Ventilation Considerations during Aerosol Generating Procedures

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• No disclosure
Objectives

- Definition
- Types of Aerosol Generating Procedures (AGPs)
- Risk assessment
- Risk minimization
- Ventilation Requirement
Definition: World Health Organization

- Aerosol Generating Procedures (AGPs) are those procedures which result in the production of airborne particles (aerosols)

- These particles are created by air currents moving over the surface of a film of liquid at the air–liquid interface
  - The faster the air, the smaller the particles
  - Mechanical action, e.g. dental power tools

- Particles produce during AGPs are of various sizes, including droplet
  - < 5 µm in size and can remain suspended in the air and travel over a distance and have the potential to cause infection, if inhaled
Fig. 1.5 Host defence mechanisms in the respiratory tract and the use of appropriate PPE to protect against the infection spread by droplet and airborne routes.

NO INTERNATIONAL CONSENSUS on the list of AGPs

• Current scientific studies lack appropriate quality or strength

• The published evidence is
  • Weak or extremely weak
  • Heavily confounded by an inability to separate out specific procedures performed as part of CPR, e.g., chest compression, defibrillation, manual ventilation and intubation-impossible to disentangle the various transmission mechanisms

NHS Scotland. Assessing the evidence base for medical procedures which create a higher risk of respiratory infection transmission from patient to healthcare worker. National Services Scotland, 12th May 2020.
Aerosol Generating Procedures

- **Weak evidence** for an increased risk of respiratory infection transmission associated with the following procedures:
  - **Open suctioning** of the respiratory tract of mechanically ventilated patients
  - **Dental procedures** using high speed devices such as ultrasonic scalers and drills
  - **High speed cutting** in surgery/post-mortem procedures
  - **Manual ventilation**
  - **Non-invasive ventilation**
  - Performing a **tracheotomy**
  - Performing **tracheal intubation**

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No evidence of appropriate quality or strength was identified for the following procedures:

- High frequency oscillating ventilation
- Bronchoscopy
- Induction of sputum (associated with nebulisation of hypertonic saline)
- Tracheotomy removal
- High flow nasal oxygen therapy
- Administration of nebulized saline
- Medication or drugs
- Chest compressions
- Chest physiotherapy
- Defibrillation
- Administration of oxygen therapy
- Abdominal suctioning
- Airway Suctioning of newborn infants
- Amputation with open arterial surgery
- Bone drilling
- Chest drains with activate air leak (pneumothorax or following cardiothoracic surgery)
- Colonography
- Dental procedures not involving high speed devices, e.g. scaling by hand
- Diathermy (smoke generated)
- Harvesting split thickness skin grafts
- Heavy exhalation during labour
- Hydro surgical debridement

- Inhalation sedation, Entonox use or other inhaled gases (not nebulised)
- Irrigation during surgery
- Laparoscopy/Laparotomy
- Laryngectomy care including surgical voice restoration (stoma inspection; voice prosthesis changes)
- Lower GI endoscopy
- Manual saw during surgery
- Nasendoscopy
- Nasogastric tube insertion
- Needle decompression of a tension pneumothorax
- Nose and throat swabbing
- Peak flow device meter use
- Percutaneous lung biopsy
- Phacoemulsification
- Pulsed lavage during surgery
- Supraglottic airway insertion
- Surgical procedures in head and neck area not involving the upper respiratory tract, paranasal sinuses or oral cavity
- Swallowing assessments (SALT)
- Thoracoscopy
- Tracheostomy care and management without suctioning procedures, with and without connection to mechanical ventilator
- Trans Oesophageal Echo (TOE)
- Upper GI endoscopy
- VAC dressing application
- Vitrectomy

NHS Scotland. Assessing the evidence base for medical procedures which create a higher risk of respiratory infection transmission from patient to healthcare worker. National Services Scotland, 12th May 2020.
<table>
<thead>
<tr>
<th>Aerosol Generating Procedures</th>
<th>WHO¹</th>
<th>CDC²</th>
<th>UK³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual ventilation</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Endotracheal intubation and extubation</td>
<td>YES</td>
<td>YES</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-invasive ventilation (NIV); Bi-level Positive Airway Pressure Ventilation (BiPAP) and Continuous Positive Airway Pressure Ventilation (CPAP)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Induction of sputum using nebulised saline</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Cardiopulmonary resuscitation (CRP)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Respiratory tract suctioning</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Autopsy procedures</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Nebulizer administration</td>
<td>LIMITED DATA</td>
<td>UNCERTAIN</td>
<td>NO</td>
</tr>
<tr>
<td>High flow nasal oxygen (HFNO)</td>
<td>LIMITED DATA</td>
<td>UNCERTAIN</td>
<td>YES</td>
</tr>
<tr>
<td>Upper ENT airway procedures that involve suctioning</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Upper gastrointestinal endoscopy, where there is open suctioning of the upper respiratory tract</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>High speed cutting in surgery/post mortem procedures if this involves the respiratory tract or paranasal sinuses</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Dental procedures using high speed devices such as ultrasonic scalers and high speed drills</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>High Frequency Oscillatory Ventilation (HFOV)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>High speed cutting : Surgery and Pos-mortem</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

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Types of Aerosol Generating Procedures

**Induced aerosol generation in respiratory tract**

*Examples:* Intubation, Bronchoscopy, CPR

**Mechanical aerosol generation in respiratory tract**

*Examples:* Ventilation, Suctioning

*Mechanical action using dental power tools*
The surrounding area is very heavily contaminated.

**AGPs are prolific dispersers of droplets and splatter, not just aerosols!**
MULTI-MODAL APPROACH
Prevention of transmission of infections from AGPs

- **Full Personal Protective Equipment**
  - Full sleeves *splash-proof gown*
  - Full face visors for eye protection
  - N95, FFP2 or FFP3 respirator for protection of respiratory tract
    (Requirement: Fit testing and proper seal)
  - Practical training donning and doffing- **Buddy system**

- **Minimum numbers of people**

- **Avoid** performing AGPs in an *open ward*

- **Intensive care unit:** Consider put a *solid* partition/screen between patients

- **Preform AGPs in** **WELL VENTILATED ROOM !**
Negative pressure rooms

• A room where *more air is extracted than supplied*

• Can leak, but *leak inwards* – actual value irrelevant except insofar as it can be monitored

• Can be monitored by:
  • *Electronic gauge* with remote (delayed) alarm (excellent)
  • *Mechanical gauge* recorded regularly (adequate)
  • Need an *air change rate* compatible with *patient comfort* for long-term isolation

© Peter Hoffman
If it is filtered, care with changes of HEPA and prefilters as these will concentrate infectious particles.

Negative pressure airborne isolation room.

- OUTLET FOR CONTAMINATED AIR
- HEPA filter
- Negative pressure isolation room
- Exhaust fan
- ANTEROOM For changing PPE
- Private Bathroom
- Pressure Monitor
- Air Pumping & suction separated from hospital

Low- and middle-income (LMI) countries

Point of emission must be safe

(Next slide)

It does not need to be filtered in LMI

Source: https://www.ahgservicesllc.com/post/2016/03/22/title-title
https://www.deconta.eu/english/d100.html
Solution for LMI: Installation of exhaust fans

• Care is needed because the fans need to be installed so that the *air is released safely directly outdoors*

• The fan must be *extract only*!

• **Positioning the exhaust fan** should be done so that it is **NOT** close to
  • Ventilation air intake
  • Windows
  • People’s breathing zones, etc.

• A **reliable electricity supply** is required for the exhaust fan

• The *number* and *technical specification* of exhaust fans will depend on the **size** of the room and the *desired ventilation rate*
How to check direction of airflow (esp. in LMI)

• Airflow direction can be assessed by measuring the *pressure difference* between the rooms with a differential pressure gauge.

• **SMOKE TEST PUFFER:** If measuring the pressure difference is not feasible, the airflow direction from a clean to a less-clean area can be assessed using *cold smoke*

**Note:** Clearance of smoke should occur within a few seconds of release

• **Incense stick** can also be used if cold smoke test puffers are not available.
  **Note:** But beware of *fire hazarded* (Oxygen is used in the clinical area)
Current confusion about Airborne Transmission

• Interpretation of data from research from the Physical Sciences & Biology
  • Controlled condition
  • Detection of virus by PCR
• Epidemiology with consideration of real-life aspects, because infection depends on the
  • Route of exposure
  • Size of inoculum
  • Infective dose of live virus: Unknown for Covid-19
  • Duration of exposure
  • Host defenses

VIRAL NUMBERS ARE CRUCIAL!

Very minor aerosols may be produced when breathing, speaking, coughing etc. but they carry too few virus to be a realistic vector of infection
Recovery of viral RNA from air does not prove aerosol-based transmission!
Primary mode of transmission of Covid-19

- CONTACT and DROPLET transmission
  - Individuals (Asymptomatic, pre-symptomatic and/or infected)
  - Social distancing, cough etiquette & face mask
  - Infected secretions from droplets
  - Social distancing
  - Use of PPE e.g. face mask, eye protection, etc.
  - Avoid touching face and mucous membrane
  - Contaminated fomites from droplets
  - Avoid unnecessary touching
  - Hand hygiene
  - Environmental cleaning
  - Decontamination of items & equipment

**Current WHO recommendations**

**Transmission of SARS-CoV-2: implications for infection prevention precautions**

**Background**
This is the final edition of WHO’s interim guidance on infection prevention and control (IPC) strategies during the COVID-19 pandemic. The guidance is periodically updated to take into account new research findings and experience with the virus. It provides general guidance, information, and recommendations on IPC measures to prevent the transmission of SARS-CoV-2 during the COVID-19 pandemic. It is based on solid evidence available at the time of publication and on the best available information. The recommendations are intended for all healthcare facilities and are applicable to all healthcare workers and patients, regardless of their setting. The recommendations are not exhaustive, and additional guidance may be required in specific situations, such as in the context of outbreaks or pandemics.

**Recommendations**
- **Prevent the spread of SARS-CoV-2**
  - Identify and isolate patients with suspected or confirmed infections, and prevent transmission to healthcare workers and others.
  - Implement appropriate infection control and IPC measures to prevent the spread of SARS-CoV-2 in healthcare settings.
  - Provide education and training to healthcare workers on IPC measures.
  - Implement IPC measures to prevent transmission of SARS-CoV-2 to the community.

**Transmission**
Transmission of SARS-CoV-2 occurs through direct, indirect, or close contact with infected or asymptomatic individuals, particularly in settings where physical distancing is not feasible or not possible.

**Airborne transmission**
Airborne transmission is defined as the spread of an infectious agent caused by the exhalation of droplets from the nose, mouth, or upper airway, and the inhalation of these droplets by other individuals. The presence of an infectious agent in the air is determined by the size and composition of the droplets. The droplets are typically small, droplet nuclei, which are small enough to remain suspended in the air for longer periods of time.

**Droplet transmission**
Droplet transmission occurs when infected respiratory secretions (e.g., sneezes, coughs, or talking) are expelled into the air and then inhaled by a susceptible individual. The droplets may travel long distances and can infect individuals who are not in close proximity to the infected individual.

**Surface transmission (fomites)**
Surface transmission occurs when infectious agents are transferred to a surface, such as a door handle or table, and then transferred to another individual through contact with the surface.

**Contaminated fomites**
Contaminated fomites can transmit infectious agents to susceptible individuals, especially in settings where hands are frequently touched, such as in healthcare settings.

**Environmental cleaning**
Environmental cleaning is an essential component of IPC measures to prevent the transmission of SARS-CoV-2. It involves the decontamination of surfaces, items, and equipment to reduce the risk of transmission.

**Decontamination of items & equipment**
Decontamination of items and equipment is a critical step in preventing the spread of SARS-CoV-2. It involves the use of appropriate decontamination methods to remove infectious agents from surfaces, items, and equipment.

**Use of PPE**
The use of PPE, such as face masks, eye protection, and gloves, is essential in preventing the spread of SARS-CoV-2. PPE should be properly selected, fit-tested, donned, and doffed to prevent exposure to infectious agents.

**Hand hygiene**
Hand hygiene is a crucial component of IPC measures to prevent the spread of SARS-CoV-2. It involves the use of soap and water or an alcohol-based hand rub to remove infectious agents from the hands.

**Social distancing**
Social distancing involves maintaining a safe distance from others to prevent the spread of SARS-CoV-2. It is an essential component of IPC measures to prevent the spread of the virus.

**Cough etiquette**
Cough etiquette involves covering the mouth and nose with a tissue or elbow when coughing or sneezing to prevent the spread of infectious agents.

**Conclusion**
In conclusion, the current WHO recommendations on infection prevention and control (IPC) strategies during the COVID-19 pandemic provide general guidance and recommendations on IPC measures to prevent the transmission of SARS-CoV-2 during the COVID-19 pandemic. The recommendations are intended for all healthcare facilities and are applicable to all healthcare workers and patients, regardless of their setting. The recommendations are not exhaustive, and additional guidance may be required in specific situations, such as in the context of outbreaks or pandemics.
Risk from AGPs: Observational case reports

- **SINGAPORE**: 41 HCWs were exposed to multiple prolonged AGMPs in a COVID-19 patient
  - 6 wore N95 respirators
  - On serial testing, no staff acquired COVID-19


- **CANADA**: COVID-19 patients are *routinely managed in droplet/contact precautions*
  - *No increased risk of infections* in HCWs when compared to community populations

... the balance of currently available evidence suggests that long-range aerosol-based transmission is not the dominant mode of SARS-CoV-2 transmission.
Risk assessment and risk minimization

• Is it **really** an Aerosols Generating Procedure?
  • Based on the current evidence *vs* ‘just in case’ or precautionary principle?
  • Are they **high** or **low** risk AGPs?

• Have you taken other **IPC precautions** recommended for AGPs?
  • Full PPE (full face visors, N95, FFP2 or FFP3 respirator)
  • Minimum no. of HCWs presence, etc.

• Are virus **particles viable**?
  • PCR + *vs* presence of viruses in cell culture

(COVID-19 virus has been **detected by RT-PCR in air samples** gathered in the rooms of COVID-19 patients **who did not undergo AGPs**, none of these studies have been able to **culture the virus from these air particles** a step that is critical to determining the infectiousness of viral particles)
Risk assessment and risk minimization

• Does the clinical Procedure generate *infectious* or *non-infectious* aerosols?
  • Tracheal intubation/extubation *vs* nebulized medication

• Are you performing AGPs in *an adequately ventilated room*?
  • Negative pressure (6-12 ACH per hrs)
  • Natural ventilation in LMI Countries
Key references

https://apps.who.int/iris/bitstream/handle/10665/112656/9789241507134_eng.pdf?sequence=1

NHS Scotland. Assessing the evidence base for medical procedures which create a higher risk of respiratory infection transmission from patient to healthcare worker. National Services Scotland, 12th May, 2020


CDC: Guidelines for Environmental Infection Control in Health-Care Facilities.2003 (Updated: July 2019).
https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf?fbclid=IwAR2pFN9R0k_Mi1h8t3V38CGz5PGrGxaUC6fY7XPtG1tPaVlCmWTohhzyA14


Thank You