

Bowel injuries caused by ingestion of multiple magnets in children: a growing hazard

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Abstract

Purpose There are no definite guidelines on the management of ingested magnetic objects in children. The aim of this study was to present our experience and to highlight the importance of strict follow-up.

Methods Within 6 months period, four children presented to the emergency department after ingestion of multiple magnets. We reviewed retrospectively the patients' documents, radiological reports, operative findings and outcome. We also performed a literature search for all reports of multiple magnets ingestion on MEDLINE and EMBASE.

Results Daily abdominal radiographs to monitor migration of magnetic objects together with clinical examination revealed early detection of perforations in two patients. Explorative laparoscopy and suturing of perforations resulted in a rapid recovery and good cosmetic appearance. Literature search resulted in 44 published articles with a total of 52 cases of multiple magnet ingestion in children.

Conclusions This report stresses the need for prompt follow-up and early detection of complications in order to operate those patients without delay. Laparoscopy is the method of choice in exploring the abdomen when perforation is suspected.

Keywords Magnet ingestion · Multiple magnets · Bowel perforation · Explorative laparoscopy · Children

Introduction

Children are well known to ingest foreign materials as they experiment throughout their development. Magnetic object ingestion is, however, very rare, but do occur and it is very important that the hazards of ingesting magnetic bodies are well known to the physician. Bowel perforation following magnetic material ingestion has been well documented in the literature [1–5]; however, there are no definite guidelines on the management of ingested magnetic objects in children. In isolation, a single magnet is typically innocuous and is expected to behave much like other foreign bodies, however, several reports in surgical and pediatric journals proclaim the danger in children whenever more than one swallowed magnet travels beyond the stomach [2]. The force of multiple magnets that attract each other has been reported to be 1,300 G [6]. The magnets will hold the intestinal wall in between them and result in ischemia, pressure necrosis, perforation, fistula formation and/or intestinal obstruction [3].

The aim of this report was to present our experience with ingested magnets in children. An aggressive follow-up is stressed as migration of the magnetic objects only allows for greater morbidity.

Patients and methods

Four children who ingested multiple magnets presented to the emergency department in Astrid Lindgren Children's Hospital in Stockholm, from January 2011 through June 2011. The clinical reports, radiological findings and operative notes were reviewed retrospectively. We describe each case separately to give a better clue on the findings

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and at the same time to highlight the policy of our department in different scenarios.

Electronic searches

For the literature review we searched the following databases:

- MEDLINE (1980 to July 2011);
- EMBASE (1980 to July 2011)

The following search strategy was used:

1. MeSH descriptor multiple magnets, children explode all trees,
2. ingested, swallowed,
3. (#1 AND #2),
4. gastrointestinal complications,
5. (#1 AND #2 AND #4),
6. ingested NEXT multiple magnets NEXT children,
7. (#3 OR #4 OR #5 OR #6).

There were no restrictions on the basis of language of publication, date of publication, or publication status.

Searching other resources

We searched the bibliographies of all retrieved and relevant publications identified by these strategies for further studies.

Results

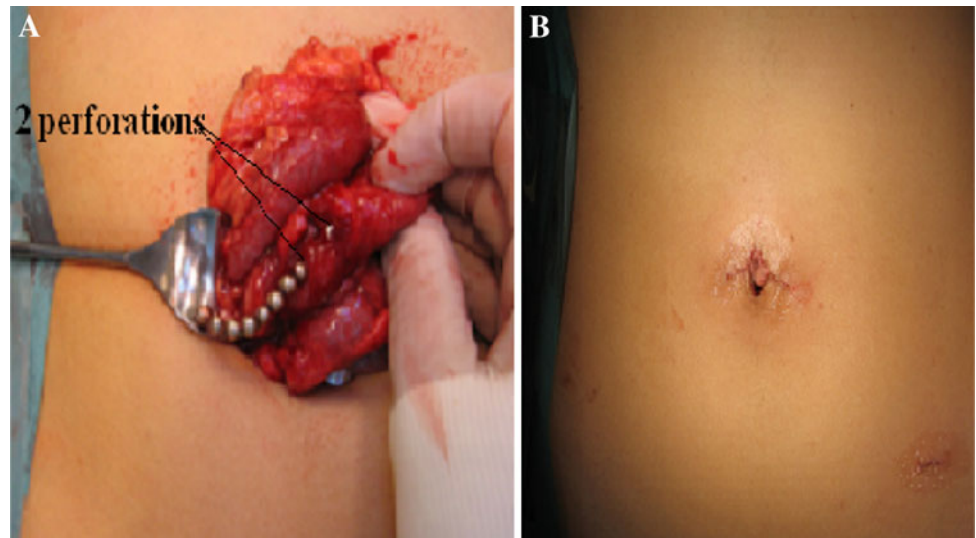
Case 1

An otherwise healthy 12-year-old girl presented to the emergency department with abdominal pain and vomiting following ingestion of magnetic balls while playing a game with her brother. According to the patient she swallowed around 4–5 magnetic balls of about 5 mm diameter in size. Her vital signs were within normal limits and her abdomen was soft. Abdominal radiographs revealed 14 consecutive metal balls, stretching a distance of 7 cm, in the small intestine, likely in the jejunum (Fig. 1). She was sent home and planned for abdominal radiographs after 24 h and there after once daily. By the 4th day, she was admitted to the hospital as she developed abdominal pain, mainly on the right side. The serial abdominal radiographs showed no migration of the foreign bodies. Her abdominal pain continued and her abdomen was tender on the right side, however, her vital signs remained stable. She was then scheduled for explorative laparoscopy (5 days after ingestion), which showed the magnetic balls located along the mesocolon close to the hepatic flexure. On-table fluoroscopy revealed that all the 14 magnets were attached to each other. The umbilical incision of laparoscopy was then extended via a Tan–Bianchi incision and the transverse colon was brought to the incision. Two perforations of the colon, about 2 cm apart from each other, were identified and 7 of the balls were lying in the mesocolon, coming out from one of the perforations (Fig. 2). This corresponded

Fig. 1 Abdominal radiographies showing 14 multiple magnets. **a** lateral view, **b** frontal view



Fig. 2 **a** Two perforations in the transverse colon. **b** Cosmetic outcome



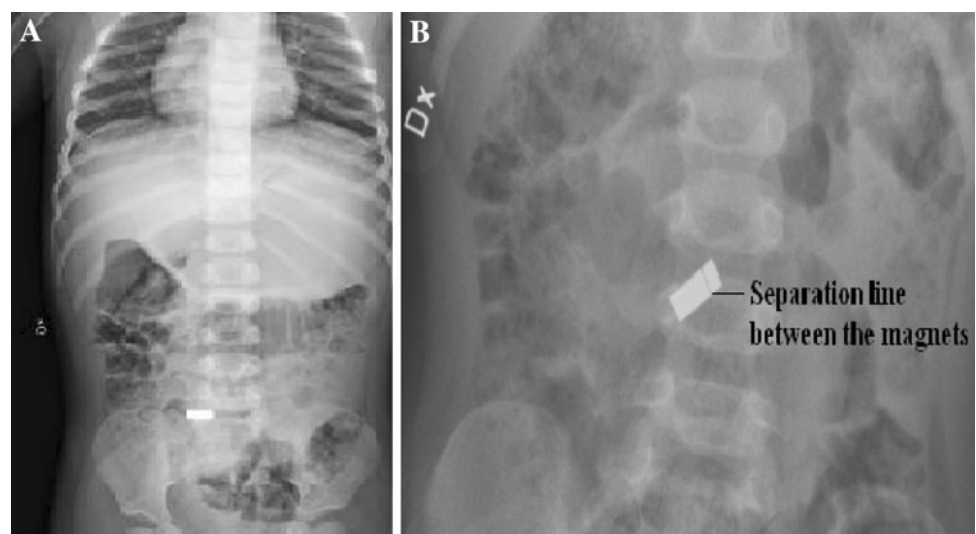
with areas of perforation from pressure necrosis on the bowel wall caused by the magnetic attraction. The remainder of the balls were inside the colon. All the 14 magnets were extracted. A coloraphy in 2 layers was sutured. She recovered well postoperatively and was discharged after 4 days.

Case 2

A 2-year-old boy was brought to the emergency department by his parents who had seen him ingest four refrigerator magnets. Abdominal radiographs identified four 15 × 6 mm cylindrical shaped metal objects in the inferior aspect of the abdomen, just right of the midline (Fig. 3a). His vital signs were stable and the abdomen was soft. The patient was sent home and a follow-up appointment for abdominal radiography was planned the next 24 h. He represented the next day with abdominal pain and vomiting.

Clinically, his vital signs were still stable, but the abdomen was generally tender. Repeat radiographs revealed the foreign bodies remaining in the same position, with no migration. It also showed a thin separating line between two magnets (Fig. 3b) that could not be seen on the previous film and this line was thought to be representing a bowel wall lying in between the magnets. The patient was then admitted to hospital for observation and after 2 days he still had ongoing abdominal pain. Radiographs showed no migration of the magnetic balls, and a decision for explorative laparoscopy was therefore taken (4 days after ingestion). Inspection revealed yellow fluid in the pelvis and a perforation in the cecum was also noted. The umbilical incision of laparoscopy was then extended via a Tan–Bianchi incision and the bowel brought to the incision. Inspection of the small intestine identified another perforation in the middle of the jejunum about 5 mm long. All four magnets were located along a perforation in the

Fig. 3 Abdominal radiographies showing multiple objects at **a** day 1 where the objects attach together and **b** day 2 where there is a separation line between objects



mesentery of the ileum. The ileum was intact; however, the magnets had perforated through the mesentery to lie just below its edge. All the foreign bodies were extracted. The perforation in the cecum was then stapled with Endo GIA Staplers. The jejunal perforation was then also stapled across with one line. Postoperative period was uneventful and he was discharged on day 5.

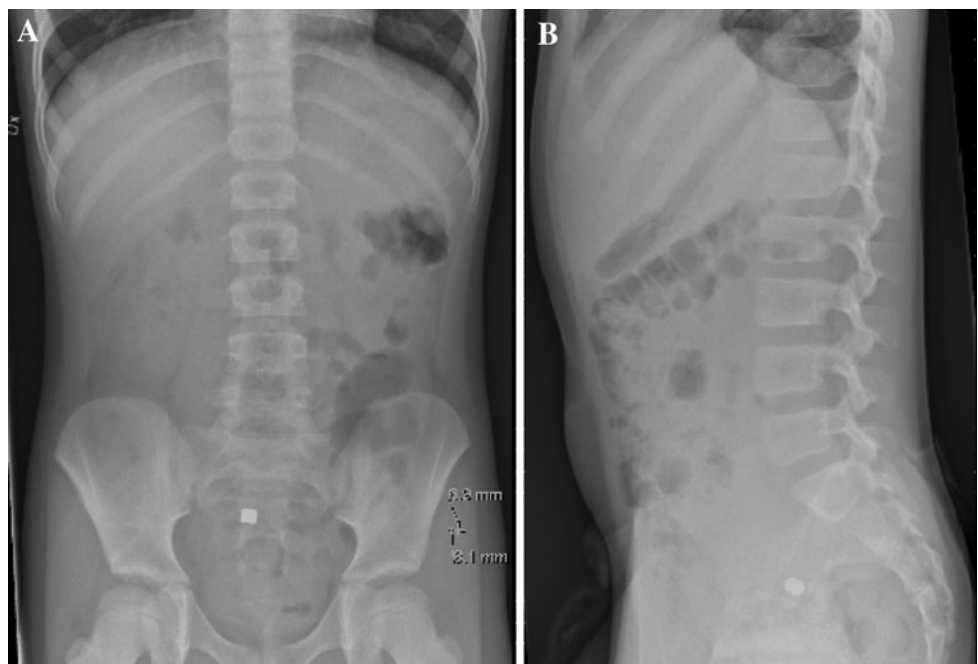
Case 3

A 2.5-year-old boy was brought to the emergency department after ingestion of two magnetic objects that was witnessed by his accompanying father. He had no symptoms at presentation. Abdominal radiographs, 4 h after ingestion, identified two 0.9×13.1 mm cylindrical shaped metal objects in the small intestine (Fig. 4). The patient was sent home with a follow-up abdominal radiography every 24 h to monitor the migration of the two magnets and their relation to each other. The magnets were attached to each other all the way and came out after 3 days.

Case 4

A 1.5-year-old boy presented to the emergency department after ingestion of a magnetic ball. He had no abdominal symptoms. Abdominal radiography, 2 h after ingestion, showed a rounded 10×10 mm foreign body in the stomach. The patient was sent home with a follow-up telephone contact after 4 days. By the 3rd day the magnet passed out with defecation.

Fig. 4 Abdominal radiographies showing two attached foreign bodies in **a** frontal and **b** lateral view



Results of the electronic search

The search strategy for the review resulted in 44 articles; as shown in Table 1. Four were review articles while the rest were case reports. Eight articles were in a foreign language and we were able to extract the required data from the abstracts of four [17, 26, 42, 43], while the other four were excluded. The first published report was from Japan (Honzumi et al. [6]). Since then, 52 cases were reported up to July 2011. Male to female ratio was nearly 2:1.

32 patients were under 4 years of age. Five children had potentially relevant conditions, including autism, developmental delays and/or neurologic disorders [12, 18, 20, 36, 39].

Discussion

There are no definite guidelines in managing children who have ingested magnetic objects. The famous rule that is saying: “*once foreign bodies travel beyond the esophagus, most traverse the gastrointestinal tract without complications*” is not applicable here. It is important to recognize that the whole gastrointestinal tract is at risk of perforation following ingestion of multiple magnetic objects and not applying an aggressive approach to treat these patients may lead to serious morbidity and even mortality. Awaiting migration of magnetic bodies poses a risk in itself as the bowel may be injured and perforated at any stage during movement of the objects and result in complications. The

Table 1 Reported cases of multiple magnets ingestion

First author	Year	No. of cases	Age (years)	Sex	Presentation	Type of intervention	Surgical findings	Types of magnet	History of ingestion	Duration till intervention (days)
Honzumi [6]	1995	1	3	F	AP + bilious emesis	Exp. laparotomy	J1 fistula	Multiple magnets	Yes	x
Kubota [7]	1995	1	1.3	F	IO	Exp. laparotomy	J1 fistula + IH	Multiple magnets	No	x
Lee [8]	1996	2	2	F	AP + IO	Exp. laparotomy	J1 fistula	Multiple magnets	No	1
			3	F	No symptoms	Exp. laparotomy	GJ fistula	Multiple magnets	Yes	11
McCormick [9]	2002	1	9	F	Ap + emesis	Exp. laparotomy	5 SB perforations	Multiple magnets	x	2
Cauchi [10]	2002	1	9	F	AP + fever	Exp. laparotomy	5 ileal perforations	12 magnets	no	7
Chung [11]	2003	2	0.8	M	AP + IO	Exp. laparotomy	II fistula	Multiple magnets	Yes	7
			1.8	M	AP	Exp. laparotomy	II fistula	Multiple magnets	No	180
Oestreich [12]	2004	1	12.5	M	AP + Autistic	Exp. laparotomy	SB perforation	Multiple magnet toys	No	x
Tay [13]	2004	1	9	M	AP	Exp. laparotomy	Jejunal perforation	Magnets + metallic balls	No	7
Haraguchi [14]	2004	1	2	M	x	Exp. laparotomy	J1 fistula + IH	5 magnets	x	x
Nui [15]	2005	1	1	M	IO + bilious emesis	Exp. laparotomy	Ileal volvulus	2 magnets	No	3
Wildhaber [16]	2005	1	9	F	Ap + emesis	Exp. laparotomy	SB strangulation	5 magnet toys	x	2
Encinas [17]	2005	1	x	M	Ap + emesis	x	3 fistulae	Constriction toys	x	15
Liu [18]	2005	1	7	M	AP + DD	Endoscopy + laparotomy	DC fistula	10 construction toys	No	3
Nagaraj [19]	2005	1	10	M	Ap + emesis	Exp. laparotomy	Ileal perforation	Magnet toy + battery +bar	x	2
Ohno [20]	2005	1	7	F	Ap + emesis + Autism	Endoscopy	GD fistula	Constriction toys	x	8
de la Fuente [21]	2006	1	2	M	AP + fever	Exp. laparotomy + colonoscopy	SB volvulus	Magnet toy + battery	No	1
Vijaysadan [22]	2006	1	11	M	Ap + emesis	Exp. laparotomy	J1 fistula + II fistula	2 magnets	Yes	21
Reed [23]	2006	1	11	M	AP + emesis	Exp. laparotomy	4 ileal perforations	1 magnet + metal object	No	3
Uchida [24]	2006	1	2	F	IO + fever	Exp. laparotomy	DJ fistula	32 magnet toys	x	4
Cortes [25]	2006	3	4	M	x	Exp. laparotomy	Jejunal ulceration	Multiple magnets	x	x
			4	F	x	Exp. laparotomy	Gastric perforation	3 magnets	x	x
			4	F	x	Exp. laparotomy	3 SB perforations	Multiple magnets	x	x
Anselmi [26]	2007	1	3	M	AP	Exp. laparotomy	2 ileal perforations	2 construction toys	No	4
Palanivelu [27]	2007	1	2	M	No symptoms	Laparoscopy + endoscopy	GJ fistula	Multiple magnets	Yes	x
Fenton [28]	2007	1	6	M	AP + emesis	Exp. laparotomy	IH + SB obstruction	2 magnet toys	No	x
Pryor [29]	2007	2	4	M	AP + emesis	Exp. laparotomy	2 ileal perforations	2 magnet toys	No	4
			12	M	Constipation	Colonoscopy + laparoscopy + laparotomy	2 J1 fistulae	Multiple magnet toys	Yes	60
Alzahem [30]	2007	1	4	M	Ap + emesis	Exp. laparotomy	2 ileal perforations	2 magnets	x	4

Table 1 continued

First author	Year	No. of cases	Age (years)	Sex	Presentation	Type of intervention	Surgical findings	Types of magnet	History of ingestion	Duration till intervention (days)
Ilçe [31]	2007	1	4	F	AP + emesis	Exp. laparotomy	Volvulus + 2SB perforations	4 magnet toys	No	4
Kircher [32]	2007	1	3	M	No symptoms	Exp. laparotomy	Multiple SB perforation	Multiple magnets	Yes	2
Dutta [4]	2008	1	4	M	AP	Laparoscopy	IC fistula	Multiple magnets	Yes	3
Schierling [33]	2008	1	6	M	AP	Exp. laparotomy	Multiple SB fistulae	Multiple toys + 7 balls	No	21
Robinson [34]	2009	1	3	M	AP	Exp. laparotomy	IC fistula + appendicitis	Multiple magnets	No	90
Shah [35]	2009	1	2	M	AP + emesis	Exp. laparotomy	SB fistula + IH	4 magnets	No	7
Saeed [36]	2009	3	3	M	AP	Exp. laparotomy	2 ileal perforations	Multiple magnets	Yes	x
			11	M	DD + AP	Exp. laparotomy	JC fistula	Multiple magnet toys	No	7
			3.5	F	AP	Exp. laparotomy	Ileal obstruction	x	No	3
Kabre [37]	2009	4	2	F	Bilious emesis	Exp. laparotomy	Gastric perforation	2 magnets	No	3
			7	M	AP + emesis	Exp. laparotomy	Volvulus + 3 perforations	2 magnets	No	7
			8	M	Ap + emesis	Exp. laparotomy	SB obstruction	4 magnets	No	x
			2	F	Ap + emesis	Exp. laparotomy	Volvulus	3 magnets	No	3
Wong [38]	2009	1	5	F	AP + emesis	Laparoscopy + laparotomy	Multiple perforations	2 magnets	x	x
Brown [39]	2010	1	11	M	DD + AP + fever	Exp. laparotomy	Duodenal perforation	Multiple magnet toys	Yes	3
Zampieri [40]	2010	1	4	M	Pneumonia + AP	Exp. laparotomy	Ileal obstruction	x	No	x
Sahin [41]	2010	1	4	F	AP + bilious emesis	Exp. laparotomy	Duodenal perforation	2 magnets	No	5
Kramhout [42]	2010	1	3	M	AP + emesis	Exp. laparotomy	Volvulus + SB fistula	3 magnet toys	x	x
Schroepfer [2]	2010	1	1.8	M	AP + bilious emesis	Exp. laparotomy	2 ileal perforations	Magnet toy + 2 metal objects	No	3
Ahmed [43]	2010	1	5	F	x	x	Jejunocolic fistula	2 magnet toys	x	x
Shastri [44]	2011	2	4	M	AP	Laparoscopy	Ileocecal fistula	Magnet + battery	No	3
			2	M	No symptoms	No intervention	None	Magnet + battery	Yes	1

AP abdominal pain, IO intestinal obstruction, JJ jejunoleal, GJ gastrojejunal, IH internal hernia, SB small bowel, II ileoileal, DJ duodenojejunal, IC ileocolic, DD developmental delay, JC jejunocolic

mentioned scenario happened in two of our patients (cases 1 and 2). Our explanation is that; the propulsive force of peristalsis may result in detachment of the magnetic objects from each other. After a while the attractive magnetic force reattaches the objects together resulting in entrapment of mucus membrane or the whole thickness of bowel wall (of one segment or two different segments of bowel) in between the magnetic objects leading to necrosis, perforation and fistula formation. In case 1, the wall of one segment, which was the transverse colon entrapped between the magnetic objects resulting in two perforations. In case 2, the walls of two segments, which were the cecum and jejunum where entrapped in between the magnets, resulting in perforations. Furthermore, as reported by Dutta and Barzin [4], magnets ingested even days apart, which may be seen radiologically isolated in different anatomic locations, will still be attracted to each other and cause bowel injuries.

At our center, once the multiple magnetic materials are identified, the practice has been to try strict conservative management with serial imaging daily for a few days (as in cases 1–3). If this fails, as serial images show a gap between magnets (case 2), lack of migration of the foreign bodies, or the patient deteriorates clinically (case 1), explorative laparoscopy is promptly indicated. In case 3, the strict follow-up was successful and the two magnets were attached to each other all the way according to abdominal radiographs and came out with defecation after 3 days. If the ingested multiple magnets are still in the stomach, it should be attempted to retrieve them by endoscopy to avoid serious sequelae. In case 4, there was a rounded single magnet in the stomach and it was expected to behave much like other foreign bodies in an innocuous way, therefore the follow-up protocol was to send the patient home with a planned telephone contact after 4 days.

From our experience, we recommend laparoscopy as the first option for exploration. It gives better view of the whole abdomen and pelvis with better localization of the foreign bodies, favorable cosmetically and rapid postoperative recovery. After localization of the foreign bodies and identification of the perforations, we decided to repair the bowel extracorporeally (in cases 1 and 2). This combination gave us a better visualization and facilitated the repair of bowel and at the same time resulted in a good cosmetic outcome.

Literature review showed that the ingested foreign bodies were multiple magnets or construction toys in most of the cases. In four cases there were magnets and batteries [19, 21, 44] while different associated metallic objects were present in five cases [2, 13, 19, 23, 33]. With regard to the type of intervention to retrieve multiple magnets, explorative laparotomy was performed in 42 cases. Laparoscopy was the first alternative in five cases [4, 27, 29, 38,

44] and was converted to laparotomy in two cases [29, 38]. Endoscopy was reported in only one case [20] as the sole intervention modality but it was used as an adjuvant to operative technique in four cases [18, 21, 27, 29]. There is only one reported case [44] in which no intervention was required and the magnets passed out with defecation. In this review, we reported the second case of ingested multiple magnets that passed out without intervention (case 3 in our material). We reported also two cases that were operated with laparoscopy and converted to laparotomy to retrieve the multiple magnets (cases 1 and 2).

Only in 11 cases, the parents witnessed the ingestion of magnets (Table 1). The time interval between the ingestion to the date of intervention varied widely from 1 day to 6 months. More than half of the cases were presented in the first week of ingestion of magnets.

While treatment is our focus here, prevention is the key. The authors are particularly concerned that these magnets are widely available in children's toys. The magnets may become easily detached. Parents should be warned of the risk of magnet ingestion particularly in small children. We believe that public awareness of this risk may help in prevention.

Conclusions

A more aggressive follow-up is strengthened in cases of multiple magnets ingestion as migration of the objects only allows for greater morbidity. Explorative laparoscopy is recommended when serial radiographies show no migration of the foreign bodies or the patient deteriorates clinically. Prevention is the key and parental involvement is crucial.

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