Preparing ophthalmologists for the use of mechanical ventilation during the COVID-19 pandemic

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To the Editor:

Many ophthalmologists, such as the corresponding author, have already, or will soon find themselves deployed elsewhere, including the intensive care unit (ICU), where mechanical ventilation is central to the care of COVID-19 patients. We propose that an understanding of cataract surgery and phacodynamics well prepares ophthalmologists to understand the principles of mechanical ventilation.

The cataract surgeon is well accustomed for balancing inflow and outflow of fluid to optimise the surgical environment. Similarly during ventilation the inflow and outflow of air must be tightly regulated. Additional considerations are required in acute respiratory distress syndrome (ARDS), a rapid and widespread inflammatory lung disorder, which in a Wuhan population arose in 41.8% of patients hospitalised with COVID-19 and carried a mortality of 52% [1].

Ventilation can be defined by the pressures and volumes it generates. The peak inspiratory pressure (PIP), is the maximal pressure obtained at the end of inspiration, Fig. 1. To initiate expiration, the ventilatory pressure drops to a minimal pressure, positive end-expiratory pressure (PEEP), often set at ~5 cmH₂O, Fig. 1. The frequency with which the ventilator cycles between these two pressures in 1 min defines the respiratory rate (RR). This multiplied by the volume generated each cycle gives the minute volume (MV).

The primary role of the infusion in phacoemulsification is to maintain a stable anterior chamber preventing its collapse. The PEEP therefore provides the same function as

bottle height by preventing alveolar collapse. In ARDS the lungs stiffen increasing alveolar collapse and ventilation/perfusion mismatch. Think of these patients like our own challenging (collapsible) patients, the hypermetropic eyes with a narrow anterior chamber. Unfortunately, cohesive viscoelastic is not an option in the lung so to keep the alveoli open in the setting of ARDS, the PEEP is increased, often to >10 cmH₂O, to promote alveolar recruitment and to improve oxygenation [2].

During phacoemulsification we can alter the contents of the infusion fluid to optimise our surgery. Similarly by increasing the fraction of inspired oxygen ranging from 0.21 (21%) or room air to 1 (100%), we can improve oxygenation.

In the most complex of cataract cases, if the lens nucleus drops, sometimes we require a vitreoretinal surgeon to approach things from a different angle. In the ventilation of patients with ARDS, gravity will cause the localised collapse of posterior segments of the lung whilst simultaneously shunting blood to these poor oxygenated portions of the lung, increasing V/Q mismatch. Placing patients in

Fig. 1 Graph demonstrating airway pressure as a function of time over a single respiratory cycle. Airway pressure increases to peak pressure during inspiration before falling to peak end expiratory pressure at the end of expiration.

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Table 1 Demonstration of the key differences between volume and pressure control.

Mode of ventilation	Independent variable	Dependent variable	Advantage
Volume control	Vt, PEEP, RR	PIP	Controls tidal volume to protect lung from hyper-inflation/volume trauma
Pressure control	PIP, PEEP, RR	Tidal volume	Controls maximal pressure to protect lung from barotrauma

Vt tidal volume, *PEEP* positive end-expiratory pressure, *RR* respiratory rate, *PIP* peak inspiratory pressure.

the prone position is a technique to counter gravity dependant collapse/atelectasis and as for post macular hole surgery patients, longer is better and 16+ hours is advised [3].

Together the FiO₂, PEEP and prone positioning are three tools for addressing hypoxia. Prone positioning is increasingly used in treating patients with COVID-19 and therefore, it is likely, our technical skills will be called upon to aid in the complex manoeuvre of placing patients in prone position in the ICU.

Central to understanding phaco fluidics is an understanding of what pump system we are using. A peristaltic system adjusts the speed of the rotation of the peristaltic rollers to maintain the desired vacuum but a venturi system will use an inflow/outflow differential of pressurised gas. These two systems can help us understand ventilator control modes.

The two main ways of driving flow to the lung are pressure control and volume control (Table 1). In volume control, the ventilator delivers a constant tidal volume (*Vt*) and the ventilator titrates the pressure (*PIP*) in accordance with the patient's thoracic compliance.

In pressure control the clinician defines the ventilatory pressures and the *Vt* becomes the dependent variable. In the context of COVID-19 related lung disease, pressure control may be preferable because the operator is able to limit barotrauma by setting a ceiling pressure on the ventilator. Lung damage is reduced at the expense of lower tidal volumes, *MV* and therefore reduced CO₂ clearance. Conversely, to increase CO₂ clearance, either the *RR* or *Vt* must be increased, however the ARDS.net study showed

that smaller tidal volumes, 6–8 ml/kg IBW, improve outcomes despite a higher CO₂ [4].

In summary, ophthalmologists can use the principles outlined here, under the guidance of our ICU colleagues to understand basic ventilator parameters, modes and common issues.

Compliance with ethical standards

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

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