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Plain films in the evaluation of batteries as esophageal foreign bodies

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Summary

Objective: To determine the sensitivity and specificity of plain films in differentiating coin batteries from coins.
Setting: Study was conducted at a tertiary referral university medical center.
Methods: Eleven radiographs were taken of various objects and independently reviewed by 14 radiologists and otolaryngologists. Reviewers were asked to identify the object filmed as either a battery or not a battery. In addition, otolaryngologists were asked if they would immediately proceed to the operative suite for removal based on the film. Results were tabulated and analyzed using a spreadsheet.
Results: Overall, plain films had a sensitivity and specificity of 80.4% and 79.1%, respectively with an overall accuracy of 79.8%. When used as a test to determine urgency of removal, sensitivity increases to 94.4% while specificity decreases to 67.1% with an overall accuracy of 83.1%.
Conclusions: Plain films are an effective method of evaluating for the possibility of batteries as esophageal foreign bodies.

1. Introduction

Pediatric foreign body ingestion is one of the most common problems encountered by otolaryngologists. Incidence has not been reported but judging from the various series in the literature, an emergency room at an academic center can expect to see from 35 to 139 cases of pediatric foreign body ingestion in a year with most reports in the range of 50 cases a year [1–6]. The most common foreign body ingested is a coin with one study reporting that 88% of all such ingestions are coins [3]. Coin ingestion is generally a benign experience and serious complications are rare and as such, in the absence of distress, removal is not a surgical emergency.

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However, a more dangerous ingested foreign body is the button or disc battery. These are used in common electronic devices such as cameras, calculators, hearing aids, watches, and toys and are found with increasing frequency as an ingested foreign body. Because of the chemical composition of these batteries which are most commonly lithium ion or mercury oxide based, they can cause severe burns in upper aerodigestive tract and have been linked to several complications including death from tension pneumothorax [7], vocal cord paralysis [8], tracheoesophageal fistula [9], systemic absorption of lithium and mercury [10,11], esophageal perforation, and esophageal stricture. The high complication rate for disc batteries lodged in the esophagus necessitates urgent removal. Because of the disparity in clinical course between disc batteries and other ingested foreign bodies such as coins, it is important to be able to make the distinction so that the urgency of surgical intervention can be assessed accurately. Currently, the standard radiologic workup for a pediatric ingested foreign body is AP and lateral chest films; however, disc batteries closely resemble the most common ingested object, coins, on plain films. In this study, we assess the sensitivity and specificity of plain films in distinguishing between coins and disc batteries.

2. Methods

2.1. Object selection and preparation

US currency and batteries were chosen to most resemble each other. US coins were obtained out of the general circulation and batteries were purchased from Radio Shack. Coins and batteries were then attached to foam blocks using tape to aid in their orientation during radiography.

2.2. Radiography

Radiographs were taken using a Fujifilm Velocity SpeedSuite. AP and lateral films of the objects were taken with setting consistent with pediatric chest films. Two objects were intentionally underpenetrated to investigation the effect of poor technical quality on accuracy. Detailed settings are shown in Table 2. Films were viewed on computer workstations. In total, there were five films of coins and six films of batteries taken.

2.3. Examination

Films were independently examined by 14 otolaryngology attendings and senior residents and 9 radiology attendings and residents who were asked to fill out a worksheet where they marked whether they felt that the object being viewed was more likely a battery or more likely not a battery. The films could be viewed in any order and examiners were free to go back and review films and needed and change their answers as they felt was appropriate. In addition, otolaryngologists were also asked on their worksheet if they would urgently take a patient to the operating room based on the film. Examinees were allowed to change windowing and magnification and not given any time limit. Examinees were not given any additional training before the test and were blinded to the identity of the objects and told that the objects could represent any common household item.

Data analysis was performed using Microsoft Excel.

3. Results

For this study, 11 AP and lateral plain films were taken (Fig. 1). Nine sets of objects were used and two of the objects were radiographed twice — once with normal settings and once with settings that would underpenetrate the object. The objects were chosen and then arranged to mimic each other as much as possible often including multiple objects in one film.

The overall sensitivity of plain films in detecting a battery was 80.4% with a specificity of 79.1% giving an overall accuracy of 79.8% (Table 1). The false positive rate and false negative rate were 20.9% and 19.6%, respectively. It became clear in the very initial stages of the study that certain films were readily recognized by the examiners while others presented a great deal of uncertainty. Therefore it was decided to add a question on the survey to otolaryngologists on whether they would take the theoretical patient to the OR based on the film because many felt they would go to the OR if the film was ambiguous to them. When this question was analyzed, sensitivity increased to 94.4% and specificity decreased, as would be expected, to 67.1% with an overall accuracy of 83.1%. Also there was an expected increase in the false positive rate to 32.9% but a welcome decrease in false negative rate to 3.6%.

The accuracy of identification for each individual film is shown in Table 2. This demonstrates that single coins are readily identified by most examiners with a range of 91.3—100% correct for single coins. Batteries radiographed under normal settings are recognized between 78.3% and 95.7% of the time while underpenetrating the film leads to a worse