What are You Smoking in the Operating Room?

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Objectives

• Describe research outcomes that demonstrate the hazards of surgical smoke.
• Describe perioperative nursing care for surgical patients to minimize the hazards of surgical smoke.
• Discuss the surgical smoke evacuation recommendations by various organizations and agencies.
• List control measures to ensure compliance with the evacuation of all surgical smoke created in the OR.
• Discuss implementation of a smoke evacuation program.
What are You Smoking in the OR?
What is Surgical Smoke?

• Surgical smoke (ie, smoke plume) is the vaporization of substances (ie, tissue, fluid, blood) into a gaseous form
  • by-product of surgical instruments used to destroy tissue

• Instruments
  • Lasers – CO$_2$, ND:YAG, KTP, and Argon
  • Monopolar and bipolar electrosurgery units
  • Powered drills & saws
  • Ultrasonic scalpels
  • Mechanical morcellators
Composition of Surgical Smoke

- Plume is 95% water vapor
- Acts as a carrier for other materials
- The remaining 5% of smoke contains...
  - Toxic chemicals (many of same found in cigarette smoke)
  - Tissue and blood particulates

Inhaling Surgical Smoke

• Using the CO2 laser on one gram of tissue is like inhaling the smoke from **three cigarettes in 15 minutes.**

• Using ESU on one gram of tissue is like inhaling smoke from **six cigarettes in 15 minutes.**

Surgical Smoke is Toxic

Occupational Safety and Health Administration of US Department of Labor concludes:

• Smoke plume contains toxic gases and vapors such as
  • benzene, hydrogen cyanide, and formaldehyde
  • bioaerosols with dead and live cellular material
    • blood fragments
    • bacteria and viruses
• Smoke gases potentially mutagenic and carcinogenic
# Examples of Toxic Substances found in Surgical Smoke

<table>
<thead>
<tr>
<th>Substance</th>
<th>Substance</th>
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</thead>
<tbody>
<tr>
<td>Acetaldehyde***</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Acrolein</td>
<td>Formaldehyde**</td>
</tr>
<tr>
<td>Acrylonitrile**</td>
<td>Hydrogen cyanide</td>
</tr>
<tr>
<td>Benzene**</td>
<td>Methane</td>
</tr>
<tr>
<td>Butadiene***</td>
<td>Phenol</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Polycyclic aromatic hydrocarbons*</td>
</tr>
<tr>
<td>Cyanide</td>
<td>Toluene</td>
</tr>
</tbody>
</table>

*** Carcinogen  
** Potential Carcinogen  
* Increased risk of certain cancers  

Mihashi S, Jako GJ, Incze J, Strong MS, Vaughan CW. (1976),
Particulate Matter

• Carbonized tissue
• Blood
• Intact virus and bacteria
  • human immunodeficiency virus (HIV)
  • human papilloma virus (HPV)
  • Hepatitis
• Particulate Matter
  • 90% is respirable (< .3 micron)
  • Increases risks for sore throats, eye irritation, respiratory infection
  • Potential contact lens absorption
Particle Size and Distribution

- Particle size varies
  - ESU particles – smallest
  - Laser particles – largest
  - Ultrasonics release cool aerosols – carry live particles
- Smoke is evenly distributed throughout the OR
- Smoke particles can travel about 40 mph
- When ESU is activated, the concentration of the particles can rise from 60,000 particles/cubic feet to over 1 million particles/cubic feet
  - It takes 20 min after the activation of the ESU for the concentrations to return to baseline level

Particle Sizes

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So... is Surgical Smoke Harmful?

Past Misconceptions:
“Surgical Smoke is not Hazardous”
“Surgical Smoke is Sterile”

Surgical Smoke is Hazardous to Your Health!
Inhalation and Exposure

Potentially Harmful

• Patients

• Perioperative Team Members

• Others (anyone in the procedure room)
Patient Safety: Exposures to Surgical Smoke

Laparoscopic procedures present unique exposures to smoke to the patient.
Levels of carboxyhemoglobin of patients who underwent laparoscopic procedures using laser were significantly elevated

Pulse oximeter readings may be falsely elevated and could result in unrecognized patient hypoxia

Carbon monoxide levels increase in the peritoneal cavity and exceed recommended exposure limits

Exposure to Surgical Smoke during MIS: Risks to Patients

- Exposure to carbon monoxide
- Increased levels of carboxyhemoglobin
- Occurrence of methemoglobin
- Loss of visibility in the surgical field or potential delay of the procedure
- Port-site metastasis


Worker Safety: Exposures to Smoke/Plume

“Each year, an estimated 500,000 workers, including surgeons, nurses, anesthesiologists, and surgical technologists, are exposed to laser or electrosurgical smoke.”

Laser/Electrosurgery Plume. Occupational Safety and Health Administration (OSHA) Quick Takes. United States Department of Labor
Health Effects Reported by Healthcare Workers

- Eye, nose, throat irritation
- Headaches
- Nausea, dizziness
- Runny nose
- Coughing
- Respiratory irritants
- Fatigue
- Skin irritation
- Allergies

44-year old laser surgery developed laryngeal papillomatosis with biopsy identified the same virus type as anogenital condyloma

- Rarely evacuated surgical smoke when using laser to vaporize condyloma
- Demonstrates transmission of viable organisms in surgical smoke

Exposure to Surgical Smoke during MIS: Perioperative Team Members

• Health effects to the perioperative team
  • Release of pneumoperitoneum into the OR without filtration
• Important to use a filtering device or a closed evacuation system
American National Standards Institute (ANSI) (Safe Use of Lasers in Healthcare)

Airborne Contaminants:
Shall be controlled by the use of ventilation (ie, smoke evacuator) and respiratory protection for any residual plume escaping capture.

*Note*: ESU produces the same type of airborne contaminants as lasers.
Ventilation combination of general room and local exhaust ventilation (LEV)
• portable smoke evacuators
• room suction systems
NIOSH/CDC: Work Practices

- The smoke evacuator or room suction hose nozzle inlet must be kept within 2 inches of the surgical site
- The smoke evacuator should be ON (activated) at all times when airborne particles are produced
- Health care workers should follow standard precautions
Follow Standard Precautions at the Completion of the Procedure

- All smoke evacuator tubing, filters, and absorbers
  - considered infectious waste
  - disposed of appropriately

- New tubing should be installed on the smoke evacuator for each procedure

- Change filters according to manufacturer’s directions

- Local exhaust ventilation (LEV) equipment
  - regularly inspected and maintained
General Duty Clause:
Employers **MUST** provide a safe workplace environment!
OSHA Respiratory Protection

Recognizes:
Lasers and electrosurgical plume contains toxic, mutagenic, and carcinogenic elements

Mandates and identifies:
Removal of atmospheric contaminants with acceptable engineering controls and local ventilation, including smoke evacuation systems.

Emergency Care Research Institute (ECRI)

- Independent, nonprofit organization
- Researches the best approaches to improving the safety, quality, and cost-effectiveness of patient care
- Electrosurgical smoke is overlooked
- The spectral content of laser and ESU smoke is very similar
Canadian Standards Association (CSA)

- CSA Z305.13: Plume scavenging in surgical, diagnostic, therapeutic, and aesthetic settings, 2013 publication
- Supersedes the previous edition published in 2009
- Provides detailed standards on surgical smoke evacuation
IFPN Guideline on Risks, Hazards, and Management of Surgical Plume 2015

• Smoke particles may contain bloodborne pathogens and potential for viral transmission
• Identification of smoke as a workplace safety hazard
• Respiratory protection
• Use of standard precautions
• Use of local exhaust ventilation with ULPA filter
• Smoke evacuation methods
AORN Guidelines

• Electrosurgery
• Laser Safety
• Minimally Invasive Surgery (MIS)
AORN Guidelines

“Recommendation X - Potential hazards associated with surgical smoke generated in the practice setting should be identified and safe practices established.” pg. 128-129

“Recommendation V - Potential hazards associated with surgical smoke generated in the laser practice setting should be identified and safe practices established.” pg. 141-142

“Recommendation IV - Personnel should take additional precautions when using electrosurgery units (ESUs) during MIS and computed assisted procedures.” pg. 597-600
Guideline Interventions

• Evacuate smoke with a smoke evacuation system during open and laparoscopic procedures

• Used smoke evacuator filters, tubing, and wands should be disposed of as potentially infectious waste following standard precautions

• Personnel should wear respiratory protection during procedures that produce surgical smoke
Methods to Reduce Exposure

- Surgical Masks
- Wall Suction
- Smoke Evacuation Units
  - Central Systems
  - Portable Systems
  - Ceiling Mounted Systems
  - Laparoscopic Systems
Surgical Masks

• Standard masks filter >0.5 micron
• High Efficiency Masks filter >0.1 micron
• No mask provides absolute protection
  • Perimeter leakage
  • Diminished effectiveness with wear
Wall Suction

• Works for procedures that **do not** produce large volumes of smoke

• Must use in-line filtration with this method

When there is no in-line filter:
  • **Damage to health care facility air exchange system**
Wall Suction: Use an In-Line Filter

- Simple
- Use an in-line filter:
  - Use and change as recommended by the manufacturer’s instructions
  - Use standard precautions when changing and disposing of in-line filters
Wall Suction: In-Line Filters

From the patient >

To wall suction >

Example of a filter
Central Systems

• Central unit that connects to several ORs
• Quiet operation, easy to maintain
• More effective than wall suction
Portable Systems

- Highest recommended method by CDC & NIOSH
- Available in many different sizes and configurations
- Easy to use, maintain, & move around
- Lowest capital equipment cost
Ceiling Mounted systems

Many manufacturers have conveniently integrated portable smoke evacuation technology into their ceiling mounted systems.
Specialty Tubing

Specialty tubing can eliminate the need for an extra set of hands to manage tubing
Laparoscopic Systems

Specialty tubing for laparoscopic cases can:

• Dramatically improve visibility
• Minimize operating time
• Minimize patient absorption of toxic gases into their tissues
Choosing a Smoke Evacuation System

Important Factors to consider...

• Noise Levels
• Filtration Efficacy
• Suction Capability
• Portability
• Maintenance
• System Warranties
• Disposable Costs

• Ease of use
• Quiet
• Foot pedal activation and/or automatic on-off
• Indicators for filter changes
• Efficiency
• Cost
Smoke Evacuation Units

• Generally the most effective method

• Look for...
  
  • HEPA Filtration 99.97% efficient @ .3 micron
  
  • ULPA Filtration **99.9995%** efficient @ **.1 micron** (100 times more effective than HEPA)
Triple Filter System

- Pre filter
  - captures large particles

- ULPA filter
  - captures small particles

- Charcoal filter
  - captures toxic gases and odors

Disposal and Changing Smoke Evacuation Filters

• Used filters are an occupational hazard
• Wear PPE when handling
• Dispose of used smoke evacuation filters per manufacturer’s instructions and your facility’s procedures
Smoke Evacuation Program

• Increase awareness of the hazards of surgical smoke
• Promote and implement safe practices
• Interdisciplinary Team
  • Include staff RNs, anesthesia professionals, surgeons, scrub persons, and personnel from administration, infection prevention, employee health, safety, and risk management
Promote Evidence-based practices

Administration:
- Director
- Infection Prevention
- Safety
- Risk Management

Perioperative RNs, Scrub Personnel, Sterile Processing, Environmental Services

Business and Finance:
- Contracts
- Capital
- Cost Analysis

Surgeons and other Physicians:
Implementing Smoke Evacuation Practices

• Provide data and evidence to support best practices
  • Scientific research data
  • Financial analysis
  • AORN guidelines for perioperative practice

• Work collaboratively:
  • Administrative Safety Committee
  • Infection Prevention
  • Risk Management
## Barriers to Compliance for Smoke Evacuation Practices

<table>
<thead>
<tr>
<th>Equipment not available</th>
<th>Surgeons' resistance or refusal</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician</td>
<td>Cost</td>
<td>Distraction</td>
</tr>
<tr>
<td>Noisy Equipment</td>
<td>Bulkiness</td>
<td>Ergonomic difficulty of equipment</td>
</tr>
<tr>
<td>Complacent staff</td>
<td>Excessive noise</td>
<td>--Watson, 2010</td>
</tr>
</tbody>
</table>

--Ball, 2010

--Edwards & Reiman, 2012
Conclusions

• Surgical smoke plume and aerosols are hazardous to healthcare workers and patients

• Hazards can be removed with proper engineering controls

• Surgical smoke from MIS procedures can dramatically impair visibility, increase surgical time, and put the patient at risk

• Proper equipment selection and filter construction are important for implementing an efficient smoke evacuation program
Questions?