Radiostethoscopes: An innovative solution for auscultation while wearing protective gear

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Abstract

Objective: To demonstrate a radiostethoscope that could be modified and successfully used while wearing protective gear to solve the problem of auscultation in a hazardous material or infectious disease setting.

Design: This study was a randomized, prospective, and blinded investigation.

Setting: The study was conducted at the University of Miami-Jackson Memorial Hospital Center for Patient Safety.

Participants: Two blinded anesthesiologists using a radiostethoscope performed a total of 100 assessments (50 each) to evaluate endotracheal tube position on a human patient simulator (HPS).

Interventions: Each lung of the HPS was ventilated separately using a double lumen tube. Four ventilation patterns (i.e., right lung ventilation only; left lung ventilation only; ventilation of both lungs; and an esophageal intubation or no breath sounds) were simulated. The ventilation pattern was determined randomly and participants were blinded. An Ambu-Bag was used for ventilation. An assistant moved the radiostethoscope to the right and left lung fields and then to the abdomen of the HPS while ventilating. Subjects had to identify the ventilation pattern after listening to all three locations. A third member of the research team collected responses. Each subject, who wore both types of respirator (positive and negative), performed a total of 25 trials. Participants later compared the two types of respirators and their ability to auscultate for breath sounds.

Results: Subjects were able to verify the correct ventilation pattern in all attempts (100 percent).

Conclusions: Radiostethoscopes appear to provide a viable solution for the problem of patient auscultation while wearing protective gear.

Key words: auscultation, disaster training, emergency preparedness, medical education, HAZMAT gear:

Introduction

The use of direct auscultation has been shown to be both reliable and effective in the evaluation of endotracheal placement but may prove difficult and awkward to perform while wearing protective gear especially a facemask or hood. In the event of exposure to toxic agents, especially inhalants, nerve agents, or infectious diseases, patients may develop severe respiratory insufficiency and require airway management, including intubation and ventilation. The current accepted standard for determining proper placement of an endotracheal tube (ETT) is by detection of end-tidal carbon dioxide (ETCO₂) and direct lung auscultation. In the event a patient is exposed to toxic agents, such as a nerve agent, a colorimetric ETCO₂ detector may prove unreliable if it becomes wet or contaminated and waveform ETCO₂ detectors may not be available in decontamination environments or in ward situations. Additionally, sensors may give a false negative reading in patients with very low cardiac outputs or severe pulmonary edema. Last, ETCO₂ cannot indicate whether an ETT is correctly placed above the carina; and in patients with a compromised
pulmonary status, correct positioning of an ETT may be required to provide sufficient oxygenation. For these reasons, despite current technology, the ability to auscultate heart and lung sounds is still a vital component of patient care.

A recent study evaluating protective gear revealed that respirators diminish providers’ ability to auscultate lungs for correct placement of ETT. In addition to the challenges of auscultating a patient in a hazardous material (HAZMAT) or infectious disease setting, there is a risk of self-exposure with a standard auscultatory stethoscope as well as extremely loud ambient noise found in many field settings.

A potential solution for securing an airway in HAZMAT gear is the use of a radiostethoscope. Although radiostethoscopes have been available in some clinical settings for a number of years, none of the current devices are designed to be used in hazardous environments, under combat conditions, or while exposed to water (a common means of patient decontamination). Additionally, current radiostethoscopes are fitted with small switches that might be difficult to use with thick protective gloves, thus restricting their effectiveness for use in HAZMAT settings. In this study, a radiostethoscope that could be modified and successfully used while wearing protective gear to solve the problem of auscultation of a patient in a HAZMAT or infectious disease setting is demonstrated.

Methods

Study design

This study was conducted as a randomized, prospective, and blinded investigation.

Setting and selection of participants

After obtaining approval from the Institutional Review Board of University of Miami (exemption from full review), two blinded anesthesiologists (subjects) using a radiostethoscope performed a total of 100 assessments (50 each) to evaluate the position of ETT on a patient simulator (ETT University’s human patient simulator (HPS) version 6, Sarasota, FL). The simulation lab is part of the University of Miami-Jackson Memorial Hospital Center for Patient Safety.

Subjects wore full protective gear: boots, protective cover suit, butyl rubber gloves, and either a positive pressure respirator (3M Breath Easy™ 10 hood PPR system with a FR-57 filter, St. Paul, MN) or a negative pressure respirator (3M™ 7000 series NPR with a FR-64 filter, St. Paul, MN). A receiver for the radiostethoscope was attached to the belt, and subjects positioned a monaural earpiece before donning protective gear. The radiostethoscope was constructed from an electronic stethoscope, which was acoustically coupled to a small frequency modulation (FM) transmitter. This prototype device is an FM wireless, crystal locked, and acoustically shielded transmitter operating on an FM carrier frequency of 912-915 MHz. The device is able to detect and amplify cardiac and respiratory sounds. Reception range is up to 150 linear feet. The transmitter frequency response range is 100-15,000 Hz. Dynamic range is more than 78 dB. The current prototype is powered by one standard AA battery and at constant use has an operational life of 20 hours (Figure 1).

The current FM receiver for the prototype is an oscillator saw resonator with a signal processing expander. It has an output level of ~2 mW, 16 Ω. The current prototype (receiver and transmitter) with battery weighs ~9 oz (256 g).

Methods of measurement

Each lung of the HPS was ventilated separately using a double lumen tube; an assistant performed the positioning and ventilation of the subject could not see its location or orientation. There were four ventilation patterns that were simulated (ie, right lung ventilation only; left lung ventilation only; ventilation of both lungs; and an esophageal intubation or no breath sounds). The ventilation pattern was determined randomly before subject evaluation and participants were blinded as to which of the four ventilation patterns were being used. An Ambu-Bag was used for ventilation and three breaths were provided for each location where the radiostethoscope was placed. An assistant moved the radiostethoscope to the right and left lung fields and then to the abdomen of the HPS while ventilating. Subjects had to identify which ventilation pattern was being simulated after listening to the respiratory and cardiac sounds from all three locations. A third
member of the research team collected responses. Each subject, who wore both types of respirator (positive and negative), performed a total of 25 trials. Later, participants compared the two types of respirators and their ability to auscultate for breath sounds.

Results

Subjects were able to verify the correct ventilation pattern in all attempts (100 percent). Neither the negative pressure respirator nor the positive pressure respirator appeared to affect the ability of the subjects to auscultate breath sounds in this setting.

Discussion

The demonstration on a patient simulator that a radiotestoscope can be used to confirm the placement of ETT with a high degree of accuracy even while wearing a respirator and protective gear is explained. A major difficulty in managing patients while wearing protective gear, especially respirators, is that the isolation of the suits makes auscultation of a patient’s heart and lungs sound difficult. This is especially important when dealing with intubated patients. Although other techniques such as ETCO₂ detectors may confirm the overall placement of ETT, they cannot be used to confirm bilateral lung ventilation. Additionally, patients who have very low cardiac outputs may have significantly reduced ETCO₂, making detection difficult with colorimetric devices. While there is some evidence that waveform ETCO₂ may detect very low levels of ETCO₂, these are not often available on the wards or in a HAZMAT setting.

The prototype used in this study is resistant to water as well as other common decontamination fluids. Water resistance for electronic devices is critical in the management of HAZMAT patients, as the primary method of decontamination involves copious amounts of water. An additional benefit of radiotestoscopes not examined in this study is their capability for amplification and filtration. In a critical situation, such as a large HAZMAT event, even without wearing protective gear, amplification and filtration may be required to overcome background noise that may be encountered. Under our study conditions, subjects had no difficulty in understanding verbal instructions.

This study was conducted on a patient simulator in a quiet environment by two experienced anesthesiologists. Whether the same positive results would have been achieved by less experienced personnel in a more realistic field setting has yet to be determined and therefore requires further evaluation.

Conclusions

Overall, radiotestoscopes appear to provide a viable solution for the problem of patient auscultation.
while wearing protective gear. They allow verification of ETT placement while allowing the user to maintain a protective barrier against potential hazards.

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References