DROWNING
OVERVIEW: DROWNING

• Definitions
• Nx findings
• Histo findings
ASPHYXIA

• An umbrella term for death due to body-wide lack of oxygen (hypoxia/ anoxia)
  • Asphyxia is a *mechanism of death*, not a COD
  • Previously terminology inconsistent, recent review/standardization (Sauvageau 2012)
  • Asphyxia is classified into 4 broad categories:
    1. Suffocation
    2. Strangulation
    3. Mechanical asphyxia
    4. Drowning
Types of Asphyxia

- Suffocation
  - Choking
  - Confined spaces / entrapment / vitiated atmosphere
- Strangulation
  - Smothering
- Mechanical asphyxia
  - Positional asphyxia
  - Traumatic asphyxia
- Drowning
  - Hanging
  - Manual strangulation
  - Ligature strangulation
DROWNING DEFINITION

• Fatal respiratory impairment from submersion / immersion, with the airway covered by liquid*
  • A liquid/air interface is present at the entrance of the airway, preventing breathing air
  • Not “filling the respiratory tract with liquid”
• Small amounts of liquid can RARELY cause drowning
• Drowning after any H2O-related activities
  • Playing in pools, sprinklers, lakes, streams, baths, etc.

*World Congress on Drowning 2002
DEFUNCT DEFINITIONS

- **Non-fatal drowning**
  - Water aspirated $\rightarrow$ rescue $\rightarrow$ survives

- **Fatal drowning**
  - Water aspiration $\rightarrow$ rescue $\rightarrow$ dies

- **No longer used:**
  - Active & Passive drowning, Dry & Wet drowning, Near-drowning, Secondary drowning

- Confusing terminology arose due to drowning victims with few/mild initial respiratory signs
  - Most signs are immediate, nearly all in 8 hrs, up to 24 hours later
The Drowning Process

H2O in pharynx

Aspiration

Cough reflex

More aspiration

Hypoxemia

Loss of consciousness

Apnea

Salt & Fresh H2O:
Surfactant destruction & washout → alveolar wall damage

Cardiac arrest
DROWNING: NX GOALS

• If Hx of exposure to liquid, consider drowning
• For bodies is found in H20, determine:
  • **Animal alive or dead at the time of submersion**
    • Not all bodies recovered from H20 drowned;
    • Often, bodies are *disposed of in water*
    • Death due to something else while in water
  • Rule in/out drowning, other CODs
• **Contributing illness making submersion fatal**
  • Seizures, ataxia, blindness, etc.
DROWNING: NX FINDINGS

- Body wet ("spiked" haircoat)
- **Foam / froth in upper airways**
  - Mix of aspirated H2O, mucus, & surfactant
- **Emphysematous & edematous lungs**
  - Soggy (edema) and/or crepitant (emphysema)
  - +/- Rib impressions
  - Copious fluid exudes from the cut surface
- Multifocal, **patchy, red** areas in lungs
  - Due to congestion, atelectasis, & hemorrhage
  - *If no significant pulmonary edema, ascribing the COD to drowning is unwise*
- Water, mud, sand, plant matter in alveoli or stomach
Drowned wallaby. Wet hair coat looks “spiked”. (Also head trauma)
Drowned cat with liver fracture. Lungs have not collapsed, & small scattered areas of hemorrhage.
Drowned raccoon. Lungs are look “full” & failed to collapse.
Drowned squirrel. Lungs hyper-inflated, failed to collapse.
Drowned dog. Multifocal areas of congestion / hemorrhage & failure to collapse.
DROWNING: HISTOLOGY

- H2O does **not** passively seep into the **deep lung tissue** in deceased or unconscious people—**Aspiration requires active ventilation**

**HISTO:**
- Alveolar edema & hemorrhage
- Expansion / coalescing alveolar spaces with torn (blunted/ clubbed) alveolar walls
  - AKA Emphysematous change
- Foreign material (plant, sand, etc.) in airways
  - Especially in terminal /deeper airways
Lung, drowned cat. Unidentified foreign material in bronchioles.
EXCEPTION: DIVING ANIMALS

• Lunged species that spend a significant % of time in water rarely if ever aspirate, even though drowning is certain based on circumstances (caught in nets, etc.) – JG opinion/ communication
  • Ex: Seals, sea turtles, otter…
• These animals may never involuntarily aspirate (gasp); larynx stays closed → hypoxia → death
• COD is suffocation
BURNS
OVERVIEW: BURNS

• Classification of burns
  • Depth
  • Cause / 6 types

• N\textit{x} goals
  • Assess depth & estimate the extent
  • How to evaluate burned / charred remains
BURNS

- Burn = Wound due to excessive heat
- Severity depends on:
  - **Temperature**
  - **Duration** of exposure
  - Ability of the tissue to *dissipate* heat
SKIN BURN DEPTH

• #1 organ burned
• Classified by thickness (degree)
• **Superficial** (1\textsuperscript{st} degree)
  • Some/all epidermis $\rightarrow$ erythema
• **Partial thickness** (2\textsuperscript{nd} degree):
  • Entire epidermis & some/all dermis $\rightarrow$ blisters, skin necrosis
• **Full thickness** (3\textsuperscript{rd} & 4\textsuperscript{th} degree)
  • Epidermis & dermis plus some/all SQ $\rightarrow$ charred tissue, exposure of fat & muscle
  • Painless (nerves dead)
SUPERFICIAL BURNS

- Epidermis only
  - Red +/- swollen (erythema & edema)
  - Mildly painful
  - **Do not scar.** No injury to basement membrane / stem cells
PARTIAL THICKNESS BURNS

• Entire epidermis + some Dermis injured
  • Ooze blood/ serum → Scab; Humans blister
  • +/- Scar, +/- Alopecia
  • Depends on whether stem cells were injured
• Painful
FULL THICKNESS BURNS

• All of epidermis & entire dermis injured
  • SQ exposed (3rd degree) +/- injured (4th degree)
  • Not painful (nerves dead)
  • No re-epithelialization → Scar
• +/- Eschar = dry, black scab of necrotic skin from burns
EVALUATING BURNS

• Rate depth based on worst-affected area
• Often challenging; most are a mix of depths
• Full extent often peaks several days after exposure
• Histo may be helpful to determine depth
Dog. Burn depth (thickness)?
Partial thickness / 2nd degree
Dog. Depth (thickness)?
Dog. Full thickness burn, cause unknown. An eschar is present.
BURN TYPES: EXAMPLES

1. **Scalds**
   - Ex: Garden hoses left in the sun

2. **Fire/ flame**
   - Ex: House fires

3. **Electrical**
   - Ex: Electrical cords

4. **Contact**
   - Ex: Heat rocks, Car mufflers, Brands

5. **Radiation**
   - Ex: Sunburns (UV), microwaves, Radiation Tx

6. **Chemical burns**
   - Ex: Petro-chemical burns, Severe contact dermatitis
CIGARETTE BURNS

• Purposeful burns made by holding the cigarette perpendicular to skin ➔
  ~1.0 cm diameter round crater, well-defined edge

• Accidental brushing up against a cigarette ➔
  “Comet” lesion: Round spot & tapering tail
SCALDS

- Contact with **wet heat**
  - Ex: Boiling H2O, steam, etc.

- Pattern
  - 1 or more usually coalescing burns, *often on dorsum*
  - Margins irregular, elongated dorsal to ventral (gravity)
    - Severity lessens ventrally (liquid cools & drips off)
  - Tiny satellite burns d/t Drips & Splashes

- Even superficial scalds can produce significant scarring
- No *singeing* of hair
Healing scald with peripheral re-epithelialization.
Healing scald with peripheral re-epithelialization. Note dorsal distribution & “splash / drip” pattern (arrows).
CONTACT BURNS

• A hot surface directly contacts the body
  • Ex: Heat rocks, Car mufflers, Brands, irons, etc.

• Dog. Contact burn (hot pavement)

• Thickness?
CONTACT BURNS

• A hot surface directly contacts the body
  • Ex: Heat lamps / heat rocks, Car mufflers, Brands

• Dog. Contact burn (hot pavement)

• Partial thickness
ELECTRICAL BURNS

• May cause focal or branching (arborizing) skin lesions
  • Ex: Cautery, bit electrical cords, & lightning
• High voltage: Central crater w/brown-yellow margin
  • May be see in combo w/ flame burn if the hair coat catches on fire
• Low voltage: No lesions OR Central chalky white crater with erythema
• Electricity causes distinct histological changes
  • “Windblown” (elongated) nuclei
Electric collar (invisible fence) collar wound - NOT A BURN. Pressure necrosis. No gross signs of a burn.
MICROWAVE BURNS

• Microwaves heat water, inc. water in tissues
  • Tissue with a high H2O content reaches a higher temp than tissues with less water
• Primarily affects **skin, muscle & internal organs**; **spares SQ fat** (contains little water)
• Well-demarcated & unevenly distributed
  • Focal “hot spots” where 1 tissue abuts another
• The severity of the injuries corresponds to the duration of exposure
MICROWAVE BURNS

- 2008 Munro: Fatal feline cases
  - Flexure of the forelimbs at the carpus with or without ex-sheathing of the claws (~pugilistic posture)
  - Fragility of the skin +/- splitting with sharp, well delineated, edges
  - Crumpling & reddening of the tips of the ears
  - Congestion of all lung lobes
  - Internal organs readily disintegrate & have the odor of cooked chicken
  - Absence of singed hair
Woman killed cat for eating her goldfish by putting it in a microwave. (Sentence: Jail-14 weeks)

https://www.express.co.uk/news/uk/464624/Woman-jailed-for-14-weeks-after-putting-cat-in-microwave
FIRES & FLAME BURNS

• Skin is in direct contact with a flame
  • Severity depends on duration of exposure
    • *Singes* hair, then *chars* skin, nails, & deeper tissues
  • **Flash burns**— sudden ignition / explosion of a volatile substance (accelerants)
    • Produces a uniform burn (1\textsuperscript{st} or 2\textsuperscript{nd} degree) on all exposed areas & singes the hair
Singed whiskers.
Only seen with fire / flame burns.
**Flash Burn.** Cat doused with lighter fluid & set on fire. Even *singeing, charring & contraction of the skin (heat)*. Found alive but quickly euthanized.
Cat; body burned on a fire after death in an attempt to dispose of the body/ destroy evidence. Well delineated areas of singed hair.
Burned cat, section of lung. Small pieces burned hair in the bronchi & alveolar spaces (circled).
Young Pit Bull put in oven. Not a fire / flame burn, but similar?
Dog that was in a house fire with thermal burns.
Toxic epidermal necrolysis (TEN) in a dog & cat. Similar “clown-face” appearance to flame burns. Function of thinness of skin? Lack of improvement with supportive care, lack of accelerant odor, & histo of the affected areas differentiate TEN from burns.
BURNED REMAINS: NX GOALS

- Was death due to fire, or was the body burned?
  - **Soot in upper airway** = Evidence of smoke inhalation ("vital change") = proves animal was alive to inhale smoke
    - Have area set aside for examination of pluck
    - Avoid cross contamination of soot on body into organs
      - Use new/clean gloves & clean knife to get histo samples
  - +/- **Accelerant testing**
  - +/- **Blood carbon monoxide [CO]** (standard in people)
    - Look for **cherry red livor mortis**
    - CO-Hb is **very** stable with no exposure to light
      - Test likely valid for days
      - EDTA heart blood sample
      - Human lab?
BURNED REMAINS: ARTIFACTS

- Artifacts of extreme heat:
  - **Bone Fx** including skull
  - Epidural hematomas
  - Skin splitting
  - "Pugilistic posture" flexion of the elbows & carpi
- Internal organs typically preserved

Brain of burned cat with small epidural hematoma
FIRES: ACCELERANT TESTING

- Animals *not* spontaneously combustible; Accelerants must be used
- **Collect ASAP!**
  - Accelerants (volatiles) evaporate quickly
- Collect anything that smells
  - Ex: collars, haired skin
- Collect least-burned areas
  - Accelerant least–consumed
- Clean metal or glass container
Dog in house fire (hind end). **Pugilistic posture**: Flexion of the hips, stifles & digits & extension of hocks, due to heat contraction of collagen in muscle & tendons.
Dog (same as previous). Flexed shoulders, elbows & carpi, contracture of skin & curled back lips. Well delineated area of spared skin & hair (white patch). Tracheal ulceration (thermal injury) → COD = smoke inhalation.
CHEMICAL BURNS

• Strong acids & alkalis cause direct cell damage
• Severity depends on the agent, strength / concentration, & duration of contact
  • Alkaline agents (pH greater than 11.5) tend to produce more severe (full thickness) injury compared to acids
• Gross lesions resemble other burns, especially scalds
• Predominantly skin
  • Tissue necrosis
  • +/- Blistering (people)
  • More superficial compared to thermal burns
CHEMICAL BURNS

• Ddx chemical from thermal difficult
  • Histo *might* help
    • Heat “wicked” by hairs, disproportionate damage to follicles
  • Chemical residue - Odor or liquid itself
• Ddx accidental from purposeful may be difficult
  • Hx / investigation dependent
  • Severe irritant contact dermatitis
    • Idiosyncratic reactions to topical Rx, especially flea/tick preparations
Suspected chemical burn with ventral distribution: Paws, rump, elbows, from sitting/walking in the chemical, & mouth from licking it off.

Photos courtesy Dr. Robert Reisman, ASPCA
The dorsal midline burn is a common pattern, seen with a wide variety of accidental & purposeful causes. Determining the cause without a history may be impossible.

**LEFT:** Severe irritant contact dermatitis from a reaction to topical flea/tick medication (right).

**RIGHT:** Scald caused by garden hose.
ESTIMATING % AFFECTED

• “Rule of 9s” not accurate for other species

• How many credit cards does it take to cover the burn?
  • Determine Body Surface Area based on weight -- standard conversion charts (as for chemo)

\[
\% \text{TBSA burn} = \frac{\text{number of cards} \times 0.45}{\text{m}^2}
\]
% BSA = [# cards x 0.45] / total BSA

EXAMPLE: 6kg dog; 22 card burn

\[
22 \times 0.45 = 0.33\text{m}^2
\]

= 30%
BURNS: NX GOALS

1. Document location(s) affected
   • Remember to check oral cavity

2. Estimate % body surface affected

3. Assess the depth

4. Diagnostic features
   • Eschar, blisters, “splashes”

5. Cause of death = Burn
   • ID type (if possible): Scalding, Contact, Flame, Electrical, Microwave, & Chemical

• Does the burn fit with the explanation?
SUMMARY

• 6 types of Burns:
  • Scalding, Contact, Flame, Electrical, Microwave, & Chemical

• Burns should be described in terms of:
  1. Depth: superficial, partial, complete thickness
  2. Extent: % total body surface area affected
  3. Distribution (Pattern): Anatomic location(s), drips/splashes?
  4. Features of the burn: singed or charred tissue, or eschar

• Animals exposed to fires – evaluate for exposure to:
  • Smoke/ fumes & Carbon monoxide
  • Exposure to heat.

• Consider accelerant testing
REFERENCES

• Sobhakumari et al. Pathology of carbon monoxide poisoning in two cats. BMC Veterinary Research (2018) 14:67