Coronavirus Disease 2019: Epidemiological Factors During Aerosol-Generating Medical Procedures

To the Editor

We read with great interest the important editorial by Orser1 that outlines recommendations for performing aerosol-generating medical procedures (AGMPs). The coronavirus disease 2019 (COVID-19) pandemic places health care workers (HCWs) at high risk of exposure. As of April 2020, HCWs comprised 10% of the COVID-19 cases in Italy.2 We agree that extreme caution must be exercised and preventative strategies be used when performing AGMPs, including tracheal intubation and manual ventilation, to minimize the risk of transmission.1,3 This article broadens the current COVID-19 infectious control strategies through the concept of the epidemiological triad to further protect HCWs performing AGMPs.

Snow,4 a pioneer anesthesiologist and father of modern epidemiology, first described the epidemiologic triad to trace the source of cholera outbreaks in London in the 1850s. The epidemiological triad (Figure) helps us understand the spread of diseases through 3 components: agent, environment, and host.4 In the context of COVID-19, the agent is the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), including the pathogenicity and virulence of various strains. The environment refers to extrinsic factors that affect the agent and opportunities for exposure like respiratory droplets and contaminated surfaces. The host is any uninfected person and their individual susceptibility characteristics (eg, age, sex, and comorbidities). Minimizing the interactions between these components would reduce the spread of COVID-19.

Factors that disrupt the proliferation of COVID-19 can be conceptualized into 3 scenarios (Figure): community, hospital, and AGMPs. “Interrupting factors” (IFs) between any 2 components can be categorized as agent–host IFs (decreasing the host’s susceptibility or diminishing the virus’ virulence), agent–environment IFs (eliminating or decreasing the viral burden in droplets and surfaces), and environment–host IFs (decreasing the opportunity for active virus to infect new hosts).

AGENT–HOST IFs

While a COVID-19 vaccine and/or treatment is the most effective agent–host IFs, they are still being developed. Thus, the focus should remain on promoting practical strategies that optimize environment–host and agent–environment IFs until a vaccine or treatment becomes available.

ENVIRONMENT–HOST IFs

Environment–host IFs in the community include shelter-in-place policies and social distancing. Similarly, hospitals have implemented interim cancellations of elective surgical cases, restricted hospital visitors, and encouraged personal protective equipment (PPE) use. In both settings, frequent hand washing or disinfection, avoidance of physical contact, and restraint from touching one’s face have been vital to controlling the spread of COVID-19.3

During AGMPs, PPE (including N95 respirators, powered air purifying respirators [PAPRs], face shields, gowns, and gloves) remains the major environment–host IF protecting HCWs. For AGMPs, such as intubation, video laryngoscopy provides slightly more distance between the infected patient and the HCW when compared to direct laryngoscopy, but the HCW still remains at high exposure risk. Although various innovative plastic barrier enclosure devices for performing AGMPs have been widely publicized,3 these barriers remain an exposure risk when removed or cleaned as the virus is temporarily contained rather than eliminated. Following the AGMP, HCWs must also remain cautious of exposed areas within the barrier, including the patient’s head, OR table, and the HCW’s own clothing, as infectious particles may settle on these surfaces.

AGENT–ENVIRONMENT IFs

Agent–environment IFs in the community include the self-quarantine of infected individuals, respiratory hygiene, and mask wearing by infected individuals, and restriction of travel from areas with widespread ongoing transmission. In hospitals, airborne infection isolation rooms (AIIRs or negative pressure rooms) and dedicated hospital wards with devoted COVID health care teams limit transmission to the rest of the hospital. Despite these isolation measures, extensive contamination of environmental surfaces is found in the rooms of COVID-19 patients.3 Because SARS-CoV-2 can persist on inanimate surfaces for up to 9 days, surface decontamination with disinfectants is an essential agent–environment IF.3 Portable ultraviolet (UV)-light disinfection systems utilizing the germicidal properties of UVC (100–280 nm) irradiation have the added benefits of “no touch,” maintenance of a room’s ventilation, and lack of residue.3

Given the nature of AGMPs, implementation of agent–environment IFs is challenging. The infected
Letters to the Editor

Patient cannot be isolated from the HCW nor can the patient’s body be chemical disinfected or irradiated. High-efficiency particulate air (HEPA) filters on ventilator circuits have been used but are only useful in continuity with the patient’s airway. A facemask on the patient can decrease the aerosolization of SARS-CoV-2 into the environment but hinders performance of the AGMP. Performing an AGMP in an AIIR or negative pressure OR protects only HCWs outside of the room. Although AIIRs require a minimum of 12 air-flow changes per hour (ACH) and ORs require a minimum of 15 ACH, the viral particles are recirculated rather than refreshed resulting in increased exposure risks to the HCWs within the room. In fact, the Anesthesia Patient Safety Foundation (APSF) and the American Society of Anesthesiologists (ASA) recommend decontamination of the OR after care of COVID patients and “entry should be delayed until sufficient time has elapsed for enough air changes to remove aerosolized infectious particles.”

Safety practices used by other occupations exposed to hazardous particulates provide a great resource for alternative agent–environment IFs for HCWs performing AGMPs. Local exhaust ventilation hoods near the contamination source provide effective control of dust and fumes generated in industries utilizing woodworking and soldering. Recently, a similar evacuation system for AGMPs was described. A commercially available, disposable oxygen face tent was repurposed and connected to a high-efficiency waste management system with a HEPA filter to form an aerosol evacuation system. Although clinical studies have not been performed, this evacuation system for AGMPs is encouraging because it is grounded in the same technology used by other high-risk occupations exposed to hazardous particulate matter.

As the world begins to relax its protective interventions, we must “beware of the second wave of COVID-19.” The epidemiological triad provides a framework to decrease the spread of COVID-19 by strengthening currently used IFs and refocusing innovative

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**Figure.** Epidemiological triad. A, The interrelationship of the 3 components: agent, environment, and host. B, The interrupting factors characterized into 3 scenarios: community, hospital, and AGMPs. AGMP indicates aerosol-generating medical procedure; AIIR, airborne infection isolation room; COVID-19, coronavirus disease 2019; HCW, health care worker; OR, xxx; PAPR, powered air purifying respirator; PPE, personal protective equipment; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; UVGI, xxx.
development to address underutilized IFs without increasing exposure risks to HCWs.

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