Asian Biomedicine Vol. 5 No. 2 April 2011; 235 - 241
DOI: 10.5372/1905-7415.0502.030

Original article

Pneumatic reduction of intussusception: factors affecting outcome in Thailand

Supika Kritsaneepaiboon[a], Surasak Sangkhathat[b], Samornmas Kanngurn[c]
[a]Department of Radiology; [b]Pediatric Surgery Unit, Department of Surgery; [c]Department of Pathology, Faculty of Medicine, Prince of Songkla University, Hat Yai 90110, Thailand

Background: Pneumatic reduction has become a therapeutic method for intussusception instead of surgery. It is more successful than barium reduction, but it depends on how much the operator is familiar with the method and equipment.
Objective: Determine success rate and recurrent rate of intussusception and factors affecting outcome of pneumatic reduction in Thailand.
Materials and methods: Fifty-eight children with 73 numbers of intussusception who underwent pneumatic reduction at Songklanagarind Hospital, Thailand between January 2002 and March 2007 were retrospectively reviewed. Age, sex, clinical parameters, physical examination, imaging findings, and reduction technique were evaluated.
Results: Overall success rate was 54 out of the 73 episodes and recurrent rate was 10 out of 58 patients with intussusception. Long duration of symptom, rectal bleeding, dehydration, and leukocytosis significantly affected poor outcome. Radiographic findings of gut obstruction and ascites as well as sonographic findings of thickened colonic wall, trapped fluid between intussusceptum and intussuscipien, and small bowel obstruction could also predict the poor outcome.
Conclusion: Many factors from clinical presentation, plain radiographic, and sonographic findings affect poor outcome of pneumatic reduction. However, it can be performed unless peritonitis and sepsis/shock are present.

Keywords: Intussusception, pneumatic reduction

Intussusception is a major cause of small bowel obstruction in children and is an emergency condition that occurs in children aged less than one year. If diagnosis is delayed, it may result in bowel ischemia and perforation [1]. Classic symptoms of clinical presentation are abdominal pain, vomiting, and red currant jelly stool. It is important to differentiate this condition from other self-limited abdominal pain such as viral gastroenteritis [2, 3]. According to Smith et al. [4] and Daneman et al. [5], sensitivity and specificity of abdominal plain film interpreted by pediatrician in emergency department to diagnose intussusception is 80.5% and 58.0%, respectively.

Ultrasound imaging is a choice to diagnose intussusceptions. Its accuracy and negative predictive value is 100% [5, 6]. In addition, it can identify 66% of pathologic leading point and other causes of abdominal pain [5].

Recently, contrast enema reduction under fluoroscopic or sonographic guidance has become a therapeutic method for intussusception instead of surgery. Several studies reported that pneumatic reduction had a better success rate than barium reduction [1, 7, 8]. However, it depends on how much the operator is familiar with the method and equipment. In this study, we determined success rate, recurrent rate of intussusceptions, and factors affecting outcome of pneumatic reduction at Songklanagarind Hospital, Thailand where pneumatic reduction has been used with fluoroscopic guidance since 1994.

Correspondence to: Supika Kritsaneepaiboon, MD, Department of Radiology, Faculty of Medicine, Prince of Songkla University, Hat Yai 90110, Thailand. E-mail: supikak@yahoo.com

Materials and methods

This study retrospectively reviewed all pediatric patients who were diagnosed intussusception and

underwent pneumatic reduction at Songklanagarind Hospital, Thailand between January 2002 and March 2007. The study has been approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University. Age, sex, clinical history (duration of symptom, previous viral infection, abdominal pain, vomiting, rectal bleeding, and failed pneumatic reduction from another hospital), physical examination (body temperature, degree of dehydration, and palpated mass), and white blood cell count were recorded.

Imaging evaluation

All available images for abdominal plain films and ultrasound were reviewed. All images between 2005 and 2007 were assessed by using a Picture Archiving and Communication System (PACS) (Fujifilm Medical Systems, Tokyo, Japan). Presence or absence of gut obstruction, pneumoperitoneum and ascites were evaluated in plain radiographs. For sonographic findings, we recorded colonic wall thickness, presence or absence of free fluid, trapped fluid, color flow, small bowel obstruction, and mesenteric node enlargement.

Pneumatic reduction technique

Pneumatic reduction was performed using inflated air via a sphygmo-manometer under strapping tape at buttocks and fluoroscopic guidance. Applied pressure was less than 120 mmHg. Failed procedure was defined when intussusception was not reduced into terminal ileum or sudden pneumoperitoneum occurred. Location of intussusception before reduction, applied maximum pressure and attempts of procedure were recorded. In the unsuccessful group, operative and histopathologic findings were obtained.

Statistical analysis

Normally distributed continuous data were compared by the Welch two sample *t*-test and expressed as mean standard deviation (SD). Wilcoxon rank sum test with continuity correction was used for abnormally distributed continuous data and summarized by median, minimum, and maximum values. Discrete data were compared using Pearson's Chi-squared test with Yates' continuity. Statistical analysis was performed using the R statistical software (R version 2.5.0). Two-sided values of $p < 0.05$ were considered statistically significant.

Results

The study consisted of 58 children (42 males and 16 females) with 73 intussusception episodes who underwent pneumatic reduction, ranging in age from four months to 10 years. **Table 1** shows 73 episodes of pneumatic reduction (54 successful and 19 unsuccessful). We note no statistical difference in age and gender between the two groups.

Table 2 shows clinical histories of pneumatic reduction (54 successful and 19 unsuccessful). Interestingly, only 20 of 73 cases (27.4%) presented classic clinical triad (abdominal pain, rectal bleeding and palpable mass). The results of physical examination can be seen in **Table 3**.

Radiographic and sonographic findings

Figure 1 shows an example of radiographic and ultrasonic imaging of one boy who presented vomiting and diarrhea with rectal bleeding for three days.

Table 4 shows 72 cases of pneumatic reduction (53 successful and 19 unsuccessful) for radiographic findings.

Table 1. Patient characteristics**.**

Characteristics (Number/Percentage)	**Successful group (n = 54)**	**Unsuccessful group (n = 19)**	**P-value**
Age group			
Birth <6 months	9 (47.4)	14 (25.9)	0.31
6 - <12 months	8 (42.1)	26 (48.1)	
12 - <18 months	0	5 (9.3)	
18 - <24 months	1 (5.3)	7 (13.0)	
24 - 120 months	1 (5.3)	2 (3.7)	
Sex	(n = 39)	(n = 19)	
Male	29 (74.4)	13 (68.4)	0.64
Female	10 (25.6)	6 (31.6)	

Table 2. Clinical history.

Clinical history (Number/Percentage)	Successful group (n = 54)	Unsuccessful group (n = 19)	P-value
Recurrence	19 (35.2)	0	0.007□
Failed reduction from another hospital	5 (9.3)	4 (21.1)	0.348
Duration of symptom			0.004□
<1 day	19 (35.2)	5 (26.3)	
1-2 days	25 (46.3)	3 (15.8)	
2-3 days	8 (14.8)	6 (31.6)	
>3 days	2 (3.7)	5 (26.3)	
Previous viral infection* ***(n = 64)***	7 (13.0) (n = 48)	4 (21.4) (n = 16)	0.556
Abdominal pain	29 (53.7)	8 (4.1)	0.547
Vomiting	46 (85.2)	19 (100)	0.177
Rectal bleeding	28 (51.9)	16 (84.2)	0.023□

*Available history in the medical record. □significantly different between the two groups (p <0.05).

Table 3. Results of physical examination.

Physical examination (Number/percentage)	Successful group (n = 54)	Unsuccessful group (n = 19)	P-value
Body temperature (degree celsius)	37.5 ± 0.8	37.3 ± 0.7	<0.000□
Degree of dehydration			0.011□
None	27 (50.0)	3 (15.8)	
Mild	23 (42.6)	10 (52.6)	
Moderate	4 (7.4)	5 (26.3)	
Severe	0	1 (5)	
Palpable mass	32 (59.3)	15 (78.9)	0.207
White blood cell count	12,300 (2,900-23,100)	12,500 (6,600-28,100)	<0.000□

□significantly different between the two groups (p <0.05).

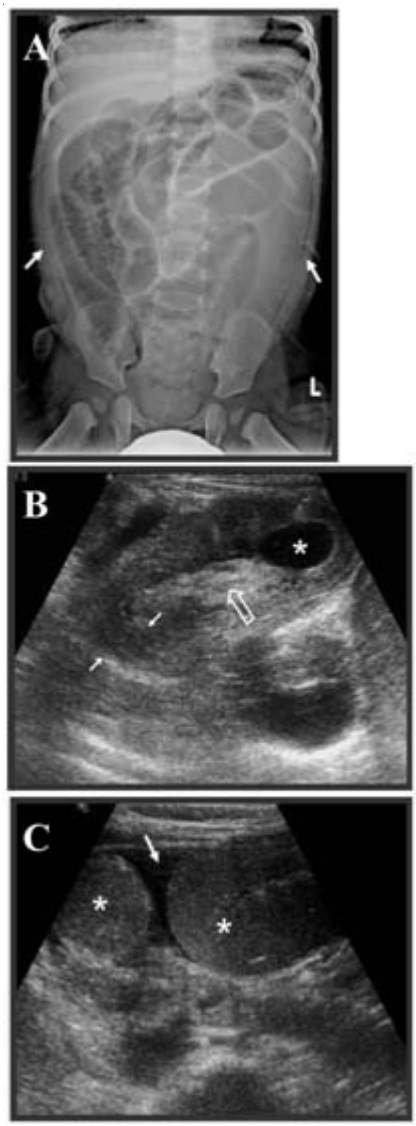

Figure 1. Radiographic and ultrasonic images in nine-month-old boy with vomiting and diarrhea with rectal bleeding. Pneumatic reduction failed after three attempts. Operative finding found irreducible ileo-colic type of intussusception with gangrenous ileal segment. No pathologic leading point was observed. **A:** Plain abdominal radiography showed multiple dilated small bowel loops and possible ascites (arrows). **B:** Ultrasonund showed intussusception up to descending colon with trapped fluid between intussusceptum and intussuscipien (*). Open arrow indicates internal hyperechogenicity that is invaginated mesenteric fat of intussusceptum, and thin arrow indicates colonic wall of intussuscipien with mild thickening. **C:** Evidence of small bowel obstruction (*) and small ascites (arrow).

Table 4. Radiographic findings.

Radiographic findings (Number/Percentage)	Successful group (n = 53*)	Unsuccessful group (n = 19)	P-value
Gut obstruction	19	15	0.003□
Ascites	10	12	0.001□

*Unavailable plain radiograph in one patient in the successful group. □significantly different between the two groups ($p < 0.05$).

Sonographic findings were not recorded for all patients. **Table 5** shows findings of colonic wall thickness (>10 mm), trapped fluid between intussusceptum and intussuscipien, evidence of small bowel obstruction, and other findings (ascites, absent color flow and presence of mesenteric nodal enlargement).

Details in pneumatic reduction

We classified location of intussusceptum before pneumatic reduction was performed into four locations (ascending to hepatic flexure, transverse colon, splenic to descending colon and sigmoid colon to rectum). **Table 6** shows location of intussusceptum, applied maximum pressure, and number of attempts in 73 cases of pneumatic reduction (54 successful and 19 unsuccessful).

Discussion

Pneumatic reduction has become widely acceptable [7, 9, 10]. Our study results showed successful rate of pneumatic reduction about 74% similar in range 51%-95% from the past review [7] and higher than Songklanagarind Hospital in the past (33% to 50%) [11]. Long duration of symptom, more than 24 hours, was the most consensus clinical predictor found in previous reports [12-15]. Younger age or less than three months age had been reported to decrease successful rate or increase risk for perforation [12, 16]. In our study, clinical predictors influencing reducibility were long duration of symptom, recurrent episode, rectal bleeding, body temperatures, dehydration, and leukocytosis. We found 19 recurrent intussusceptions in 10 children, all of whom were in the successful group. The present recurrent rate was

Table 5. Sonographic findings.

Sonographic findings	Successful group (A/B)*	Unsuccessful group (A/B)*	P-value
Colonic wall thickness	4/41	9/14	0.000□
Ascites	19/43	11/14	0.054
Trapped fluid	6/33	8/12	0.002□
Absence color flow	0	2/14	0.107
Small bowel obstruction	10/42	10/14	0.004□
Presence of lymph node enlargement	25/41	8/13	0.772

*Available history in the medical record. A = numbers of positive finding, B = numbers of performed sonography and available sonographic images for review.□ significantly different between the two groups ($p < 0.05$).

Table 6. Details in pneumatic reduction.

Details in pneumatic reduction (Number/Percentage)	Successful group (n = 54)	Unsuccessful group (n = 19)	P-value
Location of intussusceptum			
Ascending-hepatic colon	31 (57.4)	6 (31.6)	0.001□
Transverse colon	16 (29.6)	2 (10.5)	
Splenic-descending colon	6 (11.1)	7 (36.8)	
Sigmoid colon-rectum	1 (1.9)	4 (21.1)	
Applied maximum pressure (mmHg)* (n = 62)	87.8 ± 18.5 (n = 44)	118.3 ± 5.2 (n = 18)	<0.000□
Attempts			
One time	41 (75.9)	0	<0.000□
Two times	7 (13.0)	0	
Three times	6 (1.1)	16 (84.2)	
Four times	0	3 (15.8)	

*Available history in the medical record.□ significantly different between the two groups ($p < 0.05$).

17.2%, which was similar to previous studies (5.4% to 15.4% under fluoroscopic guidance) [5]. Out of these 10 patients, nine of them had one to three recurrences, while one patient had nine recurrences. Interval between each recurrence ranged from three to 185 days. It was believed that multiple and recurrent intussusceptions were loose and easy to reduce and surgery only indicated when the enema reduction failed [17, 18]. Rectal bleeding was found as one of irreducible predictors. The bleeding results from bowel ischemia and the reduction should be carefully performed due to risk of bowel perforation [12, 14]. Although body temperatures or dehydration reported no effect for the outcome, sick patients increased risk for perforation [19]. In our study, the unsuccessful group had significantly less temperature than the successful group. It might be due to less body's inflammatory response in sicker patients.

Abdominal plain radiograph still has a role to diagnose intussusception in case of clinically suspicious peritonitis, which pneumoperitoneum should be sought before reduction [1, 5]. We found evidence of significantly more ascites and small bowel obstruction by plain radiographs in the unsuccessful group compared with the successful one. Previous studies reported small bowel obstruction as a significant failure predictor [13, 14]. Not only failure indicator, but also complete small bowel obstruction was at increased risk for perforation. Tightness between intussusceptum and intussuscipien may impair blood circulation, inducing pressure ischemia and necrosis [19]. It was difficult for us to detect air moving during the procedure since small bowel loops already filled with air and fluid. However, pneumatic reduction is still possible in small bowel obstruction unless there is clinical peritonitis.

Since ultrasound has 100% accuracy to diagnose intussusceptions, it is still reliable even when scanned by junior residents [5, 20]. In addition, ultrasound features, such as colonic wall thickness of intussuscipiens, presence and amount of free fluid, trapped fluid, small bowel obstruction, and blood flow in bowel wall of intussusceptiens can predict reducibility. Lee et al. [21] reported 13 cases with colonic wall thicker than 1.6 cm underwent surgical reduction. According to Mirilas et al. [22], 100% successful hydrostatic reduction is achieved when colonic wall <7.2 mm. additionally, surgery was required when colonic wall > 14 mm or presence of trapped fluid. However, both colonic wall thickness and ascites were not contraindicated for enema reduction either significant predictor by several studies [23-25]. In addition, high reduction rate (93%) was observed when there was an absence of free fluid, trapped fluid, and small bowel obstruction [25]. Our study with limited numbers of sonographic imaging review still revealed that colonic wall thickness (equal or thicker than 10 mm), trapped fluid, and small bowel obstruction were significant predictors of outcomes.

In our procedure, the more proximally located intussusceptum, the easier and more successful the reduction. In about 76% of successful reduction, the procedure was performed in only one attempt. In three out of 19 patients of the unsuccessful group, the reduction was delayed and repeated in the fourth attempt but eventually failed. One of them had colonic perforation during the procedure. Time for repeat reduction ranged from two to six hours. Sandler et al. [26] suggested that delayed repeat air reduction should preserve in case of intussusceptum with significant movement in each attempt and ideal timing for repeat reduction was two to four hours.

In the unsuccessful group, three cases had pneumoperitoneum during procedure or perforation rate, or about 4%, which was higher than previous reports ranging from 1% to 2.8% [10, 12]. It might be due to referral to our tertiary care hospital where patient's history and clinical conditions were more complicated. Two of them underwent bowel resection and the histological result showed transmural and mucosal necrosis. Daneman et al. [27] found the perforation occurred in patients under six month age with a long duration of symptoms (>36 hours) [27]. In our study with limited number of perforated cases, all of them had duration of symptom more than 72 hours.

Conclusion

Pneumatic reduction was a choice of treatment for intussusception unless absolute contraindications (peritonitis and shock or sepsis) were present. Other clinical presentations (long duration of symptoms, rectal bleeding, dehydration, and leukocytosis), radiographic findings (gut obstruction or ascites) and sonographic features (thickened colonic wall, trapped fluid, and small bowel obstruction) were not the exclusion criteria for reduction. However, these factors were poor outcome predictors and the surgical team should be ready for prompt operative reduction.

Acknowledgement

The authors would like to thank Mr. Sumrit Reungjan (technician, Department of Radiology of Prince of Songkla University) who created pneumatic reduction set and made the procedure more convenient. The authors have no conflict of interest to report.

References

1. Applegate KE. Clinical suspected intussusception in children: evidence-based review and self-assessment module. Am J Radiology. 2005; 185:s175-83.
2. Wall Jarrod. Acute abdominal pain in children: is it intussusception? Trinity Student Med J. 2001; 2:22-4.
3. Mccollough M, Sharieff GQ. Abdominal pain in children. Pediat Clini North Am. 2006; 53:107-37
4. Smith DS, Bonadio WA, Losek JD, Walsh-Kelly CM, Hennes HM, et al. The role of abdominal x-rays in the diagnosis and management of intussusception. Pediatr Emerg Care. 1992; 8:325-7.
5. Daneman A, Navarro O. Intussusception. Part1: a review of diagnostic approaches. Pediatr Radiol. 2003; 33:79-85.
6. Grosfeld JL. Intussusception then and now: a historical vignette. J Am Coll Surg. 2005; 201:830-3.
7. Daneman A, Navarro O. Intussusception. Part 2: an update on the evolution of management. Pediatr Radiol. 2004; 34:97-108.
8. Meyer JS, Dangman BC, Buonomo C, Berlin JA. Air and liquid contrast agents in the management of intussusception: A controlled, randomized trial. Radiology.1993; 188:507-11.
9. Kirks DR. Air intussusception reduction: "the winds of change". Pediatr Radiol. 1995; 25:89-91.
10. Stringer DA, Ein SH. Pneumatic reduction: advantages, risks and indications. Pediatr Radiol. 1990; 20:475-7.
11. Sangkhathat S, Patrapinyokul S, Tatayatikom K. Pediatric intussusception: toward less surgery. Songkla Med J. 1998; 16:197-203.
12. Stein M, Alton DJ, Daneman A. Pneumatic reduction of intussusception: 5-year experience. Radiology. 1992; 183:681-4.
13. Gorenstein A, Raucher A, Serour F, Witzling M, Katz R. Intussusception in children: reduction with repeated, delayed air enema. Radiology. 1998; 206:721-4.
14. McDermott VG, Taylor T, Mackenzie S, Hendry GMA. Pneumatic reduction of intussusception: clinical experience and factors affecting outcome. Clin Radiol. 1994; 49:30-4.
15. Fragoso AC, Campos M, Tavares C, Costa-Pereira A, Estev□o-Costa J. Pneumatic reduction of childhood intussusception. Is prediction of failure important? J Pediatr Surg. 2007; 42:1504-8.
16. Jennings C, Kelleher J. Intussusception: influence of age on reducibility. Pediatr Radiol 1984; 14:292-4.
17. Ein SH. Recurrent intussusception in children. J Pediatr Surg. 1975; 10:751-5.
18. Daneman A, Alton DJ, Lobo E, Gravett J, Kim P, Ein SH. Patterns of recurrence of intussusception in children: a 17-year review. Pediatr Radiol. 1998; 28: 913-9.
19. Humphry A, Ein SH, Mok PM. Perforation of the intussuscepted colon. Am J Radiology. 1981; 137: 1135-38.
20. Eshed I, Gorenstein A, Serour F, Witzling M. Intussusception in children: can we rely on screening sonography performed by junior residents? Pediatr Radiol. 2004; 34:134-7.
21. Lee HC, Yeh HJ, Leu YJ. Intussusception: the sonographic diagnosis and its clinical value. J Pediatr Gastroenterol Nutr. 1989; 8:343-7.
22. Mirilas P, Koumanidou C, Vakaki M, Skandalakis P, Antypas S, Kakavakis K. Sonographic features indicative of hydrostatic reducibility of intestinal intussusception in infancy and early childhood. Eur Radiol. 2001; 11:2576-80.
23. Verschelden P, Filiatrault D, Garel L, Grignon A, Perreault G, Boisvert J, Dubois J. Intussusception in children: reliability of US in diagnosis-a prospective study. Radiology. 1992; 184:741-4.
24. Feinstein KA, Myers M, Fernbach SK, Bhisitkul DM. Peritoneal fluid in children with intussusception: its sonographic detection and relationship to successful reduction. Abdom Imaging. 1993; 18:277-9.
25. Britton I, Wilkinson AG. Ultrasound features of intussusception predicting outcome of air enema. Pediatr Radiol. 1999; 29:705-10.
26. Sandler AD, Ein SH, Connolly B, Daneman A, Filler RM. Unsuccessful air-enema reduction of intussusception: is a second attempt worthwhile? Pediatr Surg Int. 1999; 15:214-6.
27. Daneman A, Alton DJ, Ein S, Wesson D, Superina R, Thorner P. Perforation during attempted intussusception reduction in children - a comparison of perforation with barium and air. Pediatr Radiol 1995; 25:81-8.