



UW HEALTH BURN CENTER

INHALATION INJURY


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MGM Grand Hotel Las Vegas
November 20, 1980





MGM Grand Hotel Las Vegas
Nov. 21 1980
10:00 AM



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MGM: The Layout

MGM Grand
Typical Floor Plan
Floors 5-22

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MGM: The Fire

- Started in 'Deli' on the first floor
- Electrical ground fault short
 - Wire pulled through conduit stretched and frayed
 - Conduit heated and melted starting plastic fire in wall

3/4" Flexible
Electrical
Raceway

Approximate
at Maximum
Capacity 50
OH

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MGM: The Response

- 7:17am: local fire department (*single unit: one truck, 4 men*)
 - Thick smoke
 - Fireball spreading into casino
 - Evacuated themselves
- Fire spread at 15-19 feet/second
- Fire horizontal, smoke both vertical and horizontal


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MGM: The Spread


- Hallways to center stairwells and elevators
 - Heat and smoke rose up shafts
 - Stretched and melted elevator cables, they snapped, counter weights fell and crushed elevators
 - Two elevators fell into basement



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MGM: The Smoke


- Up stairwells, earthquake joints, fresh air vents, elevator shafts
 - Guests opened stairwells adding forced air, sucking in more smoke
 - Dampers in air vents inoperable or actually bolted open



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MGM: The Guests


- Found out by:
 - TV newscast
 - Smelled smoke
 - Saw / heard helicopters hovering
 - No alarms or verbal instructions



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MGM: The Result


- 85 deaths
- 650 admitted to hospital
- 5000 evacuated in 4 hours
 - Most by helicopters from roof
 - Some via 'safe' stairwells



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MGM: The Victims


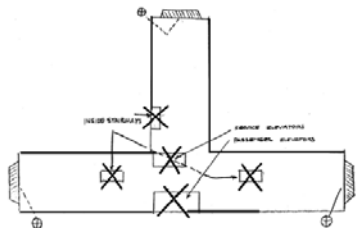
- Fatalities
 - 75 from smoke and CO
 - 4 smoke only
 - 1 burns only
 - 3 smoke and burns
 - 1 massive head trauma
- 650 to hospital



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MGM: The Secret


ONLY THE OUTSIDE STAIRWAYS WILL BE USED TO EVACUATE THE HOTEL



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MGM: Some Lessons


- Stairwells must open onto all floors
- Stairwells must be vented
- Guests must be warned and verbally instructed
- Safe escape routes must be posted in rooms



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MGM: More Lessons


- Smoke rises – highest floors most dangerous
- Going down risks entering the fire
- Cyanide poisoning not common even in plastic fires
- If not killed outright, smoke inhalation has a low mortality



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Inhalation Injury



- About 20% of those admitted to burn centers
 - Directly related to burn size
 - Directly related to prolonged ventilator dependence, hospital stay, and death



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Increased overall mortality



- Lungs can not be excised and grafted
- Must be protected from further injury
- On-going inflammation leads to further problems

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Consensus Conference for Inhalation Injury



- Held December 2007 Couer d'Alene, ID
- Topics
 - Diagnosis and grading
 - Effects of toxic gases
 - Therapies
 - Ventilation
 - Systemic Therapies
 - Airway access
 - Extubation adjuncts
 - Outcomes

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Injury to tracheobronchial areas



- Only a chemical injury
- Thermal injury rare
 - Ciliated cells separate from basement membrane
 - Dilation of surrounding circulation

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Edema formation



- Activated neutrophils
- Thromboxane A₂, C_{3a}, C_{5a}
- Blockers
 - Sulfo Lewis C
 - Anti-interleukin-8 antibody
- Nonfunctional mucociliary escalator
- Increased TNF- α and superoxide ions

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Pulmonary dysfunction

- Hypoxia
- V/Q mismatch
- Increased airway resistance
- Increased alveolar epithelial permeability
- Decreased pulmonary compliance
- Increased pulmonary vascular resistance

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Inhalation injury diagnosis

- Closed-space fire
- Face burns




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Terminology



- Inhalation injury “nonspecific”
 - Thermal injury
 - Upper airway
 - Local chemical irritation
 - Throughout airway
 - Systemic toxicity
 - CO



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Clinical diagnosis


- History and physical
 - Exposure
 - Duration
 - Enclosed space
- Diagnostic studies



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Other signs and symptoms



- Lacrimation
- Cough
- Hoarseness
- Dyspnea
- Disorientation
- Anxiety
- Wheezing
- Conjunctivitis
- Carbonaceous sputum
- Singed hairs
- Stridor
- Bronchorrhea



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Objective data



- Bronchoscopy
 - Edema
 - Infraglottic soot
 - Hyperemia
 - Mucosal sloughing
- Sensitivity near 100% under IDEAL circumstances



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Objective data



- Xenon-133
 - Areas that retain isotope for > 90 seconds have small airway obstruction
- Bronchoscopy and Xenon
 - 93% accuracy
- Specificity
 - Normal FEV₁/FVC = 96%



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Grading of injury


- No reliable indicators of progressive respiratory failures
- No studies have found any correlation with initial findings and clinical outcomes and progress



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Management

- ABC's
- Stop the burn
- 100% FIO₂
- Secure IV access
- Lung protective strategy



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Management

- Upper airway edema is maximal at 24 hours post injury
- Use appropriate fluid protocol
 - Those with inhalation injury can require 2 times Baxter
- DO NOT try to “protect the lung”

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Management

- Minimize airway edema
- Adequate pulmonary toilet
- Treat bronchospasm
- Aggressive bag/suction much better than bronchoscopy to remove mucus plugs



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Problems



- Hypoxia
 - More oxygen
- Copious secretions
 - IS, chest PT, NT suctioning
- Inspissated secretions
 - Humidification, NT suctioning

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Problems


- Wheezing
 - First: bronchodilators
 - Last: bronchoscopy
- Lobar collapse
 - First: bag/suction
 - Last: bronchoscopy



 

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Problems

- Pulmonary failure
 - Intubation
 - Ventilation
 - Permissive hypercapnia
 - Tracheostomy





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Poison management = CO



- 500 unintentional deaths each year
- Persistent Neurologic Sequelae
 - May improve over time
- Delayed Neurologic Sequelae
 - Relapse later

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Poison management = CO



- Treatment
 - CO level means nothing to predict outcome
 - Length of hypoxia is the determining factor
 - Oxygen
 - HBO
 - No studies show benefit in treatment

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Pathophysiology


- *The* main factor responsible for mortality in thermally injured patients
- Carbon monoxide the most common toxin
 - 200 times greater affinity
 - Competitive inhibition with cytochrome P-450

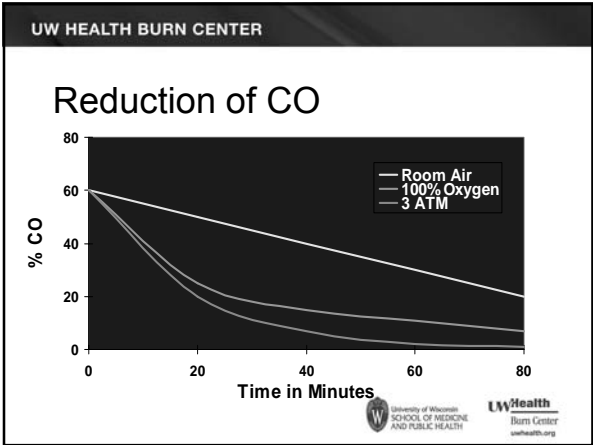
 

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Carbon monoxide

- Half-life
 - 250 minutes on room air
 - 60 minutes on 100%
 - 30 minutes at 3 ATM






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Early Complications



- Barotrauma
 - Pneumothorax
 - Mucosal ischemia
- Infectious
 - Tracheobronchitis
 - Pneumonia 38%, mortality 30%
 - Source = patient



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Pneumonia diagnosis



- Fever and leukocytosis
 - NOT USEFUL
- Must Have
 - Sputum
 - > 20 WBC's and organisms on Gram stain
 - CXR
 - Infiltrate
- BAL has not increased sens/spec

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Pneumonia treatment


- Empiric IV antibiotics after Gram stain
- Narrow the spectrum after identification
- Prophylactic antibiotics have NO role
- AGGRESSIVE pulmonary toilet



 

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Late complications

- Mechanical complications
 - Iatrogenic tube injuries
- Inflammatory complications
 - Bronchiectasis
 - Bronchial stenosis




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Ventilation strategy



- Limit MV_E with low VT
 - Trend toward hypercapnea
 - May minimize hyperinflation of non-dependant regions
 - Pressures as low as 30 cm H_2O have been shown to cause barotrauma



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Oxygenation strategy


- Open aerated lung units that cause shunt
- PEEP
 - Increases FRC
 - Decreases venous admixture
 - Shift VT to more compliant portion of pressure volume curve



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Use of β -agonists



- β_2 -adenoreceptors located in greater density in smaller airways versus large airways
- β_2 -agonists are:
 - Bronchodilators
 - Anti-inflammatory
 - Increased fluid clearance



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Use of β -agonists



- Randomized Clinical Trial of continuous nebulized β_2 -agonists (not burns)
 - Increased fluid clearance
 - Decreased duration and severity of ALI
- Studies needed in burns

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Nebulized heparin



- Shown in animals to soften fibrin airway casts
- Another treatment that has been tried
- No conclusive data

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Future directions


- Reduction of barotrauma
 - High frequency / low volume
 - Jet ventilation if conventional does not work
- ECMO
- Arteriovenous CO₂ removal

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Prospective therapies

- Mechanisms of neutrophil recruitment and activation
- Modulation of lipid peroxidation
- Extracellular proteases and oxygen radicals
- Role of deficient surfactant function
- Role of inflammatory mediators



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Questions?

