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The utility of a handheld metal detector in detection and localization of pediatric metallic foreign body ingestion

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ABSTRACT

Objective: To test the ability of a handheld metal detector (HHMD) to identify the presence and location of ingested metallic foreign bodies (MFBs) in children.
Methods: Prospective case series enrolling children suspected of metallic foreign body ingestion presenting to the Emergency Department. Thirty-eight children were enrolled and the HHMD was used to detect the presence and location of a MFB. Results were compared to standard radiographic studies.
Results: Thirty-seven of the 38 ingested foreign bodies were MFBs. Of the 37 MFBs, the HHMD positively identified 33, and 4 were missed by HHMD but identified on radiography. When positive, the location indicated by HHMD correlated 100% with radiograph. There were 33 true positives, 0 false positives, 4 false negatives, and 1 true negative. This resulted in a sensitivity of 89% (95% CI of 75%–96%) and specificity of 100% (95% CI of 2.5%–100%).
Conclusion: Our study demonstrates the accuracy of HHMD in the identification and localization of metallic foreign bodies. We propose an emergency room foreign body protocol that uses HHMD as an early screening tool in triage in order to expedite the process of obtaining Otolaryngology consultation and potentially shorten the wait time to the operating room or discharge. In instances were outside films are previously performed, HHMD use may be able to minimize the overall radiation exposure to children by obviating the need for repeat radiographs.
As the sensitivity is not 100%, a negative HHMD screening does not negate the need for a standard radiograph in order to avoid missed MFBs. HHMD is best suited for detection of coins, which accounts for the majority of the MFB ingestions, and may not be suitable for all metallic objects since the amount of metal may decrease its sensitivity.

1. Introduction

Ingestion of foreign bodies is a common occurrence in children, and up to 85% are reported to be metallic foreign bodies (MFBs) [1]. The most frequently swallowed MFBs are coins [2], but children may swallow many other types of MFBs including pins, screws, magnets, button batteries, nails, and others. In a home based survey, up to 4% of the parents reported that their children had swallowed a coin at some point in their life [3].

As in most diagnoses in medicine, the most important piece of information is the parental history of a witnessed ingestion, as patients can be asymptomatic and remain so for over 5 days in about 70% of cases of an ingested esophageal coin [4]. Although most esophageal MFBs can be managed in a straightforward manner, a delay in diagnosis may lead to increased risk of serious morbidities [5]. The incidence of esophageal perforation associated with ingested blunt foreign bodies is approximately 1% [6], but can be higher with impacted foreign bodies ranging from 2 to 15% [7]. Other complications include mediastinitis [8], false or true esophageal diverticula, tracheoesophageal fistulas, tracheal stenosis [9], aortoesophageal fistulas, and death [10].

The current standard of care for the identification and localization of swallowed MFBs is plain films of the neck, chest and/or abdomen. If positive, then Otolaryngologists are consulted for endoscopic removal, typically in tertiary centers. Often plain films are first obtained at ambulatory clinics or community hospitals prior to children being referred to a tertiary pediatric Emergency

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Department. Depending on the length of the transfer process, repeat films are often necessary for confirmation and localization prior to surgery. Exposing children to repeated bouts of radiation is becoming less favorable, as the medical community has become more aware of the higher lifetime risk of developing secondary malignancies in children exposed to radiation at a young age [11].

A handheld metal detector (HHMD) is an inexpensive and readily available adjunct in the management of MFBs that minimizes the risk of ionizing radiation. A HHMD operates by generating a low-intensity magnetic field that passes from one end of the detector to the other. If a metal object is within the field, the magnetic field is disrupted and the sensor will detect the change and set off an alarm by emitting an audible beep, a red LED light flash, and tactile vibration. A HHMD does not generate any ionizing radiation.

The aim of this study is to evaluate the ability of a HHMD to identify the presence and location of an ingested MFB. Our hypothesis is that a HHMD may accurately detect the presence and location of a MFB. We propose to integrate the HHMD into a formalized emergency department foreign body pathway in order to minimize wait time, streamline evaluation, reduce cost, and decrease the use of ionizing radiation.

2. Materials and methods

This is a prospective study enrolling children between the age of 1 and 18 with suspected MFB ingestion who presented to the Emergency Department at Rady Children's Hospital San Diego from March 1, 2014 to February 29, 2016. The study obtained research approval from the University of California San Diego Institutional Review Board committee. Inclusion criteria was any child presenting to the Emergency Department with a suspected MFB ingestion who was clinically stable with parents or guardians present to give consent. Exclusion criteria were subjects with respiratory distress who required immediate resuscitation and urgent operating room intervention, and subjects with implanted devices who may be sensitive to an electromagnetic field such as pace makers, ICDs or spinal cord stimulators. After the initial Otolaryngology consultation in the Emergency Department the patient and family were recruited into the study with informed consent and a HIPAA waiver.

After the initial history and physical examination, the patients underwent HHMD scanning. When using the HHMD, any metal in the immediate scanning area were removed such as jewelry, eyeglasses, buttons, belt buckles, zippers, or objects around the patient such as the hospital bed metal railing, and surrounding medical equipment. The patients were dressed in a hospital gown and stood if age appropriate or held on the lap by their parent or guardian away from any surrounding metallic objects. The patients were positioned with their hands up and away from their body, and their neck in extension exposing their entire anterior neck (see Fig. 1). The HHMD was then verified to be working by waving it over a piece of metal, and then waved over the front of the patient starting over the nose and down to the pubic symphysis and then again behind the patient. The collected information was then recorded as: presence of metallic object (yes or no), and the location of the metallic object was drawn on a standard body diagram with categorized locations as: neck – above the sternal notch, chest – between sternal notch and xyphoid process, and abdomen – below the xyphoid process. Then standard plain films with both anteroposterior and lateral views were obtained as the current accepted standard of care. The plain films then served as the criterion standard for comparison of the results obtained with the HHMD.

Patients with present MFBs in the neck or chest were then taken to the OR for removal and the type of MFB was recorded. Children with MFBs that passed the gastroesophageal junction on plain film were reassured and discharged home with instructions to return if abdominal pain, vomiting or bloody stools occur since it has been demonstrated that most ingested foreign bodies below the esophagus can be spontaneously passed without complication [12].

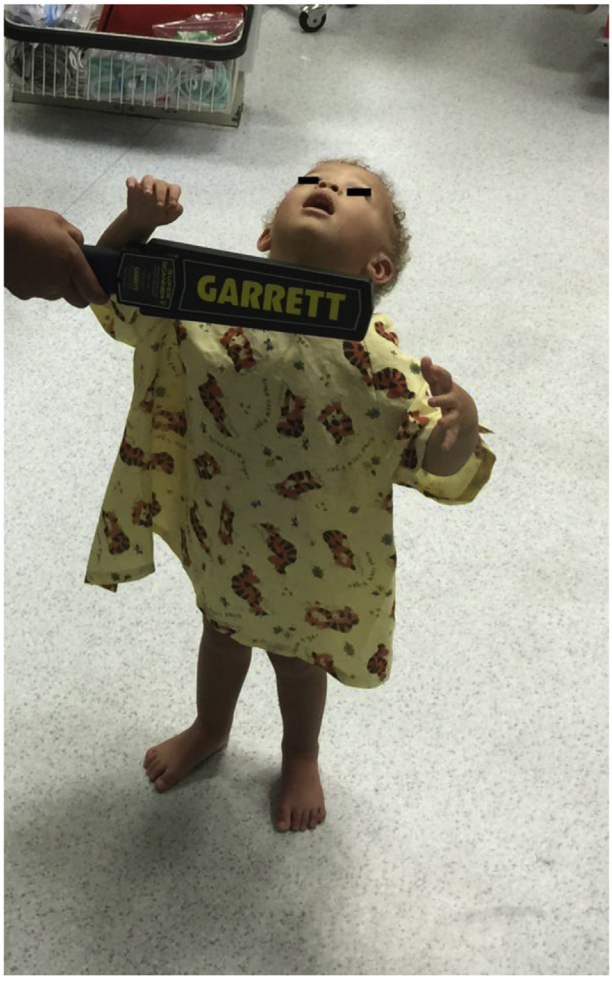

Fig. 1. Demonstration of wanding technique. Patient positioned in center of room away from any surrounding metallic objects. Patient placed in hospital gown with no zippers or buttons. During examination patient extends head to expose the neck, and hold hands up and away from the body. The HHMD is slowly passed from the chin to the pubic symphysis in front and in back of the patient.

The HHMD used for this study was the Garrett Super-scanner® V (Garrett Electronics, Inc. Garland, Texas). The dimensions were 42 cm long, 8.3 cm wide, 4.13 cm thick, and weighed 500 g. The HHMD is not FDA approved for this specific medical purpose; however, the use of HHMD for security purposes is ubiquitous, and is currently being used in many US and International airport security checkpoints. Studies have shown that because of its non-ionizing properties, the very low magnetic field generated in a metal detector will not cause harm to even pregnant women and their fetuses with routine and/or repeated scanning [13,14]. Therefore, the use of the device in clinical care does not pose any significant risk to subjects. The electromagnetic fields produced by Garrett products are similar to those encountered in the daily environment and meet U.S. and International standards for electromagnetic emissions [15]. The scanner was used according to manufacturer instructions.