NERVTAG consensus statement on Cardiopulmonary Resuscitation (CPR) as an AGP

NERVTAG was asked to undertake an evidence review to consider whether chest compressions and defibrillation are associated with an increased risk of transmission of acute respiratory infections. Furthermore, it was asked to give an opinion on whether chest compressions and defibrillation should be considered to be aerosol generating procedures (AGPs).

The evidence review was based on work done by Health Protection Scotland - https://hpspubsrepo.blob.core.windows.net/hps-website/nss/2893/documents/1_tbp-lr-agp-v1.pdf.

Summary Findings: The scientific evidence base is extremely weak and heavily confounded by an inability to separate out specific procedures performed as part of CPR, e.g. chest compression, defibrillation, manual ventilation and intubation. A systematic review found that chest compressions and defibrillation were not significantly associated with an increased risk of SARS infection (Tran et al, 2012).

It is biologically plausible that chest compressions could generate an aerosol, but only in the same way that an exhalation breath would do. No other mechanism exists to generate an aerosol other than compressing the chest, and an expiration breath, much like a cough, is not currently recognised as a high-risk event or an AGP. Defibrillation is not likely to cause any significant breath exhalation. Airway intubation and manual ventilation consistently come out as the most high-risk procedures that take place during CPR.

In conclusion, we do not consider that the evidence supports chest compressions or defibrillation being procedures that are associated with a significantly increased risk of transmission of acute respiratory infections.

When recommending what personal protective equipment (PPE) healthcare workers should use when performing chest compressions or defibrillation, other considerations will include;

- The risk to a healthcare worker should they become infected

- The harm that may come to patients in whom chest compressions and defibrillation are delayed while responders don PPE.

Author:

Personal Data

Dr Ben Killingley

Chair of NERVTAG:

Personal Data

Professor Peter Horby

Supplementary Information

Evidence Summary:

Table of Case-control / Cohort studies:

Study	Controls	No. infected	Procedure	Exposed Infected	Exposed non infected	OR	P
Lau	144	72	High risk incl CPR	12	18	1.22	0.8
Loeb	37	6	CPR	0	8		0.55
Raboud	598	26	Chest compressions	1	8		0.32
Liu	426	51	Chest compressions	5	10		0.02
Tran Review			Chest compressions			1.4 (0.2-11.2)	

Evidence Base

1. **Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. Hae-Sung Nam, Mi-Yeon Yeon, Jung Wan Park, Jee-Young Hong, Ji Woong Son. Epidemiology and Health. 2017 Volume: 39**

Case report – one HCW involved

This report describes the investigation of a case of MERS-CoV transmitted to a HCW during a large hospital outbreak in South Korea in 2015. The HCW was a nurse who performed CPR on an infected patient for around 1 hour. Haemoptysis was continuously observed whilst intubation and suctioning of the airways was performed. CPR was performed in a negative pressure isolation room, a large amount of body fluid was splashed during the procedure and the nurse remained in

the room for around 2-3 hours after performing CPR to clean the room. After recovery the nurse noted that her goggles were heavy and had slid down along with her surgical mask while performing CPR, in addition CCTV revealed she had touched the masks and goggles with contaminated gloves and had wiped away sweat.

Commentary:

- *The multiple factors that could have led to infection transmission in this case make it very difficult, if not impossible to identify the high-risk elements of the process.*

2. Christian MD, Loutfy M, McDonald LC, Martinez KF, Ofner M, Wong T, Wallington T, Gold WL, Mederski B, Green K, Low DE and on behalf of the SARS Investigation Team. 2004. Possible SARS Coronavirus Transmission during Cardiopulmonary Resuscitation. Emerging Infectious Diseases 10: 287-293

Case cluster report – 9 HCWs involved; 3 were symptomatic, 1 tested positive for SARS, 1 indeterminate, 1 negative

"We investigated a possible cluster of SARS-CoV infections in healthcare workers who used contact and droplet precautions during attempted cardiopulmonary resuscitation of a SARS patient. The index case-patient was unresponsive, and the intubation procedure was performed quickly and without difficulty. However, before intubation, the patient was ventilated with a bag-valve-mask that may have contributed to aerosolization of SARS-CoV".

Positive HCW performed - IV insertion in foot (<5 min), medication administration (10 min), application of EKG leads (<1 min)

Inderterminate HCW performed chest compressions for 10-15 mins

The authors conclude –
"Two explanations may account for the transmission observed in this case:
1) an unrecognized breach in contact and droplet precautions occurred, or
2) an airborne viral load was great enough to overwhelm the protection offered by droplet precautions, including non–fit-tested N95 disposable respirators.
If the last form of transmission was responsible, airborne virus may have been generated by the coughing patient before her cardiopulmonary arrest or due to a "cough-like" force produced by the airway pressures created during asynchronous chest compressions and ventilations using the bag-valve-mask".

Commentary:

- *Manual ventilation alone is a known risk factor and greater emphasis could have been placed on this in the conclusion. The suggestion that overwelming of properly worn PPE occurred is slightly odd, more likely be reflected in a breach of improperly used PPE.*
- *Current CPR protocols do not include the delivery of chest compressions and manual ventilation at the same time.*

3. **Lau JT, Fung KS, Wong TW et al. (2004) SARS transmission among hospital workers in Hong Kong. Emerging Infectious Diseases 10, 280–286.**

A case-control study of 72 hospital workers with SARS and 144 matched controls. "Inconsistent use of goggles, gowns, gloves, and caps was associated with a higher risk for SARS infection (unadjusted odds ratio 2.42 to 20.54, $p < 0.05$). The likelihood of SARS infection was strongly associated with the amount of personal protection equipment perceived to be inadequate, having <2 hours of infection control training, and not understanding infection control procedures".

"No significant differences existed between the case and control groups in the proportion of workers who performed high-risk procedures (intubation, suction, cardiopulmonary resuscitation), reported minor protection equipment problems, or had social contact with SARS-infected persons. Perceived inadequacy of personal protection equipment supply, infection control training <2 hours, and inconsistent use of personal protection equipment when in contact with SARS patients were significant independent risk factors for SARS infection".

High risk procedures:
Exposed non-infected = 18, Exposed Infected = 12 , OR = 1.22 (0.45 to 3.14), p = 0.8061

Commentary:

- *Implicates compliance with infection control procedures to be the issue, rather than certain procedures*

4. **Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. Khai Tran, Karen Cimon, Melissa Severn, Carmem L. Pessoa-Silva, John Conly. PLOs One, 2012, 7(4), e35797.**

Tran et al identified 5 case-control and 5 retrospective cohort studies which evaluated transmission of SARS to HCWs. Procedures reported to present an increased risk of transmission included
[n; pooled OR(95%CI)];

- tracheal intubation [n = 4 cohort; 6.6 (2.3, 18.9), and n = 4 case-control; 6.6 (4.1, 10.6)]
- non-invasive ventilation [n = 2 cohort; OR 3.1(1.4, 6.8)]
- tracheotomy [n = 1 case-control; 4.2 (1.5, 11.5)]
- manual ventilation before intubation [n = 1 cohort; OR 2.8 (1.3, 6.4)]

This review found that chest compressions and defibrillation were not significantly associated with an increased risk of SARS infection. Pooled estimates suggested that chest compressions might be associated with an increased risk of transmission, but the odds ratios were not statistically significant.

- Chest compressions = 1.4 (0.2, 11.2)
- Defibrillation = 2.5 (0.1, 43.9)

The studies that were included in this review are detailed below.

5. Loeb M, McGeer A, Henry B, Ofner M, Rose D, et al. (2004) SARS among critical care nurses, Toronto. Emerg Infect Dis 10: 251–255.

Cohort study - 43 nurses, 32 had patient contact, 6 infected

To determine factors that predispose or protect healthcare workers from severe acute respiratory syndrome (SARS), we conducted a retrospective cohort study among 43 nurses who worked in two Toronto critical care units with SARS patients. Eight of 32 nurses who entered a SARS patient's room were infected. The probability of SARS infection was 6% per shift worked. Assisting during intubation, suctioning before intubation, and manipulating the oxygen mask were high-risk activities. Consistently wearing a mask (either surgical or particulate respirator type N95) while caring for a SARS patient was protective for the nurses, and consistent use of the N95 mask was more protective than not wearing a mask. Risk was reduced by consistent use of a surgical mask, but not significantly. Risk was lower with consistent use of a N95 mask than with consistent use of a surgical mask. We conclude that activities related to intubation increase SARS risk and use of a mask (particularly a N95 mask) is protective.

Cardiopulmonary resuscitation: Exposed = 0/3 (0), non exposed = 8/29 (28), p = 0.55
Debrillation: Exposed = 0/2 (0), non exposed = 8/ 30 (0.27), p = 1.00

Commentary:

No infections were found in those exposed to CPR activities.

6. **Raboud J, Shigayeva A, McGeer A, Bontovics E, Chapman M, et al. (2010) Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. PLoS ONE 5:e10717.**

Cohort study – 624 nurses interviewed, 26 were infected

A retrospective cohort study was conducted to identify risk factors for transmission of SARS-CoV during intubation from laboratory confirmed SARS patients to HCWs involved in their care. All SARS patients requiring intubation during the Toronto outbreak were identified. All HCWs who provided care to intubated SARS patients during treatment or transportation and who entered a patient room or had direct patient contact from 24 hours before to 4 hours after intubation were eligible for this study.

Results: 45 laboratory-confirmed intubated SARS patients were identified. Of the 697 HCWs involved in their care, 624 (90%) participated in the study. SARS-CoV was transmitted to 26 HCWs from 7 patients; 21 HCWs were infected by 3 patients. Transmission to 22 HCWs could be definitively attributed to a single patient. The remaining four HCWs who acquired SARS had cared for more than one SARS patient during the high risk period, making it difficult to precisely identify which patient was the source of infection.

In multivariate GEE logistic regression models the following were associated with increased risk of transmission of SARSCoV;

- presence in the room during fiberoptic intubation (OR = 2.79, p = .004)
- ECG (OR = 3.52, p = .002)
- unprotected eye contact with secretions (OR = 7.34, p = .001)
- patient APACHE II score (OR = 17.05, p = .009)
- patient Pa02/Fi02 ratio (OR = 8.65, p = .001)

The following are picked out from CPR activities though they did not occur in isolation

- Cardiac compressions: Exposed not infected = 8 (1%), Exposed infected = 1 (4%), p = 0.32
- Defibrillation: Exposed not infected = 3 (1%), Exposed infected = 1 (4%), p = 0.15

In CART analyses, the four covariates which explained the greatest amount of variation in SARS-CoV transmission were covariates representing individual patients.

Conclusion: Close contact with the airway of severely ill patients and failure of infection control practices to prevent exposure to respiratory secretions were associated with transmission of SARS CoV. Rates of transmission of SARS-CoV varied widely among patients.

Commentary:
No evidence is presented to suggest that chest compressions or defibrillation alone are associated with infection transmission

7. Liu W, Tang F, Fang L-Q, De Vlas SJ, Ma H-J, et al. (2009) Risk factors for SARS infection among hospital healthcare workers in Beijing: A case control study. Trop Med Int Health 14: 52–59

Case control study that relied on staff surveys – 477 HCWs, 51 infected

The objective was to evaluate possible severe acute respiratory syndrome (SARS) infection associated risk factors in a SARS affected hospital in Beijing by means of a case control study.

Methods: 51 infected and 426 uninfected staff members were asked about risk behaviours and protective measures when attending to SARS patients. Univariate and multivariate logistic regression analyses were performed to identify the major risk and protective factors.

Results: Multivariate analysis confirmed the strong role of performing chest compression (or intubation, which is highly correlated), contact with respiratory secretion, and emergency care experience as risk factors to acquire SARS infection.

Chest compression: Exposed non-infected = 10, Exposed Infected = 5, p = 0.02
Intubation; Exposed non-infected = 6, Exposed infected = 6, p = <0.001

Commentary:
This paper implicates chest compressions but states that intubation happened as well and that the model can't distinguish between them. Intubation is known to be a high-risk procedure from other work and is likely to represent the infection risk here too.