D21/E21: Code Red
A Team Approach to Surgical Fires

Council on Surgical & Perioperative Safety
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Presenters in this session have nothing to disclose

Session Objectives

- Identify scenarios of high risk of fire injury
- Implement team strategies in complex surgical environments
The Fire Triangle

Oxidizer, Nitrous Oxide, Room Air

Ignition Source

Fuel

Alcohol-based Skin Preps, Surgical Drapes, Patient

Pennsylvania Health Care Cost Containment Council Data

Table 1. Rates of fires per 100,000 Surgical Operations

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NO. OF PATIENTS</th>
<th>NO. OF OPERATIONS</th>
<th>OPERATIONS PER PATIENT</th>
<th>NO. OF SURGICAL FIRES</th>
<th>OPERATIONS PER FIRE</th>
<th>RATE OF SURGICAL FIRES PER 100,000 OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2007 to June 2008</td>
<td>1,683,170</td>
<td>1,722,896</td>
<td>1.03</td>
<td>11</td>
<td>157,345</td>
<td>0.63</td>
</tr>
<tr>
<td>July 2008 to June 2009</td>
<td>1,727,387</td>
<td>1,775,920</td>
<td>1.03</td>
<td>7</td>
<td>253,703</td>
<td>0.39</td>
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<td>July 2009 to June 2010</td>
<td>1,757,928</td>
<td>1,807,384</td>
<td>1.03</td>
<td>12</td>
<td>150,615</td>
<td>0.66</td>
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<tr>
<td>July 2010 to June 2011</td>
<td>1,805,835</td>
<td>1,855,832</td>
<td>1.03</td>
<td>6</td>
<td>309,305</td>
<td>0.32</td>
</tr>
<tr>
<td>Total</td>
<td>6,974,320</td>
<td>7,172,132</td>
<td></td>
<td>36</td>
<td>199,226</td>
<td>0.50</td>
</tr>
</tbody>
</table>

1 Data obtained from the Pennsylvania Health Care Cost Containment Council.
2 Surgical fires reported to the Pennsylvania Patient Safety Authority.
Surgical Fire Epidemiology

- Surgical Fires (~300-600/ yr)
  - 44% Head/Neck/Upper Chest
  - 21% Airway
    - Tracheostomy, Tonsillectomy
- Frequency comparable to:
  - Retained foreign objects
  - Wrong side/site surgery
- Low Frequency – Highly Preventable

Outcome of Skin Mole Excision

Lauren Wargo
May 23, 2010

Cleveland Plain Dealer
OXIDIZERS

Alexander A. Hannenberg, M.D.
Immediate Past Chair, CSPS
Past President
American Society of Anesthesiologists

Anesthetic Gases

- Oxygen
- Nitrous Oxide
- Medical Air
- Helium
ASA Closed Claims Study 1985-2009
Key Findings

- 103 Closed Claims – OR Fires
- 90% Ignition = Electrocautery
- 85% Head/Neck/Upper Chest
- 84% Open Oxygen source
- 20% Permanent Disability/Death

Mehta SP et al. Anesthesiology 118:1133, 2013

Recommendations

“The risk of OR fires can presumably be reduced by following the recommendations of the ASA Practice Advisory, the Anesthesia Patient Safety Foundation and the recent initiative surgical fire prevention program by the Food and Drug Administration to promote safer practices and share fire prevention resources. **The approach involves all of the members of the surgical team – surgeons, anesthesia providers, nursing and technical staff.** Team communication of fire risk and prevention is important during the presurgical checklist, as well as intraoperatively....”

Mehta SP et al. Anesthesiology 118:1133, 2013
Oxygen Delivery

Open Oxygen Delivery Systems
- Mask, Nasal Cannula

Closed Oxygen Delivery Systems
- Laryngeal Mask, Endotracheal Tube

Supplemental Oxygen: Think Twice
A **FUEL** is defined as anything that will burn.  
*(AORN)*

**OR FIRES** are defined as fires that occur on or near patients who are under anesthesia care, including surgical fires, airway fires and fires within the airway circuit. *(ASA)*

**AIRWAY FIRES** are a specific type of surgical fire that occurs in a patient’s airway. Airway fires may or may not include fire in the breathing circuit *(ASA)*
INTRINSIC
Emphasis on Communication and Teamwork

THE PATIENT

PERSONNEL
Fat is highly flammable

Muscle
Lanugo – fine hair that covers most bodily surfaces (found predominately on the face. Once burning – fire propagates at 2 – 10 feet per second.

Prevention – Covering hairs with water soluble lubricant

Emergency Care Research Institute: The patient is on fire: A surgical fires primer. Health Devices, 21:19, 1992

Skin (with prep solutions)

Human Flatus - Gastrointestinal Gases
Hydrogen and methane – extremely flammable gases – produced in GI tract –
Approx. 200mls/day
Adding 5% oxygen - explosions can occur with hydrogen (4-72%) and methane (5-15%)


A FUEL SOURCE
EXTRINSIC
Emphasis on Communication and Teamwork

**Prep Solutions**

Antiseptic skin agents, especially with alcohol bases are very flammable.

**Prep solutions with alcohol must be allowed to dry before use**

Betadine solution (10% povidine-iodine) is also inflammable - not recommended for the cleaning of skin in the presence of an ignition source. Explosions have occurred in the presence of high oxygen or nitrous oxygen concentrations. *(Prep + 2 elements of the fire triangle)*


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**LESS OBVIOUS SUBSTANCES that can ignite and be catastrophic**

- Tinctures
- Collodian - a syrupy solution(a.k.a) – nitrocellulose, cellulose nitrate, flash paper and gun cotton in either and alcohol
- Dermatome Glue
- Bone Cement
- Other – DRAPEs, GAUZES
- Gowns
- Tape
- Head Coverings
- Shoe Coverings
- Blankets
- Gloves
- Tubings (Extrinsic)
A FUEL SOURCE
A FUEL SOURCE

Drapes (Most commonly ignite)

There are no fire-retardant drapes. Few drapes have some degree of resistance to ignition in ambient air, but they will burn in an oxygen enriched environments (AORN)
DRAPES
Emphasis on Communication and Teamwork

- Oxygen enriched environments can exist beneath drapes
- During facial and ophthalmic procedure special awareness for potential disaster exists

Barnes A., Frantz, R. (2000). Do oxygen-enriched atmospheres exist beneath surgical drapes and contribute to fire hazard potential in the operating room. AANA Journal. 68(2)

Oxygen Index (OI)
Emphasis on Communication and Teamwork

"An effective method for minimizing operating room fires is to use materials that are least flammable in air and in oxygen-enriched atmosphere"

OI = minimum amount of oxygen required to support a candle-like flame on a test specimen:

"Ignited materials with OIs less than or equal to 21% (woven cotton and non-woven cellulose) a flame can propagate away from the ignition points and encompass the entire drape."

"Utilizing a drape with an OI greater than 21% (such as polypropylene) would prevent such scenario.

Serrao, GW, Micou, MK, Sidebotham, GW and Wolf, GL. The Oxygen Index of Surgical Drape Materials. The Cooper Union for the Advancement of Science and Art
**OXYGEN INDEX (OI)**

Woven cotton towels = 17.8  
Non-woven Cellulose Draping = 18.5  
Polypropylene draping = 22.8  

*Both cloth and paper drapes (the most implicated fuel for fires – ignitable by devices)*

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**Strategies to Prevent Drape Fires**  
Emphasis on Communication and Teamwork

- “Drapes should not be allowed to cover the face”

- “If drapes over the face are necessary for sterile field purposes….tenting the drapes to allow the heavier oxygen molecules to sink to the floor instead of being trapped just below the drapes and near the operative site” is suggested

- Barnes, A. & Frantz, R. 2000. Do oxygen-enriched atmospheres exist beneath surgical drapes and contribute to fire hazard potential in the operating room. AANA Journal. 68 (2)
A FUEL SOURCE

Endotracheal tubes

- Highly Flammable PVC or Silicone
- They can also be made out of plastic, red rubber and metal. Only metal is non-flammable.
- Danger due to close proximity to the tube with high concentrations of oxygen.

- Cuffed polyvinyl chloride endotracheal tubes may decrease the risk of fire. (Low flammibility index; prevent oxygen leakage into the surgical area) (Int J pediatr Otorhinolaryngol. 2008; 72 (7):1013-1021)

EXTRINSIC
Emphasis on Communication and Teamwork
**EXTRINSIC**

**Emphasis on Communication and Teamwork**

- Gauzes / Dressings

  - An intervention can be the use of moist towels when using a laser device. Water soaked items require higher temperatures to ignite compared to when they are dry.

  - Use saline-moistened instead of dry sponges in the surgical field (Health Devices, 2009; 38 (10): 319)

**Interventions**

**Emphasis on Communication and Teamwork**

- Moist sponges
- Water based ointments on facial hair and close to the surgical site
- Prevent pooling of skin prep solutions
- Remove prepping drapes or towels that catch the pooled solutions
- Allow skin preps to dry and fumes to dissipate before draping

- Conduct a skin prep “time out” (AORN)

- Emphasis on Draping Techniques
- Emphasis on Tubes
A combination of fuel sources decreases the amount of energy (ignition source) required to start a fire. Example, an alcohol soaked towel will ignite faster than a dry towel will. (AORN)

Sources of Ignition in the Operating Room

T Forcht Dagi MD, DMedSc, MPH, FAANS, FACS, FCCM, FRCSEd
Harvard Medical School and Queen’s University Belfast
Potential sources of ignition

- Power cords
- Electrocautery
- Lasers
- Light sources
- Drills, and burrs
- Defective grounds and short circuits
- Static electricity
- Hyperthermia units
- Blood and fluid warmers
- Pumps
- Microscopes
- Monitors
- Computers

Electrocautery

- All types of electrocautery have been implicated
  - Monopolar
  - Bipolar
  - Battery-operated
  - Power sources
  - Tips
- Temperature can reach several hundred degrees
  - More than sufficient to ignite paper or cloth drapes or other fuel sources
Lasers

- Intense, focused light
- Temperature sufficient to melt or ignite
- All frequencies, colors and types
- Direct ignition
  - From the beam onto paddies, sponges, drapes, throat packs, swabs, clothing, hair, tubes
- Indirect ignition
  - By reflection
    - Shiny instruments
    - Puddles of water

Light sources

- Overhead
- Headlights
- Endoscopes
- Fiberoptic
- Mechanisms include
  - Defective wiring
  - Proximal electrical or thermal failure at light source
  - Distal electrical or thermal at light bulb or tip of fiberoptic cable
Surgical instruments

- Heat from drills and burrs spinning with insufficient irrigation
- Sparking electrical instruments
- Defective grounds and short circuits

Static Electricity

- Buildup and discharge
- Ineffective grounding
Other sources of ignition

- Hyperthermia units
- Blood and fluid warmers
- Pumps and lavage systems
- Microscopes
- Defibrillators
- Embers from charred tissue
- Monitors
- Computers
- Power cords

Preventing ignition

- Awareness
- Communication, teamwork and training in the operating room
- Include technicians, residents, assistants, students, anesthesiologists, radiographers, orderlies, students, perfusionists, engineers, environmental services
- Effective maintenance of equipment and apparatus
- Adequate grounding and anti-static precautions
- Watch for concentrated light sources of any origin
Specific measures

- **Electrocautery**
  - Keep tip in the holster when not in use — preferably off patient
  - Avoid automated electrocautery
  - Avoid placing rubber catheter sleeves over electrosurgical electrodes
  - Activate only with tip in view, especially during microsurgery
  - Deactivate unit before the tip leaves the surgical site

- **Lasers**
  - Standby mode when not in active use
  - Use non-reflecting surgical instruments
  - Monitor any reflecting surface, such as pools of liquids
  - Watch for transparent drapes in the path of the laser

- **Fiberoptics**
  - Complete all fiberoptic cable connections before activating light source.
  - Power up high-intensity light sources only when in use
  - Place light sources on standby, or turn the unit off when disconnecting cables.
  - Never leave an illuminated light cord on patient drapes

- **Adequate cooling when drilling or shaping**

Summary: Fire Prevention

- **Technical**
  - Well maintained equipment
  - Safe practice
  - Vigilance
    - Systematic risk (random, non-specific or aggregate)
    - Non-systematic risk (non-random, specific or inherent)

- **Human**
  - Training
  - Communication
  - Collaboration
  - Commitment
Operating room fires are preventable

THIS MATTERS

Thank you