Forensic Medicine and Toxicology

MBBS Recap: high-yield notes for revision

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Revision notes for the MEC PG entrance, set out by topic; read the section for any question you missed and then the facts bolded in it.

Thanatology

Death and its signs

- **Somatic (clinical) death** is irreversible loss of brain, heart and lung function; molecular death follows tissue by tissue over hours. Organs stay viable for different times: cornea and skin much longer than brain.
- **Brainstem death** is the legal and clinical criterion for organ retrieval: irreversible loss of consciousness and brainstem reflexes (pupils, corneal, oculovestibular, gag, cough) with apnoea off the ventilator, after excluding sedatives, hypothermia and metabolic causes.
- Early signs after circulatory arrest: the cornea turns hazy within about an hour (earlier if the eyes are open); the **Kevorkian sign** is fragmentation of retinal blood columns ("trucking" or cattle-tracking) within minutes; **tache noire** (brown-black horizontal band on the sclera in eyes left open) appears in about 3-4 hours.
- **Putrefaction is the surest sign of death**.
- **Cause, mechanism and manner of death**: the **cause** is the disease or injury that began the fatal sequence (coronary atherosclerosis, a stab wound); the **mechanism** is the physiological derangement through which it killed (arrhythmia, haemorrhage, hypoxia); the **manner** is the classification as **natural, accident, suicide, homicide or undetermined**. One mechanism can follow many causes, and one cause can have different manners.
- **Tripod of life** (Bichat): the heart, lungs and brain; failure of any one leads to failure of the others.
- **Suspended animation** is apparent death with vital signs too faint to detect (drowning, electric shock, hypothermia, newborn asphyxia, deep anaesthesia, yogic states); a doctor must look for signs long enough before certifying death.

Cooling (algor mortis)

- Cooling follows a **sigmoid curve**: a plateau of about 1-2 hours, then near-linear loss, then slowing as body and surroundings equalise. Average fall about 1.5 °F (0.8 °C) per hour; rectal temperature is used.
- Slower cooling: **obesity, thick clothing**, high ambient temperature, still air, a large body, a muscular build. Faster: thin or infant body, nakedness, wet or cold water, wind. A child cools faster than an adult.
- Fever, heat stroke, sepsis and some poisons raise the starting temperature, so the estimate is crude.
- **Postmortem caloricity**: the body temperature **rises after death** in sunstroke, tetanus, strychnine poisoning, septicaemia, cholera and pontine haemorrhage, because of continued heat production or poor heat loss.

Lividity (livor mortis, hypostasis)

- Blood settles by gravity into dependent parts as purple-pink patches, starting at 1-2 hours, **merging by 4-6 hours** and becoming **fixed at about 8-12 hours** (texts quote 6-12) once blood has haemolysed and stained the tissues. Before that, turning the body shifts the patches.
- Areas pressed against the surface, such as the shoulder blades, buttocks and calves lying flat, stay **pale (contact pallor)** because vessels are compressed.
- **Colour clues**: cherry red in carbon monoxide; bright red to pink in cyanide, hypothermia and refrigeration; chocolate brown (methaemoglobin) in nitrites, potassium chlorate, aniline and nitrobenzene; dark brown or yellowish in phosphorus; bluish green in hydrogen sulphide.
- **Hypostasis versus bruise**: hypostasis lies only in dependent parts, blood stays within the vessels, so it **blanches on pressure (until it is fixed) and washes out of cut sections**; a bruise is anywhere, raised, has extravasated blood that cannot be washed out and changes colour. Hypostasis in internal organs (lung bases, kidneys) can be mistaken for pneumonia or infarction.
- Marked lividity with petechiae suggests asphyxial death; a pale body suggests haemorrhage.

Rigor mortis

- Stiffening of muscle as **ATP falls below a critical level** so actin and myosin stay locked; it is not due to calcium alone and is not a nervous effect.
- **Nysten's rule**: the **order of onset** is eyelids, face and neck first, then trunk, then limbs, and it passes in the same order. The **myocardium** stiffens within about an hour. Onset 1-2 hours, fully developed by about 12 hours, lasts 12 hours, passes in the next 12 (about 36 hours in all in a temperate climate; shorter, about 18-36 hours, in a hot South Asian summer). **Shapiro** argued that rigor starts in all muscles at once and is only noticed first in the small ones, so the order is apparent, not real.
- **Earlier and shorter** in heat, exertion before death, convulsions (strychnine, tetanus), wasting diseases and in children (where it is also weak); **delayed and longer lasting** in cold and in well-built muscular adults.
- Rigor can be broken by stretching and then does not return (if broken early, it may recur once).

Special forms of stiffening

Feature	Cadaveric spasm	Rigor mortis
Onset	**At the moment of death**, no flaccid stage	After primary relaxation (1-2 h)
Muscles	Only a group, those active at death	All muscles

Feature	Cadaveric spasm	Rigor mortis
Medicolegal value	Shows the last act (weapon gripped, weed in drowning)	Time since death
Cause	Emotion/exertion, perhaps depleted ATP	Falling ATP
Stretching	Not broken easily	Broken by force

- **Heat stiffening**: protein coagulation, cannot be broken; **cold stiffening**: freezing of body fat and tissue fluids.
- **Pugilistic attitude** is from heat coagulation of muscle protein in burns (flexors bulkier, so limbs flex); it occurs in ante- or postmortem burns and has **no medicolegal significance**.

Time since death: chemical methods

- **Vitreous humour potassium** rises roughly linearly after death as it leaks from retinal cells; it is **the most useful and widely used chemical method** (formulas of Sturner and of Madea and Henssge). Because the vitreous is isolated, it is **less affected by putrefaction and contamination than blood or CSF**; useful for about 100-120 hours, with wide error that grows with the interval.
- Other methods: stomach contents (gastric emptying), insect activity, rise in CSF and blood potassium, fall in blood glucose and rise in urea nitrogen, falls in CSF/blood chloride.
- **Entomology**: blowflies lay eggs within minutes to hours of death; in warm weather the eggs hatch into maggots in about 8-24 hours, which pupate at about 4-5 days; the oldest larval stage and pupal cases estimate the postmortem interval, especially after several days.

Putrefaction

- **First external sign**: greenish discolouration of the **right iliac fossa** (caecum, near the abdominal wall and rich in bacteria), at 12-18 hours in a hot summer and 24-48 hours in cooler weather (sulphmethaemoglobin); **first internal sign** is greenish discolouration of the under-surface of the liver.
- Later: marbling of vessels, gas blisters, bloating, skin slippage, purge fluid. Foamy ("Swiss-cheese") liver by clostridial gas.
- **First organs to putrefy**: larynx, trachea, stomach, intestines, spleen; **last**: prostate and non-gravid uterus (with the heart and kidney late); bone is the most resistant.
- **Casper's dictum**: a body decomposes in air faster than in water and in water faster than in earth, in the ratio 1 : 2 : 8 (one week in air equals two in water and eight in earth).
- Arsenic and antimony poisoning delay decomposition.

Preservation changes

- **Adipocere** (grave wax): **warm, damp, anaerobic** surroundings and a fatty body; hydrolysis and hydrogenation of fat to a greyish-white waxy mass of saturated fatty acids and soaps, helped by clostridial enzymes. Starts at about 3 weeks; full change takes months.
- **Mummification**: **hot, dry, ventilated** surroundings; dry brown leathery, odourless body, commoner in thin bodies and infants.
- **Maceration** is aseptic autolysis of a fetus dead in utero in sterile amniotic fluid.

Autopsy methods

Technique	Method
Virchow	Organs removed one by one; most common
Rokitansky	In situ dissection, then removal; used in high-risk infections (HIV, hepatitis B) to limit handling
Letulle	Organs removed en masse as a block
Ghon	En bloc in organ blocks (thoracic, abdominal, pelvic)

- Modern practice adds postmortem CT ("virtopsy") and CT angiography for trauma and when relatives refuse invasive autopsy; they cannot replace histology and toxicology.
- **Nepal, Muluki Criminal Procedure Code 2074, s. 20**: on learning of a death by another's act, an accident, suicide, or in an unnatural or suspicious way, the **investigating (police) officer goes to the body at once and holds the inquest (लाश जाँच)**, recording in the prescribed muchulka (Schedule 14) the identity, the place and state of the body, every wound with its number, length, breadth and depth, the means of death, and other signs, with photographs of the body and scene. The officer then sends the body, at government cost, for **post-mortem to a government doctor, a specialist named by the Government of Nepal, or a licensed doctor**; the report is in the format of Schedule 15. If the inquest shows no offence or suspicion, the officer may record the reasons, before local witnesses, for not sending it (s. 20(6)); a body too decomposed for autopsy may still go for other scientific tests (s. 20(7)); a **team of experts** may do the autopsy when needed (s. 20(11)); the body is then handed to the next of kin, or cremated at government cost if none takes it (s. 20(8)-(9)). The inquest in Nepal is a police inquest; India's magistrate and coroner inquests do not apply.
- A medicolegal autopsy is done on the investigating authority's request, so the relatives' consent is not needed (a clinical, pathological autopsy does need it).

Identification

Establishing identity

- Identity rests on **primary identifiers** (fingerprints, DNA, dental records) and secondary ones (scars, tattoos, clothing, documents, medical implants with serial numbers). DNA profiling uses short tandem repeats (STRs); mitochondrial DNA is for old bone or hair without roots.
- **Locard's principle of exchange**: every contact leaves a trace both ways. **Poroscopy** (sweat pores between ridges) and **cheiloscopy** (lip prints) are lesser identifiers; **Galton's details** (ridge minutiae) are what is compared, and the **Henry system** is the classic ten-print classification (now automated, AFIS). **Quetelet's rule** (no two people are exactly alike in all their measurements) is the basis of **Bertillon's anthropometry**, the system fingerprints replaced.
- **Fingerprints**: patterns are loops (**most common**, about 60-70%), whorls (25-35%), arches (6-7%) and composites (least common, 1-2%). They form by the fourth month of fetal life and do not change. Destroyed temporarily by burns and abrasions (they regrow); permanent loss in **leprosy**, radiation, electrocution and some dermatoses.

Sex from the skeleton

- Reliability of sex determination (Krogman): whole skeleton almost 100%, skull plus pelvis about 98%, **pelvis alone about 95%**, skull alone 90%, long bones 80%. The **pelvis is the most reliable single bone**.

- Features that distinguish the male pelvis: heavy, large acetabulum facing laterally, narrow deep **greater sciatic notch** (the best single criterion), **V-shaped (acute) subpubic angle**, **large, oval obturator foramen** (in the female it is small and triangular), narrow pelvic inlet (heart-shaped), inverted ischial tuberosities. The female has the opposite: wide notch, subpubic angle over 90° (U-shaped), **preauricular sulcus** often present, ventral arc, larger pelvic outlet.
- Skull: male has a prominent glabella, mastoid process, supraorbital ridge, square chin, thick bone; female has a smooth rounded skull and a pointed chin.
- Sex differences in the sternum (**Hyrtl's law**: the manubrium is more than half the length of the body in the female; body longer in the male), femoral head diameter, and DNA (amelogenin gene) in fragmentary remains.

Age by teeth

- Deciduous teeth: 20; first erupts at about 6 months (lower central incisor); complete by 2-2.5 years.
- The **first permanent tooth is the first molar** (6-7 years); incisors 6-8, premolars 10-12, canines 11-12, **second molars 12-14**, **third molar (wisdom tooth) 17-25 years**. Mnemonic: the "six-year molar".
- Dental age is most reliable up to about 14 years. After 25, age uses attrition, secondary dentine, cementum, root translucency (**Gustafson's method**) and the ratio of aspartic acid racemisation.

Age by bones (ossification)

- Appearance of ossification centres is exact to within months in the young; fusion is used from 14 to 25.
- Fusion times (approximate): elbow region 14-17; **shoulder and wrist 17-19**; hip and knee 17-19 (epiphyses of the lower limb, **fusion complete by 18-20 years**); **iliac crest fuses at about 18-22 years** (Indian texts give about 20; modern data 17-23); **medial end of the clavicle is the last to fuse, at about 22-25 years** in the Indian texts (modern radiological data put complete fusion as late as 25-30); the **basi-occiput (spheno-occipital synchondrosis)** unites at 17-25.
- So a skeleton with all long-bone epiphyses fused and the iliac crest united, but the medial clavicular epiphysis not yet fused, is likely **20-24 years**.
- Cranial sutures: obliteration starts at about 30 (endocranial) in the sagittal suture; unreliable. After 40 use the pubic symphysis (Todd, Suchey-Brooks), rib ends, and auricular surface.
- The **Greulich-Pyle atlas** (hand-wrist) and **TW3** are used in living persons; **Risser's** sign (iliac apophysis) in adolescents.

Stature

- Height can be estimated from long bones by **Karl Pearson** and **Trotter and Gleser** regression formulae (Trotter and Gleser's are the most used); population-specific formulae are best. Femur ≈ 27% of height, tibia 22%, humerus 20%, spine 35%. Stature is about equal to the arm span (**armspan = height**). A **body measures about 2-2.5 cm longer after death** than in life, from relaxation of muscles and joints; height falls slightly with age in life.
- Race from the skull and long bones: **cephalic index** = breadth / length x 100: **dolichocephalic below 75** (Africans, Aryans 70-74.9), mesaticephalic 75-80, **brachycephalic over 80** (Mongoloids). Black races have a prognathic face, a wide nasal aperture; Mongoloids shovel-shaped incisors and flat face.
- **Brachial index** = length of the **radius ÷ length of the humerus × 100**; **crural index** = **tibia ÷ femur × 100**. Both are higher in people of African descent, so they are used with the cephalic index to suggest ancestry (Reddy).

Fetal age

Method	Rule
Haase's rule	Up to 5 months, age in months = **square root of crown-heel length in cm** (9 cm gives 3 months; 16 cm gives 4)
Haase's rule, second part	After 5 months, age in months = length in cm / 5 (35 cm gives 7 months)
Ossification	Calcaneus about 5-6 months; talus 7 months; lower femoral epiphysis (**Béclard's nucleus**) at 36 weeks (full term); upper tibial epiphysis shortly after birth
Hess/others	Crown-rump lengths and weights

- A **mature fetus** (term): length about 50 cm, weight about 3 kg, **Béclard's centre present**. **Viability** is conventionally from 28 weeks (medico-legal; modern neonatal care survives earlier), minimum weight 500 g by WHO.
- **Live birth tests**: **hydrostatic (Raygat's) test** (lungs float after air entry); the chest becomes barrel-shaped; **Breslau's second life test** (air in the stomach and intestine, which float); **Wreden's test** (air in the middle ear); changes in the umbilical cord and ductus arteriosus. False positives for floating lungs include putrefaction gases and artificial respiration; false negatives: atelectasis, pneumonia, consolidation. Milk or food in the stomach is the surest proof of live birth.
- **Signs of intrauterine death**: skin slippage and maceration, **Spalding's sign** (overlapping of cranial bones), **Robert's sign** (gas in great vessels); rigor in a dead fetus appears only after 7 months.
- **Superfecundation** (two ova of one cycle fertilised by coitus on separate occasions, possibly by different men) versus **superfetation** (ova from different cycles fertilised in an already pregnant woman). **Pseudocyesis** is a false belief of pregnancy.

More points often asked

- **Luminol** (3-aminophthalhydrazide) sprayed in the dark gives a **chemiluminescent glow with old, washed or diluted blood**; it is presumptive only, and can react with some metals and bleach. Do not confuse it with ninhydrin (fingerprints on paper) or the Takayama and Teichmann tests (confirm haem crystals).

Injuries

Mechanical injuries

Injury	Key points
Abrasion	Superficial epidermal loss by friction; no bleeding; shows direction (heaped epidermis at the end where the object left); heals without a scar in about 10 days
Contusion (bruise)	Extravasated blood in tissue with intact skin; deep bruises may appear late; "ectopic" bruises track along fascia (for example a black eye from a forehead blow)
Laceration	Tearing by blunt force; irregular, bruised margins, tissue bridges across the wound, no sharp edges
Incised wound	Sharp edge; length greater than depth; clean margins, no bridging; severe bleeding

Injury	Key points
Stab wound	Depth greater than length and width; a knife gives a wedge shape with one sharp, one blunt end
Chop wound	Heavy sharp instrument (axe, kukri); gaping with underlying bone cut

- **Age of bruise** by colour (unreliable, but classic): red at first; **blue to purple** (deoxygenated haemoglobin) in hours to 3 days; **blue-black to brown** (haemosiderin) 4-5 days; **green** (biliverdin) 5-6 days; **yellow** (bilirubin) 7-12 days; normal by about 2 weeks. Colour changes begin at the edge. Never time a bruise exactly in court; histology (haemosiderin and macrophage infiltration) is better.
- **Age of abrasion**: fresh bright red; **reddish scab** at 12-24 hours; reddish-brown scab 2-3 days; dark brown to brownish-black scab 4-7 days; the scab dries and falls off after about 7 days, leaving a depigmented area; complete healing about 10-14 days.
- **Types of abrasion**: **scratch** (linear, from a point), **graze (sliding, brush burn)**, the **commonest** type, from friction against a rough surface; **pressure (crush) abrasion** (a ligature, a heavy object), and **imprint (patterned) abrasion**, which reproduces the pattern of the object (**tyre tread**, a weapon's surface). **Degloving** is tearing of the skin from deeper tissue, seen in vehicle injuries.
- Penetrating wounds enter a cavity; **perforating** wounds enter and exit; **split lacerations** over bony prominences (scalp, shin) look incised and can be mistaken for sharp wounds (distinguished by tissue bridges and bruised margins under the microscope).
- **Defence wounds** point to homicide: **passive** ones are bruises on the extensor surface and ulnar border of the forearms and the backs of the hands, raised to ward off blows; **active** ones are cuts on the palms and the palmar surface of the fingers, from grasping a blade (on the legs too in a victim kicking out from the ground); **hesitation (tentative) cuts** mark suicide; suicidal cutting is usually on the wrist or throat, on accessible sites.
- **Antemortem versus postmortem wounds**: an antemortem wound **gapes, its edges are swollen and everted, blood infiltrates the tissue, and a firm clot adheres** (vital reaction, with inflammation if survival is long enough); a postmortem wound gapes little, bleeds scantily, leaves fluid blood or soft "currant jelly" or "chicken-fat" postmortem clot and shows no reaction. Wounds made just after death can mimic the antemortem picture.

Head injury

- Fractures: **linear (fissured)** is the commonest vault fracture; **depressed** (a heavy object over a small area, takes the shape of the weapon, a signature fracture); **mosaic (spider's web)**; **pond (indented) fractures** in infants; **gutter** by a glancing blow or bullet; **diastatic** along the suture lines; **ring fracture** around the foramen magnum from a fall from height onto the feet or buttocks.
- **Base of skull**: anterior fossa gives **raccoon (panda) eyes** and CSF rhinorrhoea; middle fossa gives **Battle's sign** (mastoid bruising) and bleeding from the ear; **hinge fracture** (transverse across the base) in side impacts such as motorcyclists.
- **Extradural haemorrhage**: tear of the **middle meningeal artery** after fracture of the temporal bone (pterion), typically with a **lucid interval** (present in only about a third of cases); biconvex (lens-shaped) on CT; surgical emergency. A boy hit on the temple, unconscious briefly, then drowsy with a dilated pupil on the same side: **middle meningeal artery bleeding**.
- **Subdural**: tearing of bridging veins (brain atrophy, alcoholism, elderly, abused infants); crescentic. **Subarachnoid** from trauma or a ruptured berry aneurysm. **Contrecoup contusions** are typical of falls (occiput blow gives frontal and temporal contusions), whereas coup injury lies under the impact in a blow to a stationary head.
- **Diffuse axonal injury** (rotational acceleration) causes coma from the start.

Firearm injuries

- **Entry wound** features: round, small, with **abrasion collar** (the bullet rubs the skin) and often a grease (dirt) ring; the skin edges are inverted. **Exit wound**: larger, irregular or stellate, everted edges, no collar. The entry wound of a long-range rifle bullet is typically **smaller than the calibre** because of **elastic recoil of the skin**.
- Effects by range:

Component	Effect	Range
Flame	Scorching, singeing of hair	Close (within about 15 cm for pistols)
Smoke (soot)	Blackening or smudging, wipes off	Up to about 30 cm
Unburnt powder grains	**Tattooing (peppering)**, cannot be wiped off	Up to about 60-90 cm for handguns (to about 1 m or more for shotguns and rifles)
Bullet	Entry wound with collar	All ranges

- **Contact shot**: burning and blackening within the track; cherry-red tissue (carboxyhaemoglobin); a large, stellate or cruciate wound where gas expands under skin over bone; the muzzle imprint. **Intermediate range**: tattooing, no burning. **Distant**: only the bullet's own wound.
- **Shotgun** pellets spread with distance: a single hole to about 1 m, a hole with satellite pellet marks to about 2-3 m, scatter beyond; the rule of thumb: the spread in inches roughly equals the range in yards (varies with the choke).
- Bullet terms: **ricochet** (deflected), **tumbling** (rotation end over end), **dum-dum** (expanding soft-nose with a central notch), **tracer**, **tandem**, **frangible**. **Gunshot residue** test on a suspect's hand: modern use is scanning electron microscopy with energy-dispersive X-ray for lead-barium-antimony particles; the old paraffin (dermal nitrate) test is obsolete and unreliable. **Puppe's rule** gives the sequence of multiple skull gunshot fractures (a later fracture line stops at an earlier one).
- Gunpowder (black): potassium nitrate 75%, charcoal 15%, sulphur 10%; smokeless powder is nitrocellulose.
- **Infrared photography** shows powder blackening and tattooing that are hidden by blood or dark clothing.

Burns, heat, electricity and lightning

- **Burn depth** (modern classification): superficial, partial thickness (superficial and deep) and full thickness; the older Dupuytren six degrees still appear in exams. **Rule of nines** estimates area.
- **Proof that a burn was sustained in life**: a red **vital reaction (line of redness)** at the margin, blisters with serous fluid and inflammatory cells, and **soot in the air passages with raised carboxyhaemoglobin** (over about 10% in a non-smoker; levels above about 50% are usually fatal by themselves); soot

in the bronchi and a raised COHb prove respiration after the fire began. Postmortem burns show none of these.

- **Heat rupture** of skin and muscle: split-like, with coagulated blood in intact vessels, intact nerves, no bruising. **Heat haematoma** (extradural, heat-related) is a fissured, honeycomb collection with no lucid interval, a postmortem artefact.
- **Heat stroke**: **core temperature above about 40 °C (some texts 41 °C) with central nervous system dysfunction** (confusion, convulsions, coma), the skin hot and dry or sweaty; **heat exhaustion**: sweating, raised temperature, pale skin, mind intact; **heat cramps**: muscle cramps with sweating.
- **Electrocution**: ventricular fibrillation is the **commonest cause of death**; alternating current is more dangerous than direct current (tetanic grip); current (amperes) is more important than voltage. The **Joule (electric) burn** at the contact is a **pale crater with a raised firm rim** and a surrounding blanched zone; "**current pearls**" (globules of melted bone mineral) and "crocodile skin" (arcing) are high-voltage signs; **streaming of nuclei** in the epidermis is the characteristic microscopic feature (nuclei elongated and aligned, "Swiss-cheese" vacuolation).
- **Electrocution path**: the danger depends on the current through the heart. **Hand to hand, or arm to the opposite leg, crosses the chest and is the most dangerous**; foot to foot, or a path through one limb, tends to cause only local burns.
- **Lightning**: a high-voltage direct current of very short duration; **Lichtenberg figures** (fern-like marks), "flower pattern" burns, magnetisation of metal objects.
- **Cold**: **hypothermia** deaths show pink lividity, **paradoxical undressing** and **terminal burrowing (hide-and-die)**; Wischnewski spots (gastric erosions).

Cold, blast and other conditions (curriculum additions)

- **Frostbite**: freezing of tissue (below about -0.55 °C); superficial (frostnip, then first and second degree) to deep (third and fourth degree with gangrene); hands, feet, ears and nose; **immersion (trench) foot** follows prolonged cold wet exposure above freezing. Treatment is **rapid rewarming in water at 37–39 °C**; never rub, never rewarm if refreezing is likely.
- **Blast (explosive) injury** has four phases: **primary** (the pressure wave: air-containing organs, so **tympanic membrane, lung and bowel** are hurt), **secondary** (flying fragments: penetrating wounds, the commonest cause of injury and death), **tertiary** (the body thrown) and **quaternary** (burns, crush, inhalation). A body in an **aircraft crash** or disaster is identified by **dental records, fingerprints and DNA**, and the pattern of injuries shows the occupant's seat.
- **Pedestrian injuries**: a car bumper strikes an adult at **leg level**, so the **tibia and fibula fracture**, often with a **wedge-shaped (Messerer) fragment whose base lies on the side struck and whose apex points the way the car was travelling**; the height of the fracture above the heel gives the bumper's height. **Ring fracture of the skull base** follows a fall on feet or buttocks, **hangman's fracture** hyperextension.
- **Contrecoup**: a moving head suddenly stopped (a fall) bruises the brain **opposite** the blow; a fixed head struck by a weapon gives **coup** injury at the site.

Transportation injuries

- Pedestrian accidents: a **primary impact** (bumper at the legs), a **secondary impact** (bonnet or windscreen) and a **secondary injury** from the fall to the road. **Waddell's triad**, in a child struck by a car: femoral fracture (bumper), chest or abdominal injury (bonnet) and contralateral head injury (the road). **Bumper fracture** (Messerer's wedge): the wedge fragment's base is at the side of impact and its apex points in the direction of travel; **low injury level** suggests the driver braked; injuries at different levels of the two legs mean the victim was walking.
- Cyclists and motorcyclists show **hinge** basal fractures. **Whiplash injury** is hyperextension of the neck in rear-end collisions. **Seat-belt sign** and chest/abdominal injuries are seen in drivers; **steering wheel** injuries chest and sternum.

Asphyxial deaths

Classification

- **Asphyxia** is failure of oxygen to reach or be used by tissues. Mechanical forms: **hanging, strangulation (ligature, manual throttling), suffocation (smothering, choking, gagging, traumatic/crush asphyxia, overlaying), drowning**. Environmental or chemical hypoxia (low oxygen air, carbon monoxide, cyanide) is separate.
- **General signs of mechanical asphyxia**: the viscera are **congested**, the blood **dark and fluid**, with **subserosal petechiae** (Tardieu's spots) and cyanosis; these findings are typical but **not specific**, so the diagnosis rests on the local signs (the ligature mark, the neck injuries, the water findings).
- **Hanging**: constricting force is the body's weight. Death is by **venous congestion, arterial occlusion and vagal inhibition**, not by tracheal compression alone. Force to occlude: **jugular veins 2 kg, carotid arteries 5 kg, trachea 15 kg, vertebral arteries 30 kg** (the classic figures; some texts give 3.5 kg for the carotids and 16-20 kg for the vertebrals). **Typical hanging** has the knot at the occiput; **atypical hanging** has the knot elsewhere. **Judicial hanging** (a long drop) causes fracture-dislocation at C2-C3, the **hangman's fracture** (bilateral fracture of the pars or pedicles of C2); it is rare in suicidal hanging.
- Findings in hanging: ligature mark **oblique, non-continuous, above the thyroid cartilage** and directed upward to the knot, with a **gap at the suspension point**; face often pale; **saliva dribbling** (a vital sign), neck stretched, petechiae less common, **la facies sympathique** (unilateral dilated pupil with open eye) characteristic.

Hanging versus ligature strangulation

Feature	Hanging	Ligature strangulation
Mark	Oblique, interrupted, **above thyroid**	**Horizontal, complete, at or below thyroid**
Face	Pale	Congested and cyanosed
Petechiae	Few	Common
Hyoid/thyroid fracture	Uncommon	More common
Manner	Usually suicidal	Usually homicidal
Saliva	Dribbles from the mouth corner	Not typical

- **Manual strangulation (throttling)**: fingernail marks, bruises on both sides of the neck, fractured hyoid or superior horns of the thyroid; mostly homicidal. **Garrotting** (metal collar or cord tightened from behind), **mugging** (neck squeezed in the crook of an elbow) and **bansdola** (neck compressed between

bamboo poles, Indian subcontinent) are named forms. **Pseudostrangulation** is a skin fold in an obese neck or an infant mistaken for a ligature mark. **Lynching** is mob hanging.

- **Tardieu's spots** are **petechial haemorrhages** under the visceral pleura, pericardium (and also scalp, conjunctiva and face) from raised venous pressure in asphyxia; they are suggestive, never specific. The **hyoid** greater horns fuse to the body by about 40 years, so they fracture more readily in older victims; in the young the cartilaginous joints give.

Other forms of suffocation

- **Smothering**: external blocking of mouth and nose (bruising of lips, gums). **Choking**: obstruction inside the airway (café coronary). **Gagging**. **Traumatic (crush) asphyxia**: compression of the chest (crowd crush at stadia and festival stampedes) gives a purple-blue head and neck with petechiae above the compression and pallor below. **Burking**: smothering with chest compression. **Postural (positional) asphyxia** in restraint.
- **Autoerotic asphyxia** accidents and **choking-game** deaths are seen in adolescents; the scene of a partly suspended body with protective padding is the clue.

Drowning

- **Types (the exam's classical terms)**: wet drowning (fluid in lungs, about 80-90%), dry drowning (laryngospasm, little fluid in lungs, 10-20%), **immersion syndrome** (vagal reflex cardiac arrest on sudden cold water immersion), secondary drowning (pulmonary oedema hours after rescue), near-drowning. **Current practice** (WHO 2002 and the Utstein style, ILCOR): drowning is "respiratory impairment from submersion or immersion in liquid", with outcomes death, morbidity or no morbidity; "dry", "secondary" and "near" drowning are discouraged terms.
- **Fresh versus sea water**:

Feature	Fresh water (hypotonic)	Sea water (hypertonic)
Fluid shift	Passes from alveoli into blood	Draws plasma into alveoli
Blood	**Haemodilution, haemolysis, hyponatraemia, hyperkalaemia**, ventricular fibrillation	Haemoconcentration, hypernatraemia, hypovolaemia
Lungs	Wet, plump	Heavy, pulmonary oedema
Cause of death	Ventricular fibrillation	Hypoxia, shock
Gettler's test	Chloride **lower in left heart** blood	Chloride **higher in left heart** blood (a difference of over 25 mg/100 mL is significant; unreliable, now little used)

- **Signs of antemortem drowning**: **fine white lathery froth at the mouth and nostrils** (most characteristic external sign; persists as long as the body is not washed), **cadaveric spasm** gripping weeds or sand, water, weed or mud in the stomach and airways, and **diatoms in the bone marrow** (siliceous algae reaching the circulation; lungs alone do not prove drowning because particles pass postmortem; found in organs such as the liver, kidney, brain and the marrow of long bones). **Paltauf's haemorrhages** (large, pale-red subpleural patches from rupture of alveolar walls during violent respiratory efforts, the colour paled by haemolysis), and **emphysema aquosum**: bulky, ballooned, water-logged lungs that overlap the heart, pit on pressure and ooze frothy fluid when cut, seen when a body is drowned alive.
- **Not indicators**: washerwoman skin (maceration of hands and feet) and cutis anserina (goose skin) occur after death in water.
- Body recovered from water: usually sinks, then refloats by putrefaction gas after 1-2 weeks in warm water, 2-3 weeks in cold. Fresh-water diatom tests may fail in salt water.
- Alcohol and head injury are common contributors; **homicide by drowning** is hard to show, with head or neck injury and bound limbs.
- Modern management of drowning: **Utstein/ILCOR** consensus; ventilation first (rescue breaths) then CPR; the hypothermic patient resuscitated for longer.

Sexual offences

Terms

- **Sodomy** (anal intercourse), **buccal coitus** (oral), **tribadism/lesbianism**, **paedophilia** (sexual attraction to prepubertal children), **sadism**, **masochism**, **voyeurism**, **exhibitionism**, **fetishism**, **frotteurism**. **Incest** is intercourse between close relatives.
- **Nepal's law** (Muluki Criminal Code 2074): **rape (jabarjasti karani)** is defined in s. 219: sex with a woman without her consent, or **with a girl under 18 even with consent**; consent obtained by coercion, undue influence, fear, deception, abduction, or from a person not of sound mind is no consent; and penetration with the penis of the anus, mouth or vagina, even partial, **or of the vagina with any object**, is rape (Muluki Criminal Code 2074, s. 219(2)). India's definitions do not apply.
- **Penalties in s. 219(3)**: **life imprisonment** if the victim is under 10, fully incapacitated, has a disability, or is over 70; **18-20 years** for 10 to under 14; **12-14 years** for 14 to under 16; **10-12 years** for 16 to under 18; **7-10 years** for 18 and over. **Fines (s. 219(3ka))**, paid into the victims' relief fund: Rs 7 lakh for the first two bands, Rs 5 lakh for the next two, Rs 3 lakh for an adult victim. Aggravation (gang rape; a victim more than six months pregnant, incapacitated, disabled, or physically or mentally ill; or showing a weapon) **adds up to 5 years** (s. 219(7)). **Marital rape** is an offence, with **up to 5 years** (s. 219(4)), the marriage not counting as subsisting during a partition or divorce case or after separation. Knowingly raping while **HIV-positive adds** the penalty of s. 105 (up to 10 years and up to Rs 1 lakh) to the sentence; with another sexually transmitted infection, it adds up to 3 years and Rs 30,000 (s. 219(6)). Rape of a woman within the prohibited degrees adds the penalty for incest (s. 219(8)). Do not rely on figures printed in older books (an earlier Muluki Ain gave different numbers).
- **Child sexual abuse** short of rape (touching, forced touching, taking a child to a secluded place with sexual intent) is separately an offence (s. 225, **up to 3 years and up to Rs 30,000**).

Examination of the victim

- **Consent of the victim** (or a guardian for a minor) and an authorised police request are needed; examine as early as possible; in Nepal a woman's body is examined **by a female doctor where possible, otherwise by a male doctor in the presence of a woman** (Muluki Criminal Procedure Code 2074, s. 21(1)), and an injury examination report is made in the

prescribed form by a government doctor or health worker (s. 22); do not make a "virginity test" (the "two-finger test" has no scientific value and is condemned by WHO, 2014 and 2018). Record history, injuries, and a head-to-toe examination; collect clothing in paper bags; take swabs and combings.

- **Time limits for sperm**: motile sperm in the vagina for a few hours (about 3 hours in the classic texts, up to 6 or more in some series), non-motile sperm up to **about 3 days (72 hours) with the cervical canal retaining sperm longest** (up to 5-7 days with DNA techniques). A woman examined three days later: the **cervical os swab** is the best site. In the dead, sperm persist in the vagina longer. Males: sperm in the anal canal for up to about 3 days; in the mouth for hours.
- **Hymen**: an **intact hymen neither proves nor excludes penetration**; a hymen can be elastic, annular or crescentic, and may remain intact after penetration; a torn hymen can result from non-sexual events (a fall astride, cycling, tampons). Old tears reach the base and show healed edges; fresh tears are red, swollen and bleed. The **hymen is torn typically at 5 and 7 o'clock positions**.
- **Injuries**: bruises on thighs and breast, nail marks, bite marks (compare with the suspect's teeth), vulval and perineal tears.
- **The accused**: examine for injuries (scratches, bites), smegma (its presence argues against recent penetration in an uncircumcised man), transferred hair, and take penile swabs for the victim's cells. Potency cannot be proved by examination; the doctor reports only whether there is anything to suggest he is incapable of intercourse.
- **Date-rape drugs**: **flunitrazepam**, **gamma-hydroxybutyrate (GHB)** and **ketamine**. Urine collected within 72 hours; GHB is gone from blood in hours.

Seminal stain

- Screening: **acid phosphatase** (prostatic), **Florence test** (choline iodide crystals, dark brown rhombic), **Barberio's test** (spermine picrate, yellow needles), UV fluorescence (bluish white). **Confirmation is by finding spermatozoa**; modern forensic labs use **prostate-specific antigen (p30)** and DNA typing (including Y-STR).
- The **Kastle-Meyer (phenolphthalein)** test is for **blood**, not semen; other blood tests: benzidine, orthotolidine, leucomalachite green; confirmatory **Teichmann (haemin crystals)** and Takayama (pyridine haemochromogen crystals); spectroscopy; species by the **precipitin test**.

Toxicology

General principles

- **Poison** in law is a substance that can cause harm in the dose and way used. **Cumulative poisons** (arsenic, lead, mercury, thallium) build up. Principles of treatment: stabilise airway-breathing-circulation, decontaminate (gastric lavage only for a life-threatening dose within about 1 hour; **activated charcoal** 1 g/kg (50 g in an adult), ideally within 1 hour, for most drugs, but not for corrosives, alcohols, metals such as iron and lithium, or hydrocarbons), enhance elimination (urinary alkalinisation for salicylate; haemodialysis for methanol, ethylene glycol, lithium, salicylate), and give the **specific antidote**.
- **Commonest suicidal poison in Nepal and South Asia: pesticides, above all organophosphorus (OP) compounds**, with aluminium phosphide rising; in the UK and other high-income countries it is paracetamol and other medicines. Commonest homicidal poison (classical Indian texts): **arsenic**; **ideal homicidal poison: thallium** (tasteless, odourless, soluble; some texts give arsenic). Local poisoning pattern, not just textbook lists, is asked.
- **Forced diuresis** (the classical answer): alkaline diuresis for acidic poisons (salicylates, phenobarbital), acid diuresis for basic ones (amphetamine, phencyclidine, quinine, strychnine). **Current practice** (AACT/EAPCCT position paper 2004): forced diuresis with large fluid volumes is abandoned; **urine alkalinisation** with sodium bicarbonate, without forcing fluid, is used for salicylate (and phenobarbital, chlorpropamide, chlorophenoxy herbicides), and acidification is never used, because it worsens myoglobin precipitation and acidosis.
- **Samples**: viscera preserved in **saturated salt solution** (routine); **rectified spirit** is an alternative, but not in poisoning by alcohol itself, phenol, phosphorus, kerosene, chloroform, formaldehyde, paraldehyde or acetic acid; blood, vitreous and CSF in **sodium fluoride**; urine in thymol; histology in 10% formalin; **no preservative** if analysed within 24 hours. Do not use sodium fluoride in fluoride poisoning.
- **Postmortem smells**: **kerosene** (OP compounds with hydrocarbon solvent), garlic (arsenic, phosphorus, aluminium phosphide, selenium, DMSO), bitter almonds (cyanide), rotten eggs (hydrogen sulphide), fruity (alcohol, acetone), burnt rope (cannabis).
- **Stomach mucosa**: **red velvety** in arsenic; slate grey in mercury; black necrosis with sulphuric and other strong acids; yellow in nitric acid; **leathery, thickened** in carbolic acid (phenol).

Corrosives

	Acids	Alkalis
Necrosis	**Coagulative**, an eschar that limits spread	**Liquefactive**, no eschar, spread continues until neutralised
Depth	Superficial, mainly stomach	**Deeper, esophageal damage and perforation**
Examples	Sulphuric, nitric, hydrochloric	Caustic soda, ammonia

- **Alkalis usually injure more deeply than acids** of similar strength because liquefactive necrosis keeps penetrating. Do not induce vomiting or give neutralisers; early endoscopy at 12-24 hours and surgery for perforation.
- **Sulphuric acid**: black charring; "oil of vitriol"; **nitric acid**: yellow (xanthoproteic) stains. **Hydrofluoric acid** causes hypocalcaemia, hypomagnesaemia and hyperkalaemia; give calcium gluconate (topical and IV).
- **Carbolic acid (phenol)**: white eschar, leathery mucosa, urine dark green (carboluria; ochronosis in chronic use); gastric lavage is allowed; rectified spirit is a contraindicated preservative.
- **Oxalic acid** (toilet cleaners, stain removers): **binds calcium, giving hypocalcaemia and tetany**, with **calcium oxalate crystals in urine** and renal tubular damage; ethylene glycol does the same. Give calcium gluconate.

Organophosphates and carbamates

- **Mechanism**: **irreversible inhibition of acetylcholinesterase** (phosphorylation, then "ageing" makes the bond permanent), so acetylcholine accumulates at muscarinic, nicotinic and CNS synapses. Carbamates inhibit reversibly and shortly.

- **Muscarinic** features (mnemonic DUMBELS): diarrhoea, urination, miosis, bronchorrhoea and bronchospasm, emesis, lacrimation, salivation, bradycardia. **Nicotinic**: fasciculations, weakness, paralysis (respiratory failure is the cause of death). **CNS**: agitation, convulsions, coma.
- **Treatment**: ABC and decontamination of skin and clothes; **atropine 1.8-3 mg IV, the dose doubled every 5 minutes until atropinised: a clear chest on auscultation (the main endpoint), heart rate over 80, systolic pressure over 80 mmHg, dry axillae; the pupils are not a guide**; then an infusion of 10-20% of the loading dose an hour; **oximes (pralidoxime)** reactivate the enzyme before ageing but their benefit is debated (a randomised trial, Eddleston 2009, and Cochrane reviews show no clear mortality benefit; still taught, and still in many protocols); benzodiazepines for seizures. **Intermediate syndrome** (24-96 hours; proximal and neck weakness and respiratory failure) and **delayed polyneuropathy** (OPIDN, 2-3 weeks, from tri-ortho-cresyl phosphate) are later features. Red cell cholinesterase is more specific than plasma (pseudo) cholinesterase.
- **Organophosphates**: highly **lipophilic** compounds (such as fenthion) are stored in body fat and released slowly, so poisoning can **relapse or persist for days**, and the intermediate syndrome may follow.

Plant and animal poisons

- **Aconite (monkshood, bikh)**: aconitine opens **voltage-gated sodium channels persistently**; paraesthesia and numbness of the mouth and tongue, hypersalivation, nausea, hypotension, ventricular arrhythmias (bidirectional VT) and weakness. No antidote: ABC, activated charcoal, amiodarone first for the arrhythmias (flecainide and magnesium in case reports; cardioversion often fails), and ECMO or bypass in refractory cases.
- **Datura (dhaturo, thorn-apple)** and belladonna: anticholinergic ("**mad as a hatter, red as a beet, dry as a bone, blind as a bat, hot as a hare**"): flushed hot dry skin, dilated pupils, fever, tachycardia, urinary retention, delirium; **physostigmine** is the antidote when delirium or serious toxicity is present (caution in tricyclic overdose), with benzodiazepines.
- **Cannabis** (bhang from leaves, ganja from flowering tops, **charas (hashish) the resin, most potent**): THC; conjunctival injection, tachycardia, amotivational syndrome and "run amok" are classic points. **Cocaine**: Magnan's sign (formication), septal perforation, hypertension, hyperthermia, seizures. **Strychnine (nux vomica)**: a **glycine-receptor antagonist** in the spinal cord, giving convulsions with an alert mind, **opisthotonus**, risus sardonicus, triggered by a touch or noise; treat with diazepam and a quiet room.
- **Opioids**: respiratory depression, coma and **pinpoint pupils**; the **specific antagonist is naloxone** (0.4-2 mg IV, repeated, with an infusion for long-acting opioids such as methadone). Death in heroin overdose is by pulmonary oedema and respiratory arrest.
- **Alcohol**: **Widmark's formula** estimates blood alcohol; the driving limit in many countries is 0.08 g/dL (80 mg/dL), lower in others. **McEwan's sign**: in alcoholic coma the contracted pupils dilate on a painful stimulus (pinching) and then slowly contract again. (Macewen's sign, the cracked-pot note on percussion of the skull in hydrocephalus, is unrelated.)
- **Alcohol**: chronic use causes **Wernicke encephalopathy** (confusion, ataxia, ophthalmoplegia; thiamine) and **Korsakoff psychosis** (amnesia with confabulation); **morbid (Othello) jealousy** is a delusion of a partner's infidelity. **Gas-liquid (gas) chromatography** of blood is the best medicolegal method for alcohol; ethanol is eliminated by **zero-order kinetics** at usual blood levels. **Withdrawal** is treated with a long-acting benzodiazepine such as **chlordiazepoxide** or diazepam (lorazepam in liver failure), with thiamine before glucose; relapse prevention uses **disulfiram, naltrexone and acamprosate**. **Disulfiram-like reactions** (flushing, palpitations, vomiting with alcohol) also follow **metronidazole, chlorpropamide, cefamandole and cefotetan**, by blocking aldehyde dehydrogenase: the exam answer for metronidazole, though controlled studies have not confirmed a true reaction with it, and the warning stays in practice (Tripathi; reviews since 2000).
- **Methanol**: converted by alcohol dehydrogenase to formaldehyde and by aldehyde dehydrogenase to **formic acid (the main toxic metabolite)**, causing high anion-gap metabolic acidosis, blindness (optic neuropathy) and basal ganglia necrosis. Treat with **fomepizole** (preferred), ethanol if unavailable, folate, bicarbonate, **haemodialysis** for severe cases.
- **Ethylene glycol**: oxalate, hypocalcaemia, renal failure; same antidotes.
- **Cardiac poisons** include aconite, oleander, digitalis and nicotine. **Truth-serum** drugs (scopolamine, thiopentone, amobarbital) are not reliable evidence. LSD causes flashbacks and synaesthesia; it causes no physical dependence and no withdrawal syndrome.

Snake bite (Nepal)

Snake	Venom	Features
Cobra, krait (Elapidae)	**Neurotoxic**; krait bites are painless, often at night while asleep, with abdominal pain and ptosis	Descending paralysis, respiratory failure
Russell's viper, saw-scaled viper (Viperidae)	**Haemotoxic**: local swelling, bleeding, **incoagulable blood**	Positive **20-minute whole-blood clotting test (20WBCT)**, AKI
Pit vipers (Crotalinae; green pit vipers in Nepal)	Mainly local swelling and pain; bleeding uncommon in Nepal	Indian antivenom is not used for them
Sea snakes	**Myotoxic**	Rhabdomyolysis

- **Treatment**: immobilise, do not cut, suck, tie a tight tourniquet or give herbal remedies; give **polyvalent anti-snake venom** early for systemic signs (WHO SEARO guidelines 2016; a neostigmine trial can help neurotoxic bites); monitor the **20WBCT** every 6 hours; intubate and ventilate for paralysis. **Neostigmine with atropine** helps in cobra bite (postsynaptic toxin), not in krait bite (presynaptic β-bungarotoxin), which needs ventilation (Nepal's national guidelines, 2019).
- **Venomous versus non-venomous** (general rule): venomous snakes have small head scales (except cobra and krait), **large belly scales covering the whole width**, canalised fangs, two fang marks, and a compressed tail in sea snakes.
- Snakebite is commonest in South Asia's plains in the monsoon, in farmers and at night; in Nepal it is mainly a problem of the Terai. **Nepal** (National Guidelines for Snakebite Management in Nepal, Ministry of Health and Population 2019): most envenoming is by **elapids, the spectacled cobra and the common krait**, with other kraits now reported; the

antivenom is **polyvalent, imported from India**, against India's "big four" (Russell's viper, cobra, common krait, saw-scaled viper), and **saw-scaled viper is not yet reported from Nepal**; the antivenom should **not be used for pit viper bites**; 20WBCT is repeated 6 hours after each antivenom dose.

Mushroom poisoning

Group and toxin	Onset and picture
Amatoxin (Amanita phalloides, the death cap; Galerina)	**6–12 hours** after eating: severe vomiting and **watery diarrhoea**, then an apparent recovery on day 2, then **hepatic failure** (jaundice, coagulopathy, encephalopathy) on days 3–5, kidney failure later. **Inhibits RNA polymerase II**. Treatment: fluids, **silibinin, N-acetylcysteine**, penicillin G in some protocols, **liver transplant** for failure
Muscarine (Inocybe, Clitocybe)	Within **30 minutes to 2 hours**: cholinergic signs (sweating, salivation, lacrimation, bradycardia, miosis); **atropine**
Ibotenic acid and muscimol (Amanita muscaria, A. pantherina)	30 minutes to 2 hours: confusion, hallucinations, ataxia, drowsiness; supportive care
Orellanine (Cortinarius)	**Delayed 2–20 days**: **renal failure** (tubulointerstitial nephritis)
Gyromitrin (false morel)	6–12 hours: gastrointestinal upset, seizures; pyridoxine

- **Rule**: the **earlier the onset, the milder** (under 6 hours is usually benign gastrointestinal upset or cholinergic); **onset after 6 hours is dangerous** (amatoxin, orellanine, gyromitrin). Cooking, drying and the colour of the cap do not make a mushroom safe.

Metals and metalloids

- **Arsenic**: inhibits pyruvate dehydrogenase and uncouples oxidative phosphorylation. **Acute**: garlic odour, burning throat, rice-water vomiting and diarrhoea (gastroenteric form; resembles cholera), shock; postmortem red velvety stomach. **Chronic**: raindrop pigmentation, hyperkeratosis of palms and soles, **Mees' (Aldrich-Mees') lines (transverse white lines across the nails)**, peripheral neuropathy, skin and lung cancers, blackfoot disease; **arsenic in groundwater** is a public-health problem in Nepal's Terai tube wells (WHO guideline value 10 µg/L). Delays decomposition. **Dimercaprol (BAL)** is the chelator in acute arsenic, mercury and gold poisoning; **DMSA (succimer)** or DMPS for chronic or oral use. Samples: hair, nails, urine, and bone. **Marsh test** and **Reinsch test** detect arsenic. **Mees' lines also occur in thallium**.
- **Lead**: **blood lead concentration is the best confirmatory test**. Chronic features: colicky abdominal pain, **constipation**, **microcytic anaemia with basophilic stippling** (lead inhibits pyrimidine 5′-nucleotidase, so RNA remnants stay in the red cells), a **blue (Burtonian) line on the gums**, wrist drop, encephalopathy in children, **inhibition of ALA dehydratase and ferrochelatase** (raised urinary ALA and coproporphyrin, raised free erythrocyte protoporphyrin). Treatment: remove exposure; chelate with **EDTA, DMSA (succimer) or dimercaprol** depending on level and symptoms; battery work, paints and traditional medicines are sources.
- **Mercury**: chronic gives **blue-black gum line, tremors (hatter's shakes, "Danbury tremors"), erethism (irritability), salivation, gingivitis**, acrodynia in children; **Minamata disease** is organic methylmercury; acute corrosive sublimate causes a metallic taste and renal tubular necrosis. BAL (acute) or DMSA.
- **Arsenic**: **arsenic trioxide (white arsenic, "sankhiya")** is the compound commonly used in poisoning (trivalent arsenic is more toxic than pentavalent, and **arsine gas** is the most toxic form, causing haemolysis); **exhumation** is most often asked about in suspected arsenic poisoning because it persists in **hair, nails and bone for years**. **Lead**: **tetraethyl lead** was the petrol antiknock agent (leaded petrol was phased out worldwide by 2021, UNEP); it is an organic lead that acts mainly on the brain; gum lines also occur with iron, mercury, bismuth, silver and copper. Chronic mercury poisoning can discolour the lens capsule (**mercuria lentis**).
- **Copper sulphate**: blue-green vomit, metallic taste, haemolysis, jaundice and renal failure; **D-penicillamine** is the antidote, and the stomach contents are blue-green at autopsy.
- **Chelators**: **dimercaprol (BAL)** for arsenic, mercury, gold and bismuth; **sodium calcium edetate (EDTA)** for lead; **D-penicillamine** for copper (also Wilson disease), mercury and lead; succimer (DMSA) for lead in children.
- **Thallium**: alopecia (hair loss at 2-3 weeks), painful ascending neuropathy, **Prussian blue** antidote. **Iron**: gastroenteritis and later liver failure; **desferrioxamine**. **Cadmium**: proximal tubule necrosis, painful osteomalacia (itai-itai). **Phosphorus**: garlic breath, luminous vomit, "smoky stool syndrome", **phossy jaw** and fatty liver.

Aluminium phosphide

- **Rat-killer ("celphos" tablets)**: releases **phosphine gas** with moisture in the stomach, which inhibits cytochrome oxidase; garlic or rotten fish odour on the breath, vomiting, **profound hypotension and shock**, arrhythmia, metabolic acidosis, ARDS, hypomagnesaemia; mortality 30-70%. **No specific antidote**; supportive care with fluids, vasopressors, magnesium and, where available, ECMO. Gastric lavage is controversial, since water releases more phosphine; some South Asian protocols use potassium permanganate (1:10,000) or coconut or paraffin oil; keep the patient in a well-ventilated area to protect staff.
- **Silver nitrate test**: a **filter paper soaked in silver nitrate held at the mouth turns black** (phosphine reduces silver); also used on the gastric contents (that is the same principle).

Cyanide, carbon monoxide and hypoxia

- **Types of hypoxia**: **hypoxic** (low PO_2 at altitude), **anaemic** (haemoglobin cannot carry oxygen: CO, anaemia), **stagnant** (low flow: shock), **histotoxic** (cells cannot use oxygen: **cyanide**).
- **Cyanide**: binds **cytochrome c oxidase**, so tissues cannot use oxygen and **venous blood remains bright red** with a high venous PO_2; "**bitter almond**" odour (not detected by all); bright red (cherry-red to brick-red) lividity; very rapid death. **Treatment**: **hydroxocobalamin** (5 g IV; first line in modern practice), or the older **sodium nitrite then sodium thiosulphate** (nitrites make methaemoglobin that binds cyanide; avoid in smoke inhalation because of reduced oxygen carriage), 100% oxygen.
- **Carbon monoxide**: affinity for haemoglobin about **200-250 times that of oxygen**; **carboxyhaemoglobin** lowers oxygen content and shifts the dissociation curve left, with **normal PaO_2** and **normal SpO_2 by ordinary pulse oximetry**, and no cyanosis (the skin may be cherry-red); headache, confusion,

delayed neurological sequelae and globus pallidus lesions. **Treat with 100% oxygen** (half-life of COHb falls from about 4-5 hours on air to about 1 hour); **hyperbaric oxygen** for coma, pregnancy, or COHb above 25-40%. Sources: charcoal heaters in cold Nepali homes, fires, vehicle exhausts. Use co-oximetry.

Paracetamol

- **Toxic dose** over about 150 mg/kg (about 10 g or more in an adult; lower in malnutrition, chronic alcohol use and enzyme induction); **metabolite NAPQI** depletes glutathione and injures hepatocytes (centrilobular necrosis). **Phases**: 0-24 h nausea and vomiting (or none), 24-72 h right-upper-quadrant pain and rising transaminases and INR, 72-96 h peak liver failure.
- **Treatment**: **N-acetylcysteine (NAC)** replenishes glutathione and is most effective within **8 hours**; **start NAC without waiting for enzyme results** if the dose is potentially toxic and the time unknown or after 8 hours; the **Rumack-Matthew nomogram** (classical treatment line at 150 µg/mL at 4 hours, the exam answer; the UK has used a line at 100 µg/mL since 2012; use only for a single acute ingestion between 4 and 24 hours). Normal liver enzymes at 8 hours do not exclude toxicity. Activated charcoal if presenting within 1 hour. **King's College criteria** determine transplant listing.
- **Exam answer**: the classic **three-bag 21-hour IV NAC regimen** (150 mg/kg over 1 hour, 50 mg/kg over 4 hours, 100 mg/kg over 16 hours). **Current practice**: simpler regimens with fewer anaphylactoid reactions, the **two-bag** regimen (200 mg/kg over 4 hours, then 100 mg/kg over 16 hours; Australian and New Zealand guidelines 2020) and the UK's **12-hour SNAP** regimen.

Other drugs commonly asked

- **Benzodiazepines**: **flumazenil** is rarely used, because it may precipitate seizures. **Tricyclics**: sodium bicarbonate for QRS widening. **Digoxin**: digoxin-specific Fab. **Beta-blockers**: glucagon. **Calcium channel blockers**: calcium, insulin euglycaemia therapy. **Heparin**: protamine. **Warfarin**: vitamin K, PCC. **Isoniazid**: pyridoxine. **Iron**: desferrioxamine. **Methaemoglobinaemia**: methylene blue. **Salicylate**: alkaline diuresis, haemodialysis. **Lithium**: haemodialysis. **Ethylene glycol and methanol**: fomepizole. **Anticholinesterases**: atropine and pralidoxime. **Opioids**: naloxone. **Paracetamol**: NAC. **Cyanide**: hydroxocobalamin. **Lead**: EDTA, DMSA. **Arsenic, mercury**: BAL (dimercaprol). **Thallium**: Prussian blue.
- **Electrolyte clues**: oxalic acid and ethylene glycol give hypocalcaemia; hydrofluoric acid hypocalcaemia and hyperkalaemia; digoxin hyperkalaemia.

Forensic psychiatry and legal

Criminal responsibility

- **Actus reus** (the guilty act) and **mens rea** (the guilty mind) are both needed for a crime. **Corpus delicti** is the body of the crime: proof that a crime occurred (the legal injury) and that a criminal agency caused it, independent of any confession.
- **M'Naghten rule** (1843, England): a person is not criminally responsible if, through a **disease of the mind**, they **did not know the nature and quality of the act, or did not know it was wrong**. Other tests: the **New Hampshire rule** (1870s, the forerunner of Durham), the **Durham (product) rule** (1954: the act was the product of mental disease), the **Currens rule** (1961: lacked substantial capacity to conform conduct to the law), the **ALI (Model Penal Code) rule** (1962: lacks substantial capacity to appreciate wrongfulness or to conform conduct), and the **irresistible impulse** test. Insanity is a legal term; psychiatrists speak of unsoundness of mind.
- **Nepal**: Muluki Criminal Code 2074 **s. 14**: an act done by a person who, because of **mental unsoundness at the time of the act, could not understand its nature, quality, wrong or consequence**, is not a crime. This follows the M'Naghten idea; **India's IPC s. 84 does not apply**.
- **Age of criminal responsibility in Nepal** (Code s. 13 and s. 45): **under 10: no crime and no punishment**; 10 to under 14: no fine, a warning, or, for an imprisonable offence, up to 6 months' imprisonment or up to one year in a reform home; **14 to under 16: half the adult punishment**; **16 to under 18: two thirds**; below 16, imprisonment only for heinous, grave or repeated offences. (Muluki Criminal Code 2074, ss. 13, 45.) Do not use India's age limits.
- **Homicide classes in the Code**: intentional killing, including death later from a grievous injury inflicted with intent, **s. 177, life imprisonment**; causing death by an act the person knew or had reason to believe would ordinarily kill, **s. 178, life imprisonment**; killing in **grave and sudden provocation**, by **exceeding the right of private defence in good faith**, or in the heat of a **sudden quarrel**, s. 179 (10-15 years and Rs 1-1.5 lakh; not if premeditated or out of malice); killing a person other than the one intended takes the same penalty (s. 180); **death by a reckless act, s. 181 (3-10 years and Rs 30,000-1 lakh)**; by a negligent act, s. 182 (up to 3 years and up to Rs 30,000), and by pure accident where death was not foreseeable, 6 months to 2 years or up to Rs 20,000 or both (s. 182(3)). **Attempted murder**, s. 183 (up to 10 years and up to Rs 1 lakh). Abandoning a newborn, child, sick or old dependant, s. 184 (up to 3 years; up to 7 years if death follows; a newborn's death from abandonment is punished as murder under s. 177). Abetment of suicide, **s. 185** (up to 5 years and up to Rs 50,000). **Torture** by an official, s. 167 (up to 5 years or up to Rs 50,000 or both; superior orders no defence).
- Hurt: **beating (kutpit)** s. 191 (causing bodily pain, transmitting a disease, or disabling; up to 3 years or up to Rs 30,000 or both); **grievous hurt, "angabhanga"** s. 192 (destroying sight, smell, hearing or speech; cutting off a woman's breast; making a woman sterile or a man impotent; breaking, dislocating or disabling the spine, back, a limb or its joint; or disabling someone from their occupation; also when the result appears later; **up to 10 years and up to Rs 1 lakh**, half if only one of a pair of organs is lost) and s. 192Ka for **acid attacks** (a fixed 20 years and Rs 10 lakh where both eyes or both ears, the nose, the whole face, both breasts or the genitals are destroyed; 15-20 years for lesser destruction; the fine goes to the victim). Note the Code's own list; Indian IPC grievous-hurt categories do not apply.
- **Intoxication**: voluntary intoxication is no defence in most legal systems; involuntary intoxication may be. **Delirium tremens** and other organic states can lead to a plea of unsoundness of mind.

Evidence and witnesses

- **Direct evidence** is eyewitness evidence of the fact itself; **circumstantial (indirect) evidence** supports an inference; **hearsay** is secondhand and generally inadmissible. A neighbour who saw the accused enter with a gun gives direct

evidence of the entry, but circumstantial evidence of the killing.

- **Dying declaration**: a statement by a victim about the cause of death, made when death is expected. It is **recorded preferably by a magistrate, or a doctor if none is available**, in the declarant's own words, after the doctor certifies a sound mind, with no oath and no cross-examination; if the person survives it is no longer a dying declaration, though it may still be used to support their later evidence. **Dying deposition** is taken on oath by a magistrate with the accused or lawyer present, with cross-examination. Nepal's Evidence Act governs admissibility there; the rules above are the general principle.
- **Court procedure**: oath; **examination-in-chief** (by the party that called the witness; leading questions not allowed except for a hostile witness), **cross-examination** (opposing side; leading questions allowed), **re-examination** (to clarify what cross-examination raised), and questions by the judge. A **hostile witness** is one who testifies against the party who called them.
- **Expert witness** gives an opinion, not facts: **a doctor is an expert witness when giving opinion and a witness of fact when stating what they found**. A **summons** compels attendance. **Perjury** is false evidence on oath.
- **Medical negligence**: duty of care, breach, causation, damage (the **Bolam test** for the standard of care; **Bolitho** adds logical defensibility). **Res ipsa loquitur** ("the thing speaks for itself"): negligence is inferred from the nature of the accident (instrument left in the abdomen, wrong-limb amputation). **Novus actus interveniens**: a new intervening act that breaks the chain of causation. **Medical misadventure (maloccurrence)** is an undesirable outcome unrelated to care quality.
- **Professional misconduct**: working while impaired by alcohol or drugs (an intoxicated surgeon) is serious professional misconduct even if no patient is harmed; negligence needs a breach of duty that causes damage. In Nepal the **Nepal Medical Council**, which keeps the register, takes disciplinary action under its Act and its Code of Ethics and Professional Conduct, up to removing the name from the register.
- **Consent**: a competent adult gives their own informed consent; if refusal persists after counselling, respect the autonomy and document it. **Medicolegal cases (MLC)**: injuries, poisoning, unnatural death and sexual assault are to be reported to the police. **Professional confidentiality** may be broken only by law or with consent.
- **Therapeutic privilege**: the narrow exception allowing a doctor to withhold information when disclosing it would itself seriously harm the patient; the doctor must be able to justify it. It differs from **privileged communication** (what the patient tells the doctor in confidence).
- **Drunkenness**: assess the smell of alcohol plus coordination. No smell and normal coordination means not consumed; smell with abnormal coordination means consumed and under influence; smell with normal coordination means consumed but not under influence.

Child abuse

- **Shaken baby syndrome (abusive head trauma)**: **triad of subdural haemorrhage, retinal haemorrhages and encephalopathy**, with little or no external sign of impact; most children are under 1 year (nearly all under 2); fractures of posterior ribs at the costovertebral junction and metaphyseal "corner" fractures accompany it. It is the **commonest cause of death from physical child abuse**. The triad is now interpreted with care in court because of debate about the strength of the evidence.
- **Battered baby (Caffey's) syndrome**: non-accidental injury, usually in children under 3, with fractures of different ages, subdural bleeding and bruises; distinct from Caffey's disease (infantile cortical hyperostosis).
- **Signs suggesting abuse**: spiral fractures of long bones in a non-walking child, **posterior rib fractures**, "**six-penny**" (circular) bruises and **cigarette burns**, immersion scalds with sharp lines, multiple fractures at different healing stages, delay in seeking care, a history inconsistent with the injury. Differential: **osteogenesis imperfecta**, bleeding disorders, Mongolian spots.
- **Munchausen syndrome by proxy (factitious disorder imposed on another)**: **a caregiver, usually the mother, fabricates or induces illness in a dependent child** to gain attention and seeks repeated medical care; a form of child abuse. **Munchausen syndrome** is self-induced illness. **Cinderella syndrome**: a single child (often a girl) singled out for battering or neglect. **Vulnerable child syndrome**: parents see the child as fragile after an earlier life-threatening illness.
- A doctor's duty on suspecting abuse: document, protect, inform the child-protection agency and the police; consider radiological **skeletal survey** in under-2s.

Sudden infant death and the newborn

- **Sudden infant death syndrome (SIDS)**: sudden unexpected death of an infant under 1 year that stays unexplained after a full autopsy, scene examination and review of the history (a **diagnosis of exclusion**). **Peak 2–4 months, rare after 6 months**; commoner in boys and in winter. Risks: **prone sleeping**, soft bedding, overheating, parental smoking, prematurity, bed sharing; protective: **supine sleep on a firm surface**, breastfeeding, a dummy. Postmortem signs are non-specific (petechiae on the lungs, thymus and pleura, pulmonary congestion).
- **Hydrostatic (floating lung) test**: lungs that have breathed float, but it supports and does not prove live birth. **False positives**: **putrefactive gas** or **artificial respiration**; **false negatives**: lungs of a child that breathed briefly and **collapsed** (and some cases of fetal pneumonia). Read it with an air-containing stomach and gut (Breslau's test) and the other signs of live birth.
- **Neonaticide** is killing of a newborn in the first 24 hours, **infanticide** of an infant under 1 year (terms of the texts, not of Nepal's law). In Nepal a newborn's killing is homicide under the Muluki Criminal Code 2074 (s. 177), and **abandoning a newborn** so that its life is endangered is an offence (s. 184; if the newborn dies of it, punished as murder under s. 177); and where an attempted abortion ends in a live birth and the child dies at once, it counts as abortion (s. 188(4)). No Indian provision applies.

Reproductive medicolegal terms

- **Superfecundation**: two ova released in **one cycle** fertilised in separate acts of intercourse (possibly by different men). **Superfetation**: fertilisation of an ovum from a **later cycle** in a woman who is already pregnant. **Pseudocyesis** (false pregnancy); **suppositious child** (a substituted baby). **Viability**: the classical medicolegal limit is 28 weeks (WHO's perinatal definitions use 500 g or 22 weeks).

- **Abortion in Nepal (Muluki Criminal Code 2074, ss. 188-189)**: by a **health worker with the woman's consent up to 12 weeks**; **up to 18 weeks if the pregnancy follows rape or incest**; and **at any stage on the opinion of a licensed doctor** that the woman's life is at risk or her physical or mental health may be harmed, or that the child will be disabled; also for a woman with HIV or another incurable disease. Illegal abortion, or abortion forced on a woman, is punished by **up to 1 year and Rs 10,000 (up to 12 weeks), up to 3 years and Rs 30,000 (over 12 to 25 weeks) and up to 5 years and Rs 50,000 (over 25 weeks)** (s. 188(3)); **sex-selective abortion** and sex identification for it are separate offences (s. 188(7)-(8): 3-6 months for identifying the sex for abortion, and up to one further year added to the abortion penalty). The Right to Safe Motherhood and Reproductive Health Act 2075 (2018) also governs abortion and allows up to 28 weeks on some grounds; know both. India's MTP Act does not apply.
- **Signs of recent delivery and abortion in the living and dead**: examine the uterus, breasts, lochia and perineum; in a dead woman, clots or fetal parts in clothing, labial congestion and perforation of the uterus or posterior fornix.
- **Infanticide, concealment of birth and stillbirth**: live birth is shown by the hydrostatic (floating lung) and other tests; see Identification.
- **Still-born versus dead-born** (the texts' terms): a **still-born** child was alive in the uterus but died during labour, so it is fresh and may show signs of birth such as caput succedaneum or moulding, without having breathed; a **dead-born** fetus died in the uterus before labour and shows at least one sign of intrauterine death (**maceration**, mummification, Spalding's sign). **Current usage** (WHO, ICD-11): every baby born without signs of life at 28 weeks or more is a stillbirth, divided into **antepartum** (macerated) and **intrapartum** (fresh).

Torture and Nepal's law (curriculum additions)

- **Torture** (UN Convention against Torture 1984) is severe physical or mental pain deliberately inflicted by or with the consent of a public official for a purpose (information, confession, punishment, intimidation). The doctor's duties: examine, document injuries accurately (the **Istanbul Protocol**, OHCHR 1999, revised 2022, is the standard for documenting torture), and report; the doctor must never take part. Findings: patterned bruises, **falanga** (beating of the soles: bruised, swollen soles, later chronic pain), suspension injuries, burns, electrical marks, and psychological sequelae (PTSD).
- **Nepal**: the **Muluki Criminal Code 2074, s. 167 (Yatana dina nahune)** forbids any officer with power of investigation, prosecution, control, custody or detention to inflict physical or mental torture or cruel, inhuman or degrading treatment on a person; torture is defined as deliberate pain or suffering inflicted to get information, to get a confession, to punish, to intimidate or coerce, or for another unlawful purpose. The penalty is **up to 5 years or up to Rs 50,000 or both** by the gravity of the act, and whoever orders or helps is punished as the principal (s. 167(2)-(3)). In the same Code, torture or cruel, inhuman treatment while committing any offence is an **aggravating circumstance** (s. 38), and **killing by cruel torture** is one of the offences whose life imprisonment lasts **for the rest of the offender's life** (s. 41(a)). The practice is the standard of the Istanbul Protocol; India's law does not apply.
- **Age estimation, drunkenness and pregnancy** (curriculum list): age is estimated from teeth, ossification and sexual characteristics (see Identification), each with an error of about 2 years in the adult; drunkenness is assessed as in the evidence section; a **pregnancy** is established in the living by urine hCG and ultrasound, in the dead by the uterus and its contents.

Sources

Reddy; Parikh; Narayan Reddy on medical jurisprudence; Bolam and Bolitho (UK case law); Royal College of Paediatrics and Child Health, Abusive Head Trauma guidance (2018); **Muluki Criminal Code 2074, ss. 13, 14, 45, 105, 167, 177-185, 188-192Ka, 219, 225** (read in the Code); **Muluki Criminal Procedure Code 2074, ss. 20-22** (the Law Commission's text); **Right to Safe Motherhood and Reproductive Health Act 2075**, as summarised in this site's book-corrections note.

Standard texts for the other sections: Reddy's Essentials; Parikh; Knight's Forensic Pathology; DiMaio; Dix and Calaluce; Goldfrank's Toxicologic Emergencies; KD Tripathi; Katzung; Harrison; Gray's Anatomy; Dutta; Saukko and Knight; Eddleston and others on organophosphate poisoning (Lancet 2008; PLoS Med 2009); guidelines of WHO (drowning definition 2002; responding to sexual violence 2014), ILCOR, WHO SEARO (snakebite 2016), Nepal's National Guidelines for Snakebite Management (2019), the UK's MHRA (paracetamol 2012).

- Mushroom poisoning and torture additions: Goldfrank's Toxicologic Emergencies (Amanita and orellanine); Istanbul Protocol (OHCHR, 2022); Nepal Muluki Criminal Code 2074 (ss. 38, 41, 167, 177, 184), from the Code's own text.