

# Literature matters research bulletin

## Chemical Composition of Smoke Produced by High-Frequency Electrosurgery

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### Introduction:

The potential hazard of surgical smoke has been a source of concern over recent years. Numerous studies have attempted to determine the risks that these aerosols pose both to patients and surgeons.<sup>1</sup> Unprotected exposure to electrosurgical by-products is still a common practice in many operating theatres. The long term effects of surgical smoke on surgeons and theatre personnel have not been determined. Smoke created both with laser and electrocautery contain mainly hydrocarbons, nitriles, fatty acids and phenols.<sup>2</sup> Of these, formaldehyde, acrolein, mixtures of benzene, toluene, ethylbenzene, xylene (BTEX), and polyaromatic hydrocarbons are of most concern. In the case of polyaromatic hydrocarbons, benzene and formaldehyde, they are known carcinogens. The toxicity of surgical smoke has been estimated to be similar to cigarette smoke. The mutagenic potential of thermal destruction of 1 g of tissue has been calculated to be equivalent to three cigarettes with tissue ablation and up to six cigarettes with electrocautery.<sup>3</sup>

### Materials and Methods:

Sorbent sample tubes were constructed in the laboratory by filling glass Pasteur pipettes with 0.85 g activated carbon and plugging both ends with cotton wool. The sorbent tubes were placed in the evacuation system while the smoke was generated during surgical procedures. Samples from patients undergoing surgery were collected at the author's hospital. Charcoal cartridges prepared in the laboratory were provided for sample collection. A sample sorbent tube was inserted into the suction extraction system attached to a standard diathermy pencil. After the volatile compounds were collected, the charcoal tubes were removed from the system, wrapped in foil, and sent to the laboratory for analysis. Electro-cauterization was carried out to ensure homeostasis.

### Results:

Different types of tissues yielded varying chromatographic profiles after being subjected to electrosurgery. Table 1 to the right lists the compounds of greatest concern identified.

### Discussion:

It has been reported that the nature of the surgical procedure determined the smoke content. The cauterization process had been demonstrated to generate more complex and toxic gaseous mixtures.<sup>1</sup> Cyclohexanone was found as a major component during abdominal surgery. Cyclohexanone is a potent respiratory irritant. It is classified as a suspected carcinogen for humans and suspected neurotoxic. The airborne exposure limit is set at 50 ppm by Occupational Safety and Health Administration (OSHA). Perchloroethylene (PCE) was identified in both verruca extraction and abdominal surgery. PCE exposure limits are set at 25 ppm by OSHA. Epidemiological studies suggest increased risk of exposure to PCE for several types of cancer, therefore, it is classified by the Environmental Protection Agency (EPA) as potentially carcinogenic for humans. Additionally, reproductive and neurological adverse effects have been reported. In this study, the presence of irritant, carcinogenic and neurotoxic compounds in electrosurgical smoke was demonstrated. Toluene, ethylbenzene and xylene were quantified and other volatile compounds were estimated using standard toluene. The content of these compounds has been estimated to be similar to cigarette smoke.<sup>3</sup>

Surgeons and operating room personnel should be informed of about the potential hazards of surgical smoke. Measures should be implemented to reduce this potentially serious occupational risk. This study may contribute to heightening the awareness of the potential risks that exposure to surgical smoke poses to the health of all involved in surgical practice.

Compound	Verruca extraction (µg/ml DCM)	Pilonidal sinus removal (µg/ml DCM)	Abdominal surgery (µg/ml DCM)
Cyclohexanone	6.13	19.9	48.6
Decene	ND	1.86	4.79
Decane	2.20	0.6	3.00
Dodecene	ND	1.21	4.01
Dodecane	23.06	0.95	4.35
Ethylbenzene	3.23	D	D
Heptanal	ND	ND	0.31
Nonanal	ND	ND	6.06
n-propylbenzene	ND	ND	D
Pentadecane	ND	0.6	D
Perchloroethylene	0.35	D	0.03
Tridecane	0.50	0.72	0.11
Tetradecane	1.86	0.95	0.19
Tetradecene	ND	0.31	0.58
Toluene	4.39	2.11	0.80
Undecane	2.09	0.68	5.76
Undecene	ND	1.17	1.00
Xylene	6.06	D	D

ND not detected. D detected below detection limit

Verruca extraction (n = 2), pilonidal sinus removal (n = 2), abdominal surgery (n = 9)

**Table 1, Compounds identified of greatest concern.**

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1. Barrett WL, Garber SM (2003) Surgical smoke – a review of the literature. *Surg Endosc* 17(6):979-987.
2. Hensman C, Baty D, Willis RG, Cuschieri A (1998) Chemical composition of smoke produced by high-frequency electrosurgery in a closed gaseous environment. *Surg Endosc* 12(8):1017-1019.
3. Tomita Y, Mihashi S, Nagata K, Ueda S, Fujiki M, Hirano M, Hirohata T (1981) Mutagenicity of smoke condensates induced by CO<sub>2</sub>-laser irradiation and electrocauterization. *Mutat Res* 89(2):145-149

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