FIRE SAFETY IN THE OPERATING ROOM

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THE OR IS AN ENVIRONMENT REQUIRING CONSTANT MONITORING OF FIRE RISKS.

STATISTICS
NUMBER OF SURGICAL PROCEDURES YEARLY IN THE U.S.
23 MILLION INPATIENT SURGICAL PROCEDURES
27 MILLION OUTPATIENT SURGICAL PROCEDURES
50 MILLION TOTAL PROCEDURES

HOSPITAL FIRES

APRIL 13TH, 1918
OKLAHOMA STATE HOSPITAL
OKLAHOMA CITY, OKLAHOMA
38 PEOPLE DIED

HOSPITAL FIRES

JANUARY, 1929
AN ANESTHETIST WAS MANIPULATING A VALVE ON A TANK OF NITROUS OXIDE THAT HAD BEEN CONTAMINATED BY AN ETHYLENE TANK VIA THE ANESTHESIA MACHINE. IT WAS REPORTED THAT THE FORCE OF THE EXPLOSION HURLED THE PHYSICIAN’S BODY THROUGH A SIX INCH WALL. THE ACCIDENT WAS FATAL.

HOSPITAL FIRES

1930 AMERICAN MEDICAL ASSOCIATION
RISK OF DEATH FROM ANESTHESIA EXPLOSIONS ESTIMATED AT 1:100,000

HOSPITAL FIRES

MAY 15TH, 1929
CLEVELAND CLINIC
CLEVELAND, OHIO
125 PEOPLE DIED
HOSPITAL FIRES

APRIL 5TH, 1949
ST. ANTHONY'S HOSPITAL
EFFINGHAM, ILLINOIS
77 PEOPLE DIED

JANUARY 7TH, 1950
MERCY HOSPITAL
DAVENPORT, IOWA
41 PEOPLE DIED

JUNE 11TH, 1999
VANDERBILT UNIVERSITY MEDICAL CENTER
NASHVILLE, TENNESSEE
0 DEATHS

JUNE 2ND, 2003
DUKE MEDICAL CENTER
DURHAM, NC
A SICK INFANT UNDERGOING AN OPERATION SUFFERED BURNS AFTER THE SURGICAL DRAPES CAUGHT FIRE. THE CHILD WAS BEING PLACED ON ECMO AT THE TIME THE DRAPES CAUGHT FIRE.

THE JOINT COMMISSION ON ACCREDITATION ON HEALTHCARE ORGANIZATION ESTIMATES BETWEEN 100 AND 200 OPERATING ROOM FIRES BREAK OUT EACH YEAR IN THE 17,000 HOSPITALS ACCREDITED.

THIS GIVES AN INCIDENCE OF:

1-2 FIRES PER 170 HOSPITALS
100% OF FIRES ARE PREVENTABLE!

WHY IS THIS TOPIC IMPORTANT IN THE 21ST CENTURY

- Concern for fires in the OR has decreased since elimination of flammable anesthetics
- Approximately 100 or fires annually in US
- Many or fires only appear on incident reports so actual number may be under-reported
- There are no universal standards or recommendations for fire prevention in OR
- They may be or are a source of litigation
- Litigation, regardless of justification, may bring serious hardship to CRNA

OUTLINE

- Introduction
- Triad of Fire
- Types of Fires
  - Fires in the Patient — Case Examples
  - Fires on the Patient — Case Examples
  - Prevention of OR Fires
- AANA Standards, Hospital Policy
- Extinguishing a Fire

LIABILITY ISSUES

- No universal standards
- Less concern for flammability
- Most or fires lead to litigation
- Under-reported
- Denial

AGENCIES WITH STANDARDS

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- Compressed Gas Association (CGA)
- National Fire Protection Association (NFPA)
- American Hospital Association (AHA)
- JCAHO

INCIDENCE

- No clear reporting requirements
  - 9 – 10 severe fires per year
  - 20 – 30 less severe per year
- Insurance companies estimate 100+ per year that result in patient or employee injury.
HOSPITAL FIRES

VOLATILE ANESTHETIC AGENTS OF PAST

- DIETHYL ETHER 1842
- NITROUS OXIDE 1844
- ACETYLENE 1924
- ETHYLENE 1924
- VINETHINE
- CYCLOPROPANE 1933

HALOTHANE 1956

THE FIRST NONFLAMMABLE VOLATILE ANESTHETIC AGENT

FUEL SOURCES - ALCOHOL

BECAUSE OF ITS FLAMMABILITY AND POTENTIAL VAPORS/FUMES, USE OF ALCOHOL & PREPS CONTAINING ALCOHOL CAN CAUSE SIGNIFICANT RISK IN THE OR. PRECAUTIONS TO BE TAKEN WHEN USING ALCOHOL:

- ALCOHOL MUST BE ALLOWED TO DRY PRIOR TO USING CAUTERY
- ALCOHOL FUMES SHOULD BE ALLOWED TO DISSIPATE PRIOR TO DRAPING

OR BEFORE REDRAPING AFTER REPREPPING

- THIS PROCESS TAKES APPROXIMATELY THREE 3 MINUTES.

LOCATION OF FIRES

TYPES OF OR FIRES

- FIRES IN THE PATIENT
  - AIRWAY FIRES
  - FIBEROPTIC BRONCHOSCOPE
  - INTRAABDOMINAL FIRE
- FIRES ON THE PATIENT
  - IGNITION OF DRAPES
  - SURFACE FIRES FUELED BY OXYGEN

Ehrenwerth J: ASARCL 226:1;2002

CAUSES OF OR FIRES

- 34% - Airway (Upper - Trachea - Bronchus, etc.)
- 28% - Face, Head, Neck and Chest
- 24% - Anywhere else on the Body
- 14% - In the Body

WHY DO THE FACE & AIRWAY LEAD AT 62%?

PRODUCTS OF COMBUSTION

- Heat
- Light
- Smoke
- Fire Gases
- Charred/Unburned Fuel

FIRES KILL IN 5 WAYS

- Asphyxia
- Inhalation Super Heated Gases
- Inhalation Smoke
- Toxic Fumes
- Flames
  - Rarely from Flames

BEST WAY TO FIGHT A FIRE

PREVENT IT!
AIRWAY FIRES

LASER SURGERY OF THE AIRWAY

- Light Amplification by Stimulated Emission of Radiation
- CO₂ Laser – Most widely used
- Nd:YAG Laser (Neodymium-Yttrium-Aluminum-Garnet)
- Deeper penetration than CO₂ Laser

AIRWAY FIRES

The reported incidence of airway fire during CO₂ upper airway laser surgery is 0.4%.


AIRWAY FIRES

The regions usually involved:
- Subglottic
- Epiglottic
- Oropharyngeal

AIRWAY FIRES

Inhalation of smoke can lead to:
- Chemical injury
- Bronchospasm
- Local edema
- Respiratory failure
- Spread of pathogens

AIRWAY FIRES

Patient Protection

Eyes: Taped closed & moist dressings
Nontarget tissue: Moist gauze packing
Drapes: Moisten in saline

Dressing protect the underlying tissues from laser damage. Moisture absorbs the heat of a laser and prevents ignition.

AIRWAY FIRES

Polyvinyl chloride tubes:
- Burn vigorously and produce hydrogen chloride which is a known pulmonary toxin

Red rubber tubes:
- Char, melt, and then can burn producing carbon monoxide gas
AIRWAY FIRES

• NITROUS OXIDE AND OXYGEN SUPPORT COMBUSTION
• AN IGGITED ENDOTRACHEAL TUBE WITH A NITROUS OXIDE OXYGEN MIXTURE BLOWING THROUGH IT BECOMES AN EFFECT BLOW TORCH AND WILL CAUSE SIGNIFICANT PULMONARY BURNS

AIRWAY FIRES

HOW CAN WE PROTECT OUR ENDOTRACHEAL TUBE FROM IGNITION?

✓ USE METAL TUBES OR TUBES WRAPPED WITH METALLIC TAPE (IGNITION TIMES INCREASE FROM 4 TO 60 SECONDS)
✓ FILL THE CUFF WITH METHYLENE BLUE DYED SALINE
✓ DOUBLE-CUFFED SILICONE-COATED METAL ENDOTRACHEAL TUBES ($$$)

AIRWAY FIRES

HOW DO WE DECREASE THE RISKS OF IGNITION?

✓ KEEP THE OXYGEN/NITROUS MIXTURE TO LESS THAN 30%
✓ MIX OXYGEN WITH HELIUM, 60%+
✓ APNEA DURING LASER FIRING WITH ANESTHETIC VIA TIVA +/- ET TUBE VS. VENTILATING METALLIC BRONCHOSCOPE

AIRWAY FIRES

WHAT DO YOU DO IF THE WORST HAPPENS?

✓ DON'T PANIC
✓ IMMEDIATELY TURN OFF GAS FLOW (EASIEST WAY IS TO SEPARATE OR DISCONNECT TUBE FROM THE CIRCUIT)
✓ REMOVE THE TUBE
✓ REINTUBATE
✓ A B C'S
AIRWAY FIRES

POST-OP CONSIDERATIONS:
- SUPPORTIVE CARE
- HEAD UP POSITION TO AVOID EDEMA
- HUMIDIFIED OXYGEN SUPPORT
- STEROIDS & RACEMIC EPINEPHRINE ARE DEBATABLE

POINTS TO PONDER

- ANY PATIENT UNDERGOING AIRWAY SURGERY IS AT RISK OF AIRWAY FIRE
- REDUCING O₂ CONCENTRATION TO LOWEST POSSIBLE, AVOIDING N₂O IS PRUDENT
- USE A LASER RESISTANT TUBE
- FILL CUFF WITH COLORED SALINE TO DETECT EARLY CUFF PERFORATION
- NO PREVENTIVE MEASURE GUARANTEES FIRES WILL NOT OCCUR

POINTS TO PONDER

ENDOTRACHEAL TUBE SAFETY DURING ELECTRODISSECTION OF TONSILLECTOMY
- UNCUFFED ETT, POSITIVE-PRESSURE VENTILATION
- TUBE IGNITED INDIRECTLY BY ARCING PRODUCED AT THE CAUTERY INTERFACE IN THE PRESENCE OF O₂A
- RETROGRADE AIR LEAK, PPV, INCREASED O₂ CONCENTRATION IN OROPHARYNX

POINTS TO PONDER (CONT.)

- DISTANCE FROM ETT THAT CAUTERY CAN BE SAFELY USED INCREASES AS LOCAL O₂ % INCREASES
- COAGULATION OR CUTTING CURRENT ARE BOTH CAPABLE OF IGNITING ET


FIRES ON THE PATIENT

FLAMMABLE MATERIALS (FUELS) IN OR

<table>
<thead>
<tr>
<th>Hair, skin</th>
<th>Preparatory Agents</th>
<th>Ointments</th>
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<tr>
<td></td>
<td>Benzoin</td>
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<tr>
<td>Acetone</td>
<td>Petroleum jelly</td>
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<td>Aerosol adhesives</td>
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<td>Alcohol</td>
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<tr>
<td>Antiseptic agents</td>
<td>Equipment and supplies</td>
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<tr>
<td>Linens</td>
<td>Dressing material</td>
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FIRES ON THE PATIENT

A 70 YO IS SCHEDULED FOR EXCISION OF FACIAL LESION UNDER MAC ANESTHESIA. THE PATIENT IS COMPLETELY COVERED IN DRAPES, HEAD TO TOE. A 10L O₂ FLOW RUNS WITH A FACE SHIELD. THE ELECTROCAUTERY IS USED AND THE PATIENT IS BURNED. SHE UNDERGOES TREATMENT AT A NEARBY BURN CENTER.
POINTS TO PONDER

• What elements constitute the triangle of fire in this case?
• How much O₂ is needed?
• What precautions might be taken to reduce risk?

Fires on the patient

A 81 yo is scheduled for surgery for excision of lesions of face and hand. She has a history of anxiety, SOB, anemia, and hypertension. The case is done under MAC (Room Air General with 2 Versed, 2 Fentanyl, Propofol 200 mg). She receives 2L O₂, is covered by drapes, out of visual field of CRNA. Cautery is used and a fire occurs. What now?!

Plaintiff’s opinions centered around:
• Draping
• Triangle of fire
• O₂ supplementation creating OEA
• How much if any O₂ is needed?
• Is there a standard for patient protection in a case like this?

Findings

• Minor but statically higher oxygen values were observed in supplemental O₂ group
• Frequency of desats below 90% or below 5% baseline similar in both
• Supplemental O₂ not routinely required in selected patients having ophthalmic surgery


Do oxygen-enriched atmospheres exist beneath surgical drapes and contribute to fire hazard potential in operating rooms?

Study

• Convenience sample of 12 healthy volunteers
• Pt supine, draped, O₂ applied nasal cannula at 0, 1, 2, 3, 4 L/min
• Following 10 min, pt redraped and procedure repeated using a scavenger system consisting of suctioning to wall suction at 170-180 mmHg
FINDINGS

• Although mean O2 sat never fell below 95%, O2 concentration beneath the drapes were lower than normal room air when no O2 used.
• With O2 and no scavenger, O2 concentration under drapes elevated, as high as 45% with 4 L/min.
• Scavenger in place, mean oxygen concentrations reached 34 to 39% beneath drapes.
• Higher O2 concentrations occurred beneath the drapes with each change in O2 flow rate.
• Regardless of flow, O2 beneath drapes significantly reduced with use of scavenger system.

PREVENTION OF FIRE
RECOMMENDATIONS FOR AVOIDING LASER FIRES

PREVENTION OF FIRES ON THE PATIENT

- Reduce inspired O2 concentration with O2-air ratio of 2:3 (52%) or less as patient condition permits.
- 50:50 mixture helium — O2 has been recommended.
- Spontaneous ventilation when possible to prevent inspired gases from flow retrograde around ETT.
- Use moist, occlusive pharyngeal packs.
- Maximize distance between ET and ECU.

PREVENTION OF FIRES ON THE PATIENT (CONT.)

- Set ECU as low as possible to prevent arcing.
- Use lowest possible O2 flow to maintain SATs; consider reducing sedation to reduce need for supplemental O2.
- Tent drapes so oxygen will go to floor and be diluted with room air.
- Discontinue O2 60 sec to 5 min before ECU used.
- Use scavenger system beneath drapes.

PREVENTION OF FIRE
RECOMMENDATIONS FOR AVOIDING LASER FIRES (CONT.)

- As an alternative, use jet ventilation or intermittent apnea.
- Be aware of type of laser used and its risk.
- Cover patient’s eyes — reflected light can cause retinal damage; personnel wear googles.
- Keep electric cautery tip in holster when not in use.

PREVENTION OF FIRE
RECOMMENDATIONS FOR AVOIDING LASER FIRES

- Use wet pledgets above the cuff, replace string with wire.
- Use colored saline in cuff to allow early detection of cuff rupture.
- Place the cuff as far distally as possible in the trachea.
- Use an appropriately protected or designed ETT.

Barnes AM et al. AAJAJ 68:153;2000
IS THERE A STANDARD FOR PATIENT PROTECTION AGAINST FIRES

AANA STANDARD VIII
"APPROPRIATE SAFETY PRECAUTIONS SHALL BE TAKEN TO MINIMIZE THE RISKS OF FIRE, EXPLOSION, ELECTRICAL SHOCK AND EQUIPMENT MALFUNCTION."

AANA STANDARD VIII INTERPRETATION
"SAFETY PRECAUTIONS AND CONTROLS, AS ESTABLISHED WITHIN THE INSTITUTION, SHALL BE STRICTLY ADHERED TO, SO AS TO MINIMIZE THE HAZARDS OF ELECTRICITY, FIRE, AND EXPLOSION IN AREAS WHERE ANESTHESIA CARE IS PROVIDED."

FOLLOW RACE PROTOCOL
- RESCUE THOSE IN DANGER
- ALERT
  - SHOUT "CODE RED"
  - PULL ALARM
  - CALL 6911
  - OFF CAMPUS CALL 911
- CONFINE THE FIRE BY CLOSING DOORS
- EXTINGUISH OR EVACUATE

GENERAL MANAGEMENT OF OR FIRES
- BELIEVE YOUR EYES — THERE IS A FIRE
- DISCONTINUE OXYGEN SOURCE AND REMOVE ETT OR OTHER OBJECT ON FIRE
- DOUSE THE FLAMES WITH NORMAL SALINE
- RESUME ANESTHESIA WITH MASK VENTILATION USING 100% OXYGEN
- PERFORM DIAGNOSTIC LARYNGOSCOPY/BRONCHOSCOPY TO INSPECT EXTENT OF DAMAGE
- REMOVE ANY DEBRIS

GENERAL MANAGEMENT OF OR FIRES (CONT.)
- CONSIDER GENTLE BRONCHIAL LAVAGE FOLLOWED BY FIBEROPTIC SURVEY OF DAMAGE
- REINTUBATE IF AIRWAY DAMAGE PRESENT
- CONSIDER A LOWER TRACHEOSTOMY IF DAMAGE SEVERE
- USE OF STEROIDS MAY BE HELPFUL
- CHECK CHEST RADIOGRAPH
- COMPLETE A CRITICAL INCIDENT REPORT — MAKE SURE IT’S GIVEN TO LOCAL FIRE DEPARTMENT

FIRE IN ANOTHER ROOM
- ASSESS POTENTIAL FOR SPREAD
- DISCONNECT AND BLEED ALL GAS LINES
- SWITCH TO TANKS
- SWITCH TO TIVA
- LOCATE FIRE HOSE/EXTINGUISHER
FIRE EXTINGUISHMENT

• Limit or interrupt one or more of the essential elements in the combustion process

EXTINGUISHMENT BY TEMPERATURE REDUCTION

• Cool a fire with water.
• Solids and liquids with high flash points can be extinguished by cooling.
• Reduction of temperature is dependant on the application of an adequate water flow in proper form to establish a negative heat balance.

EXTINGUISHMENT BY FUEL REMOVAL

• Fire can be effectively extinguished by removing the fuel source.
• This can be accomplished by stopping the flow of liquid or gaseous fuel or by removing solid fuel in the path of the fire.
• This may also be accomplished by removal of a heat source; i.e. cutting electrical power.

FIRE EXTINGUISHMENT

TEMPERATURE REDUCTION
REMOVAL OF FUEL
EXCLUSION OF OXYGEN
INHIBITION OF CHAIN REACTION

EXTINGUISHMENT BY OXYGEN DILUTION

• Reducing oxygen content in an area puts out the fire.
• This may be accomplished by flooding an area with an inert gas such as carbon dioxide to displace the oxygen.
• This may also be accomplished by separating the fuel from the air with a barrier such as foam.
EXTINGUISH BY CHEMICAL INHIBITION

- Extinguishing agents, such as dry chemicals and halogenated hydrocarbons (Halon) interrupt the flame-producing chemical reaction and stop flaming.
- This is effective on gas and liquid fuels because they must flame to burn.

FIRE EXTINGUISHERS

PASS

FIRE EXTINGUISHERS

CLASS A
CLASS B
CLASS C
CLASS D

FIRE EXTINGUISHERS

PULL THE PIN
AIM THE EXTINGUISHER NOZZLE AT THE FIRE'S BASE
SQUEEZE THE TRIGGER (HOLD THE EXTINGUISHER UPRIGHT)
Sweep the extinguisher from side to side and put out the fire!!!!

FIRE EXTINGUISHERS

WHEN TO LEAVE.
- Should your path of escape be threatened.
- The extinguisher runs out of agent.
- The extinguisher is ineffective.
- You cannot safely fight the fire (too much smoke, etc...)
Use your head and think things thru!!!!!!!!
CLASS A FIRES

- Ordinary combustible material.
  - Wood
  - Cloth
  - Paper
  - Rubber
  - Plastic

CLASS A FIRE EXTINGUISHMENT

- Reduces temperature of burning material below its ignition temperature as its method of extinguishment.

CLASS A FIRE EXTINGUISHER

- Water
- Foam

DE-IONIZED WATER

CLASS B FIRES

- Liquids
- Greases
- Gases
CLASS B
FIRE EXTINGUISHMENT

• THE SMOTHER OR BLANKET EFFECT OF OXYGEN EXCLUSION IS THE METHOD OF EXTINGUISHMENT.

CLASS B
FIRE EXTINGUISHERS

CARDON DIOXIDE
HALON 1211
BROMOCHLORODIFLUOROMETHANE
HALON 1301
BROMOTRIFLUOROMETHANE

CLASS C FIRES

ENERGIZED ELECTRICAL EQUIPMENT

CLASS C FIRES

BEST METHOD: TURN OFF POWER

NEXT CHOICE: DECREASE TEMPERATURE
DECREASE OXYGEN CONTENT

CLASS C FIRE EXTINGUISHER

CARBON DIOXIDE
HALON
DRY CHEMICAL
DRY CHEMICAL FIRE EXTINGUISHERS

- Sodium Bicarbonate
- Potassium Bicarbonate
- Potassium Chloride

Nitrogen gas is the pressuring agent

CLASS D FIRES

- Class D fires burn at extremely high temperatures
- Dust from Class D materials can cause powerful explosions

CLASS D FIRE EXTINGUISHMENT

- Cover the burning material to smother the fire.
- Personal note: Never put water on a Class D fire, it will cause one hell of an explosion.

CLASS D FIRES

Combustible Metals
- Aluminium
- Magnesium
- Potassium
- Lithium
- Sodium
- Calcium
- Titanium
- Zinc
- Zirconium

CLASS D FIRE EXTINGUISHER

Must be agent specific
PORTABLE EXTINGUISHERS

- The most common fire protection appliance.
- It is an excellent stop to use on incipient fires.
- If used early, it will stop most fires.

FIRE EXTINGUISHERS

FIRE EXTINGUISHERS ARE LOCATED NO MORE THAN 75 FEET TRAVEL DISTANCE FROM ANY LOCATION IN THE HOSPITAL. WRAMC USES “ABC” FIRE EXTINGUISHERS WHICH CAN COVER MOST CLASSES OF FIRE. (COMBUSTIBLES, FLAMMABLE LIQUIDS, & ELECTRICAL EQUIPMENT)

PASS

P - Pull the pin
A - Aim nozzle at base of fire
S - Squeeze handle
S - Sweep back & forth across base of fire

NO SIMPLE ANSWER TO COMPLEX ISSUE!

“While simply discontinuing supplemental O2 may initially seem the most straight forward solution, this should be done with caution in light of hypoxic mixtures beneath surgical drapes.”


QUESTIONS?