



Personal protective equipment (PPE) for vitreoretinal surgery during COVID-19

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SARS-CoV-2 is the recently discovered virus which has resulted in the pandemic illness known as coronavirus disease 2019 (COVID-19) [1]. It is from the family of viruses known as Coronaviridae, which were also responsible for severe acute respiratory syndrome (SARS), which originated in China in 2002, and Middle East respiratory syndrome coronavirus in 2012. It is thought to be a zoonosis, possibly originating in bats, which has undergone intra-species transfer between intermediary hosts and humans.

The high infectivity of SARS-Cov-2 is a major contributor to this pandemic. Infectivity of a pathogen can be quantified as the basic reproduction number (R0). This is the number of cases directly generated by one case in a population where all individuals are susceptible to infection [2]. Estimates suggest that, for SARS-CoV-2, R0 is >2.4 [3–5]; thus for every case which occurs, on average more than two additional cases are generated in a susceptible population, in the absence of adequate measures such as isolation. For comparison, seasonal flu has an R0 of ~1.2 [6].

A major issue with regards to infectivity, particularly when considering implementing targeted measures to reduce spread, is the potential for transmission by asymptomatic patients. The risk of contagion presented by asymptomatic or mildly symptomatic cases of SARS-CoV-2 is unclear. The majority of descriptive papers investigating mild symptoms are focused on inpatients [7], specific populations [8] or modelling [9]. Although there are suggestions of lower infectivity amongst asymptomatic patients [9], this has not been confirmed. Estimates for the proportion of asymptomatic patients infected with SARS-CoV-2 in different populations range between 7 and 80% [10–12], with a substantial proportion of transmission occurring prior to illness onset [13, 14].

Protecting healthcare workers is an imperative [15], particularly for those who work in close proximity to patients' faces including ophthalmologists. Regularly updated recommendations have been issued to reduce patient contact and adjust patient flow for ophthalmology during the pandemic [16]. Gloves, disposable aprons, eye protection, fluid resistant type IIR surgical masks and slit

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lamp guards are recommended as personal protective equipment (PPE) for ophthalmic clinic assessment by the Royal College of Ophthalmologists [17]. In addition, the optimal type of respiratory protective masks remains a matter of important debate and varies. Within Europe, filtering face piece (FFP) respirator masks are graded based on filter efficacy and face adhesion: FFP 1–3 are able to filter with efficacies of 80%, 94% and 99% respectively [14, 18]. Within the USA, FFP2 masks are termed N95. Guidelines for mask use vary worldwide. The European Centre for Disease and Prevention and the US CDC [19] recommend FFP2 masks (N95) for care of patients with COVID-19, whilst the WHO recommends standard surgical masks [20]. Within the UK, Public Health England regularly update their guidance with regard to PPE [21].

A major discriminator in determining mask use is whether staff are exposed to aerosols. SARS-CoV-2 likely binds in the first instance to nasal epithelial cells before migrating through the bronchial tree where it preferentially infects alveolar type II lung cells leading to a viral laden mucus that passes up the respiratory tract [22]. Transmission can occur through droplets and viral laden aerosols generated from breathing, coughing and sneezing and, in the healthcare environment, from procedures known as aerosol generating procedures. Large droplets are propelled through the air and can cause infection through a contact mechanism with or without fomites [12, 23]. Small droplets may evaporate to create an aerosol; defined as small particles (<10 µm diameter) in suspension in gas [24]. Aerosols can remain suspended in the air for long periods, with the potential of travelling large distances (metres) transmitting disease by being inhaled and penetrating deeply into the respiratory tract. Symptomatic patients with SARS tend to develop lower respiratory tract infections, suggesting aerosol transmission is important [25]. Numerous studies have demonstrated the presence of influenza virus in exhaled breath [26, 27]. SARS-CoV-2 has been demonstrated in tears [28], and causes ocular signs in patients with COVID-19 [29], although infrequently. Therefore, there is a potential for ocular mucosal transmission, though this is likely to be much less than via the respiratory mucosa. Viral presence in intraocular contents is unknown.

In AGPs, aerosols can be generated by applying sufficient mechanical energy (from high speed devices) to an air-water interface to form fine droplets. They can be generated from the evaporation of larger droplets (<100 µm) as they settle in air and also by fragmentation of large droplets once they dry on surfaces and are later resuspended.

AGPs involving the upper respiratory tract including endotracheal intubation and airway suction are recognised to be associated with an increased risk of SARS transmission to healthcare workers [30] including SARS-CoV-2 [31] but the risks from other anatomical sites are less clear.

PHE has also included “surgery with high speed devices” as AGPs [21]. There are reports of high speed drills and hydro-surgical debridement used in spinal surgery generating aerosols [32, 33], and viable viral pathogen on dental drills [34]. Mask use in the context of AGP is more stringent. To try to avoid inhalation of small viral laden particles in the air requires a tight seal around the edge of the mask and greater filtering capacity. However, the exact requirements mandated vary throughout the world. Chinese physicians suggest that in addition to N95 masks, that “Full-face respiratory protective devices or powered air-purifying respirator” be employed [35]. In the UK, PHE recommends single use FFP masks [21].

There is, as yet, no robust evidence on the AGP nature of our intraocular surgical instruments. The frequency of modern phacoemulsification handpieces exceeds 40 kHz and modern pars plana vitrectomy (PPV) handpieces have cut rates in excess of 5000 cuts/min. These can therefore certainly be considered “high speed” surgical devices. In addition, it is possible that other vitreoretinal surgical manoeuvres could generate droplets or aerosol, such as fluid-air exchange. During the SARS-CoV-2 pandemic, it is likely that PPV for rhegmatogenous retinal detachment will be the most commonly performed intraocular surgery. The length of surgery in close proximity to patient airways poses further risk. To minimise risk of transmission, we as the Royal College of Ophthalmologists and the British and Eire Association of Vitreoretinal Surgeons have issued specific guidelines regarding these procedures [17]. These include reducing surgical volume, minimising staff presence and potential use of additional surgical drapes to minimise aerosol transmission. In particular, despite the absence of complete evidence at present, but based on the balance of risk and probability, we consider PPV should be treated as an AGP. We therefore advise appropriate PPE including FFP3 masks for surgeon and nurses during these procedures. Given the asymptomatic burden of SARS-Cov-2, we have recommended these precautions should be applied regardless of patients’ symptoms [17]. We are pleased to note that the American Society of Retinal Specialists has more recently made similar recommendations [36] embodying a wider consensus. Recommendations will continue to adapt, reflecting the impact of social measures, new scientific evidence, more reliable viral testing and population healthcare needs.

The increased use of PPE worldwide is inevitably leading to supply shortages. Guidance from PHE continues to be updated in response to this issue, with advice now on reuse of gowns [37]. In the long term however there needs to be close coordination between medical, engineering, research and manufacturing communities to evaluate and extend the options for recycling and re-sterilising PPE on a large scale whilst maintaining

anti-viral properties and protection. This needs to be undertaken multilaterally and urgently as the precious resource of PPE is shrinking.

The anxieties during this pandemic will not easily be allayed. However, by employing cautious clinical principles and ensuring high standard of protection, we hope to minimise the risk to surgeons, nurses and patients.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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