

# SIGNS AND SYMPTOMS RELATED TO INHALATION OF SURGICAL SMOKE BY SURGEONS

*Sinais e sintomas relacionados à inalação da fumaça cirúrgica por cirurgiões*

*Signos y síntomas relacionados con la inhalación del humo quirúrgico por cirujanos*

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**ABSTRACT: Objective:** To determine the association between the prevalence of signs and symptoms related to the inhalation of surgical smoke and time in practice of the exposed surgeons. **Method:** A cross-sectional, descriptive, quantitative field study was conducted. The data were collected by one of the authors in an individual interview with 45 surgeons, with the aid of an instrument aimed at collecting sociodemographic information and data on variables referring to signs and symptoms related to the inhalation of surgical smoke described in the literature. **Results:** The sample consisted mostly of male surgeons, mostly from the obstetrics and gynecology clinic. There was no statistical significance between the association of signs and symptoms related to smoke inhalation and time in practice of the exposed surgeons ( $p>0.05$ ). **Conclusion:** There was a higher prevalence of eye irritation symptoms and foreign-body sensation in the throat in surgeons with more than 30 years of practice; 60.0% of surgeons did not believe that the symptoms were related to the inhalation of surgical smoke. It is recommended that an exhaust fan be installed in the operating room and that an N95 mask be used by workers exposed to this risk to minimize the signs and symptoms of smoke inhalation.

**Key words:** Surgeons. Signs and symptoms. Electrocoagulation. Occupational health.

**RESUMO: Objetivo:** Verificar a associação entre a prevalência de sinais e sintomas relacionados à inalação da fumaça cirúrgica e o tempo de atuação desde a formatura dos cirurgiões expostos. **Método:** Estudo de campo, transversal, descritivo, quantitativo. Os dados foram coletados por uma das pesquisadoras em entrevista individual com 45 cirurgiões, com o auxílio de um instrumento contendo dados sociodemográficos e variáveis referentes aos sinais e sintomas relacionados à inalação da fumaça cirúrgica descritos na literatura. **Resultados:** A amostra foi composta, em sua maioria, de cirurgiões do sexo masculino, com prevalência da clínica de ginecologia e obstetrícia. Não houve significância estatística entre a associação dos sinais e sintomas relacionados à inalação da fumaça e o tempo de atuação desde a formatura dos cirurgiões expostos ( $p>0,05$ ). **Conclusão:** Houve maior prevalência dos sintomas irritação nos olhos e sensação de corpo estranho na garganta entre os cirurgiões com mais de 30 anos na função desde a formatura; 60,0% dos cirurgiões não acreditam que os sintomas estejam relacionados à inalação da fumaça cirúrgica. Recomenda-se, para a minimização dos sinais e sintomas, a instalação de exaustores de fumaça em salas cirúrgicas e o uso da máscara N95 pelos trabalhadores expostos a esse risco.

**Palavras-chave:** Cirurgiões. Sinais e sintomas. Eletrocoagulação. Saúde do trabalhador.

**RESUMEN: Objetivo:** Determinar la asociación entre la prevalencia de signos y síntomas relacionados con la inhalación de humo quirúrgico y el tiempo en la práctica de los cirujanos expuestos. **Método:** Se realizó un estudio de campo cuantitativo, descriptivo y de corte transversal. Los datos fueron recopilados por uno de los autores en una entrevista individual con 45 cirujanos, con la ayuda de un instrumento destinado a recopilar información sociodemográfica y datos sobre variables relacionadas con signos y síntomas relacionados con la inhalación de humo quirúrgico descrita en la literatura. **Resultados:** la muestra estuvo compuesta principalmente por cirujanos varones, principalmente de la clínica de obstetrícia y ginecología. No hubo significación

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Received: 03/27/2018 – Approved: 08/28/2018

DOI: 10.5327/Z1414-4425201800040005

estadística entre la asociación de signos y síntomas relacionados con la inhalación de humo y el tiempo en la práctica de los cirujanos expuestos ( $p > 0.05$ ). Conclusión: Hubo una mayor prevalencia de síntomas de irritación ocular y sensación de cuerpo extraño en la garganta en cirujanos con más de 30 años de práctica; El 60,0% de los cirujanos no creía que los síntomas estuvieran relacionados con la inhalación de humo quirúrgico. Se recomienda que se instale un ventilador de extracción en la sala de operaciones y que los trabajadores expuestos a este riesgo utilicen una máscara N95 para minimizar los signos y síntomas de la inhalación de humo.

**Palabras clave:** Cirujanos. Signos y síntomas. Electrocoagulación. Salud laboral.

## INTRODUCTION

The Surgical Center (SC) can be considered one of the most complex units of the hospital in view of its specificities and the constant health risk both for the patient, in relation to the necessary surgical intervention, and for the workers due to the procedures while providing care<sup>1</sup>.

Electrocautery is one of the radiofrequency-based technologies used regularly in the SC in different specialties, to facilitate the visualization of the operative field and to reduce bleeding and surgical time<sup>1</sup>.

The instrument used may be monopolar or bipolar. The monopolar one, because of its versatility and efficiency, is more often used in the dissection and coagulation of vessels. Bipolar cauterization, on the other hand, is used in delicate tissues, which are placed between the electrodes<sup>2</sup>. There is no difference between monopolar and bipolar electrocautery with regard to the amount of the chemicals generated during its use and released into the air in the form of surgical smoke<sup>3</sup>.

Surgical smoke is formed by the incomplete cauterization of the tissues and is composed of toxic gases that can accumulate as living or dead organic material, where this can be harmful to the health of those who inhale it, as in the case of surgeons, anesthetists and the nursing team of the SC.

This smoke can contain viruses, bacteria and chemical and biological contaminants; 95% of it is composed of water, and the other 5% consists of particles potentially harmful to health<sup>4,5</sup>. The toxic gases of fetid odor, formed from the surgical smoke, release small particles that can cause respiratory complications and pathogens that can be transmitted to the surgical team<sup>6,7</sup>. The substances produced by the surgical smoke can be absorbed by the skin or respiratory tract of the exposed surgeons during their work activities, in the form of dust, smoke, mist, gases or vapors, and this smoke is one of the main chemical risks present in operating rooms (OR)<sup>8</sup>.

The chemical risk of surgical smoke is related to odor, particle size and gas concentration. The great threat is represented by the odor-causing toxins, which are released into the air when the tissue is cauterized by electrocautery. This odor

is characteristic of chemicals formed from the combustion of proteins and lipids during electrocautery<sup>4,9-12</sup>. These chemicals cause headache, sore throat, nausea, vomiting, eye irritation, weakness, dizziness<sup>13</sup>, burning in the pharynx, nasal congestion, sneezing and mucosal irritation in the nose and mouth<sup>1</sup>.

Surgical smoke contains polycyclic aromatic hydrocarbons (PAH)<sup>14,15</sup>, volatile organic compounds (VOC)<sup>16</sup>, carbon monoxide (CO)<sup>3</sup> and toluene<sup>17</sup>, among others. These chemical compounds are responsible for mutagenic<sup>18</sup> and/or carcinogenic effects<sup>19</sup>, depending on the worker's exposure time.

In a study aimed at comparing the risks related to the inhalation of surgical smoke in laparoscopic procedures with open procedures, it was observed that the surgical smoke produced remained in the patient's abdominal cavity and then released after the trocar valve was opened<sup>16</sup>. The analysis of this smoke revealed the presence of carcinogenic substances such as ethanol, dichloroethane, benzene and ethylbenzene.

There are no studies in the Brazilian or international literature that shows a connection between exposure to surgical smoke and the presence of related signs and symptoms in exposed surgeons. With this in mind, we posed the following question: is there an association between the prevalence of signs and symptoms related to the inhalation of surgical smoke and the exposed surgeon's time in practice?

## OBJECTIVE

To determine the association between the prevalence of signs and symptoms related to the inhalation of surgical smoke and the exposed surgeon's time in practice.

## METHOD

We conducted a cross-sectional, descriptive, quantitative field study from February to June 2016.

The study population consisted of surgeons from several clinics in a city in the northern Paraná, Brazil, who had a certain private medical agreement with the municipality. The inclusion criterion was surgeons who were exposed to the inhalation of surgical smoke produced by electrocautery at least once a week. The exclusion criterion was surgeons who smoked, since they could show symptoms similar to those produced by exposure to surgical smoke.

Surgeons were selected on the basis of information from the health insurance they carried. The data were collected by one of the authors, in an individual interview, in the surgeon's office, after scheduling it with the secretary.

The data collection instrument used was composed of the sociodemographic variables sex, age, clinic and the surgeon's years in practice, and clinical variables regarding the presence of signs and symptoms related to the inhalation of surgical smoke, namely headache, foreign-body sensation in the throat, nausea, vomiting, eye irritation, weakness, dizziness<sup>13</sup>, burning in the pharynx, nasal congestion, mucosal irritation in the nose and mouth and sneezing<sup>1</sup>. At the end of the interview, the surgeons were questioned if they considered that the presence of these signs and symptoms could be related to the inhalation of surgical smoke.

For statistical analysis, the software Statistical Package for the Social Sciences (SPSS), version 20.0 for Windows, was used. Descriptive analyses of simple frequency were performed for the categorical variables, and mean and standard deviation (SD), along with minimum and maximum values were determined for the numerical variables. Fisher's exact test was used to assess the possible associations between the signs and symptoms related to the inhalation of surgical smoke and the surgeon's time in practice. The level of significance was set at 0.05.

The project was approved by the Research Ethics Committee, via Plataforma Brasil, under CAAE No. 46229915.0.0000.5231, according to Resolution No. 466/2012 of the National Health Council. The study was explained to the surgeons, who after agreeing to participate, signed an informed consent form.

## RESULTS

The sample of this study consisted of 45 surgeons. Table 1 shows their sociodemographic characteristics.

Table 2 shows the association between the prevalence of signs and symptoms related to the inhalation of surgical smoke and the exposed surgeons' time in practice.

Table 3 shows the prevalence of signs and symptoms related to electrocautery smoke inhalation.

When questioned whether the presence of signs and symptoms was related to inhalation of surgical smoke, 60% (n = 27) of interviewees answered no and 40% (n = 18) believed that there was a relationship.

## DISCUSSION

In a similar study conducted in Mexico, 86% of the interviewees were male, as shown here<sup>1</sup>. However, these authors found that the most frequent symptoms displayed a different prevalence than what was seen in our study; the following rates were reported: foreign-body sensation in the throat, 58%; burning in the pharynx, 22%; nausea, 4%; and nasal congestion, 2%. The specialties with higher rates of exposure to electrocautery smoke were neurosurgery, general surgery and obstetrics and gynecology.

In the work environment of surgeons, surgical smoke containing gases and chemical particles of different sizes is

**Table 1.** Sociodemographic characterization of surgeons exposed to surgical smoke inhalation.

Variable	Up to 30 years in practice (n=21)	More than 30 years in practice (n=24)
	n (%)	n (%)
Age in years, mean (SD)	51 (4.0)	64 (6.0)
Minimum	43	56
Maximum	59	79
Sex		
Male	16 (46.7)	22 (48.9)
Female	5 (11.1)	2 (4.4)
Clinic		
Obstetrics and Gynecology	12 (26.7)	9 (20.1)
Urology	5 (11.1)	4 (8.9)
Vascular	0 (0.0)	4 (8.9)
Thoracic	2 (4.4)	1 (2.2)
Neurology	0 (0.0)	3 (6.7)
Cardiac	0 (0.0)	2 (4.4)
Orthopedics	1 (2.2)	0 (0.0)
Proctology	1 (2.2)	0 (0.0)
Pediatrics	0 (0.0)	1 (2.2)

SD: standard deviation.

a cause for concern regarding the health of these workers, since most of the symptoms occur in practice in the long term<sup>6,10</sup>. Although it was not statistically significant, there was a higher prevalence of symptoms of eye irritation and foreign-body sensation in the throat (Table 2) among surgeons with more than 30 years in practice.

In turn, electrocautery smoke poses a number of health risks:

- Inhalation: Ninety percent of the particles present in surgical smoke are so small that they can penetrate into the alveoli of the worker. These particles usually

**Table 2.** Association between prevalence of signs and symptoms related to surgical smoke inhalation and time in practice.

Variable	Up to 30 years in practice (n=21)	More than 30 years in practice (n=24)	p*
	n (%)	n (%)	
Eye irritation			
Yes	4 (8.9)	4 (8.9)	0.83
No	17 (37.8)	20 (44.4)	
Sneezing			
Yes	3 (6.7)	1 (2.2)	0.23
No	18 (40.0)	23 (51.1)	
Foreign-body sensation in throat			
Yes	1 (2.2)	2 (4.4)	0.63
No	20 (44.4)	22 (48.9)	
Burning in pharynx			
Yes	1 (2.2)	1 (2.2)	0.92
No	20 (44.4)	23 (51.1)	
Nasal congestion			
Yes	2 (4.4)	0 (0.0)	0.12
No	19 (42.2)	24 (53.3)	
Weakness			
Yes	0 (0.0)	1 (2.2)	0.34
No	21 (46.7)	23 (51.1)	
Headache			
Yes	0 (0.0)	1 (2.2)	0.34
No	21 (46.7)	23 (51.1)	
Dizziness			
Yes	0 (0.0)	1 (2.2)	0.34
No	21 (46.7)	23 (51.1)	
Nausea and/or vomiting			
Yes	1 (2.2)	0 (0.0)	0.28
No	20 (44.4)	24 (53.3)	

\*Fisher exact test.

cause irritation of the nose and throat and respiratory problems, and allergic reactions may also occur. The smaller these particles, the more dangerous they are from the chemical point of view<sup>20</sup>.

- Poor air quality: During cutting and coagulation with electrocautery, there is an unpleasant odor in the air, which reduces air quality in the OR, to the point that the team gets headaches and nausea<sup>20</sup>.
- Impaired vision: Electrocautery smoke can make vision difficult during procedures, because it restricts the vision of the operative field and also irritates the eyes<sup>20</sup>.
- Surgical masks: Contrary to popular belief, these conventional masks do not provide sufficient protection against surgical smoke, since they do not prevent the inhalation of toxic gases and aerosols. They have been developed to protect the patient from infections during surgical procedures<sup>20</sup>. They also form a barrier to protect the surgeon's face from large drops and spills of blood and other body fluids<sup>21</sup>, but they do not provide adequate protection against electrocautery smoke<sup>13</sup>.

The option would be the use of top-quality filter masks or double masks, which could increase filtration capacity, and a smoke extraction device positioned 2 to 5 cm from where electrocautery is being used, thus ensuring the surgical team's safety<sup>13</sup>. Another option is an N95 mask, which prevents the passage of atmospheric particulate matter considered dangerous and which is therefore indicated as a great tool for the prevention of signs and symptoms related to the use of electrocautery<sup>22</sup>.

**Table 3.** Prevalence of signs and symptoms related to electrocautery smoke inhalation.

Signs and symptoms	n (%)
Eye irritation	8 (17.8)
Sneezing	4 (8.9)
Foreign-body sensation in throat	3 (6.6)
Burning in pharynx	2 (4.4)
Nasal congestion	2 (4.4)
Weakness	1 (2.2)
Headache	1 (2.2)
Dizziness	1 (2.2)
Nausea and/or vomiting	1 (2.2)
Mucosal irritation in nose and mouth	0 (0.0)

Surgical smoke is recognized as potentially hazardous to the health of exposed workers<sup>23</sup>. The solution to the management of this smoke and its symptoms is its complete evacuation, so that the air is constantly clean, ensuring a safe environment for healthy work<sup>24</sup>.

Therefore, capturing the surgical smoke means collecting it during a surgical procedure and removing it to a distant area, to be filtered. An example is a local exhaust fan, recommended by professional organizations and government health agencies. This apparatus is connected to activated carbon filters, which absorb chemicals and odors present in the smoke. The ultra-low penetration air (ULPA) filters remove 99.9% of contaminants that measure 0.12 microns or more in diameter, filtering the air of large amounts of surgical smoke<sup>5,25</sup>.

The reasons for not using smoke removal devices are related to the lack of knowledge about the risks of inhalation of this smoke, and are often the decisive factors in choosing whether or not to use exhaust devices. Lack of interest in surgical smoke removal can be explained by the following reasons: anxiety associated with any change in routines; lack of knowledge about sources that recommend the removal of surgical smoke; annoyance caused by the noise from the smoke extractor; unavailability of devices that allow high smoke capture efficiency; the need for the entire surgical team to be involved with smoke removal devices<sup>26</sup>. These findings support the data presented here, which revealed the disbelief of most surgeons (60.0%) about the risks of showing signs and symptoms related to the use of electrocautery.

The limitation of this study was the small number of surgeons who participated, where they were often not available to attend one of the researchers. The small sample size may be related to the non-significant associations

between the presence of signs and symptoms related to the inhalation of surgical smoke and the time in practice of the exposed surgeons.

However, this study advances our scientific knowledge regarding the negative consequences of the inhalation of surgical smoke. Knowing the changes that this inhalation can cause in surgeons is of great importance for the implementation of measures that minimize this exposure.

## CONCLUSION

This study did not find a statistical significance for an association of signs and symptoms of surgical smoke exposure and the time after training among the surgeons studied. However, there was a higher prevalence of eye irritation symptoms and foreign-body sensation in the throat among surgeons with more than 30 years in practice. It is noteworthy that 60.0% of them did not believe that the symptoms were related to the inhalation of surgical smoke. It is recommended that smoke extractors be installed in the OR and that the N95 mask be used by workers exposed to surgical smoke, to minimize the signs and symptoms of this smoke exposure.

Finally, new studies are suggested in relation to the N95 mask, to obtain scientific evidence that justifies the use of this individual protection equipment for filtering out the chemical components of surgical smoke, since there are reported studies that these substances are harmful to exposed workers. In addition, follow-up studies to determine the time of onset of signs and symptoms of exposure and the development of scales that can measure them will also be important.

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