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The Evaluation of Concentration of Harmful Chemical Pollutants in Fume Caused by Surgical Cauterization in Hospital Surgery Rooms Related to Pharmacological Aspects

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Harmful chemical pollutants of pharmaceutical origin present in the environmental pollutants especially surgical room may have the same toxic specifications of chemicals from industrial sources. The aim of this study was to evaluate the concentration of harmful chemical pollutants in fume caused by surgical cauterization in hospital surgery rooms.
Methods: This is a quantitative, cross-sectional and practical study. The study population consisted of all personnel who are working in hospital surgery rooms. Samples were prepared according to NIOSH standard method. The tool for data collection is Occupational Exposure Limits booklet (OEL).

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Sample Size: 30 samples were required according to surgery room conditions. In order to evaluate and measure the concentration of workplace air pollutants and individual exposure to them, the individual sampling method is used compliant with the standard procedures of the NIOSH or OSHA organizations, that according to the type of material and for each material, a particular method is mentioned and has a specific code. In this study, NIOSH Organization Method No. 1501 was used. The data were analyzed based on the data obtained from sampling and comparing them with the allowed limits.

Results: In this study, the organic aromatic hydrocarbons including, Benzene, Ethylbenzene, Toluene and Xylene were investigated and fortunately, in all samples, these pollutants are below the permitted level.

Conclusion: According to the results, the measured concentration of pollutants are less than the allowed limit. It is also recommended that other pollutants be evaluated at any time in order to gain the necessary knowledge of the personnel exposure status.

Keywords: Chemical pollutants; surgery rooms; cauterization.

1. INTRODUCTION

Nowadays, hospitals surgery rooms are an inseparable part of any hospital and are one of the most perilous working environments due to the increasing number of various and refractory diseases that require surgery, so, air pollution is a major problem, which has a serious toxicological impact on human health and the environment [1]. In addition, pharmaceutical products and illicit drugs as an alternative indicator of drug-use trends should be considered as well as there are a variety of physiological, chemical, ergonomic, and biological detrimental factors, each of which has its own side effects that can endanger the health of staff if not controlled. One of the most important detrimental factors is the fume from surgery. Today, this fume can put approximately 1 million people at risk of cancer worldwide [2]. Studies on surgical fume began in early 1988 [3]. Surgery fume due to cauterization and laser application contains 95% vapor and 5% solid ingredients [4]. Cauterization fume also produces particles of less than 0.1 microns [1-5]. Surgical fume also contains cyclic aromatic hydrocarbons, which are also carcinogenic in some way.

The United States Environmental Protection Agency (USEPA, EPA) has identified 16 polycyclic aromatic compounds (PAH-Polycyclic Aromatic Hydrocarbones) as important and priority pollutants in terms of their toxicity and carcinogenicity and hospital operating theaters (suites) that comprise operating rooms or surgical theatres are among the most demanding health care work areas [6-7]. Materials that are produced include aromatic hydrocarbons such as kerosene, phenol, benzene, toluene, xylene; aldehydes including formaldehyde, acetaldehyde, acrolein and hydrocyanic acid; carbon monoxide and nitrile compounds [8-10]. For example among these compounds, benzo[a]pyrene as the strongest carcinogenic substance and often as an indicator of contaminant cancer risk. It is also considered to be carcinogenic [11] Also, acrylonitrile is classified in Group 2a by the International Agency for Research on Cancer (IARC), which includes substances that are likely to be carcinogenic in humans [4]. It produces hydrocyanic acid that is permeable to the body through the skin and lungs [12]. Benzene is also a substance that causes long-term exposure to hematopoietic disorders (hematopoietic system) with anemia. Leukemia and diseases of the lymphatic system [13]. Therefore, the aim of this study was to evaluate the concentration of harmful chemical pollutants that are available in fume caused by surgical cauterization rooms (including benzene, ethylbenzene, toluene, styrene and xylene) in hospital surgery rooms.

2. MATERIALS AND METHODS

This is a quantitative, cross-sectional and practical study. The study population consisted of all personnel who are working in hospital surgery rooms. According to the study method no statistical sample is needed and the samples were prepared according to NIOSH standard method. The tool for data collection is Occupational Exposure Limits booklet (OEL). Sample size: 30 samples were required.

2.1 Performance Method

In order to evaluate and measure the concentration of workplace air pollutants and

individual exposure to them, the individual sampling method is used compliant with the standard procedures of the NIOSH or OSHA organizations, that according to the type of material and for each material, a particular method is mentioned and has a specific code. In this study, NIOSH Organization Method No. 1501 was used.

1. Selection of absorbent material, flow rate, and volume of sampled air
2. Sampling pump calibration
3. Sampling
4. Correction of the volume of sampled air in standard conditions according to the following formula:

$$\mathrm{V}stp = \mathrm{V}measured\ \frac{(\mathrm{P}bar - \mathrm{P}w).273}{760.(273+\mathrm{t})}$$

V_{STP} = Air volume in standard conditions in liters
V_{MES} = Volume of sampled air in liters
$P_{ba\ r}$= Barometric pressure in millimeters of mercury
P_{w} = Saturated steam pressure at t temperature in millimeters of mercury
T = Ambient temperature in celsius scale
273 = Kelvin equals to zero celsius scale

5. Calculation the concentration of the pollutant during 8 hours according to the following formula:

$$\mathrm{M} = \frac{\mathrm{m}.\ 10^6}{\mathrm{Vs}}$$

10^6 = volume and mass of pollutants conversion unit in mg/m^3
M = Concentration rate during 8 hours (mg/m^3)

Since people usually work for 8 hours in the workplace, and on the other hand, standards are also based on 8 hours or 1000 liters (m3) of air. The final concentration should be obtained within 8 hours using the above formula to compare with the allowed limit.

M = The obtained concentration at the sampling time of in mg/m^3
V = Standard air volume at the sampling time

mg/m^3 to PPM conversion

Concentrations of gases and pollutant vapors are usually expressed in PPM, which can be obtained by the following formula:

$$PPM = \frac{mg}{m3\ \frac{24.47}{Mw}}$$

PPM = Part Per Million
Mw = Molecular mass of pollutants

Whereas the sampling is not done within 8 hours and according to standard methods information and working conditions that done in less than 8 hours, and on the other hand the standards are based on 8 hours of working (one shift). For example, sampling should be done to indicate the pollutant concentration within 8 hours of operation, that's so known as TWA (Time Wieting Average) or the average time concentration of 8 hours, as follows:

1. If the pollutant diffusion in the workplace be monotone for 8 hours, we achieve the obtained concentration during the sampling time for the 8 hours according to the above formula.
2. At times when pollutant diffusion are different, we done the sampling and finally calculate the obtained concentration during the sampling time according to the following formula for 8 hours of working .

$$TWA = \frac{\mathrm{C}1T1 + \mathrm{C}2\mathrm{T}2 + \mathrm{C}3\mathrm{T}3 + \mathrm{C}n\mathrm{T}n}{8}$$

C1,C2,….,Cn = Concentration of pollutant at intended or different times

T1,T2,T3,……Tn = Sampling time at intended or different times

8 = Duration of a shift work

2.2 Data Analysis Method

The data are analyzed on the basis of the obtained data from the sampling and compared with the allowed limits.

3. RESULTS

According to the operating conditions of the surgery rooms, the type of surgery, the duration of the cauterization in the surgeries, and the standard conditions of sampling procedures, it was attempted to perform the surgeries that their cauterization usually last a long time, as well as in all surgery rooms where these were performed. And place the surgical staff around the surgery bed as well as at different sampling dates to assess and evaluate the status of all

Table 1. Chemicals sampling results

Evaluation	Final concentration (TWA) PPM	Concentration at the time of sampling PPM	Corrected volume (litr)	The volume of suctioned air (litr)	Air pressure (mmHg)	Temperature (°C)	Flow rate (litr/min)	Sampling time (min)	Name of the material	Cauterization time (min)	Type of surgery
Less than allowed limit	<0.07 <0.06 <0.052 <0.052	<0.0003 <0.00026 <0.00023 <0.00023	4.4	6	612.4	27	0.2	30	BTEX	10	Gynecomastia surgery
Less than allowed limit	< 0.07 < 0.06 <0.052 <0.052	<0.0003 <0.00026 <0.00023 <0.00023	4.4	6	612.4	28	0.2	30	BTEX	5	removing plaque
Less than allowed limit	<0.05 <0.042 <0.038 <0.038	<0.0003 <0.00026 <0.00023 <0.00023	6	8	615.5	25	0.2	40	BTEX	3	Open cholecystecto my
Less than allowed limit	<0.017 <0.015 <0.013 <0.013	<0.0003 <0.00026 <0.00023 <0.00023	17.6	24	609.6	25	0.2	120	BTEX	30	Elimination of spine deviation
Less than allowed limit	<0.024 <0.022 <0.017 <0.017	<0.0003 <0.00026 <0.00023 <0.00023	12.8	16	636.7	25	0.2	80	BTEX	10	Open cholecystecto my
Less than allowed limit	<0.012 <0.01 <0.009 <0.009	<0.0003 <0.00026 <0.00023 <0.00023	25	34	606.8	24.6	0.2	170	BTEX	10	Diaphragmatic hernia
Less than allowed limit	<0.004 <0.005 <0.0037 <0.0037	<0.0003 <0.00026 <0.00023 <0.00023	61.8	84	610.8	25.3	0.2	420	BTEX	40	Elimination of spine deviation
Less than allowed limit	<0.018 <0.015 <0.015	<0.0003 <0.00026 <0.00023	16.9	23	608	24.8	0.2	115	BTEX	7	Thyroidectomy

Evaluation	Final concentration (TWA) PPM	Concentration at the time of sampling PPM	Corrected volume (litr)	The volume of suctioned air (litr)	Air pressure (mmHg)	Temperature (°C)	Flow rate (litr/min)	Sampling time (min)	Name of the material	Cauterization time (min)	Type of surgery
	<0.013	<0.00023									
Less than allowed limit	<0.031 <0.027 <0.024 <0.024	<0.0003 <0.00026 <0.00023 <0.00023	9.35	12	646.9	25.3	0.2	60	BTEX	5	Inguinal hernia
Less than allowed limit	<0.015 <0.013 <0.011 <0.011	<0.0003 <0.00026 <0.00023 <0.00023	19.8	24	660.4	25.3	0.2	120	BTEX	20	DHS
Less than allowed limit	<0.037 <0.032 <0.029 <0.029	<0.0003 <0.00026 <0.00023 <0.00023	7.9	10	660.4	27	0.2	50	BTEX	30	Pilonidal cyst sergury
Less than allowed limit	<0.018 <0.017 <0.015 <0.015	<0.0003 <0.00026 <0.00023 <0.00023	15	19	658.4	23.8	0.2	95	BTEX	15	Laparotomy cholecystecto my
Less than allowed limit	<0.04 <0.035 <0.03	<0.0003 <0.00026 <0.00023 <0.00023	7.42	10	611.5	23	0.2	50	BTEX	5	Hiatal hernia
Less than allowed limit	<0.015 <0.013 <0.012 <0.012	<0.0003 <0.00026 <0.00023 <0.00023	19	26	607	25.3	0.2	130	BTEX	15	Elimination of spine deviation

available conditions and to judge the results. The sampling specifications are detailed in Table 1.

The term BTEX refers to the chemical pollutants released from the surgical treatment of cauterization, which include benzene, toluene, ethylbenzene and xylene, respectively.

The 8-hour exposure limit (TWA-Time weighting average) of the above materials is 0.5 - 20 - 20 - 100 PPM respectively, which is 1.6 - 75.3 - 86.83 - 434.2 mg / m3, respectively.

As can be seen, the values obtained in all samples are below the occupational exposure limit.

4. DISCUSSION

Air is the most urgent human need that contains various ingredients and pollutants. These pollutants cover a wide range of particles, minerals, organic matter and microorganisms, which the type, size and concentration of them depend on the living and working environment of the individual [14]. Chemical pollutants are airborne particles that are in a wide range of shapes and sizes [15]. Contact with pollutants is associated with a wide range of health effects, including acute toxic effects, allergies and cancer [16-17]. Respiratory complications and impaired lung function are the most important health effects of encounter to these pollutants.

In this study, organic aromatic hydrocarbons including, benzene, ethylbenzene, toluene and xylene were investigated which were found to be lower than allowed limit in all samples and the results are in line with a 2009 study by Weston, et al. which investigated the effects of chemical pollutants on mastectomy electrocauter fume. (From 30 samples taken in 27 (90%) samples the amount of toluene was between 0.463 to 0.003 mg / m, but the amount of ethyl benzene and styrene was low [18].

In a study conducted by Hsin-shun Tseng, et al. In 2014 named Cancer risk due to contact of mastectomy surgery personnel with polycyclic aromatic hydrocarbons in fume induced by electrocauter, the results showed that micron particles and high concentrations of polycyclic aromatic hydrocarbons (PAH-Polycyclic Aromatic Hydrocarbones) occur during the electrocauter of mastectomy surgery, most of which were in the range of 0.3-0.5 microns, which may be potentially penetrate the human respiratory system through respirators. The mean concentration of PAH in the respiratory area of the persons was 1.415-1.131 ng / m3, especially as it was calculated 20-30 times higher than the toxicity factor requirements and between 270 * 10^{-6}- 117 * 10^{-6} especially that the risk of cancer for anesthesia technicians is due to greater presence in the surgery room [19].

In another study conducted by Sara Naslund Anderson, et al. In 2012 at Apsala Hospital, Sweden, to investigate the quantities, concentration of polycyclic aromatic hydrocarbons and fume from peritonectomy, the researchers found that all 16 polycyclic aromatic hydrocarbons in the USEPA list - The United States Environmental Protection Agency (USEPA) manufactures surgical fume, among them, naphthalene was the most common, and according to the Swedish Occupational Contact Limit Standards, benzo-alphaapyron and naphthalene were not excessive [20], which was in accordance with the present study.

In another study conducted by Lin YW, et al. In 2010 to determine the amount of volatile compounds in electrocauter fume of breast surgery, the researchers found that the toluene concentration was 2.48-5.50 mg / m3. Higher concentrations were observed during modified radical methods. In surgery of patients with more body mass and by getting longer the time of surgery, the concentration of toluene increased [21].

The results of this study are in line with the results of other similar studies, which one of the most important reasons is the improvement of technology and methods of surgery and, consequently, doing less cauterization as needed. It should be noted, however, that other materials that were even more perilous, were not sampled because of the lack of sampling or analysis facilities and the difficult storage or transport conditions. As a result, only four common pollutants that were more likely to be present in surgical fume were measured.

5. CONCLUSION

According to the results, the measured concentrations of pollutants are below the allowed limit. It is also recommended that other pollutants be evaluated whenever possible to obtain the necessary exposure information. Similar studies have been conducted in other hospitals to make better judgments. Although the above substances are below the allowed limit,

they are not a definite limit of safety and risk due to the limitations provided, and in view of the dangers of these materials, especially benzene, which is a definite carcinogen for humans and thus lacks the allowed limit. It is also necessary that personnel to observe the safety principles, as other studies have proven the existence of other hazardous contaminants.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All information provided by personnel is confidential and the executors are committed to this subject.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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