

Aerosol generation and risk of transmission of acute respiratory infections: A systematic review

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Abstract: The studies selected were HTAs, systematic reviews, meta- analyses, randomized controlled trials, and non-randomized controlled trials that evaluated the risk of disease transmission to health care workers exposed to aerosol-generating procedures. Procedures that showed a statistically significant increased risk of SARS transmission to health care workers, or were a statistically significant risk factor for SARS infection in health care workers, included tracheal intubation, non-invasive tracheotomy, and manual ventilation before intubation. As noted in the results, for a number of potentially aerosol-generating procedures (bronchoscopy,2 non-invasive positive pressure ventilation,3 manipulation of BiPAP mask,2 and insertion of nasogastric tube2), point estimates suggested an increased risk, but confidence intervals were wide and were not statistically significant. The estimated risk of transmission of infection through aerosol-generating procedures or of a certain procedure being a risk factor for infection transmission in the included studies could have been confounded by the medical characteristics of the patients, the level of infection control training, and compliance with the use of effective personal protection methods among health care workers. Our findings suggest that some procedures potentially capable of generating aerosols have been associated with increased risk of SARS transmission to health care workers or were a risk factor for transmission, with the most consistent association across multiple studies identified with tracheal intubation.

Keywords: aerosol-generating procedures, SARS transmission, SARS infection, tracheal intubation.

I. INTRODUCTION

It has been hypothesized that aerosol- generating procedures expose health care workers to respiratory pathogens, thereby increasing the risk of contracting the associated infectious diseases. However, the risk of transmission of acute respiratory infections from each aerosol-generating procedure has not been fully determined. World Health Organization (WHO) guidelines¹ have listed procedures that may be associated with an increased risk of respiratory pathogen transmission.

II. OBJECTIVE

The objective of the report was to answer the following research question:

What is the clinical evidence for the risk of transmission of acute respiratory infections to health care workers caring for patients undergoing aerosol- generating clinical procedures, compared with the risk of transmission to health care workers caring for patients not undergoing aerosol-generating procedures?

III. METHODS

An information specialist performed a literature search on key health technology assessment (HTA) resources. The search included all languages and was limited to articles published between January 1, 1990 and October 22, 2010. Regular alerts were current to January 15, 2011. Filters were applied to limit the retrieval to HTAs, systematic reviews, meta-analyses, randomized controlled trials, non-randomized controlled studies, and guidelines. The studies selected were HTAs, systematic reviews, meta-analyses, randomized controlled trials, and non-randomized controlled trials that evaluated the risk of disease transmission to health care workers exposed to aerosol-generating procedures. The outcome of interest was risk of disease transmission. The quality of evidence was rated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system.

IV. RESULTS

Ten relevant non-randomized studies were identified: five case-control and five retrospective cohort studies. All studies evaluated the transmission of severe acute respiratory syndrome (SARS) to health care workers while caring for ill patients in hospital or intensive care unit settings during the 2002-2003 SARS outbreaks. Procedures that showed a statistically significant increased risk of SARS transmission to health care workers, or were a statistically significant risk factor for SARS infection in health care workers, included tracheal intubation, non-invasive tracheotomy, and manual ventilation before intubation. The risk of transmission associated with suction before intubation, suction after intubation, manual ventilation after intubation, bronchoscopy, nebulizer treatment, oxygen mask manipulation, BiPAP (bi-level positive airway pressure) mask manipulation, defibrillation, chest compressions, insertion of nasogastric tube, and collection of a sputum sample was not statistically significant. As well, high-frequency oscillatory ventilation, high-flow oxygen, endotracheal aspiration, suction of body fluid, administration of oxygen, chest physiotherapy, and mechanical ventilation showed either no statistically significant difference in the risk of transmission or were a statistically significant risk factor for transmission. All studies were rated very low quality according to GRADE assessment of the evidence.

V. LIMITATIONS

The included studies in this report have a number of limitations. The evidence (all 10 included studies) was of very low quality, according to assessments made using a GRADE approach. Details of limitations of individual studies are presented in the summary table of GRADE evidence profiles. In general, limitations in design and imprecision are main issues in all studies that lead to the very low rating according to GRADE. Further, all of the included studies evaluated the risk of transmission of SARS and may not be generalizable to other acute respiratory pathogens, specifically the influenza virus. The extent of multivariate adjustments varied across studies, and thus the effects of residual confounding may vary from study to study. Also, with the exception of tracheal intubation, a limited number of studies was identified (one to three) for each procedure.

Seven out of ten studies conducted the investigation at only one hospital, which could limit the generalizability of the results. Four studies included fewer than 100 patients. The number of health care workers included in the studies who were exposed to the aerosol-generating procedures was small, ranging from two to 120. The sample size of the studies could limit statistical power, and results from analyses based on studies of small sample size may be less reliable than those based on a larger sample size. Related to this, the number of events was small in a number of studies. As noted in the results, for a number of potentially aerosol-generating procedures (bronchoscopy,² non-invasive positive pressure ventilation,³ manipulation of BiPAP mask,² and insertion of nasogastric tube²), point estimates suggested an increased risk, but confidence intervals were wide and were not statistically significant. Not all health care workers caring for SARS patients were included in the studies, as there were some health care workers who refused to participate in the interview. The recollections of health care workers might be imperfect, thus generating recall bias if some were more complete or more accurate than others. As the source of transmission (i.e., primary, secondary, or tertiary cases) was sometimes unclear, it is difficult to accurately determine whether health care workers were infected directly or indirectly from the index patients.

The estimated risk of transmission of infection through aerosol-generating procedures or of a certain procedure being a risk factor for infection transmission in the included studies could have been confounded by the medical characteristics of the patients, the level of infection control training, and compliance with the use of effective personal protection methods among health care workers. Among the included studies, five⁴⁻⁸ showed that infection control training and personal protective measures were effective against the nosocomial spread of SARS. These factors might also influence the spread of the diseases, in addition to the aerosol-generating procedures themselves.

VI. CONCLUSIONS

Our findings suggest that some procedures potentially capable of generating aerosols have been associated with increased risk of SARS transmission to health care workers or were a risk factor for transmission, with the most consistent association across multiple studies identified with tracheal intubation. Other associations included non-invasive ventilation from two studies, and manual ventilation before intubation and tracheotomy each from single studies. These findings must be interpreted in the context of the very low quality of the studies, which was assessed using well-established GRADE methods. A significant research gap exists in this area. Studies of higher methodological quality are required to provide more precise information about the risk of aerosol generation and the risk of transmission of microbes causing specific acute respiratory infections, including influenza, to health care workers from patients undergoing aerosol-generating procedures.

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