Journal of Hospital Infection (2005) 59, 365–368
Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
www.elsevierhealth.com/journals/jhin

SHORT REPORT

Protecting healthcare staff from severe acute respiratory syndrome: filtration capacity of multiple surgical masks

J.L. Derrick*, C.D. Gomersall

Department of Anaesthesia and Intensive Care, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, Hong Kong, China

Received 18 September 2003; accepted 8 October 2004
Available online 26 January 2005

KEYWORDS
Respiratory protective devices; Severe acute respiratory syndrome; Safety; Occupational; Disease transmission; Patient to professional; Aerosols; Infection control

Summary Guidelines issued by the Centers for Disease Control and Prevention and the World Health Organisation state that healthcare workers should wear N95 masks or higher-level protection during all contact with suspected severe acute respiratory syndrome (SARS). In areas where N95 masks are not available, multiple layers of surgical masks have been tried to prevent transmission of SARS. The in vivo filtration capacity of a single surgical mask is known to be poor. However, the filtration capacity of a combination of masks is unknown.

This was a crossover trial of one, two, three and five surgical masks in six volunteers to determine the in vivo filtration efficiency of wearing more than one surgical mask. We used a Portacount to measure the difference in ambient particle counts inside and outside the masks. The best combination of five surgical masks scored a fit factor of 13.7, which is well below the minimum level of 100 required for a half face respirator.

Multiple surgical masks filter ambient particles poorly. They should not be used as a substitute for N95 masks unless there is no alternative.

Introduction

Severe acute respiratory syndrome (SARS) is a highly contagious, potentially life-threatening condition that frequently affects healthcare workers caring for infected patients.[1] The exact mode of transmission is unknown but may involve airborne as well as respiratory droplet and fomite spread. In view of the possibility of airborne transmission, current guidelines issued by the Centers for Disease Control and Prevention (CDC) and the World Health

* Corresponding author. Tel.: +852 2632 2735; fax: +852 2637 2422.
E-mail address: jamesderrick@pobox.com

0195-6701/$ - see front matter
doi:10.1016/j.jhin.2004.10.013

Organisation (WHO) state that healthcare workers should wear N95 masks or higher-level protection during all contact with suspected SARS patients. These masks are expensive and not necessarily easily available in poorer countries. In some areas, multiple layers of surgical masks have been tried to prevent SARS transmission.

The filtration capacity of a single surgical mask is known to be poor.[2] It is not known whether this improves when more than one mask is worn simultaneously.

Methods

This was a prospective unblinded study of six healthy volunteers using combinations of one, two, three or five surgical masks (Surgikos, Johnson & Johnson, Arlington, TX, USA). The Surgikos mask is a pleated rectangular three-ply mask with a bacterial filtration efficiency of 95% at 3 μm. All volunteers gave written informed consent. Approval was obtained from the Clinical Research Ethics Committee of The Chinese University of Hong Kong.

All six volunteers underwent a set of tests with each of the combinations of masks. These involved standard testing procedures using a protocol described previously.[3] In brief, the tests consisted of comparisons of particle counts inside and outside the masks during a series of activities: normal breathing, deep breathing, turning the head from side to side, flexing and extending the head, talking loudly, and bending over followed by normal breathing again. The tube for sampling the mask particle count was connected to a test probe that was inserted through the fabric of the protective device. The probes were provided by TSI (TSI Incorporated, St Paul, MI, USA) for this purpose. The design of the probe is such that there is no leak around the insertion point, so the efficiency of the mask at filtering ambient particles should remain unchanged. The insertion site was centrally in the area directly in front of the mouth, as per the instructions for use provided by TSI. The tube for sampling the ambient particle count was fixed approximately 3 cm from the sampling probe.

A PortaCount Plus (TSI Incorporated) connected to a computer running FitPlus for Windows software (TSI Incorporated) was used to count particles and calculate the ratio of ambient to device particle counts. This device counts all particles with a diameter between 0.02 and 1 μm. It calculates a fit factor, which is the average ratio of atmospheric to device particle concentrations. The equation used is:

$$\text{Fit factor} = \frac{N}{\sum_{j=1}^{N} \frac{1}{\text{ff}_j}}$$

where N is the number of exercises performed and ff_j is the fit factor for the individual exercise.

One modification was made to the PortaCount Plus. The re-usable tubing supplied by the manufacturer was replaced with disposable PVC tubing of the same internal diameter and length to minimize any risk of cross-infection. To ensure an adequate ambient particle count throughout the testing, the 8026 Particle Generator (TSI Incorporated) was used to generate saline particles throughout the testing procedures. Each surgical mask was tied separately.

The American National Institute for Occupational Safety and Health requirements for a half mask respirator are that it should have an assigned protection factor of 10.[4] Further to this, a safety factor of 10 is required when conducting performance or fit testing, so a half face respirator should achieve a minimum fit factor of 100.

Data obtained while wearing one mask were compared with data obtained while wearing five masks using a paired t-test (Statview 5.0, SAS Institute, Cary, NC, USA). A P value <0.05 was considered to be significant.

Results

Results of the filtration capacity of the devices are

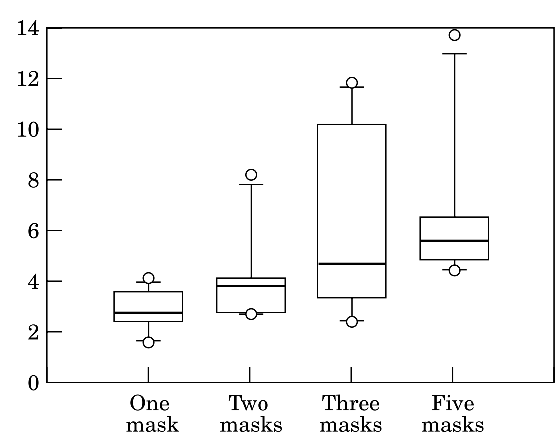

Figure 1 Particle count reductions seen with varying numbers of surgical masks. Median values for one, two, three and five masks were 2.7, 3.8, 4.6 and 5.5, respectively. The boxes outline the 25th and 75th centiles, the bars indicate the 10th and 90th centiles and the circles indicate the outlying values. A half face respirator such as an N95 mask should achieve a minimum 100-fold reduction in particle count.