The Royal College of Surgeons of England

GENERAL

Ann R Coll Surg Engl 2007; **89**: 162–165
doi 10.1308/003588407X155752

Current attitudes and practices towards diathermy smoke

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ABSTRACT

INTRODUCTION The hazards of surgical smoke are well documented and electrosurgical units (ESUs) are an integral part of surgical practice. The aim of this study was to gauge the opinions of general surgical consultants, specialist registrars and senior theatre nurses in the Wessex Region towards the hazards of ESU smoke.

MATERIALS AND METHODS A literature search was carried out using Ovid Medline. A questionnaire was sent to 169 consultants, SpRs and nurses in the 14 hospitals across the Wessex Region, exploring current practices, perceived hazards and whether adequate precautions were currently in use.

RESULTS Only 3 of 98 surgeons used dedicated smoke extractors, despite the fact the majority (72%) felt that, currently, inadequate precautions were taken to protect staff and patients from surgical smoke. There was also uncertainty about the hazards amongst the respondents.

CONCLUSIONS The use of smoke extraction equipment is very limited. Greater awareness of the hazards and available technology to extract fumes from the theatre environment might lead to greater uptake.

KEYWORDS
Diathermy – Electrocoagulation – Surgical smoke – Occupational exposure

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The electrosurgical unit (ESU) was developed by WT Bovie in 1926 and popularised by H Cushing.[1]

Despite a slow initial uptake by surgeons, the ESU has become an indispensable tool to the modern surgeon and is used in the majority of surgical procedures. Using different electrical waveforms, current is passed through tissues and the resistance encountered produces heat. For cutting diathermy, the heat causes intracellular water to boil, the cells explode and tissues divide; coagulation current develops less heat, causing cell drying and thus coagulation.[2] This produces a varying degree of plume, or surgical smoke.

The aim of this study was to gauge the views of general surgical consultants, higher trainees and senior theatre nurses in the Wessex Region about the perceived hazards from surgical smoke, any avoidance measures taken and any adverse events they have experienced.

Materials and Methods

A standard questionnaire was sent to all general surgical consultants and specialist registrars (SpRs) in the Wessex Region and an abbreviated questionnaire sent to the head theatre nurse in each of the Region's hospitals with surgical capabilities.

Questions asked related to the degree of diathermy use amongst surgeons and the attitude of surgical and nursing staff towards the smoke created, the perceived hazards of smoke inhalation, measures used to clear the smoke and whether additional precautions were used. Finally, they were asked for any known adverse events from surgical smoke and whether they felt that current methods were adequate to protect staff and patients.

Results

A total of 169 questionnaires were sent to general surgical consultants (n = 103), SpRs (n = 52), and senior theatre nurses (n = 14) in the 14 hospitals within the Wessex Deanery with surgical services. There were responses from 67 consultants (65%), 40 SpRs (77%) and 11 senior theatre nurses (79%). All general surgical subspecialties were represented and a response from each hospital was obtained from at least two of the three groups.

Of 111 consultant and SpR responses, 108 (97%), used diathermy always or often. Overall, 43% of consultants cleared away surgical smoke compared with 70% of SpRs; reasons for clearing were to improve the view, safety, and smell (see Table 2). Of those who cleared smoke, 89% of consultants and 92% of SpRs, used standard wall-mounted suction, 14% of consultants used specific laparoscopic smoke extractors/filters, whilst 8% (and 11% of SpRs) vented smoke by opening laparoscopic ports. One consultant blew smoke away to improve views. Two consultants (5%) and one SpR (4%) stated they used smoke extractors, but only for pseudomyxoma cases at one hospital. Additional precautions were taken by 7% of consultants and 20% of SpRs, including not using diathermy excessively or wearing a mask (with or without eye guards).

Of consultants, 51% felt diathermy plume was harmful, compared with 78% of SpRs and 91% of theatre nurses: respectively, 22%, 38% and 18% felt that there were currently adequate precautions taken against surgical smoke, 60%, 58% and 64% felt precautions were inadequate and 13%, 5% and 18% were unsure. A few had heard, or read, of adverse events, but other than the smell- and smoke-induced coughing there were no adverse events reported.

There was some uncertainty amongst consultants of the dangers of diathermy smoke and, therefore, the need for extra precautions. Many felt more evidence was needed to prove *in vivo* harm. Some had already raised this issue, but found no support from the management or occupational health. Others commented that new technologies, such as the harmonic scalpel and ligasure were reducing the amount of smoke generated in a case and that smoke extractors were available, but too expensive and awkward to use on everyday cases. A handful of consultants commented that they would welcome smoke extractors, but were unaware of any efficient systems available. One consultant, who had worked in the US, commented that it was compulsory to clear surgical smoke in the US.

Amongst SpRs there was less uncertainty with regards to the hazards from surgical smoke. A few had personal experience of smoke extractors (attached to pencil diathermy); these were uniformly negative, stating they were expensive and cumbersome, therefore increasing the risk of surgery.

The nurses' responses were similar to those of consultants namely: unsure of the risks, feeling more should be done to improve protection, but that the technology was unavailable to them.

Discussion

A search of Ovid Medline – using the headings surgical smoke, surgical plume, electrocoagulation, electrosurgical units, occupational hazards and diathermy – revealed many papers investigating the risks from surgical smoke. Further articles were obtained from the references cited in the initial literature reviewed.

A large proportion of the evidence is from experimental data using laser-generated smoke. Due to more widespread use, greater smoke production and the charring effect, ESU smoke may be more harmful. Despite this, laser use is afforded more care than ESU within the theatre setting.[3–5] However, laser- and ESU-generated smoke contain the same constituents and thus can be considered to have identical hazard profiles.[4–7] Research into plume generated by both modalities was included in this review.

Surgical smoke is produced by the thermal destruction of tissue. Chemical analysis has shown its constituents to be 95% water vapour, the remaining 5% containing chemicals and cellular debris.[7] It is the effects of these chemicals and the potential risk from airborne cellular debris which has raised concern about the hazard of surgical smoke to staff and patients.

In vitro studies analysing the chemical composition of surgical smoke have identified up to 80 chemicals,[8,9] including hydrocarbons, nitriles, fatty acids and phenols.

In a theatre-based, controlled trial, Sagar *et al.*[10] listed 5 chemical constituents each of which was detectable postoperatively in at least one of the trial patients and none of the controls. Although most were not carcinogenic, they could be irritant to eyes and skin, have CNS effects or renal and hepatic toxicity. However, benzene (a known carcinogen for which the recommend exposure is nil) was also detected. Others have explored the effects on staff and list considerable potential morbidity from surgical smoke inhalation (Table 1).[5]

Visible changes have been detected in the lungs of rats exposed to surgical smoke for between 32–224 min duration

Table 1 Potential risks of surgical smoke inhalation[14]

Airway inflammation
Hypoxia/dizziness
Coughing
Headaches
Tearing
Nausea/vomiting
Asthma
Pulmonary congestion
Chronic bronchitis
Emphysema
Hepatitis
Carcinoma
AIDS

over 7 or 14 days.[11] Examination of the lungs revealed a spectrum of damage from inflammatory interstitial pneumonia to extensive emphysema. The changes increased proportionally with smoke exposure. However, it was noted that the level of exposure was greater than would be experienced in practice.[11] Lung damage was prevented by filtering the smoke.[12]

A major concern is the risk of transmission of biological agents. Ferenczy *et al.*[13] demonstrated the presence of potentially infectious human papilloma virus (HPV) DNA, but not intact viruses, but were unable to isolate any DNA or virus from samples taken from the surgeon during the procedure. Other studies concur;[7,14] Garden *et al.*[14] isolated both intact HPV, as well as HPV DNA. More worrying is the *in vitro* isolation of human immunodeficiency virus (HIV), although it could not be cultured beyond 14 days, possibly due to thermal damage.[12] However, there is currently no evidence that infections have been transmitted to humans in this way, except anecdotal reports of nasopharyngeal infection in surgeons treating papillomas.[7,15]

The occurrence of port-site metastases following laparoscopic bowel cancer resections led to concerns that surgical smoke carried malignant cells, deposited as the pneumoperitoneum escapes around the trocar.[15] Surgical smoke produced from different cancers has been studied, with similar results: morphologically intact cells, mostly mesothelial and blood cells, are found in the plume. Few of these have been identified as being viable[15–17] and, of those identified as viable, none grew on subsequent culture.[17] No malignant cells were detected in any of these studies.

Much of the literature reviewed focused on staff and patient protection. In the US, the National Institute for Occupational Safety and Hazard (NIOSH) recommends high capture velocity suction (at least 100–150 ft/s), not standard, wall-mounted suction, together with high efficiency particulate air filters (effective down to particles 0.1 μm in size). NIOSH suggests that the smoke capture device should be within 2 inches of the surgical site and suction should be on whenever any surgical smoke is produced.[18] However, Garden *et al.*[14] found being 1 cm away 98% effective, but > 2 cm from operation site caused a 50% decrease in efficiency of smoke removal. It has been suggested that filters and tubing should be changed between cases and treated as infectious waste.[18] To date, the North American regulating body, the Occupational Safety and Health Administration, has not made it law, awaiting empirical evidence.[3,6] In the UK, the equivalent bodies, the Health and Safety Executive and the Medicines and Healthcare products Regulatory Agency (formerly the Medical Devices Agency) have not published any advice due to lack of evidence of the exact risk.

This is the largest UK study of current practice in this field to date, with a 70% response rate to our questionnaire. Diathermy equipment was used by all the surgeons who responded. Many surgeons clear surgical smoke for a variety of reason. The use of wall suction was the most common method, although some used specifically designed devices, such as laparoscopic evacuators/filters. Only 3% used a specific smoke evacuator.

Table 2 Reasons for clearing surgical smoke

	View	Safety	Smell
Consultants (n = 37)	27 (73%)	21 (57%)	6 (16%)
Specialist registrars (n = 28)	23 (82%)	19 (68%)	4 (14%)

Only 26% of respondents felt that adequate precautions exist at present. Although many were undecided, most felt the need for more clinical data and better technology for smoke evacuation before surgical smoke evacuation became routine.

Wall-mounted suction was the most frequently used form of extraction for surgical smoke in our study. Despite most research suggesting that this is inadequate, unless used in laparoscopic cases where the smoke is contained.[6] However, one study using specifically designed pencil diathermy with in-built channel for smoke extraction, a filter and wall-mounted suction (set to 30 l/min)[15] showed significantly reduced quantity of smoke reaching the surgeon, improved view and reduced noxious smell. Another theatre-based study, to establish health and safety guidelines for surgical smoke, failed to identify any biological or chemical hazards in significant quantities in the theatre environment during selected operations.[14] Clinical studies such as these are important as they investigate actual working conditions. This must be taken into account when evaluating laboratory-based studies, because extrapolation to the clinical setting may be misleading.

Far greater regulation exists in the US, Canada and Australia regarding the extraction of surgical smoke.[3,6,18,19] It has been recognised that the potential for future litigation for occupational exposure must be factored into any economical considerations for using smoke extractors.[3] Although there will be reservations about adopting new systems, many have been implemented in the past and proved successful.

Conclusions

Clinical and experimental evidence suggesting the potential for harm from surgical smoke exists, but remains difficult to quantify at present. This survey suggests that knowledge of the dangers of surgical smoke is limited, but

is a cause for concern amongst staff exposed to surgical smoke in theatres. Greater awareness of the hazards and available technology to extract fumes from the theatre environment might lead to greater uptake.

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