Pediatr Radiol (2015) 45:667–674
DOI 10.1007/s00247-014-3214-7

ORIGINAL ARTICLE

Current methods for reducing intussusception: survey results

Rebecca Stein-Wexler · Rachel O'Connor · Heike Daldrup-Link · Sandra L. Wootton-Gorges

Received: 16 July 2014 / Revised: 18 September 2014 / Accepted: 17 October 2014 / Published online: 29 November 2014

Abstract
Background Intussusception is a common pediatric abdominal emergency, treated with image-guided reduction. Available techniques include fluoroscopic and ultrasonographic monitoring of liquid and air.
Objective The purpose of this study was to determine current practices and establish trends by comparing our findings with reports of previous surveys.
Materials and methods This study is based on an e-mail survey sent to all 1,538 members of the Society for Pediatric Radiology. It included questions about demographics, presence of parents/surgeon during procedure, patient selection/preparation, use of sedation, preferred methods of reduction and technical details, approach to unsuccessful reduction, and self-reported incidence of success/perforation.
Results The 456 respondents (30%) reported attempting 3,834 reductions in the preceding 12 months. Of these, 96% use fluoroscopy and 4% use US guidance for reduction; 78% use air, 20% prefer fluid; 75% require intravenous access; 63% expect a surgeon to be present in hospital; 93% do not sedate. Although inflating a rectal balloon is controversial, 39% do so, and 50% employ a pressure-release valve. Seventy-two percent attempt reductions three times in the same position. In case of unsuccessful reductions, 64% wait and re-attempt later, 19% apply manual pressure, and 15% try again in left decubitus position. About 20% reattempt reduction after waiting 2 h or more.
Conclusion By providing a better understanding of both trends in and diversity of current practice, we hope to increase the confidence with which the individual practitioner will approach each case.

Keywords Intussusception · Intussusception reduction · Practice patterns · Survey · Pediatric

R. Stein-Wexler (✉) · S. L. Wootton-Gorges
Department of Radiology Pediatric radiology section,
University of California, Davis Medical Center,
4860 Y St., Suite 3100,
Sacramento, CA 95817, USA
e-mail: Rebecca.steinwexler@ucdmc.ucdavis.edu

S. L. Wootton-Gorges
e-mail: sandra.gorges@ucdmc.ucdavis.edu

R. O'Connor
Department of Radiology, University of California,
Davis, Medical Center,
Sacramento, CA, USA
e-mail: racheloconnor14@gmail.com

H. Daldrup-Link
Department of Radiology Pediatric radiology section,
Lucile Packard Children's Hospital,
Stanford School of Medicine,
Stanford, CA, USA
e-mail: heike.daldrup@gmail.com

Introduction

Intussusception is a common pediatric abdominal emergency, often treated with image-guided reduction. Various reduction techniques have been utilized [1–5]. Optimal technique is important to maximize success. Air and liquid have been used in Europe since the 19th century [6]. Surgical reduction was popular in the early 20th century in the United States and Britain [5]. Since the 1920s, reductions have been monitored radiographically. Pneumatic reduction was introduced to North America in the late 20th century and has gradually assumed the lead [4,5]. However details of reduction practices continue to vary and evolve [2, 3, 7–13]. We sought to determine current practices of pediatric radiologists and to identify techniques that maximize success.

Materials and methods

Our institutional review board reviewed and approved this project. Under the auspices of the Society for Pediatric Radiology (SPR), we emailed the society's 1,538 members, inviting them to complete a survey about their approach to and success with intussusception reduction. The questionnaire was planned with an expert in survey construction and used SurveyMonkey software (SurveyMonkey, Palo Alto, CA). Members received two e-mail reminders with links to the survey, which we asked the SPR to send when the response rate dropped off (after approximately 3 weeks).

We collected demographics about the respondents, including level of practice, years of experience, location and environment (academic- or community-based). We asked questions about patient preparation, performance of intussusception reduction, and solutions to unsuccessful attempts. Attempts were defined as conduction of the

Background data

If you are in the United States in which state do you practice?

If you are not in the United States, in which country do you practice?

Are you currently:

- Attending pediatric radiologist
- Fellow in pediatric radiology
- Radiology resident
- Other

How many years have you practiced pediatric radiology (excluding fellowship)?

Where do you currently practice?

- Free standing childrens hospital
- Childrens hospital embedded in university hospital
- Community hospital
- Other

Patient preparation

Do you allow parents in the room during the procedure? (yes, no)

Do you require a surgeon to be present in the hospital while the procedure is being performed? (yes, no)

What do you consider to be contraindications to attempting intussusception reduction (other than peritonitis or signs of perforation)?

- Symptoms longer than two days
- Severe hematochezia
- Severe dehydration
- Free fluid demonstrated at ultrasound
- Decreased blood flow demonstrated by Doppler ultrasound
- Other

Do you require the patient to have IV access during the procedure? (yes, no)

Do you require continuous monitoring of vital signs? (yes, no)

Do you use any form of sedation during the procedure? (yes, no); if so, what medications do you use?

What position do you most commonly place the patient in for the procedure?

- Prone
- Supine
- No preference

The reduction procedure

Do you predominantly use fluoroscopy or ultrasound? (fluoroscopy, ultrasound)

Do you prefer to use air or liquid? (air, liquid)

When using liquid for the reduction, what type of liquid do you predominantly use?

- Cystograffin
- Gastrograffin
- Barium
- Never use liquid
- Other

Which type of catheter or enema tip would you use for a 12 month old child?

- 14 Fr Flexitip pediatric enema tip (green)
- 18 Fr Flexitip pediatric enema tip (green)

Fig. 1 Compilation of all questions asked in the survey sent to members of the society for pediatric radiology

24 Fr Flexitip pediatric enema tip (blue)
Junior flexitip enema tip (with angle) (blue)
Foley catheter (10-12F)
Foley catheter (14-16F)
Foley catheter (18-20F)
Foley catheter (22-24F)
Other

What technique(s) do you use to avoid air leak by creating a seal around the catheter?

Inflate foley balloon
Tape
Gauze plug at anal verge
Tape plug wrapped around catheter
Other

Do you modify the tubing that connects to the contrast bag or air device?

No modification
Shorten the tubing
Other

If using barium, at what maximum height do you hang the bag? (3, 4, 5, 6 ft, other)

H. If using water soluble contrast agents (eg, cystograffin or gastrograffin) at what maximum height do you hang the bag? (3, 4, 5, 6 ft, other)

If using air, what maximum pressure do you use? (80, 100, 120, 140, >140 mmHg, other)

J. If using air, do you use a pop-off valve? (yes, no)

In case of incomplete reduction (eg, ileum stuck at ileocecal valve)

How many attempts do you make with the intussusceptum unchanged in position? (1, 2, 3, 4, 5, 6, > 6)

If unsuccessful at reducing intussusception, what maneuvers do you employ?

Place patient left side down
Wait and reattempt procedure at a later time
Manual pressure on abdomen
None
Refer the patient for surgery
Other (please specify)

If you wait to reattempt procedure, how long do you wait? (0-15, 15-30, 30-60, 60-120, >120 minutes)

When you do reattempt a reduction, about how often does the delayed attempt succeed? (0-20, 21-40, 41-60, 61-80, 81-100%)

Reduction experience

About how many intussuception reductions have you attempted in the last 12 months of your practice? (enter a number)

Of these cases, how many did you succeed in reducing? (enter a number)

Of these cases, how many perforated? (enter a number)

How many of your cases of intussuception reduction have resulted in bowel perforation during the last ten years (after completing fellowship)? (enter a number)

How many of your cases have resulted in tension pneumoperitoneum (resulting from intussuception reduction) during the last ten years? (enter a number)

Do you have any additional comments?

Fig. 1 (continued)

procedure, regardless of outcome. A successful attempt was associated with resolution of the intussusception, while an unsuccessful attempt resulted in persistence of the intussusception. Further details about the questionnaire are listed in Fig. 1.

Of 1,538 surveyed SPR members, 457 responded and 456 completed the questionnaire (30%). Not all answered every question and some questions allowed multiple responses. Therefore, the sum of responses rarely equals the number of respondents. Responses were expressed as percentage of total responses.

Results

The 456 respondents reported 3,834 attempted reductions in the preceding 12 months.

Exclusion criteria (Table 1)

Forty-five percent considered factors besides free air and peritoneal signs as contraindications (we did not ask details about free air and peritoneal signs, assuming these contraindications are universal). Sixty-four percent would not reduce in the presence

Table 1 Exclusion criteria (indications for which respondents said they would not attempt intussusception reduction)

Exclusion criterion	% (*n*)
Severe dehydration	64% (133/207)
Severe hematochezia	20% (41/207)
Reduced Doppler flow in intussusception	19% (40/207)
Free fluid	16% (33/207)
Symptoms exceeding 2 days	13% (26/207)

of severe dehydration, 12% commenting they would after fluid resuscitation. Other contraindications included severe hematochezia (20%), reduced color Doppler blood flow (19%), free fluid (16%), or symptoms lasting more than 2 days (13%).

Preparation (Table 2)

Seventy-five percent of respondents required IV access. Thirty-five percent required continuous monitoring of vital signs, 63% required the presence of a surgeon in the hospital, and of these 4% required a surgical resident's presence at the procedure.

Sedation (Table 2)

Ninety-three percent of respondents used no intravenous sedation. For n=27 who used sedation, Midazolam was the most popular sedative (n=13), and morphine was the most popular opiate (n=14).

Catheter (Table 3)

Catheter choices were diverse: 45% used a Foley catheter and, of these, 1/3 (15% of total respondents) selected the largest size listed (22–24 F). Twenty-two percent preferred a 24-Fr blue infant Flexi-Tip catheter (E-Z-EM Inc., a subsidiary of Bracco Diagnostics Inc., Princeton, NJ).

Producing a seal (Table 3)

Of the respondents, 97% taped the buttocks together. In addition to taping, 48% used a tape-wrapped catheter, 38% inflated a rectal balloon, 18% applied manual compression to the buttocks, 12% used a gauze plug, and only 5% also used an occlusion disc. Among those who reported not taping the buttocks, 60% inflated a Foley balloon.

Table 2 Preparation and sedation criteria

Preparation and sedation	% (*n*)
Require IV access	75% (329/440)
Require continuous monitoring of vitals	35% (151/436)
Allow parents to stay in room	85% (377/443)
Require surgeon in hospital	63% (278/444)
Of those requiring a surgeon in hospital, require surgical resident at procedure	4% (10/278)
No intravenous sedation	93% (408/439)

Table 3 Catheter choice and mechanism of seal

	% (*n*)
Mechanism of seal	
Tape buttocks together and also	97% (404/417)
No additional measures	15% (60/404)
Inflate rectal balloon *	38% (152/404)
Gauze plug	12% (50/404)
Tape-wrap catheter	48% (195/404)
Squeeze buttocks	18% (74/404)
Occlusion disc	5% (22/404)
Catheter choice	
Foley catheter	45% (176/391)
Large Foley catheter (22–24 F) (subset of those choosing Foley)	15% (58/391)
24-Fr blue infant Flexi-tip catheter	22% (86/391)

*Many of those who did not tape the buttocks inflated a rectal balloon (60% [18/30]). Thus the total inflating a rectal balloon is 39% (170/435)

Other technical issues

Of the respondents, 68% preferred supine positioning, 26% preferred prone, 15% placed the patient left-side down, and 8% commented they changed patient positions during the procedure. Five percent shortened the tubing to improve pressure transduction, one respondent injected air through large syringes, one had designed a pump and tubing system, and another had a locally designed machine connecting to wall oxygen.

Ultrasound to monitor reduction

Only 4% predominately used US to monitor reduction. Those using US averaged 9.5 reductions during the last year (range 0–20), with 84% average success rate (range 0–100%). Eighty-two percent of those using US required a surgeon in

Table 4 Preferred reduction medium

Medium	% (*n*)
Exclusively air	79% (349/440)
Prefer liquid	20% (86/440)
If using liquid:	
Cystografin	59% (132/224)
Gastrografin	25% (57/224)
Barium	16% (35/224)
Other	12% (27/224)

Table 5 Pressure employed to reduce intussusception

Height of contrast media above patient						
Liquid contrast	3ft	4ft	5ft	6ft	As high as possible	Other
Barium	49% (17/35)	31% (11/35)	6% (2/35)	3% (1/35)		11% (4/35)
Water-soluble	44% (106/240)	24% (57/240)	11% (26/240)	6% (14/240)	10% (25/240)	5% (12/240)

Maximum air pressure						
Air	100mmHG	120mmHG	140mmHG	>140mmHG	Do not monitor	Other
	5% (18/349)	75% (261/349)	7% (25/349)	4% (15/349)	4% (14/349)	5% (16/349)
Pressure-release valve used by 50%						

hospital, 82% required IV access, 63% required continuous monitoring, and 38% used sedation.

Reduction medium and pressure (Tables 4 and 5)

Seventy-nine percent preferred air for intussusception reductions, and 20% preferred liquid, including cystografin (59%), gastrografin (25%), barium (16%) or other (12%) (Table 4). Of those who preferred air, 75% allowed 120 mmHg maximum pressure and 50% used a pressure-release valve (Table 5). Of those using barium or water-soluble contrast media, the plurality (49% for barium, 44% for water-soluble) hung the bag at 3 ft.

When to stop (Table 6)

Of the respondents, 72% honored the classic rule to attempt reduction three times with the intussusceptum in the same position; 18% made more than three attempts, and 10% attempted fewer than three times.

Table 6 Number of times respondents attempt reduction with intussusceptum in same position

<3	3	4–6	>6
10% (41/429)	72% (308/429)	14% (61/429)	4% (19/429)

Other maneuvers (Table 7)

If initially unsuccessful, respondents employed various techniques, including reattempting reduction later (64%), applying manual pressure (19%), and trying left decubitus positioning (15%). In addition, 6% of respondents commented that they would change the patient's position, slightly more than 1% would sedate the patient, and less than 1% would administer glucagon to improve bowel relaxation.

Delayed attempts (Table 7)

If reattempting reduction, 37% would wait 0–15 min, 20% 15–30 min, 22% 30–120 min, and 22% >120 min. Five percent of respondents commented they might re-attempt up to several hours later.

Number of procedures, perforations and pneumoperitoneums

Respondents had performed 3,834 reductions in the preceding 12 months, which averages 9.5 reductions per respondent (range 0–60). Overall, 83% of intussusceptions were successfully reduced (range 0–100%); 0.5%, or 5 out of 1,000, perforated within a given year. Over 10 years, 89 practitioners reported

Table 7 Maneuvers if unsuccessful

Maneuver			% (*n*)	
Apply manual pressure			19% (84/435)	
Use left decubitus position			15% (66/435)	
Reattempt reduction later			64% (280/435)	
Waiting period (minutes)				
0–15	15–30	30–60	60–120	>120
37% (122/332)	20% (66/332)	13% (42/332)	9% (29/332)	22% (73/332)

133 perforations, with a maximum 12 per individual. Excluding the 61 who did not answer this question and those who provided a range, the mean incidence of perforation per respondent was 0.34 over 10 years, or 1 in 30 years. Thirty-two respondents encountered tension pneumoperitoneum (four maximum per individual). Of note, we consider pneumoperitoneum to be a subset of perforation, because a perforation occurring during a liquid enema does not manifest with pneumoperitoneum.

Discussion

We have evaluated current practices of intussusception reduction in order to understand trends in procedural approaches and related outcomes. The average respondent reduces 9.5 intussusceptions per year and has a 34% chance of encountering perforation once in the course of 10 years.

In accordance with our data, it is not uncommon for reductions to fail at community hospitals yet succeed at specialized institutions [14, 15]. This emphasizes the impact of specialized training and the benefit of having experienced pediatric radiologists available to perform child-specific procedures. Our data, which include more than twice as many respondents as any previous survey regarding intussusception, show that some new practices have evolved, while others have remained unchanged over the last two decades [16–22].

Previous investigators found practitioners were more likely to consider symptoms of more than 48 h an absolute contraindication [18, 20], but most of our current practitioners (86%) said they are willing to attempt reduction even though symptoms have been present for more than 2 days. We consider this appropriate because studies have shown that although the probability of reduction falls with longstanding intussusception, a successful reduction is still possible [23–27]. Research has also shown that although likelihood of success with free or trapped fluid is relatively low, success is still possible [28, 29], and the vast majority (86%) of our respondents said they attempt reduction despite the presence of free fluid. Similarly, reduction is less likely but still possible if decreased blood flow is demonstrated by Doppler US [30], and 82% of our respondents perform the procedure despite decreased blood flow (similar to a previous study) [19].

There seems to be an increasing trend toward demand for IV access (75% vs. 50%) and presence of a surgeon in the hospital (82% vs. 46%) compared to reports from 1999 [19]. Interestingly, a recent survey of practices in the United Kingdom found a much higher reduction rate if the surgeon was actively involved in the reduction procedure [22].

There seems to be a decreasing trend to employ sedation, which is used by only 7% of our respondents compared to up to 54% in previous studies [18]. The effect of sedation on outcome is controversial: some studies reported a lower reduction rate [18], while others found a higher rate of success with sedation [31]. A recent paper reports excellent success with propofol, perhaps secondary to long-lasting bowel relaxation [32], while glucagon did not confer any benefit in two independent studies [33, 34].

Although inflation of a rectal balloon to achieve a seal is controversial [1, 4, 13, 18–21], our survey found that this practice remains popular. It is still accepted practice to use tape, place a gauze plug at the anal verge or create a tape wrap around the catheter to achieve a seal [1, 4]. Although catheter diameter has been shown to have a significant effect on pressure conduction of liquid contrast media, diameter appears less important for gas reduction [35].

Given the small number of respondents who primarily use US for reduction (5%), only limited conclusions can be drawn from our study. US appears to be more popular among our international respondents, which is in accordance with previous reports [19]. In our study, those using US guidance had more peri-procedural requirements, including sedation (38% vs. 6%), requiring a surgeon in the hospital (82% vs. 62%), and continuous monitoring (63% vs. 33%).

We found a continuing trend away from barium reduction and an increasing use of air, now utilized by 78%. In 1989 barium was standard in 85% of North American pediatric hospitals [16]. Over subsequent years, investigators started to use alternate fluids, such as iodinated contrast agent and saline [17, 18]. In 1999, Schmit et al.'s [19] survey of 200 members of the European Society of Paediatric Radiology found air reduction to be the dominant technique, which was confirmed by three later surveys of practitioners in the United Kingdom [20–22]. Although evaluation of studies comparing air with liquid reduction is limited by differences in individual practices and study design [36], there seems to be an overall consensus that air is more effective [11, 13, 36–38].

Interestingly, 50% of those using barium place the bag higher than 3 ft, and most of those using water-soluble contrast material do not compensate for its lower specific gravity [39] by hanging it higher, perhaps because the maximum height of the bag's holding device is utilized, regardless of its content.

Those who use air seem to allow increasing maximum pressures. In 1999, a U.K. survey found wide variation of acceptable pressures, with 33% using pressures at or below 100 mmHg [21]. Use of higher pressures (130–180 mmHg) has been reported in those performing the most intussusceptions per year [18]. In accordance with our findings, a recent U.K. survey (2014) found that 19 of 22 centers use 120-mmHg maximum pressure, and three allowed pressures as high as 180 mmHg [22].

Although relatively little has been reported on manual reduction techniques [40], we found that fewer (19%) practitioners apply manual pressure to the abdomen if reduction is not initially successful compared to reports in 1992 (36%) [18]. A recent report describes success in 80% of cases using external manual pressure alone (monitored by US, without

intraluminal contrast material) [41]. However, there may also be an increased risk of perforation with this technique [42].

Practitioners are more likely today to allow a significant delay before reattempting reduction after an unsuccessful procedure. Twenty-two percent of our respondents will wait more than 120 min, whereas in an earlier study only 3% would wait even 60 min — and most would not wait at all [19]. Literature supports the value of longer delays [25, 43, 44].

Limitations

Our survey relied on individual's memory of experiences, which may be inaccurate. Although our response rate was excellent, bias may have been introduced by self-selection. Furthermore, although respondents could remain anonymous, they may have been reluctant to admit to practices outside the perceived norm. By only asking SPR members, we missed non-pediatric-trained radiologists. Not surveying other international organizations limits conclusions about practice outside the United States, and in particular loses information about the increasing practice of US-guided reduction of intussusception. Although we asked respondents to report the incidence of successful reduction as well as perforation, we did not correlate those results with practice patterns. Unfortunately we did not obtain information about fluoroscopy times, use of continuous or pulsed fluoroscopy, or radiation dose per study. We did not expect accurate results about these from a survey based on recollection. However, systematic approaches for minimized exposure would be important subjects of future investigations.

Conclusion

By providing a better understanding of both trends in and diversity of current practice, we hope to increase the confidence with which the individual practitioner will approach each case.

Acknowledgments We would like to acknowledge the assistance of Dr. Mark Lubell, Department of Environmental Science and Policy, University of California, Davis, in developing the survey.

Conflicts of interest Dr. Stein-Wexler has a small financial interest in Lucy LLC, a company that produces a simulation device for learning intussusception reduction.

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