ORIGINAL ARTICLE

SURGICAL SMOKE INHALATION, ITS HAZARDS AND PREVENTION AMONG PAEDIATRIC SURGERY RESIDENTS IN PAKISTAN

Murad Habib, Muhammad Amjad Chaudhary

Department of Paediatric Surgery, The Children's Hospital Pakistan Institute of Medical Sciences Islamabad-Pakistan

Background: For thousands of years human beings have been using heat as a source of ligature and to treat the wound either it's from the trauma or fought in the wars. In 1854 an imminent surgeon Albrecht Theodor Middendorf published a paper on the application of electrocautery in surgical operations. The objective of the present study was to analyze the hazards of surgical smoke inhalation in Paediatric Surgery residents and to create awareness of its signs and symptoms, risk factors and utilizing preventive measures. **Methods:** A Cross-sectional study was conducted involving all the Paediatric Surgery residents enrolled on a supervised training program in Pakistan between 1st July 2022 to 30th June 2023 at all the tertiary care hospitals in Pakistan. Their socio-demographic, academic data, signs and symptoms and risk factors were calculated. Data was analyzed with descriptive and comparative analysis using SPSS. A Pearson contingency coefficient is used to determine the association between categorical variables. **Results:** Our study included all the Paediatric Surgery residents in Pakistan n=155 over one year starting from July 1st 2022 to June 30th 2023. N=75 (48.4%) were males and n=80 (52.6%) were female residents. Their mean age was 29.5 years±4 (SD). 41% of the residents were from Khyber Teaching Hospital Peshawar, 32% from The Children's Hospital Lahore, 14% from National Institute of Child Health Karachi, 9.8% from The Children's Hospital Islamabad (PIMS) and 5.2% from Lady Reading Hospital Peshawar. N=135 (87.1%) of the residents used electrocautery while performing the surgery (p=0.006). N=121 (78.1%) were aware of its hazards (p=0.341). 90% think they are at an increased risk (p=0.032). Most of them (84.6%) wear a surgical mask while only (64%) wear protective equipment (p=0.321). Think they are at an increased risk of cancers (83.9%) (p=0.002) and should be screened (93.7%) (p=0.343). **Conclusion:** Paediatric Surgery residents are at an increased risk of surgical smoke inhalation, pointing to the emerging need to adopt protective measures by creating awareness, and utilizing health safety checklists and smoke evacuation mechanisms in operation rooms. All residents should seek knowledge on the subject and use personal protective equipment for less harmful effects on their health.

Keywords: Surgical smoke inhalation; Paediatrics; Surgery; Pakistan

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INTRODUCTION

For thousands of years human beings have been using heat as a source of ligature and treating the wound either it's from the trauma or fought in the wars. In 1854 an imminent surgeon Albrecht Theodor Middendorf published a paper on the application of electrocautery in surgical operations.[1] He called it Galvanocautery, whose principal was converting electric current into heat thus can perform tissue dissection and ligature of vessels. He also invented an electric snare (Ligetura Candens) for polypoid tumours. These instruments are direct ancestors of modern-day electrocautery.[2] It was later in 1920 when William T. Bovie, an eccentric inventor with a doctorate in plant physiology, developed electrocautery at Harvard University. Late on Cushing popularized its use in neurosurgery and went on to use it in 500 surgical procedures.[3]

Surgical Smoke' is yielded as a result of the thermal dissection of tissues inside the human body using high-frequency electric currents which convert it into heat disseminating the tissues. The use of electrocautery has now become a quotidian; therefore, it's imperative to analyze the hazards of electrocautery smoke.[4] The integrants of this smoke primarily comprise blood, tissue components, and chemicals, as a result of burning, as well as bacteria and viruses, hazardous gases like CO, HCN and formaldehyde among others are also produced and inhaled.[5]

The application of electrocautery on tissues results in changes in the protein nature of the tissue, which ultimately vaporizes due to high levels of heat and an incision is made along with hindrance of bleeding. As much as this process is revolutionary it doesn't guarantee any safety benefits to the surgeons. It is an occupational hazard causing physical harm and

a major health concern not only to the surgeon or anaesthetist but the entire operating room staff.[6] The presence of bacteria and viruses in the surgical smoke puts the surgeons and associated staff present in the ORs at a high risk of developing infections. There are also various perilous chemicals in the smoke that have a great tendency to cause serious respiratory problems and even carcinogenicity at times depending upon the type and nature of chemicals inhaled e.g., in the case of inhalation of acrylonitrile.[7]

It is one of the major causes of surgeons experiencing headaches in the operation room but data are scarce. However, the possible perils of this smoke can be closely probed putting into consideration the constituents of the smoke and its prospective effects on different parts of the human body.[8]

Our study aimed to present data on surgical smoke inhalation in paediatric surgical residents, its signs and symptoms, socio-demographics, its health concerns and to create awareness among them.

MATERIAL AND METHODS

A Cross-sectional study was conducted involving all the Paediatric Surgery residents enrolled on a supervised training program in Pakistan between 1st July 2022 to 30th June 2023 at all the tertiary care hospitals in Pakistan. Their socio-demographic, academic data, signs and symptoms and risk factors were calculated. Data was analyzed with descriptive and comparative analysis using SPSS. A Pearson contingency coefficient is used to determine the association between categorical variables. A total of 155 met the inclusion criteria and were enrolled in the study.

All the Paediatric Surgery residents who were in a supervised training program at a tertiary care hospital were included in the study.

Those Paediatric Surgery residents who had completed their training and those who were about to start the training were excluded from the study.

Patient data were analyzed by using SPSS 24.0. Frequencies and percentages were calculated for qualitative variables. The association between different parameters was determined by using the chi-square test, and a *p*-value ≤0.05 was considered significant.

RESULTS

Our study included all the Paediatric Surgery residents in Pakistan n=155 over one year starting from July 1st 2022 to June 30th 2023. N=75 (48.4%) were males and n=80 (52.6%) were female residents. Their mean age was 29.5 years ±4 (SD). 41% of the residents were from Khyber Teaching Hospital Peshawar, 32% from The Children's Hospital Lahore, 14% from the National Institute of Child Health Karachi, 9.8% from The Children's Hospital Islamabad (PIMS) and 5.2% from Lady Reading Hospital Peshawar. N=135 (87.1%) of the residents used electrocautery while performing the surgery.

Table-1: Distribution of frequencies

Question	Yes n (%)	No n (%)	Total n (%)
Do you use electrocautery	135 (87.1)	20 (12.9)	155 (100)
Do you prefer the use of electrocautery*	64 (41.3)	18 (11.6)	155 (100)
Do you smoke	25 (16.1)	130 (83.9)	155 (100)
Are you aware of the hazards of electrocautery	121 (78.1)	34 (21.9)	155 (100)

Table-2: Response of residents toward surgical smoke inhalation

Question	Male n (%) Yes	Female n (%) Yes	Total n (%)	*p*-value
Do you use electrocautery	71 (94.7)	64 (80)	135 (87.1)	0.006
Do you prefer the use of electrocautery	37 (49.3)	27 (33.75)	64 (41.3)	0.026
Are you aware of the hazards of electrocautery	61 (81.3)	60 (75)	121 (78.1)	0.341
Do you smoke	22 (29.3)	3 (3.8)	25 (16.1)	0.000
Do you have any lung disease	7 (9.3)	13 (16.3)	20 (12.9)	0.199
Do you think the operating surgeon is at risk of surgical smoke inhalation	72 (96)	75 (93.8)	147 (94.8)	0.527
Do you think the assistant is at risk of surgical smoke inhalation	43 (57.3)	47 (58.8)	90 (58.1)	0.032
Do you use personal protective equipment	45 (60)	55 (68.75)	100 (64)	0.321
Do you wear a surgical mask while operating	62 (82.7)	72 (90)	134 (84.6)	0.182
Do you think the surgical mask can provide adequate protection	10 (13.3)	16 (20)	26 (16.8)	0.422
Do you use the WHO surgical safety checklist	66 (88)	74 (92.5)	140 (90.3)	0.344
Do you have a smoke evacuation mechanism in your operation rooms	8 (10.7)	9 (11.3)	17 (11)	0.104
Would you prefer a smoke evacuation mechanism in your operation rooms	69 (92)	70 (87.5)	139 (89.7)	0.349
Have you ever experienced any headaches while operating	30 (40)	28 (35)	58 (37.4)	0.577
Do you think inhaling surgical smoke for longer periods of time can cause cancer	63 (84)	67 (83.8)	130 (83.9)	0.002
Do you think that the residents should be screened	74 (98.3)	77 (96.3)	151 (97.3)	0.343

Procedures while n=64 (41.3%) of the residents preferred the use of electrocautery. The majority of the population were non-smokers n=130 (83.9%) and only n=25 (16%) were smokers of which n=6 (3.9%) smoked greater than 3 cigarettes per day. The majority of the residents were aware of the hazards of electrocautery use n=121 (78.1%).

All the responses were gathered on a *Performa* n=71 (94.7%) male while n=64 (80%) of the female residents used electrocautery (p=0.006). of which n=121 (78.1%) residents were aware of the hazards of surgical smoke (p=0.341). out of n=25 smokers n=22(29.3%) was male and n=3(3.8) were females (p=0.000) who were found to be at greater risk (p=0.178). Most of the residents did not have prior lung disease n=7 (9.3%) males and n=13(16.3%) females had lung disease including cough allergies and asthma and were prone to the excessive use of electrocautery smoke (p=0.015).

The majority of the residents thought that the operating surgeon was at a greater risk of inhaling surgical smoke n=147 (94.8%) (p=0.527) while n=90 (58.1%) concluded that the assistant is at risk (p=0.032) n=27(17%) also stated that during the procedures anaesthetist is also at the risk of surgical smoke inhalation (p=0.001). The majority of the residents use personal protective equipment n=134 (84.1%) wear a surgical mask while operating and think it can provide adequate protection from surgical smoke inhalation (p=0.422). 90% of the operation theatres use the WHO surgical safety checklist n=140 (p=0.344) but most of the operation rooms 79.4% were not up to the WHO standards (p=0.906) as they lack the laminar flow and smoke inhalation mechanism (p=0.104). One-third of residents experienced headaches while operating n=58 (37.4%) (p=0.577). N=37 23.9% had a dry cough and n=2 (1.3%) had a productive cough (p=0.502) but almost all the residents n=151 (97.3%) thought that they should screened for diseases caused by inhaling surgical smoke for a longer duration of time as they are more prone to diseases p=0.343 as in the longer duration it can cause lung cancer p=0.002.

DISCUSSION

This study was the first to systematically evaluate the hazards of surgical smoke and its prevention in Pakistan. In addition, we gained insight into the state of knowledge and the corresponding attitudes of surgical residents in the operating rooms.[9] Consistent with other studies mentioned above, personal protective equipment plays a major role in protecting the surgeon as our data states majority of the residents use personal protective equipment n=134 (84.1%) wear a surgical mask while operating and think it can provide adequate protection from surgical smoke inhalation (p=0.422) but the published recommendations are not satisfactorily known. As far as the awareness of surgical smoke as a potential health hazard is concerned.[10] Majority of the residents were aware of the hazards of electrocautery use n=121 (78.1%) were well aware of the hazards caused by electrocautery smoke. More consistent instructions and updates in the use of technical equipment and smoke-avoidant working techniques would hopefully improve deficits and might counteract the fatalism of smoke inhalation among surgeons.[11]

Fit-tested surgical masks covering the mouth and nose for filtration of high-penetration particles and microbes and found them not to be sufficient.[12] And the majority of our residents n=125 (80%) wore the surgical mask alone n=21 (13.5%) wore a surgical mask plus eye equipment while only n=9 (5.8%) of the residents wore a surgical mask plus eye equipment plus a face shield. Hence most of them are at an increased risk. Moreover, our operation rooms are not designed in a way to keep the laminar flow 79.4% were not up to the WHO standards (p=0.906) as they lack the laminar flow and smoke inhalation mechanism (p=0.104) and instead of electro-ventilation we use the mechanical ventilation which instead of evacuating the smoke spreads it in the operation room. The low-pressure suctioning used during the procedures also results in the retention of the smoke so the manufacturing unit where suction is connected directly to electrocautery or canister is recommended.[13] Hence in the US the use of local exhaust ventilation (LEV) systems has been recommended by the Association of peri-operative Surgeons to minimize the health risks for surgeons working in the operation rooms.[14] Hill *et al* stated in a UK study that smoke extraction systems were only available in 66% of 50 plastic surgery units investigated.[8]

The extensive study by Steege *et al* with over 4500 respondents provides a good overview of various protective measures in operating rooms in the USA. Only half of the respondents reported that LEV was always used during laser surgery and a minority of the respondents (14%) said this was true during electro-surgery. Most respondents reported never wearing any special respiratory mask and 74/39% of the staff exposed to surgical smoke during laser and electro-surgery wear special eye protection we noted similar findings where only 19% of the residents wore eye equipment.[15]

Aside from the macroscopic problems the threats that the microscopic components of surgical smoke can cause are enormous as they have the tendency to initiate the process of carcinogenesis.[16] Since they have no protection n=130 (83.1%) of the residents thought that by inhaling the surgical smoke

and its particles in one-surgery they were at an increased risk of cancers. This happens as a consequence of the transfer of mutagenic chemicals from the fumes as well as the tumour cells that become a part of the fumes from the burnt tissues.[17] The presence of extremely pernicious viruses and bacteria in the fumes sparks a great danger for the surgical staff to develop life-threatening infections through viruses like Human Papilloma Virus and Human Immunodeficiency Virus and bacteria like Staph. Coccus and Neisseria from patients already infected by these viruses.[18]

Though the evidence proving the carcinogenic effects of Surgical Smoke is low owing to the possible reason that it causes its effects over a longer period rather than immediately; however, it's of utmost importance that surgeons and the related staff are cognizant of the hazards that the Surgical Smoke carries so that they can demand proper ventilation systems to exhaust out the smoke from the operation room as soon as it is produced.[11] Proper and specialized ventilation, incorporating transportable ventilating units and suction units, is the key component when it comes to protection against surgical smoke; the required propriety is that the polluted air is exchanged several times in the period of an hour.[19]

The microparticles (0.1–0.5 mm) that are not visible to the naked eye are a strong indicator of hidden menaces of surgical smoke to the surgeons and surgical staff. The smaller the particle, the easier it is for it to invade and surpass the human body's defences.[20] We are well aware of the fact that the surgical masks used by surgeons and other surgical staff present in operation theatre have a pore size equal to 0.3–10 micrometres, which can easily allow the entry of hazardous surgical smoke particles and pathogens through it. This explains how the safety measures taken by surgeons and surgical staff are in no way near enough to protect them from the pitfalls of Surgical smoke.[21]

Despite the recommendations the level of protection among the residents is very low keeping in mind they are exposed to surgical smoke all day which makes them more vulnerable. Very few people utilize the WHO surgical safety checklist. And on top of that, our operation rooms are outdated and out of practice. It needs re-thinking, re-evaluating and policy-making for a change. Everywhere in the operation rooms, there should be standard operating procedures that should be followed. Preventable behaviour is necessary to identify obstacles and even positive thinking can bring greater change.

Our study was a pioneer in the country that highlighted the hazards of surgical smoke inhalation in Paediatric Surgery residents. The risks of the disease, its signs and symptoms and moreover preventive measures. This information reaffirms the importance of finding strategies to prevent risks related to exposure to surgical smoke.

CONCLUSION

Paediatric Surgery residents are at an increased risk of surgical smoke inhalation, pointing to the emerging need to adopt protective measures by creating awareness, and utilizing health safety checklists and smoke evacuation mechanisms in operation rooms. All residents should seek knowledge on the subject and use personal protective equipment for less harmful effects on their health.

Data Availability

The data that support the findings of this study are available from the corresponding author upon request to the corresponding author.

Code Availability

All study code is available upon request to the corresponding author.

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Conflict of interest

The authors have no conflicts of interest relevant to this article to disclose.

Ethical Approval

This study was reviewed and approved by the ethical review board of the Pakistan Institute of Medical Sciences Islamabad.

Consent to Participate

All participants provided informed consent before study participation

AUTHORS' CONTRIBUTION

MH, MAC: Concept. MH: Acquisition of data. MH, MAC: Interpretation of data. MH, MAC: Statistical analysis. MH: Writing, editing and formatting. MAC: Supervision

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Address for Correspondence:
Murad Habib, Resident Paediatric Surgery, The Children's Hospital, Pakistan Institute of Medical Sciences Islamabad, Pakistan
Email: muradhabib007@gmail.com