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The Hazards of Surgical Smoke or Plume

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Abstract
DURING SURGICAL PROCEDURES using laser or electrosurgical units, the thermal destruction of tissue creates a smoke byproduct. Research study has indicated that this smoke plume contains toxic gases and vapours. At high concentrations, the smoke causes ocular and upper respiratory irritation in healthcare workers and creates visual problems for the surgeon. The smoke has unpleasant odour and has been shown to have mutagenic pathogens.

A study was undertaken in 1999 aimed to evaluate the surgical smoke produced in laser surgery. It showed that the particulate matter of laser smoke originating from biological tissues should be classified as cytotoxic, genotoxic and mutagenic.'

INTRODUCTION
During surgical procedures using laser or electrosurgical units, the thermal destruction of tissue creates a smoke byproduct. Research study has indicated that this smoke plume contains toxic gases and vapours. At high concentrations, the smoke causes ocular and upper respiratory irritation in healthcare workers and creates visual problems for the surgeon. The smoke has an unpleasant odour and has been shown to have mutagenic pathogens.

The aim of this paper is to review the evidence of toxicity from surgical smoke by-products and to out- line the importance of Defence health facilities using surgical smoke evacuation devices to effectively control toxic smoke and gasses.

HISTORY
In the late 1980s and early 1990sl, laser clinicians and researchers became concerned about the potential dangers of breathing smoke or "plume" generated by laser surgery. Numerous study results began to appear that described the contents of laser smoke. These studies addressed the transmission of dangerous chemical contaminants, viruses, bacteria and viable cells in laser smoke. As the research reached the market place, concern grew and hospitals working with laser surgery began to purchase smoke evacuators to remove the surgical plume generated during laser surgery. There was, however, little investigation and evidence produced to support the use of smoke evacuators during electrosurgery (ES).

In 1987, Baggish published research results on surgical smoke hazards.[3] He demonstrated that fine particulate matter produced by carbon dioxide laser use caused pathological changes in the lungs of rats.[3] In 1991, Baggish found Human Immunodeficient Virus (HIV) cells in the smoke. He had collected smoke through sterile Silastic tubing, cultured it and revealed that the HIV survived for as long as two weeks. He concluded that smoke evacuation collection tubing was hazardous. In further studying the smoke, he concluded that efficient smoke evacuation must be maintained close to the operative field in order to remove the smoke before the operating room staff inhales it and that universal precautions must be observed with smoke by-products in all patients.

Another study by the Hazard Evaluation and Technical Assistance Branch of the National Institute for Occupational Safety and Health in the USA revealed that the electrosurgical unit (ESU) smoke was mutagenic. Further research also found that the mutagenic particles found in ESU smoke were unstable and they showed mutagenic potential for up to two hours[4].

ANALYSIS OF SURGICAL SMOKE/PLUME
Various research studies have confirmed that the contents of surgical smoke may contains:

1. **Biological Agents.**
   These may include:
   - Viruses – HIV, Hepatitis B and C;
   - Bacteria – Staphylococcus aureus, Mycobacterium tuberculosis, E. coli; and Fungus – Fungal spores.

2. **Cellular Tissue.**
   May include carbonized tissue and aerosolized blood.

3. **Chemicals.**

These may include:

- Mutagens, carcinogens, allergens, irritants to respiratory tract and toxic gases; and
- Other chemical byproducts, including acetonitrile, acrolein, free radicals, hydrogen cyanide, acrylonitrile, alkyd benzenes, benzene, butene, carbon monoxide, creols, ethane, thylene, formaldehyde, methane, propene, propylene, pyridine, pyrrole, styrene, toluene, and zylene.

A study, undertaken in 1999 to evaluate the surgical smoke produced in laser surgery, has shown that the particulate matter of laser smoke originating from biological tissues should be classified as cytotoxic, genotoxic and mutagenic.[1] It is now believed that the smoke produced in electrosurgery is as toxic as that produced in laser smoke.

Patients, healthcare workers and observers in the Operating Room (OR) are exposed to toxic smoke in a surgical procedure in which smoke from tissue inter- action with an ESU or laser is not evacuated. As out- lined above, the aerosols produced when lasers or ESU are used may contain particulate matter, gases, mutagens, carcinogens and sometimes DNA components. In one study, when smoke evacuators were not used, the OR filled rapidly (within five minutes) with particulates and the surgical smoke did not dissipate through the ventilation system until 20 minutes after the ESU ceased[5].

RECOMMENDED PRACTICES

The current recommended practice for surgical smoke in the OR was amended in December 2000. The amendment states that the Australian Council of Operating Room Nurses (ACORN) believe that evacuation of surgical smoke in the operating room creates a safer environment for the patients and the healthcare workers.

ACORN STANDARDS

This standard (Table 1) is to be used in conjunction with Standard All- Laser Safety in the Operating Suite[6].

Table 1: ACORN Standards[6]

Standard	Criteria
The healthcare facility shall provide protection from potential hazards of smoke for peri-operative personnel.	The peri-operative nurse: Provides protection by utilising smoke evacuation and ultra-low penetration air CULPA) filtration systems. High filtration masks may be used as further protection from occupational exposure to surgical smoke.
Activities shall be directed to confine and contain contaminants generated by surgical smoke during the surgical procedure.	The peri-operative nurse: • Positions suction collection devices at the source of the smoke; • vents laparoscopic smoke by means of a filtered system; • utilises evacuation systems according to the manufacturers' instruction; and

	• disposes of all smoke evacuation supplies according to the Infection Control Policy for biohazard.
Peri-operative personnel shall demonstrate competency in the use of equipment used to evacuate surgical smoke.	The peri-operative nurse; • ensure primary education in the use of the equipment; and • attends continuing education programs
The healthcare facility ensures that the selection criterion for equipment used for surgical smoke extraction reflects new technological advances as they become available.	

CONCLUSION

There are two issues to be considered when operating room personnel are exposed to surgical smoke. The first is the biohazard. The possibility of contracting viral diseases and/or inhaling fine particulates that affect the lungs makes smoke inhalation potentially very harmful. Therefore, surgical smoke must be considered with other bodily fluids. It must be disposed of correctly and the consumables used to dispose of the surgical smoke must be considered as biohazards and also disposed of as such.

The second issue is the adoption of safe work practices whenever surgical smoke is generated. This should include the implementation of guidelines that include the use of appropriate protection equipment. The ACORN standards address the use of surgical smoke evacuators, in-line suction filters, the routine suctioning of diathermy smoke and the recommended method, appropriate masks, patient protection and the disposal of items used in the control of surgical smoke.

It is plausible that operating room staff, including managers, will be cautious in adopting new standards and procedures concerning diathermy smoke whilst the viability or otherwise of DNA and matter isolated from ES filtrate is still under discussion.[6] Operating Room personnel and supervisors in the OR have a duty of care if they consider that an identified risk exits. While this risk is ill-defined, there appears to be the potential for contamination and mutagenic effects from repeated exposure to the toxic and gaseous by products of ESUs and Laser smokes OR supervisors must consider ways to overcome surgical smoke exposure to their patients, staff and visitors.[7]

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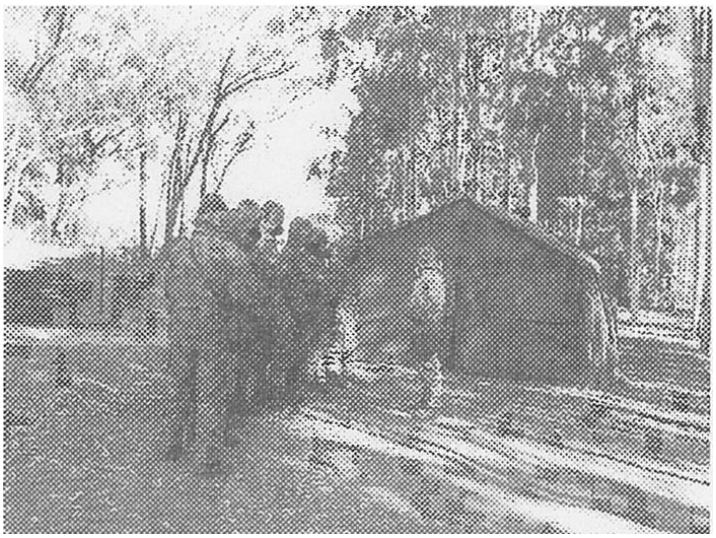

Students preparing for the Mask testing Facility at the last Medical Officers' Nuclear Biological and Chemical Defence Course – April 2002

Photo courtesy of CAPT Andy Robertson