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Intussusception reduction 1991: an international survey of pediatric radiologists

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Abstract. A detailed survey of intussusception reduction practices at the International Pediatric Radiology '91 meeting in Stockholm yielded 78 responses from radiologists representing 21 countries on six continents. Results indicate a striking lack of concensus on basic technical issues such as the type of contrast material or reducing agent, the pressure limits for reduction, the use of balloon-tip tubes, the role of sedation, manipulation of the abdomen during reduction, and duration of symptoms beyond which reduction would not be attempted. For example, while gas reduction has been strongly promoted in the literature during the late 1980's, only 34.7 % of the respondants indicated that this was their principle choice of reducing agent. Among technique choices which produced significant correlations with outcome, it is noteworthy that pooled data suggest an eightfold increase in perforations among those using gas rather than liquid for reduction. Also, although 53.8 % of respondants use parenteral sedation at least part of the time, those who reported using it regularly had significantly lower success rates than all other radiologists. This study provides a current sampling of international opinion in a subject of importance to all pediatric radiologists; and by linking the responses with reported outcomes suggests opportunities for further investigation.

Since 1876, when Hirschsprung first popularized enema techniques for intussusception reduction, controversies about the methodology have been incessant [1, 2], Major issues have included the role of surgery versus enema pressure reduction, the characteristics of the reducing agent, the role of external manipulation of the abdomen, and the use of medications during reduction [3–5]. The most far-reaching recent methodological change has been the spread of gas reduction methods developed almost 40 years ago [5]. This has by no means been universally embraced. With these controversies in mind, a questionaire was devised to sample the current opinions and practices of radiologists attending the IPR '91 meeting in Stockholm, Sweden.

Materials and methods

The one page questionaire was distributed to attendees of the IPR '91 meeting at the second scientific session the morning of May 28, 1991. No studies on intussusception had yet been presented at the meeting. The radiologists were requested to leave the completed forms at their seats at the end of the session. 65 completed surveys were obtained at that session. 13 additional forms were later handed in or received by mail within 3 weeks. The mailed forms were not appreciably different from the initial group and were therefore included. These 78 responses form the basis for this study.

The survey was arranged into 3 sections, the first of which sought demographic and experiential data. The second section listed technique choices for contrast/reducing agents, tube types, restraints, manual manipulations, and pharmacologic adjuncts. The respondants were to circle numerals 1–6, corresponding to these 6 numbered statements above the section: 1) It is part of my regular method 2) I use it sometimes 3) It is helpful in difficult cases 4) I have never used it 5) I have discontinued using it 6) I believe it is unsafe. Statement 3 was selected infrequently, and was therefore combined in the data analysis with statement 2. The final section asked for limits of liquid column height, gas pressure, repetitions, patient age and duration of symptoms within which the radiologist would attempt intussusception reduction. Statistical relationships were evaluated using Chi square, one way analysis of variance, Tukey's studentized range, Pearson correlation analysis, and squared multiple correlation (linear regression) tests. Success and perforation rates were analyzed both by averaging individual rates and by pooling data for various categories of respondants. Pooled data were obtained by combining estimates of the total number of cases each respondant had performed with their current method. This was based upon the responses to questions about annual caseload and duration of use of the current reduction method.

Results

General information

Demographics and response rate. The 78 respondants were from 21 countries, grouped into four categories; North America ($n = 41$), Europe ($n = 23$), Oceania (Australia and New Zealand, $n = 8$), and Other ($n = 6$) (Table 1). North American responses were from 17 states and 3 provinces. Response rates based on meeting registration were lowest for Europe; probably because of incomplete attendence and the language barrier.

Table 1. Demographic information

Region	Regional response rate	Countries	Number of respondants	Number of hospitals
North America	23.4%	United States	35	30
		Canada	6	5
Europe	10.2%	Sweden	5	5
		Netherlands	4	4
		France, Germany, Norway, Spain	2 (each)	2 (each)
		Austria, Belgium, Finland, Switzerland	1 (each)	1 (each)
		United Kingdom, Yugoslavia (Slovenia)	1 (each)	1 (each)
Oceania	44.4%	Australia	7	5
		New Zealand	1	1
Other	30.0%	Israel	2	2
		Brazil, Japan, South Africa, Taiwan	1 (each)	1 (each)

Table 2. Success rates with current method by region

	Range (%)	Mean (%)	Pooled (%)
North America	20–94.4	72.13*	76
Europe	60–100	82.76	90 #
Oceania	70–100	82.62	81
Other	60–100	78.34	81
Total	20–100	78.34	81

* $p = 0.0777$

# $p < 0.001$ vs. North America, $p = 0.002$ vs. Oceania, $p = 0.008$ vs. Other

Table 3. Opinions of contrast/reducing agents

	Air	02	Barium	Ionic	Nonionic	Water
Regular routine	22	4	46	10	4	3
Use sometimes	8	0	11	24	17	3
Never used	44	70	3	36	55	63
Quit using	2	1	14	5	2	0
Believed unsafe	2	3	4	3	0	9

Experience. The average length of time in radiology practice was 13.63 years, with a range of 2 to 31 years. There were 23 radiologists in practice for less than 10 years, 26 from 10 to 19 years, and 29 for 20 or more years. There was a trend ($p = 0.097$) toward more experience in the group called Others, with a mean practice time of 20.83 years, than North America (12.54), Oceania (14.00), and Europe (14.87).

Volume of intussusception cases. The mean number of intussusceptions at the hospitals of the respondants were 30.51 per year, with the median being 20. The means for the regional groups were not significantly different (Oceania = 39.29, Europe = 33.25, North America = 29.74, Other = 15.42). The range of the number of cases per year was 3–300. Two hospitals also reported 100 and 150 intussusceptions per year.

Success rates. Respondants were asked for their success rates using their current method. The mean reported success rate for all respondants was 78.34% with a range of 20% to 100%. Eleven respondants noted success rates of less than 67% with their current method. 17 responses were 70–79%, 27 were 80–89%, and 16 were 90–100%. There was a strong trend toward a lower reported mean success rate for North America than other regions and a significantly higher pooled success rate for Europe than elsewhere (Table 2).

Correlation was sought for significant association of several other variables with success rate. Total time in practice, number of intussusceptions at the hospital per year, number of reductions attempted by the respondant per year, incidence or raw number of perforations, and preferred reducing agent did not show statistical significance. Surprisingly, an inverse relationship between the number of years using the current method and individual success rate was found ($p = 0.0198$). This was not a manifestation of the use of gas reduction as success rates for barium and gas reduction were similar.

Perforations. 59 respondants indicated that they had had no perforations using their current method. 10 people reported one perforation, 5 reported two perforations. 3 responses were atypical: 1 individual stated that 7 perforations had occurred, 1 listed a percentage rather than a number of perforations (which was calculated to equal 0.72 perforations), and 1 response was "1–2", which was treated statistically as 1.5. Using these data, the mean number of perforations per respondant using current methods was 0.38. The individual perforation rates were as high as 11.4%, which skewed the arithmetic mean of the perforation rates to 0.41%. However, using the pooled data, one can estimate an overall perforation rate of 0.13%. Eight perforations were reported on incomplete surveys; but even including these, the rate for the total population (representing almost 16000 cases) is at most 0.18%. Those who adopted their current method relatively recently tended to have the highest perforation rates ($p = 0.1185$).

The pooled perforation rate for gas reduction (air and oxygen) is 0.438% excluding the hospital with seven perforations but an unknown denominator. If one includes these seven perforations with a reasonable denominator such as 300 cases [6], the overall perforation rate for gas is estimated at 1.091%. This contrasts with the rate of perforation for all types of liquid reductions combined, which

Table 4. Demographic data by preferred reducing agent

Agent	Regional distribution				Years in practice		Years with method	
	N. AM.	Eur.	Oc.	Oth.	mean	range	mean	range
Air	17	3	0	1	10.95	2–20	1.80	0.25–4
02	0	1	3	0	10.00	2–21	1.62	1–3
Barium	19	11	4	5	15.18	4–31	15.06	4–31
Ionic	4	2	0	0	11.75	2–22	8.50	2–21
Nonionic	0	2	0	0	14.00	8–22	3.00	3
Barium or water soluble	1	4	1	0	18.75	5–30	13.33	5–23

Table 5. Opinions of type of tubing

	Shiels or similar	Foley inflated	Foley deflated	Other, no balloon	Mano-meter
Regular routine	21	26	8	27	17
Use sometimes	4	8	11	11	5
Never used	50	31	54	34	49
Quit using	0	1	2	3	1
Believed unsafe	1	10	1	1	1

Table 6. Opinions of restraint methods

	Tape on buttocks	Tape around knees	Board with straps
Regular routine	70	10	17
Use sometimes	3	10	13
Never used	4	57	47
Quit using	1	0	1
Believed unsafe	0	0	0

Table 7. Opinions of manual techniques

	Jiggling abdomen	Press upon intussuscep-tum	Milking/ stripping	Touch abd. in any way
Regular routine	7	8	2	9
Use sometimes	9	16	4	25
Never use	51	36	52	29
Quit using	2	3	5	5
Believe unsafe	8	15	15	10

is at most 0.124 % (including the respondant with one perforation and an unknown denominator).

Techniques

Contrast/reducing agents. The opinions of six reducing agents or contrasts are compiled in Table 3. While 17 radiologists had switched away from barium, it was still being used regularly or sometimes for intussusception reduction by 73 % of respondants. Of the 36 radiologistas who had ever used gas reduction, 33 still use it at least part of the time. The water soluble contrasts were the most popular second line agent, whether the first choice was gas or barium. 5.1 % of respondants felt that barium reduction was unsafe. Up to 3.8 % thought gas was unsafe.

In 72 questionaires, it was possible to determine which agent was the actual current preference for intussusception reduction. The other six expressed equal preferrence for barium and one of the water soluble contrasts. Use of gas reduction was fairly evenly distributed within North America and Oceania, the 2 regions where it has become common. Although the length of experience with each agent varied widely, enough senior radiologists had changed methods that there was no significant difference in length of time in practice between those using various reducing agents (Table 4).

Tubing. Foley catheters with the balloon inflated were as popular as any other single tube type (Table 5). However, the preferred tube did not have an inflated balloon for 64 % of respondants; and balloon-inflated Foleys were felt to be unsafe by 13.2 % of respondants. Manometer use nearly paralleled the use of the Shiels type tubes, although at least 20 % of those favoring gas reductions are apparently not regularly using manometry. No significant regional differences or correlations with outcome were found in tubing selection.

Restraint methods. Taping the buttocks during preparation for intussusception reduction was the most widespread behavior in the survey (Table 6). Other immobilization methods were much less common. There was not a significant correlation between restraint methods and outcome.

Manual techniques. As shown in Table 7, 56.4 % of respondants never touch the abdomen during reduction attempts; while another 7.7 % sometimes touch the abdomen, but will not use any of the other manual methods. The remaining 35.9 % at least occassionally employ a jiggling, pressing, milking, or stripping action. 19.2 % of the respondants thought pressing or milking the intussusceptum were unsafe, and many thought it was not safe to touch the abdomen in any way. No significant regional differences were observed in these opinions.

The success rates for those who use manual techniques were virtually identical with those who avoid touching the abdomen. There was actually a trend ($p = 0.2711$) toward fewer perforations among the group that uses jiggling, milking, stripping or pressing techniques than among those who restrict abdominal contact (Table 8).

Medicines. Glucagon, was the technical component abandoned by the largest number of radiologists (Table 9). Regional differences were significant ($p = 0.020$) with seven of the eight radiologists still using glucagon being from North

Table 8. Perforation occurrances vs. use of manual techniques

	Perforations		
	0	1	>1
Does not use manual techniques	32	7	5
Uses touch only, no other manipulation	3	2	1
Uses jiggle, milk or press	24	2	1

Table 9. Opinions of medicines used during reduction attempts

	Glu-cagon	Oral sedation	Parenteral sedation	General anesthesia	Other meds
Regular routine	0	2	12	0	2
Use sometimes	8	14	30	5	1
Never used	49	53	28	68	75
Quit using	21	4	5	2	0
Believed unsafe	0	1	3	3	0

Table 10. Reduction pressure limits

Agent	Units	Minimum		Maximum[a]	
		mean	range	mean	range
Air or O2	mm Hg	47.33	0–80	118.55	70–180
Barium	cm (mm Hg[b])	85.53 (95)	30–150	107.34 (122)	90–200 (100–220)
Water sol.	cm (mm Hg[b])	90.57 (75)	60–100	148.53 (120)	120–180

[a] All nonnumeric responses (e.g. "ceiling") set to 180 cm
[b] Utilizing data from Kuta and Benator [8] and assuming 60 % wt. vol. for barium and equivalence to a 1:3 dilution of meglumine sodium diatrizoate for water soluble agents

Table 11. Correlations with maximum gas pressures

	Number	Years in practice*	Intuss per yr #
70–100 mm Hg	7	16.857	17.417
120 mm Hg	19	9.842	24.763
130–180 mm Hg	3	4.667	53.333

* $p = 0.0264$
# $p = 0.0025$

America. In Europe, only 8.7 % had used it previously; whereas at least half of those in North America and Oceania had employed it in the past. Parenteral sedation was by far the most used sedation or anesthetic technique, employed by 53.8 % at least part of the time. Only 3.8 % felt that it was not safe, a number which may change in light of experimental data presented later at the IPR meeting [7]. The use of medications, even parenteral sedation, did not seem to effect perforation rates. However, the success rates for the 12 people who used parenteral sedation as part of their regular method were lower than for the rest of the respondants ($p = 0.0178$). Of 11 respondants with success rates less than 70 %, 5 were regular users of parenteral sedation.

Procedure limits

Pressures. Minimum and maximum pressure limits for various reducing agents are listed in Table 10. These are compared by using the data of Kuta and Benator to convert liquid column heights to mm Hg (assuming the dilutions shown) [8]. The 5 nonnumeric responses such as "ceiling", "no limit", etc. were assigned the value of 180 cm for statistical purposes as that was the greatest height assessed by Kuta and Benator. For maximum gas reduction pressure, 18 of 29 responses were 120 mm Hg. Interestingly, lower gas pressures were employed by radiologists performing fewer reductions ($p = 0.0025$) or having more years in practice ($p = 0.0264$) (Table 11). For each agent, there was not a significant correlation between column height or pressure and success or perforation rate.

Repetitions. 68 numeric responses were received, ranging from 2 to 10. After assigning four non-numeric responses ("no limit") a value of 10, the mean was 3.96. Increasing the number of repetitions showed a nearly linear (but not significant, $p = 0.327$) increase in the mean success rate (Table 12). All 11 of the respondants with personal success rates below 67 % limited their repetition attempts to four or less.

Age limits. Of those indicating a lower age limit, 36 answers were "zero" and 23 ranged from two weeks to one year. The mean lower age limit was 0.115 years or about 6 weeks. There were 36 numeric responses for a maximum age limit, 31 with no upper limit, and 11 missing responses. Those with upper age limits ranged from 1 to 18 years. Eleven radiologists indicated a limit of one to three years, 20 had a limit of 4 to 9 years, and 5 had a limit of 10 or more years. The age limit choices did not correlate with success or perforation rates.

Duration of symptoms. A definite maximum symptom limit for a nonsurgical reduction attempt was listed by 29 respondants, ranging from 10 h to 1 week (Table 13). 40 others indicated no fixed limit. The group with a 72–96 h symptom limit averaged significantly more reduction attempts per year ($p = 0.0488$) than those with lesser or greater symptom duration limits. There was also a trend toward greater success rates in the 72–96 h symptom limit group ($p = 0.0707$).

Discussion

This survey is the most extensive to date in assessing the wide variety of intussusception reduction methods at a particular point in time. While it does not canvas global pediatric radiology completely, it does provide a sufficiently representative sample that many interesting conclusions can be drawn. Although barium use is declining, gas reduction was used by less than 40 % of those surveyed. Worldwide, the use of gas in China may be offset by barium reductions done elsewhere by general radiologists and surgeons [9].

An individual's success rate may reflect his/her ability to influence local referral patterns as much as his/her skill in

Table 12. Mean success rates versus maximum number of repetitions.*

Repetitions	Success
2	71.2%
3	74.56%
4	78.21%
5–10	83.2%

* $p = 0.3269$

Table 13. Maximum symptom limits

Limit	*n*	Mean reduct. attempts/yr.	Mean success rate
10–24 h	5	10.83	75.07%
36–60 h	10		
72–96 h	11	45.86*	86.19% #
5–7 days	3	19.04	75.32%
No fixed limit	40		

* $p = 0.0488$
# $p = 0.0707$

reducing difficult intussusceptions. Nevertheless, it is clear from our survey that at least an 80% success rate is a reasonable goal. Factors which were found to correlate with higher success in this survey do not offer an easy guide for self-improvement. There was a cluster of respondants, mostly American, who had been in practice for many years, continued to use barium, favored parenteral sedation, and had poor success rates. These radiologists were largely responsible for the observations that those using their method a long time and those using parenteral sedation had significantly poorer success rates than other respondants. These factors were not entirely independent as the mean number of years in practice for those who do not use parenteral sedation, 7.44 years, tended to be less than for those who use it sometimes, 10.07 years, or use it regularly, 10.08 years. It is difficult to know whether parenteral sedation itself causes poorer outcomes, or if it is a marker for radiologists whose general approach to intussusception reduction is less successful than the rest of the pediatric radiology community. Americans had less overall success than Europeans, but the above technical differences do not explain this. Other possibilities include misreporting of actual success, longer delays in reaching American hospitals, greater skill or perseverence in reduction attempts in Europe, or perhaps greater American fear of litigation. A far more detailed study would be necessary to investigate this type of discrepancy.

The least desirable outcome, perforation, was substantially higher for gas reduction than for liquid reduction technique and there was a trend ($p = 0.1128$) toward a higher perforation rate among those using their current method for a short time. These variables are also not independent; and it remains to be determined whether the increased incidence of perforation with gas is due to inexperience with the method, an inherently greater likelihood of perforation (due to lower viscosity, for example), or a more cavalier attitude toward the consequences of a gas perforation [6]. The largest study of air reduction, 6396 cases from China, showed a perforation rate of 0.141%, similar to that of liquid agents in this survey [9]. This suggests that Western inexperience with the gas reduction is a major factor in our higher perforation rate.

While this survey is not sufficiently rigorous to provide firm data condemning or extolling particular technical practices in intussusception reduction, it is quite evident that we have failed to reach a concensus on the majority of the key issues in this procedure. In fact, disagreement is so strong that virtually all respondants perform intussusception reductions in a manner which some other respondant would consider unsafe. Changes in the nonsurgical treatment of intussusception during its 115 year history, such as the abandonment of manual techniques, have sometimes been based upon anecdotal information [4, 5, 10]. Our study underscores the need for a concerted effort by pediatric radiologists to design scientific studies which will address the many remaining disputes in optimizing nonsurgical intussusception reduction.

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