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Literature matters research bulletin

Health risks associated with exposure to surgical smoke for surgeons and operation room personnel

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Introduction:
Although electrosurgical technology was developed by Harvey Cushing and William T. Bovie in 1926[1], "surgical smoke" was not officially recognized as a significant hazard until the National Institute for Occupational Safety and Health (NIOSH) published and distributed a Health Hazard Evaluation Report in 1985.[2]

Surgeons and operating room (OR) personnel are routinely exposed to surgical smoke. Many research studies have confirmed that this smoke can contain potentially hazardous substances, including dead and living cellular material[3,4], blood fragments[5], bacteria[6,7], viruses[8,9,10,11], toxic gases and vapors (e.g., benzene[2,12], toluene[13,12,14,15,16], carbon monoxide[17,18], acrylonitrile[12], methylpropene[16], acetaldehyde[19] and lung – damaging particulates.[20]

Surgical smoke control by local exhaust ventilation (LEV) has been recommended by professional organizations and government agencies in the U.S., including the Association of periOperative Registered Nurses (AORN), the American National Standards Institute (ANSI), the Occupational Safety and Health Administration (OSHA), NIOSH and the CDC.[21,22] However, according to a survey from the U.S. and Canada, many ORs still do not provide protection from exposure to surgical smoke, and the most common obstacle to providing such protection has been the surgeons' resistance or refusal to allow the use of LEV.[23]

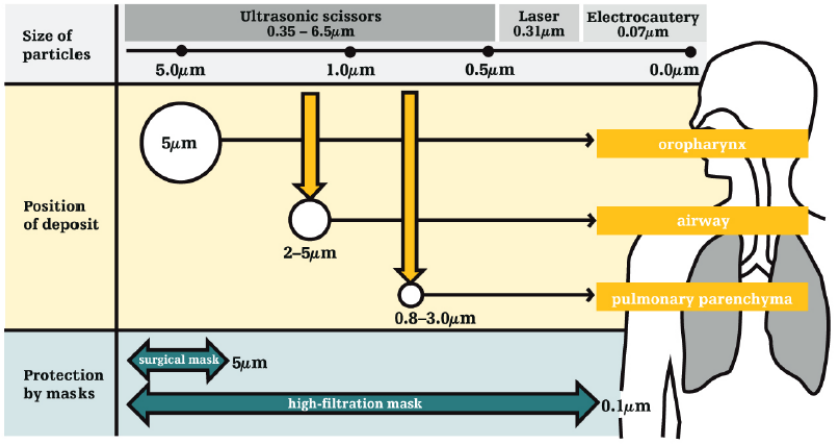
The authors set out with a primary objective of this article to demonstrate to surgeons that surgical smoke may present serious hazards to themselves and other OR personnel. The secondary objective is to discuss the possible means of avoiding or minimizing exposure to surgical smoke.

Potential health risks of surgical smoke:
The composition of surgical smoke varies considerably, with the nature and size of the particles generated depending greatly on the type of procedure, energy used and power level employed. The adverse effects to OR personnel vary depending on what the smoke contains. A list of potential risks to health are shown in the table to the right.

The Risks of Surgical Smoke[24]	
Respiratory System	Nasopharyngeal lesions, sneezing, throat irritation, acute and chronic inflammatory changes in respiratory tract (emphysema, asthma, chronic bronchitis)
Eyes	Eye irritation, lacrimation
Skin	Dermatitis
Gastrointestinal System	Nausea, vomiting, colic
Blood Disorder	Anemia, leukemia
Infection	HIV, hepatitis, HPV
Other	Carcinoma, lightheadedness, hypoxia, dizziness, headache, weakness, anxiety

Particles that are 5 μm or larger are deposited on the oropharyngeal walls, whereas aerosols between 2 and 5 μm are delivered to the airways and aerosols between 0.8 and 3.0 μm reach the pulmonary parenchyma.[25]

Surgical smoke exposure may increase the risk of acute or chronic pulmonary conditions, such as asthma or pneumonia. With respect to acute respiratory symptoms, Navarro-Meza et al.[26] reported that in Mexico, many surgical residents develop lumps in their throat (58%) and sore throat (22%) as a result of exposure to electrocautery smoke. The plastic surgeons at Bryn Mawr Hospital experiencing acute health effects, including upper respiratory and eye irritation, headache and nausea, during breast reduction procedures.[2] Ball et al. reported that the incidence of some respiratory problems, such as bronchitis, asthma, sinus infections and allergies in perioperative nurses was double that of the general population.[27,28]



Components of surgical smoke:
Surgical smoke is made up of 95% water or steam and 5% cellular debris in the form of particulate materials.[22] The mean aerodynamic size of particles generated varies greatly depending on the device used. Electrocautery creates particles of the smallest aerodynamic size (0.07 μm)[29], whereas laser tissue ablation creates larger particles (0.31 μm)[30], and the largest particles are generated by ultrasonic scalpels (0.35–6.5 μm)[5]. In general, smaller particles are of greater concern from a chemical standpoint, whereas larger particles are of more concern from a biological standpoint.[31]

Chemical composition:
The chemical composition of surgical smoke has been well documented; a number of toxic chemical byproducts have been identified. According to a review by Pierce et al.[32], researchers have reported 150 chemical constituents of plume. Electrothermal injuries and the burning of proteins and lipids produce a noxious odor that is noticeable to personnel in the OR.

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Smoke generated by various surgical devices:
Numerous chemicals, some of which are hazardous and present in greater than negligible quantities, have been found in surgical smoke generated by electrocautery. The most abundant chemicals in electrocautery smoke are hydrocarbons, nitriles, fatty acids and phenols.[31]

Exposure to surgical smoke in the OR:
It is commonly believed that the scrubbed members of a surgical team are at greater risk from inhaling smoke than those further away. In fact, surgeons working 20-40 cm from the point of smoke generation are exposed to the highest concentrations of plumes.[33] However, nurses and other OR personnel, along with anesthesia providers, are constantly exposed to the hazards of surgical smoke; the exposure of surgeons is often much less because they may operate only a few times a week.[21]

Limitations of surgical masks and respirators:
Surgical masks are the most commonly used type of protective facemask in perioperative and other hospital settings. Although surgical masks provide a barrier to splashes and droplets impacting on the wearer's nose, mouth and respiratory tract, they do not provide protection against airborne (aerosol) particles[34]: most surgical masks are designed to filter particles that are >5 μm.[21]

Key take-aways:
- **Surgical masks do not provide protection against airborne (aerosol) particles in surgical smoke.**
- **Surgical smoke should be removed by a smoke evacuation system during both open and laparoscopic procedures.**
- **Surgeons should assess the potential dangers of surgical smoke, educate the OR staff about these dangers and encourage the use of evacuation devices to minimize potential health hazards to surgical personnel.**

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