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Special Article

COVID-19 and the anaesthetist: a Special Series

Controversies in airway management of COVID-19 patients: updated information and international expert consensus recommendations

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As knowledge and experience in the management of critically ill coronavirus disease 2019 (COVID-19) patients has increased with time, a panel of international experts convened and formulated consensus opinions regarding controversial topics in advanced airway management based on current literature. Here we summarise updated information and international expert opinion on several controversial topics concerning airway management in critically ill patients with COVID-19.

Personal protective equipment

Recommendations for the personal protective equipment (PPE) required during aerosol-generating procedures (AGPs), such as advanced airway management, are inconsistent amongst different countries and regions.[1–8] Two new studies report conflicting results, either supporting[9] or opposing[10] tracheal intubation and extubation as AGPs. Both studies were limited by small sample size, and used different definitions of AGPs and particle detection methods. Additional carefully designed studies are necessary to clarify the risk of aerosolised viral spread during tracheal intubation and extubation. In the interim, it is prudent to continue to consider both as AGPs. Maximal interventions to safeguard healthcare workers from cross infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) must be maintained until this question is adequately studied.

Studies from China have classified levels of PPE (Fig 1).[11] Level III has been reported to protect healthcare workers from cross infection during a variety of AGPs including tracheal intubation (Table 1),[11,12,14,15] high-flow nasal oxygen (HFNO) usage and tracheal intubation using a flexible intubating endoscope in patients with COVID-19.[15] Level II PPE, often used in other countries and regions outside China,[4,5,7] may not provide full protection from cross infection. Cross infection rates in healthcare workers range from 0% to 14.7% (Table 1).[27,28] The primary difference between level II and III PPE is that level III includes use of a face shield, eye goggles, water-resistant gown, and hooded coverall. This assists in avoiding exposure of skin or eyes to air and potentially aerosolised viral particles (Fig 1). Table 2 summarises the commonly used levels of PPE around the world and the reported cross infection rates in healthcare workers. Videolaryngoscopy is the recommended approach for tracheal intubation in patients with COVID-19 in order to maximise first pass success rate and minimise exposure of healthcare workers during the procedure.[1,12,13] Awake tracheal intubation (ATI) has been performed successfully using flexible bronchoscopy. To date, cross infection of healthcare workers has not been reported during ATI. Therefore, ATI should be considered for management of the anticipated difficult airway, especially when tracheal intubation under general anaesthesia is considered unsafe.[14] Level III PPE should be used.

Expert consensus

It appears that the higher the level of PPE used, the better the protection against cross infection. However, adequate protection of healthcare workers is often limited by the availability of PPE during a world pandemic. It is recommended to use the highest level of PPE available in the management of patients with COVID-19, especially during performance of high-risk AGPs such as tracheal intubation, extubation, or tracheostomy.[1,12,17,37] Fit testing and supervised donning and doffing of PPE remain critical steps in the avoidance of cross infection of healthcare workers. It is crucial to note that PPE must be a part of a comprehensive infection control strategy in order to be effective. Healthcare workers remain a precious resource in the fight against COVID-19.[38]

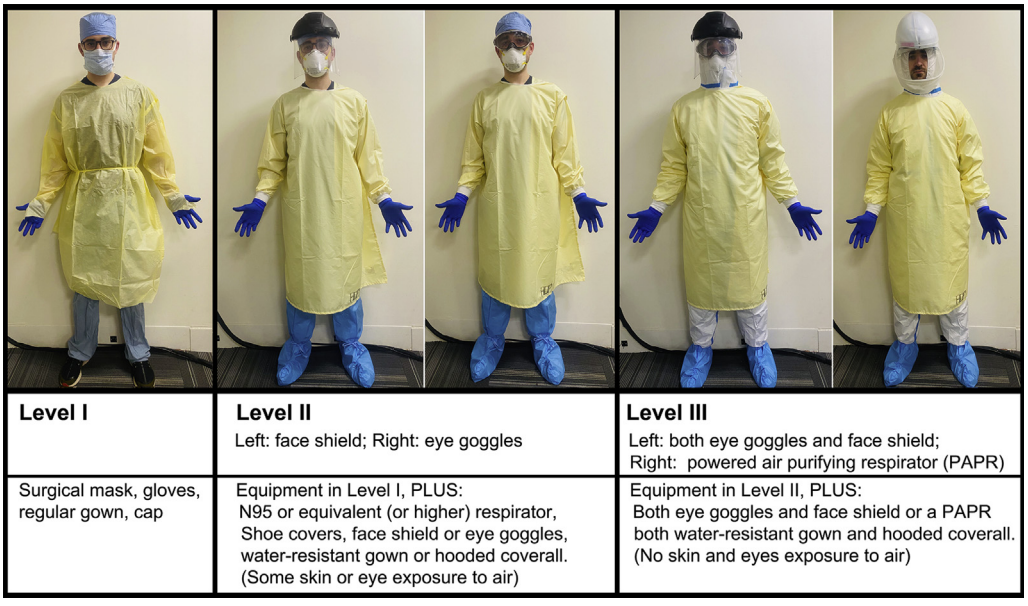

Fig 1. Classification of personal protective equipment.[11,12,13] Note an N95 mask respirator or surgical mask could be used inside the powered air purifying respirator (PAPR) hood to protect against potential self-contamination during doffing of personal protective equipment (PPE).

Table 1 Healthcare workers cross infection rate at different levels of personal protective equipment. *Tracheal intubation and other aerosol generating procedures. †No infection in operators with Level III PPE. ‡Total cases were not reported. ¶Total infection rate among asymptomatic HCWs. §The rate listed is the incidence of laboratory-confirmed COVID-19 diagnosis or new symptoms requiring self-isolation or hospitalisation after a tracheal intubation episode. This study included intubation in known and suspected COVID-19 patients. HCW, healthcare worker; PPE, personal protective equipment.

	Infection rate of HCWs after tracheal intubation	Overall infection rate of HCWs	Proportion of HCWs in confirmed COVID-19 cases
China			
Lack of protection			
Meng and colleagues[13]			29% (40/138)
Level I			
Lai and colleagues[16]		1.4% (93/6574)	
Level II			
Lai and colleagues[16]		0.5% (17/3110)	
Level III[3]			
Wu and colleagues[15]	0% (0/6)		
Cai and colleagues[14]	0% (0/9)		
Yao and colleagues[12]	0% (0/52)		
Liu and colleagues[17]	0% (0/420)*		
Levels I–III			
Liu and colleagues[11]	2% (11/554)†		
Wu and colleagues[18]			3.8% (1716/44 672)
Italy			
Level II[7]			
Livingston and Bucher[19]			9% (2026/22 512)
Li and colleagues[20]			>8% (>1116/13 882)
Anelli and colleagues[21]			9% (4824 HCWs)‡
UK			
Level II[6]			
Treibel and colleagues[22]		11% (44/400)¶	
USA			
Level II[4]			
Sullivan and colleagues[23]		14.7% (508/3466)	
Morcuende and colleagues[24]		12.1% (11/91)	
South Africa			
Level II			
Mendelson and colleagues[25]	0% (0/41)		
International (17 countries)			
Level II[5]			
El-Boghdadly and colleagues[26]	10.7% (184/1718)§		

Use of high-flow nasal oxygen therapy

Many guidelines initially prohibited or discouraged use of high-flow nasal oxygen (HFNO) therapy in patients with COVID-19, based on the potential risks of aerosol generation and viral spread.[1] The extent of this risk remains unresolved.[36] Some studies support[29,30] use of HFNO whereas others do not (Table 2).[31–33] Use of HFNO in critically ill patients with COVID-19 with hypoxic respiratory insufficiency has been examined for its potential benefit as the mortality rate of mechanically ventilated patients remains high.[39] Patients with COVID-19 with pulmonary failure but normal lung compliance appear to respond favourably to HFNO treatment, but those patients with impaired lung compliance may not derive the same benefit.[40] A cohort study from the 2009 epidemic of respiratory failure caused by influenza A found that use of HFNO reduced the need for mechanical ventilation by 45%.[34] The future use of HFNO in patients with COVID-19 will be based on its efficacy to diminish hypoxaemia, the need for mechanical ventilatory support, and mortality.

Use of appropriate PPE, and supervised donning and doffing, are critical in avoiding cross infection from any AGP. Other factors, such as negative pressure rooms, high air exchange rates through the ventilation system, the ventilation system itself, and use of an anteroom, are additional important interventions to reduce the risks of cross infection. The use of HFNO for apnoeic oxygenation during laryngoscopy and tracheal intubation is recommended for selected patients with COVID-19 at high risk of hypoxaemia.[15]

Another controversy associated with the use of HFNO is the concomitant use of a simple surgical mask as a means to minimise dispersion of aerosols in spontaneously breathing patients with COVID-19. A preliminary study using computational fluid dynamic simulation determined that addition of a surgical mask over a properly fitted HFNO device may be an effective option to reduce droplet deposition from exhaled gas flow.[41] A recent study of healthy volunteers evaluated aerosol production with HFNO and noninvasive positive pressure ventilation (NIPPV) compared with 6 L min^{-1} low-flow nasal oxygen (LFNO).[35] HFNO and LFNO were studied with and without subjects wearing a type 1 surgical face mask. Aerosol size and mass were measured at 2 and 6 ft from the patient's nasopharynx. There was no significant difference in aerosol production between HFNO, NIPPV, or LFNO. The use of a surgical mask over the HFNO device did not change aerosolised particle spread.[35] Further study is critical to confirm the safety and efficacy of the practice of applying a mask over HFNO devices. Barotrauma is a risk when HFNO is delivered simultaneously with a tightly sealed face mask, such as an anaesthesia face mask, owing to excessive delivered pressure, so this combination should be avoided.[42]

Table 2 Studies on use of high-flow nasal oxygen (HFNO) therapy and risks of viral spread. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Authors	Type of study	Subject	Details
Restrict use			
Santarpia and colleagues[29]	Clinical observation	SARS-CoV-2	The highest concentrations of virus in air were recorded during oxygenation through a nasal cannula.
Loh and colleagues[30]	Simulation study	SARS-CoV-2	HFNO increased the dispersion distance of cough-generated droplets
Support use			
Leung and colleagues[31]	Randomised controlled crossover trial	Gram-negative bacteria	HFNO was not associated with increased air or contact surface contamination by bacteria in ICU patients
Hui and colleagues[32]	Simulation study	Respiratory virus	HFNO with good interface fitting was associated with limited exhaled air dispersion of virus
Tran and colleagues[33]	Systematic review	SARS-CoV	HFNO did not increase transmission risk significantly
Rello and colleagues[34]	Cohort study	H1N1v	No secondary infections in healthcare workers, nor nosocomial pneumonia occurred during HFNO therapy
Miller and colleagues[35]	Volunteer simulation study	Aerosol production	No significant difference in aerosol production between either HFNO and low-flow nasal cannula
Neutrality			
Agarwal and colleagues[36]	Systematic review	SARS-CoV-2	Unknown effects of HFNO on risk of virus spreading

Expert consensus

There is currently no convincing evidence that HFNO increases the risk of COVID-19 cross infection to healthcare workers. Well-designed prospective studies are warranted to clarify the risk, if any, and to assess risk-reducing interventions. It is recommended that use of HFNO in patients with COVID-19 depends on the risk/benefit ratio determined by the clinician for each patient until additional information is available.

Early or late tracheal intubation

Recent studies[1,2,12,43] have recommended early tracheal intubation to minimise the risk of cross infection of healthcare workers. Early tracheal intubation may obviate the need for urgent intubation and may lessen the severity of hypoxaemia and haemodynamic instability during induction of anaesthesia and tracheal intubation. Results of the combined use of noninvasive respiratory support and awake prone positioning,[44] particularly in patients with the type L (high compliance) acute respiratory distress syndrome (ARDS), are encouraging.[40] A recent report showed a significant decrease in the mortality rate of patients admitted to ICU with COVID-19. This is likely attributable to multiple factors, including increased clinical experience, rapidly developing management strategies and therapeutics and increased use of noninvasive ventilatory support such as HFNO.[45] Use of HFNO may delay tracheal intubation and mechanical ventilation, and reduce the need for admission to ICU.[36,46–48]

Expert consensus

This controversy regarding early *vs* late tracheal intubation is still evolving.[49] It is recommended that the appropriate time to intubate patients with COVID-19 may be dependent on their individual pathology and pathophysiology, the acute trajectory of their illness, in addition to their responsiveness to trials of noninvasive airway management.

Summary

Level III PPE appears to provide healthcare workers with maximum protection against cross infection by aerosolised SARS-CoV-2 viral particles. The highest level of PPE should be considered in the management of patients with COVID-19, especially during performance of AGPs. Global efforts should provide adequate levels of PPE for all healthcare workers during the pandemic and uniform application of environmental controls. Use of HFNO should be considered for management of acute respiratory failure and after tracheal extubation of patients with COVID-19 as long as optimal environmental measures and protective PPE are available for healthcare workers. Noninvasive ventilation is encouraged as the first-line approach before tracheal intubation and mechanical ventilation in critically ill patients with COVID-19 with the aforementioned caveats, although further study of this approach is warranted.

Authors' contributions

All authors were involved in the conception and writing of manuscript

Declarations of interest

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