

EUROPEAN OPERATING ROOM

NURSES ASSOCIATION



# **EORNA RECOMMENDATION ON:**

# **PREVENTION AND PROTECTION OF SURGICAL PLUME 2018**

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### **EORNA Recommendations**

The recommended practices are developed with the purpose to provide guidance for perioperative nurses in their nursing care in relation to surgery to achieve patient safety. The recommended practice are aimed at perioperative nurses in countries in Europe, and internationally. Nurses' code of ethics (ICN, 2012), nurses' specialist framework (ESNO, 2015), nurses' core competences (QSEN, 2003; Cronenwett et al., 2007; Cronenwett, 2009) and description of competence (EORNA, 2009) are important fundamental documents according to the recommendations.

Intentions with the recommendations are that every unique patient should be offered safe nursing care from the perspective of evidence based nursing and from the perspective of healthy workplace for perioperative nurses and co-workers in the surgical team.

This recommendations may be of advantage for practice in healthcare and especially in the operating rooms. EORNA recognizes the various settings in which surgical procedures are performed and where perioperative nurses practices.

The recommendation were developed by the EORNA Perioperative Nursing Care Committee.

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## Recommendation of protection and prevention of surgical plume

The following recommendation of protection and prevention of ultrafine particles in surgical plume has been developed by Perioperative Nursing Care Committee of EORNA. This recommendation may be of usefulness in various settings where smoke/plume are generated from heat-producing devices or rapid mechanical tools, during surgical interventions.

### Statement/Short summary

**Surgical plume contains gaseous by-products which could be hazardous to the members in the surgical team, including the patient. During surgery when using devices that produces smoke/plume the team-members may respire the by-products or the ultrafine particles, UFP, may fell on the skin or one gets it in the eyes. In laparoscopic procedures the ultrafine particles in the plume may absorbs into the patients' blood stream through peritoneum and cause hypoxic stress. Protection and prevention from ultrafine particles are of importance for the patients and health care personnel involved during the surgery.**

### Key words

*Prevention, protection, surgery, plume, smoke, heat-producing device, rapid mechanical tool, laser, diathermy, ultrasound device.*

### Purpose

The purpose with the recommendation is to offer a knowledge base for operating room nurses and health care personnel working in the perioperative environment to be aware of the risks of surgical smoke/plume of gaseous by-products used during surgical interventions. Another purpose is to know about prevention and protection room from hazardous ultrafine particles.

### Introduction

*Including: description of the problem, assessment of risks, special observations?*

During almost all surgical procedures heat-producing equipment are used in the patients' tissue. These devices uses for dissection or hemostasis. These medical technical equipment is necessary and serve important functions for example;

- by preventing that bleeding occur
- to coagulate small blood vessels
- to allow more visibility in the surgical field
- shorten the procedure-time.

The benefits of these devices offers more efficient surgical techniques and they allow surgery within various surgical risk-areas.

When using rapid mechanical devices and heat-producing devices, smoke or one may say plume, is generated. Surgical plume, which are combustion gases, are formed during heat-producing energy and are generated for example when using monopolar and bipolar diathermy, laser surgery, dissection with argon gas, ultrasound, high speed burrs, saws, drills, cutters and mechanical morcellators etc.<sup>1,2,3</sup> Surgical plume is described in the literature as a gaseous by-



product resulting from energy-based instruments and devices used in tissue. These gaseous by-products are ultrafine particles, UFP, and contains bio aerosols with both viable and non-viable cellular material. Diathermy plume contains chemical and biological substances that are considered as mutagenic, carcinogenic, and possibly infectious. The plume contains dead and living cell material from the patient's tissue, HPV DNA, toxic gases, mutagenic and carcinogenic materials.<sup>2, 3, 4, 5, 6, 7</sup>

The most common chemical substances occurring in surgical plume are described in the literature as hydrocarbons, fatty acids, phenols, nitriles, acrylonitrile, hydrogen cyanide, benzene and toluene.<sup>8, 9, 10</sup> Chemicals identified in laser plume are benzene, formaldehyde, carbon monoxide and hydrogen cyanide. HIV-DNA and bovine papilloma virus DNA has been detected in the laser aerosols.<sup>11</sup>

By-products of ultrasonic devices usually describes as aerosols or steam. These aerosols arising on low temperature are more likely to contain viable and infectious carrying particles compared to particles generated at higher temperature.<sup>6, 12</sup> Large quantities of cellular material are found in surgical plume produced by ultrasonic dissection.<sup>13</sup>

Saws, drills, etc. are included into these, which become hot during use. These devices are cooled down with flushing of cold sterile fluid to reduce the temperature of the tissue, and this in turn creates steam of aerosols that may contain blood and fluid products.<sup>2</sup>

#### **Particle size**

Living cells have a size of about 5-50 microns.<sup>14</sup> The plume generated by the use of heat-producing medical devices includes ultrafine particles, UFP, of less than 0.1 microns.<sup>10</sup> Electrosurgical particles are 0,07 micrometers and is considering dangerous because of the chemical composition. Laser particles are 0,31 micrometers and particles from ultrasonic dissection are 0,35 – 6,5 micrometers. Viruses and bacteria may be of minor size.<sup>15</sup>

#### **Effects of surgical plume**

The chemical components may be absorbed through the skin and lungs. They have a toxic effect that can affect irritation of the eyes, nausea and vomiting, headache, sneezing, weakness and dizziness. Even emphysema, asthma and chronic bronchitis can be caused by surgical plume. Benzene is documented as a "trigger" for leukemia.<sup>2, 12</sup> Carbon monoxide is problematic for the patient during laparoscopic surgery, because the risk of absorbing carbon monoxide through the peritoneum into the blood stream. Increased amounts of carboxyhemoglobin, HbCO, and methemoglobin, MetHb, cause hypoxic stress in healthy individuals through reduced oxygen-carrying capacity.<sup>3</sup> Benzene and toluene has been found postoperatively in patients' urine after laparoscopic cholecystectomy.<sup>16</sup>

#### **Distance of plume, spread of plume**

In the environment, due to the spread of plume, it can be seen that the plume from various medical devices spreads the plume in different ways. De Boorder et al.<sup>15</sup> who studied the plume from electrosurgery and carbon dioxide laser could see the plume of carbon dioxide laser was spread more explosive and further away from the surgical field compared to the plume from electrosurgical devices. High concentrations of ultrafine particles, UFP, occurs over short exposure periods during abdominal surgery according to Bruske-Hohfeld et al<sup>17</sup> and the first seconds, when using diathermy or laser, generates high levels of UFP and thus contains many hazardous substances.<sup>18</sup> Curved or straight blades of the instruments has significance for the



spread of the plume,<sup>19</sup> and the material of the blade has another importance for reducing the surgical plume.<sup>20</sup>

### **Prevention and protection**

#### **Ventilation in the operating room**

Conventional ventilation, at least 15-20 air exchanges/hour, the air is filtered by HEPA (high efficiency particulate air) or it may be ventilation where laminar airflow are used.

#### **Evacuation systems**

A central evacuation system is powerful and it is a quiet system as it is installed outside the operating room.<sup>2</sup> This system may be seen as the most important system as it transfer the smoke/plume out from the operating room immediately, and it has an ULPA (ultra-low particulate air) -filter before the plume is filtered to the outdoor air.

Mobile evacuation system - The most effective systems is the triple filter system with an ULPA (ultra-low particulate air) -filter or HEPA (high efficiency particulate air) -filter, which take particles 0.1 microns and larger, the capacity is nearly 100%. The systems have a pre-filter which catches the largest particles. The ULPA filter is the second stage of the filtration. The final filter is an activated charcoal filter that absorbs toxic chemical ingredients and the odors in the plume.<sup>21</sup>

It is important to place the diathermy-pen with its suction within 2 cm from the source of smoke production. Factors affecting the capability of capturing the plume; the capacity of aspiration flow (liters/min), the distance between the suction and the source of smoke production, the inner diameter of the suction hose and the amount of plume produced during the operation.<sup>21</sup>

When bipolar diathermy is in use it is preferable to have a wand for plume evacuation, which is connected to the evacuation system with HEPA or ULPA-filter, and the same recommendation may be used for ultrasonic dissection devices, or a wand may be connected on the instrument in use.

Laparoscopic plume/smoke evacuation system with ULPA-filters: special filters are available and should be connected on a trocar during the whole operation to prevent leakage of plume in the open air in the operating room.

Plume/smoke evacuation systems should always be used during the procedure with heat-producing instruments or devices.

#### **Personal protective equipment**

To reduce exposure for surgical plume, personal protective equipment is used.

It is important to protect the respiratory system, the eyes and the skin.<sup>22</sup> The eyes need protection by glasses and for the skin a coat and gloves are appropriate safeguards. Face masks used today (IIR), filter particles 5 microns or larger, according to Ulmer<sup>2</sup> and Benson et al.<sup>22</sup> Respirators can filter particles that are 0.1 microns.<sup>2, 22</sup> Respirators FFP3 are classified according to European Standard EN 149: 2001 + A1: 2009. The most effective is respirators with HEPA filters. When using respirators it must be taken on correct according to the manufacturer's instructions.<sup>23</sup> The face mask or the alternative respirator is "*the last line of defense*" against inhalation of ultrafine particles, UFP, and as health care personnel it is important to assess what is relevant to use.





### Filter replacement

Changing filters in the mobile evacuation systems should be considered as hazardous. The filters should be considered as infectious materials,<sup>4</sup> because of the waste from surgical plume. It may remain a risk to inhale ultrafine particles (UFP) or get these UFP on the skin or in the eyes, therefore should the filters be sealed effectively to prevent particles from entering the room air. Important to remember when changing the filters, is to protect the respiratory system, to wear eye protection and gloves, as well as protection of the working suit against contamination.

### Education and training

Education and information about protections and preventions should be held and be available, specifically requires training to take on respirators properly.<sup>22</sup> In Europe, the employer have to inform the workers about proper donning of protective respirators FFP 3.<sup>24</sup>

### EU Directive

Legislation in Europe aims to minimize the health risks of biological agents at the workplace<sup>25</sup> European Parliament and Council Directive 2000/54 / EC on the protection of workers from risks related to exposure to biological agents at work) and carcinogens or mutagens at work<sup>26</sup> Directive 2004/37/EC. These regulations are minimum requirements which must be transposed into national law. In the directive of biological agents are divided into four risk groups depending on whether they can cause diseases and the possibilities of prevention and treatment. In the index list of the Directive, it is listed potential allergenic or toxic effects of biological agents. When it comes to activities that could pose a risk of exposure to biological agents, the nature, degree and duration of workers' exposure must be determined in order to make it possible to assess the risks for the workers' health or safety and to determine the measures to be taken. In the Directive includes measures described for mitigation.<sup>27, 28</sup>

The Directive requires the employer to:

- Assess the risks posed by biological agents
- Reduce the risk to the workers by:
  - elimination or substitution
  - exposure prevention and control
  - information and training of the workers, and
- Provide health surveillance as appropriate

European Commission has recently produced a fourth list of indicative occupational exposure limit values.<sup>29</sup>

Developments are done quite rapidly and in the future there may be other methods of preventions and protections.



## Recommendations

- ✓ Ventilation in the OR at least 15 – 20 airchanges/hour with a positive pressure
- ✓ When using medical technical devices that generates ultrafine particles, recommends effective evacuation systems and proper, correct use of the device during the whole time the device is used and at the disposal of the product.
- ✓ Personal protective equipment should be applied correctly for not being exposed to ultrafine particles when using these medical technical equipment.
- ✓ Education of hazardous situations and prevention and protection should be mandatory and held by the employer for the health care personnel when new employment, or when new equipment is introduced to the workplace.

### ***Quality- and safety control preoperatively:***

The instrument nurse/operating room nurse/scrub nurse/registered nurse should when preparing the surgical intervention inspect the medical technical equipment that generates ultrafine particles if they are correct prepared with evacuation system. The personal protective equipment as surgical face mask, respirator and eye protection should be taken on before the start of the procedure. When risk for exposure of ultrafine particles, in these cases when smoke evacuation systems are not sufficient, a respirator should be used. Control of the smoke evacuation system should be tested.

### ***Quality- and safety control intraoperatively:***

Continuously controls are made of the evacuation system during the surgical intervention.

### ***Quality- and safety control postoperatively:***

After the surgical intervention the equipment should be disposed carefully, for not harm any health care personnel or patient. The ultrafine particles may still be left in the system. The filter is changed in accordance with the recommendation for the specific medical device so that they may continue to function optimally and do not pose health risks.

## Observations

- ✓ If accidentally a regular suction has been used for plume evacuation it is important to change the filter after the procedure and that the contents in the container can be evacuated in a safe and secure way, single use suction is recommended.
- ✓ If reusable suction have been used, one has to be aware of the health risk when the contents are to be emptied in the disinfectant. Use appropriate personal protective equipment.





- ✓ In cases where surgery is performed only with surgical gloves, and not surgical gown, it is important to remember when the medical technical devices are used, they may produce ultra-fine particles to be absorbed through the skin.
- ✓ Other health care personnel, as for example students or personnel from outside the perioperative environment, should be aware that the dissemination of ultrafine particles also can reach personnel who are further away in the operating room, from the surgical site.



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