Cardiopulmonary resuscitation and risk of transmission of acute respiratory infections to rescuers: a systematic review snapshot

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Abstract: The novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was identified in Wuhan City, China, in December 2019. Currently, the zoonotic origin of SARS-CoV-2 is unknown. However, one of the hallmarks in severe cases of coronavirus disease 2019 (COVID-19) is hypoxemic respiratory failure. Management of severe cases involves procedures such as non-invasive ventilation and endotracheal intubation that have the potential to generate respiratory aerosols. During the current coronavirus (COVID-19) pandemic, we need to mitigate any risks related to resuscitation as best we can, even if this is disruptive or at some point proven to be overly cautious. Unless we are presented with new evidence, any maneuver performed during cardiopulmonary resuscitation (CPR) should be considered an aerosol generating procedure. Limited data from the SARS epidemic suggests baseline risk of infection among health care workers may be 10%. Performing endotracheal intubation is associated with a 3–5 times higher risk. If causative, this represents an enormous potential for harm (an absolute risk increase of up 40%). Thus, performing endotracheal intubation during CPR should be treated as a very high-risk procedure and managed with the highest precautions, including donning appropriate full enhanced personal protective equipment before entering the scene, to guard against contact with both airborne and droplet particles. The aim of this systematic review snapshot was to identify and summarize in the form of a clinical synopsis the literature surrounding the potential risk of infection transmission associated with key interventions performed in the context of cardiac arrest.

Keywords: Severe acute respiratory syndrome coronavirus (SARS-CoV); SARS-CoV-2; coronavirus disease 2019 (COVID-19); aerosol generating procedures (AGP), cardiopulmonary resuscitation (CPR)

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Introduction

High-quality cardiopulmonary resuscitation (CPR) and early defibrillation improve chance of survival during cardiac arrest (1,2). Current resuscitation guidelines highlight the importance of rescuer safety (1,2). In normal circumstances most cardiac arrest patients requiring CPR will not have an acute respiratory infection that has a high risk of transmission to health care workers (HCWs), including providers of CPR (3). However, the delivery of CPR to a patient infected with COVID-19 may place HCWs at risk.

The coronavirus (COVID-19) pandemic has highlighted the need for reassessment of acute respiratory infection transmission risks for healthcare providers (4,5). More importantly, the reassessment of those lifesaving interventions performed when attempting treatment of cardiac arrest that may generate aerosols that remain

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infectious when suspended in air, increasing the risk of infectious transmission (6-9).

This systematic review snapshot summarizes estimates for pooled data on the basis of the available evidence evaluating procedures that might generate aerosols or droplets and the risk of transmission of acute respiratory infections to HCWs. Unfortunately, most of the data comes from the fast severe acute respiratory syndrome coronavirus (SARS-CoV) epidemic in 2002–2003 (10).

Aims and objective

The aim of this systematic review snapshot was to identify and summarize in the form of a clinical synopsis the literature surrounding the potential risk of infection transmission associated with key interventions performed in the context of cardiac arrest.

Methods

Data sources

Data sources were PubMed, EMBASE, MEDLINE, CINAHL, the Cochrane Library, Index Medicus for South East Asia, LILACS, Indian Medlars, EuroScan, University of York CRD databases (01/01/1990 to 10/22/2010), Google and other Internet search engines, references of relevant articles and previously published literature, and, through contacts, experts in the field for article recommendations or unpublished work.

Study selection

Randomized controlled trials, non-randomized studies, systematic reviews, and meta-analyses. The study population involved HCWs caring for patients with acute respiratory infections undergoing aerosols generated procedures (AGPs) and the researches evaluated the risk of transmission of acute respiratory infections from patients to HCWs. Their predefined outcome of interest was the risk of transmission of acute respiratory infections from patients to HCWs. Exclusion criteria were not reported.

Data extraction and synthesis

One investigator extracted data after independently assessing each study for methodological quality. Relevant data was verified by a second investigator using the predesigned data extraction form to capture the study characteristics and the outcomes of interest. Effect sizes were reported as odds ratio (OR) and its 95% confidence interval (CI). The authors used random-effects modeling for the meta-analyses and heterogeneity was assess by using the I^2 statistics. Where statistical heterogeneity was found, sensitivity analysis on treatment effect was conducted. Publication bias was not assessed. The authors calculated summary estimates of procedures that might promote the generation of aerosols or droplets and their association with the risk of transmission of acute respiratory infections from patients to HCWs.

Results

The authors identified 1,862 potential studies, of which 10 met the inclusion criteria (3,075 HCWs). No randomized controlled trials were identified. There were five non-randomized cohort studies and five retrospective cohort studies. All studies investigated the risk factors for transmission of SARS-CoV from patients to HCWs during the 2002–2003 SARS outbreaks. Most of the included studies were each conducted at single centers. Five studies were carried out in China, four in Canada, and one in Singapore. The majority of the studies evaluated whether HCWs had proper infection control training or wore personal protective equipment (PPE) while caring for patients with SARS. There was high heterogeneity across predictors of interest (range, 0% to 73.1%). Confounding was a universal source of bias across all studies included studies, given the observational nature of the evidence. The quality of the evidence was rated very low according to GRADE (11). *Table 1* shows the risk of SARS transmission to HCWs exposed to AGPs compared to no exposure.

Commentary

During the global spread of SARS (12,13), a great deal was discovered about the illness and the SARS-associated coronavirus (14,15). Studies from the SARS-CoV epidemic suggest that some procedures performed during CPR, including chest compressions, defibrillation, bag valve mask ventilation, or endotracheal intubation are potentially capable of generating aerosols associated with increased risk of SARS transmission to HCWs or were a risk factor that increase infection for transmission, with the most consistent association across multiple studies of increased risk for transmission identified with endotracheal intubation (10).

Table 1 Summary estimates for pooled data—aerosol generating procedures as risk factors for transmission for SARS-CoV*

Aerosol generating procedures	No. of studies	Statistical method	Effect size	Heterogeneity (I^2)
Tracheal intubation†	4	OR (M-H, Random, 95% CI)	6.6 (2.3–18.9)	39.6%
Tracheal intubation‡	4	OR (M-H, Random, 95% CI)	6.6 (4.1–10.6)	61.4%
Suction before intubation	2	OR (M-H, Random, 95% CI)	3.5 (0.5–24.6)	59.2%
Suction after intubation	2	OR (M-H, Random, 95% CI)	1.3 (0.5–3.4)	28.8%
Nebulizer treatment	3	OR (M-H, Random, 95% CI)	0.9 (0.1–13.6)	73.1%
Manipulation of oxygen mask	2	OR (M-H, Random, 95% CI)	4.6 (0.6–32.5)	64.8%
Non-invasive ventilation	2	OR (M-H, Random, 95% CI)	3.1 (1.4–6.8)	0%
Insertion of nasogastric tube	2	OR (M-H, Random, 95% CI)	1.2 (0.4–4.0)	0%
Chest compressions	2	OR (M-H, Random, 95% CI)	1.4 (0.2–11.2)	27.3%
Defibrillation	2	OR (M-H, Random, 95% CI)	2.5 (0.1–43.9)	55.3%
Chest physiotherapy	2	OR (M-H, Random, 95% CI)	0.8 (0.2–3.2)	0%

Notes: the following interventions: high-flow oxygen (1 cohort study) 0.4 (0.1–1.7), manual ventilation before intubation (1 cohort study) 2.8 (1.3–6.4), bag valve mask ventilation before intubation 2.8 (1.3–6.4), and bag valve mask ventilation after intubation 1.3 (0.5–3.2) represent an approximate 95% CI around the point estimate of an OR. Intervention with an increased risk of transmission included: tracheal intubation [pooled OR 6.2, 95% CI: 3.4 to 11.3 (calculated); 8 studies], non-invasive ventilation (pooled OR 3.1, 95% CI: 1.4 to 6.8; 2 studies), bag valve mask ventilation before intubation (OR 2.8, 95% CI: 1.3 to 6.4; 1 study) and tracheotomy (OR 4.2, 95% CI: 1.5 to 11.5, 1 study). The other interventions were considered to be statistically non-significant (10). *, summary estimates represent pooled OR ratios with 95% CI comparing the risk of SARS transmission to HCWs exposed to AGPs *vs.* no exposure. †, refers to cohort studies. ‡, refers to case-control studies. AGPs, aerosol generating procedure; HCWs, health care workers; CI, confidence interval; OR, odds ratio; SARS-CoV, severe acute respiratory syndrome coronavirus.

The aim of this systematic review snapshot is to present a clinical synopsis of the risk of transmission of SARS-CoV infection to HCWs exposed to patients undergoing AGPs compared with the risk of transmission to HCWs caring for patients not undergoing AGPs. This review also attempts to highlight the lack of adequate studies regarding the topic and SARS-CoV-2. Although no direct clinical implications are immediately available this definitely is a necessary first step in summarizing the data or the lack of till date. At the same time this review does not attempt to question whether this deadly, novel, yet closely related coronavirus is airborne, as this remains strongly debated and is, presently, unclear. *Table 2* outlines the existing arguments suggesting for and against air borne transmission of SARS-CoV-2.

Respiratory infections in which the pathogens can cause diseases such as influenza, SARS, and COVID-19 have high morbidity and mortality. On February 11, 2020, the World Health Organization (WHO) announced the newly identified coronavirus that causes COVID-19, which has been called SARS-CoV-2. As of February 5, 2021, a total of 105,243,379 cases, including 2,294,180 deaths, have been reported in at least 192 countries/regions (16). The WHO has categorized CPR as an aerosol generating procedure (AGP) (4,5). However, to date little is known about SARS-CoV-2 and the risk of transmission to HCWs, including the risk of AGPs performed by providers during CPR. PPE protocols have been proposed by several local, statewide, and international institutions, but these recommendations are based on very low-quality evidence. *Table 3* outlines the minimum PPE needed to evaluate a patient with suspected or confirmed COVID-19 and to perform AGPs as recommended by the American Heart Association' interim guidance for Basic and Advanced Life Support and the Centers for Disease Control and Prevention (8,17). Although SARS-CoV-2 is slightly different from the coronavirus that causes SARS, most of the data we have on the risk of acute respiratory infections transmission to HCWs exposed to AGPs, including lifesaving interventions such as CPR, comes from the SARS-CoV epidemic in 2002–2003 (10).

Unanswered questions persist and a significant research gap exists in this area. The debate on whether interventions performed during resuscitation should be considered AGPs remains unclear. Therefore, although there is almost no

Table 2 Evidence suggesting for and against air borne transmission of SARS-CoV-2

Suggesting of airborne
ACE-2 abundant on alveolus
Considered airborne with aerosol-generating procedure
Causes early alveolar lung disease
Live virus found in air samples no associated with aerosol-generating procedure
SARS-CoV can be airborne
Symptomatology increases virulence
SARS-CoV-2 can behave a bit like an airborne virus.
SARS-CoV-2 can remain viable in aerosols
Super-emitter/spreading events
Rapid global transmission
RNA found in air samples no associated with aerosol-generating procedure
Virus stable when aerosolized
Non-suggesting of airborne
Angiotensin-converting enzyme-2 heavily expressed in oral mucosa epithelium
No distant transmission proven
No human-to-human transmission
Ro of proven airborne virus typically higher

ACE-2, angiotensin-converting enzyme; SARS-CoV, severe acute respiratory syndrome coronavirus; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; RNA, ribonucleic acid.

clear scientific evidence on which to base our decisions, during the current COVID-19 pandemic it is important that we understand the potential risk of transmission that can occur during resuscitation versus the known risk of resuscitation delays; many of these procedures, in particular endotracheal intubation, have been associated with transmission of acute respiratory infections to HCWs. Four cohort studies showed that HCWs performing or being exposed to a endotracheal intubation had a higher risk of disease transmission of SARS compared with the control group (unexposed HCWs). The study's authors reported a pooled OR for this outcome of 6.6 with a 95% CI of 2.3 to 18.9 (P<0.0005; 4 cohort studies; 584 controls and 167 cases; very low-quality evidence) (*Figure 1*) (10). Four case-control studies identified that endotracheal intubation was a significant risk factor for transmission of SARS to HCWs compared with the control group (unexposed HCWs). The study's authors reported a pooled OR for this outcome of 6.6 with 95% CI of 4.1 to 10.6 (P<0.0001; 4 case control studies; 1,454 controls and 259 cases; very low-quality evidence) (*Table 1*) (10). However, the overall certainty of the evidence was very low and at high risk of bias.

It is noteworthy that some of these interventions were performed with very sick patients, which is an important potential factor for confounding and a stronger predictor of HCWs contracting the infection than the procedure itself. Critically ill patients should be managed with the highest precautions; full enhanced PPE is recommended when managing patients during resuscitation especially during the COVID-19 pandemic to reduce the risk of SARS-CoV-2 transmission from patients with an unknown or known COVID-19 status. This review also serves as an effort to present some of the most common procedures performed during CPR that are potentially capable of generating aerosols which could increase the risk of transmission of acute respiratory infections to HCWs and to announce rescuer workers that we are still in the dark about the risks of infection transmission from COVID-19 during the aforementioned procedures and thus open the gates for studies to be initiated as we did not find any direct evidence

Table 3 Minimum recommended PPE required to evaluate suspected or confirmed COVID-19 patients and perform aerosol generating procedures

PPE equipment required to evaluate COVID-19 patients
Long sleeve gown covering wrists
Gloves extended to cover wrist of gown
Surgical mask or respirator (N95 or FFP3)
Eye and face protection (fluid-resistant surgical mask with integrated full-face shield/visor or safety glasses)
PPE equipment required to perform AGPs on patients suspected or positive for COVID-19
Long sleeve gown covering wrists
Double gloves extending to cover wrist
Fit tested respirator (N95 or FFP3) or PAPR
Eye and face protection (fluid-resistant fit tested respirator with integrated full-face shield/visor)

Notes: the United States National Institute for Occupational Safety and Health (NIOSH) classifies particulate filtering facepiece respirators into nine categories. This classification is based on the resistance of particulate filtering facepiece respirators to oil and their efficiency in filtering airborne particles. N indicates not resistant to oil; R is moderately resistant to oil; and P is strongly resistant to oil. The letters are followed by numerical designations, which indicate the filter's aerosol filtration percentage efficiency of 95%, 99%, and 99.97% of airborne particles (<0.3 microns). The European standard classifies filtering face piece respirators into three classes: FFP1, FFP2, and FFP3. The FFP1 filters at least 80% of airborne particles, the FFP2 filters at least 94% of airborne particles, and the FFP3 mask is the most filtering of the FFP masks, it filters at least 99% of airborne particles. AGPs, aerosol generating procedure; COVID-19, coronavirus disease 2019; PARP, powered air-purifying respirator; PPE, personal protective equipment; FFP, filtering face piece.

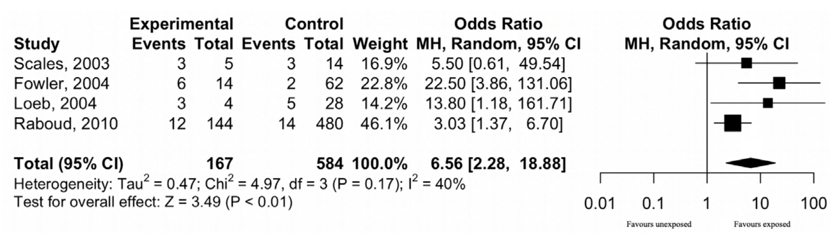

Figure 1 Risk of SARS transmission to healthcare providers exposed to tracheal intubation (10). SARS, severe acute respiratory syndrome.

that lifesaving procedures performed during CPR either are or are not associated with transmission of infection. Even though the basic reproductive rate (R_0) for SARS-CoV-2 seems to be comparable to SARS-CoV 2.5 (range, 1.8–3.6) *vs.* 2.0–3.0 (18), we cannot conclude the risk of transmission of COVID-19 is same with SARS-CoV. It is very critical issue, and it might too early to think that this deadly, novel, yet closely related coronavirus imposed the same or higher risk of transmission of SARS.

Research priorities

(I) While performing endotracheal intubation is there evidence of increased risk of acute respiratory infection transmission to HCWs?

(II) While performing endotracheal intubation is there evidence that this procedure can be done safely without full enhanced PPE?

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Footnote

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jeccm-20-158). The author has no conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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