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Can handheld micropower impulse radar technology be used to detect pneumothorax? Initial experience in a European trauma centre

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ABSTRACT

Background: Pneumothoraces are a common injury pattern in emergency medicine. Rapid and safe identification can reduce morbidity and mortality. A new handheld, battery powered device, the Pneumoscan (CE 561036, PneumoSonics Inc., Cleveland, OH, USA), using micropower impulse radar (MIR) technology, has recently been introduced in Europe for the rapid and reliable detection of PTX. However, this technology has not yet been tested in trauma patients. This is the first quality control evaluation to report on emergency room performance of a new device used in the trauma setting.
Material and methods: This study was performed at a Level I trauma centre in Switzerland. All patients with thoracic trauma and undergoing chest X-ray and CT-scan were eligible for the study. Readings were performed before the chest X-ray and CT scan. The patients had eight lung fields tested (four on each side). All readings with the Pneumoscan were performed by two junior residents in our department who had previously received an instructional tutorial of 15 min. The qualitative MIR results were blinded, and stored on the device. We then compared the results of the MIR to those of the clinical examination, chest X-ray and CT-scan.
Results: 50 patients were included, with a mean age of 46 (SD 17) years. Seven patients presented with PTX diagnosed by CT; six of these were detected by Pneumoscan, leading to an overall sensitivity of 85.7 (95% confidence interval 42.1–99.6)%. Only two of seven PTX were found during clinical examination and on chest X-ray (sensitivity 28.6 (95% CI 3.7–71.0)%). Of the remaining 43 of 50 patients without PTX, one false-positive PTX was found by the Pneumoscan, resulting in a specificity of 97.7 (95% CI 87.7–99.9)%.
Discussion: The Pneumoscan is an easy to use handheld technology with reliable results. In this series, the sensitivity to detect a PTX by the Pneumoscan was higher than by clinical examination and chest X-ray. Further studies with higher case numbers and a prospective study design are needed to confirm our findings.

Introduction

Pneumothorax (PTX) after blunt or penetrating chest trauma is potentially life-threatening,[1,2] depending on the nature and extent of concomitant injuries or the development of tension PTX. Rapid and safe identification of PTX at the trauma point-of-care can therefore be life-saving. However, it can be difficult to detect PTX.[1] Current methods include clinical examination and common imaging modalities, such as chest X-ray (CXR), CT and ultrasonography (US).[3] These tools perform well in situations where the patient is stable, the equipment is readily accessible, and trained personnel are available to interpret the findings.

Traditional plain-film CXRs are used to detect PTX, but an increasing body of evidence suggests that CT offers a higher degree of accuracy in PTX detection.[3–5] The drawbacks of CTs, however, are that they are associated with high doses of radiation, are not as widely available, cost more and take longer. In addition, scattered radiation can be harmful for personnel in charge of the patient.[6]

Bedside US has therefore recently been proposed as a no-radiation alternative for PTX detection, but its diagnostic ability is highly operator-dependent.[3,7–9] Recent research has focused on new technologies that are robust, fast, cheap, simple to handle, available for preclinical and clinical settings, and that do not emit radiation. A newly developed device named the Pneumoscan (CE 561036, PneumoSonics Inc., Cleveland, OH, USA) has been

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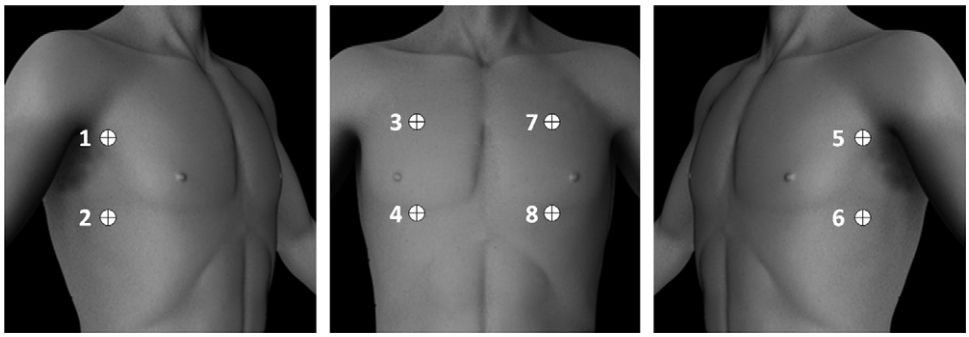

Fig. 1. Readings were taken at eight defined points, four on each side of the thorax. Four lateral readings were taken on the axillary line (1, 2, 5, 6) and four anterior readings on the midclavicular line (3, 4, 7, 8). A complete reading took less than 2 min.

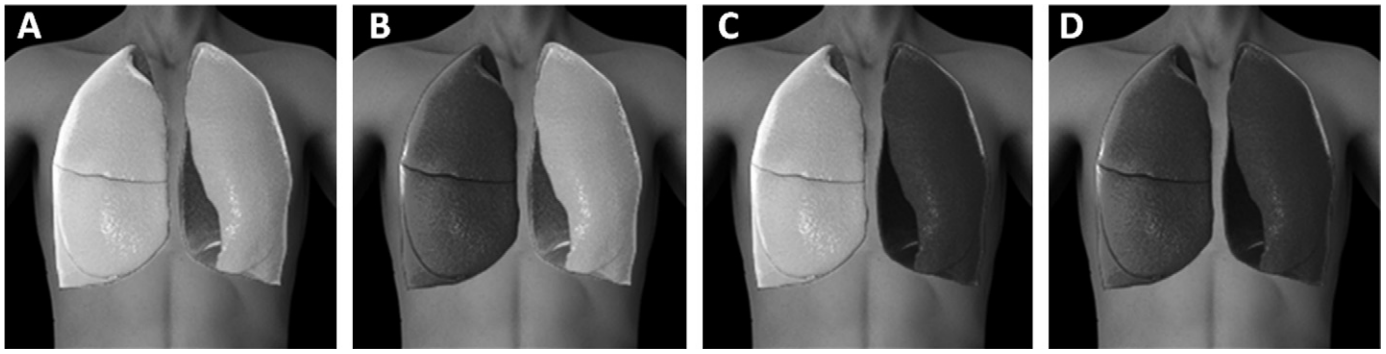

Fig. 2. After each reading, the qualitative results are shown in real time indicating the presence or absence (green (light grey) vs. red (dark grey)) and the side (left vs. right) of a PTX. (A) No PTX; (B) right PTX; (C) left PTX; and (D) bilateral PTX.

introduced to detect the presence of PTX rapidly and reliably at the point-of-care.[10] The device uses micropower impulse radar (MIR) technology and can be used in a variety of clinical and first-responder settings. In comparison to US, which uses cyclic sound pressure at frequencies between 1 and 40 MHz, micropower impulse radar (MIR) utilises very short ultra-wideband electromagnetic pulses (50–250 ps) that spread over a frequency from 500 MHz to 6 GHz.[11] Shorter pulses result in wider frequency bands that can penetrate human tissue, yielding a great deal of information on the reflecting surfaces. Unlike discrete frequency radar, these pulses are at extremely low power levels making them extremely safe to use in medical devices. The combination of broad spectrum, low power, and extremely short pulses causes much less interference with other devices than do conventional narrowband wireless systems. The transmitted energy is reflected at each tissue interface as a function of the tissue's dielectric properties. Since fat, muscle, bone, lungs, and skin have very different dielectric properties, they may be differentiated by MIR. By reconstructing the reflected waves and applying a special algorithm, it is possible to measure the approximate depth and recognise the abnormal tissue conditions that indicate that the patient has a pneumothorax.[11]

The Pneumoscan device can be effectively used after only limited training; no special medical knowledge is required. Eight readings (four on each side of the thorax) are taken in the axillary and midclavicular lines (Fig. 1). The qualitative results are shown in real time, indicating the presence or absence (green vs. red coding) and the side (left vs. right) of a PTX (Fig. 2). The device is a free-standing, battery-powered system (Fig. 3). According to the manufacturer, the power output of the device is very low and raises no significant safety questions, being generally in the range of 100 pW.[10]

The device has not yet been evaluated in serial use in the everyday clinical setting. This is the first quality control evaluation to report on emergency room performance of the device in the trauma setting. Our trauma unit is the first in Europe to use this device.

Methods

The evaluation was conducted at our level one trauma centre in alpine Switzerland. On average, about 1000 severely injured patients are treated in our hospital per year. Of these, about 350 present with an ISS score >16 points, and about 75 patients present with traumatic PTX. Between February and April 2011, a Pneumoscan, a full-body X-ray, and a full-body CT scan were obtained from all trauma patients treated in our resuscitation room.[12] Initial management was performed according to the advanced trauma life support (ATLS®) guidelines.[2] Instead of single plain radiographs of the chest during the primary survey, a

Fig. 3. The Pneumoscan device is shown. The MIR – antenna (left) is connected to a Motorola MC75 enterprise digital assistant (right). The results obtained from the scan are shown in real time.