

First responder communication in CBRN environments: FIRCOM-CBRN study

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ABSTRACT

Introduction Recent terror attacks and assassinations involving highly toxic chemical weapons have stressed the importance of sufficient respiratory protection of medical first responders and receivers. As full-face respirators cause perceptual-motor impairment, they not only impair vision but also significantly reduce speech intelligibility. The recent introduction of electronic voice projection units (VPUs), attached to a respirator, may improve communication while wearing personal respiratory protection.

Objective To determine the influence of currently used respirators and VPUs on medical communication and speech intelligibility.

Methods 37 trauma anaesthetists carried out an evaluation exercise of six different respirators and VPUs including one control. Participants had to listen to audio clips of a variety of sentences dealing with scenarios of emergency triage and medical history taking.

Results In the questionnaire, operators stated that speech intelligibility of the Avon C50 respirator scored the highest (mean 3.9, \pm SD 1.0) and that the Respirix Powered Respiratory Protective Suit (PRPS) NHS-suit scored lowest (1.6, 0.9). Regarding loudness the C50 plus the Avon VPU scored highest (4.1, 0.7), followed by the Draeger FPS-7000-com-plus (3.4, 1.0) and the Respirix PRPS NHS-suit scored lowest (2.3, 0.8).

Conclusions We found that the Avon C50 is the preferred model among the tested respirators. In our model, electronic voice projection modules improved loudness but not speech intelligibility. The Respirix PRPS NHS-suit was rated significantly less favourably in respect of medical communication and speech intelligibility.

INTRODUCTION

NHS England has faced an unprecedented number of terror attacks over the last 18 months: Westminster Bridge, Manchester Arena, London Bridge, and Finsbury Park mosque.¹ March 2018, saw the assassination attempts in Salisbury with the highly toxic and persistent 'Novichok' agent.^{2,3} The injuries and deaths of untargeted members of the public and the decontamination process in the aftermath placed a great strain onto the emergency services and other NHS facilities. Twelve months earlier, emergency services in Kuala Lumpur International Airport in Malaysia also faced a lethal assassination attack with the chemical weapon, VX, in a public space.⁴ These incidents are tragic examples where acute life support of critically ill patients contaminated with chemical, biological radiological or nuclear

Key messages

What is already known on this subject

- ▶ Resuscitation of contaminated or contagious casualties requires adequate communication and speech intelligibility. Respiratory protective equipment is known to significantly reduce sound transmission.

What this study adds

- ▶ Within our range of respiratory protective equipment studied, we identified respirators with good speech intelligibility. However, we found the sound transmission significantly poorer within the powered respirator suit, that we currently use in the NHS. The studied electronic voice projection modules improved loudness but not speech intelligibility.

substances (CBRN) required respiratory equipment for responding agencies.

'Hot Zone' management, controlling access to and from the incident scenes as well as control of movement of contaminated victims requires adequate communication and speech intelligibility.⁵⁻⁷ Facepieces used in air-purifying respirators, powered air-purifying respirators, or self-contained breathing apparatus are known to significantly reduce sound transmission. Speech intelligibility is the primary performance criterion used to assess the quality of speech sound transmission through a respirator's speech transmission components.⁸ Respirators impair speech intelligibility by attenuating and distorting sound and by restricting lower jaw articulation.^{8,9} To improve speech intelligibility manufacturers have now tried to enhance sound transmission by developing electronic voice projection units (VPUs).

The aim of our study was to compare the specific influence of advanced respiratory protection design on communication and speech intelligibility in a sample of medical first responders and receivers.

METHODS

This study was prospectively registered by the United Kingdom Clinical Research Network (UKCRN) under the portfolio ID 132375.

Recruitment

The objective was to recruit all anaesthetists within our trust who respond to trauma calls in the ED. The sample size estimation was guided by our



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Table 1 Questionnaire ratings for six types of respirators and VPUs on a six-point scale (0=worst to 5=best). Values are mean (SD)

	C50	C50 VPU	FM12	FPS	FPS VPU	NHS suit	P value
Speech-intelligibility	3.9 (1.0)	3.7 (1.0)	2.8 (0.7)	1.8 (1.0)	1.8 (1.0)	1.6 (0.9)	0.0001
Loudness	3.8 (1.0)	4.1 (0.7)	2.3 (0.9)	2.5 (0.9)	3.4 (1.0)	2.3 (0.8)	0.0001

VPU, voice projection unit.

previous studies using the same model. Thirty-seven compliant subjects gave consent after having been given a detailed explanation of the study protocol.

Respirators and VPUs

We examined seven groups of digital recordings using six different respiratory protective devices and one control. The following full face mask respirators were used: (1) The Avon C50 mask (Avon, Melksham, UK). (2) The Avon C50 mask with the Avon VPU. (3) The Avon FM12 respirator. (4) The Drager FPS7000 (Drager, Luebeck, Germany). (5) The Drager FPS7000-com-plus respirator with the inbuilt VPU. The sixth device tested was the current standard NHS issue Powered Respiratory Protective Suit (PRPS) (Respirex, Surrey, UK).

Audio recording equipment

Prior to the study, a 'Medical Emergency History Taking and Communication Script' was compiled and recorded by current Emergency Medicine staff at St Thomas' Hospital ED. This script and the recordings were supervised by a senior consultant in Emergency Medicine. The script was read by a male and a female emergency medicine trainee, recordings were made by a Tascam DR-40 Digital Recorder (TEAC, Montebello, USA). The readers presented the sentences of the study script wearing the different respirators and VPUs and without respiratory protective equipment as controls.

Study protocol

Volunteers were asked to wear Sennheiser HD380 Headphones while listening to the script, which was played from a computer. The order of the respirators/controls playlist was randomised. Volunteers used a questionnaire to evaluate intelligibility and loudness of the respirators and controls by numerical rating on a six-point scale (0=worst to 5=best).

Statistics

The required sample size had been established by our previous studies using the same model.¹⁰ Statistical analysis was performed using SPSS Statistics V.24.0. Non-parametric data was tested using the Mann-Whitney U test. A p value of <0.05 was considered statistically significant.

RESULTS

In the questionnaire, operators stated that speech intelligibility of the Avon C50 respirator significantly scored the highest (mean 3.9, SD 1.0) and that the PRPS NHS-suit significantly scored lowest (mean 1.6, SD 0.9) (table 1). Regarding loudness the C50 plus the Avon VPU scored highest (mean 4.1, SD 0.7) and the PRPS-suit scored lowest (mean 2.3, SD 0.8). There were no adverse events.

DISCUSSION

As resuscitation is a team effort, effective communication between medical first responders, receivers and patients is of paramount importance. Previous studies have focused on the

locomotor and visual impairment of respiratory protective equipment.¹⁰ This is the first study evaluating speech transmission and communication during medical triage and medical history taking in the emergency room under CBRN conditions. To gain the highest clinical relevance a standardised 'Medical Emergency History Taking and Communication Script' had to be developed by emergency care physicians. Our study detected distinct differences between the respiratory protective equipment used. Another novelty of our study was the use of electronic voice transmission units. Manufacturers claim that newly developed noise reduction technology filter out any interference and thereby offer enhanced communication. We found that the Avon C50 mask scored highest for speech intelligibility and, in combination with the optional VPU, it scored highest for loudness. The Avon FM12, which uses a speech horn around the exhalation valve, scored slightly lower for intelligibility or loudness. Comparing the results of the Drager FPS7000, we found even lower scores for intelligibility or loudness. When using the FPS7000-com-plus variant, loudness increased but speech intelligibility could not be improved. The poorest communication results were found using the NHS-PRPS suit. As the need for respiratory protection for medical first responders and receivers is likely to increase in the future, our results present some valuable insights for the choice of personal protective equipment.

Limitations

The study simulated communication in CBRN environments but was performed under safe conditions without any distress. Communication during operations with multiple casualties might become even more challenging.

CONCLUSIONS

We conclude that certain models of respiratory protection equipment allow better communication, however, we found a significant shortfall in medical communication with the PRPS suit.

Contributors JS planned the study, was responsible for the overall content as guarantor, compiled and submitted the manuscript. JA collected the data. JVR collected the data and helped to compile the manuscript. FG compiled the 'Medical Emergency History Taking and Communication Script'. KP provided military medicine expertise and helped to compile the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The study received National Research Ethics Service approval by the South London REC Office and GSTFT Research and Development approval.

Provenance and peer review Not commissioned; externally peer reviewed.

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