Burns And Smoke Inhalation: Things To Do and Not Do

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Case Scenario

- Windy afternoon
- Working on the garden in the backyard
- Dogs barking
- Horses running
- Run to the front yard
- Field on fire, just starting to burn the barn
Case Scenario

• Hook up the trailer
• Grab the 2 horses you could get
• Throw the dogs in the truck
• Call 911
• NOW WHAT????

Sadly- Limited Information

• EQUINE VETERINARY EDUCATION 04 September 2017
• https://doi.org/10.1111/eve.12806
• Findings and strategies for treating horses injured in open range fires
• E. W. Herbert

Fire and Smoke Inhalation Injury in Horses
Peggy S. Marsh, DVM

OCTOBER 2005 (VOL 27, NO 10) COMPENDIUM
Update on Equine Therapeutics: "Treating Burn Injuries in Horses"
By R. Reid Hanson, DVM, DACVS, DACVECC
What To Do About Burns? at Do You Do????

Initial Treatment

• Remove blankets or wraps which may be holding heat
• Cool the patient with Cool to Luke Warm Water in the initial minutes post fire

• DO NOT USE extremely cold water
• Blood vessels constrict-areas don’t get much needed oxygen
Initial Treatment-CALL YOUR VET!!!

- **SECOND GOAL: GET VENOUS ACCESS**
  - Animals can develop substantial edema within hours of a burn
  - Placement of a catheter very difficult
  - Anti-inflammatories are needed
  - Sedation may be needed-
    - Need to be careful how much is given depending upon extent of injuries and blood pressure

Assessment of Patient

- Examine entire patient
- Not just burns
- Severe dehydration/hypovolemia is common
- Respiratory difficulty
- Suppression of immune system

*Figure from Hanson, Compendium 2005*
Initial Treatment

- Fluids are extremely important for multiple reasons
  - Loss of fluids due to burn itself
  - Break down of red cells due to inflammation can lead to kidney damage and other problems

Review-Epidermis
Burn Classification-Depth of Injury

First degree burns
- Involve only the superficial layers of the epidermis
- Painful burns
- Characterized by erythema, edema, desquamation of superficial layers of skin

1st Degree Burn
- Germinal layer of epithelium is intact
- Burns heal without complication
- Prognosis-excellent unless ocular or respiratory involvement
2nd Degree Burns

- Partial thickness burns
- Superficial Second Degree Burns
  - Involve the stratum corneum
  - Painful due to intact tactile and pain receptors
  - Basal layers intact-heal rapidly with minimal scarring within 14-17 days
- Prognosis is good

2nd Degree Burn-Deep

- Involve all the layers of the epidermis
- Include the basal layers
- Characterized by erythema and edema, at the epidermal-dermal junction
Deep 2nd Degree Burns

- May heal spontaneously in 3-4 weeks
- If further ischemia is prevented of the dermal layer
- This could lead to full thickness necrosis
  - Prognosis:
    - Unless grafted
    - Healing is with extensive scarring

3rd Degree Burns

- Loss of epidermal and dermal components,
- Including adnexa and underlying components
- No cutaneous sensation
- Wounds range in color from white to black
3rd Degree Burns

- Fluid loss and significant cellular response at the margins and deeper tissues
- Eschar formation
- Lack of pain

3rd Degree Burns

- Shock
- Wound infection
- Bacteremia and septicemia may occur
- Healing is by contraction and epithelialization
- Frequently complicated by infection
- Prognosis is poor depending upon extent
4th Degree Burns

• Involve all of skin layers and underlying muscle, bone, ligaments, fat and fascia
• Prognosis is grave

Pathophysiology of Fire Injury

• Type and extent of injury dependent upon factors related to the fire
  • Duration of exposure
  • Location of patient relative to point of origin of fire
Extent of Burn

• Depends upon the size of the area exposed
• Severity relates to maximum temperature the tissue attained and duration of overheating
• This is why skin injury extends beyond original burn

Extent of Burn

• Skin takes a long time to absorb heat
• Skin also takes a long time to dissipate absorbed heat
• Longer the horse is exposed, the poorer the prognosis
Thermal Injury

• Local initially
• Microvascular insult
• Tissue coagulation
  • Leads to local inflammation, edema and necrosis

• Extensive local injury lead to systemic response

Hypermetabolic State

• Development of immune suppression
• Systemic changes can lead to GI disturbance
• Translocation of bacteria which further complicates pathophysiology
  • Acute hemolysis-breakdown of red cells
  • Anemia
  • Kidney failure
  • Myositis-inflammation of muscles
  • Laminitis
Hypermetabolic State

- Long term effects
- Loss of body mass
- Human patients with 40% of body surface burn can lose a quarter of their weight even with enteral nutrition
- Horses have the same effect even with good appetite

Figuring Extent of Burns
Rule of Nines

- **Body surface area**: The total surface area of the human body.
- the BSA = the square root of product of the weight in kg times the height in cm divided by 3600
- The "normal" BSA is generally taken to be 1.7 m²
- BSA depends on more than just height and weight.
- Other influential factors include the age and gender of the individual. For example:
  - Average BSA for adult men: 1.9 m²
  - Average BSA for adult women: 1.6 m²
  - Average BSA for children (9 years): 1.07 m²
  - Average BSA for children (10 years): 1.14 m²
  - Average BSA for children (12-13 years): 1.33 m²

Lund and Browder Chart

- Relative Percentage of
- Body Surface Area Affected
- by Growth
- More accurate
- than rule of nines
- More accurate method for
- estimating burns
- Especially in young children

<table>
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<tr>
<th>Age in years</th>
<th>0</th>
<th>1</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (head, back or front)</td>
<td>9%</td>
<td>8%</td>
<td>8%</td>
<td>5%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>B (1 thigh, back or front)</td>
<td>2%</td>
<td>3%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>C (1 leg, back or front)</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Palm Trick

• Use the patient’s palm size to represent approximately 1% TBSA.
• Imagine a rectangle the width and length of your entire hand (from wrist to fingertips)
• Size of “one palm.”

Diagnostics

• No simple formula
• BSA = surface area of shoulder region one side x 2 x 100
  10
• Smaller horses, ponies divide by 16
• Theoretic methods exist but NOT an exact science in human trauma
• Very limited information in the horse
• Some tools are useful for cardiovascular monitoring
  • Blood pressure
  • Serial lactate measurements
  • Urine production
Diagnostics

**Protein loss monitoring**
- Colloid oncotic pressure
- Serial albumin concentrations

**Other parameters**
- Serial hematology and biochemistry values
- Useful for evaluation of other organ system dysfunction
- Examples: kidney failure, Anemia

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Treatment-Wound Management

- **Complex**
  - Topical antimicrobial therapy is used to protect damaged areas
  - Silver sulfadiazine is the most widely used topical treatment in burn patients
Treatment-Wound Management

- Thermoregulation can be a problem
- Environmental temperature control is important
- Strict hygiene
- Meticulous nursing care
- Optimal nutritional support
- Prophylactic antimicrobials not used in humans

Treatment-Nutrition

- High caloric well-balanced diet is essential
- Maintain healthy gastrointestinal tract
- Enteral nutrition is preferred if possible
- Human patients require 1.4-2 times resting energy requirements
- Equine patients are no exception!!!
- High quality hay, grain and energy fat rich food is imperative
Treatment - Pain management

- Difficult to differentiate shock and pain sometimes
- Comprehensive pain management plan is important
- Opioids
- Lidocaine and ketamine CRI
- Multi-modal pain management

Treatment

- Severely effect equine patient’s treatment is medically challenging
- Multiple issues to manage
- Treatment of burns can be prolonged and require lifelong care
- Important to discuss possible duration and cost of treatment
How About the Lungs?

Know What Normal Is!!!!

- Heart rate 24-48 bpm
- Resp Rate 8-20 breaths/minute
- Temp 99-101.5 F

Horses should be examined by a veterinarian if any of the following are noted:

- Respiratory rate is consistently greater than 30 breaths/minute at rest
- Nostrils have obvious flaring
- There is obvious increased effort of breathing when watching the horse’s abdomen and rib cage
- There is repetitive or deep coughing, OR
- Abnormal nasal discharge
Pathophysiology of Smoke

- Complex and multi-factorial
- Much of the reaction depends upon the fuels that burned
- Completeness of combustion
- Generated heat intensity

Three Primary Mechanisms

- **Direct Thermal Effects**
  - Can be limited to the upper respiratory tract
  - Occurs due to laryngeal reflexes and efficient heat exchange within the nasal passages

- **Toxic Gas Effects**
  - Direct or indirect damage via inflammatory mediators
  - Carbon monoxide is common in human injury
  - Newer building materials have other toxins such as hydrogen cyanide

- **Hypoxia**
  - Combustion $\rightarrow$ consumption of oxygen
  - Low PaO$_2$ $\rightarrow$ pulmonary vasoconstriction
  - Generalized hypoxia
Three Phases of Pulmonary Dysfunction

- **First Stage-Acute Phase**
  - Acute pulmonary insufficiency
  - Carbon monoxide
  - Combines with hemoglobin to form carboxyhemoglobin
  - Reduces circulating oxygen capacity
  - Hemoglobin has 200-250 x greater affinity for CO compared to affinity for oxygen

Pulmonary Dysfunction

- Left shift of deoxyhemoglobin curve
  - Decrease oxygen release at tissue level
  - Tissue hypoxia
- CO also combines with myoglobin
  - Impairs oxygen diffusion to muscle
- Progressive edema and necrosis of upper respiratory tract
  - Leads to airway obstruction
  - Bronchoconstriction of lower respiratory tract leads to altered pulmonary blood flow
Second Phase 24-72 Hours Post Exposure

- Formation of pulmonary edema
- Lower airway obstruction
- Pulmonary parenchymal lesions
- Infiltration of neutrophils via pulmonary macrophages
- Release of cytokines, proteolytic enzymes, and oxygen free radicals.

Second Phase

- Vessel damage
- Increased extravascular lung water
- Increased fibrin
- Obstruction of small airways
- Plugging of small airways leads to increase airway pressure
- Results in barotrauma and alveolar damage
Third Phase 1-2 Weeks

Bronchopneumonia

Result of impaired host immune system

Locally and systemically

Clinical signs- 1st 6 hours

- Initially
  - Signs of shock
  - Tachycardia
  - Tachypnea
  - Change in mucous membrane color
  - Carbon monoxide toxicity may occur

- Severe hypoxemia may be present
  - Depression
  - Disorientation
  - Ataxia
  - Moribund to comatose
Clinical signs: 12-24 hours

Edema and necrosis progress in upper respiratory tract
Dypsnea
Stridor

Auscultation of Thorax
Decreased air movement
Crackles
Wheeze
Airflow may be restricted
Edema fluid may be visible at the nostrils
Later may become purulent exudate
Concurrent generalized edema occurs

Treatment

• Depends upon the stage of injury
• Improve or maintain cardiovascular homeostasis
• IVF cornerstone of initial resuscitation of human burn victims
• Amount of IVF vary and need to be tailored to patients needs
• Urine output is reasonable indicator of organ perfusion
Treatment-Fluids

- Hypertonic saline
- Mobilizes water from cells that may be over accumulating fluid
- Controversial
- Must monitor sodium levels
- Study in human burn shock revealed increase in renal failure and death
- Other studies show improved survival...
Treatment

- Flunixin meglumine (1.1 mg/kg q 12 hours)
- Pentoxifylline (8.4 mg/kg PO q 8 hours)
- Acetylcysteine (50-140 mg/kg PO or IV slowly or via nebulization 0.25-1 g q 6-8 hours)
- Corticosteroids not recommended in human medicine
- Controversial in equine patients
- Broad spectrum antimicrobials

Treatment - Respiratory

- Oxygen support
- Helps reduce hypoxia and carbon dioxide toxicity
- Use humidified oxygen
- May need a tracheostomy
- Nebulization is useful
- Bronchodilators may help
- Diuretics ie furosemide 1-2 mg/kg
Things To Not Do:

- Nebulize your horse without instructions from a veterinarian
- Silver is not good to nebulize-inert metal, stays in lungs, and other organs
- Causes damage to lungs, kidneys, liver
- Start exercise too soon

Exercise

- The particulate matter we all have been breathing
- Much like smoking 20-40 pack of cigarettes a day
- The airways need time to recover
- Even if particulate matter was between 100-175 ppm
- Recommendation:
  - Minimum wait 2 weeks after first clear day
Exercise

- If greater particulate matter greater than 200 ppm
- Wait 4-6 weeks
- GO SLOW
- Start 10-15 minutes a day
- Observe recovery
- If any questions, please call your vet

Questions

- Don’t hesitate to contact WSU
  - jgold@wsu.edu
  - 509-432-6764