Spotlight on lung health in operating theatre staff

Occupational inhalant exposures in the operating theatre are an under-recognised hazard, particularly in low- to middle-income countries (LMICs), where control measures are often inadequate. Healthcare professionals working in these environments are subjected to chronic exposure to various inhalant exposures, which may affect lung health, especially the airways, over time.

The cross-sectional study of theatre staff in Sudan by Ibrahim *et al.*[1] assessed spirometric indices among 92 healthcare professionals who routinely worked in operating theatres, including anaesthetists, surgeons, scrub nurses and assistants. Comparison with a matched unexposed group revealed that operating theatre personnel had significantly lower mean lung function indices for forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC ratio, and peak expiratory flow parameters. The decrease in lung function was more pronounced with increasing years of working in the operating theatre, especially among scrub nurses and assistants, who are commonly exposed to chemical disinfectants and surgical smoke. This is one of few studies to report on lung function in operating theatre personnel. However, there were some limitations, including the choice of a suitable comparison group, small sample size, possible over-adjusting in the analysis, and lack of objective exposure information. The study raises an important question – what are the likely causative agents responsible for the decrements in lung function observed in these theatre staff? Potential candidates to be considered include waste anaesthetic gases (WAGs), surgical smoke, cleaning agent aerosols and bio-aerosols (including non-infectious natural rubber latex particles), or in all likelihood a combination of these exposures.

A cross-sectional Brazilian study showed that young physicians exposed to elevated concentrations of WAGs over a 3-year period during their residency had significantly higher biomarkers of DNA damage, increased micronucleus frequency, and elevated inflammatory markers (interleukin (IL) 17) compared with controls,[2] while another study also found increased levels of IL-8.[3] Both these proinflammatory interleukins (IL-8 and IL-17) can affect the airways and contribute to respiratory pathology and airway disease.[4] A recent systematic review of exposure studies of halogenated anaesthetic gases in hospitals suggested that monitoring practices for WAGs varied considerably between countries and that there were no internationally based exposure standards for desflurane and sevoflurane, despite them being commonly used.[5] Furthermore, real-time environmental monitoring was rarely used, hampering early detection to enable risk mitigation. It is probable that exposures can often exceed occupational exposure limits in operating theatres, especially those without effective scavenging or ventilation systems, which is likely to be the case in under-resourced settings.

Surgical smoke, generated during electrocautery and laser procedures, may be another potential culprit. It is composed of fine particulates, toxic organic compounds, and biological contaminants (viable and non-viable material). However, few studies have quantified the long-term impact of surgical smoke on lung function. A study of perioperative theatre staff in Malaysia revealed that levels of nitrous oxide and halogenated agents exceeded international exposure standards, and were accompanied by increased reports of symptoms among theatre nurses and anaesthetists.[6] The study suggested that prolonged exposure to surgical smoke was associated with an increased prevalence of airway symptoms, including asthma-like symptoms (12%). However, a recent meta-analysis concluded that the risk of exposure to surgical smoke has historically been overstated and that there was little evidence for health risks associated with exposure to surgical smoke.[7]

Evidence for the role of cleaning agents in causing lung function abnormalities is perhaps more convincing. In a recent review, Mwanga *et al.*[8] identified various synthetic chemical disinfectant or cleaning agents, including aldehydes, peracetic acid and quaternary ammonium compounds, as significant contributors to airway disease, including asthma and chronic obstructive pulmonary disease, in hospital workers. In particular, symptoms of irritant-induced asthma and lung function abnormalities have been associated with regular use of these agents, especially in the aerosolised form. Given that theatre assistants are often tasked with cleaning instruments and surfaces between procedures, their cumulative exposure is likely to be considerable, increasing their risk of developing asthma.

In addition to these ubiquitous exposures in theatre environments, latex aeroallergens represent a historically significant but constantly overlooked inhalational hazard. Powdered latex gloves, widely used in these environments in the past, release airborne latex proteins that are inhaled, causing immunoglobulin E-mediated sensitisation and occupational asthma. Various studies have shown that replacement of powdered high-protein gloves with powder-free, low-protein or non-latex alternatives has led to a substantial decline in new sensitisation cases and latex-induced asthma globally, especially in high-income countries.[9] However, in many LMIC or under-resourced settings, cost considerations mean that these gloves continue to be used, especially in public sector health facilities, posing a risk to theatre staff.

These various studies suggest that a constellation of inhalant exposures in the operating theatre have the potential to cause airway disease and pulmonary function abnormalities if unaddressed. The heterogeneity in agent types, exposure duration and integrity of environmental control measures makes it difficult to attribute the decreased lung function observed in the Ibrahim study[1] to a specific cause. Furthermore, the specific occupational exposures in this setting were not characterised, and they were not specifically correlated with work-related respiratory symptoms or adverse lung function outcomes. It is plausible, however, that the absence of effective control measures in such facilities, such as active scavenging for WAGs, surgical smoke evacuation systems, adequate general ventilation and appropriate respiratory protective equipment, could have contributed to the adverse lung function outcomes observed. Given the small sample size and the cross-sectional nature of the study design, the Ibrahim study[1] lacked the power to conduct more advanced exposure-response analysis to identify the causative factors associated with these lung function deficits. Future longitudinal studies conducted in larger populations of health workers and incorporating both exposure and adverse respiratory outcomes, including work-related symptoms and

repeated spirometric measurements, will have greater ability to assess deterioration over time.

Nevertheless, the findings of Ibrahim *et al*.[1] and other related studies of operating theatre environments have important implications for occupational health surveillance and policy, especially in LMIC healthcare institutions. Regular environmental and medical surveillance of theatres and theatre staff should be performed to identify prolonged high-risk exposure settings. Risk reduction strategies, including improved ventilation, routine use of scavenging and smoke evacuation systems, and substitution of high-risk cleaning agents with safer alternatives, should be required in such facilities. To achieve optimal ventilation in healthcare environments, various international bodies have consistently proposed higher air change rates for operating theatres, as contained in the ANSI/ASHRAE/ASHE Standard 170 for Ventilation of Health Care Facilities. This standard requires conventional operating theatres to have a minimum of 25 air changes per hour (ACH) when built. While the level may fall to 20 ACH for older theatres over time, it is advised that air changes should be kept at this level through regular maintenance.[10,11] Latex exposure that continues to exist in certain settings should be eliminated through the procurement of non-powdered, low-protein gloves or latex-free gloves. Training of staff in best practices for reducing airborne exposures to chemical and bio-aerosols is also essential.

In conclusion, while it is probable that operating theatre staff are at increased risk of adverse lung function outcomes as a result of cumulative multiple inhalational exposures from various sources, the attributable fraction of these causes needs further investigation in well-designed longitudinal studies of workers in high-risk occupational settings.

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