Aerosol generation: the safety of phacoemulsification in the pandemic era

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Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

—Marie Curie

With an estimate of 3.6 million cataract surgeries performed in the United States annually, and at least 20 million worldwide, it would have been impossible in 2019 to imagine that 2020 would bring a near halt to this and other elective procedures to aggressively address the coronavirus (COVID-19) pandemic.1

Person-to-person transmission of the severe acute respiratory syndrome coronavirus (SARS-CoV)-2 seems to be the main mechanism of infection. This occurs through direct contact or through droplets propelled through the air mostly by coughing or sneezing from an infected individual, which are then deposited on the conjunctiva, mouth, nasal, throat, or pharynx mucosa of another person (droplet transmission). Droplets might also deposit on objects and surfaces that can become contaminated and serve as vehicles for viral transmission (fomites).2

Since elective procedures began to resume worldwide, albeit at reduced capacity, there have been questions on whether phacoemulsification can generate droplets and aerosols in general. Aerosols are produced when an air current moves across the surface of a film of liquid, generating particles at the air–liquid interface. The particle size depends on different factors, including the force and pressure at emission and the initial size of the aerosol, and environmental conditions (eg, temperature, relative humidity, and airflow). The World Health Organization classifies aerosols that contain infectious agents as droplets (“large” particles, >5 μm in diameter) and droplet nuclei (“small” particles, ≤5 μm in diameter), the latter usually originating from evaporation of droplets coughed or sneezed into the atmosphere.2 The cutoff particle size is considered to be 10 μm by some authors.3 Large droplets usually travel short distances (<1 m) and do not remain suspended in the air. However, the spread of an infectious agent caused by the dissemination of droplet nuclei that remain infectious when suspended in air over long distances and time is what constitutes airborne transmission, according to the World Health Organization.7 Particles generated from respiratory activities (breathing, coughing, sneezing, and talking) range from 0.01 to 500 μm in size. Although large particles (droplets) would likely impact onto respiratory epithelial mucosal surfaces or be trapped by cilia before reaching the lower respiratory tract of another person, droplet nuclei have the potential to readily penetrate the airways all the way down to the alveolar space.3,4

Some authors describe transmission by either large or small particles (the later referred to as aerosol-sized particles) as airborne transmission. Others use the term aerosol transmission to describe pathogens that can cause disease through inspirable particles of any size. This is because a large droplet can remain airborne for longer times if the ambient airflows are able to sustain its suspension.3,4 The most common convention, however, is to use the term airborne transmission to mean transmission by small particles.2 Whatever the term used, the importance of maintaining a distinction between small and large particles is due to the significant qualitative differences, including suspension time in air, and penetration of different regions of the airways, as discussed earlier. Furthermore, this distinction has a fundamental impact on the types and costs of infection control interventions that are required, including selection of personal protective equipment, for example, N95 respirators vs surgical mask level requirement. Surgical masks can act as a direct physical barrier to droplets of size >20 μm.2,3

This issue features 2 laboratory studies addressing the question of possible aerosol generation during phacoemulsification. In an ex vivo study from the United Kingdom, Lee et al. used porcine eyes (page 1290). An optical particle counter was used to measure the number of particles with a size of ≤10 μm generated in the following phacoemulsification scenarios on continuous power mode: 80% longitudinal setting, 100% torsional setting, and 80% longitudinal setting with copious application of hydroxypropyl methylcellulose on the ocular surface at the start of phacoemulsification. The authors found no aerosol generation of particles ≤10 μm during phacoemulsification with the 3 settings evaluated.

In another ex vivo study from India, Shetty et al. used high-speed shadowgraphy to visualize and quantify the size of the...
aerosols generated during phacoemulsification (page 1297). This technique uses a pulsed laser or LED as the light source, which is focused toward the camera, creating a white image. The dark outline of fast-moving objects can then be captured using short exposure times. Their study also provided calculation of the maximum spread distance of any aerosol. Phacoemulsification was performed using titanium straight tips (2.2 and 2.8 mm in diameter) on enucleated goat eyes and cadaveric human corneoscleral rims mounted on an artificial anterior chamber. Standard settings for sculpt and quadrant removal were used in linear and fixed modes. Incision sizes were 2.2, 2.8, and 3.2 mm, titrated equal to and larger than the sleeve size. Based on the camera settings and illumination light source power spectrum used in this study, a resolution of approximately 20 μm per pixel was possible. Visible droplets usually have a size of at least 50 μm. This study showed aerosol generation composed of droplets (size of approximately 50 μm and maximum calculated spread of 1.3 m) only when the phacoemulsification tip was completely exposed next to the ocular surface. Leakage of fluid from the main wound was seen when the incision size was larger than the sleeve size.

The safety of the phacoemulsification procedure regarding aerosol generation suggested by the aforementioned 2 studies has to be further interpreted in the light of the following facts. Samples of tear and conjunctival secretions of SARS-CoV-2–infected patients yielded positive results under the reverse-transcription polymerase chain reaction assay. The presence of the virus on the ocular surface can, however, be mitigated by the preoperative use of topical povidone–iodine, which was found to be effective against coronaviruses. To date, there is no evidence of the presence of SARS-CoV-2 in the aqueous or vitreous. In addition, phacoemulsification starts with the replacement of the aqueous humor with an ophthalmic viscosurgical device, which is then replaced by a balanced salt solution that is irrigated from the phacoemulsification tip. Therefore, any aerosol formation would basically correspond to an aerosolized balanced salt solution and not aqueous humor.

Knowledge on various aspects of the COVID-19 pandemic continues to evolve, and we anticipate that more studies on aerosol generation during phacoemulsification will become available because variations of different parameters in this procedure can still be explored. Studies will also assess the possibility of aerosol generation in other subspecialties in ophthalmology, such as in corneal, refractive, glaucoma, and retinal procedures. Health agencies and ophthalmology societies will look at all of these studies as one of the bases to elaborate guidelines for the progressive increase in elective surgeries, so the demand that was likely generated by the pandemic can be met, while appropriately minimizing the risk of infection for healthcare workers and patients. May science and common sense continue to drive this entire process!

REFERENCES