

# Factors affecting surgical plume evacuation compliance

## Abstract

Despite the acknowledgement of the hazards of surgical plume, compliance with smoke evacuation is not routine.

This review examines the current literature on factors influencing compliance with smoke evacuation. Factors identified included the design of the smoke evacuation device, surgeon refusal, education and managerial support. Strong leadership, education and policy enforcement from a local facility level are required to improve surgical plume evacuation compliance. More research in this field would help to further strengthen these findings.

**Key words:** surgical plume, smoke evacuation, surgical smoke, compliance

## Introduction

The Australian College of Operating Room Nurses (ACORN) standards and the recently released New South Wales (NSW) Health guideline include recommendations about surgical plume in the operating theatre; however, it is unclear what impact these have had on compliance. The evidence shows that surgical plume is dangerous to personnel yet, from experience, compliance with smoke evacuation is less than ideal. The objective of this review is to identify and appraise the best available evidence on factors that influence compliance with surgical plume evacuation.

Surgical plume is generated by heat-generating devices such as electro-surgical units, lasers, ultrasonic devices, high-speed drills, burrs and saws<sup>1</sup>. These pieces of

equipment are vital and are used in many surgical procedures worldwide. Surgical plume, also called surgical smoke, is the result of thermal destruction of bone or tissue<sup>2</sup>. In the United States, it is estimated that more than 500 000 health care workers are exposed to surgical plume every year<sup>3</sup>. Potential risks to health care workers exposed to surgical plume include acute and chronic inflammatory respiratory changes, eye irritation and headache<sup>1</sup>.

Toxic substances, pathogens, mutagens and carcinogens are released into the atmosphere by electrosurgery, powered instruments and lasers<sup>2</sup>. A systematic review conducted by Mowbray et al.<sup>4</sup> confirmed that surgical plume contains potentially carcinogenic compounds physically small enough to inhale and reach the lower airways. Surgical plume can contain a variety of contaminants, including bacteria, viruses, cellular debris, gases, vapours and fumes<sup>5</sup>. Each heat-generating device produces particles of a different size<sup>1</sup>. The smaller the particle size, the further it travels<sup>1</sup>. This means that all personnel in the operating theatre can be affected, not just personnel in the surgical field. Surgical plume can also affect patients. During laparoscopic surgery, surgical plume is absorbed into the peritoneal cavity<sup>6</sup>. A study conducted by Beebe et al.<sup>7</sup> to determine detectable levels of carbon monoxide produced by electrosurgery during laparoscopic cholecystectomy procedures revealed that carbon monoxide was present in the peritoneal cavity within five minutes. Both intraoperative and postoperative carbon monoxide levels exceeded levels recommended

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Standards Australia stipulate that when laser is used contaminants need to be evacuated appropriately from the surgical field<sup>8</sup>. Airborne contaminants need to be captured as close as possible to the point of evolution and removed by localised exhaust ventilation (LEV)<sup>8</sup>. Compared to laser, less attention has been paid to mitigating the risks associated with exposure to diathermy plume. However, in 2015 NSW Health released a guideline 'Work health and safety – Controlling exposure to surgical plume'. This guideline states that each NSW health organisation has a primary duty to ensure the health and safety of workers and other persons in the workplace<sup>5</sup>. The NSW health organisation must eliminate risks to health and safety so far as is reasonably practicable and if eliminating the risk is not practicable, to minimise the risk<sup>5</sup>. Control measures include adequate plume evacuation at the source. Plume evacuation systems aim to remove plume from the environment, reducing potential hazards of exposure<sup>5</sup>. The ACORN standard 'Surgical plume' states exposure to surgical plume is a workplace health and safety hazard and must be mitigated by methods appropriate to the procedure and instrumentation<sup>9</sup>.

Smoke evacuation systems vary. Many are portable and can be activated by a foot switch or automatically<sup>5</sup>. These systems capture smoke through tubing positioned usually within five centimetres of the plume source<sup>5</sup>. The captured plume is passed through filters and the filtered air is

then released back into the room<sup>5</sup>. These plume evacuation systems need to have ultra-low penetrating air (ULPA) filters with an efficiency rating of not less than 99.999 per cent<sup>9</sup>.

For endoscopic or laparoscopic procedures, both active and passive devices exist. They are single use devices that provide improved visibility into the peritoneal cavity without compromising room air or pneumoperitoneum and minimise patient exposure to surgical plume<sup>5</sup>.

Local stationary evacuation systems have a suction source located in a surgical boom or in the interstitial space above the operating theatre<sup>5</sup>. These systems capture plume with a capture device and hose and vent the filtered air inside or outside of the theatre<sup>5</sup>. If medical vacuum systems are used, an in-line ULPA filter must be used between the fluid trap and the vacuum regulator<sup>5</sup>. Filters are to be changed according to manufacturer's instructions and hospital policy<sup>5</sup>.

Despite the evidence showing the dangers of surgical plume, research shows that compliance is still low. In a study carried out in the United Kingdom, a list of 56 British plastic surgery units was obtained from the British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS)<sup>10</sup>. Of the 56 plastic surgery units, 50 responded to the survey. Smoke evacuators were available for use in 66 percent of plastic surgery units. Despite this, their use was not universal and was dependent upon the surgeon and the procedure<sup>10</sup>.

## The Search

An initial, limited search of MEDLINE and Cumulative Index to Nursing and Allied Health Literature (CINAHL) was undertaken followed by analysis of the text words contained in the

title and abstract and of the index terms used to describe the article. A second search was undertaken using all identified keywords and index terms. Keywords included surgical smoke, surgical plume, smoke evacuation, compliance and barriers. The reference lists of all identified reports and articles were searched for additional studies. All studies published in English were considered. As surgical plume is produced by laser and electrosurgery, all studies discussing these methods were included. Studies that did not discuss compliance or factors influencing compliance were excluded. A total of fifteen articles were used in this literature review.

## Results

Results were varied and produced multiple types of research: literature reviews, cross-sectional surveys and many questionnaires. Results of the literature search have been separated into themes.

### Surgeon refusal

According to a study conducted by Shultz<sup>11</sup> a dismissive attitude towards smoke inhalation is often the decisive factor in the choice not to use smoke evacuation devices. Similarly, in a random sample study conducted by Ball<sup>12</sup> surgeon refusal was a common barrier to smoke evacuation compliance. A literature review by Lindsey et al.<sup>13</sup> reported nurses did not feel empowered to use protective equipment because this use was at the discretion of the surgeons. In a survey to identify compliance with smoke evacuation, carried out by Edwards and Reiman<sup>14</sup>, it was found that the most commonly reported obstacle was surgeon resistance or refusal. Similar results were found in a cross-sectional survey in the United Kingdom. In this survey, three per cent of surgeons used dedicated smoke evacuators,

despite the fact that 72 per cent felt that inadequate precautions were taken to protect staff and patients<sup>15</sup>.

### Smoke evacuation system design

Edwards and Reiman<sup>14</sup> found that obstacles to the use of smoke evacuator systems included the bulkiness of the systems which caused them to get in the way and take up too much room. Other obstacles found by Edwards and Reiman<sup>14</sup> included excessive noise produced by the smoke evacuator system. Ball<sup>12</sup> also found that excessive noise was a deterrent to compliance. This was partly due to the fact that older models were in use, which can be noisier than newer models on the market today<sup>14</sup>. Newer models of smoke evacuators are padded to abate the noise produced when the system is activated<sup>12</sup>. The bulkiness of the smoke evacuation pencil was also mentioned as a barrier<sup>14</sup>. The handpieces were found to be too heavy, awkward and prone to clogging<sup>14</sup>.

### Attitudes of personnel

In an analysis of surgical plume capture and evacuation, Shultz<sup>11</sup> found a dismissive attitude towards the risks of plume is often the decisive factor in the choice not to use smoke evacuation devices. Similarly, in a web-based survey, several respondents stated that physicians did not recognise surgical plume as a hazard<sup>14</sup>. A cross-sectional survey completed by consultant surgeons, registrars and perioperative nurses on current attitudes and practices towards diathermy smoke found registrars (70 per cent) were more likely to use evacuation equipment than consultants (43 per cent)<sup>15</sup>. There was uncertainty amongst the consultants as to the dangers of surgical plume, and a belief that more evidence was

required<sup>15</sup>. Ball<sup>3</sup> conducted a random sample survey of perioperative nurses and concluded that physicians need to be educated on the documented hazards of smoke inhalation. However, results from Ball<sup>3</sup> also showed that if nurses' perceptions about surgical plume recommendations were positive, they were more likely to comply with recommendations.

## Managerial support

A web-based survey targeted at perioperative nurses found a lack of support from management contributed to non-compliance<sup>16</sup>. A cross-sectional survey interviewing perioperative nurses in the United States found that strong leadership support is a key component to compliance<sup>3</sup>. Ball<sup>3</sup> also found that leaders must show a keen interest in making sure equipment is available and mandating use through policy enforcement. Scott et al.<sup>17</sup> carried out a quality project in their operating theatre suite to improve compliance with smoke evacuation. It was recognised that management played an important role in supporting the nursing staff to use evacuation equipment and rewarding changes in practice<sup>17</sup>.

## Education

A random sample survey reported that education and demonstration of equipment helps to convince nurses of the need to evacuate surgical plume<sup>3</sup>. The study also found if smoke evacuation policies are easy to understand and implement, nurses will comply with them<sup>3</sup>. Education and training programs are important for compliance: if nurses have knowledge about the hazards of surgical plume, they are more likely to want to use smoke evacuators<sup>12</sup>. A literature review by Lindsey et al.<sup>13</sup> on the hazards of diathermy plume found that nurses used lower

levels of protection with diathermy compared to laser. Surgeons also need to receive education about the hazards of surgical plume<sup>12</sup>. Ball<sup>12</sup> found that many surgeons need to see the evidence before they are willing to change their practice. Edwards and Reiman<sup>16</sup> found that the frequency of smoke evacuation reflected the clinicians' perception of the relative hazard.

## Discussion

This literature review shows that there are various factors influencing smoke evacuation compliance. Limitations of this literature review include the quality of evidence: the majority of studies were cross-sectional surveys, many with a small sample size. Response rates in many studies were also low. The literature mainly focused on perioperative nurses' perceptions. Whilst perioperative nurses' perceptions are important, perhaps more future studies could include surgeon perceptions as the literature demonstrates surgeon refusal is a barrier to successful smoke evacuation compliance. Many studies were also online. Perhaps further studies could be observational and onsite to determine factors influencing compliance, as opposed to perception. Future studies could compare hospitals to determine significant differences in compliance. The majority of studies included in this literature review were conducted in the United States and the United Kingdom; research in Australia, particularly in NSW, to determine the impact of the NSW Health guideline would be beneficial.

## Conclusion

This literature review has shown there are many factors, both positive and negative, influencing compliance with smoke evacuation. Strong leadership and education are

vital to ensuring smoke evacuation compliance. Managers need to agree and stand strong on smoke evacuation. Managers generally tend to have positive relationships with surgeons, which is important to work through the barrier of surgeon refusal<sup>18</sup>. Physicians that support smoke evacuation should be supported and encouraged to serve as advocates<sup>14</sup>. As stated in the NSW Health guideline, policies should be developed at a local level and they should be developed in consultation with surgeons. Policies should be clear, concise and simple to follow. Policies should state when evacuation devices are required to be used and represent the department's stance on plume evacuation. Education, not just for nursing staff but for all perioperative personnel, is important. Surgeons need to be made aware of the hazards of surgical plume and the impact this could potentially have on personnel within the theatre. The literature shows that when nurses are aware of the hazards, compliance increases<sup>3</sup>. This could potentially be the same with surgeons. Education programs should be implemented in all operating suites and made mandatory. Smoke evacuation practices should be monitored regularly for compliance. Compliance should be recognised and non-compliance should be investigated to determine the possible cause.

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The former Australian Council for Safety and Quality in Health Care developed the ‘Standard for credentialing and defining the scope of clinical practice of medical practitioners, for use in public and private hospitals’ in 2004. Its implementation is underway in all jurisdictions and across the private hospital sector. The structures and processes being used vary between states and different health care settings.

The information above is from The Australian Commission on Safety and Quality in Health Care website at <https://www.safetyandquality.gov.au/our-work/credentialing>.



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