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Reducing Aerosol Related Risk in the Era of COVID-19

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COVID-19 is an emerging viral pandemic affecting > 178 countries. SARS-CoV-2 is the virus that causes COVID-19 and it belongs to the same class of coronavirus as those which result in Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS), both of which infected many health care workers (HCWs) in the course of providing patient care. This new acute respiratory infectious agent is primarily transmitted between people through respiratory droplets and contact routes. A recognized key to transmission of COVID19, and droplet infections generally, is the dispersion of bioaerosols from the patient. Droplets generated by infected persons when they cough, sneeze, talk, sing, breath range from 0.1 to 100 µm in diameter. They can land in the mouth, nose, or eyes of those in close proximity, or may possibly be inhaled into the lungs, but mostly settle in the vicinity. The contribution of respirable particles < 5 µm, sometimes called droplet nuclei, is uncertain but airborne transmission between individuals over long distances is unlikely [3]. Most of this bioaerosol settles on surfaces around the infected subject, where they may remain infectious by contact for days.[4]

National and international guidelines recommend droplet/aerosol and contact precautions for those caring for COVID-19 patients. Increased risk of transmission has been associated with Aerosol Generating Procedures (AGPs) that generate bioaerosols when performed. Such AGPs include endotracheal intubation, bronchoscopy, open suctioning, administration of nebulized treatment, manual ventilation before intubation, turning the patient to the prone position, disconnecting the patient from the ventilator, non-invasive positive-pressure ventilation, tracheostomy and cardiopulmonary resuscitation. Certain AGPs may increase the production of pathogen containing bioaerosols from the patient (i.e. intubation, open suctioning tracheotomy, manual ventilation, bronchoscopy), while others potentially disperse bioaerosols from the patient to the surrounding area (e.g. oxygen administration, NIPPV, HFNC and medical nebulizer). Medical aerosols produced by inhalers and nebulizers (such as bronchodilators, anti-inflammatory agents, mucokinetics, antivirals, antibiotics and prostanoids) do not contain pathogens unless contaminated by the patient or HCW. Medical aerosol from nebulization derives from a non-patient source (the fluid in the nebuliser chamber) and does not carry patient-derived viral particles. Thus, "if a droplet in the aerosol coalesces with a contaminated mucous membrane, it will cease to be airborne and therefore will not be part of an aerosol.[5]

Many AGPs were identified during previous outbreaks of SARS, MERS and other viral infections such as influenza A. Early response of the SARS outbreak in Hong Kong was to ban all medical aerosols, and subsequently included them as AGPs.[6] Retrospective analysis of SARS reports and research identified pooled analysis of risk for a variety of AGPs, with intubation and non-invasive manual ventilation creating a 6.6 fold and 3.3 fold increased risk of infection of HCWs, respectively. In contrast, the pooled risk from medical nebulizer treatment from 3 cohort reports was considered non-significant (0.9).[7] Nevertheless, HCWs should learn how to reduce risks associated with all aerosol delivery devices.

Inhalers, such as pMDIs, have been suggested to reduce risk[7], presumably because drug is enclosed and less open to contamination than in open cup nebulizers, and the low emitted dose (100 µl/actuation) produces less aerosol mass. However, exhaled bioaerosols are not avoided or contained with use of pMDIs or DPIs, whether with cough (common with inhalers) or even normal exhalation. Cough associated with inhalers likely generates as much bioaerosol as with nebulizers with no mechanism to filter patient exhalation. While medical aerosol treatments may increase the mass and dispersion of aerosol, they do not increase the infective load of bioaerosols unless the nebulizer is contaminated. Jet nebulizers driven with flows up to 10 L/min increasing the dispersion of aerosol, and the reservoir of the nebulizer is open to contamination by secretions, condensate and even bioaerosols. This is the basis of CDC recommendations that jet nebulizers be replaced, rinsed, air dried, washed, disinfected and/or sterilized after each treatment.

By design, vibrating mesh nebulizers (VMNs) such as the Aerogen® Solo separate the medication from the patient interface, including breathing circuits by the barrier of the mesh. This mesh maintains pressure in the ventilator circuit wen the medication reservoir is open to add medication, without a measurable leak of gas through the nebulizer to atmosphere, allowing medication to be added without breaking the circuit. In addition, the medication reservoir of the Solo is closed to the environment via a cap and positioned above the circuit, minimizing the potential for gravity-

dependent contamination from condensate in the circuit and patient generated secretions. As VMNs do not use gas flow to generate aerosol, they do not contribute to dispersion of bioaerosol. The label of the Aerogen® Solo indicates it is a single patient, multiple dose device that can remain in the ventilator circuit up to 28 days. CDC recommendations defer to the manufacturer's product label for VMN.

Due to the required gas flow, dispersion of bioaerosols with oxygen administration, including venturi, simple and non-rebreather masks all disperse bioaerosols from the patient farther than a VMN. Placing a simple mask over a nasal cannula, low or high flow, reduces dispersion of patient generated bioaerosols as well as medical aerosols. Placing a filter on the outlet of nebulizer and ventilator greatly reduces dispersion of bioaerosols. Droplet transmission is by no means unique to COVID-19. Acute respiratory infections, particularly of the lower respiratory tract, are the leading cause of morbidity and mortality from infectious disease globally, accounting for an estimated 4 million deaths annually. Although bacteria are a common cause of lower respiratory tract infections, the majority are caused by viruses or a mix of viral/bacterial infections, all of which can be expelled by infected patients as bioaerosols. It is now known that COVID-19 subjects can be asymptomatic and still shed virus, producing droplets by just breathing, so HCWs should assume every patient is potentially infected. Taking actions to reduce risk of transmission to HCWs is therefore a vital consideration for safe delivery of all medical aerosols. Guidelines for use of personal protective equipment (gloves, gowns, N-95 masks, shield or PAPRs during high risk proRRTcedures are essential, and should also be considered for use with lower risk procedures such as administration of medical aerosols.

Recommendations:

- treat every patient as infected;
- protect yourself and the patient with PPE for aerosol protection (surgical mask or N-95 gloves, gowns);
- wash hands and put on fresh gloves prior to filling the nebulizer reservoir and administering treatments. Use proper aseptic technique to avoid contamination of aerosol reservoirs and medication;
- perform AGPs in a negative pressure room, if available for COVID-19 patients, or rooms with high air exchange rates;
- have patients wear simple mask when possible (i.e. over simple nasal cannula and HFNC) and between treatments;
- have tissues available and encourage covering cough or sneeze with tissues; discard use tissue immediately;
- use unit dose vs multiple dose medication containers;
- reduce dispersion of aerosols;
    - reduce flow of gas driving aerosol – VMN requires no flow to generate aerosol, unike JN that require up to 10 L/min;
    - use mouthpiece with handheld applications when possible, since Open and valved aerosol masks release more aerosol to atmosphere and are harder to filter;
    - social distancing: try to stay more than 30 cm (maximum dispersion distance with oxygen and medical aerosol) away from the patient's airway;
    - Reduce release of medical aerosols into the environment: use a VMN with valved holding chamber in which medical aerosol collects and is available on demand, or a breath synchronized nebulizer that does not generate aerosol after inhalation;
    - place filter on exhalation port of nebulizers, NIV circuits and ventilators;
    - avoid breaking open the ventilator circuit to add medication or change nebulizers, as this generates aerosol from condensate that may be infectious;
    - aerosol can be administered via HFNC; lower flows reduce dispersion.
    - A simple mask placed over oxygen cannulas, nose and mouth acts as a barrier to contain bioaerosols generated and reduce dispersion distance.

Note: HCWs should comply with the requirements and guidelines of their region and institution.

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