Objective: To examine the utility of handheld metal detectors in confirming the position of radiopaque foreign bodies in the esophagus before delayed endoscopic removal.

Design: Prospective study of patients evaluated between June 1, 1997, and August 31, 1999.

Setting: Tertiary pediatric referral center.

Patients: Twenty-six of 139 children presenting consecutively for evaluation of esophageal foreign bodies met eligibility criteria and completed the study protocol. Inclusion in the study was contingent on a delay of at least 6 hours from the time of diagnosis to the time of endoscopic removal. All patients underwent both radiographic evaluation and handheld metal detector scanning of the chest and abdomen on presentation and immediately before endoscopic removal.

Results: All patients evaluated during the study period had coins lodged within the esophagus. Handheld metal detector scanning accurately confirmed this position before endoscopic removal in all cases.

Conclusion: Our data suggest that handheld metal detectors may obviate the need for repeated radiographs in patients whose foreign bodies cannot be removed at presentation.

Early removal of ingested foreign bodies located in the esophagus is paramount to avoiding potentially devastating complications. Nevertheless, such objects rarely require emergency intervention, and there is usually ample time for proper preoperative evaluation. Because most esophageal foreign bodies are radiopaque, routine management usually entails initial anteroposterior and lateral neck and chest radiographs. These studies confirm the ingestion of a foreign body, establish the location of the foreign body in the esophagus, characterize the shape and orientation of the foreign body, and rule out the presence of multiple foreign bodies. Sometimes, several hours may elapse before definitive treatment; in these cases, an anteroposterior radiograph is commonly repeated to confirm that the foreign body has not migrated distally. These studies add expense and additional radiation exposure to the preoperative workup. The objective of this study was to examine the utility of handheld metal detectors (HHMDs) in confirming the position of radiopaque foreign bodies in the esophagus before delayed endoscopic removal. If accurate, HHMD scans could preclude repeated radiographs and their concurrent cost and radiation exposure without compromising necessary preoperative information.

Results: A total of 139 patients presented for evaluation of suspected esophageal foreign bodies during the 2-year study; 29 were eligible for study inclusion. Three patients did not undergo the second radiographic evaluation, leaving 26 who completed the study. Patients’ ages ranged from 9 to 92 months (median, 30 months); 13 patients were boys and 13 were girls. Ingestion of the foreign body had been witnessed in 13 of the 26 patients. In cases in which the time of the event could be established, median time to foreign body removal was 14 hours (range, 8 hours to 25 weeks). Mean time between radiographs was 8.8 hours (range, 5.0-15.0 hours).
PATIENTS, MATERIALS, AND METHODS

Candidates for inclusion in this study included all children evaluated for esophageal foreign bodies at Children’s Hospital of The King’s Daughters, Norfolk, Va, between June 1, 1997, and August 31, 1999. Patients enrolled from this group had a radiographically confirmed esophageal foreign body and no history of esophageal, pulmonary, cardiac, or other disease requiring thoracic surgery with implementation of radiopaque hardware. Children with “high-risk” foreign bodies (ie, disc batteries or objects with points, sharp edges, or irregular or indeterminate shapes) or impending complications were excluded; in these patients, removal was performed on an urgent basis. In each case, endoscopic removal was electively delayed at least 6 hours as a result of a full stomach or a nighttime hospital admission, necessitating repeated radiographs at least 6 hours after the initial radiographs. A parent or guardian of each patient signed a consent form approved by the institutional review board of the Eastern Virginia Medical School, Norfolk.

After the initial history was taken and physical examination was performed, patients underwent HHMD scanning and anteroposterior and lateral neck and chest radiographs to include the gastric bubble to assess for an esophageal impaction and any associated complications. Data recorded included demographic, anatomic level of an audible signal from the HHMD scanning, and endoscopy. All metallic jewelry, eyeglasses, and clothing with metallic elements were removed from them before scanning. With the child standing or held upright away from metal interferences, an HHMD (Garrett Super Scanner; Garrett Security Systems, Garland, Tex) was passed over the child’s body in a “zigzag” fashion from the cervical esophagus to the umbilicus anteriorly and posteriorly (Figure 1). The anatomic level of an audible signal from the HHMD was recorded on the patient’s skin and compared with the original radiographic findings. The timing of endoscopic removal of an esophageal foreign body was at the discretion of the attending otolaryngologist and anesthesiologist. Another HHMD scan was performed within the hour before endoscopic removal of the foreign body, followed by repeated anteroposterior radiographic imaging. Data recorded included the age and sex of patients; whether the event was witnessed vs unwitnessed; time from foreign body ingestion to endoscopic removal; time between initial and repeated radiographs; original location of the foreign body by radiographs and HHMD scans; and final location of the foreign body by radiography, HHMD scanning, and endoscopy.

In 24 of 26 patients, preoperative radiographs demonstrated a radiopaque foreign body at the sternal notch. In 1 patient, the foreign body was identified substernally, and in the remaining patient it was at the gastroesophageal junction. In all patients, the HHMD scan confirmed the position of the foreign body. In 2 patients, signal was also inexplicably detected over the lower extremities.

Before undergoing endoscopic removal, all 26 foreign bodies were predicted by HHMD scanning to be stable in location, and, in all cases, repeated anteroposterior radiographs of the chest confirmed the position. On rigid esophageal endoscopy, 100% of the foreign bodies were found to be coins, and all were in the locations predicted by preoperative studies. In 1 patient excluded from the study for failure to undergo follow-up radiography, no foreign body was found on rigid endoscopy. Metal detector scanning in the operating room suggested that the foreign body had moved distally, and the object was found in the stomach on subsequent flexible endoscopy. No postoperative complications were observed.

COMMENT

Esophageal foreign bodies are most common in children aged 6 months to 6 years who are inclined to use the oral cavity to explore their environments. Some esophageal foreign bodies pose potentially devastating risks to children, including reflexive regurgitation with aspiration, esophageal perforation, upper respiratory tract infections, mediastinitis with or without abscesses, tracheoesophageal fistula, aortoesophageal fistulas, extraluminal migration of the foreign body, false or true esophageal diverticula, and esophageal obstruction.

Despite the changing nature of esophageal foreign bodies during the past 25 years, coins remain by far the most common foreign body ingested by children. Symptomatic esophageal coins or those resulting from witnessed ingestions are rarely associated with significant morbidity because they are removed promptly. However, because coin impactions of long duration may cause complications and nearly half are asymptomatic, it has been suggested that all children with suspected coin ingestions undergo anteroposterior and lateral neck and chest radiographs to include the gastric bubble to assess for an esophageal impaction and any associated complications. The initial radiographic studies yield valuable information: presence or absence of a radiopaque foreign body; presence of multiple radiopaque foreign bodies; size, shape, and orientation of the foreign body; and mediastinal or thoracic complications from resultant esophageal perforations. These studies may also suggest the presence of nonradiopaque foreign bodies when peri-esophageal inflammation is seen.

On the other hand, many esophageal foreign bodies pass uneventfully through the gastrointestinal tract. Hodge et al reported that 10 (40%) of 25 confirmed esophageal foreign bodies passed spontaneously into the stomach after 1 to 5 hours. Schunk et al reported that 6 of 9 asymptomatic and 2 of 21 symptomatic patients passed coins spontaneously into the stomach within 4 hours. These authors suggest waiting as long as 12 to 24 hours to allow coins to pass spontaneously, thus avoiding an invasive procedure without an increased risk of severe complications. Furthermore, in many cases, there may be a delay in management of an esophageal foreign body from the time of initial diagnosis. Reasons for such delays may include transfer of the patient to an appropriate facility for treatment; a full stomach, which could cause complications for patients during induction of an-
esthesia; availability of the endoscopist or the endoscopy suite; or late-night admission to the hospital. When the delay exceeds the 4- to 5-hour wait described by Schunk and Hodge and their colleagues, many practitioners repeat the anteroposterior radiograph to confirm the persistence of a foreign body within the esophagus before endoscopic removal.

Use of an HHMD for following the progression of coins through the gastrointestinal tract was first described in a letter by Lewis in 1980. Kessler et al subsequently reported a case in which an HHMD accurately localized an esophageal razor blade that went undetected both on plain films and fluoroscopic swallow with contrast. Arena and Baker reported that HHMD scans correctly diagnosed 15 positive cases and 13 negative cases of gastrointestinal tract metallic foreign bodies when plain radiographs were used as the gold standard. They recorded no false-positive or false-negative results. Ros and Cetta studied the use of HHMDs in localizing ingested coins in children using simulated scans of metallic foreign bodies through soft tissues. Distances between the scanner and the foreign body were taken from measurements from the anterior chest to the gastroesophageal junction on computed tomographic images of healthy children aged 3 months to 6 years. The authors reported an accuracy of 100% in 40 positive cases and 10 negative cases at distances of 6.1 to 7.9 cm. They subsequently reported sensitivity of 91% and specificity of 100% in localizing swallowed coins in a clinical trial of 14 children. The sole failure of the Garrett Super Scanner was in a child with a rectal coin in whom management was not likely to be affected. Biehler et al reported failure to detect several objects, including a safety pin, paper clip, tack, watch battery, AA battery, and iron pill, in simulated scans through an examiner’s forearm. Subsequently, however, Sacchetti et al reported 94% sensitivity and 100% specificity in detecting 15 of 16 radiopaque foreign bodies (11 coins, a button battery, a medallion, a token, and a leaded glass marble). The undetected foreign body was a sewing needle that was barely perceptible on plain films. The HHMD used was the same as that used by Ros and Cetta at one of the 2 emergency department settings in the study. Tidey et al recently reported the correct positive and negative detection of 13 radiopaque foreign bodies in 20 children, including 8 coins, 1 ball bearing, 1 screw, 1 gold ring, 1 staple, and 1 washer. None of the foreign bodies were localized to the esophagus, however.

A recent study using HHMDs to localize ingested foreign bodies, performed in part at Eastern Virginia Medical School, compared the technique of experienced investigators with that of inexperienced investigators. Using chest radiographs as a gold standard, metal detection by experienced investigators had a positive predictive value of 90.9% and a negative predictive value of 100%. In less experienced hands, HHMDs achieved a positive predictive value of 77.0% and a negative predictive value of 96.6%, reflecting a higher false-positive rate. The difference between experienced and inexperienced investigators was not statistically significant; however, this difference may explain the false-positive signals detected in our study, in which the resident on call performed the HHMD scan.

Our review of the literature found no studies comparing the accuracy or sensitivity of different HHMDs. While several investigators used the same Garrett Super Scanner used in the present study, other devices used included the EBEX 610 (Ebiner, Köln, Germany), model 2000 (White’s Electronics, Inc, Sweet Home, Ore), Backpacker-2 TR (AH Electronics, Inc, Arlington Heights, Ill), Enforcer G2 (Garrett Security Systems), and AD 15 (Adams Electronics, Inc, East Sussex, England, and Enid, Okla). It is our impression that smaller, more sen-

Figure 1. The metal detector is passed in a “zigzag” fashion over the cervical esophagus in front of (A) and behind (B) the patient.
On the other hand, Seikel et al reported a case in which preoperative evaluation of esophageal foreign bodies was reduced by 50 to 100 mRad (0.5-1 mGy) estimated to be $87.30 per patient. In addition, radiation shootings as a result of eliminating a repeated radiograph were cur in the study group and are extremely unlikely in the selected population, such events could potentially occur during the “delay” interval in a larger population and would be missed radiographically using the study protocol. Nevertheless, our data suggest that HHMDs are a useful adjunct in the evaluation and treatment of esophageal foreign bodies when removal is performed on a delayed basis.

Our protocol for evaluation of esophageal foreign bodies still calls for initial radiographic imaging of the chest. High-risk foreign bodies must be identified immediately because these objects require earlier intervention. In addition, we have observed cases in which the radiographic findings significantly altered our instrumentation and approach to the foreign body (Figure 2). On the other hand, Seikel et al reported a case in which 2 HHMD scans identified an ingested aluminum can pull tab that was not seen on initial radiographs of the chest. In some cases, therefore, both modalities may be useful.

All of the radiopaque foreign bodies in this study were metallic and were, in fact, coins. The results must therefore be interpreted with caution when the type of foreign body remains uncertain. Other study limitations include a small sample size and the absence of multiple or migrated foreign bodies. Although complications did not occur in the study group and are extremely unlikely in the selected population, such events could potentially occur during the “delay” interval in a larger population and would be missed radiographically using the study protocol. Nevertheless, our data suggest that HHMDs are a useful adjunct in the evaluation and treatment of esophageal foreign bodies when removal is performed on a delayed basis. Although the HHMD used in this study retails for $199 and can be purchased at a significant discount, cost savings as a result of eliminating a repeated radiograph were estimated to be $87.30 per patient. In addition, radiation exposure was reduced by 50 to 100 mRad (0.5-1 mGy) per patient. We conclude that HHMDs have a place in the preoperative evaluation of esophageal foreign bodies.

Figure 2. Anteroposterior radiograph of the chest (A) demonstrating a round foreign body (arrow) consistent with a coin; however, the object is also round on the lateral radiograph (B). The foreign body removed at endoscopy was a marble.