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Adesh Shrivastava,  
Noor-Ul-Huda Maria,  
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Luis Rafael Moscote-Salazar



# Surgical smoke, neurosurgical practice and coronavirus: a few words of caution

Adesh Shrivastava<sup>3</sup>, Noor-Ul-Huda Maria<sup>2</sup>, Rakesh Mishra<sup>6</sup>,  
William Florez-Perdomo<sup>4,5</sup>, Amit Agrawal<sup>3</sup>,  
Luis Rafael Moscote-Salazar<sup>1</sup>

<sup>1</sup> Centre of Biomedical Research (CIB) Faculty of Medicine University of Cartagena, COLOMBIA

<sup>2</sup> Punjab Institute of Neurosciences, Lahore, PAKISTAN

<sup>3</sup> All India Institute of Medical Sciences, Bhopal, INDIA

<sup>4</sup> Latin-American Council of Neurocritical Care, COLOMBIA

<sup>5</sup> South Colombian University, Neiva, COLOMBIA

<sup>6</sup> National Institute of Mental Health and Neurosciences, Bengaluru, INDIA

## ABSTRACT

Surgical smoke also referred to as cautery smoke is a gaseous mixture produced during surgical procedures where there is ablation, cutting, coagulation, desiccation or vaporization of the tissue. In a true sense “surgical smoke” refers to surgically generated gaseous contents. The surgical smoke results from the destruction of bones and tissues, causing microscopic particles to get suspended in the environment.

Coagulation devices such as ultrasound, electrical instruments and laser generate nebulization of particles viral, carcinogens and toxic substances. [4, 6] The recent appearance of COVID19 infection has emerged as a risk factor for surgical practice. Surgical smoke contains particulate matter which passes the upper respiratory tract and gets deposited. [7-9] The overall effect of surgical smoke is determined by the duration of the working hours in the operating room [5, 10] as well as safety measures adopted to protect from the surgical smoke. [5]

The global pandemic of Covid-19 has made surgeons rethink their strategies to maximize the safety of treating personnel. Neurosurgery is not untouched by the current situation of this pandemic. There are many concerns including the safety of health care workers, poor availability of resources etc. Many of the elective surgical procedures are postponed all-round the globe as a means to prevent transmission. [11] Since the majority of neurosurgical illness is progressive and can transform from elective to emergency with time. Also, like in other specialities, neurosurgery is benefitted with technological advances to maximize the efficacy and minimize

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Corresponding author:  
**Luis Rafael Moscote-Salazar**

Department of Neurosurgery,  
University of Cartagena, Colombia

rafaelmoscote21@gmail.com

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the morbidity associated with neurosurgical procedures. There are concerns with the use of ultrasonic aspirator, drill system which potentially generates aerosols and surgical smoke. With ongoing pandemic, it is evident that these procedures cannot be postponed indefinitely and no alternative is yet available to ensure a better outcome. Even in neurosurgical emergencies and Neurooncological surgeries, it is of utmost importance to take cognizance of potential effects of surgical smoke and precautions while operating on patients who are suspected or proven Covid-19 positive. Neurological surgery comprises a versatile set of different surgical domains that include spinal surgery, cranial surgery, endoscopic surgery and minimally invasive surgical procedures which have their own biological and physical factors. Since the surgical smoke has heterogenous composition, it is not clear which surgical procedure has more potential to generate smoke containing viral products as particulate matter.

The surgical smoke thus generated consists of 95% water and 5% particulate matter consisting of chemical compounds, cell particles, bacteria, viruses and even drugs are taken by patients.[10, 12-15] Several chemical compounds ( $\geq 80$  different toxic chemicals) have been found in surgical smoke. [16, 17] which have the potential to cause cell damage. [1, 16] Prolonged exposure to surgical smoke (with cumulative dose effect) can cause mild symptoms like headache, irritability, mood changes to severe injuries like an injury to the lungs and in long term infections and a certain type of malignancies. 1, 9, 18 Particulate matter in surgical smoke is mostly less than 5  $\mu\text{m}$  in size. [12, 19] Although many regulatory bodies agree on the dangers of surgical smoke, the degree of hazard and methods to prevent is yet to be firmly established<sup>20</sup>. Electrocautery generates heat which damages the cell membranes and generates smoke containing mostly water vapour which gets aerosolized in the operating room. [2, 8, 21], In addition, it chars the neighbouring cells. This causes further thermal necrosis and releases carbonized cell fragments and gaseous hydrocarbons.[22] The byproduct of diathermy coagulation and biochemicals present in the smoke depends on the settings of diathermy and the tissue being burnt with the gray matter being low particulate matter tissues. [1, 18, 23-27] Similarly ultrasonic aspirators create aerosols by creating cavitation nuclei. The combined

action of ultrasonic aspirators and diathermy electrocoagulation has potential to generate aerosols containing infective particulates. Electrocautery produces more particulate matter than lasers and ultrasonic devices, but because the smoke generated by lasers and ultrasonic devices is colder and has more biohazard with the risk of transmitting infection [1, 26, 27] as the smoke and aerosols can be inhaled and gets deposited in the respiratory system.<sup>28</sup> Though, there is insufficient evidence for COVID-19 transmission through surgical smoke, data, existing studies and expert opinion suggests it a theoretical risk.<sup>29, 30</sup> A review was done based on the existing studies suggested the methods to mitigate the potential risk of surgical smoke and COVID-19 transmission to OR personnel. [29]

The composition of this hazardous surgical smoke depends much on the type of surgical procedure, the duration, the devices/instruments used, the structure of the operating theatre, the expertise of the surgeon, the pathology operated upon and the precautionary measures taken during surgery. It is not hard to imagine that such surgical procedures carry the potential of a generation of heavy and potentially hazardous surgical smoke. While on the other hand, for brain surgery, a use of bipolar cautery, CUSA, ultrasonic probe, generation of biological particle including tumours and again infectious matter, bone dust because of bone drilling and craniotomy flap elevation, neuronavigation and laser contribute in the generation of the Surgical Smoke. Studies on biohazards of surgical smoke have shown the presence of viral DNA, activated Corynebacterium, Hepatitis B, Human papillomavirus. [1, 31-38] In a few studies, 80% of the surgical smoke from infected patients contained viral particles suggesting the potential risk of transmission to personnel in OR. [39-41] Bacteria and viruses can survive in the surgical smoke for up to 72 hours'[19] It has been shown that in aerosols SARS-CoV-2 can survive up to 3 hours and on the surfaces up to 72 hours.<sup>38</sup> However, no data is yet available for transmission of SARS-CoV-2 through smoke produced in a surgical procedure. Majority of the literature available is related to laparoscopic surgeries. [11, 42] Even the biohazard potential is not very well established in other surgical specialities [42-44] SARS-CoV-2 has shown transmission potential through aerosols and fomites similar to SARS-CoV-1 in experimental conditions [38].

To reduce the risk of transmission of SARS-CoV-2 through surgical smoke, preventive strategies suggested by Zheng et al. seems appropriate and worth considering in neurosurgical patients.[11] Chow et al have mentioned the method to convert existing OR into negative pressure OR.<sup>45</sup> Unilaminar airflow in OR is effective in removing 97% of particulate matter of size more than or equal to 0.3  $\mu\text{m}$ .<sup>46</sup> Various filters can be used along with smoke evacuators in the OR like, charcoal filters, coconut shell charcoal, ultralow particulate air (ULPA) filters.<sup>29</sup> these filters can retain particles up to 0.1  $\mu\text{m}$  in size. Different surgical societies all around the world have published guidelines involving comprehensive measures, changes in OR and filtration systems aimed to prevent the established and hypothetical risk of transmission. [47-49] Neurosurgical procedures are not immune to the production of surgical smoke given the usage of ultrasonic aspirators, high-speed pneumatic drills. In parallel to other surgical association, the neurosurgical community should assess the size of the risk to provide quality surgery to the patient and protection of the surgical team. The American National Standards Institute (ANSI) has established strategies for smoke reduction during laser surgery. <sup>50</sup> In the current pandemic of COVID-19, health care worker needs to have PPE and N95 masks. Available masks to prevent inhalation of surgical masks and its health hazards include Surgical mask, N85 masks and High filter masks.[51-53] Surgical mask doesn't provide tight face seal, positive pressure inside the facepiece and filter particulate matter less than 5  $\mu\text{m}$  in size and therefore may fail to protect from transmission of infective pathogens through surgical smoke.[21, 54] Surgical masks may provide > 90% protection and has been in use for a century and N95 mask may not offer adequate protection in these potential contagious procedures and activated carbon filters in addition to N95 may be more appropriate. [21, 55-58] However, N95 masks have their own challenges which includes CO<sub>2</sub> build up, difficulty in breathing after a certain time and subjective symptoms of headache, light headedness etc. [59]

In summary, there is an increased need to create awareness regarding the side effect of surgical smoke, to train an individual to minimize the exposure and develop facilities for the safe evacuation of the surgical smoke in the operation

theatre and thus to safeguard the personnel's in the operating theatre. [21]

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