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ORIGINAL ARTICLE

# Needle decompression to avoid tension pneumoperitoneum and hemodynamic compromise after pneumatic reduction of pediatric intussusception

**Sara C. Fallon · Eugene S. Kim · Bindi J. Naik-Mathuria · Jed G. Nuchtern · Christopher I. Cassady · Jose Ruben Rodriguez**

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**Abstract**
*Background* The contemporary management of children with ileocolic intussusception often includes pneumatic reduction. While failure of the procedure or recurrence after reduction can result in the need for surgical treatment, more serious adverse sequelae can occur including perforation and, rarely, tension pneumoperitoneum. During the last year, four cases of perforation during attempted pneumatic reductions complicated by tense pneumoperitoneum have occurred in our center.
*Objective* We have elected to report our patient experience, describe methods of management and review available literature on this uncommon but serious complication.
*Materials and methods* Using ICD-9 diagnosis codes, we reviewed the records of children with intussusception during 2011. Demographic and therapeutic clinical data were collected and summarized.
*Results* During the study period, 101 children with intussusception were treated at our institution, with 19% (19/101) of them requiring surgical intervention. Four children (4%) experienced a tense pneumoperitoneum during air enema reduction, prompting urgent needle decompression in the fluoroscopy suite. These children required bowel resection during subsequent laparotomy. No deaths occurred.
*Conclusion* Pneumoperitoneum is a real and life-threatening complication of pneumatic enemas. It requires immediate intervention and definitive surgical management. Caution should be exercised by practitioners performing this procedure at institutions where pediatric radiology experience is limited and immediate pediatric surgical support is not available.

**Keywords** Intussusception · Enema reduction · Bowel obstruction · Children

## Introduction

Ileocolic intussusception is a common cause of bowel obstruction in children. Approximately 56/100,000 infants and children are hospitalized annually with intussusception [1]. Diagnosis is typically made in the emergency room with ultrasonography, which in the radiologic literature has a sensitivity approaching 100% [2]. In the absence of systemic signs of infection or peritonitis, either hydrostatic or pneumatic reduction can be attempted. It is increasingly recognized that a pneumatic enema has advantages over a traditional liquid contrast enema. Air reduction is generally quicker, uses less radiation and is associated with less peritoneal contamination if perforation occurs [3, 4]. Successful reduction rates with all methods vary widely, with more recent reports quoting 61% to 91.5% [5–7]. However, several studies suggest reduction rates are consistently higher using the air technique [8, 9].

The benefits of successful reduction, and thereby avoidance of an operation, must be weighed against the risk of developing bowel necrosis and subsequent perforation (necessitating bowel resection) from repeated vigorous attempts. Acknowledging this important trade-off has led

S. C. Fallon · E. S. Kim · B. J. Naik-Mathuria · J. G. Nuchtern · J. R. Rodriguez
Division of Pediatric Surgery, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, TX, USA

C. I. Cassady
Department of Pediatric Radiology, Texas Children's Hospital, Houston, TX, USA

J. R. Rodriguez (✉)
Texas Children's Hospital, 6701 Fannin St., Suite 1210, Houston, TX 77030, USA
e-mail: rxrodri2@texaschildrens.org

to the adoption in our institution of a strategy of performing multiple reduction attempts, under appropriate circumstances, with the underlying assumption that unsuccessful reduction results in surgery.

Complications of pneumatic enema include failure of reduction, perforation, and tension pneumoperitoneum in rare cases [5]. While tension pneumoperitoneum is a known complication of attempted pneumatic reduction for intussusception, reports in the literature remain anecdotal. Although infrequent, this condition can be life-threatening. Emphasis should be placed on the importance of radiologist awareness and immediate reaction if this complication occurs during a reduction procedure.

We report four recent cases of perforation requiring immediate needle decompression to prevent a large pneumoperitoneum from causing hemodynamic compromise, discuss management strategies with this complication, and review the literature regarding the potential complications of pneumatic enema.

## Materials and methods

After IRB approval, we reviewed the hospital records of infants and children diagnosed in 2011 with intussusception. ICD-9 diagnosis codes were used for their identification. Demographic and therapeutic clinical data were collected and summarized.

At our institution, the management of pediatric intussusception is standardized as follows: after the diagnosis has been made, generally in the emergency room, Pediatric Surgery is consulted and the child is examined. If no peritonitis is present, prophylactic single-agent broad-spectrum antibiotics are administered and the child proceeds to radiology for attempted reduction. Children are attached to electronic cardiorespiratory monitors but are not sedated at the time of the procedure. All procedures are performed either by or under the supervision of experienced attending radiologists. The typical starting pressure is 60 mmHg, which is gradually increased to a maximum sustained resting pneumatic pressure during reduction near 110 mmHg, though the pressure transiently is higher with increases in intra-abdominal pressure, such as with crying or Valsalva maneuvers. The enema is considered successful if the intussuscepted mass disappears on imaging and air freely refluxes into the small intestine. If movement of the intussusceptum is seen but the mass persists without free reflux of air into the small bowel, the procedure is terminated and the child is returned to the emergency department. After a short period of observation in the emergency department, usually 2–4 h after the initial attempt, repeat reduction is attempted. Multiple repeated reductions are attempted in all cases if continued, progressive, retrograde movement of the intussusceptum is seen. Radiographs are not obtained between reduction attempts because we have never experienced a perforation while the child was awaiting a repeated enema attempt. Before each subsequent attempt at reduction, the child is re-examined for developing signs of peritonitis; if peritonitis is noted, the child is taken to the operating room for treatment. If the attempts are successful in reducing the mass completely, children are admitted to the Surgical Service for 23-h observation. Diet is gradually reintroduced and the child is discharged when symptoms have resolved. If attempts in reducing the mass are unsuccessful, the child is transferred to the operating room for definitive treatment.

Should the intestine perforate during the reduction attempt with subsequent abdominal distention and tension, manual insufflation is immediately discontinued and needle decompression is performed by the practitioner in the procedure room. The pneumoperitoneum can be identified on clinical examination with a suddenly enlarged abdomen, or under fluoroscopy with the Rigler sign (air around the liver, under the diaphragm, and often in the lateral gutters) (Fig. 1). After applying a quick ChloraPrep cleanse (CareFusion, San Diego, CA) to the abdomen, an 18-gauge needle with a catheter sheath is inserted immediately above or below the umbilicus in the midline, directed craniad and horizontal to the table to avoid intra-abdominal solid organ and bladder injury. The needle tip should be directed toward the volume of free air in the most ventral, nondependent portion of the distended abdomen. After the needle tip is in the peritoneal space, the needle is removed to avoid visceral injury, and the plastic cannula remains to remove the air. Once the abdomen has decompressed, any tension pneumoperitoneum has been converted to a simple pneumoperitoneum and the child is considered to be in a more clinically stable situation, allowing safe, yet expeditious, transport to the operating room for definitive therapy.

**Fig. 1** AP fluoroscopic image demonstrates tense pneumoperitoneum after perforation during a pneumatic enema

## Results

During 2011, 101 children with intussusception were treated at our institution. In these 101 children, 118 distinct pneumatic reduction attempts were made, with 19 children (19%) requiring surgical intervention. In four children (4%), perforation occurred during the course of a pneumatic enema attempt and pneumoperitoneum developed immediately; the remainder of this report focuses on these children. All four perforations were immediately identified by fluoroscopy and were treated with needle decompression using an 18-gauge needle prior to the development of hemodynamic instability. Satisfactory evacuation of the air was confirmed by fluoroscopy or by radiography. Each child was transferred immediately to the operating room for laparotomy without complication.

Demographic and clinical data for the perforation group are presented in Table 1. The mean age at time of presentation was 4.6 months, with two children only 2 months old. All of the children had emesis and bloody stools as presenting symptoms, and one had fever. The number of hours of symptoms prior to presentation ranged 24 h to 72 h. On examination, two children were identified as having a palpable mass, and only two had mild tenderness and abdominal distention. Two children had leukocytosis on preprocedural laboratory evaluation. None had evidence of peritonitis or systemic symptoms, such as lethargy, which would preclude initial attempts at non-operative management. None of the children had evidence of perforation on any preprocedural imaging, including the fluoroscopic scout view obtained immediately prior to the procedure.

One child had undergone an unsuccessful attempt at hydrostatic reduction with contrast material at another institution and was subsequently transferred to our care. In two children, perforation occurred during the second reduction attempt, and the second attempts were had been performed using air enema; in the other two children, perforation occurred during their initial pneumatic procedure. In the child who had undergone both reduction attempts at our institution, the time between the initial attempt and the subseqent one resulting in perforation was 4 h. All pneumatic enemas were performed following the standard protocol outlined above.

During laparotomy, all children required bowel resection, and an obvious perforation with extensive surrounding deserosalization was noted intraoperatively in all children. The perforations were all seen in the intussuscepted segment. There was no bowel injury secondary to the needle decompression. None of the patients had an identifiable pathological lead point, and pathology of the resected segments demonstrated lymphoid hyperplasia and intestinal necrosis, likely related to the initial intussusception. All children had primary anastomosis; no diverting colostomy or ileostomy was required. One child had a complicated postoperative course including reoperation for further excision of multiple ischemic perforations in the intestinal segment proximal to the intussusceptum. The three other children had a benign postoperative course, and the median postoperative length of stay for the whole group was 8 days (range: 6–17 days).

## Discussion

Radiologic reduction of intussusception has transformed disease treatment, with pneumatic enema emerging as a refinement to the technique of contrast reduction. The overall complication rates related to the radiologic treatment of intussusception are generally low [5]. Tension pneumoperitoneum has been anecdotally described as a serious complication of both endoscopic and radiologic procedures, including pneumatic reduction of intussusception [10, 11]. In addition to two remotely reported deaths, in larger series of patients spanning multiple years of observation, at most one incident of tension pneumoperitoneum at most has been reported [3, 4, 12, 13].

If perforation occurs during the procedure, intra-abdominal pressure instantly increases from the equilibration of air into the peritoneal cavity, with consequent potential compression of the inferior vena cava, splinting of diaphragmatic excursion and eventually hemodynamic compromise. Exactly when hemodynamic instability occurs and how long it takes for it to develop are not entirely clear. Treatment of tension pneumoperitoneum is rapid needle decompression of the abdomen, typically in the supra- or infraumbilical region (Fig. 2). In our series, decompression was performed to preempt impending cardiovascular compromise because none of our patients had signs of hemodynamic instability. After perforation, prompt surgical exploration is necessary to limit the degree of peritoneal contamination by intestinal contents. If immediate surgery is achieved, definitive resection and primary anastomosis can be performed safely. If gross peritoneal contamination is encountered during laparotomy, intestinal diversion (enterostomy) is recommended.

When pneumatic, as opposed to hydrostatic, reduction is used, peritoneal soiling is significantly reduced and postoperative complications are thought to be fewer [3]. In one series comparing perforations from liquid (positive) vs. air (negative) contrast enemas, the patients who had undergone positive contrast enema had higher rates of bowel resection at operation and longer hospital stays [3]. Perforation rates are generally reported to be less than 2% in multiple series of both hydrostatic and pneumatic enemas [5]. Yoon et al. [14] reported a 4% perforation rate with pneumatic reduction; however, this observed increase was attributed to the

**Table 1** Clinical and demographic data of the children with perforation occurring during the course of a pneumatic enema attempt

| | Patient 1 | Patient 2 | Patient 3 | Patient 4 |
|---|---|---|---|---|
| Age (months) | 8.9 | 2.2 | 2.2 | 5.1 |
| Presenting symptoms | Emesis, bloody stool | Emesis, bloody stool | Emesis, bloody stool | Emesis, bloody stool, fever |
| Duration of symptoms (days) | 1 | 1 | 3 | 3 |
| Physical examination | Left upper quadrant mass | Diffuse tenderness | Right upper quadrant mass, distention | Distention |
| Abnormal laboratory findings | Urinalysis 3+ketones | None | White blood cell count $17.6 \times 10^9$/l | White blood cell count $10.3 \times 10^9$/l, 34% bands |
| US findings | + Doppler flow, + small free fluid | Intussusception, no other findings | + Dilated loops small bowel, + interloop fluid | + Doppler flow, + fluid in intussuscepiens |
| Total fluoroscopy time at our institution (min) | 10 | 2 | 8 | 4 |
| Number of reduction attempts | 2 | 2 | 1 | 1 |
| Operation | Resection of hepatic flexure, appendectomy | Ileocecectomy with ileocolic anastomosis, resection of proximal sigmoid colon perforation with primary colocolostomy | Right hemicolectomy, primary ileocolostomy | Ileocecectomy with ileocolic anastomosis |
| Operative findings | Ileocolic intussusception to hepatic flexure, with significant deserosalization and small perforation | Ileocolic intussusception to descending colon, with necrosis, large proximal sigmoid perforation | Ileocolic intussusception to hepatic flexure with deserosalization and perforation | Ileocolic intussusception to transverse colon with serosal tears and ascending colon perforation |
| Complications | Reoperation for perforated, necrotic bowel with extended right hemicolectomy; central line infection with gram-positive cocci | None | None | None |
| Length of stay (days) | 17 | 6 | 9 | 7 |

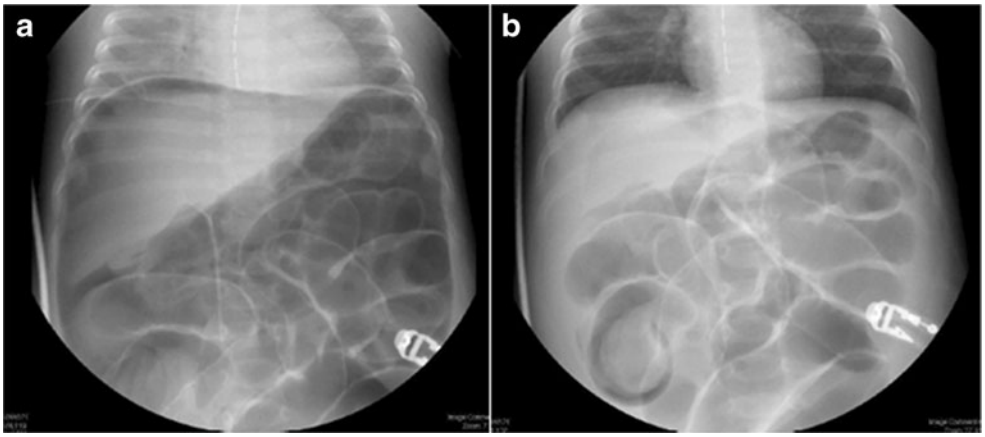


**Fig. 2** AP fluoroscopic image demonstrates extensive intraperitoneal air before (**a**) and immediately after (**b**) needle decompression

learning curve associated with introduction of the technique to their practice. One of our patients had a complicated postoperative course after initial laparotomy related to delayed perforation in an ischemic segment of bowel but otherwise each child had a relatively benign postoperative course in spite of perforation in the radiologic suite. We continue to recommend observation even after successful reductions, as we have learned from our experience with laparotomies in these children that significant but reversible ischemic changes can be seen even when resection is not required.

Multiple factors have been suggested to predict the need for operative treatment, including a prolonged duration of symptoms, the presence of a lead point or air–fluid levels, an intussusception distal to the splenic flexure, and lower case volumes [15–18]. Prior attempts at reduction have not been proved to decrease the success rate of enema reduction, and current recommendations are to conduct repeated, delayed enema attempts if progressive retrograde movement of the intussusceptum is observed during each attempt [15, 19]. However, today the questions of how many attempts and how frequently they should occur are still answered generally by experience and judgment.

In our series, none of the children had a constellation of factors that would have predisposed them to difficulty with reduction. All of the children had progressive movement of the intussuscepted segment prior to perforation, and with fluoroscopy times under 5 min, the perforations occurred relatively quickly during the course of the reduction attempts. However, young age has been reported in the literature to be associated with higher rates of perforation, and it is noteworthy that two of our patients were very young infants [3, 20]. Including our series, in the 38 reported perforations with patient age included, 32 (84%) patients were 7 months or younger [3, 19–22]. It is possible that younger children are more susceptible to these types of complications because of a thinner bowel wall. Modifications to treatment protocols to take into account age-based recommendations, including the upper limits of sustained pressure used during pneumatic enema attempts, might be indicated.

## Conclusion

This case series illustrates a number of important points regarding the management of intussusception and highlights the evolution of its treatment at specialized centers. Practitioners performing pneumatic enemas at centers where immediate pediatric surgical consultation is not available should use caution with vigorous and repeated attempts, as perforation requires immediate surgical intervention. The supplies for needle decompression should be readily available so that if a sudden expanding pneumoperitoneum occurs during reduction, rapid evacuation of air via needle decompression can be performed to avoid the development of hemodynamic instability. Expedient, multidisciplinary collaboration is an important component of disease management to maximize patient safety and optimize outcomes.

**Conflicts of interest** We have no conflicts of interest to declare.

## References

1. Parashar UD, Holman RC, Cummings KC et al (2000) Trends in intussusception-associated hospitalizations and deaths among US infants. Pediatrics 106:1413–1421
2. Pracros JP, Tran-Minh VA, Morin de Finfe CH et al (1987) Acute intestinal intussusception in children. Contribution of ultrasonography (145 cases). Ann Radiol 30:525–530
3. Daneman A, Alton DJ, Ein S et al (1995) Perforation during attempted intussusception reduction in children – a comparison of perforation with barium and air. Pediatr Radiol 25:81–88
4. Gu L, Alton DJ, Daneman A et al (1988) John Caffey Award. Intussusception reduction in children by rectal insufflation of air. AJR Am J Roentgenol 150:1345–1348
5. Daneman A, Navarro O (2004) Intussusception. Part 2: an update on the evolution of management. Pediatr Radiol 34:97–108, quiz 187
6. Samad L, Marven S, El Bashir H et al (2012) Prospective surveillance study of the management of intussusception in UK and Irish infants. Br J Surg 99:411–415

7. Tareen F, Ryan S, Avanzini S et al (2011) Does the length of the history influence the outcome of pneumatic reduction of intussusception in children? Pediatr Surg Int 27:587–589
8. Kaiser AD, Applegate KE, Ladd AP (2007) Current success in the treatment of intussusception in children. Surgery 142:469–475, discussion 475–477
9. Hadidi AT, El Shal N (1999) Childhood intussusception: a comparative study of nonsurgical management. J Pediatr Surg 34:304–307
10. Chiapponi C, Stocker U, Korner M et al (2011) Emergency percutaneous needle decompression for tension pneumoperitoneum. BMC Gastroenterol 11:48
11. Kealey WD, McCallion WA, Boston VE (1996) Tension pneumoperitoneum: a potentially life-threatening complication of percutaneous endoscopic gastrojejunostomy. J Pediatr Gastroenterol Nutr 22:334–335
12. Ng E, Kim HB, Lillehei CW et al (2002) Life threatening tension pneumoperitoneum from intestinal perforation during air reduction of intussusception. Paediatr Anaesth 12:798–800
13. Stein M, Alton DJ, Daneman A (1992) Pneumatic reduction of intussusception: 5-year experience. Radiology 183:681–684
14. Yoon CH, Kim HJ, Goo HW (2001) Intussusception in children: US-guided pneumatic reduction – initial experience. Radiology 218:85–88
15. Curtis JL, Gutierrez IM, Kirk SR et al (2010) Failure of enema reduction for ileocolic intussusception at a referring hospital does not preclude repeat attempts at a children's hospital. J Pediatr Surg 45:1178–1181
16. Jen HC, Shew SB (2009) The impact of hospital type and experience on the operative utilization in pediatric intussusception: a nationwide study. J Pediatr Surg 44:241–246
17. Ramachandran P, Gupta A, Vincent P et al (2008) Air enema for intussusception: is predicting the outcome important? Pediatr Surg Int 24:311–313
18. Saxena AK, Hollwarth ME (2007) Factors influencing management and comparison of outcomes in paediatric intussusceptions. Acta Paediatr 96:1199–1202
19. Navarro OM, Daneman A, Chae A (2004) Intussusception: the use of delayed, repeated reduction attempts and the management of intussusceptions due to pathologic lead points in pediatric patients. AJR Am J Roentgenol 182:1169–1176
20. Maoate K, Beasley SW (1998) Perforation during gas reduction of intussusception. Pediatr Surg Int 14:168–170
21. Bramson RT, Blickman JG (1992) Perforation during hydrostatic reduction of intussusception: proposed mechanism and review of the literature. J Pediatr Surg 27:589–591
22. Okazaki T, Ogasawara Y, Nakazawa N et al (2006) Reduction of intussusception in infants by a pediatric surgical team: improvement in safety and outcome. Pediatr Surg Int 22:897–900