Editorial

Aerosol generating procedures: research, guidance and implementation

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On 11 March 2020, the World Health Organization formally declared COVID-19 to be a pandemic. Although knowledge of the disease was far from complete, it was clear that anaesthetists would play a vital role in accommodating the expansion of critical care and managing deteriorating patients. Based on experience of previous outbreaks, airborne transmission was identified as a potential route of transmission for SARS-CoV-2. Involvement in aerosol-generating procedures (AGPs) was therefore thought to be high-risk for transmission of infection to healthcare workers. Clinical guidance relating to AGPs was issued rapidly, with substantial changes in practice including the avoidance of general anaesthesia where possible and the use of cumbersome 'airborne' personal protective equipment (PPE).

In this issue of *Anaesthesia*, Shrimpton et al. report a mixed methods study of the perceptions and practices of UK anaesthetists in relation to PPE and COVID-19 [1]. The study showed that AGPs were initially a major focus for anaesthetists but that, over time, the perceived significance of these procedures diminished. Initial perceptions were characterised by fear and uncertainty, tempered by a sense of duty and bravery. However, by the time of the study, many respondents described the establishment of individualised practices based on personalised risk perceptions. Some of these practices deviated substantially from infection prevention and control guidance, for example, by abandoning certain elements of PPE [1, 2]. This was justified, in part, by perceptions that PPE impaired the efficiency and safety of care and communication, concerns about the resource and environmental implications of PPE use, and the impacts on training. The fact that clinicians deviated from national recommendations suggests that there came a point in the pandemic when infection prevention and control guidelines failed to 'work' for healthcare professionals. In this editorial, we will consider the context and timing of the study by Shrimpton et al., review how our understanding of AGPs and their implications for practice have evolved over the course of the pandemic and suggest how this work may inform future practice.

The study by Shrimpton et al. comprised a survey between November and December 2021 (333 respondents) and interviews between December 2021 and February 2022 (18 respondents) [1]. The study period therefore spanned the surge in the omicron BA1 variant and was conducted in the context of a vaccination programme that had been established for 12 months in the UK [3]. In addition, there was an increasing body of evidence (much of which was conducted by the same authors) that called into question the legitimacy of labelling many anaesthesia-related procedures as being aerosol generating.

The transmission of SARS-CoV-2 has been conceptualised as occurring via three modes: contact; droplet; and aerosol. Each was accompanied by different infection prevention and control guidance for PPE [4]. It was hypothesised that aerosols, defined as small particles which remain suspended in air, were only generated in significant amounts during specific procedures. Therefore, airborne PPE comprising a respirator (e.g. filtering facepiece class 3 (FFP3)), eye protection, gown and gloves, was only required to be worn when conducting an AGP. Following an AGP, aerosol clearance (fallow) times were advised in many settings before staff not wearing airborne PPE could enter [4-6]. This had an important impact on the efficiency of operating theatre work, at a time when NHS waiting lists are overwhelmed.

Aerosol-generating procedures have potentially important impacts on staff, healthcare practices and efficiency; it is therefore important that these are accurately defined. Before the COVID-19 pandemic, however, the scientific understanding of AGPs was limited, being largely derived from epidemiological evidence acquired during outbreaks of SARS-CoV-1. This evidence, summarised in a systematic review by Tran et al. [7], was instrumental in the development of the original UK Health Security Agency (then Public Health England) 'AGP list' which included several procedures intrinsic to the practice of anaesthesia (Table 1) [8]. In June 2020, data from the intubateCOVID registry found that 1 in 10 healthcare workers present at the time of tracheal intubation of patients with COVID-19 subsequently tested positive for SARS-CoV-1 [9], potentially reinforcing concerns regarding AGPs and disease transmission. Following this early epidemiological work, research was then undertaken to assess the amount of aerosol generated by AGPs in comparison with physiological respiratory activities. Though much of this work had been published at the time of the study by Shrimpton et al., little of it had impacted policy, as noted by some interview respondents. Particularly significant were the studies that sampled aerosols at the time of high-flow nasal oxygen administration, facemask ventilation, tracheal intubation/extubation and supraglottic airway device insertion/removal [10-14]. These studies showed that anaesthetic procedures generate little aerosolised material and yet remained prominent in the AGP list. We can only speculate as to why guidelines failed to accommodate new evidence in a timely fashion, but plausible explanations include the risk of frequent guideline changes causing confusion amongst clinical staff, potential embarrassment of a ‘U turn’ on a prominent clinical issue that defined practice in the early days of the pandemic and uncertainties regarding the generalisability of evidence generated by patients and volunteers without COVID-19 to the SARS-CoV-2 positive population.

At the time of the study by Shrimpton et al., the prevalence of SARS-CoV-2 infection in England peaked at 6.85% (week commencing 31/12/2021) [15]. Yet despite this, the UK adopted a ‘living with COVID-19’ approach based largely on personal responsibility instead of public health measures, and this is reflected in the data from Shrimpton et al. The first member of the UK public was vaccinated against SARS-CoV-2 infection on 8 December 2020, and by the time of the study by Shrimpton et al., 41 million UK citizens (including 91% of NHS staff) had completed a course of two vaccinations, with 31 million having received an additional booster [16]. The UK vaccination programme is modelled to have prevented an additional 427,900 deaths by the end of 2021 [17, 18]. Furthermore, the omicron variant, prevalent at the time of data collection by Shrimpton et al., appeared to cause less severe disease in many patients. These factors are likely to have bolstered respondents’ decisions to take an individualised approach to their use of PPE.

As a mixed methods study, understanding the implications of the work by Shrimpton et al. should include assessments of generalisability (applicability of findings to the population – used in quantitative research where sampling should represent a larger group), and transferability (applicability of findings to others – used in qualitative research where sampling often intentionally focuses on specific individuals). The survey has some elements that support the generalisability of findings, including a demographic spread that mirrors that of the anaesthesia workforce. However, out of almost 15,000 anaesthetists in the UK, only 333 responded to the survey. Could the low response rate reflect busy clinician lives or an element of fatigue, not only with surveys, but with the pandemic itself? Of those who responded, 20% identified as “*clinically extremely vulnerable*", compared with around 6% of the population overall [19]. This, combined with the low response rate, raises the question of whether this survey appealed more to some potential respondents. The qualitative component made use of several techniques to promote the quality of data acquisition and analysis including: use of a topic guide during interviews; regular team meetings; supervision by a methodologist and researcher; analyst triangulation; and maintenance of a reflexive diary [20].However, the sampling strategy, although designed to represent “*the range of respondent characteristics and levels of concern about AGPs*” through purposive sampling, arrived at a sample where doctors in training were under-represented relative to the workforce, with only a single core trainee and no acute care common stem trainees involved. This could be an important omission: rotations mean that doctors in training had to work with a variety of PPE guidelines across different hospital Trusts, making them simultaneously well-placed to comment on the variety of guidance and particularly vulnerable to the effects of inconsistent advice. We wonder if trainees did not feel best placed to comment amid having to keep up with so many changes in policy. It is also worth noting that much of the work and guidance discussed pertains to the UK in what is an ongoing global pandemic, and most of the aerosol work has been undertaken by anaesthetists. Whilst relevant to UK anaesthetic practice, how does this apply internationally? And is it relevant to our intensive care, emergency medicine and allied healthcare professional colleagues to name but a few?

The publication of the study by Shrimpton et al. comes shortly after a change in the NHS England list of AGPs [8]. Published following a review of evidence in June 2022, this new list (Table 1) reflects that activity in patients who are anaesthetised poses less risk than originally thought [21]. It is notable, however, that changes to this list have been made only through exclusion, with no addition of new AGPs despite evidence, for example, that coughing generates substantial quantities of aerosolised material. Again, we can only speculate as to why this is. It is possible that because coughing is not a 'procedure' as such, it could be argued to fall outside the scope of the guidance. However, it is also clear that the impact of recognising coughing as aerosol generating in national infection prevention and control guidance would have huge implications for PPE use. Originally, it was felt that staff working in anaesthesia and intensive care were at greatest risk and, as such, were provided with higher-grade PPE than ward-based colleagues [4]. With what we know now, should this be reversed? One can't help but wonder how this would have impacted supplies and infection rates in 2020.

Going forward, we should consider variables in the whole chain of infection when considering how best to protect healthcare workers, including the: pathogen; reservoir; portal of exit; mode of transmission; portal of entry; and host susceptibility. The list of AGPs has changed, with a clear direction of travel towards minimising PPE use, but does this accommodate the considerations of the immunocompromised worker or those providing care to patients without a clear diagnosis? Notably, the National Infection Prevention and Control Manual still recommends FFP3 use for any patient contact with untreated tuberculosis – it appears that not all potentially-airborne pathogens are treated equally [8].

The limitations of the evidence and appropriate application of policy are important. We should be cautious about making blanket statements based on a list of AGPs. The balance between worker preferences, individual risk and organisational duty to prevent industrial injury is controversial. Several European countries recognise COVID-19 as an occupational disease [22]. However, the Industrial Injuries Advisory Council have yet to confirm COVID-19 as a 'prescribed disease' (i.e. with occupational mortality risk) in the health and social care setting [23-25]. Other sequelae are also relevant and may ultimately have greater impact than primary COVID-19, including long COVID, post-intensive care syndrome, pulmonary embolism and stroke.

The efficiency of peri-operative care is a pressing concern, with a backlog of six million people waiting for pre-planned NHS care. Could alterations to infection prevention and control practices enhance operating theatre throughput? Abandoning aerosol clearance times seems to be an obvious way to increase list capacity in light of recent evidence. But further marginal efficiency gains could be made by reducing the use of cumbersome PPE. Would this be truly 'living with COVID', or an irresponsible approach to staff welfare? A subsequent study co-authored by some members of the same research group has documented an association between respiratory protective equipment and adverse events in the operating theatre [26], which perhaps supports the notion that clinical judgement has an important role to play in reconciling the advantages and disadvantages of PPE use.

In the current phase of the pandemic, PPE guidelines are called on to meet the needs of multiple stakeholders: to be standardised but individualised; evidence-based but consistent; and safe but expedient. The study by Shrimpton et al. shows that as the pandemic has progressed, anaesthetists have become alert to the dynamic nature of the evidence base and are well placed to make judgements accordingly [1]. Whilst it may be convenient to match modes of transmission to PPE requirements in national guidance, this does little to accommodate staff, patient or institutional factors. As winter looms and waiting lists continue to grow [27], perhaps it is time for PPE guidelines to acknowledge complexity and make room for professional judgement.

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Table 1: Changes to the NHS England aerosol-generating procedure list over time.

	January 2020	**May 2020**	**June 2022**
Airway	▪ Tracheal intubation, extubation and related procedures ▪ Tracheostomy procedures	▪ Tracheal intubation and extubation ▪ Tracheostomy procedures	▪ Tracheostomy procedures
Ventilation	▪ Manual ventilation ▪ Non-invasive ventilation, including BiPAP and CPAP. ▪ HFNO ▪ HFOV	▪ Manual ventilation ▪ Non-invasive ventilation, including BiPAP and CPAP. ▪ HFNO ▪ HFOV	
Respiratory	▪ Bronchoscopy ▪ Induction of sputum ▪ Open suctioning	▪ Bronchoscopy ▪ Induction of sputum using nebulised saline ▪ Respiratory tract suctioning	▪ Awake* bronchoscopy (including awake tracheal intubation) ▪ Induction of sputum ▪ Respiratory tract suctioning
Surgery	▪ Some dental procedures (e.g. high speed drilling). ▪ Surgery and post-mortem procedures in which high-speed devices are used	▪ Dental procedures using high-speed devices ▪ Upper ENT airway procedures that involve suctioning ▪ Upper gastro-intestinal endoscopy where there is open suctioning of the upper respiratory tract ▪ High-speed cutting in surgery or post-mortem if involving the respiratory tract or paranasal sinuses	▪ Dental procedures (using high-speed or high frequency devices, e.g. ultrasonic scalers/high speed drills) ▪ Awake* ENT airway procedures that involve respiratory suctioning ▪ Awake* upper gastro-intestinal endoscopy ▪ Surgery or post-mortem procedures (like high-speed cutting/drilling) likely to produce aerosol from the respiratory tract (upper or lower) or sinuses

BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; HFNO, high-flow nasal oxygen; HFOV, High-frequency oscillatory ventilation; ENT, ear, nose and throat. *includes conscious sedation