Magnetic Foreign Body Ingestions

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Abstract: Magnets are inherently attractive to young children, but present a risk when ingested. If consumed alone, small, smooth magnetic foreign bodies are likely to pass without significant event; however, ingestion of multiple magnets may have catastrophic consequences, including bowel perforation, obstruction, peritonitis, and death. Increasing reports of morbidity and mortality in recent years from the US National Electronic Injury Surveillance System have led to numerous safety statements from the American Academy of Pediatrics and the Centers for Disease Control and Prevention, as well as several product recalls from the Consumer Product Safety Commission. This article presents the background and mechanism of injury of magnet ingestion, as well as recommended management and potential complications. We also review current legislation and opportunities for further patient advocacy regarding this polarizing problem.

Key Words: magnet, neodymium, rare earth, foreign body ingestion, injury prevention

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TARGET AUDIENCE

This continuing medical education activity is intended for physicians, physician assistants, nurse practitioners, and emergency medical service providers who care for pediatric patients.

LEARNING OBJECTIVES

After completion of this article, the reader should be able to:
1. Summarize the background and mechanism of injury of magnetic foreign body ingestions.
2. Report the epidemiology of magnetic foreign body ingestions in the United States.
3. Discuss the management of magnetic foreign body ingestions in children.

In 2003, they were repurposed for use in toys and building sets intended for children, including Polly Pocket Magnetic Playsets by Mattel and Magnetix by Mega Brands America (formerly Rose Art), but voluntarily recalled in 2006 after rising injury reports. In 2009, however, they were successfully remarked for commercial use by a number of adult toy companies, including Maxfield & Oberton, the creators of Buckyballs and Buckycubes. They have also been marketed by similar product makers, including Zen Magnets (Zen Magnets LLC), Magnicube (Star Networks), Nanospheres (Kringle Toys and Gifts), and Effective Collaboration is Magic Sets (Adobe), to name a few.

Although foreign body ingestion (FBI) is not a new problem, reports of magnetic FBIs began to rise in 2009 as sales of neodymium magnet desktop toys (marketed to adults and adolescents) increased. These small (<1 cm) unusually strong magnetic amusements were sold in large quantities (12–100s/package). Their compact, pea-sized form and often brightly colored surfaces made them an easy target for explorative toddlers, leading to unwitnessed ingestion. Parents or other caregivers may not recognize that symptoms such as abdominal pain, vomiting, or decreased oral intake may be delayed up to 8 to 24 hours after magnetic FBI. Therefore, the clinician must maintain a high index of suspicion to recognize and manage these ingestions.

EPIDEMIOLOGY

Pediatric magnetic FBIs remain a serious public health threat and account for more than 2000 Emergency Department visits per year, increasing at an alarming rate over the past 2 decades. A 2013 trend analysis by Abbas et al2 highlights that during a 10-year period from 2002 to 2011, the National Electronic Injury Surveillance System (NEISS) estimates that there were 16,386 possible magnetic FBIs among children younger than 18 years in the United States, with a 75% increase per year and a terminal 8.5-fold increase in incidence by 2011. It is important to note that NEISS estimates are projections based on probability sampling from data reporting from 100 representative emergency department departments (20% children’s hospitals and 80% general emergency departments of varying sizes) across the United States. Analytics are limited by the inability to separate suspected versus actual ingestions and insufficient outcome follow up after ED disposition. Another survey from the North American Society of Pediatric Gastroenterology Hepatology and Nutrition (NASPGHAN) highlights at least 320 cases, half of which affected children 13 months to 6 years of age. Despite this young majority, approximately one-quarter of reported cases consisted of older children and incidents related to magnets as false oral or nasal “piercings” (24%) and comorbid psychiatric disorders.3

On the basis of a recent retrospective analysis of 2 Consumer Product Safety Commission (CPSC) databases by De Roo et al, objects intended for adults, including toys and kitchen gadgets, caused most magnetic FBI injuries among children. Among these 72 reported injuries between 2000 and 2012, the average age was 6 years (mean, 6.4; median, 6.5), but there was a bimodal age distribution with peaks at 2 to 4 and 8 to 10 years. Although most young ingestions were by males (54.2%), all ingestions by teenagers were female. Reasons for ingestion included faux piercings (19.4%) and mistaking magnets for candy (6.9%). Alarmingly, only 1 case was witnessed directly. Interestingly, patients more
likely to have ingested multiple magnets were found to be older than 5 years. Hospitalization was required for 73.6% of patients (range, 1–54 days), endoscopic removal performed in 7.6% of cases, and surgery was performed in 69.7% of the cases, with 16.7% experiencing long-term consequences. Only 21.2% of magnets passed naturally without intervention.2,4 Approximately half (50.7%) of the magnets causing injury were products intended for use by adults.

Case series detailing multiple magnetic ingestions have demonstrated an intestinal perforation rate as high as 50%.3 A 2014 Canadian study by Strickland et al6 echoed these demographics and trends, highlighting a concerning increase in the incidence of multiple, small magnetic ingestions with greater morbidity.

TYPICAL PRESENTATION AND COMPLICATIONS

Most cases of magnetic FBIs are asymptomatic in the early phase. Progression of symptoms is dictated primarily by timing and location, with varying degrees of mucosal erosion or mechanical obstruction. Fistula formation may occur within 2 to 5 days of ingestion.7 A 2014 case series by Brown et al8 highlights 4 upper aerodigestive magnetic FBIs that required removal by otolaryngology. Similarly, an illustrative 2013 case series by Ojeti et al9 highlights the myriad gastrointestinal sequelae of magnetic ingestions. Patients may present with obvious symptoms such as nausea, vomiting, diarrhea, coughing, difficulty feeding, drooling, and pain, but may present with insidious or absent symptoms.9 When more than one magnet is ingested, tissues that lie between pairs of magnets can undergo pressure ischemia and necrosis. When ingested in larger quantities, magnetic chains, conglomerates, or loops can create a sizeable impediment to physiologic processes, resulting in obstruction or volvulus. In addition, concurrent ingestion of ferromagnetic objects contributes compounding risks of injury.

Patients at highest risk of ingestion and subsequent injury include children who are younger than 5 years, nonverbal, developmentally delayed, cognitively impaired, depressed, or behaviorally disturbed (eg, attention deficit and hyperactivity disorders, schizophrenia, pica).10 Although FBIs are more likely to be low-risk objects such as coins, magnets—like button batteries—pose a higher risk for complications.11 Complications may include ulceration, necrosis, perforation, rupture, stricture, fistula (enteroenteric, arteriogastrointestinal, or tracheoesophageal), hemorrhage, mediastinitis, peritonitis, gastric outlet or bowel obstruction, volvulus, sepsis, and death.12,13

A 2012 survey by NASPghan of its members identified that of 424 patients with magnetic FBI during a 10-year period, 52% of patients required endoscopic removal alone, 20% required endoscopic and surgical intervention, 8% required surgical removal alone, and 15% were managed with observation alone. Forty-one percent of surgical cases required repair of perforation or fistula, whereas 22% underwent partial bowel resection.18

EVALUATION AND MANAGEMENT OF MAGNET INGESTION

Although more than 99% of ingested foreign bodies pass without surgical intervention, ingestion of multiple magnetic foreign bodies provides a substantially higher risk of injury due to self-association and therefore requires a more aggressive clinical approach.19 To date, there is no large, prospective study to guide management, but in 2015, the NASPghan Endoscopy Committee released a clinical report, detailing current consensus among expert opinions (Fig. 1). Indications and timing for intervention is dependent on multiple factors, including patient size, anatomic location, symptoms, and time since ingestion. For example, if the magnetic FBI is identified within the esophagus, stomach, or small intestine and the patient is not managing secretions, emergent removal (<2 hours, regardless of NPO status) is indicated by endoscopy. However, if the patient is able to manage secretions, urgent removal (<24 hours from presentation, within NPO guidelines) is indicated by endoscopy.11 Foreign bodies that are too large for endoscopic retrieval will require surgical removal.

If a patient, or more likely, his/her parent reports magnet ingestion or has developed unexplained gastrointestinal symptoms after suspicious environmental exposure to magnets, prompt ED evaluation is required. Upon arrival, a single view anterior–posterior radiograph of the chest and abdomen should be obtained, with follow-up lateral radiographs as needed to clarify foreign body position. Fortunately, all magnets are radio-opaque. Once identified, a member of the aerodigestive team (pediatric GI, ENT, and/or Pulmonology) should be contacted for coordination of removal, dependent on anatomic location and available institutional resources. Concurrent radiographic evidence of bowel entrapment, obstruction, or perforation (which is more likely with larger magnetic burden based on size alone) requires emergent surgical consultation.20

When a single magnetic FBI is identified without further notable complications, endoscopic removal may not be necessary, but should be considered if the patient is at risk for further ingestion, has poor means of close follow-up, or displays obstructive symptoms (pain, vomiting, tachycardia, etc). If endoscopy is unavailable, providers should follow progression and confirm passage by obtaining serial abdominal radiographs with strict avoidance of further magnetic exposures and stool surveillance. Spontaneous passage is more likely after the foreign body has traversed the esophagus. Delayed transit should be mitigated with stool softeners or polyethylene glycol. Failure of movement should prompt reconsideration of endoscopic or surgical intervention. It is important to note that closely stacked magnets may mimic a single magnet,22 but pose a greater risk for distal separation and subsequent transmural attraction, leading to intestinal injury. If diagnostic imaging is in question, fluoroscopy or low-dose, limited-field CT would offer enhanced imaging clarity. For obvious reasons, including magnet migration and heat conduction, MRI is contraindicated for evaluation of suspected magnetic ingestion. Ultrasound may prove a useful adjunct for clarifying anatomic location of an ingested foreign body.23 If imaging proves unrevealing, but suspicion of intestinal injury from magnetic FBIs remains, Wooten et al24 illustrate a case where laparoscopy proved both diagnostic and therapeutic.

If multiple magnets (or a single magnet plus additional ferromagnetic objects) are identified within the stomach or esophagus, endoscopic removal is recommended within 12 hours of ingestion; if endoscopy is unavailable or the procedure would be delayed more than 12 hours, transfer to a referral center and coordination with pediatric surgery is recommended. If endoscopic removal is successful, the patient should be discharged home only after demonstrating adequate oral intake with planned outpatient follow-up and anticipatory guidance regarding home safety; if unsuccessful, prompt surgical removal is indicated.11

When multiple magnets traverse the stomach, coordination with both pediatric GI and pediatric surgery is recommended, and ultimate management is dependent upon clinical concerns. Symptomatic patients with evidence of obstruction or perforation will require surgical intervention. Asymptomatic patients should undergo endoscopy or colonoscopy for removal when available, or undergo surveillance with serial radiographs every 4 to 6 hours. If there is no progression on repeat x-rays, stool softeners or laxatives may encourage passage and will at least provide bowel preparation for potential colonoscopy. At this point, inpatient

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monitoring and continued serial radiographs every 8 to 12 hours should proceed, with ultimate endoscopic or surgical removal. In the event of progression of magnets on serial radiographs, providers may consider close follow-up and stool surveillance for confirmation of foreign body passage. Development of gastrointestinal symptoms or failure to progress should prompt hospitalization for definitive removal of magnetic foreign body. For inpatient safety, all metallic and magnetic objects should be removed from the patient’s environment and one-to-one observation provided for patients at risk for self-injury.

PREVENTION: LEGISLATION AND RECALLS

Although neodymium magnets have been available since the 1980s, the first large report of associated injuries did not appear in the literature until 2002, when McCormick published a case series of 24 pediatric patients and their varied ingestions. Since that time, there have been rising reports of ingestions throughout the mid 2000s, including at least 2 highly publicized fatalities in 2006 and 2012, involving toddlers younger than 2 years.

In 2006, the CDC released a report warning parents and caregivers of the inherent risk of gastrointestinal injury from high-powered magnets. The CPSC worked initially with retailers to update safety warnings on packaging, but due to rising reports of magnetic ingestions with increasing morbidity and mortality, several products were recalled (all of which are highlighted here: http://www.consumeraffairs.com/magnet-warnings-and-recalls). As a result, the CPSC issued a strong federal safety standard for high-powered magnets in 2014. Under the Consumer Product Safety Act, this performance standard stipulates that any magnet manufactured or imported on or after April 1, 2015, must be large enough to decrease its ingestion hazard (larger than a CPSC-designated small parts cylinder; Fig. 2) or the magnetic force must be lowered to a flux index of 50kG² (37 times weaker than some

FIGURE 1. Proposed management algorithm for magnet ingestion in children. Adapted from Hussain et al. ED, Emergency department; GI, gastrointestinal; PEG, polyethylene glycol.
Although critics decry governmental overreach, advocates cite injury statistics. It is important to note that the CPSC safety standards limit only the sale, not possession, of high-powered magnet sets. Additionally, they do not apply to household gadgets or jewelry. After great commercial success, high-powered magnet sets that were purchased legally before April 1, 2015, are still in circulation and may continue to pose a household threat to children. Furthermore, these toys are still available commercially in other countries, excluding New Zealand and Australia, which have also banned high-powered magnets. Consumers in possession of high-powered magnet sets are encouraged to seek rebates or at a minimum, to keep vintage neodymium magnets out of reach of children and adolescents.

Pediatricians and members of the American Academy of Pediatrics have been instrumental in advocating for CPSC standards. On the clinical level, pediatricians should continue to counsel patients on magnet safety, discuss safe and age-appropriate toys, and warn about the serious health hazards associated with magnet ingestion. Adolescents should be discouraged from use of magnets to mimic facial piercings, which may lead to unintentional ingestion. In the event of ingestion, parents and patients must seek immediate medical attention, as delay in management may increase the risk of complications. Clinicians, parents, or other advocates should report any known cases of magnet ingestion to the CPSC at www.SaferProducts.gov. Continued reports may prove important for future regulatory changes and enhance injury prevention.

CONCLUSIONS

Despite their attraction, high-powered magnets are an avoidable source of potentially life-threatening injury. Parents and caregivers should remove them from the reach of children, and medical providers should maintain a high index of suspicion of their ingestion. Prompt evaluation and likely removal may be lifesaving and intestine saving. Although the CPSC has made strides in commercial regulation, only time will tell if these regulations can halt the alarming rise in magnetic FBIs among children in the United States.

REFERENCES


