SELF-STUDY FORENSIC PATHOLOGY MODULE

General Pathology Course
FORENSICS DEFINED

Section I
• **Forensic science**
  - Study and application of many disciplines of the natural sciences as they pertain to legal and criminal investigations.

• **Forensic medicine**
  - Branch of medicine that interprets/establishes medical facts in civil or criminal law cases.

• **Forensic pathology**
  - Subspecialty of pathology (medical specialty) involved in determining the cause of death.
• A physician officially authorized by a governmental unit to ascertain causes of deaths, especially those not occurring under natural circumstances.
  - Works independently of legal or justice system.
  - There are medical examiner systems in place, either county or state, in more than half of the United States.
  - Most medical examiners are pathologists, usually board certified in forensic pathology.
A coroner is an elected official (in most cases, not a physician) that has jurisdiction and may sign the death certificate.

- Many states use a coroner system.
- Some states have both coroners and medical examiners.
- Continued debate and effort to improve and standardize death investigative systems.
The State of Death Investigations

The use of medical examiners or coroners varies not only among states, but even within states. Twenty-two (including the District of Columbia) use some type of medical examiner system, 11 use some type of coroner system, and 18 use a mix.

Source: U.S. Centers for Disease Control
ROLE OF MEDICAL EXAMINER

- Identification
- Cause of death
- Manner of death
- Perform autopsy
- Collect evidence
- Document findings
- Recover materials
- Interpret findings
- Estimate time since death
- Serve as expert witness
ELEMENTS OF POST-MORTEM EXAMINATION

• Circumstances
• Identification
• Medical history
• External examination
• Internal examination
• Ancillary studies
• Cause and manner of death
• Final report
CAUSE, MECHANISM AND MANNER OF DEATH

Section II
MANNER OF DEATH

The circumstances under which the person died.

Natural
• Death due to disease or medical condition

Accident
• Unintentional death

Suicide
• Intentional injury death to self

Homicide
• Intentional injury death to another

Undetermined
• Manner cannot be determined because of insufficient or conflicting information
## Cause and Mechanism of Death

### Cause of death

- The disease or injury that initiated the lethal chain of events that brought about a person’s death
  - Immediate (just prior to death)
  - Intermediate
  - Proximate (what started the chain of events)

### Mechanism of death

- The nonspecific final common pathway by which the cause of death exerts its lethal effect
  - Has a broad differential
  - Not acceptable as the sole cause of death
  - Examples:
    - Hemorrhage
    - Renal failure
    - Cardiac arrest
A 59 year-old man with a history of smoking, high cholesterol, high blood pressure and diabetes has a myocardial infarction. After being hospitalized and treated he dies suddenly on Day 3. Autopsy reveals left ventricular rupture and cardiac tamponade.

**CAUSE OF DEATH**

**Immediate cause of death:**
- Pericardial tamponade

**Intermediate cause of death:**
- Myocardial infarction

**Proximate cause of death:**
- Atherosclerosis
A 76 year-old woman presents with severe shortness of breath and chest pain. She arrests in the emergency department. She is found to have a deep venous thrombosis (DVT) involving her left lower extremity. Despite efforts to resuscitate her, she dies. Autopsy reveals a ‘saddle’ pulmonary embolus and pancreatic cancer.

CAUSE OF DEATH

Immediate cause of death:
Pulmonary embolus

Intermediate cause of death:
Deep venous thrombosis

Proximate cause of death:
Pancreatic cancer
CHANGES AFTER DEATH

Section III
CHANGES AFTER DEATH

- Algor mortis
- Livor mortis
- Rigor mortis
ALGOR MORTIS

• Postmortem cooling

• Postmortem body temperature decreases until the ambient temperature is reached.

• The rate of cooling is fastest immediately following death and stops with a reduced gradient.

• Rate of cooling may be used for estimating the time interval since death.
• Factors affecting body cooling:
  • Clothing
  • State of nutrition
  • Environmental temperature
  • Wind
  • Relative humidity
  • Contact of body with hot and cold objects
  • Temperature of body at death
LIVOR MORTIS

- Postmortem lividity
- Purplish discoloration due to the settling of blood by gravitational forces within dilated, toneless capillaries in the skin
  - May begin as early as 20 minutes following death
  - Gradual process which becomes more pronounced with time
  - Found in the dependent areas of the body
LIVOR MORTIS

-A pale area will form where the skin is pressed against a hard surface (See image- right upper)

-Early stages of livor mortis can be blanched by compression

-After 8 hours, blanching does not occur

-Late stages of livor may result in tardieu spots, a consequence of capillaries bursting and forming pinpoint hemorrhages (see image right lower)
RIGOR MORTIS

- Immediately after death, the body is flaccid.

- This is followed by increasing stiffness or rigidity usually beginning in the first hour after death.

- Rigor is a consequence of a biochemical reaction within the muscle.

- Lactic acid production, free calcium ions and the lack of ATP result in fixed actin/myosin bridges.
  - Progresses for 12 hours
  - Remains for another 10-12 hours
  - Then body becomes flaccid again

- Hypothermia and cold temperatures will slow the chemical reactions and delay the rigor process.

- Hyperthermia and hot temperatures the entire process may occur faster
RIGOR MORTIS

The appearance of rigid limbs may be useful in determining the final position of the body at the time of death.

From Spitz and Fisher’s Medicolegal Investigation of Death
POSTMORTEM CHANGES

- Decomposition - disintegration of body tissues
  - Affected by state of health and by environment
  - Bacterial and other organisms lead to putrefaction and additional body changes
  - The effects of predators such as insects and rodents should always be a consideration when assessing postmortem body changes
    - Gnaw marks with the removal of tissue, and the absence of blood are signs of postmortem animal activity.
    - Soft tissue around the eyes and mouth are common sites.
INTERPRETING DECOMPOSITION CHANGES

- Postmortem bloating may be misinterpreted as obesity

- Bloody decomposition may be misinterpreted as bleeding due to trauma

- Postmortem decomposition of stomach with fluid leakage may be misinterpreted as a perforated ulcer

- Focal autolytic changes in pancreas may be misinterpreted as pancreatitis

- Tardieu spots may be misinterpreted as premortem petechiae

- Injury may be caused postmortem by a variety of scavengers: ants (see image to right), roaches, pets and flies (laying of eggs)

From Spitz and Fisher’s Medicolegal Investigation of Death
SUDDEN AND UNEXPECTED DEATH NATURAL IN ADULTS

Section IV
Sudden Unexpected Death

• Sudden and unexpected are terms that may mean different things to different people

• No exact definition exists

• May occur in a patient with known disease whose death was not expected

• May occur in a patient with non medical history whose death and perhaps underlying diagnosis come as a surprise

• Many cases of the medical examiner are medical – due to ‘natural’ causes
Sudden Death

Cardiovascular

• Predominate
• Most related to atherosclerotic heart disease
• Other causes
  • Hypertensive heart disease
  • Cardiomyopathies
  • QT prolongation
  • Mitral valve prolapse
  • Aortic dissection

Non-cardiovascular

• Involve any organ system:
  • Cerebrovascular hemorrhage
  • Gastrointestinal hemorrhage
  • Pulmonary embolism
  • Obesity and associated problems
  • Sleep apnea
  • Pneumonia
  • Anaphylaxis
  • Malignancy
Sudden Cardiac Death

- Death from atherosclerotic heart disease:
  - Pump failure
    - Usually after multiple ischemic events and with an electrically stable heart
  - Sudden arrhythmia
    - Most persons dying from atherosclerotic disease outside of the hospital die of some sort of an arrhythmia
    - May be caused by fixed obstruction
    - May be caused by transient functional factors such as increase in blood pressure, increased neural sympathetic discharge, sympathomimetic irritation
Sudden Cardiac Death

Points:
- Many cases will reveal no history of cardiac disease.
- If a patient dies immediately following a myocardial infarction, there may be no pathologic findings to confirm this.
- Hemopericardium may result with ventricular rupture following a myocardial infarction.
- There are other causes of cardiac death that may become evident with careful dissection of the heart:
  - Left ventricular hypertrophy related to hypertension.
  - Cardiomyopathy.
  - Myocarditis.
Sudden Unexpected Death
Non-Cardiovascular Causes

- Pneumonia
- Morbid Obesity
- Malignancy
- Drug overdose
- CNS hemorrhage
- Aortic dissection
TYPES OF INJURY
BLUNT FORCE, SHARP FORCE, GUNSHOT, ASPHYXIA, THERMAL INJURY

Section V
BLUNT FORCE INJURY
Blunt force injury is caused by a non-penetrating object that tears, shears or crushes. Skin manifestations of blunt trauma differ depending on the force, location of the injury and the nature of the impact. A fall or blow from a blunt instrument are examples, many of which may leave a patterned injury.
• Contusion
  • A wound occurring as a result of hemorrhage into the soft tissues caused by rupture of blood vessels

• Abrasion
  • A wound produced by friction scraping away epidermis or disruption of the epidermis by direct pressure or rubbing

• Laceration
  • Tear due to crushing or shearing forces that results in tissue bridging at site of the wound.
Blunt Force Injury

Contusion

Results from a blow that ruptures blood vessels but does not result in disruption of the skin.

Contusions may be patterned

From Spitz and Fisher’s Medicolegal Investigation of Death
BLUNT FORCE INJURY

Abrasion

-Rubbing off of superficial layer of skin

-Skin pattern may provide information as to type of object and force of injury
Tissue bridging— with connective tissue fibers is characteristic of a laceration, here, after a blow to left eye

From Spitz and Fisher's Medicolegal Investigation of Death
PENETRATING VS. BLUNT FORCE INJURY
SHARP FORCE INJURY

Forensic Pathology
SHARP FORCE INJURY

- Wounds produced by sharp objects either by cutting or stabbing or both
  - **Incised wounds**
    - Produced when the sharp object is drawn over the skin with pressure to cause injury that is longer than it is deep.
  - **Stab wounds**
    - Results from penetration of a pointed or thinly tapered instrument causing a wound that is deeper than it is long.
INCISED WOUND

-Incised wounds may be caused by a variety of sharp objectives

-Seen here are defensive wounds on the left arm

From Spitz and Fisher's Medicolegal Investigation of Death
STAB WOUND

-Stab wounds tend to be sharp and straight and often devoid of bruising and abrasions.

-If bruising occurs, this is usually the result of pressure or the fist that held the weapon.

-If the entire blade enters the body, an abrasion or bruising may occur where the handle or hilt abut the skin as seen in the image to the right.

From Spitz and Fisher’s Medicolegal Investigation of Death
SHARP FORCE INJURY
STAB WOUND

From Spitz and Fisher's Medicolegal Investigation of Death
INJURY BY FIREARMS

Forensic Pathology
INJURY BY FIREARM

- Materials that leave the gun when it is fired:
  - Bullet
  - Gunpowder
  - Metal
  - Gas and soot

- The autopsy of a victim of firearm may provide information regarding:
  - Range of fire
  - Direction of fire
INJURY BY FIREARMS

- Range of fire
  - Contact: Weapon in contact with the body
  - Close-range: Gunpowder is deposited on the target
    - Fouling: Dust-like gunpowder that can be wiped off.
    - Stippling: Superficial wounding of the skin caused by unburnt gunpowder
  - Distant: No gunpowder is deposited on the target; only the bullet makes it to the body
Contact Range

- Gunpowder is usually not visible on tight contact shots - the gunpowder is deposited within the tissues of the wound.

- There may be splitting of wound edges as depicted here.

- Contact wounds from high powered rifles often result in very large wounds and significant tissue destruction.

*From Spitz and Fisher’s Medicolegal Investigation of Death*
CLOSE-RANGE

- Fouling (around the entrance wound) and stippling (larger area of skin injury blocked by the victim’s eyeglass stem) are seen in this image.

- Gunpowder deposition is dependent on the length of the barrel of the firearm.

- Gunpowder residue is usually circumferentially distributed—may be uneven around the wound if the weapon is fired at an angle.

*From Spitz and Fisher’s Medicolegal Investigation of Death*
Distant Range

- No gunpowder is deposited
- In the absence of gunpowder, no distinction can be made between distant shots

From Spitz and Fisher’s Medicolegal Investigation of Death
Injury by Firearm: Direction of Fire

- Entrance wound
  - Characterized by:
    - Circumferential marginal abrasion that darkens as it dries.
    - With approximation, usually still retains a small central defect.
  - If the bullet strikes at an angle, the wound is still round, but the surrounding abrasion may be oval.
  - Often smaller than the size of the bullet because the stretched skin returns to its normal size
  - Entrance wounds may be patterned or irregular due to clothing, or striking of a hard object.
ENTRANCE WOUND

Example of entrance wound

From Spitz and Fisher’s Medicolegal Investigation of Death
Injury by Firearm: Direction of Fire

- Exit Wound
  - Significant variety in size and appearance
    - High power rifle shots often produce large and ragged exit wounds
  - Usually larger than the caliber of the bullet
    - Exit wounds of the head are frequently star-shaped
  - When a bullet hits a hard object such as a long bone, the jacket of the bullet may separate and form its own path – different from the core
EXIT WOUND

Example exit wound
ASPHYXIA

Forensic Pathology
Asphyxia

- Term referring to a variety of conditions that result in decreased intake and/or utilization of oxygen.
  - Compression (of the neck)
    - Hanging
    - Strangulation
  - Obstruction of airway
    - Smothering
    - Aspiration
    - Swelling
    - Positional
  - Compression (of the chest)
  - Exclusion of oxygen
    - Carbon dioxide poisoning
    - Carbon monoxide poisoning
    - Cyanide poisoning
HANGING

- Body can be in any position

- Veins (and arteries) are more compressible than the airway

- Amount of pressure on the neck that can bring about loss of consciousness is low

- Potential autopsy findings in a hanging victim:
  - Petechiae on face above noose
  - Groove or pattern on the neck
  - Abrasions at the site of knot or other
  - Skin stretching, pinching or blisters
  - Protrusion of tongue
  - Blood or bloody mucus

From Spitz and Fisher's Medicolegal Investigation of Death
STRANGULATION

-May be homicidal, suicidal or accidental (manual strangulation is always homicidal)

-Potential autopsy findings:
  - Bruising of neck
  - Fingernail marks on neck (could be victim or assailant)
  - Abrasions of neck
  - Petechiae
  - Fractures of hyoid and other neck structures

-See chart to compare findings of strangulation by ligature vs. hanging

From Spitz and Fisher’s Medicolegal Investigation of Death
SMOTHERING

Blockage of nose and mouth with subsequent inability to breath

-Homicidal in most cases

-Other forms include entrapment (such as in an avalanche) and the use of plastic bags

ASPIRATION

A foreign object in the airway (see hotdog remnant in image below)

From Spitz and Fisher’s Medicolegal Investigation of Death
THERMAL INJURY

Forensic Pathology
Classification of Burns

• First degree
  • Superficial, red discoloration, edema and pain (sunburn)

• Second degree
  • Blistering, upper layers of skin are destroyed

• Third degree
  • Involves entire thickness of skin; epidermis and dermis. Pain is usually absent as nerve fibers are destroyed.

• Charring
  • More extensive, usually completely destroys skin and sometimes bone
THERMAL INJURY

- Severity of burn depends on fire temperature and length of exposure

- House fires are unlikely to be hot enough to completely destroy all remains of a victim

- Soot in airway may be seen (right)
• The study of forensics includes the natural sciences and legal/criminal investigations.

• There are many ‘natural’ causes of death identified by the medical examiner.

• Postmortem changes should be distinguished from pre-mortem injury.

• Careful inspection and dissection of the body with specific knowledge of a variety of types of injury can provide information regarding the cause and manner of death.
REFERENCES


• http://library.med.utah.edu/WebPath/webpath.html