Outline

- Terminology
  - Sequelae leading to injury and death
    - Cell death, local, secondary infection, shock
  - Physical injury
    - Fractured bones
    - Muscle trauma
    - Gunshot
    - Lightning strike/electrocution
    - Drowning
  - Temperature related
    - Burns
    - Frost bite
    - Hypothermia
    - Hyperthermia
- Take home

Terminology

- Trauma = an injury produced by a sudden, violent force that results in compression, stretching, torsion, or penetration of the tissues
- Abrasion = tearing away of epidermal cells by friction or crushing (scrape)
- Laceration = a split or tear caused by excessive stretching of tissue (NOT a cut)
- Incision = a wound caused by the pressure or friction against skin or other tissues by an instrument with a sharp edge; longer than deep (cut)
Terminology Continued

- **Penetrating injury** = the impact of an appropriately shaped object against the skin that causes wound that is deeper than long (stab)
- **Contusion** = the force of an impact is transmitted through the skin into the underlying tissue and disrupts the walls of small blood vessels, causing interstitial bleeding without disruption of epidermis (bruise)
- **Fracture** = mechanically produced disruption in the continuity of bone (broken bone)

Cell Response to Injury

- **Trauma:**
  - Direct rupture
  - Disruption of blood supply
- **Extreme cold:**
  - Impairs blood flow
  - Intracellular ice crystals
- **Extreme heat:**
  - Denatures enzymes and proteins
  - Increases rate of metabolism, disrupting level of substrates, water and pH

Trauma Sequelae: Local

- **Hemorrhage**
  - Lacerated vasculature
- **Internal organ damage**
  - Direct laceration or
  - Hypoxia
- **Inflammation**
- **Infection**
### Trauma Sequelae: Infection

- Disruption of protective layer of cells can lead to portal of entry for infection either on surface of instrument or subsequently gain access to tissue
- If primary wound infection does not occur, can get secondary infection through blood
- Source: soil
  - Clostridium tetani, C. welchii
- Source: skin
  - Streptococci spp., Staphylococci spp., Proteus vulgaris, Pseudomonas aeruginosa, Escherichia coli
- Source: mucous membranes:
  - Streptococci spp., Pneumococci spp., Meningococci spp., Haemophilus influenzae, Klebsiella pneumoniae, E. coli, Corynebacterium diphtheriae, and C. welchii

### Trauma Sequelae: Hypovolemic Shock

- Absolute loss of intravascular volume
- Reduced circulating blood volume due to blood loss (internal or external bleeding), or secondarily due to fluid loss from vomiting, diarrhea, or burns
- Outcome: decreased blood pressure and tissue perfusion
- Compensation: peripheral vasoconstriction and fluid movement into plasma
- **Determinants of acute outcome:**
  - $\text{<10\% blood volume loss}$ – return to homeostasis
  - $\text{10\% blood volume loss}$ – loss of pressure and perfusion
  - $\text{>35\% blood volume loss}$ – pressure and cardiac output fall drastically
- Animals can survive chronic blood loss at slow rate
Cardiogenic Shock

- Failure of the heart to adequately pump blood due to severe impairment of cardiac function
- Outcome: decreased tissue perfusion
- Compensation: sympathetic stimulation of the heart
- Determinants of outcome:
  - Nature of cardiac damage
  - Ability of heart to respond

Maldistribution or Distributive Shock

- Inadequate intravascular blood volume compared to intravascular capacity caused by vasodilation (not blood loss)
  - Trauma to nervous system (electrocution), stress, hypersensitivity to allergens, endotoxemia
- Outcome: decreased peripheral vascular resistance and pooling of blood in peripheral tissues resulting in hypoperfusion
- Compensation: vasoconstriction mechanisms
- Types:
  1. Anaphylactic
  2. Neurogenic (trauma)
  3. Septic (bacterial endotoxin or fungi)
Force

• Kinetic energy or wound-producing capacity determined by mass (M) and velocity (V); \( g \) = the acceleration of gravity

\[
\text{Force} = \frac{MV^2}{2g}
\]

Fractured Bones

• Classification: Simple break, explosive comminution, or compound fracture
• Outcome:
  – Loss of function
  – Loss of structural support
  – Soft tissue damage
  – Hematoma
• Secondarily: anemia and hypovolemic shock
• Hit by vehicle (~1 million animals/day), fighting, predation, gunshot or arrow, striking objects, capture, accidents

Closed or Simple Fracture
Comminuted Fracture

Open or Compound Fracture

Fracture Sequelae: Hemorrhage
Fracture Healing

Complications: inadequate blood supply, instability, and infection

Muscle Trauma

- Causes:
  - Crush injury
  - Laceration (fractured bones)
  - Surgical incisions
  - Tearing from excessive stretching or exercise
  - Burns
  - Gunshot/arrows, predation
- Partial = tear of fascial sheath (hernia)
- Complete tear of large muscles
- Diaphragm is the most common torn muscle in animals due to being hit by vehicle (increased pressure in abdominal cavity)
- Healing through fibrosis

Muscle Trauma: Predation
Gunshot

- Force = MV^2/2g
- The faster the bullet is moving and the heavier the bullet, the more damage caused
- Causes cutaneous (entrance and exit wound) and internal injuries (fractured bones, hemorrhage, organ damage)

Gunshot: Entrance Wound

Circular wound with abrasion

Photos: Dr. T. Cornish

Gunshot: Internal Injuries

- Extent of injury greater than diameter of bullet due to the force projecting radially from path of bullet
- Blood vessel laceration, bone fractures, and organ damage occurs surrounding bullet path

Gunshot: Exit Wound

Often irregular in shape, with extensive hemorrhaging

Photos: Dr. T. Cornish

Electrocution

- Only occurs if circuit is completed between two conductors
- Path taken through body is most direct route between contact points
- Causes injury or death differently depending on which part(s) of body are affected:
  - Alteration of organ function (e.g., ventricular fibrillation or paralyzing respiratory center)
  - Stimulation of muscle contraction (tetanic possible)
  - Creating heat

Electrocution

http://w3.vet.cornell.edu/nst/nst.asp?Fun=Image&imgID=10634
Drowning

- **Causes:**
  - Swept away in current
  - Break through ice
  - Exhaustion
  - Commercial fishing
  - Artificial or natural flooding
  - Oil spills
  - Secondary problems (illness, injury, anesthesia, alcohol)

- **Key factors to survival:**
  - Duration
  - Water temperature (diving reflex in cold water)
  - Speed of resuscitation
Drowning

• **Outcome**: water in respiratory and alimentary tract
  • Water in respiratory tract
    – Bronchioles blocked, causing anoxia
  • Water in alimentary tract
    – No harm or vomiting
• Osmotic effect
  – Freshwater (hypotonic) = inhaled water may be pumped by the heart throughout circulation because of low osmolarity (hemolysis)
  – Saltwater (hypertonic) = lungs quite heavy due to fluid from circulation diffusing into lungs (dehydration and pulmonary edema)
• Death caused by hypoxia and respiratory acidosis leading to cardiac arrest
Trauma Secondary to Drowning

Trauma occurs due to contact with objects in water – rocks, trees, etc.

Burns

- Exposure to excessive heat source
- Partial-thickness burn
  - 1st degree
  - Epidermis only
  - 2nd degree
  - Epidermis and part of dermis
- Full-thickness burn
  - 3rd degree
  - Epidermis and all of dermis

Burns: Categories

![Burns Category Table and Diagram](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770215/?tool=pmcentrez)
Burns: Causes

- Ultraviolet light
  - Primarily animals in captivity
- Heat
  - Brush and grass fires common source in free-ranging
  - Most fire deaths result of carbon monoxide poisoning
- Chemicals
  - Man-made or natural sources
- Friction
  - Snares, nets, fences, or collars

Burns: Gross Lesions

- First-degree burns
  - Erythema (redness of skin) and edema due to capillary dilation and increased permeability (acute inflammation)
- Second-degree burns
  - Vesicle formation due to fluid accumulation at dermal-epidermal junction
- Third-degree burns
  - Desiccation and charring of epidermis with amorphous accretion (increase in size by adhesion of parts) of connective tissue (coagulation of dermis)

Burns: Pathogenesis

- Capillaries and small blood vessels become dilated as tissue temperature rises → capillary wall permeability increases → fluid components of blood leave vessel into interstitial space → edema
- Cytoplasm of cells first becomes granular then coagulated
- Collagen loses fibrillar structure and becomes gel-like
- Systemic effect of extensive cutaneous burns is hypovolemic shock from loss of plasma
Burns: Sequelae

• Denatured tissue elicits an inflammatory response
• Burn sites are very prone to secondary infection of opportunistic bacteria leading to adjacent tissue infection
  — *Pseudomonas* spp.

Burns: Healing

• First-degree
  — Heal completely with minimal scarring due to intact dermis
  — Remaining epidermis reepithelializes and adnexa (appendages such as hair and sweat glands) maintained
• Second-degree
  — Dermal scarring present, but adnexa maintained
• Third-degree
  — Histocytes (macrophages) infiltrate tissue, necrotic tissue sloughs, and granulation tissue fills in wound
  — Permanent scarring and loss of adnexa in absence of skin graft
  — Extensive burning results in life-threatening condition due to extensive fluid loss and systemic infection
• Success depends on maintaining hydration and treating infection
• Issues: scars inhibit function, keloids (collagen)

Frostbite

• Common cause of disease in captive animals
• Frequent in range cattle and birds
• Caused by severe exposure to cold temperature
• Pathogenesis: dehydration and ice crystal formation in cells, thrombosis, and metabolic disruption leading to ischemia
• Sequelae: Sloughing of tissue and dry gangrene (coagulation necrosis due to infarction)
Hypothermia

- Extensive surface area exposed to cold temperature rather than local exposure (frostbite)
- Due to exposure
  - Inability to seek shelter, capture, sudden drop in temperature or storm (spring migration of birds)
- Causes low body temperature, disrupting circulation when temperature lowers to ~ 20°C
- Cold water or wind exasperates effect
- Death from exposure normally does not exhibit striking lesions
  - Right sided cardiac dilation and pulmonary edema

Hyperthermia

- Inability to thermoregulate above a critical temperature, irreversible changes occur that can result in death
- Caused by overexposure to sun, capture/physical restraint, inadequate shelter, locked in house/car, or overcrowding
- Acute heat stress can cause similar damage as burns along with irreversible damage to kidneys, liver, heart, and brain
  - Leading to excess fluid loss and shock
- Chronic heat stress in stock results in down-regulation of metabolism and production – mechanism unknown
Hyperthermia: Rise in Temperature Causes

• Vasodilatation with reduction in effective blood volume
• Rapid pulse and dilation of heart with reduced cardiac efficiency
• Stimulation of respiration
  – Tachypnea (abnormally fast breathing)
  – Irregularity
  – Arrest of respiration

Take Home

• Physical trauma is a function of mass and velocity
• Location where trauma occurs on body will have a significant effect on outcome (head more serious than leg!)
• Sequelae involve secondary infection and shock due to blood loss
• Healing depends on type of cell injured (labile, quiescent, permanent...remember these?)
• Temperature related injury is a function of duration and extent of temperature extreme
• Sequelae also involve secondary infection and shock due to fluid loss
• Healing depends on duration, extent and severity of exposure; and secondary complications (parasites, body condition, disease, etc.)

Questions?