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An Investigation of the Effects of Surgical Smoke on the Health of Operating Room Personnel

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ABSTRACT

Surgical smoke during surgery occurs due to the use of electrical devices working at high temperatures such as laser, electrocautery, ultrasonic scalpel, bone saw, and drill used during excision, hemostasis, and dissection. Operating room workers are exposed to this harmful smoke in surgeries. No study was found in the literature comparing operating room personnel before and after working in the operating room.

This study was conducted to comparison of the effects of exposure to surgical smoke before and after working in the operating room

This study was conducted in a descriptive design. The study was performed in the operating room of Atatürk University Research Hospital between the dates January 2021 September 2021. The study was carried out with a total of 87 operating room personnel (surgeons, nurses, anesthesia technicians) who had worked in another clinic or outpatient clinic before working in the operating room. Data were collected using a questionnaire containing the sociodemographic information of the operating room personnel and a data collection form on the risks and symptoms of surgical smoke.

In the study, it was determined that 44.8% of the operating room personnel were nurses, 65.5% were female, 51.7% worked in the operating room for 1-5 years, and 46.0% stayed in the surgical operation for 4-6 hours. It was reported that various symptoms related to surgical smoke such as headache (100%), fatigue (95.8%), nervousness (98.3%), muscle pain (98.4%), discomfort (100.0%), amnesia (95.5%), and respiratory tract problems were observed in operating room personnel, especially after working in the operating room.

As a result of the study, it was revealed that the operating room personnel experienced various symptoms due to surgical smoke after working in the operating room. This study showed the adverse effects of surgical smoke on the health of operating room personnel.

Keywords: Operating room, operating room personnel, surgical smoke, occupational exposure

What is already known about the topic?

- Operating rooms are places where advanced technological tools are used and many surgical techniques and methods are applied. However, the tools and equipment used in operating rooms can pose a risk to the health of operating room personnel. One of these risks is surgical smoke.
- Surgical smoke contains many harmful substances such as dead and living cellular materials, blood fragments, bacteria, viruses and toxic gases. Surgical smoke threatens the health of operating room personnel due to these harmful substances in its content.

What this paper adds

- In this study, it was determined that operating room workers experienced various symptoms due to surgical smoke after working in the operating room.
- This study showed the adverse effects of surgical smoke on the health of operating room personnel.

Introduction

Operating rooms are places where technologically advanced devices and instruments are used. Electrosurgical, laser and ultrasonic instruments

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that generate heat in the patient's tissue are used for excision, dissection, or hemostasis during almost all surgical procedures (1,2). The high heat released during the use of these instruments causes the burning of protein and other organic materials and the formation of thermal necrosis in the cells in the surrounding tissues. Thus, surgical smoke is released with the breakdown and evaporation of fat and protein in the tissues (2-5). Surgical smoke exposure hazards first came to light in the 1980s with the initiation of pioneering research on laser plume (6). Surgical smoke, which has an odor and is sometimes visible to the naked eye, consists of 95% water or vapor and 5% cell debris (7,8). Furthermore, it is stated that surgical smoke contains bacteria, viruses, tissue material, blood cells, as well as chemical and biological substances that may have mutagenic and cytotoxic effects (8,9). Bacteria and virus cells in surgical smoke can stay alive for up to 72 hours, and these harmful substances in its content threaten the health of both the patient and the operating room personnel (7,10).

Particles of different sizes are formed by different energy devices during surgical intervention. Particles 0.-0.8 µm in size are produced by electrocautery, while 0.35-6.5 µm particles are produced by laser procedures and ultrasonic scalpels (11). The smaller the particles are, the further they travel and the more cellular damage they can cause (1,12). This may affect the sterile team during surgery as well as the non-sterile members of the surgical team (e.g. circulating nurse, anesthesia technician) (1). In a study, it was highlighted that the size of particles released during surgical procedures holds significance, as those smaller than 100 µm can remain suspended in the air, while particles of 5 µm or larger have a higher likelihood of accumulating in the upper respiratory tract (12). It is also emphasized that particles and chemicals smaller than 2 µm can settle in the bronchioles and alveoli and damage the respiratory system. (7,8)

The content and harmful effect of surgical smoke vary significantly depending on the nature and pathology of the tissue being treated and the exposure time. (10) In the literature, operating room personnel exposed to surgical smoke are faced with various problems such as nausea, vomiting, headache, sore throat, cough, dizziness, odor of the hair, sneezing, eye irritation and lacrimation, respiratory distress, hypoxia, airway inflammation, fatigue or weakness, dermatitis, muscle pain, conjunctivitis, cramps, anemia, hepatitis, and cancer (1,3,8,13-17). Exposure to surgical smoke may also increase the risk of acute or chronic lung diseases such as asthma or pneumonia. (18) Furthermore, human papillomavirus (HPV), human immunodeficiency virus (HIV), tuberculosis, hepatitis B and C viruses in surgical smoke can spread into the air. (19,20) Research findings underscore the risk of infectious disease exposure for operating room personnel arising from surgical smoke (7,15). Hill et al. (21) (2012) have noted that the impacts of surgical smoke exposure on operating room personnel closely resemble those associated with passive smoking. The long-term effects of exposure to surgical smoke have yet to be proven. (14) However, it is stated that continuous exposure to fine particulate air pollution increases the incidence of postmenopausal cardiovascular disease in women and is associated with death. (22)

Since surgical masks do not filter particles smaller than 5 µm, surgical smoke can be inhaled by operating room personnel (8). The Occupational Safety and Health Administration (OSHA) emphasizes that approximately 500,000 operating room personnel are exposed to surgical smoke every year (4,23). Therefore, surgical smoke is one of the most important problems for patients and operating room personnel (10). A limited number of studies were conducted in Turkey on the effect of surgical smoke on the health of operating room personnel. Moreover, no study was found in the literature comparing operating room personnel before and after working in the operating room. From this aspect, the study will fill the gap in the literature and will contribute to the understanding of the dangers of surgical smoke inhaled by the operating room personnel and increasing awareness of this issue. Therefore, the study was conducted to examine the effects of surgical smoke on the health of operating room personnel.

Materials and Methods

Study Design, Population, and Sample Size: This study was carried out in a descriptive design. The study was performed in the operating room of a university research hospital between the dates January 2021 September 2021. The study population consisted of the surgeon, nurse, and anesthesia technician working in the operating room of the relevant hospital. Operating room workers who had worked at least 6 months in surgical and internal clinics, pediatric clinics or polyclinics where there was no exposure to surgical smoke before working in the operating

room were included in the study. All operating room personnel who met the research criteria were included in the sample group. A total of 87 operating room personnel, including 13 surgeons, 39 nurses, and 35 anesthesia technicians, formed the study sample, apart from the operating room personnel who did not want to participate in the study and were on leave or had a sick report. Operating room personnel who had not worked in another clinic or outpatient clinic before working in the operating room were not included in the study. In this study, answers to the following questions were sought.

- Are the symptoms observed in operating room personnel different before and after working in the operating room?
- Did surgical smoke have adverse effects on the health of the operating room personnel after working in the operating room?

Data Collection Tools: Data were collected by the questionnaire method using a data collection form prepared in line with the literature for the symptoms of surgical smoke. Regarding the data collection form consisting of two parts, the sociodemographic information of the operating room personnel was included in the first part, and the symptoms related to surgical smoke were included in the second part. The data collection form was distributed to the operating room staff, and they were asked to fill it out at rest. The operating rooms were visited at regular intervals by the researchers, and the data collection forms filled out by the operating room personnel were collected. Filling out the data collection forms took approximately 5-7 minutes.

Statistical Analysis: IBM SPSS Statistics 20.0 (IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) software was used for statistical analysis and calculations. Descriptive statistics (frequency, percentage, mean) were used when evaluating the study data.

Results

In the study, it was determined that the mean age of the operating room personnel was 30.62±6.18, 44.8% were nurses, 65.5% were female, 69.0% were married, 67.8% did not smoke, 90.8% did not drink alcohol, 90.8% did not have a chronic disease, 87.4% did not use drugs regularly, 44.8% worked for 1-5 years, 51.7% worked in the operating room for 1-5 years, 55.2% worked 41 hours and more per week, 46.0% spent 4-6 hours in the surgical operation, and 52.9% were exposed to X-rays for 2 hours and less per week (Table 1).

It was determined that more than half of the operating room personnel experienced headache, fatigue, irritability, weakness, muscle pain and discomfort after working in the operating room. Other symptoms and potential risks of surgical smoke reported by operating room personnel participating in the study are shown in Table 2.

Discussion

In recent years, with the increase in the use of electrocautery and laser in surgical interventions, the risk of exposure to surgical smoke has also increased. Various symptoms related to surgical smoke are more common in personnel who spend 50% or more of their time in the operating room. (10,14,24) While the full extent of the long-term effects of exposure to surgical smoke remains uncertain, it is asserted that operating room personnel face a heightened risk of occupational diseases compared to those employed in other medical settings, primarily due to the deleterious substances present in the smoke (2,25). In particular, surgeons and nurses encounter a higher level of exposure to surgical smoke compared to other members of the surgical team, attributed to their prolonged presence in the operating room (26). It is known that gas and particles in the smoke content, which are formed due to thermal destruction in tissues during the dissection or coagulation of the tissues by electrocautery and laser, are absorbed from the skin and lungs and cause many acute or chronic symptoms or diseases in patients and operating room personnel (11,15). In this study, the majority of operating room personnel stated that they experienced various symptoms related to surgical smoke after working in the operating room. In the study, it was determined that headache, weakness, abdominal pain, discomfort, taste change, swelling, dry mouth, sensitization, skin moisture/redness, irritability, anxiety, muscle relaxation, voice changes, agitation, paleness of the face, superficial breathing, cyanosis, decreased capillary filling, abnormal mucus secretion, low blood pressure, low saturation value, rhinitis, conjunctivitis, throat irritation, loss of appetite, airway irritation, hypoxia and airway inflammation were observed in all operating room personnel after working in the operating room. Furthermore, it was determined that the operating room personnel experienced many symptoms such as vomiting, cough, sore throat, lacrimation, sneezing, dizziness, fasciculation, fatigue, nervousness, muscle pain,

Table 1: Distribution of Operating Room Personnel by Sociodemographic Characteristics (N=87)

Characteristic	n	%
Profession		
Surgeon	13	14.9
Nurse	39	44.8
Anesthesia Technician	35	40.3
Gender		
Female	57	65.5
Male	30	34.5
Marital Status		
Married	60	69.0
Single	27	31.0
Smoking Status		
Yes	28	32.2
No	59	67.8
Alcohol Consumption Status		
Yes	8	9.2
No	79	90.8
Presence of Chronic Disease		
Yes	8	9.2
No	79	90.8
Presence of Regularly Used Drug		
Yes	11	12.6
No	76	87.4
Working Period		
1-5 years	39	44.8
6-10 years	25	28.7
11-15 years	12	13.8
16 years and above	11	12.6
Working Period in the Operating Room		
1-5 years	45	51.7
6-10 years	28	32.2
11-15 years	6	6.9
16 years and above	8	9.2
Weekly Working Hours		
40 hours and below	39	44.8
41 hours and above	48	55.2
Hours Spent During Surgical Operation		
2 hours and below	4	4.6
2-4 hours	12	13.8
4-6 hours	40	46.0
6-8 hours	27	31.0
8 hours and above	4	4.6
Weekly X-Ray Exposure Time		
2 hours and below	46	52.9
2-4 hours	14	16.1
4-6 hours	11	12.6

6-8 hours	7	8.0
8 hours and above	9	10.4
	$\overline{X} \pm SS$	
Age	30.62±6.18	

abdominal pain, amnesia, tingling sensation in different parts of the body, speech disorder, skin rash, cramps, dizziness, sinus problems, bradycardia/tachycardia, asthma and B12 deficiency after working in the operating room (Table 2). This indicates that personnel in the operating room are subject to adverse physical effects resulting from exposure to surgical smoke. Furthermore, the question of the study, "Are the symptoms observed in operating room personnel different before and after working in the operating room?" was also answered. Surgical smoke poses potential risk factors, particularly for the cardiovascular and respiratory systems. These include nasopharyngeal lesions, throat irritation, acute and chronic inflammatory changes in the respiratory system, eye irritation, ophthalmia, nausea, vomiting, blood diseases, anemia, hypoxia, headache, and anxiety (7). Soysal et al. (2023) compared the physical complaints of health personnel working and not working in the operating room. The study identified a higher prevalence of complaints such as tearing, burning sensation in the eyes, odor in the hair, nausea, and cough among the operating room team compared to individuals working in other units. In the same study, it was emphasized that the negative effects of surgical smoke increased as the duration of the surgery increased (27). In the study conducted by Aydın et al. (2021), headache, nausea, cough, sore throat, eye irritation, lacrimation and respiratory problems were found to be the most common among operating room personnel exposed to surgical smoke (28). In the study carried out by Ilce et al. (2017) with doctors and nurses, the signs and symptoms related to surgical smoke were reported as headache, lacrimation, cough, sore throat, odor of the hair, nausea, weakness, dizziness and sneezing, respectively (14). In the study conducted by Alcan et al. (2017), it was found that 87.3% of nurses experienced symptoms related to surgical smoke (13). In a 2019 study involving 137 perioperative healthcare professionals to assess the prevalence of health effects from exposure to surgical smoke, participants reported acute health effects. The most frequently reported symptoms included upper airway irritation (40.0%), headache (27.4%), eye irritation (20.6%), and symptoms resembling asthma (12.0%). (29) According to Yu et al. (2022), the most prevalent symptoms among operating room nurses included drowsiness, headache, runny nose or other nasal discomforts, cough, dizziness, and tearing or other eye discomforts (30). When the literature was reviewed, it was emphasized that symptoms such as headache, nausea, cough, watering of eyes, sneezing, sore throat, nasal congestion, lacrimation, nausea, fatigue, dizziness, nervousness, hypoxia, weakness, anemia, dermatitis, muscle cramps, eye irritation, asthma and myalgia were observed in operating room personnel (1,6,13,17,24,27,31-36).

In this study, it was determined that hepatitis, HPV, and HIV were observed in operating room personnel after working in the operating room (Table 2). In the study conducted by Alcan et al. (2017), it was revealed that hepatitis was observed in 4.2% of the nurses working in the operating room (13). Although HIV, HPV, and hepatitis were reported by the participants in the study, no detailed research was carried out on whether this situation may be directly related to surgical smoke. HIV, HPV and hepatitis can be transmitted to employees in the operating room through blood or body fluids, as well as sexually. However, studies show that HPV, HIV, hepatitis B and C viruses in surgical smoke can spread into the air, and operating room personnel may be exposed to infectious diseases due to surgical smoke (7,15,19,20). Studies also revealed the presence of hepatitis B virus and HPV in surgical smoke among biological compounds, but these agents were not confirmed to be responsible for the development of diseases in smoke-exposed personnel (20,37). In a recent study, nasal swab samples were taken from 700 gynecologists and it was determined that gynecologists who performed electrosurgery were at risk for HPV infection.[38] This information is considered to confirm the findings. Furthermore, the question of the study, "Did surgical smoke have adverse effects on the health of the operating room personnel after working in the operating room?" was also answered. In summary, it can be said that the operating room personnel show various symptoms especially after working in the operating room,

Table 2: Comparison of the Symptoms Experienced By The Operating Room Personnel Before and After Working in the Operating Room

Symptom/Disease*	Before Working in the Operating Room		After Working in the Operating Room	
	n	%	n	%
Nausea	2	11.1	16	88.9
Headache	-	-	56	100.0
Vomiting	1	8.3	11	91.7
Cough	1	4.2	23	95.8
Sore throat	1	3.2	30	96.8
Lacrimation	1	3.2	30	96.8
Sneezing	1	3.6	27	96.4
Dizziness	1	2.9	33	97.1
Fatigue	3	4.2	69	95.8
Nervousness	1	1.7	59	98.3
Weakness	-	-	51	100.0
Abdominal pain	-	-	22	100.0
Fasciculation	2	6.2	30	93.8
Muscle pain	1	1.6	63	98.4
Discomfort	-	-	51	100.0
Tingling sensation in different parts of the body	2	5.7	33	94.3
Speech disorder	1	6.7	14	93.3
Skin rash	1	3.6	27	96.4
Taste change	-	-	14	100.0
Swelling	-	-	25	100.0
Dryness	-	-	29	100.0
Sensitization	-	-	29	100.0
Skin moisture/redness	-	-	32	100.0
Irritability	-	-	26	100.0
Cramp	2	5.1	37	94.9
Anxiety	-	-	41	100.0
Drowsiness	1	3.0	32	97.0
Muscle relaxation	-	-	14	100.0
Sinus problems	1	6.3	15	93.8
Voice change	-	-	9	100.0
Agitation	-	-	29	100.0
Paleness of the face	-	-	30	100.0
Superficial breathing	-	-	20	100.0
Cyanosis	-	-	7	100.0
Decreased capillary filling	-	-	9	100.0
Abnormal mucus secretion	-	-	10	100.0
Low blood pressure	-	-	11	100.0
Amnesia	2	4.5	42	95.5
Low saturation value	-	-	12	100.0
Hepatitis	1	33.3	2	66.7
HIV	-	-	1	100.0
Asthma	1	25.0	3	75.0

HPV	-	-	2	100.0
Lung/kidney disease	1	25.0	3	75.0
Peptic ulcer	-	-	17	100.0
Neurological diseases	-	-	5	100.0
Rhinitis	-	-	10	100.0
Conjunctivitis	-	-	10	100.0
Anemia	-	-	17	100.0
Dermatitis	-	-	26	100.0
Suspected liver enzyme elevation	-	-	3	100.0
Throat irritation	-	-	23	100.0
Loss of appetite	-	-	27	100.0
Airway irritation	-	-	18	100.0
Hypoxia	-	-	9	100.0
Airway inflammation	-	-	13	100.0
Myalgia	1	3.3	29	96.7
Bronchitis	-	-	3	100.0
Hematological discomfort	-	-	2	100.0
Pneumonia	-	-	2	100.0
Hyperemesis	1	33.3	2	66.7
Coordination disorder	-	-	8	100.0
Eye irritation	-	-	11	100.0
B12 deficiency	4	9.5	38	90.5

*More than one answer was given

this situation adversely affects the health of the operating room personnel, and there is a significant increase in the symptoms observed after working in the operating room.

As a result of the study, it was determined that the operating room workers experienced the most symptoms such as headache, fatigue, nervousness, burning in the throat, tearing, dizziness, and restlessness after working in the operating room. In line with these results, it can be said that it is very important to protect operating room personnel against surgical smoke with the use of appropriate equipment and procedures. It may be recommended to use effective evacuation systems to remove surgical smoke from the operating room environment. It should be ensured that the number of in-service training on the effects of surgical smoke is increased and studies are carried out to provide the compliance of operating room personnel with protective methods. Further studies may be recommended to obtain stronger results in the evaluation of the effect of surgical smoke on operating room workers. Furthermore, it may be recommended to conduct research on surgical smoke with a larger sample in order to increase awareness and carry out studies to determine the long-term effects of surgical smoke.

Limitations of the Study: The fact that the study was conducted in a single center constitutes an important limitation of the study. Furthermore, the inclusion of only operating room personnel who worked in a different clinic/outpatient clinic before working in the operating room resulted in a limited number of participants. The study is limited to the measurements obtained from the research and the self-reports of the participants.

Ethical Considerations: Ethics committee approval was obtained from a university medical faculty ethics committee before starting the study. After necessary explanations about the purpose of the study, how it would be conducted and what results would be obtained were made to the operating room personnel included in the study, approval was obtained. During the collection of research data, the ethical principle of "informed consent" was followed by informing the patients about the research, the ethical principle of "respect for autonomy" was followed by stating that participants were free to participate in the research or leave the study, and the ethical principle of "protection of confidentiality" was followed by stating that patient information would be kept confidential. Patients who were willing to participate in the study were included in the study. Since individual rights should be protected in the

study, the Declaration of Helsinki on Human Rights was adhered to during the study period.

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Conflict of Interest: The authors declare that there are no conflict of interests.

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