The following information resources have been selected by the National Health Library and Knowledge Service Evidence Virtual Team in response to your question. The resources are listed in our estimated order of relevance to practicing healthcare professionals confronted with this scenario in an Irish context. In respect of the evolving global situation and rapidly changing evidence base, it is advised to use hyperlinked sources in this document to ensure that the information you are disseminating to the public or applying in clinical practice is the most current, valid and accurate.

YOUR QUESTION

Is the use of warm humidified 'wet' circuit for mechanical ventilation recommended in ventilating patients with COVID-19?

IN A NUTSHELL

Based on the results of our search, 'dry' or hydrophobic systems are preferred from a HCW safety perspective. Cook[7] recommends that "Actively heated and humidified 'wet circuits' may be avoided after tracheal intubation to avoid viral load being present in the ventilator circuit. This will theoretically reduce risks of contamination of the room if there is an unexpected circuit disconnection" ; Scott[13] concludes that "potentially pathogenic organisms can pass through wet anaesthetic breathing filters, and found that they do so very easily. Further studies are required to investigate the potential for cross-contamination between patients if filters are used as the sole method of infection control in breathing systems for anaesthesia and intensive care."

UpToDate[5]: "Other infection precautions include use of dual limb ventilator circuitry with filters placed at the exhalation outlets as well as heat moisture exchange (HME) systems rather than heated humification of single limb circuits." Sundaram[14] states: "Hydrophobic viral filter in the ventilator circuit minimizes chances of transmission of virus."

Hydrophobic filters are also recommended in the Canadian Anesthsiologists' Society Guidelines[4] : "Use of hydrophobic/HEPA filter between the ET tube and ventilator/Laerdal bag" and "Consider taping the filter to the ET tube to reduce the risk of accidental disconnection."

In terms of efficacy for the patient, Furyk[10] when comparing HME with heated humidifiers, found that for people who are mechanically ventilated, randomized controlled trials have reported no clear differences overall between heat and moisture exchangers (HMEs) and heated humidifiers

(HHs) in terms of artificial airway occlusion [low- quality evidence], all- cause mortality [low- quality evidence], pneumonia-related mortality, pneumonia [low- quality evidence], and partial pressure of arterial carbon dioxide, duration of intensive care stay, or respiratory complications. "[Due to] potential for bias and often low event rates and/or small participant numbers, none of the analyses can be considered sufficiently robust to draw conclusions.

IRISH AND INTERNATIONAL GUIDANCE

What does the Health Protection Surveillance Centre (Ireland) say?

Health Protection Surveillance Centre (2020). Use of PPE to support infection prevention and control practice when performing aerosol generating procedures on confirmed or clinically suspected COVID-19 cases in a pandemic situation[1]

What does the WHO say?

World Health Organization (2020). Severe Acute Respiratory Infections Treatment Centre practical manual to set up and manage a SARI treatment centre and a SARI screening facility in health care facilities, March 2020[2]

This is the first edition of the practical manual to set up and manage a severe acute respiratory infection (SARI) treatment centre and a SARI screening facility in health-care facilities. The document has been developed to meet the operational needs emerging with the COVID-19 pandemic. Annex 14 covers biomedical devices needed for severe acute respiratory infection treatment centre.

Intensive Care Society of Ireland (April 2020). ICS Guidance document for the Intensive Care Management of the adult patient with confirmed or suspected COVID-19[3]

This clinical advisory document refers to the critically ill adult patient.

Canadian Anesthesiologists' Society (21 March 2020). COVID-19 recommendations during airway manipulation v3[4]

This guidance focuses on the management of the airway, open suctioning of respiratory tract, bronchoscopy and cardiopulmonary resuscitation for patients with known or suspected COVID-19.

POINT-OF-CARE TOOLS

What does UpToDate say?

Coronavirus disease 2019 (COVID-19): Critical Care Issues : VENTILATOR MANAGEMENT OF ACUTE RESPIRATORY DISTRESS SYNDROME [5]

Other infection precautions include use of dual limb ventilator circuitry with filters placed at the exhalation outlets as well as heat moisture exchange (HME) systems rather than heated humification of single limb circuits. HME should be placed between the exhalation port and the ETT.

INTERNATIONAL LITERATURE

What does the international literature say?

Al Ashry, HS et al. (2014) Humidification during mechanical ventilation in the adult patient[6]

Humidification of inhaled gases has been standard of care in mechanical ventilation for a long period of time. More than a century ago, a variety of reports described important airway damage by applying dry gases during artificial ventilation. Consequently, respiratory care providers have been utilizing external humidifiers to compensate for the lack of natural humidification mechanisms when the upper airway is bypassed. Particularly, active and passive humidification devices have rapidly evolved. Sophisticated systems composed of reservoirs, wires, heating devices and other elements have become part of our usual armamentarium in the intensive care unit. Therefore, basic knowledge of the mechanisms of action of each of these devices, as well as their advantages and disadvantages, becomes a necessity for the respiratory care and intensive care practitioner. In this paper, we review current methods of airway humidification during invasive mechanical ventilation of adult patients. We describe a variety of

devices and describe the eventual applications according to specific clinical conditions.

Cook, TM et al. (2020) Consensus guidelines for managing the airway in patients with COVID-19: Guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists[7]

Severe acute respiratory syndrome- corona virus- 2, which causes coronavirus disease 2019 (COVID- 19), is highly contagious. Airway management of patients with COVID- 19 is high risk to staff and patients. We aimed to develop principles for airway management of patients with COVID-19 to encourage safe, accurate and swift performance. This consensus statement has been brought together at short notice to advise on airway management for patients with COVID- 19, drawing on published literature and immediately available information from clinicians and experts. Recommendations on the prevention of contamination of healthcare workers, the choice of staff involved in airway management, the training required and the selection of equipment are discussed. The fundamental principles of airway management in these settings are described for: emergency tracheal intubation; predicted or unexpected difficult tracheal intubation; cardiac arrest; anaesthetic care; and tracheal extubation. We provide figures to support clinicians in safe airway management of patients with COVID- 19. The advice in this document is designed to be adapted in line with local workplace policies

Ferioli, M et al. (2020) Protecting healthcare workers from SARS-CoV-2 infection: practical indications[8]

The aim of this article is to provide evidence-based recommendations for the correct use of respiratory devices in the COVID-19 emergency and protect healthcare workers from contracting the SARS-CoV-2 infection.

Fowler, RA et al. (2004) Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation[9]

Nosocomial transmission of severe acute respiratory syndrome from critically ill patients to healthcare workers has been a prominent and worrisome feature of existing outbreaks. We have observed a greater risk of developing severe acute respiratory syndrome for physicians and nurses performing endotracheal intubation (relative risk [RR], 13.29; 95% confidence interval [CI], 2.99 to 59.04; p = 0.003). Nurses caring for patients receiving noninvasive positive-pressure ventilation may be at an increased risk (RR,

2.33; 95% CI, 0.25 to 21.76; p = 0.5), whereas nurses caring for patients receiving high-frequency oscillatory ventilation do not appear at an increased risk (RR, 0.74; 95% CI, 0.11 to 4.92; p = 0.6) compared with their respective reference cohorts. Specific infection control recommendations concerning the care of critically ill patients may help limit further nosocomial transmission.

Furyk J (2018). How do heat and moisture exchangers compare with heated humidifiers in people who are mechanically ventilated?[10]

For people who are mechanically ventilated, randomized controlled trials have reported no clear differences overall between heat and moisture exchangers (HMEs) and heated humidifiers (HHs) in terms of artificial airway occlusion [low- quality evidence], all- cause mortality [low- quality evidence], pneumonia- related mortality, pneumonia [low- quality evidence], and partial pressure of arterial carbon dioxide, duration of intensive care stay, or respiratory complications. Analyses suggest that the partial pressure of arterial oxygen may be higher (on average, by 2.80 kPa), the number of saline instillations/d moderately lower, and the decrease in body temperature greater (on average by ~0.5°C) with an HME than with an HH, and the incidence of pneumonia lower in the subgroup using a hydrophobic HME than in the subgroup using an HH (on average, 75 vs 157 per 1000 people). However, owing to potential for bias and often low event rates and/or small participant numbers, none of the analyses can be considered sufficiently robust to draw conclusions. No RCT reported on nosocomial or ventilator-associated pneumonia, nor on quality of life.

Meng, L et al. (2020) Intubation and Ventilation amid the COVID-19 Outbreak: Wuhan's Experience[11]

The COVID-19 outbreak has led to 80,409 diagnosed cases and 3,012 deaths in mainland China based on the data released on March 4, 2020. Approximately 3.2% of patients with COVID-19 required intubation and invasive ventilation at some point in the disease course. Providing best practices regarding intubation and ventilation for an overwhelming number of patients with COVID-19 amid an enhanced risk of cross-infection is a daunting undertaking. The authors presented the experience of caring for the critically ill patients with COVID-19 in Wuhan. It is extremely important to follow strict self-protection precautions. Timely but not premature intubation is crucial to counter a progressively enlarging oxygen debt despite high-flow oxygen therapy and bilevel positive airway pressure ventilation.

Thorough preparation, satisfactory preoxygenation, modified rapid sequence induction and rapid intubation using a video laryngoscope are widely used intubation strategies in Wuhan. Lung-protective ventilation, prone position ventilation and adequate sedation and analgesia are essential components of ventilation management.

Respiratory Care Committee of Chinese Thoracic Society (2020). Expert consensus on preventing nosocomial transmission during respiratory care for critically ill patients infected by 2019 novel coronavirus pneumonia[12]

Definite evidence has shown that the novel coronavirus (COVID-19) could be transmitted from person to person, so far more than 1,700 bedside clinicians have been infected. A lot of respiratory treatments for critically ill patients are deemed as high-risk factors for nosocomial transmission, such as intubation, manual ventilation by resuscitator, noninvasive ventilation, high-flow nasal cannula, bronchoscopy examination, suction and patient transportation, etc, due to its high possibility to cause or worsen the spread of the virus. As such, we developed this consensus recommendations on all those high-risk treatments, based on the current evidence as well as the resource limitation in some areas, with the aim to reduce the nosocomial transmission and optimize the treatment for the COVID-19 pneumonia patients. Those recommendations include: 1 Standard prevention and protection, and patient isolation; 2 Patient wearing mask during HFNC treatment; 3 Using dual limb ventilator with filters placed at the ventilator outlets, or using heat-moisture exchanger HME instead of heated humidification in single limb ventilator with HME placed between exhalation port and mask; avoid using mask with exhalation port on the mask; 4 Placing filter between resuscitator and mask or artificial airway; 5 For spontaneous breathing patients, placing mask for patients during bronchoscopy examination; for patients receiving noninvasive ventilation, using the special mask with bronchoscopy port to perform bronchoscopy; 6 Using sedation and paralytics during intubation, cuff pressure should be maintained between 25-30 cmH_2O; 7 In-line suction catheter is recommended and it can be used for one week; 8 Dual-limb heated wire circuits are recommended and only changed with visible soiled; 9. For patients who need breathing support during transportation, placing an HME between ventilator and patient; 10 PSV is recommended for implementing spontaneous breathing trial SBT, avoid using T-piece to do SBT. When tracheotomy patients are weaned from ventilator, HME should be used, avoid using T-piece or

tracheostomy mask. 11 Avoid unnecessary bronchial hygiene therapy; 12 For patients who need aerosol therapy, dry powder inhaler metered dose inhaler with spacer is recommended for spontaneous breathing patients; while vibrating mesh nebulizer is recommended for ventilated patients and additional filter is recommended to be placed at the expiratory port of ventilation during nebulization.

Scott DHT et al. (2010) Passage of pathogenic microorganisms through breathing system filters used in anaesthesia and intensive care[13]

In conclusion, we tested the hypothesis that potentially pathogenic organisms can pass through wet anaesthetic breathing filters, and found that they do so very easily. Further studies are required to investigate the potential for cross-contamination between patients if filters are used as the sole method of infection control in breathing systems for anaesthesia and intensive care.

Sundaram, M et al. (2020) Novel Coronavirus 2019 (2019-nCoV) Infection: Part II - Respiratory Support in the Pediatric Intensive Care Unit in Resource-limited Settings[14]

The 2019-novel coronavirus predominantly affects the respiratory system with manifestations ranging from upper respiratory symptoms to full blown acute respiratory distress syndrome (ARDS). It is important to recognize the risk factors, categorize severity and provide early treatment. Use of high flow devices and non-invasive ventilation has been discouraged due to high chances of aerosol generation. Early intubation and mechanical ventilation are essential to prevent complications and worsening, especially in resource-limited settings with very few centers having expertise to manage critical cases. Hydrophobic viral filter in the ventilator circuit minimizes chances of transmission of virus. Strategies to manage ARDS in COVID-19 include low tidal volume ventilation with liberal sedation-analgesia. At the same time, prevention of transmission of the virus to healthcare workers is extremely important in the intensive care setting dealing with severe cases and requiring procedures generating aerosol. We, herein, provide guidance on non-invasive respiratory support, intubation and management of ARDS in a child with COVID-19.

Zuo, MZ et al. (2020) Expert Recommendations for Tracheal Intubation in Critically ill Patients with Noval Coronavirus Disease 2019[15]

Coronavirus Disease 2019 (COVID-19), caused by a novel coronavirus (SARS-CoV-2), is a highly contagious disease. It firstly appeared in Wuhan, Hubei province of China in December 2019. During the next two months, it moved rapidly throughout China and spread to multiple countries through infected persons travelling by air. Most of the infected patients have mild symptoms including fever, fatigue and cough. But in severe cases, patients can progress rapidly and develop to the acute respiratory distress syndrome, septic shock, metabolic acidosis and coagulopathy. The new coronavirus was reported to spread via droplets, contact and natural aerosols from human-to-human. Therefore, high-risk aerosol-producing procedures such as endotracheal intubation may put the anesthesiologists at high risk of nosocomial infections. In fact, SARS-CoV-2 infection of anesthesiologists after endotracheal intubation for confirmed COVID-19 patients have been reported in hospitals in Wuhan. The expert panel of airway management in Chinese Society of Anaesthesiology has deliberated and drafted this recommendation, by which we hope to guide the performance of endotracheal intubation by frontline anesthesiologists and critical care physicians. During the airway management, enhanced droplet/airborne PPE should be applied to the health care providers. A good airway assessment before airway intervention is of vital importance. For patients with normal airway, awake intubation should be avoided and modified rapid sequence induction is strongly recommended. Sufficient muscle relaxant should be assured before intubation. For patients with difficult airway, good preparation of airway devices and detailed intubation plans should be made.

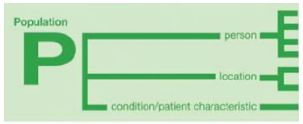
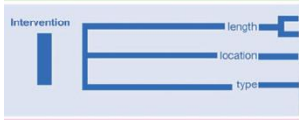
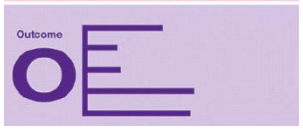
OTHER

Worcester S (April 2020). Is protocol-driven COVID-19 respiratory therapy doing more harm than good?[16]

"Dr. Gattinoni noted that COVID-19 patients in ICUs in northern Italy had an atypical ARDS presentation with severe hypoxemia and well-preserved lung gas volume. He and colleagues suggested that instead of high positive end-expiratory pressure (PEEP), physicians should consider the lowest possible PEEP and gentle ventilation–practicing patience to "buy time with minimum additional damage.".

Produced by the members of the National Health Library and Knowledge Service Evidence Team†. Current as at 15 APRIL 2020This evidence summary collates the best available evidence at the time of writing and **does not replace clinical judgement or guidance**. Emerging literature or subsequent developments in respect of COVID-19 may require amendment to the information or sources listed in the document. Although all reasonable care has been taken in the compilation of content, the National Health Library and Knowledge Service Evidence Team makes no representations or warranties expressed or implied as to the accuracy or suitability of the information or sources listed in the document. This evidence summary is the property of the National Health Library and Knowledge Service and subsequent re-use or distribution in whole or in part should include acknowledgement of the service.

The following PICO(T) was used as a basis for the evidence summary:

	MECHANICALLY VENTILATED COVID-19 PATIENTS
	"DRY FILTER" HYDROPHOBIC V "WET FILTER" HYGROSCOPIC
	
	ICU HEALTHCARE WORKERS EXPOSURE TO INFECTION IMPACT ON CARDIOVASCULAR PATIENT

The following search strategy was used:

ARTIFICIAL VENTILATION.SH. OR VENTILAT*.TW. OR (ARTIFICIA* ADJ5 (RESPIR* OR AIRWAY*)).TW. OR TRACHEOSTOM*.TW.
AND
CORONAVIRUS*.TW. OR CORONAVIRUS.SH. OR ((COVID-19 OR 2019-NCOV).TW. OR WUHAN.MP.) ADJ3 VIRUS.TW. [MP=TITLE, ABSTRACT, HEADING WORD, DRUG TRADE NAME, ORIGINAL TITLE, DEVICE MANUFACTURER, DRUG MANUFACTURER, DEVICE TRADE NAME, KEYWORD, FLOATING SUBHEADING WORD, CANDIDATE TERM WORD] OR (WUHAN ADJ3 VIRUS).TW.
AND
INFECTION CONTROL.SH. OR RISK.SH. OR (RISK* OR AIRBORNE OR SAFETY OR SPRAY* OR EXTUB* OR DISCONNECT*).TW. OR (HUMIDIFI* OR HYDROPHOBIC* OR HYGROSCOPIC* OR "HOT TEMPERATURE" OR HUMID*).TW. OR (MOISTURE ADJ3 EXCHANG*).TW.

† Anne Madden, St Vincent's University Hospital Dublin [Author]; Isabelle Delaunois, Regional Medical Library, University Hospital Limerick, Dooradoyle Limerick [Author]; Brendan Leen, Regional Librarian, HSE South, St. Luke's General Hospital, Kilkenny [Editor]

[1] Health Protection Surveillance Centre Ireland. Use of PPE to support Infection Prevention and Control Practice when performing aerosol generating procedures on confirmed or clinically suspected Covid-19 cases in a pandemic situation. Guidance V 2, 23.3.2020. https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/infectionpreventionandcontrolguidance/aerosolgeneratingprocedures/AGPs%20for%20confirmed%20or%20possible%20COVID19_v2.0_23032020.pdf [Accessed 15/04/2020]

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