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Ingestion of multiple magnets in children

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ABSTRACT

Background: The ingestion of multiple magnets is harmful in children because it can cause intestinal obstruction and/or perforation. We present an approach for the management of children visiting the emergency department with multiple magnet ingestion.
Methods: We retrospectively investigated 9 children who presented to 2 centers in Korea between January 2004 and August 2018 with a history of multiple magnet ingestion. Demographics, major symptoms, management, and outcomes were analyzed.
Results: Of the 9 children investigated, median age was 34 months with vomiting and abdominal pain as the most common initial symptoms. Six (67%) underwent surgical removal of the magnets after observing for mean 2.2 days. Reasons for surgical managements were no magnet migration on serial radiographs in 3, suspected obstruction or microperforation in 2 and failed endoscopic removal in 1. Three patients (33%) were asymptomatic and were treated with meticulous observation using serial plain radiographs for average 3.3 days. All patients discharged without adverse outcomes and complications.
Conclusions: Surgical removal is warranted in patients with symptoms suspicious of intestinal obstruction and/or perforation or without magnet migration. Asymptomatic children can be observed over at least 2–3 days with serial simple radiographs while awaiting magnet migration.
Level of evidence: IV.

Foreign body ingestion is common in children; however, in most cases, the foreign bodies are spontaneously excreted without causing serious injury. Among all documented cases of foreign body ingestion, the incidence of magnet ingestion was approximately 3.06 cases per 100,000 people [1]. Cases of magnet ingestion have increased 3-fold over the last decade owing to increased production of magnetic toys [1]. Ingestion of multiple magnets puts the body at risk of injury from strong forces of attraction between the magnets, and, in turn, bowel loops, leading to pressure necrosis and consequent intestinal obstruction and/or perforation and fistula formation [2,3]. We describe the clinical presentations of 9 cases of multiple magnet ingestion in children and discuss optimal management protocols.

1. Material and methods

1.1. Patient enrollment

Following approval by the Institutional Review Boards (IRB) of Seoul National University Hospital (SNUH, IRB No. 1902-099-1011) and Samsung Medical Center (SMC, No. 2019-05-059), we obtained the medical records of all children with multiple magnet ingestion from the aforementioned centers, where they received treatment between January 2004 and August 2018. The study included 5 children admitted to SNUH and 4 children admitted to SMC. Four different surgeons of both institutions operated on these patients.

1.2. Review of data and data analysis

We obtained details of patient demographics including age, sex, underlying medical conditions, major symptoms, and physical examination. The diagnostic methods, treatments, and posttreatment outpatient follow-up were retrospectively analyzed for all children. We included all cases of multiple magnet ingestion and excluded

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Table 1
Clinical data of patients with surgical treatment.

No.	Sex	Age	Initial symptoms	Initial physical exam	No. of magnets	Shape of magnets	Laboratory data	Duration before surgery[a]	Operation	Reasons to proceed surgery	Postoperative events / complications
1	F	12 m	Vomiting	N/S	6	Round	WBC 22,420 CRP 0.15	5	Lap. foreign body removal and primary repair of perforation site (stomach, T-colon)	No migration of magnets	N/S
2	F	13 m	Vomiting Fever	N/S	7	Round	WBC 7610 CRP 0.46	4	Lap. foreign body removal and primary repair of perforation site (stomach, T-colon)	No migration of magnets	N/S
3	F	10y	Vomiting	Diffuse abdominal tenderness with rebound tenderness	12	Bar, round	WBC 13,360 CRP 1.34	0	Lap. small bowel enterotomy and foreign body removal	Possibility of intestinal perforation	Recurrent event occurred
4	F	34 m	Vomiting Abdominal pain	Epigastric area tenderness	2	Bar	WBC 11,980 CRP 0.48	1	Lap. small bowel enterotomy and foreign body removal	Possibility of intestinal obstruction	N/S
5	M	8y	Vomiting	N/S	2	Round	WBC 11,170 CRP 0.03	1	Gastric and T-colon wedge resection with foreign body removal (open conversion)	Failed endoscopic removal	N/S
6	M	8y	Abdominal pain	Periumbilical area tenderness	2	Round	WBC 11,160 CRP 0.03	2	Small bowel segmental resection	No migration of magnets	N/S

N/S: nonspecific, WBC: white blood cells (/μL), CRP: C-reactive protein (mg/dL), T-colon: transverse colon.
[a] Duration before surgery: time interval from first symptom to operation (days).

cases of single magnet ingestion. The duration of magnet migration is defined as the interval between the admission day and the day that the magnets were identified in the stool.

Descriptive statistics including counts and percentages were analyzed. We calculated the mean interval between the onset of symptoms and the day of surgery in children undergoing surgery. Additionally, the mean time of magnet migration was obtained in children who did not undergo surgery. Mean values of laboratory test results including white blood cell (WBC) counts and serum levels of C-reactive protein (CRP) were evaluated and compared between the surgical and nonsurgical groups.

2. Results

2.1. Demographics

The 9 children in this study included 3 boys and 6 girls. The median age of children with ingestion of multiple magnets was 34 months (range 12–119 months). Six children presented with vomiting as the initial symptom and 2 of them presented with accompanying fever or abdominal pain. One child presented with abdominal pain and the other 2 showed no specific symptoms; however, their parents had seen them swallowing the magnets. Of the 9 children investigated, 8 denied underlying diseases, and 1 child, who was the oldest of the group, had a history of a developmental disorder. Tables 1 and 2 show details of children included in the surgical and nonsurgical groups, respectively.

2.2. Clinical management of patients

All children were admitted to the emergency department (ED). Upon admission, vital signs were recorded in all children, and fever (40 °C) was observed in only 1 child (Case 2). This child had been diagnosed with influenza A at another hospital on the same day where she had previously presented with vomiting. Physical examination revealed abdominal tenderness in 3 children (Cases 3, 4, and 6). Leukocytosis and mild serum CRP elevation were also observed in 7 and 2 children, respectively. In the surgical and nonsurgical groups, the mean WBC counts and serum CRP levels were 12,950 ± 5013.5 *vs.* 9193 ± 2826 cells/μL and 0.42 ± 0.50 *vs.* 0.04 ± 0.02 mg/dL, respectively without statistical differences ($p = 0.197$, 0.178 respectively). All children showed multiple radioopaque materials in the abdomen on plain radiographs (Fig. 1).

After admission to the aforementioned hospitals, 6 patients (Cases 1 to 6) underwent surgery after a mean preoperative observation period of 2.2 ± 1.9 days. Only 1 child (Case 3) underwent surgery on the day of admission. The mean duration of magnet migration was 3.3 ± 1.2 days in the nonsurgical group (Cases 7 to 9).

We evaluated the indications for surgical intervention in the study group. Three children (Cases 1, 2, and 6) showed no magnet migration on serial plain radiographs for over 48 h, necessitating surgical intervention. Moreover, the two children (Cases 1 and 2) who showed nonspecific findings at the initial physical examination developed focal abdominal tenderness after admission. These three patients underwent operations 5, 4, and 2 days after observation respectively. Endoscopic removal was attempted in Case 5; however, the magnets were deeply embedded in the stomach wall and required immediate conversion to open surgery. Case 3 who initially presented with diffuse abdominal

Table 2
Clinical data of patients without surgical treatment.

No.	Sex	Age	Initial symptoms	No of magnets	Physical exam	Lab	Duration of magnet migration[a]
7	M	18 m	Vomiting	2	N/S	WBC 9970 CRP 0.06	2 days
8	F	4 y	No specific symptoms	5	N/S	WBC 11,550 CRP 0.03	4 days
9	F	20 m	No specific symptoms.	2	N/S	WBC 6060 CRP 0.03	4 days

N/S: nonspecific, WBC: white blood cells (/μL), CRP: C-reactive protein (mg/dL).
[a] Duration of magnet migration: magnet migration interval from admission day to the day the magnets were identified in the stool (days).

tenderness across the entire abdomen with accompanying rebound tenderness underwent surgery as the first-line treatment. Case 4 swallowed bar magnets serially, and forces of attraction between the bar magnets caused small bowel obstruction necessitating surgery shortly thereafter.

Laparoscopic removal was attempted in all children who underwent surgery. The magnets were attached through the walls of the stomach and the transverse colon, and fistula formation was identified in 3 children (Cases 1, 2, and 5). Magnet removal and primary repair of the stomach and the colonic wall were performed in these children (Fig. 2). In Case 5, wedge resection on the necrotic portion of the gastric and colon wall was also performed. In 2 children (Cases 3 and 4), the magnets were attached between the small bowel loops, and no migration was observed. A minilaparotomy was performed in these patients. The bowel segment was delivered through the incision site, and a small incision was made in the bowel through which the magnets were removed. Primary repair of the small bowel was then performed. The magnets were attached to each other in the ileocecal area without further migration in 1 child (Case 6). These magnets were removed through a small bowel incision; however, severe bowel wall edema and hematoma prevented primary repair. Small bowel resection and anastomosis were performed in this patient.

Children treated conservatively were maintained on a nothing per oral (NPO) status and discharged after confirming the passage of magnets in stool and the absence of radioopaque materials in the plain radiographs. These 3 patients remained NPO for 2, 4 and 4 days respectively without additional medications or interventions.

All children underwent follow-up at the outpatient clinic after discharge, and no events or complications were reported. However, 1 child (Case 3) visited the ED after swallowing plastic toys 3 months after discharge. Two months later, she revisited the ED with magnet ingestion. She was asymptomatic, and physical examination did not reveal any specific abdominal signs. Only 1 magnet was identified on plain abdominal radiographs, and physical examination showed no changes over several hours with close monitoring in the ED. The child was discharged and returned to the outpatient clinic 2 days later to report that the magnet was eliminated through feces.

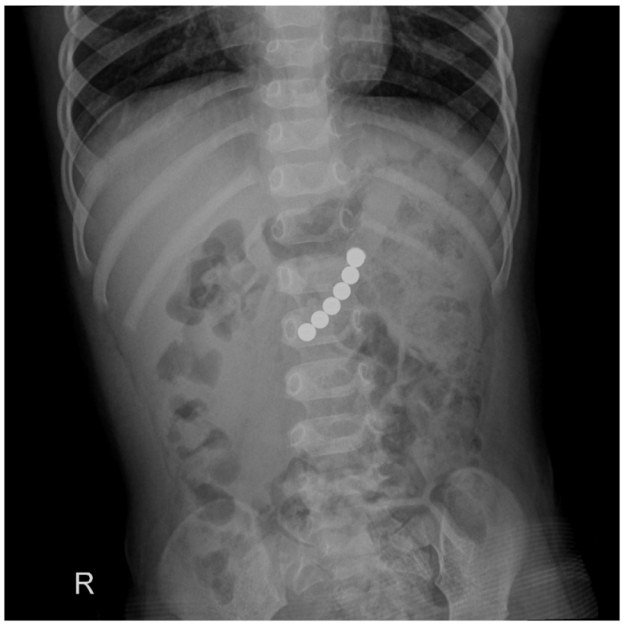

Fig. 1. Initial abdominal x-ray image (Case 1).

3. Discussion

3.1. Initial evaluation of patients with magnet ingestion

The number of children presenting with multiple magnet ingestion has increased significantly over the last decade [3,4]. Neodymium magnet-induced bowel injuries were first reported in 2002 [5], and an increasing number of cases have been reported since then. Children and infants are attracted to small and shiny magnets as playthings. Thus, since 2006, toys with magnets are not recommended for children aged <3 years in the United States. Moreover, the accidental death of a 20-month-old infant after swallowing magnets has raised awareness regarding this condition and its association with risk of death [3].

Children with ingestion of foreign bodies usually present to hospitals with nonspecific symptoms such as abdominal pain, nausea or diarrhea. In the cases we investigated, the most common complaints were vomiting and abdominal pain, which occurred in 7 of the 9 children. Sola et al. have reported that patients with magnet ingestion commonly present with abdominal pain, nausea, and vomiting, which concur with our case series [6]. Taking additional plain radiographs to identify radioopaque materials is useful for correct diagnosis of magnet ingestion.

Conclusive diagnosis of multiple magnet ingestion should be based on thorough physical examination [7]. In Cases 1 and 2 in this study, abdominal tenderness developed later in these children although no specific signs were observed during the initial physical examination. This change in physical examination findings indicated the need for surgical intervention. Notably, our study did include children who presented with abdominal tenderness at the time of admission (Cases 3, 4, and 6). Laboratory test results can be considered additional but nonessential information for initial diagnosis and decision-making process. The mean WBC counts and serum CRP levels were higher in the surgical than in the nonsurgical group; however, even if the number of patients is small, they were all statistically insignificant.

3.2. Management protocol

If a child is suspected of swallowing multiple magnets, it is necessary to determine the location in the body, whether they are lodged in the stomach or are present distal to the stomach in the small intestine or the colon. If magnets are present in the stomach and esophagus, endoscopic removal could be attempted. In children without severe symptoms in whom magnets are suspected to have advanced beyond the stomach, without evidence of obstruction and/or perforation, serial plain radiographs should be obtained while awaiting magnet migration. Following radiographic evidence of magnet migration, children can be discharged with appropriate education and close monitoring at outpatient visits. However, surgical intervention is warranted if magnet migration does not occur [3]. In other words, patients should be observed who are completely asymptomatic, with normal physical exams and early magnet migrations.

As mentioned earlier, serial plain radiographs were obtained for all children in this series except for 1 child (Case 3) who underwent surgery on the day of admission. No further intervention or surgery was performed in children in whom radiographs showed magnet migration in 2 to 4 days without abdominal pain and tenderness (Cases 7 to 9). However, patients with abdominal tenderness had early surgical removals (Cases 3 and 4). Early migration of magnets did not occur in 3 children (Cases 1, 2, and 6), also necessitating surgical removal. In Case 5, magnets were suspected to be located in the stomach, and endoscopic removal was first attempted. However, the magnets were deeply embedded in the stomach wall and required open surgical removal.

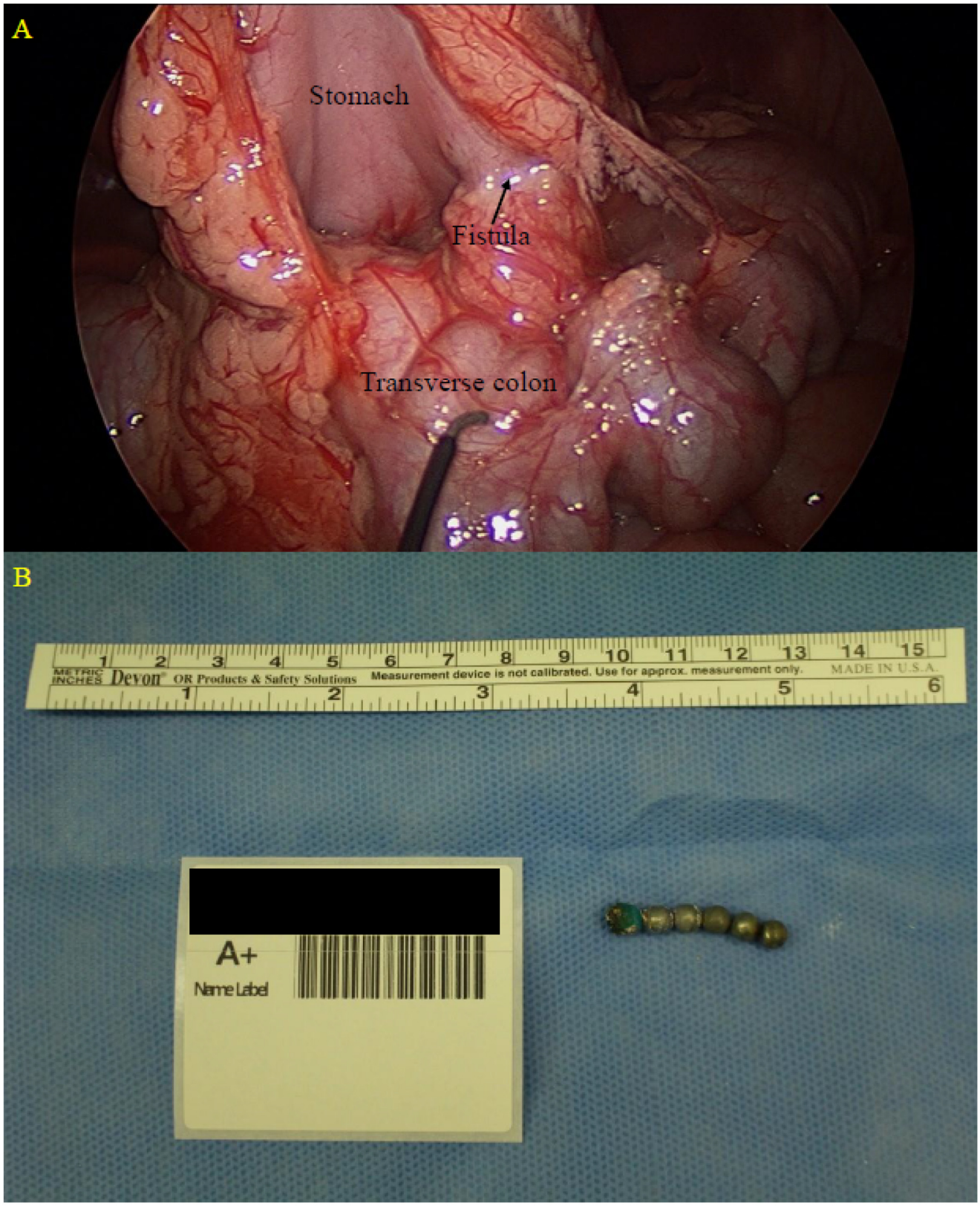

Fig. 2. Laparoscopic finding showing gastrocolic fistula formation and removed magnets (Case 1).

4. Conclusion

In summary, the following approach is important in children with multiple magnet ingestion: ingested material should be promptly identified by detailed history-taking, a thorough physical examination, and plain abdominal radiographs. If examinations indicate intestinal perforation or obstruction, immediate surgical intervention should be performed. In those presenting with nonspecific findings on physical examination, serial radiographs need to be obtained to monitor magnet migration. During the observation period, if patients develop related symptoms or

abnormality on physical exams, surgery should immediately be considered. If magnet migration is not observed even after 48 to 72 h, surgical removal is warranted for successful recovery. Observation should be warranted only for patients who are completely asymptomatic, normal on physical exams, and show early magnet migration on serial x-rays.

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