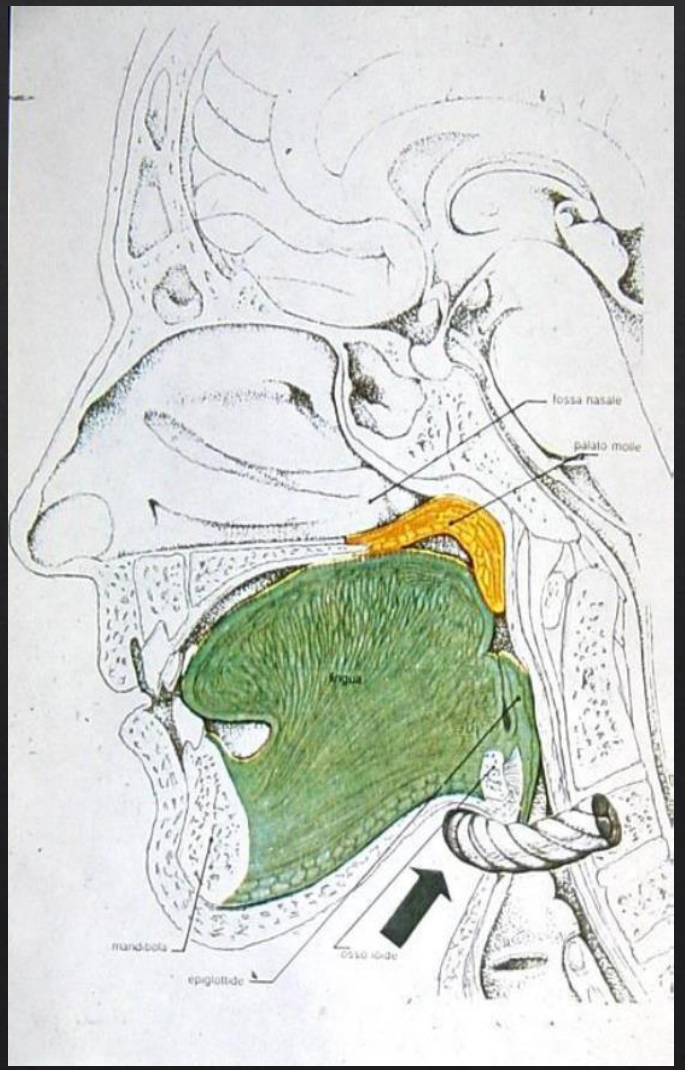
Ligature strangulation in which the force applied to the neck is derived from the gravitational drag or weight of the body or part of the body. According to the position of the knot and the foothold with the soil hanging can be:

- **Complete**: the body is suspended (Fig A)
- **Uncompleted**: the body is not completely suspended (Fig B)
- **Typical**: the knot is on the back of the neck (Fig A)
- **Atypical**: the knot is in anterior or lateral position



Physiopathological mechanisms of hanging

- **Occlusive:** compression of neck (hyoid bone, the base of the tongue is pressed against the soft palate, occluding the respiratory tract)
- **Vascular:** compression of jugular, carotids, sometimes vertebral arteries
- **Nervous**: stretching of Vagus nerve fibers and stimulation of carotid centres with an inhibitory reflex on the heart.



External signs of hanging

Groove - obliquity: the direction is backward and from below upwards

discontinuity: less deep on the side of the knot

hard (ex: rope) or soft (ex: sheets)

Socks and gloves hypostasis

Exophthalmos

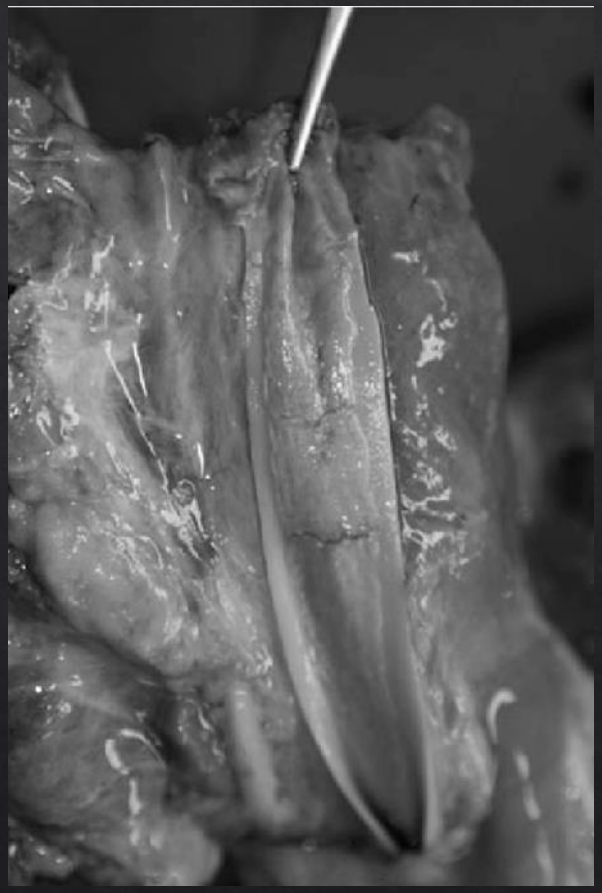
Subconjunctival petechiae

Tongue's protrusion

Spermatorrhea

Internal signs of hanging

- **Extravasion of blood** in dermis, interstitial tissues of the neck
- **Hemorrhagic infiltration** and **muscle's lacerations**, especially in the sternocleidomastoid muscle
- **Fracture** of the thyroid cartilage and of the hyoid bone
- **Amussat sign**: transverse laceration of the intima of the common carotid, usually at the bifurcation



STRANGULATION by ligature

Pressure acts on the neck employing ligature tightened by an external force. The ligature may be applied as one turn around the neck or even less, as homicides have been perpetrated by the assailant pulling a U-shaped ligature against the front and sides of the neck, while standing at the back. In suicides there are usually multiple turns.

Ligature mark

The mark tends to encircle the neck horizontally and at a lower level. Typically it eroses immediately above or belove the prominence of larynx. There may be scratches on the neck, usually caused by attempts of the victim to pull away from the ligature

MANUAL STRANGULATION (THROTTLING)

Pressure acts on the neck by one or two hands. A nervous factor (compression and stretching of the vagus nerve and the sinus) resulting in cardiac inhibition contributes to death too.

Autopsy appearances in manual strangulation

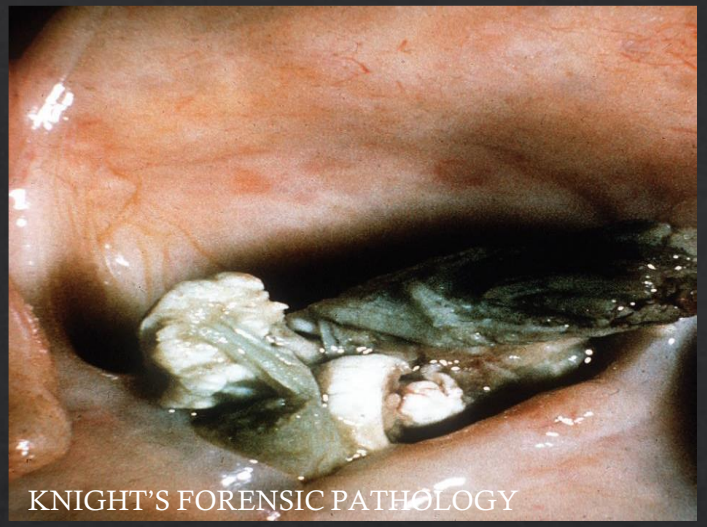
- Bruising on the neck is the result, whereas abrasions may be from either victim or assailant. The bruises are mainly discoid but may run together with longer areas of confluent bruises.
- The lateral pressure of the fingers can displace any of the four horns inwards either by direct pressure or by pressure on the thyrohyoid membrane
- Injury of the larynx: a typical finding is the fracture of the horns of the thyroid bone. Sometimes also the horns of the hyoid bone are broken.

CHOKING

Blockage of the internal airways usually between the pharynx and the bifurcation of the trachea.

Usually is given by natural causes (food, epiglottitis, foreign bodies)

It is commonly associated with acute alcohol intoxication, bad fitting dentatures, neurological injury, or senility.



POSITIONAL ASPHYXIA

Is virtually always an accident and is associated with alcohol or drug intoxication. In this entity, individuals become trapped in restricted spaces, where, because of the position of their bodies, they cannot move out of that area or position.

DROWNING

- Obstruction of the airways as a result of the penetration of an external liquid.
- The sequence of events is 1) breath holding 2) involuntary inspiration and gasping for air at the breaking point. 3) loss of consciousness 4) death

- Sometimes almost instantaneous death must be presumed. The mechanism must be attributed to a cardiac reflex in response to cold water. Alcohol is known to potentiate such effects, perhaps by general vasodilatation of skin vessels.

SIGNS OF IMMERSION DEATH

- Maceration of the skin, faster in warm water.
- Cutis anserine
- Pink hypostasis
- Mud, silt, sand, waterweed, algae, small aquatic animal life may be present on or in the body

Injuries sustained in the water

A laceration inflicted during life, unlike those inflicted after death, will usually show some bleeding into the tissue under the margin of the wound.

Differences between freshwater and seawater

In freshwater drownings, there is a massive absorption of water through the alveolar membranes, which causes haemolysis of red cells, that release Potassium. The seawater is hypertonic, so water moves from plasma into the lungs and so there is a rise in plasma Sodium concentration, deleterious for the heart function.

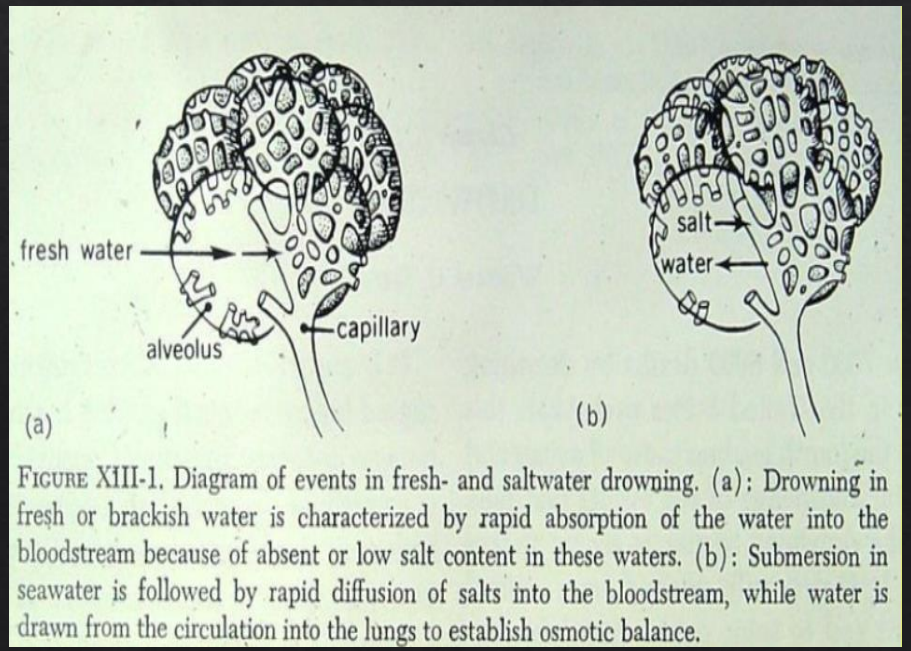


FIGURE XIII-1. Diagram of events in fresh- and saltwater drowning. (a): Drowning in fresh or brackish water is characterized by rapid absorption of the water into the bloodstream because of absent or low salt content in these waters. (b): Submersion in seawater is followed by rapid diffusion of salts into the bloodstream, while water is drawn from the circulation into the lungs to establish osmotic balance.

Autopsy signs of Drowning

- **Frothy fluid in the air passages (mouth and nostrils)**
- **Overinflation of the lungs**
- **There may be some areas of intrapulmonary hemorrhage**
- **Dilatation of alveoli**
- **Reduction of spleen weight (adrenergic response that causes contraction)**

Diatoms: microscopic algae with a silicaceous exoskeleton. They are used to distinguish real drowning from an already dead body found in the water.

Gettler chloride test: blood is analyzed from the right and left sides of the heart. If the chloride level was less on the right than on the left, the person is assumed to have drowned in saltwater.