Assessing Airway Patency And Breathing In NBC Category 4R - The RG Method.

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ABSTRACT

Introduction

Confirming airway patency and the presence of breathing has significant limitations when both the casualty and medical personnel are in NBC category 4R. In casualties with limited signs of breathing, IPE may adversely affect the efficiency of clinical assessment, and when the triage sieve is used this could result in the misdiagnosis of death. This manuscript describes and evaluates the Respirator-Glove (RG) method, of assessing airway patency and breathing in NBC category 4R.

Methods

A medical examination glove was fitted over the primary speech module of the S10 NBC respirator of a volunteer casualty dressed in 4R. Two groups were studied; the first used an intact glove the second used a glove minus one finger. Breathing patterns A, B and C, representing normal breathing, hypoventilation and apnoea respectively, were randomly performed by the casualty for 15 seconds. A blinded observer recorded the glove inflation and movement and using these signs determined if breathing was present.

Results

All of the randomly performed breathing pattern simulations were correctly identified in both groups, with glove inflation only occurring during exhalation. In the perforated glove group, the large expiratory air leak through the hole limited the development of continuous positive airway pressure and the respirator seal was maintained. In the non-perforated glove group the respirator seal was compromised. No difficulty was encountered attaching the gloves to the respirator speech module.

Discussion

As an aid to clinical examination, the Respirator-Glove (RG) method provides a reproducible visual assessment of airway patency and spontaneous ventilation in unconscious 4R casualties. It can be utilised at any point in the evacuation chain, may improve the identification of T1 casualties and could reduce the risk of death being misdiagnosed. The efficiency of clinical assessment in 4R will improve by introducing the RG method into CBRN medical training programmes.

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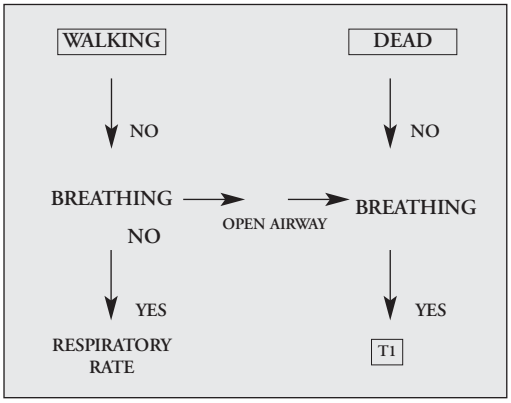

Figure 1. The initial stages of the triage sieve. Unconscious casualties are assessed for breathing and those that are apnoeic despite an open airway are dead.

Introduction

When the number of casualties exceeds the skilled help immediately available, the principles of triage are applied. Initially the casualties are quickly categorised into treatment priorities using the triage sieve (1). In unconscious casualties, the first priority of triage sieve is confirming the presence of breathing (Fig 1). If no breathing is identified, an appropriate manual manoeuvre (head tilt with chin lift or jaw thrust if cervical trauma is suspected) is performed to open the airway. The casualty is then reassessed to see if breathing has started, and those that remain apnoeic despite having an open airway are considered dead.

In the United Kingdom, the NBC dress category describes the components of individual protective equipment (IPE) that is worn and carried. The prefix R indicates that the respirator is worn, and in the highest category 4R, no skin is exposed (2). The standard 'Look, Listen and Feel' technique to confirm airway patency and the presence of breathing, has significant limitations when both the casualty and medical personnel are in NBC category 4R (3-5). In casualties with limited signs of breathing, the sensory restrictions (visual, auditory and cutaneous) associated with 4R, may make this difficult to detect.

The psychological stress and fatigue associ-

ated with working in IPE is universally accepted (6,7), but we should also consider the adverse effect on the efficiency of clinical assessment. Since airway obstruction and compromised ventilatory function may follow exposure to chemical, biological, radiological and nuclear (CBRN) warfare agents, the ability to determine if such a casualty is breathing is crucial to the triage sieve (8).

We believe the clinical assessment of airway patency and breathing in unconscious casualties in NBC category 4R is prone to observer error. The purpose of this manuscript is to describe and evaluate the Respirator-Glove (RG) method, of assessing airway patency and breathing in NBC category 4R.

Methods

A single volunteer acting as an unconscious casualty was given written and verbal instructions describing three breathing patterns (A, B and C), representing: normal breathing, hypoventilation and apnoea respectively (Table 1). Wearing IPE corresponding to NBC category 4R, the casualty was positioned supine on a resuscitation trolley.

A card printed with the letter A, B or C, corresponding to the breathing pattern with the same letter, was randomly selected and given to the casualty. A 'MICRO – TOUCH' Nitrile non-perforated medical examination glove (Ansell (UK) Ltd, Surbiton, UK), was fitted over the primary speech module of the S10 NBC Respirator (Avon Technical Products, Melksham, UK), (Figure 2). Once the glove was in place, the casualty immediately performed the breathing pattern indicated on the card and the simulation was continued for 15 seconds. An observer, blinded to the selected breathing pattern and using only the movement of the glove, was required to determine if the casualty was breathing. The movement and inflation of the glove from its resting volume was also recorded. This same method was repeated at random until five results were recorded for each of the three breathing patterns, providing a total of 15 results for the non-perforated glove group.

Pattern A (Normal).	One breath every four seconds with normal tidal volumes. Respiratory rate 15 / min.
Pattern B (Hypoventilation)	One breath every six seconds with small tidal volumes. Respiratory rate 10/min.
Pattern C (Apnoea)	Holding breath. Respiratory rate 0/min.

Table 1. Breathing patterns representing normal breathing, hypoventilation and apnoea for the unconscious casualty in NBC category 4R.

Figure 2. A nitrile non-perforated medical examination glove shown fitted over the primary speech module of the S10 NBC Respirator.

Figure 3. A maximally inflated non-perforated nitrile medical examination glove attached to the primary speech module. The glove became maximally inflated in the first exhalation during the simulation of breathing pattern A (normal breathing).

The middle finger of a fresh glove by the same manufacturer was cut off at a level approximate to the metacarpophalangeal joint (perforated glove). The method previously described was then repeated at random for all three breathing patterns using this glove. The observer was again required to determine if the casualty was breathing and the same data was recorded, providing a total of 15 results for the perforated glove group.

Results

Using glove inflation and movement during exhalation, breathing was correctly identified in all of breathing pattern A and B simulations (normal breathing and hypoventilation respectively), in both the non-perforated glove and perforated glove groups. Apnoea was also correctly identified in all of breathing pattern C simulations, in both groups, by the absence of glove inflation or movement.

Using the non-perforated glove, breathing pattern A simulations (normal breathing)

Breathing Pattern	Perforated Glove Group	Non-Perforated Glove Group
Normal Breathing (A)	Rapid Full Inflation Large Air Leak No Detachment	Rapid Maximal Inflation Moderate Air Leak Glove May Detach
Hypoventilation (B)	Partial Inflation Large Air Leak No Detachment	Partial Inflation Small Air Leak No Detachment
Apnoea (C)	No Inflation	No Inflation

Table 2. Perforated and non-perforated glove inflation and movements during exhalation, in simulated normal breathing, hypoventilation and apnoea.

resulted in the glove rapidly becoming maximally inflated during the first exhalation (Figure 3). As exhalation continued, further inflation of the glove was limited by a moderate leak of exhaled air, between the cuff of the glove and the speech module of the respirator. The glove continued to maximally inflate during subsequent exhalations, with an increasing air leak. The glove completely detached itself from the respirator in 3 out of 5 breathing pattern A simulations (60%). In breathing pattern B (hypoventilation) simulations, the non-perforated glove partially inflated during the first exhalation. A smaller air leak around the cuff was noted during this and subsequent exhalations, limiting further inflation of the glove. The glove remained attached to the respirator throughout all five simulations. A feature common to all simulations of breathing patterns A and B in the non-perforated glove group, was the partial deflation of the glove during the end-expiratory pause and inspiration.

The results of the simulations of breathing patterns A and B using the perforated glove were similar. During exhalation the glove fully inflated in pattern A (normal breathing) and partially inflated in pattern B (hypoventilation). A large leak of exhaled air through the hole in the finger prevented the glove becoming maximally inflated (Figure 4). The glove remained attached to the respirator for the duration of all simulations, and completely deflated during the end-expiratory pause and inspiration.

Figure 4. A partially inflated perforated nitrile medical examination glove attached to the primary speech module. The large leak of exhaled air through the hole in the finger prevents the glove becoming fully inflated during this breathing pattern B (hypoventilation) simulation.

In both the non-perforated and perforated glove groups, no inflation or movement of the glove was detected during the 15 second simulation of breathing pattern C (apnoea).

No difficulty was encountered attaching the gloves to the speech module of the respirator, and the same two gloves were used throughout the study without tearing at the cuff. A summary of the glove inflation and movement patterns for both groups are shown in Table 2.

Discussion

Since exhalation follows inspiration, detecting the presence of regular exhalation through the speech module of the respirator, allows us to conclude that an airway is patent and that breathing is present. The Respirator-Glove (RG) method provides an immediate visual indication that an airway is sufficiently patent to allow spontaneous ventilation in unconscious 4R casualties. It is intended as an aid to clinical examination, rather than as a substitute and once the assessment is complete, the contaminated glove should be removed from the speech module of the respirator and never reused.

Despite the differences in movement pattern and glove inflation between the two groups, our results show that this had no effect on the correct identification of normal breathing, hypoventilation and apnoea. However, it is possible that attaching an intact glove to the speech module could generate sufficient CPAP (continuous positive airway pressure) to cause failure of the respirator seal. By cutting a finger off the glove a large expiratory air leak occurs through the perforation, which limits the development of CPAP and maintains the integrity of the respirator seal. Respirator testing chamber experiments conducted at the Defence CBRN Centre, have confirmed that attaching a perforated glove (finger removed) to the speech module does not compromise the respirator seal. However, similar experiments with an intact glove caused rapid failure of the respirator seal. Consequently an intact glove must never be attached to the speech module and this group is excluded from further evaluation. To protect respirator integrity and maintain its high sensitivity, the RG method should only be performed using a perforated glove. Further justification for using a perforated glove is that a glove with a finger removed is unlikely to be retained and mistakenly reused, which minimises the risk of accidental cross-contamination from the exterior of the respirator.

A reproducible visual indicator of airway patency and breathing may be achieved using any commercially available medical examination glove, providing they easily fit onto the speech module of the S10 respirator. The availability and resupply of medical

examination gloves is a potential limitation of the RG method, but as they are an essential component of medical universal precautions, a situation where no gloves are available is unlikely.

Triage is a dynamic process and casualties require regular reassessment to determine if their category has changed (1). The value of the RG method is that it is simple to initiate, the information it provides is immediate, easy to interpret and can be utilised at any point in the evacuation chain. During the decontamination of CBRN casualties (3,4,9), if the triage sieve has not previously been performed, the RG method can provide vital clinical information. Normal tidal ventilation through a respirator is associated with an increased work of breathing, but during hypoventilation this can further compromise respiratory function, which may lead to end-organ ischaemic damage. The RG method allows hypoventilating unconscious CBRN casualties to be easily and rapidly identified so they can be given a high priority for early decontamination, respirator removal and provided with an appropriate standard of treatment (10). The dead can also be more easily identified, ensuring appropriate use of valuable resources.

All medical personnel that are likely to assess category 4R CBRN casualties should be familiar with the RG method. Regardless of seniority and experience, it provides a reproducible clinical tool with a strong visual sign, which makes a diagnostic error when the clinical signs of breathing are minimal, very unlikely. We can therefore conclude that the RG method will improve the efficiency of clinical assessment of the airway and breathing in unconscious 4R casualties, and that it should be incorporated into CBRN medical training. Under no circumstances should the RG method be performed using an intact glove and the reuse of gloves is contraindicated.

We do not anticipate that the RG method will require re-evaluation should the S10 NBC respirator be replaced by a different model.

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