REVIEW DERLEME

DOI: 10.5336/nurses.2023-99065

Not Invisible but Existing Danger Surgical Smoke: A Literature Review

Görünmez Değil Ama Var Olan Tehlike Cerrahi Duman: Literatür Derlemesi

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This study was presented as an oral presentation at 4th International Congress on Occupational Health and Safety in Health Agencies, November 30-December 3, 2022, Antalya, Türkiye.

ABSTRACT Operating rooms are dangerous areas that may pose a risk to patients and healthcare professionals. One of the risks for patients and healthcare professionals is surgical smoke. Electrosurgical devices, which cause the formation of surgical smoke, are frequently used during surgical procedures performed in operating rooms and outpatient services, during endoscopic applications such as removal of polyps, stopping bleeding and tissue resection. Many studies on surgical smoke report the negative effects of smoke on health professionals in the short term. Visible and malodorous, 95% of surgical smoke is water however, the remaining 5% consists of bacteria, viruses, living and dead cellular materials, blood, harmful chemicals. Many studies on surgical smoke report the negative effects of smoke on health professionals in the short term. Operating room personnel had headache, nausea, burning in the throat, cough, eye irritation, watery eye, sneezing, hair odor, hepatitis, cancer, asthma, dizziness, throat irritation, discomfort from smell, chronic bronchitis, rhinitis, drowsiness, anxiety, dermatitis. In the 2022 guideline of the Association of periOperative Registered Nurses, attention is drawn to the necessity of providing a surgical smoke-free working environment in healthcare institutions.

Keywords: Danger; surgical smoke; operating room; surgery; nursing

ÖZET Ameliyathaneler, hasta ve sağlık çalışanları için risk oluşturabilecek tehlikeli alanlardır. Hastalar ve sağlık çalışanları için risklerden biri de cerrahi dumandır. Cerrahi duman oluşumuna neden olan elektrocerrahi cihazları, ameliyathanelerde ve poliklinik servislerinde yapılan cerrahi işlemlerde, poliplerin çıkarılması, kanamanın durdurulması ve doku rezeksiyonu gibi endoskopik uygulamalar sırasında sıklıkla kullanılmaktadır. Cerrahi duman üzerine yapılan pek çok çalışma, dumanın sağlık çalışanları üzerinde kısa vadede olumsuz etkilerini bildirmektedir. Görünür ve kötü kokulu cerrahi dumanın %95'i sudur ancak geriye kalan %5'lik kısım bakteriler, canlı ve ölü hücresel materyaller, kan, zehirli gazlar ve virüslerden oluşmaktadır. Cerrahi duman üzerine yapılan pek çok çalışma, dumanın sağlık çalışanları üzerinde kısa vadede olumsuz etkilerini bildirmektedir. Ameliyathane çalışanlarında baş ağrısı, mide bulantısı, boğazda yanma, öksürük, gözlerde sulanma, hapşırma, saç kokusu, hepatit, kanser, astım, baş dönmesi, boğazda tahriş, kokudan rahatsızlık, kronik bronşit, rinit, uyuşukluk, anksiyete, dermatit görüldüğü tespit edilmiştir. Perioperatif Kayıtlı Hemşireler Derneği 2022 kılavuzunda sağlık hizmeti veren kurumlarda cerrahi dumansız bir çalışma ortamı sağlamasının gerekliliğine dikkat çekilmiştir.

Anahtar Kelimeler: Tehlike; cerrahi duman; ameliyathane; ameliyat; hemşirelik

There are many risk factors for patient and employee safety in operating rooms where surgical interventions are performed.[1,2] One of these factors, which are listed as forgetting a foreign object at the surgery site, blood transfusion errors, surgical burns, contaminated blood product or drug use, wrong-side surgery, patient falls, infusion pump errors, air embolism, medication errors, sharp object injuries, etc., is surgical smoke.[2] Surgical smoke can spread mutagenic gases, carcinogens, particles containing DNA components or human papilloma virus (HPV) into the air. Therefore, surgical smoke endangers the health of patients and operating room staff.[3,4]

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Peer review under responsibility of Turkiye Klinikleri Journal of Nursing Sciences.

Received: 14 Aug 2023 ***Received in revised form:*** 11 Mar 2024 ***Accepted:*** 19 Mar 2024 ***Available online:*** 16 Apr 2024

Although the harmful effects of surgical smoke are known, studies show that operating room staff do not have sufficient knowledge about these effects and do not comply with smoke evacuation guidelines.[5-7] In our country, studies examining surgical smoke risks and preventive practices are limited.[1]

In this literature review, it is aimed to give information about surgical smoke, its risks and prevention methods.

SURGICAL SMOKE

WHAT IS SURGICAL SMOKE AND HOW IS IT RELEASED?

Many definitions and nomenclatures for surgical smoke have been made before. These include aerosol, bioaerosol, vapor, diathermy fume, smoke, plume, air pollutant, air contaminant and cautery fume.[8-10] Surgical smoke occurs when the high heat generated during the use of energy-based devices used in operating rooms (electrocautery, laser, ultrasonic devices, high-speed drills, saws, etc.) burns protein and other organic substances, resulting in the breakdown and evaporation of fat and protein in the tissues.[1,8]

CONTENT OF SURGICAL SMOKE

95% of surgical smoke is water. However, the remaining 5% consists of bacteria, living and dead cellular materials, blood, harmful chemicals and viruses.[1-4] There are DNA components, HPV, carcinogens, chemical agents, mutagen gases.[7] Particles in the 5% harmful part of surgical smoke can be transported to a long distance from their own production areas via droplets. Acrylonitrile, acrolein, benzene, phenols, formaldehyde, hydrocarbons, hydrogen cyanide, hydrosonic acid, nitriles, toluene and fatty acids can be seen among the most common chemicals found in smoke.[7,8] Smoke can spread hepatitis B and C, HPV, human immunodeficienct virus, tuberculosis viruses into the air.[9-11]

ADVERSE EFFECTS OF SURGICAL SMOKE

Physical And Chemical Effects Of Surgical Smoke

Many studies on surgical smoke report the negative effects of smoke on health professionals in the short term. In the study of Aydın et al., the health professionals who are working in the operating room had headache (47.8%), nausea (35.8%), burning in the throat (31.3%), cough (31.3%), eye irritation and tearing (both). It has been reported that they were affected by complications such as 29.9%.[1] In the study of Yaman Aktaş and Aksu, surgical smoke-related symptoms were determined 81.7% of operating room personnel and nurses working in the operating room experienced headache (62.2%), burning in the throat (46.3%), nausea (45.1%), cough (45.1%), tearing (36.6%).[12]

In a study of Usta et al., nurses working in the operating room were more likely to have headache (61.9%), watery eye (54.3%), sneezing (44.8%), throat burning (43.8%), hair odor (41%), and It was determined that they experienced symptoms such as cough (41%). In the same study, it was stated that a nurse experienced hepatitis symptoms.[8] In the study of Okgün Alcan et al., it was found that nurses experienced headache (71.8%), nausea (63.4%), cough (57.7%), burning in the throat (49.3%), and tearing (46.5%). In the same study, patients with hepatitis (4.2%) and cancer (2.8%) symptoms were also reported.[13]

In a systematic review published by Canicoba and Poveda, surgical smoke caused mostly respiratory problems and headache. In the same systematic review, histopathological changes were detected in the nasal mucosa of operating room personel and toxic substances originating from smoke were detected in their urine.[14] In the guide published by the Association of periOperative Registered Nurses (AORN) in 2022, surgical smoke can cause asthma, headache, dizziness, throat irritation, eye irritation, tearing, sneezing, discomfort from smell, chronic bronchitis, vomiting, nausea, rhinitis, It has been reported to cause symptoms such as coughing and drowsiness.[15]

In addition, studies have shown that anxiety, dermatitis, darkening of the eyes, hypoxia, cardiovascular dysfunction, nasopharyngeal lesions, acute and/or chronic inflammatory changes in the respiratory tract are also encountered.[16,17] Kwak et al., it was determined that surgical smoke samples were taken from 11 hepatitis B patients and virus transmission was

found in one of the patients. In the literature, it is stated that the chemical substances in surgical smoke may be a risk factor for cancer.[19]

Surgical smoke also has adverse effects on patients.[20] In particular, it is stated that smoke causes biochemical changes in the hemoglobin structure.[21] In addition, it has been reported that it impairs the visibility of the region during surgery, prevents the detection of hypoxia as it causes false increases in the patient's oxygen saturation values, and may cause metastasis in pot areas.[22]

HIERARCHY OF PRECAUTIONS TO BE TAKEN TO AVOID SURGICAL SMOKE

AORN has specified a five-step control hierarchy in the surgical smoke safety 2022 guideline. In this control hierarchy, a hierarchy is determined from the most effective, reliable and sustainable measures to the least effective, reliable and sustainable measures (Figure 1).[15]

Precautions For Surgical Smoke Protection

In the AORN 2022 guideline, the first important detail for surgical smoke protection is that the healthcare provider should provide a surgical smoke-free working environment. For this, (1) the job description of the employees, their duties, (2) the procedure, tissue type, (3) the type and number of surgical energy device used, (4) the process of applying the devices to the tissue, and (5) the availability of smoke management systems and tools important in identifying the risk. Another important point in determining these is compliance with the control hierarchy. Suggested; even if surgical smoke cannot be eliminated, it is recommended to move to the next level in the hierarchy.[15]

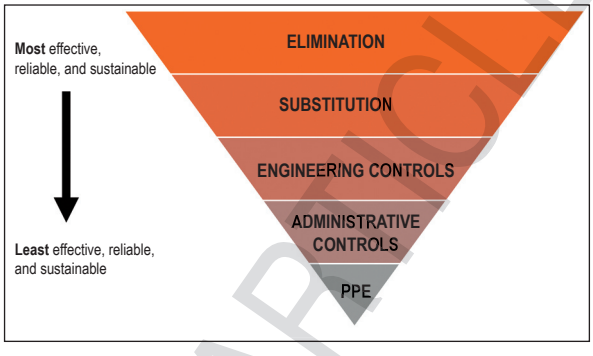

FIGURE 1: PPE: Personal protective equipment.

An important point for the elimination of surgical smoke is the existence of smoke evacuation systems-devices, ventilation systems, wall-mounted aspirators and the appropriate use of these systems.[16,17] High-efficiency particulate air (HEPA) or ultra low penetration air (ULPA) filters are the most suitable ventilation filters recommended for smoke evacuation. HEPA filters can provide 99.97% efficiency, while ULPA filters can provide 99.99% efficiency.[11] Wall-mounted aspirators are of great importance in smoke evacuation systems. Because this type of aspirators have the ability to draw at least five cuff pressure per minute.[9] AORN recommends using ULPA filters over HEPA filters. The reason for this is that ULPA filters have an efficiency of 99.99% compared to HEPA filters.[15]

The surgical smoke control hierarchy recommends the use of surgical masks with high filtration properties within personal protective equipments (PPE). In particular, it is stated that surgical masks are among the most standard equipment.[9] However, according to the AORN, the use of PPE constitutes the least effective step for protection from surgical smoke. For this reason, AORN recommends the use

TABLE 1: Surgical smoke control hierarchy.

Elimination	Eliminate exposure by not producing surgical smoke.
Substitution	Consider alternative surgical energy devices that produce less surgical smoke.
Engineering controls	Evacuate all smoke to avoid exposure to perioperative personnel and patients.
Administrative controls	Establish policies and organize training to address exposure to danger from surgical smoke.
PPE	Use PPE as secondary protection from surgical smoke.

PPE: Personal protective equipment.

of smoke evacuation devices and equipment more important than the use of PPEs. The mask recommended for filtration is N95.[13]

There are studies in the literature with the aim of determining the precautions for protection from surgical smoke. Aydın et al., the use of surgical masks (77.6%), aspiration catheters (55.2%), gowns (28.4%), glasses (26.9%) for protection in the operating room;[1] Yaman Aktaş and Aksu, operating room nurses used aspirators (95.1%), surgical masks (89%), gloves (75.6%), surgical gowns (72%) and glasses (51.2%) for protection from surgical smoke;[12] Okgün Alcan et al. it was determined that nurses working in the operating room used aspiration catheters (85.9%), surgical masks (80.3%), gowns (52.1%), glasses (33.8%) and filters (18.3%) to protect themselves from smoke.[13]

An important issue that AORN emphasizes is the provision of education on surgical smoke. According to AORN, the following items should be included in the surgical smoke training content:

- Surgical smoke and its effects,
- Sources of surgical smoke and the effect of particle size on the distribution of smoke,
- Control hierarchy for smoke management,
- Smoke management system suitable for each surgery and selection of necessary consumables,
- Testing and connecting methods of devices used for smoke management according to the instructurer's guidelines for use,
- The use of smoke evacuation equipment and the acceptance of disposable materials as medical waste and taking standard precautions,
- The policy and management of the health institution regarding smoke evacuation,
- Ensuring participation in surgical smoke quality improvement programs as determined by the employer.[15]

CONCLUSION

Surgical smoke causes many negative effects for both healthcare professionals and patients. It is of great importance that the evacuation of surgical smoke is carried out in the best way, compliance with the recommendations in this direction and the implementation of the hierarchy. Increasing the number of studies on surgical smoke in the literature is also important in terms of determining more risk factors both in the short and long term and determining the effectiveness of prevention methods.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Ufuk Kaya, Kerem Yıldız;* ***Design:*** *Ufuk Kaya, Kerem Yıldız;* ***Control/Supervision:*** *Ufuk Kaya;* ***Data Collection and/or Processing:*** *Ufuk Kaya, Kerem Yıldız;* ***Analysis and/or Interpretation:*** *Ufuk Kaya, Kerem Yıldız;* ***Literature Review:*** *Ufuk Kaya, Kerem Yıldız;* ***Writing the Article:*** *Ufuk Kaya, Kerem Yıldız;* ***Critical Review:*** *Ufuk Kaya;* ***References and Fundings:*** *Ufuk Kaya, Kerem Yıldız;* ***Materials:*** *Ufuk Kaya, Kerem Yıldız.*

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