Inhalation of surgical smoke: cohort of signs and symptoms in residents

Inalação da fumaça cirúrgica: coorte de sinais e sintomas em residentes

Inhalación de humo quirúrgico: cohorte de señales y síntomas en residentes

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Keywords
Smoke; Electrosurgery; Signs and symptoms; Occupational risks; Medical staff, hospital; Operating room

Descritores
Fumaça; Eletrocirurgia; Sinais e sintomas; Riscos ocupacionais; Corpo clínico hospitalar; Salas cirúrgicas

Descriptores
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Abstract
Objective: To analyze the signs and symptoms presented by doctors in surgery and anesthesiology residency programs exposed to surgical smoke.
Method: Prospective cohort study with resident doctors exposed to surgical smoke in a teaching hospital. There was 17-month follow-up of residents from the years 2015 and 2016, who met the criteria of being regularly enrolled in a surgery or anesthesiology residency and not being a smoker. The data collection instrument was composed of sociodemographic, academic data and the signs and symptoms related to the inhalation of surgical smoke, cited in the literature. The data analysis was descriptive and inferential, by statistical tests and measures of effect.
Results: The sample consisted of 39 residents, of which most were male (56.4%) and below 30 years old (74.3%). There was a prevalence of gynecology and obstetrics residents (30.8%), followed by general surgery (28.2%) and anesthesiology (20.5%). Burning in the pharynx (p=0.030), nausea and vomiting (p=0.018) and eye irritation (p=0.050) occurred in the first year of residence. The risk of developing burning in the pharynx was 7.765 times greater (p=0.019) in females when compared to males.
Conclusion: The signs and symptoms analyzed occurred within 12 months of the beginning of the course and the risk of burning in the pharynx was higher in females, which indicates exposure to the risks of inhalation of surgical smoke and, therefore, points to the need for the adoption of individual and collective protection measures.

Resumo
Objetivo: Analisar os sinais e sintomas apresentados por médicos residentes das clínicas cirúrgicas e anestesiologia expostos à fumaça cirúrgica.
Métodos: Estudo de coorte prospectivo realizado com médicos residentes expostos a fumaça cirúrgica em um hospital universitário. Houve um acompanhamento durante 17 meses dos residentes ingressantes nos anos de 2015 e 2016, que atendiam aos critérios de estar regularmente matriculado na residência de clínica cirúrgica ou anestesiologia e não ser tabagista. O instrumento de coleta de dados foi composto de dados sociodemográficos e acadêmicos e dos sinais e sintomas relacionados com a inalação da fumaça cirúrgica, citados na literatura. A análise de dados ocorreu de forma descritiva e inferencial, por testes estatísticos e medidas de efeito.
Resultados: A amostra foi composta por 39 residentes, cuja maioria era do sexo masculino (56,4%) e idade abaixo dos 30 anos (74,3%). Prevaleceram residentes da ginecologia e obstetrícia (30,8%), seguidos de cirurgia geral (28,2%) e anestesiologia (20,5%). Ardência na faringe (p=0,030), náusea e vômito (p=0,018) e irritação dos olhos (p=0,050) incidiram ainda no primeiro ano de residência. O risco de desenvolver ardência de faringe foi 7,765 vezes (p=0,019) no sexo feminino em relação ao masculino.
Conclusão: Os sinais e sintomas analisados incidiram em até 12 meses do início da residência e o risco de apresentar ardência de faringe foi maior no sexo feminino, o que indica a exposição aos riscos da inalação da fumaça cirúrgica e, portanto, a necessidade de adoção de medidas de proteção individuais e coletivas.

Resumen
Objetivo: analizar las señales y síntomas presentados por médicos residentes de clínica quirúrgica y anestesiología expuestos al humo quirúrgico.
Métodos: estudio de cohorte prospectivo realizado con médicos residentes expuestos al humo quirúrgico en un hospital universitario. Hubo un seguimiento durante 17 meses de los residentes que ingresaron en 2015 y 2016, que cumplían los criterios de estar regularmente matriculados en la residencia de clínica quirúrgica o anestesiología y no ser fumadores. El instrumento de recolección de datos fue compuesto por datos sociodemográficos y académicos y por señales y síntomas relacionados con la inhalación de humo quirúrgico, citados en la literatura. El análisis de datos se realizó de forma descriptiva e inferencial, por pruebas estadística y medidas de efecto.
Resultados: la muestra fue compuesta por 39 residentes, cuya mayoría era de sexo masculino (56,4%) y menores de 30 años (74,3%). Prevalecieron residentes de ginecología y obstetricia (30,8%), seguidos de cirugía general (28,2%) y anestesiología (20,5%). Ardor de faringe (p=0,030), náuseas y vómitos (p=0,018) e irritación de ojos (p=0,050) incidieron en el primer año de residencia. El riesgo de desarrollar ardor de faringe fue 7,765 veces (p=0,019) en el sexo femenino con relación al masculino.
Conclusión: las señales y síntomas analizados incidieron hasta 12 meses desde el inicio de la residencia y el riesgo de presentar ardor de faringe fue mayor en el sexo femenino, lo que indica una exposición a los riesgos de inhalación de humo quirúrgico y, por lo tanto, la necesidad de adoptar medidas de protección individuales y colectivas.

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Introduction

Electrocauterization reduces surgical time and bleeding, facilitating the visualization of the operating field [1] On the other hand, incomplete combustion during the cauterization of tissues and blood vessels generates surgical smoke, which is composed of water vapor and biological and chemical compounds that may be carcinogenic.[2,3]

Among the biological compounds, studies have revealed the presence of the hepatitis B virus and the human papillomavirus in surgical smoke; however, these agents have not been confirmed as responsible for the development of diseases in the workers exposed to this smoke.[4-6]

The chemical composition of the smoke is influenced by the tissue in which the energy is dispersed and the time of exposure to cauterization.[7,8] However, it is generally composed of substances such as polycyclic aromatic hydrocarbons (PAHs),[9,10] formaldehyde, hydrogen cyanide, benzene, carbon monoxide and nitriles[5,8,11]. Among these, benzene and cyanide are the main mutagens and/or carcinogens,[8,11] and furfural and styrene are the ones that can cause damage to the central nervous system.[12]

Workers in operating rooms are exposed to the risks of this smoke and the effects accumulate throughout their lives.[5] Surgical smoke is instantaneously dispersed in the operating rooms after its formation; however, in the breathing heights of surgeons, the PAH concentration can be 40 to 100 times greater than in the rest of the environment.[13]

The long-term effects are object of studies; however, surgical smoke also has short-term effects. The symptomatology related to this exposure is described in the literature as: foreign body sensation in the throat, nasal congestion, burning in the pharynx, nausea,[1] vomiting, headache, irritation of the eyes and other mucous membranes, sneezing, weakness, dizziness and chronic inflammations of the respiratory tract, such as asthma and bronchitis.[8]

Doctors in surgery and anesthesiology residency programs are in training and remain a great part of their residency time inside operating rooms. Therefore, they are exposed to the risks related to the inhalation of surgical smoke as much as other workers in that area.

Resident doctors working in surgical clinics where they are exposed to surgical smoke had a higher prevalence of respiratory signs and symptoms, such as: foreign body sensation in the throat, burning in the pharynx, nausea and nasal congestion.[1] Another study with nurses and physicians found a higher prevalence of headache, irritation of the eyes, cough and burning throat, besides the perception of a bad smell left by the surgical smoke in the operating rooms.[14]

Surgical smoke acts cumulatively in the human body[5]. Therefore, it is necessary to carry out longitudinal prospective studies to observe these workers and determine the incidence of signs and symptoms and support the planning of interventions to prevent health risks related to exposure to surgical smoke.

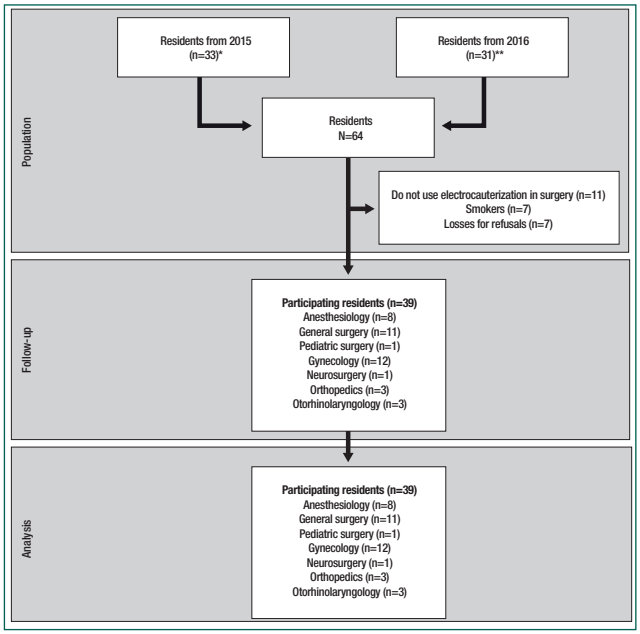
Given the above, the objective of this study was to analyze the signs and symptoms presented by doctors in surgery and anesthesiology residency programs exposed to surgical smoke.

Methods

This is a prospective cohort study conducted in a teaching hospital in South Brazil, which provides medium and high complexity health care. In this hospital 88 vacancies of professional medical residency are offered annually, of which 32 are in surgical units.

The study population was composed of medical residents, who met the inclusion criteria: being regularly enrolled in the medical residency in the years 2015 and 2016; performing activities in the surgical center; and using electrocauterization in surgical/anesthetic procedures. Smokers were excluded because the cigarette and the surgical smoke are similar in composition,[15] which could be a confounding factor.

Among the 64 residents of the study population, 39 were eligible after applying the eligibility criteria, as shown in figure 1.



* Anesthesiology (n=5); General surgery (n=8); Pediatric surgery (n=1); Vascular Surgery (n=1); Gynecology (n=8); Neurosurgery (n=1); Ophthalmology (n=3); Orthopedics (n=3); Otorhinolaryngology (n=2); Urology (n=1); ** Anesthesiology (n=4); General surgery (n=8); Pediatric surgery (n=1); Vascular Surgery (n=1); Gynecology (n=8); Neurosurgery (n=1); Ophthalmology (n=3); Orthopedics (n=3); Otorhinolaryngology (n=2); Urology (n=1)

Figure 1. Scheme for obtaining the analyzed sample

The research participants were recruited in two stages: in the first stage, the residents from the year 2015 were invited to be part of the research and received orientations about the objectives and methods of study; those who accepted to participate, signed the informed consent form. In the second stage, the same procedure was adopted for students from 2016. Measurements were performed every three months during the residents' follow-up, that is, the first measurement (T0) coincided with the three first months of residency; the second (T1) was six months after the beginning of the program; the third (T2), nine months; the fourth (T3), twelve months; the fifth (T4), fifteen months; the sixth (T5), eighteen months; and the seventh (T6), 24 months, coinciding with the completion of the medical residency. Thus, both groups were followed up for 17 months; residents from 2015 were followed up in the period from June 2015 to February 2017 and those from 2016, from June 2016 to February 2018.

The data was collected individually using a form constructed and applied by the researchers with the following socio-demographic data: age (in years), gender (male and female), time since training (in years) and specialty (anesthesiology, general surgery, pediatric surgery, obstetrics and gynecology, orthopedics, otolaryngology and neurology). For data analysis, the age was categorized as ≤ 30 years and ≥ 31 years, the time since training in ≤3 years and ≥4 years and the specialty in surgeons and anesthetists. The instrument also contained the signs and symptoms that the literature relates to exposure to surgical smoke:[1,8] foreign body sensation in the throat (yes and no), nasal congestion (yes and no), burning in the pharynx (yes and no), nausea (yes and no), vomiting (yes and no), headache (yes and no), irritation of the eyes (yes and no) and other mucous membranes (yes and no), sneezing (yes and no), weakness (yes and no) and dizziness (yes and no).

Data analysis was performed in the Statistical Package of Social Sciences (SPSS), version 20.0. Data was analyzed through descriptive statistics, using absolute and relative frequencies; and inferential statistics, with statistical tests and measures of effect. The incidence of signs and symptoms during follow-up was compared with the Cochran's Q test, considering T0, T3 and T6, since missing data were obtained on T2, T4 and T5 measurements. The associations between the dependent variables (foreign body sensation in the throat, burning in the pharynx, nasal congestion, nausea and vomiting, headache, irritation of the eyes and other mucous membranes, sneezing, weakness and dizziness) and independent variables (gender, age, training time and specialty) were verified by the Fisher's exact test. The relative risk, with a 95% confidence interval, was calculated as an effect measure. In all analyzes statistical significance was set at $p<0.05$.

The study met the ethical criteria for research involving human beings and was approved under the number of the Certificate of Presentation for Ethical Appreciation (CAAE): 46229915.0.0000.5231.

Results

The sample consisted of 39 residents, who were mostly male (56.4%), 30 years old or less (74.3%) and who had completed training less than three years prior to data collection (71.8%). Regarding their specialties,

30.8% of the residents represent obstetrics and gynecology, 28.2%, general surgery, 20.5% anesthesiology and 20.5% other specialties such as orthopedics, pediatric surgery, otolaryngology and neurology.

Table 1 presents the incidence of signs and symptoms presented by residents exposed to surgical smoke during the 17 months of follow-up. The incidence of burning in the pharynx, nausea and vomiting and eye irritation occurred until the end of the first year of residence.

According to table 2, the risk of developing burning in the pharynx was 7,765 times greater in females, compared to males. The other signs and symptoms did not present statistical significance.

Table 1. Incidence of signs and symptoms presented by residents of surgery and anesthesiology specialties exposed to surgical smoke

Signs and Symptoms	Follow-up			*p-value***
	T0 (3 months)*	T3 (12 months)*	T6 (24 months)*	
	n(%)	n(%)	n(%)	
Foreign body sensation in the throat	4(10.3)	3(7.7)	0(0)	0.156
Burning in the pharynx	1(2.6)	5(12.8)	0(0)	0.030
Nausea and vomiting	4(10.3)	0(0)	0(0)	0.018
Nasal congestion	6(15.4)	5(12.8)	1(2.6)	0.148
Headache	7(17.9)	2(5.1)	3(7.7)	0.174
Irritation of the eyes	6(15.4)	6(15.4)	0(0)	0.050
Irritation of other mucous membranes	5(12.8)	1(2.6)	1(2.6)	0.102
Sneezing	4(10.3)	2(5.1)	1(2.6)	0.368
Dizziness	2(5.1)	1(2.6)	2(5.1)	0.368
Weakness	0(0)	1(2.6)	0(0)	0.368

*time in the residency program; **Cochran's Q Test

Table 2. Association of signs and symptoms presented by residents of surgery and anesthesiology specialties exposed to surgical smoke with sociodemographic and occupational characteristics

Variables		Signs and Symptoms		p-value*	Relative Risk (95% Confidence Interval)
		No	Yes		
Foreign body sensation in the throat					
Age	≤30 years	25(86.2)	4(13.8)	0.490	0.690(0.148-3.210)
	≥31 years	8(80.0)	2(20.0)		
Gender	female	14(82.4)	3(17.6)	0.535	1.294(0.298-5.627)
	male	19(86.4)	3(13.6)		
Time since training	≤3 years	23(82.1)	5(17.9)	0.447	1.964(0.258-14.965)
	≥4 years	10(90.9)	1(9.1)		
Specialty	Surgery	27(87.1)	4(12.9)	0.358	0.516(0.114-2.334)
	Anesthesiology	6(75.0)	2(25.0)		
Burning in the pharynx					
Age	≤30 years	24(82.8)	5(17.2)	0.590	0.862(0.197-3.764)
	≥31 years	8(80.0)	2(20.0)		
Gender	female	11(64.7)	6(35.3)	0.019	7.765(1.030-58.543)
	male	21(95.5)	1(4.5)		
Time since training	≤3 years	21(75.0)	7(25.0)	0.077	**
	≥4 years	11(100.0)	0(0.0)		
Specialty	Surgery	24(77.4)	7(22.6)	0.171	**
	Anesthesiology	8(100.0)	0(0.0)		
Nausea and/or vomiting					
Age	≤30 years	24(82.8)	5(17.2)	0.206	**
	≥31 years	10(100.0)	0(0.0)		
Gender	female	14(82.4)	3(17.6)	0.375	1.941(0.364-10.348)
	male	20(90.9)	2(9.1)		
Time since training	≤3 years	24(85.7)	4(14.3)	0.562	1.571(0.197-12.545)
	≥4 years	10(90.9)	1(9.1)		
Specialty	Surgery	28(90.3)	3(9.7)	0.268	0.387(0.077-1.940)
	Anesthesiology	6(75.0)	2(25.0)		

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Continuation.

Variables		Signs and Symptoms		p-value*	Relative Risk (95% Confidence Interval)
		No	Yes		
Nasal congestion					
Age	≤30 years	21(72.4)	8(27.6)	0.493	1.379(0.350-5.443)
	≥31 years	8(80.0)	2(20.0)		
Gender	female	14(82.4)	3(17.6)	0.265	0.555(0.168-1.833)
	male	15(68.2)	7(31.8)		
Time since training	≤3 years	20(71.4)	8(28.6)	0.409	1.571(0.394-6.269)
	≥4 years	9(81.8)	2(18.2)		
Specialty	Surgery	24(77.4)	7(22.6)	0.329	0.602(0.199-1.821)
	Anesthesiology	5(62.5)	3(37.5)		
Headache					
Age	≤30 years	18(62.1)	11(37.9)	0.264	1.897(0.505-7.129)
	≥31 years	8(80.0)	2(20.0)		
Gender	female	11(64.7)	6(35.3)	0.543	1.109(0.456-2.696)
	male	15(68.2)	7(31.8)		
Time since training	≤3 years	20(71.4)	8(28.6)	0.262	0.629(0.263-1.505)
	≥4 years	6(54.5)	5(45.5)		
Specialty	Surgery	23(74.2)	8(25.8)	0.064	0.413(0.185-0.921)
	Anesthesiology	3(37,5)	5(62,5)		
Irritation of the eyes					
Age	≤30 years	18(62.1)	11(37.9)	0.264	1.897(0.505-7.129)
	≥31 years	8(80.0)	2(20.0)		
Gender	female	11(64.7)	6(35.3)	0.543	1.109(0.456-2.696)
	male	15(68.2)	7(31.8)		
Time since training	≤3 years	17(60.7)	11(39.3)	0.191	2.161(0.568-8.215)
	≥4 years	9(81.8)	2(18.2)		
Specialty	Surgery	21(67.7)	10(32.3)	0.544	0.860(0.307-2.409)
	Anesthesiology	5(62.5)	3(37.5)		
Irritation of other mucous membranes					
Age	≤30 years	23(79.3)	6(20.7)	0.410	2.069(0.282-15.155)
	≥31 years	9(90.0)	1(10.0)		
Gender	female	14(82.4)	3(17.6)	0.650	0.971(0.250-3.769)
	male	18(81.8)	4(18.2)		
Time since training	≤3 years	21(75.0)	7(25.0)	0.077	**
	≥4 years	11(100.0)	0(0.0)		
Specialty	Surgery	24(77.4)	7(22.6)	0.171	**
	Anesthesiology	8(100.0)	0(0.0)		
Sneezing					
Age	≤30 years	23(79.3)	6(20.7)	0.410	2.069(0.282-15.155)
	≥31 years	9(90.0)	1(10.0)		
Gender	female	15(88.2)	2(11.8)	0.326	0.518(0.114-2.350)
	male	17(77.3)	5(22.7)		
Time since training	≤3 years	22(78.6)	6(21.4)	0.346	2.357(0.319-17.397)
	≥4 years	10(90.9)	1(9.1)		
Specialty	Surgery	27(87.1)	4(12.9)	0.137	0.344(0.096-1.237)
	Anesthesiology	5(62.5)	3(37.5)		
Weakness					
Age	≤30 years	29(100.0)	0(0.0)	0.256	**
	≥31 years	9(90.0)	1(10.0)		
Gender	female	17(100.0)	0(0.0)	0.564	1.048(0.956-1.148)
	male	21(95.5)	1(4.5)		
Time since training	≤3 years	28(100.0)	0(0.0)	0.282	**
	≥4 years	10(90.9)	1(9.1)		
Specialty	Surgery	31(100.0)	0(0.0)	0.205	**
	Anesthesiology	7(87.5)	1(12.5)		

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Continuation.

Variables		Signs and Symptoms		p-value*	Relative Risk (95% Confidence Interval)
		No	Yes		
Dizziness					
Age	≤30 years	25(86.2)	4(13.8)	0.289	**
	≥31 years	10(100.0)	0(0.0)		
Gender	female	15(88.2)	2(11.8)	0.593	1.294(0.202-8.271)
	male	20(90.9)	2(9.1)		
Time since training	≤3 years	25(89.3)	3(10.7)	0.687	1.179(0.137-10.149)
	≥4 years	10(90.9)	1(9.1)		
Specialty	Surgery	28(90.3)	3(9.7)	0.617	0.774(0.092-6.486)
	Anesthesiology	7(87.5)	1(12.5)		

*Fisher's Exact Test; **not calculated because one of the variable was 0

Discussion

Regarding the sociodemographic characteristics of the study participants, the male gender was predominant, with 56.4%, which was also found in a cross-sectional study with 50 residents, of which 86% were male.[1] In relation to age, the majority (74.3%) were below 30 years old. In the same cross-sectional study, the mean age was 27 years, ranging from 26 to 28 years.[1]

The most prevalent symptoms in this study were irritation of the eyes, burning in the pharynx and nausea and vomiting. However, in the literature, the most prevalent symptom is foreign body sensation in the throat (58%), followed by burning in the pharynx (22%).[1]

A cross-sectional study carried out in Turkey with 45 nurses, scrubs and instrumentalists, and 36 doctors, surgeons and anaesthetists, working in a surgical center found that doctors reported headaches (58.3%), watery eyes (41.7%), coughs (27.8%), burning throat (38.9%), nausea (30.6%) followed by drowsiness, dizziness and sneeze (25%) and nurses reported headaches (48.9%), watery eyes (40%), coughs (48.9%), burning throat (40%) and nausea (44.4%).[14] These results are different from what is presented in this cohort, since burning in the pharynx, nausea, vomiting and irritation of the eyes were the signs and symptoms that occurred during the first year of exposure, with statistical significance.

Despite the predominantly male sample, it was possible to verify that the risk of developing burning in the pharynx was 7.765 times higher in females than in males. However, there are no other studies that present comparative findings. The literature shows that females present more nausea and cough than males.[15]

The compounds responsible for the appearance of signs and symptoms such as eye irritation are acetaldehyde, acrolein, decan, furfural, toluene and polycyclic aromatic hydrocarbons such as naphthalene. Carbon monoxide is responsible for the symptom of nausea and vomiting, since in a short term acrylonitriles are responsible for the release of cyanide, decan and furfural. Burning in the pharynx is reported as a symptom caused by cyclohexanone, decan, furfural, naphthalene, styrene, toluene and xylene.[7]

The particles formed during the use of the electrocauterization are approximately 0.07 microns and represent a greater risk for the patient and the surgical team because, due to their size, they can penetrate the lungs causing chronic inflammation.[16]

There are preventive measures to reduce exposure to chemical risk. It is recommended that the operating rooms are equipped with adequate ventilation systems and aspirators to remove the surgical smoke. In addition, workers should use Personal Protective Equipment (PPE), such as: mask with 95% filtering of particles (N95) and protective glasses.[17]

The standard surgical masks used as PPE in operating rooms[18] are responsible for protecting the team from droplets and biological fluids and protecting the instruments and exposed cavities from the microorganisms present in the team. However, they do not filter small particles and therefore are not effective for the protection of professionals exposed to electrocauterization.[16] In this study, there are symptoms that may be caused by the inhalation of surgical smoke, mainly due to its chemical com-

position, with particles of 0.07 microns, considered as aerosols.[16] Therefore, the surgical mask, even if recommended, is not effective for protecting the surgical team against the chemical risk of surgical smoke.

Workers entering an operating room for a surgical procedure that uses radiation wear lead aprons. However, in this study, the participants do not use adequate protection when exposed to surgical smoke, present in most procedures. This can occur due to lack of knowledge of the chemical risks related to the inhalation of surgical smoke. Thus, it is suggested that future studies analyze the aspects that influence the decision of the employee regarding measures of individual protection.

Despite the recommendations, devices for protection against exposure to surgical smoke are still rarely used, since workers report they are bothered by the use of the mask and by the noise produced by the device.[19,20]

The absence of control variables, such as pre-existing chronic respiratory diseases, time of exposure to smoke and number of surgical procedures, can be pointed out as a limitation of the present study. In addition, there was no pairing for each case with similar characteristics to make the control group and the first measurement in T0 could not be performed on the first day of admission to the residency, because the researcher also began her residency along with residents participating in the study, and the first three months were necessary for the organization of the research and approval by the research ethics committee. Moreover, the small and local sample does not allow generalization of the results.

It is suggested that future studies expand the sample, including a control group and all the staff exposed to surgical smoke, including nursing workers who are routinely exposed to this risk and often on double days. In addition, other studies should test the effectiveness of the protection methods recommended in the literature.

Despite these limitations, this study was a pioneer in the country in the follow-up of residents with this goal and it identified the incidence of signs and symptoms related to surgical smoke in the first year of residency. This information reaffirms the importance of finding strategies to prevent risks related to exposure to surgical smoke.

Conclusion

All signs and symptoms analyzed occurred within 12 months of the beginning of the residency program. Regarding the associated factors, the risk of developing burning in the pharynx was 7.765 times higher in females and the other signs and symptoms did not present statistical significance in relation to the characteristics analyzed. This study shows that surgical center workers are exposed to the risks related to the inhalation of surgical smoke, pointing to the emerging need to adopt protective measures with the use of protective devices such as the N95 mask and surgical smoke evacuation systems. Thus, all workers who participate in surgical procedures should seek knowledge on the subject and use personal protective equipment for less harmful effects on their health.

Collaborations

Stanganelli NC and Ribeiro RP contributed in the conception, design, analysis, data interpretation and writing of the article. Margatho AS, Bieniek AA, Galdino MJQ and Barbosa KH collaborated in the analysis and interpretation of data and article writing. All authors contributed to the critical review.

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