AAOS American Academy of Orthopaedic Surgeons
American Association of Orthopaedic Surgeons

Position Statement

Potential Hazards of Surgical Smoke and Mitigation Approaches

This Position Statement was developed as an educational tool based on the opinions of the authors. It is not a product of a systematic review. Readers are encouraged to consider the information presented and reach their own conclusions.

Limited evidence exists regarding the specific potential risks of electrocautery or surgical smoke (SS) in the operating room. The adverse health effects of inhaled particulate matter in smoke have been demonstrated in other settings. The adoption of smoke evacuation systems to mitigate this potential risk has been slow and these systems have not gained widespread use.

The composition of SS has been studied in depth. Of concern is the particulate matter from cellular debris. It has been estimated that surgical smoke contains up to 150 chemical compounds[1], many of which have been associated with adverse health effects.[2] Those most concerning include ultrafine particulate matter, volatile organic compounds, and polycyclic aromatic hydrocarbons. Anesthetic medications being administered to the patient, such as Sevoflurane, have also been found to be inhaled by operating room occupants. Common compounds found in SS that have known adverse health effects include acetonitrile, benzene, carbon monoxide, ethylbenzene, formaldehyde, hydrogen cyanide, styrene, toluene, and xylene.[3]

Inhalation of particulate matter less than 10 mm has been associated with systemic inflammation, oxidative stress, coronary artery disease, chronic obstructive pulmonary disease, and cardiovascular mortality.[4,5] Particles generated from electrocautery are reported to range from 0.07 to 0.42um.[6,7] These particles are small enough that many filters and masks may be ineffective.[8]

Many studies have addressed the teratogenic potential of SS. An animal model demonstrated that the mutagenic potential of cautery smoke from one gram of tissue was comparable to smoking six unfiltered cigarettes.[9] This study did not account for the dispersion of smoke in a ventilated surgical suite and as with other animal studies can be criticized for not involving human subjects.

In a plastic surgery operating room setting it was estimated that the SS produced daily was equivalent to 27-30 cigarettes.[10] Another study concluded that the lifetime cancer risk of exposure to polycyclic aromatic hydrocarbons in smoke was 117 times greater for a surgeon than for someone exposed to safe levels.[11] Notably, a direct causal relationship between SS and

cancer has not been demonstrated. The potential for mutagenic and carcinogenic effects of SS deserves attention and further study.

Another potential danger of SS is that of disease transmission. There have been four documented cases of human papillomavirus transmission to health care providers though SS.[12,13,14] Hepatitis B virus has been identified in SS during laparoscopy.[15] Although there is concern that SARS-CoV-2 could be contained in and transmitted through SS, no direct evidence for this has been documented.[16,17,18,19]

Several approaches for risk mitigation have been investigated and reported. Local Exhaust Ventilation (LEV) utilizes smoke evacuators or wall suctions with inline filters. Portable smoke evacuation systems can reduce SS up to 99% under optimal conditions.[20] LEV has been shown to reduce airborne particles by >50%.[21] Another study compared a smoke evacuation system to wall suction with inline filter and control without LEV. The smoke evacuation system was the most effective and was able to significantly reduce but not eliminate airborne particles and volatile organic compounds. The distance of the suction from the surgical site was noted to be critical and recommended to be less than 5cm.[22] Electrocautery pencil attachments to LEV are currently available from most manufacturers. These allow the suction location to be the most proximate to the electrocautery site. Respiratory protective devices have been shown to significantly reduce exposure to SS. The N95 respirator with face-seal technology was five-fold more effective than commercial N95 respirators.[23]

Despite the potential hazards of SS, LEV use is not widespread. A study surveying operating room staff in the U.S. found that only 14% of respondents reported that LEV was always used during electrosurgery. The most common reasons cited for not using LEV include “not a part of our protocol,” “exposure was minimal,” “not provided by employer.”[24] A similar study in Germany demonstrated that half of all surgeons assumed that there were high health hazards of surgical smoke without taking protective measures. Only a few of the operating room nurses felt properly informed about the topic. The most important reason for non-compliance with recommendations was a lack of problem awareness or thoughtlessness.[25]

Surgeon preference or resistance has also been cited as a reason for not using smoke evacuation systems.[26] Some of the LEV handles or pencils are bulky and could limit surgical technique. Some surgeons report inconvenience and noise levels as a barrier to use.[21] Especially given the inability to quantify the risk of SS in specific surgical settings, the cost of LEV requires consideration. A mandate for use across all specialties and all surgical settings could introduce a large cost without proven benefit.

Although it is difficult to quantify, evidence supports the potential for harm from surgical smoke (SS) to providers and patients in the operating room. There is currently insufficient evidence to quantify the risk in specific surgical settings. The potential adverse health effects are serious; increased awareness and caution are appropriate.

The American Academy of Orthopaedic Surgeons (AAOS) supports the use of mitigation techniques to reduce exposure to SS, although the optimal approach for specific surgical settings is not well defined. The AAOS supports education and training of surgeons and all operating room personnel regarding the potential risks and mitigation techniques. Further research specific to surgical settings in orthopaedic surgery are needed to guide definitive SS policy.

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