Spiral CT scanning technique in the detection of aspiration of LEGO foreign bodies

Abstract Background. Radiolucent foreign bodies (FBs) such as plastic objects and toys remain difficult to identify on conventional radiographs of the neck and chest. Children may present with a variety of respiratory complaints, which may or may not be due to a FB. Objective. To determine whether radiolucent FBs such as plastic LEGOs and peanuts can be seen in the tracheobronchial tree or esophagus using low-dose spiral CT, and, if visible, to determine the optimal CT imaging technique. Materials and methods. Multiple spiral sequences were performed while varying the CT parameters and the presence and location of FBs in either the trachea or the esophagus first on a neck phantom and then a cadaver. Sequences were rated by three radiologists blinded to the presence of a FB using a single scoring system. Results. The LEGO was well visualized in the trachea by all three readers (both lung and soft-tissue windowing: combined sensitivity 89%, combined specificity 89%) and to a lesser extent in the esophagus (combined sensitivity 31%, combined specificity 100%). The peanut was not well visualized (combined sensitivity <35%). The optimal technique for visualizing the LEGO was 120 kV, 90 mA, 3-mm collimation, 0.75 s/revolution, and 2.0 pitch. This allowed for coverage of the cadaver tracheobronchial tree (approximately 11 cm) in about 18 s. Although statistical power was low for detecting significant differences, all three readers noted higher average confidence ratings with lung windowing among 18 LEGO-in-trachea scans. Conclusion. Rapid, low-dose spiral CT may be used to visualize LEGO FBs in the airway or esophagus. Peanuts were not well visualized.

Introduction

Foreign body (FB) aspiration into the tracheobronchial tree remains a frequent and serious cause of respiratory problems in children. Infants and toddlers in particular may ingest anything within reach, with the peak age of FB aspiration between 1 and 3 years [1]. Classic symptoms include coughing, choking, cyanosis, and/or sudden onset wheezing. Wheezing in the absence of known pulmonary disease such as asthma, especially if
unilateral, should be considered FB aspiration until proven otherwise [2]. While the problem is often clinically apparent, symptoms can resolve spontaneously and quickly yet the FB remains. Many cases of FB aspiration are initially treated as asthma or respiratory infection such as bronchiolitis or croup [2]. The diagnosis of FB aspiration is correctly made in the first 24 h in only 50% of cases [3].

The radiologic diagnosis of FB aspiration is also challenging for several reasons: (a) only 10% of FBs are radiopaque, (b) the chest radiograph is normal in up to 30% of children who aspirate FBs, and (c) the presence of pulmonary infiltrates may misdirect the management away from FB aspiration [2]. Approximately 70% of FB aspiration cases in children involve radiolucent vegetable matter, the most common being a peanut. Plastic objects are generally also radiolucent and represent approximately 5–16% of FB aspiration in children. LEGOs are popular plastic toys sold throughout the world. “LEGO asthma” has been described in children who inhale LEGO FBs but are misdiagnosed with asthma for some time [4]. When a letter to the editor of the New England Journal of Medicine suggested that making LEGOs radiopaque would enable their earlier detection when aspirated, the LEGO systems company president replied that to make LEGOs radiopaque would require barium sulfate additives, which degrade the plastic and make it more likely to fragment.

We investigated a low-dose spiral computed tomography (CT) method to determine whether radiolucent FBs such as plastic LEGOs and peanuts could be seen in the trachea and esophagus in a cadaver.

**Materials and methods**

Initially, we constructed a neck phantom to test the feasibility of identifying plastic LEGOs (Enfield, Conn.) using CT. A plastic container measuring 9 cm × 14 cm × 25 cm was filled with water to simulate the soft tissues of the neck. A 2-cm diameter air-filled plastic tube was constructed to simulate the trachea. A red, square LEGO, a yellow, rectangular LEGO, and a peanut were placed within the tube. The drain ends were covered to retain air and the tube was submerged in the water bath. A latex surgical drain was obtained to simulate an esophagus. A LEGO and a peanut were placed within the drain, which was then submerged in the water bath (Fig. 1).

Plain radiographs of the phantom were obtained using high-definition film (Sterling Ultravision G, Sterling Medical, Irvine, Calif.). Anterior-posterior (AP) and lateral radiographs were obtained using the standard pediatric neck parameters at our institution: AP radiograph 73 kVp, 3.2 mA; lateral radiograph 66 kVp, 2.5 mA (Fig. 2a,b). The neck phantom was then placed in the CT scanner. All images were obtained on a Siemens Somatom Plus 4 Scanner (Siemens Medical Systems, Erlangen, Germany) using a spiral technique. Multiple spiral acquisitions were made through the model, varying collimation, pitch, kilovolt peak, and milliamperes to determine the visibility of the LEGO and peanut on the CT scans.

![Fig. 1 CT images of the neck phantom clearly demonstrated the presence of the LEGO FB. Note one-half of a peanut (curved arrow) is seen en face adjacent to the LEGO (arrow). The peanut (hollow arrow) seen at left side of image was visualized when surrounded by air](image)

Administrative approval by both the institution’s director of anatomic and surgical research using cadaveric specimens and by the morgue supervisor was obtained prior to CT imaging of a cadaver. We chose a small, adult female cadaver after we were unable to obtain a pediatric cadaver. Multiple spiral acquisitions were made from the level of the vocal cords through the main bronchi for control images without the presence of FBs. Scans were obtained by varying the kilovolt peak (80, 120), milliamperes (90, 130/135), pitch (1.0, 1.5, 2.0), and collimation (3.0, 5.0 mm) in all combinations with 0.75 s/revolution. For the tracheal experiments, the number of techniques using lower kilovolts was decreased by using only the 3-mm collimation (no 5-mm collimation technical combinations). For the esophageal experiments, we further limited the number of possible techniques to include only those using 120 kV (except for a single experiment using 80 kV, 135 mA, 2.0 pitch, 3-mm collimation). The trachea was intubated and a LEGO and a peanut were placed separately within the trachea. Similar acquisitions were also made with the LEGO and peanut within the proximal esophagus.

Three radiologists, blinded to the presence or absence of FBs, separately evaluated all images on a Digital Viewing Console (Siemens, Erlangen, Germany) first with standard lung (window 1800, level 400) and then with soft-tissue (window 408, level 48) settings for the presence or absence of FBs. Each radiologist evaluated the images for the presence of FBs on a five-point Likert scale (1 = definitely no FB, 2 = probably no FB, 3 = possibly a FB, 4 = probably a FB, 5 = definitely a FB). The sensitivity and specificity of each technique and for each radiologist were calculated based on a rating of 3, 4, or 5 as positive for a FB. Combined average sensitivity and specificity were calculated. All statistical significance testing was performed on EpiInfo version 6 (Centers for Disease Control, Atlanta, Ga.) where a value of $p \leq 0.05$ was considered significant.

The optimal scanning parameters were determined based on the results and a consensus of all three raters. Finally, the radiation dose for the optimal chest CT technique was compared to that of plain radiography of the neck.