DOI: 10.1111/jocs.14728

EDITORIAL

JOURNAL OF CARDIAC SURGERY WILEY

Aerosol-mediated transmission of SARS-Cov-2 or COVID-19 in the cardiac surgical operating room

Apart from droplet infection and transmission through fomites, it is now well established that coronavirus can spread through aerosols as well.[1] However, a significant research gap exists in the epidemiology of the risk of transmission of infections from patients undergoing aerosol-generating procedures (AGPs).[2] AGPs are generally thought to be a concern for the anesthetists and the risk to cardiac surgeons is grossly underestimated.

Even before the current corona pandemic, a global outbreak of invasive *Mycobacterium chimaera* has been reported in cardiac surgery due to aerosol release. This occurred through breaches in the heater-cooler units used in cardiopulmonary bypass circuits.[3] Thus, the risk of aerosol-mediated transmission is very real and the need for safety measures is extremely practical.

The coronavirus disease-2019 (COVID-19) virus spreads predominantly through droplet and aerosol routes and blood-borne infection is not considered a major source of transmission.[4] There are some major differences between droplet and airborne transmission that leads to airborne transmission in the operating room (OR) more of a hazard than the droplet route.

Based on electron microscopy, the size of the coronavirus-shaped spherical particles is estimated to be about 0.125 μm (125 nm) and ranges from 0.06 to 0.14 μm.[5] While droplet infections are via larger respiratory particles, generally above 5 μm diameter, and are subject to gravitational forces, aerosol-mediated transmission occurs with smaller respiratory particles (generally <5 μm) circulating in the air. As a result, while contact is necessary for droplet infections and thereby handwashing and gloves are highly effective against contact transmission, viral particles transmitted though aerosol is absorbed via the respiratory mucosa and potentially across the conjunctivae, other measures are required to prevent transmission. These smaller viral particles (<10 μm) are most likely to penetrate deep into the lung and cause infection.[6] The radius of spread is also different and is no more than 1 m for droplet infections. However, because of the smaller size, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or COVID-19 as it is popularly known as, can spread across larger areas and has been shown to remain viable in aerosols even at 3 hours.[7]

The highest viral load of the virus causing COVID-19 is in sputum and upper airway secretions and endotracheal intubation is the commonest and most relevant aerosol-generating procedure in cardiac surgery.[8] Apart from intubation and extubation, bag mask ventilation, suctioning of airways, insertion of chest drains, and thoracotomies can all lead to aerosol generation.[9] In pediatric cardiac surgery, valve repairs and at times in coronary artery bypass operations as well, transesophageal echocardiography (TEE) is often used. TEE carries an increased risk of transmission of SARS-CoV-2. While this risk is greater in nonintubated patients, viral transmission may still occur through direct contact with the patient's secretions, resulting in contaminated hands and surfaces with the potential to infect not just the echocardiographers but also other personnel in the OR.[10] Sternotomy requires a high-speed device and is considered to be a procedure that leads to blood and tissue fluid aerosolization.[4] Surgical smoke produced by heat-generating devices in cardiac surgery can also contain chemicals, blood and tissue particles, bacteria, and viruses.[11] A summary of aerosol-generating procedures is summarized in Table 1.

Carbon dioxide (CO_2) insufflation in the operative field is practiced in both open cardiac surgical procedures as well as minimally invasive cardiac surgery to aid in deairing and prevention of air embolism. This has more relevance in minimally invasive cardiac surgery (MICS) as MICS often does not permit normal deairing maneuvers.[12] OPCAB surgery relies heavily on using a blower-mister that uses CO_2 with saline and perhaps contribute to aerosol generation as well.[13] Disconnection of ventilatory circuits during use, cardiopulmonary resuscitation (before tracheal intubation), bronchoscopy, tracheal suction without a closed in-line system and nasogastric tube insertion are the other examples of aerosol-generating procedures.[8]

The prevention of aerosol-based transmission requires two approaches. First, minimizing aerosol-generating procedures and second protecting against exposure.

1 | MINIMIZING AEROSOL GENERATION

Since the greatest risk of aerosol generation is from endotracheal intubation preventive measures should primarily focus on minimizing the risk at this very stage. It is recommended that adequately ventilated single rooms should be used when performing aerosol-generating procedures. Hospitals could make adjustments to their intubation and operating practices. Ideally, it should be seen if it is possible to convert any of the operating rooms to negative pressure environments with airflow changes (>12 air flow changes/hour).[8] Failing this, patients could be intubated in a room next to the OR. If such a room does not exist and if there are two ORs next to each other, one of them could perhaps be used as an anesthetic room for intubating and the other one for operating.

TABLE 1 Summary of aerosol-generating procedures (AGP) in the operating room

Main sources of aerosol generation in cardiac surgical operating room
Airway management
Endotracheal Intubation
Bag mask ventilation
suctioning of airways
Transesophageal echocardiography
Bronchoscopy, insertion of nasogastric tubes
Surgical procedures
Sternotomy
Thoracotomy and insertion of chest drains
Surgical smoke
Carbon dioxide (CO_2) insufflation
using a blower-mister during off-pump CABG
Others
Cardiopulmonary resuscitation
Inadvertent disconnection of ventilatory circuits

Abbreviation: CABG, coronary artery bypass surgery.

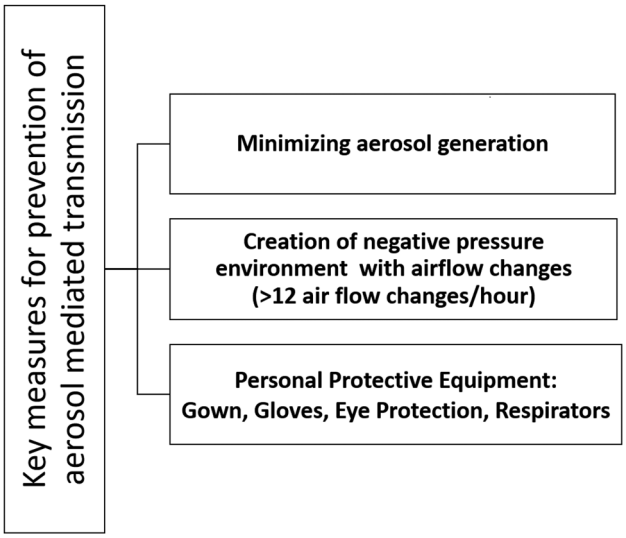

FIGURE 1 Summary of measures to protect against aerosol-mediated transmission of SARS-Cov-2 infection. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2

Currently in most centers, the negative pressure operating rooms with good rates of air exchange are not available and intubation is performed in a positive pressure environment or in areas with reduced air exchanges.[8] The positive pressure airflow environment of the OR is a risk factor for viral spread and thus aerosols once released actually stay in the environment for 3 hours or longer which often is the duration of the cardiac surgical procedure. In these situations, following intubation of the patient, the air conditioning should be turned off and after 20 minutes to allow for the droplets and aerosols to settle, the floors should be cleaned. This is known to clear the settled aerosols without refreshing the spread.[8]

Reducing the use of blower-mister during OPCAB as far as practicable and depending on traditional measures for deairing after open cardiac surgery in preference to CO_2 insufflation would also be useful in reducing the aerosol load. Also, TEE should only be performed in intubated patients in the OR and only in those perioperative situations in which the benefits outweigh the risks.[10]

2 | PROTECTING AGAINST EXPOSURE

The minimum number of personnel that can safely condusct the procedure should be present in the OR. Insertion of intrapleural chest drains at the start of the procedure and connecting them to the wall suction may reduce the aerosol generated from the electrocautery as well as from the blower-mister in OPCAB surgery. There is some evidence that double gloving for tracheal intubation might provide extraprotection and minimize spread by fomite contamination of equipment and surroundings.[10] The use of fluid-repellent long-sleeved gown, eye protection, respirators. and gloves are recommended to protect against aerosol mediated transmission of infection. Eye protection should include protection from side exposure with side shields or goggles. The key features are summarized in Figure 1.

The most common types of respirators in healthcare are N95 filtering facepiece respirators (FFRs), surgical N95 FFRs, and powered air-purifying respirators (PAPRs). PAPRs reduce the aerosol concentration inhaled by the wearer to at least 1/25th of that in the air, compared to a 1/10th reduction for FFRs. PAPRs provide increased protection and decrease the likelihood of infection transmission to the wearer as compared to FFRs. However, a PAPR has limited downward vertical field of view and also because of the blower noise it may present with difficulty in communicating.[14] Evidence from systematic review and meta-analysis have failed to confirm the superiority of one type of mask (FFP3/FFP2/N95) over another (surgical facemask).[15] This could be partly because of issues with doffing off techniques of personal protective equipment and training issues.

3 | CONCLUSIONS

Awareness about aerosol-generating procedures is key to prevent transmission of aerosol-mediated SARS-Cov-2 infection. Minimizing aerosol generation as far as practicable and taking measures to prevent exposure are important for ensuring the safety of cardiac surgeons and other team members.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

KEYWORDS

aerosol-generating procedures, cardiac surgery, COVID-19, SARS-Cov-2

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