Ingestion of Magnetic Toys: Report of Serious Complications Requiring Surgical Intervention and a Proposed Management Algorithm

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Abstract

Context: Increasing popularity of strong magnets as toys has led to their ingestion by children, putting them at risk of potentially harmful gastrointestinal tract injuries.

Objectives: To heighten physician awareness of the potential complications of magnetic foreign body ingestion, and to provide an updated algorithm for management of a patient who is suspected to have ingested magnets.

Design: A retrospective review of magnet ingestions treated over a two-year period at our institutions in the Southern California Permanente Medical Group. Data including patient demographics, clinical information, radiologic images, and surgical records were used to propose a management strategy.

Results: Five patients, aged 15 months to 18 years, presented with abdominal symptoms after magnet ingestion. Four of the 5 patients suffered serious complications, including bowel necrosis, perforation, fistula formation, and obstruction. All patients were successfully treated with laparoscopic-assisted exploration with or without endoscopy. Total days in the hospital averaged 5.2 days (range = 3 to 9 days). Average time to discharge following surgery was 4 days (range = 2 to 7 days). Ex vivo experimentation with toy magnetic beads were performed to reveal characteristics of the magnetic toys.

Conclusions: Physicians should have a heightened sense of caution when treating a patient in whom magnetic foreign body ingestion is suspected, because of the potential gastrointestinal complications. An updated management strategy is proposed that both prevents delays in surgical care and avoids unnecessary surgical exploration.

Introduction

It is well known that the curiosity of children often leads to potential harm, especially when it comes to ingestion of foreign bodies. The incidence of foreign body ingestion is estimated to be more than 100,000 patients annually in the US alone. Although it has been reported that less than 1% of ingested foreign bodies require any type of surgical intervention, a physician’s and surgeon’s awareness should be heightened especially when the ingested foreign body has a magnetic component to it. Potential gastrointestinal complications from ingestion of multiple magnets include bowel obstruction, perforation, fistula formation, volvulus, necrosis, and even death. Magnetic beads recently popular on the adult toy market is an example of a potentially hazardous product.

The purpose of this report is to draw attention to the dangers of these magnetic toys, and to heighten physician awareness of the potential consequences. Furthermore, an updated algorithm is proposed to guide the management of patients who present with ingestion of magnetic foreign bodies.

Methods

A retrospective review of all magnet ingestions treated over a recent two-year period at our institutions in the Southern California Permanente Medical Group was performed. Institutional review board approval was not required. Patient demographics, clinical information, radiologic images, and surgical data were analyzed. These data were used to propose a management strategy that both prevents delays in surgical care and avoids unnecessary surgical exploration. In this small series, no comparative analyses were performed; however, data were analyzed to determine the means.

Ex vivo experimentation with the magnetic beads was performed to identify magnetic characteristics. The magnetic beads were tested on a calibrated flat surface. Testing involved approximation of separate magnets and documentation of distances at which the magnets would attract and cling to one another. This was performed with one magnet separate from one other magnet, one magnet separate from two adherent magnets, one magnet separate from three adherent magnets, and one magnet separate from a chain of four adherent magnets. Ten trials were performed for each combination.

Results

Table 1 reveals demographic and diagnostic data from each of the 5 patients. Patients’ ages ranged from 15 months to 18 years. Symptoms primarily included nausea and nonbloody, nonbilious emesis associated with abdominal pain. Four of the 5 patients continued to have these symptoms, whereas 1 patient (Patient C) had complete resolution of the symptoms. Each of the radiologic images revealed adherent radiopaque foreign objects consistent with the ingested magnetic beads. Migration of these objects on repeated imaging was identified in only one patient (Patient C), who was found at exploration to have an intact chain of adherent magnetic beads intraluminally without evidence of perforation, fistula, or bowel obstruction.

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Table 1. Patient demographics, symptoms, and imaging results

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Symptoms</th>
<th>Imaging results</th>
<th>Migration of beads</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15 months</td>
<td>F</td>
<td>6 days of nausea, NBNB emesis, abdominal pain</td>
<td>6 beads adherent in a chain, 1 separate in the pelvis</td>
<td>No</td>
</tr>
<tr>
<td>B</td>
<td>3 years</td>
<td>F</td>
<td>1 day of nausea, NBNB emesis, abdominal pain</td>
<td>3 beads adherent in a chain, separate ring of 13 beads</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>10 years</td>
<td>F</td>
<td>10 minutes of abdominal pain, then asymptomatic</td>
<td>3 beads adherent in a chain</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>9 years</td>
<td>F</td>
<td>1 day of nausea, NBNB emesis, abdominal pain</td>
<td>Battery and magnetic bead adherent together</td>
<td>No</td>
</tr>
<tr>
<td>E</td>
<td>18 years</td>
<td>M</td>
<td>5 days of nausea, NBNB emesis, abdominal pain</td>
<td>27 beads in 2 stacked rings</td>
<td>No</td>
</tr>
</tbody>
</table>

NBNB = nonbloody, nonbilious.

Table 2 summarizes the surgical treatment and operative findings. All patients, with the exception of Patient C, had some type of serious complication from the magnetic foreign body ingestion, including pressure necrosis, perforation, fistula formation, and bowel obstruction. All 5 patients recovered postoperatively without significant complications. Total days in the hospital averaged 5.2 days (range = 3 to 9 days). Average time to discharge following surgery was 4 days (range = 2 to 7 days).

Of interest, Patient B was a 3-year-old girl with no past medical history, who presented with a 1-day history of abdominal symptoms. Patient B was witnessed to have been playing with toy magnets. This history led the evaluating physician to obtain an abdominal imaging series. Imaging revealed 3 beads aligned in a linear fashion in the upper aspect of the abdomen as well as a separate ring of 13 beads (Figure 1). Subsequent images failed to show migration, and the patient was brought urgently to the operating suite, where she underwent an esophagogastroduodenoscopy with retrieval of 1 magnetic bead in the stomach. Another bead was embedded in the gastric wall. A laparoscopic-assisted minilaparotomy was performed, with the findings of the proximal jejunum adherent to the greater curvature of the stomach. These tissues were separated, and both beads came loose. One was retrieved from the stomach via repeat upper endoscopy. The other bead was retrieved via enterotomy through an enlarged periumbilical incision. Interestingly, the beads that had formed the ring on imaging were found to be both intraluminal and extraluminal with 2 discrete areas of perforation at the terminal ileum (Figure 2). The ileum was eviscerated through the umbilical incision. The beads were broken up and removed, and repair of the terminal ileum was performed.

Table 3 shows results from the ex vivo experimentation with the magnetic beads. When a single magnet was slowly brought closer to another single magnet, the average distance at which the beads would cling together was 3.5 cm (range = 3.2 to 3.8 cm). When a single bead was tested against a chain of 2 adherent beads, the average distance at which attraction led to adherence was 4.4 cm (range = 3.9 to 5.0 cm). A single bead tested with a chain of 3 adherent beads revealed an average distance of 4.6 cm until adherence (range = 4.0 to 5.2 cm). Finally, a single bead tested with a chain of 4 adherent beads also revealed an average distance until adherence of 4.6 cm (range = 4.2 to 5.0 cm). Additionally, it was noted that a ring large enough to trap the bowel wall could be formed with 5 or more magnetic beads.

Discussion

Foreign body ingestion is a common scenario seen in the pediatric population. Less than 1% of ingested foreign bodies require any type of surgical intervention; however, when the foreign body has a magnetic component to it, a physician's and surgeon's concern should be heightened if other metal objects are present because of the likelihood that the magnet will attract metal or another magnet, causing pressure necrosis of the intervening intestine. Given the widespread use of magnets, ranging from therapeutic treatments for muscle stiffness in Asia to common household toys in the US, it is no wonder that they are often found in the hands of inquisitive children. When these objects are ingested, spontaneous
passage through the gastrointestinal tract should not be assumed.

When multiple magnets are swallowed, or when magnets and other metallic objects are ingested, serious complications may occur when the magnets cling to one another with tissue in between. Potential problems include intestinal fistula formation, bowel obstruction, perforation, volvulus, or intraperitoneal hemorrhage if mesenteric vessels are found between the magnets. In addition, a published report from the Centers for Disease Control and Prevention identified neal hemorrhage if mesenteric vessels are involved. The beads also orient themselves such that they do not repel one another.

Review of the literature reveals several suggested protocols. Wildhaber et al. proposed that observation is an option when a single magnet is ingested, whereas a patient who ingested multiple magnets should be further evaluated with endoscopy or laparotomy if signs of intestinal distress develop. This strategy reflected that of Chung et al. Building on that approach, Anselmi et al. further suggested that surgical intervention would be necessary if the locations of the magnets were unchanged on serial x-rays. Vijaysadan et al., on the other hand, recommended a more aggressive approach and proposed that exploratory laparotomy should be performed if the magnetic beads have passed the pylorus and cannot be retrieved via endoscopy. Of note, Butterworth and Feltis cautioned that a single magnet evident on radiologic imaging might not necessarily correlate with a single magnet ingestion. In their case report, radiographs falsely revealed a single magnetic stick, when in fact the stick was composed of multiple adherent magnets that had caused intestinal perforation.

Table 3. Ex vivo testing of magnetic beads for distance until adherence (centimeters)

<table>
<thead>
<tr>
<th>Magnetic combinations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>3.4</td>
<td>3.8</td>
<td>3.2</td>
<td>3.4</td>
<td>3.7</td>
<td>3.5</td>
<td>3.4</td>
<td>3.8</td>
<td>3.5</td>
<td>3.2</td>
<td>3.5</td>
</tr>
<tr>
<td>1:2</td>
<td>3.9</td>
<td>4.5</td>
<td>4.5</td>
<td>4.0</td>
<td>4.5</td>
<td>4.0</td>
<td>4.2</td>
<td>5.0</td>
<td>4.3</td>
<td>4.8</td>
<td>4.4</td>
</tr>
<tr>
<td>1:3</td>
<td>4.0</td>
<td>4.0</td>
<td>5.0</td>
<td>5.0</td>
<td>4.5</td>
<td>4.5</td>
<td>5.2</td>
<td>4.3</td>
<td>4.6</td>
<td>4.4</td>
<td>4.6</td>
</tr>
<tr>
<td>1:4</td>
<td>4.3</td>
<td>4.5</td>
<td>4.2</td>
<td>4.6</td>
<td>4.5</td>
<td>5.0</td>
<td>4.6</td>
<td>4.8</td>
<td>5.0</td>
<td>4.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>
on Day 5 to follow-up the foreign body migration. In an asymptomatic patient whose KUB x-ray reveals multiple magnets, management should be governed by additional factors. For example, if the magnets are separate entities, patients should undergo laparoscopic-assisted exploration and/or endoscopic retrieval to prevent potential gastrointestinal complications. If the magnets are adherent to each other, patients should be admitted, followed-up with KUB imaging performed every 6 hours, and examined serially. If symptoms of abdominal distress develop, or if serial KUB x-rays do not reveal definite distal migration of the foreign objects, patients should undergo laparoscopic-assisted exploration and/or endoscopy. Otherwise, close observation with serial examinations and keeping the patient on a nothing-by-mouth status for the first 12 hours is recommended. If a diet is well tolerated, the patient can be discharged home, with KUB x-rays obtained 1 and 5 days later.

This algorithm was devised on the basis of the management of the patients in this series. It is the algorithm currently in use at our facility, but it has not yet been applied to a large group of patients. One patient in this series underwent laparoscopic-assisted retrieval of the beads, and no perforation was present. In retrospect, this patient would have met the criterion for close observation and would have likely passed the short chain of beads without incident.

Most cases of magnetic foreign body retrieval may be managed via endoscopy, laparoscopy, or laparoscopic-assisted minilaparotomy. If diagnosed early enough, magnets, which appear to be in the stomach on KUB x-ray, or in the esophagus on chest x-ray, may be safely removed via esophagogastroduodenoscopy. Fluoroscopy is often useful intraoperatively to localize the beads. Laparoscopic localization is aided by the fact that magnetic beads are highly magnetic. They adhere to the metal tips of the laparoscopic instruments and inserted metal retractors. Perforated or necrotic bowel is easily repaired via exteriorization of the bowel in thin patients. Laparoscopic suturing is an option in larger patients or when it is difficult to exteriorize the bowel, for example, if the perforation is in the duodenum.

Conclusion

Physicians, surgeons, and emergency personnel should have a heightened sense of caution when treating a patient in whom magnetic foreign body ingestion is suspected. Complications such as bowel necrosis, perforation, fistula formation, hemorrhage, volvulus, and even death may arise when multiple magnetic objects are swallowed. This is no surprise given the strength of magnetic toys found on the market. The management algorithm proposed herein can prevent delays in surgical care and hopefully avoid unnecessary surgical exploration.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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References