

# AN AUDIT OF PNEUMATIC REDUCTION IN PAEDIATRIC ILEO-COLIC INTUSSUSCEPTION CASES AT CHRIS HANI BARAGWANATH AND CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITALS

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## **Declaration**

I, Parusha Pillay, declare that this research report is my own work. It is being submitted for the degree of MMed (RadDiag) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

DR PARUSHA PILLAY

On this 14th day of July 2017.

I dedicate this thesis to my parents.

## **Publications and presentations**

This work has never been published.

It has never been presented at a congress.

## **Abstract**

**INTRODUCTION:** Intussusceptions may cause significant morbidity and mortality if not treated timeously. One method of conservative management is pneumatic reduction, the outcome of which is dependent on a number of factors.

**AIM:** To determine the proportion of children with intussusception who have evidence of bowel obstruction on initial abdominal radiograph, and the failure rate of pneumatic reduction in patients with and without bowel obstruction. The study also looked into whether there were any associations between the radiological presence or absence of bowel obstruction and pneumatic reduction outcome, the finding of necrotic bowel at surgery, and CRP and WCC levels.

**METHOD:** A retrospective study was performed using an existent paediatric surgery intussusception database. Three different readers read the baseline abdominal radiographs and subjectively determined whether bowel obstruction was present or not. Treatment choices, outcomes of the pneumatic reduction, and if available, clinical presentation and lab results were captured from the patient's discharge summary and NHLS portal.

**RESULTS:** A sample size of 45 patients was studied. The median age of presentation was 7 months, with 83% of the patients having had symptoms for 3 days or less. 80% of patients had bowel obstruction on initial X-ray, and of these patients, only 17% had successful pneumatic reduction. No significant association was found between bowel

obstruction and the presence/absence of necrotic bowel. 64% had their symptoms documented, and only 26 % and 42 % had CRP and WCC documented respectively, which did not meet sample size requirements.

**CONCLUSIONS:** Even though a strong association was shown between evidence of bowel obstruction and pneumatic reduction outcome, the sample study was too small to make between-group comparisons. Due to this limitation, it is recommended that further investigation be done, possibly by including patients from other South African tertiary hospitals in order to obtain statistically significant results.

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# **1. INTRODUCTION**

## **1.1 Intussusception**

### **1.1.1 Definition and Incidence**

Intussusception occurs when a proximal segment of bowel (intussusceptum) prolapses into an adjacent distal segment (intussusciens), often resulting in intestinal obstruction. This may lead to venous congestion, bowel wall oedema, bowel wall ischaemia, necrosis, perforation, and even death, if not reduced timeously (1-4). In developing countries, studies have shown mortality rates of up to 20% (4). In a recent, local study conducted at Chris Hani Baragwanath Academic Hospital (CHBAH) and Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), a mortality rate of 9.3% was calculated from the study pool of intussusception cases (5).

The incidence of intussusception in South Africa has been crudely estimated to be 1 case per 3123 in the paediatric population under the age of 2 years (6). This incidence was calculated from a study conducted by Moore et al. over a 6 year period, using data from 9 paediatric referral units (6).

### **1.1.2 Underlying Causes and Subtypes**

There are two major groups of intussusceptions, the first being “idiopathic”, and the second “pathological”. The idiopathic group accounts for the majority of intussusception cases (75%), and occurs between the ages of 3 months and 3 years (7). They are ileo-colic in nature and do not have a pathological lead point ie. idiopathic (7). In an article published in 2007 by Rogers et al., 81% of intussusception cases were those of the ileo-colic subtype (8). “Pathological” intussusception, the second group, occurs in those under

3 months of age and in children older than 3 years, usually secondary to a pathological lead point. These include colo-colic, ileo-ileal and jejuno-jejunal intussusception. Lead points that need to be actively excluded in this group include Meckel's diverticuli, duplication cysts, polyps and tumour (lymphoma) (7, 9).

### **1.1.3 Diagnosis**

The diagnosis of intussusception is made after a thorough clinical history and physical examination has been obtained, followed, if necessary, by imaging studies, such as a plain abdominal radiograph, abdominal ultrasound, or a contrast enema. Once the diagnosis has been made, either a conservative or surgical approach is chosen depending on a number of patient clinical factors (10).

#### **1.1.3.1 Clinical Features of Intussusception:**

The clinical triad of presenting features of intussusception includes vomiting, abdominal pain, and rectal bleeding (11), however these symptoms may be very non-specific and not all children present with the entire triad. In a study by Justice et al., only 43% of patients presented with the entire classic triad (11).

#### **1.1.3.2 Abdominal X-Ray Imaging:**

Once there is any clinical suspicion of an intussusception, a plain abdominal radiograph should be obtained. According to both Sorantin and Venter et al., plain abdominal radiographs cannot exclude the diagnosis of intussusception, as they report positive diagnostic features in only 29-50% of intussusception cases (2, 7). Further imaging, such

as ultrasonography or a contrast enema, is therefore required to exclude or confirm the diagnosis.

Two characteristic features of intussusception on plain film have been described by Del-Pozo et al. (12): The “target sign”, which is a soft tissue density mass with a concentric area of lucency, which represents mesenteric fat that has been dragged into the intussusception, and the “meniscus sign”, which is a crescent-shaped lucent area of gas within the bowel lumen. The crescent shape is due to the contrast of gas outlining the soft tissue apex of the intussusception.

Sorantin et al. further describes non-specific features on a plain abdominal radiograph, which could suggest the presence of an intussusception. These features include a soft tissue mass that obscures the inferior border of the liver, an empty right lower quadrant, and features of small bowel obstruction (7). Air-fluid levels alone are not diagnostic of small bowel obstruction; they are seen as a feature of bowel obstruction when combined with dilated loops of bowel (13).

#### **1.1.3.3 Ultrasound Imaging:**

Characteristic sonographic imaging features represent the intussusception, as well as consequences and complications thereof, such as mural oedema, trapped fluid or infarction (7). These characteristic images can be seen in either an axial or longitudinal plane.

In an axial plane, a soft tissue mass may be seen, which often has a diameter of between 2.5-5.0cm (14). When the bowel wall becomes thick and oedematous, it appears thick and hypo/anechoic on sonography. The intussuscepted mesenteric fat creates a hyperechoic centre. These two contrasting layers give a “doughnut” appearance (15). If fluid gets trapped at the apex of the intussusceptum, an anechoic region within the fatty hyperechoic centre may be seen, which then gives the appearance of a “target sign” (15). If the walls are mildly oedematous, the mucosa and submucosa are not stretched; therefore these multiple layers can be seen, giving a “multiple concentric ring” appearance (12, 15). At times, a hypo-echoic lymph node may be seen in the fatty hyperechoic centre of the intussusceptum (12, 16).

In a longitudinal plane, the “doughnut sign” described above, takes on the appearance of a kidney, hence the imaging sign is called the “pseudo-kidney sign” (15). Neither the “doughnut sign” nor the “pseudo-kidney sign” are pathognomonic of intussusception. These signs may be seen whenever there is bowel wall thickening, no matter what the cause (14). When mesenteric fat is dragged between the intussusciens and intussusceptum, this fat is seen as two echogenic bands sandwiched between three hypo-echoic bowel wall stripes, creating the sign known as the “sandwich sign” (12, 15). A variant of the Sandwich Sign, is the “hayfork sign”, which is seen at the apex of the intussusceptum. The three hypo-echoic bands appear to look like a hayfork (12). The “Trapped Fluid sign” describes the image of fluid trapped between the serosal surfaces of the intussusciens and the intussusceptum, which has been shown to correlate with poor outcomes of pneumatic reduction (12, 17).

When Colour Flow Ultrasound is applied, and absent flow is seen within the bowel wall of the intussusceptum, it is not seen as a contra-indication to pneumatic reduction (PR), however it has been shown to reduce the chances of a successful PR (18).

Ultrasound diagnosis of an intussusception has a 98-100% sensitivity, an 88% specificity, and 100% negative predictive value (NPV) (12, 19). Due to the accuracy in detecting and excluding an intussusception using ultrasound imaging, contrast enemas are not necessary for diagnosis (14), and in the CHBAH and CMJAH paediatric departments, ultrasound remains the gold standard if the diagnosis of intussusception is not clinically evident.

#### **1.1.4 Treatment Options**

Once the diagnosis of intussusception has been made clinically and confirmed using radiographic and sonographic imaging, the clinician needs to decide on the best form of treatment. This can either be conservative, using the modality of pneumatic or hydrostatic reduction, or surgical.

### **1.2 Pneumatic Reduction**

#### **1.2.1 Definition and Aim**

Pneumatic reduction is a non-surgical procedure, which insufflates pressurised air into the rectum through a catheter, in an attempt to reduce an intussusception, without perforating the bowel.

### **1.2.2 Method of Non-Surgical Reduction**

Pneumatic reductions at CMJAH and CHBAH, are performed under fluoroscopy, using pressurised air insufflation into the rectum.

A Foley's catheter tip is inserted into the rectum. There are differing opinions between articles on whether the catheter balloon should be inflated or not. Sorantin et al. and Kaiser et al. advocate not inflating the balloon, the rationale behind this being that mistaken balloon over-inflation can cause rectal or colonic perforation (4, 7). Mensah et.al and Venter et.al advocate balloon inflation to create a tight seal (2, 20). In our centre, the balloon is inflated cautiously with 5-10cc of air, and the buttocks are tightly strapped or held together to ensure a tighter seal, and prevent the catheter from sliding out (21). A T-connector is connected to the catheter, which is then in turn connected to an air pump and manometer (7, 21).

The "Rule of 3's" is then applied. Three attempts at reduction are attempted at increasing pressure increments of 80, 100 and 120mmHg, for 3 minutes at each pressure. Rest periods are given after each attempt. As the air pressure is held for 3 minutes, the soft tissue intraluminal mass, which represents the intussusception, is fluoroscopically imaged, and watched as it reduces and moves towards the ileo-caecal valve. Once air refluxes into the ileum, the reduction is deemed successful (7, 21).

Hydrostatic reduction is also performed by placing a non-balloon catheter tip into the rectum, with the buttocks either strapped or held together to create a seal as described above. The "rule of 3's" is then applied. A bag filled with 60% wt/vol of Barium and connected to the rectal catheter, is held 3 feet above the patient table, with 3 attempts of

hydrostatic pressure reduction, at 3 minutes per attempt (7). Once free reflux of contrast is seen into the terminal ileum, the reduction is deemed successful (7).

### **1.2.3 Air versus Barium**

Pneumatic reduction, rather than hydrostatic reduction, is the conservative approach used at CMJAH and CHBAH. This choice is supported by many published studies such as Venter et al. (2013), Kaiser et al. (2007), Maoate & Beasley (1998), and Zheng et al. (1994).

The advantages and disadvantages of using air versus barium as a medium for reduction are summarised in the tables below (table 1.1 and 1.2).

The advantages of using air over barium as a non-surgical reduction option are as follows:

- 1) During the reduction process, if bowel perforation occurs, there is either none or only focal faecal peritoneal spillage with air reduction, as opposed to diffuse spillage when barium or liquid contrast mediums are used (2, 22).
- 2) Pneumatic reduction is less messy than hydrostatic reduction, as when liquid contrast leaks, it needs to be cleaned to prevent image artefacts, and often causes the catheter to slip out of the rectum (23)
- 3) Higher intraluminal pressures can be obtained with air (4), resulting in faster reduction times and less fluoroscopic time (i.e. less radiation) (23)
- 4) Numerous studies have shown that air insufflation compared to liquid contrast use, results in more successful reductions, with figures of 82% compared to 68% respectively (2). This reduces the rate of children needing operative intervention post pneumatic reduction (22).

**Table 1.1** Advantages of using air versus barium as a reduction medium

	AIR	BARIUM	REFERENCE
If bowel perforates during reduction	None/focal faecal peritoneal spillage	Diffuse faecal peritoneal spillage	(2, 22)
If leakage i.e. Poor rectal-catheter seal	Less messy	- catheter may slip  - contrast needs to be cleaned to prevent image artifact	(23)
Intraluminal Pressure	Higher pressures obtained, therefore faster reduction times, and less radiation	Lower pressures than air	(23)
Success Rates	Higher (82%), therefore less need operative intervention	Lower (68%)	(2) (22)

The disadvantages of using air over barium as non-surgical reduction options are as follows (23):

- 1) Tension pneumoperitoneum may develop secondary to perforation of bowel
- 2) It is more difficult to visualise the intussusception as well as successful reduction, due to the poorer contrast between air and soft tissue, when compared to that of barium and soft tissue.
- 3) For the same reason as given in point 2, lead points are often not visualised when air is used as the reduction medium.

**Table 1.2** Disadvantages of using air versus barium as a reduction medium

	AIR	BARIUM	REFERENCE
If bowel perforates during reduction	Tension pneumoperitoneum		(23)
Contrast between reduction medium and soft tissue	Poor therefore difficult to visualise intussusception, successful reduction, lead points	Good therefore easier to visualise intussusception, successful reduction, lead points	(23)

#### **1.2.4 Advantages of Pneumatic Reduction versus Surgical Reduction**

The reasons for choosing a conservative approach over that of a surgical approach are quite obvious. In an article by Mensah et al., pneumatic reduction was far cheaper to perform than surgical reduction, which was estimated to be only 20% of the cost of surgical management (20). This article also states that the hospital stay is markedly reduced, with patients only needing 2 days of bed rest compared to the 5 days when surgery was performed in uncomplicated cases (20). When a non-surgical reduction approach is chosen, there is no anaesthetic risk, or risk of post-operative complications developing, such as urinary tract infections, atelectasis, pneumonia, or bowel adhesions. A paper published by Yalcin and Cifti has shown that morbidity is reduced in patients who undergo surgical reduction after a trial of non-surgical i.e. pneumatic reduction, compared to those who have surgery without a trial of conservative management (10).

### **1.2.5 Outcomes of pneumatic reduction**

A successful pneumatic reduction occurs when the intussusception is fully reduced, with air seen to reflux into the terminal ileum, and no bowel perforation.

A failed pneumatic reduction occurs when the intussusception fails to reduce and the patient has to be taken to theatre for surgical reduction, or when bowel perforation occurs. When the bowel perforates, air fills the peritoneal cavity and can result in tension pneumoperitoneum if not treated immediately. This results in splinting of the diaphragm and acute respiratory distress (22). Treatment of the pneumoperitoneum involves immediate paracentesis, with placement of a 14G needle to decompress the abdomen, and then surgery to reduce the intussusception and repair the perforated bowel. Maoate et al. reviewed children with intussusception who perforated during enema reduction, and found that all cases had radiological evidence of bowel obstruction (22).

### **1.2.6 Factors Affecting Outcome**

There are a number of factors that influence the outcome of conservative management using pneumatic reduction of an intussusception. The factors below reduce the success rate of this conservative approach, and increase the risk of bowel perforation.

#### **1.2.6.1 Clinical Factors:**

- Age of patient less than 3 months or more than 5 years (2, 7)
- Long duration of symptoms (>48 hours) (2, 7)
- Severe dehydration (2, 7)
- Toxic appearance or lethargy (10, 24)

- Blood per rectum (7, 24)
- Increase in serum C-reactive protein (5)

#### 1.2.6.2 Abdominal X-Ray Imaging Features:

- Radiological evidence of small bowel obstruction (dilated loops of bowel, air fluid levels within bowel lumen) (2, 3, 7, 10).

Features of small bowel obstruction on plain abdominal x-rays follow the rule of 3's: (i) small bowel dilated >3cm, (ii) more than 3 air fluid levels, (iii) small bowel wall thickness greater than 3mm (25). An article published in Radiographics in April 2009 by Silva et al., describes in more detail features that indicate a high grade small bowel obstruction: (i) small bowel distension with the largest dilated loop greater than 50% of the widest colon loop, and averaging 36mm in diameter, (ii) more than 2 air fluid levels, which are wider than 2.5cm, with each air fluid level within the same loop differing by a minimum of 2cm in height (26). Table 3 shows the relationship between pneumatic/hydrostatic reduction outcomes and radiological evidence of bowel obstruction from statistics sourced from a number of published studies. These studies showed high rates of failed pneumatic reduction in patients with radiographic evidence of bowel obstruction.

McDermott et al., Stephenson et al., Blane et al. and Humphry et al. showed failure rates of 56%, 62%, 64% and 76% respectively (table 1.3) (13, 27-29).

Features of bowel obstruction have also been linked to an increased risk of the patient requiring bowel resection (11).

**Table 1.3** Summary of studies showing the association of radiographic evidence of small bowel obstruction with pneumatic/hydrostatic reduction outcomes

Year of Publication	Study	Country	Number of confirmed intussusception cases	Number of confirmed intussusception cases with AXR	No. of intussusception cases with SBO on AXR	
					Successful non-surgical reduction	Failed non-surgical reduction
1998	Gorenstein et.al (3)	Israel	71	63	22/63 (35%)	
					15/22 (68%)	7/22 (32%)
1994	McDermott et.al (27)	Edinburgh	62	48	16/48 (33%)	
					7/16 (44%)	9/16 (56%)
1989	Stephenson et.al (28)	USA	127	127	61/127 (48%)	
					23/61 (38%)	38/61 (62%)
1984	Blane et.al (13)	Canada	40	34	12/34 (35%)	
					4/11 (36%)	7/11 (64%)
1981	Humphry et.al (29)	Toronto Ontario	42	42	42/42 (100%)	
					10/42 (24%)	32/42 (76%)

The combination of prolonged duration of symptoms and radiological evidence of bowel obstruction decreases the chance of a successful reduction, however, these features according to Maoate and Beasley are not absolute contra-indications to performing non-surgical reduction of an intussusception (22).

#### **1.2.6.3 Ultrasound Imaging Features:**

- No flow signals seen within intussusception bowel wall (18). This absence of blood flow within the bowel wall indicates ischaemia as a result of compression of mesenteric vessels, and in these cases surgical reduction is the preferred management option (30).
- Free fluid (10).

#### **1.2.7 Previous and Current Contraindications**

The findings of shock, peritonitis, and bowel perforation (pneumoperitoneum) have remained contra-indications to performing pneumatic/hydrostatic reduction from the inception of this conservative approach (3, 7, 10, 13, 23, 31).

Views on radiological evidence of bowel obstruction as a contra-indication to performing non-surgical reduction (NSR), however, vary between different studies. Studies done in the late 70's and early 80's, viewed radiological evidence of bowel obstruction as a contra-indication to performing NSR techniques. Rosenkrantz et al. took this feature as a warning of bowel that was incarcerated or gangrenous, and therefore at risk of perforating (32). Turner and Rickwood viewed radiographic evidence of small bowel

obstruction as a contra-indication to NSR in patients over the age of 2 (31). Humphry et al. also viewed radiological evidence of bowel obstruction as a contra-indication to NSR, however pallor, dehydration, lethargy or skin mottling needed to be present clinically. He too viewed this sign as a warning of incarceration and likely necrotic bowel at risk of perforating when subjected to an increase in intra-luminal pressure (29).

Zheng and Frush (1994) listed small bowel obstruction as a relative, and not an absolute contra-indication to NSR (23). Yalcin et al. (2009) implied that radiological evidence of bowel obstruction is a relative contra-indication to NSR, by stating that “severe intestinal obstruction” is an “indication for primary surgery”. The article concludes by stating that lethargy, a toxic clinical appearance and air fluid levels on abdominal radiograph, not only decrease the chance of a successful NSR, but also increase the rate of surgical complications, which supports the above quoted statements (10).

Various authors have stated that radiological evidence of bowel obstruction is not a contra-indication to performing non-surgical reduction, however that it is a significant predictor of failure of this procedure (3, 13, 22, 27, 28).

A number of other factors considered as contra-indications to NSR of an intussusception are:

- Bloody stool (23, 24)
- Large/firm palpable abdominal mass (10, 23, 24)
- Child > 2 years with clinical suspicion that there is a lead point (31)
- Prolonged history (> 48 hours) (23, 24)

### **1.3 Study objectives**

This study aimed:

- 1) To determine the proportion of children with intussusception who have evidence of bowel obstruction on initial baseline abdominal radiograph
- 2) To determine the failure rate of pneumatic reduction in patients with and without evidence of bowel obstruction
- 3) To determine associations between the radiological presence or absence of bowel obstruction and
  - a. Pneumatic reduction outcome
  - b. Necrotic bowel at surgery
  - c. CRP levels
  - d. WCC levels

The aim of these research questions was to determine whether radiological evidence of bowel obstruction influences the outcome of pneumatic reduction of intussusception in children, and whether it should be seen as a contraindication or relative contraindication to pneumatic reduction, and therefore assist in protocol development at the study base hospitals.

## 2. MATERIALS AND METHODS

Ethics approval was obtained from the Human Research Ethics Committee (Medical) (see Appendix A). The research paradigm was a retrospective study of paediatric intussusception cases. Patients between the ages of 3 months and 3 years were identified from the paediatric surgery intussusception database, which was provided by the gatekeeper of the database, Professor Jerome Loveland, the head of paediatric surgery at CHBAH. Patients in this database included CHBAH and CMJAH cases. They were only included if intussusception was confirmed, either by radiological or surgical means. The baseline abdominal radiographs were retrieved either from records (printed films) or the PACS, using the hospital numbers obtained from the database. Three different readers, two paediatric radiology consultants, Dr Jaishree Naidoo and Dr Tanyia Pillay, and the author, Dr Parusha Pillay, read these radiographs, and subjectively determined whether bowel obstruction was present or not. The data was captured on the data collection sheet provided to each reader (see Appendix B). The paediatric radiologists were not privy to treatment choices or outcomes. Treatment choices were captured from the patient's discharge summary, ie. pneumatic reduction or primary surgical reduction, as well as the outcome of the pneumatic reduction (reduced, not reduced, or perforated) (see Appendix C). If available in the surgical discharge notes, patients' clinical presentation was captured in the data spreadsheet. Similarly, if available, blood results were captured.

## **2.1 Inclusion and exclusion criteria**

### **2.1.1 Inclusion criteria**

- Patients between the ages of 3 months to 3 years, with radiological or surgically confirmed intussusception were included. The reason for choosing this age group was that this group often have the idiopathic form of intussusception (7), which is amenable to pneumatic reduction in our study centres.

### **2.1.2 Exclusion criteria**

- Patients who had surgically proven colo-colic, or non ileo-colic intussusception were excluded, as these forms of intussusception are theoretically due to secondary pathological causes, which warrant primary surgical resection in our study centre (Personal Communication, Professor Jerome Loveland).
- Patients who did not have baseline abdominal radiographs.
- Patients who had poor quality radiographs, or corrupt data on the PACS were excluded.
- Patients whose surgical records could not be accessed or were insufficient.

## 2.2 Data collection

The data was collected from three main sources:

- 1) Abdominal x-rays retrieved from PACS and X-Ray Stores at CHBAH, and X-Ray Stores at CMJAH.

Findings of whether there was bowel obstruction or not, as decided on by each reader, was captured on a data collection sheet (see Appendix B). A majority conclusion of whether bowel obstruction was present or not (2/3 or 3/3 readers) was then made, and captured on the final data collection sheet (see Appendix C).

- 2) Clinical discharge summaries obtained from the Paediatric Intussusception Database.

Clinical data such as age, presenting symptoms, and duration of symptoms were captured. The treatment options of pneumatic reduction and primary surgical reduction were captured, as well as outcomes of pneumatic reduction (successful/unsuccessful/complicated) and surgical findings of necrotic bowel and subsequent bowel resection.

- 3) Blood results.

Inflammatory markers C-Reactive Protein (CRP) and White Cell Count (WCC) were captured if these results were found.

The above data was captured in a data collection sheet (see Appendix C), which was then analysed.

### 2.3 Sample size calculation

Due to the dramatic reduction in study sample size, from 150 to 45, a calculation was performed to determine whether the numbers enrolled in the study were adequate.

The results are tabulated below:

**Table 2.1** Result of sample size calculations

Table size (number of categories in each variables)	Sample size required for		
	Large effect size	Medium effect size	Small effect size
2 x 2	31	87	785
3 x 2	39	108	964
4 x 2	44	122	1091
5 x 2	48	133	1194
3 x 3	48	133	1194
4 x 3	55	152	1363

It is clear that a sample size of 45 (at best, not counting missing data and exclusions) is adequate only for the determination of large effects, if they exist (as marked in red in the table above).

Note that sample size requirements are actually increased further by unbalanced data, which is almost always the case here.

## 2.4 Statistical analysis

A descriptive analysis was performed on categorical variables using frequency and percentage tabulation. Continuous variables were analysed by means of the mean, standard deviation, median, interquartile range, and histogram.

The associations between the presence/absence of bowel obstruction on the one hand and pneumatic reduction outcome and necrotic bowel on the other hand were determined using Fisher's exact test. The phi coefficient was used to measure the strength of the associations.

The following scale of interpretation was used:

0.50 and above	high/strong association
0.30 to 0.49	moderate association
0.10 to 0.29	weak association
below 0.10	little if any association

The association between presence/absence of bowel obstruction and CRP and WCC levels was analysed using the independent samples t-test, however where the data did not meet the assumptions of these t-tests, the Wilcoxon rank sum test was used.

Data analysis was carried out using SAS. (Reference: SAS Institute Inc., *SAS Software, version 9.3 for Windows*, Cary, NC, USA: SAS Institute Inc. (2002-2010))

A P-value (calculated probability) of 0.05 was used to determine the statistical significance of the results.

The Chi-square test was used to test the association between categorical variables.

In this study, between-group tests were not carried out if missing data exceeded 30% or the sample size requirements for the detection of at least a large effect were not met.

### 3. RESULTS

#### 3.1 Sample size reduction

Unfortunately, a number of elements resulted in a reduction in sample size, from an initial 150 patients to 45 patients. These factors included:

- 1) Inability to access patient abdominal x-rays for the following reasons
  - a. X-ray packets lost
  - b. X-ray packets found, but x-rays missing
  - c. X-ray packets found, but x-rays not from intussusception admission date
  - d. Patients have taken x-rays with on discharge
  - e. Unable to retrieve images on PACS at CHBAH
- 2) Surgical notes incomplete (symptoms, duration of symptoms, no record at all)
- 3) Blood results not registered at NHLS (may be due to incorrect name or hospital number used)

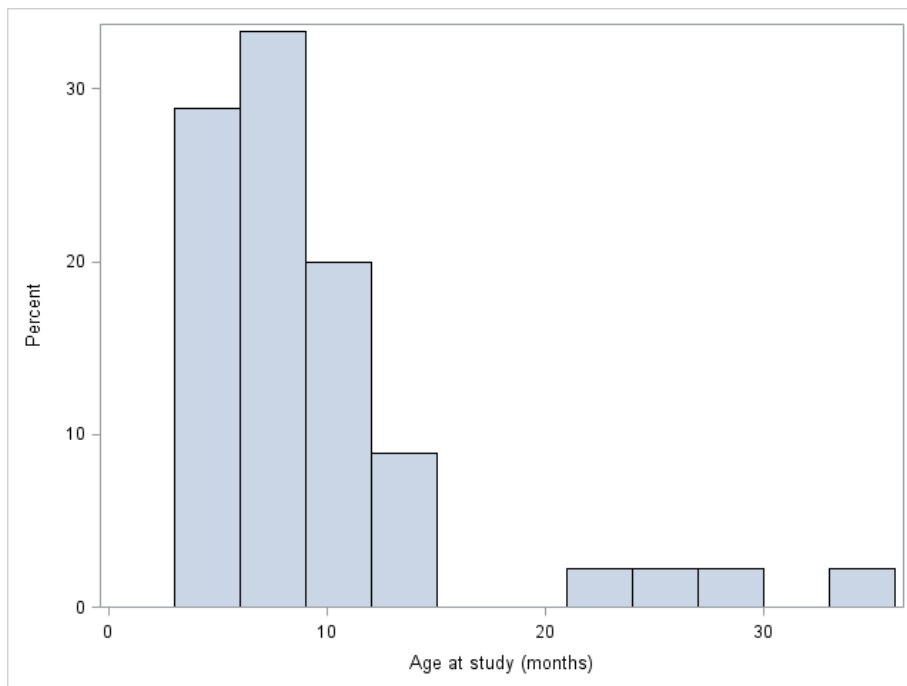


**Figure 3.1** Flow diagram demonstrating decrease in sample size

## 3.2 Descriptive analysis of the study variables

### 3.2.1 Age at presentation

The median age at presentation was 7 months (Interquartile Range [IQR] 5-9 months; range 3-36 months). The distribution of ages is shown below in Figure 3.1. 87% of the patients were aged 12 months or less.



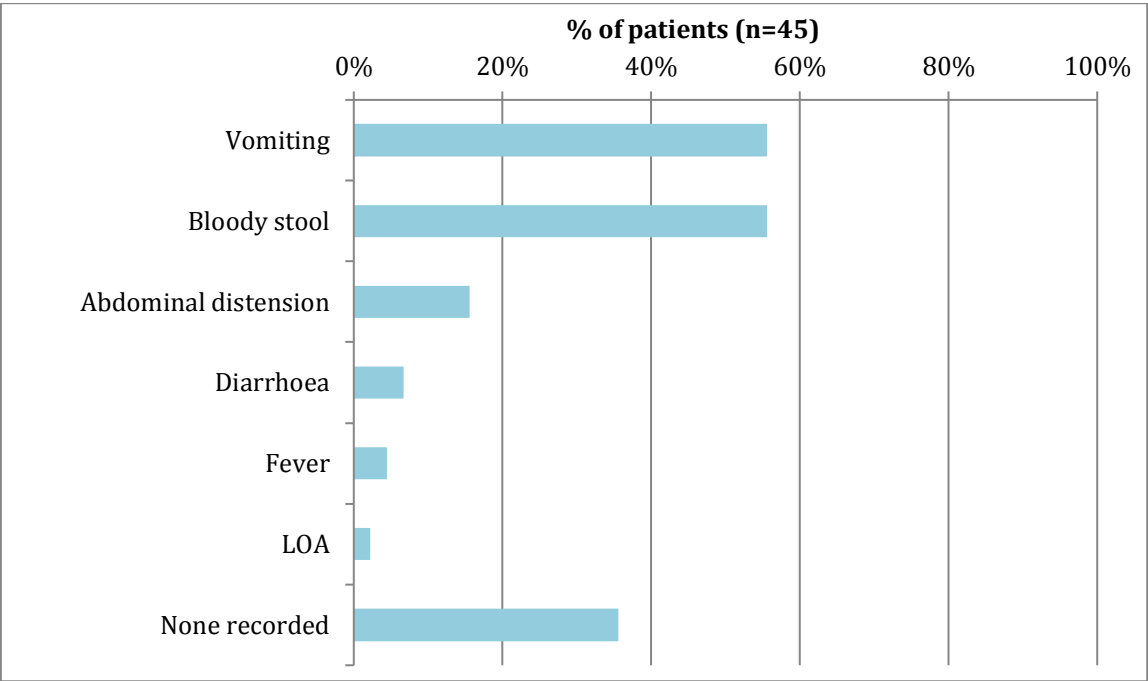
**Figure 3.2** Distribution of age at presentation of study group

### 3.2.2 Presenting Symptoms

No symptoms were recorded in the discharge summaries of 36% of the patients. The level of missing data exceeded 30% and therefore the results could not be interpreted reliably.

The percentage of patients who experienced the various symptoms is shown below in Figure 3.2. Note that percentages do not sum to 100% since some patients had more

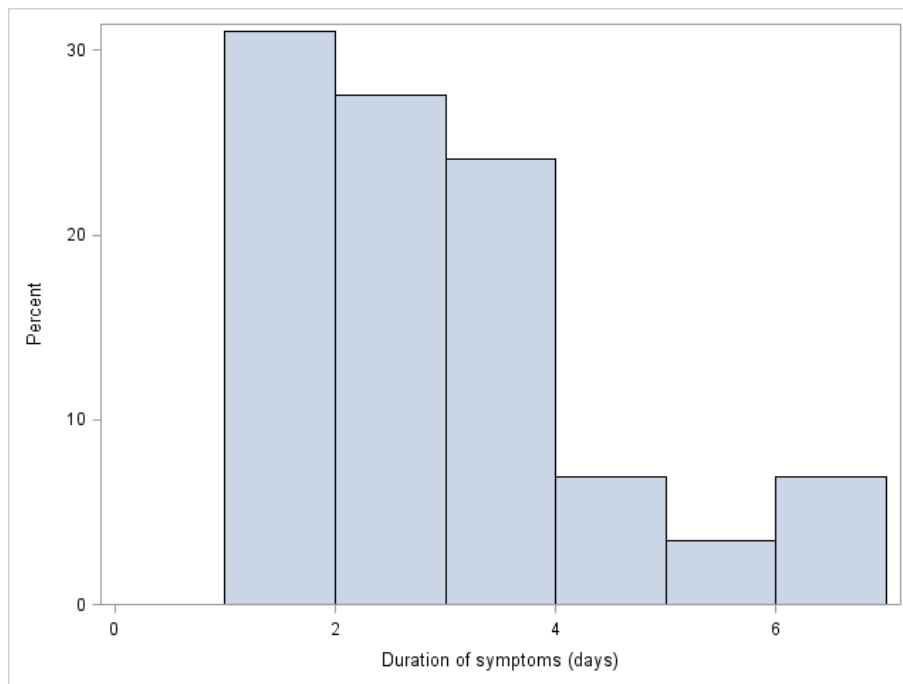
than one symptom. The most common symptoms were vomiting and bloody stool (both 56%).



**Figure 3.3** Presenting Symptoms of study group

### 3.2.3 Duration of Symptoms (n=29 for whom symptoms were recorded)

The median duration of symptoms was 2 days (IQR 1-3 days; range 1-7 days). The distribution is shown below in Figure 3.3. 83% of the patients had symptoms for 3 days or less.



**Figure 3.4** Duration of Symptoms of study group

### 3.2.4 Laboratory data (CRP & WCC)

From the sample size of 45 patients, only 12 had documented CRP levels (26% of the total). Of these 12, 9 had an elevated CRP. Of these 9, 8 had surgery (6 primary surgery, and 2 post failed pneumatic reductions), and 1 had a successful pneumatic reduction). Seven of these patients with an elevated CRP had bowel obstruction radiographically. The 3 patients with a normal CRP had 1 successful pneumatic reduction, and 2 failed pneumatic reductions, which required surgery. 1 of these

patients with a normal CRP had bowel obstruction radiographically, whereas 2 did not.

From the sample size of 45 patients, only 19 had documented WCC levels (42% of the total). Of these 19, 4 had an elevated WCC. Of these 4, 3 had surgery (1 primary surgery, and 2 post failed pneumatic reductions), and 1 had a successful pneumatic reduction). Two of these patients with an elevated WCC had bowel obstruction radiographically. The 15 patients with a normal WCC had 3 successful pneumatic reductions, 6 failed pneumatic reductions, which required surgery, and 6 primary surgeries. Eleven of these patients with a normal WCC had bowel obstruction radiographically, whereas 4 did not.

### **3.2.5 Bowel Obstruction on Initial Baseline AXR**

80% (36/45) of the patients had bowel obstruction identifiable on initial baseline abdominal X-Ray.

### **3.2.6 Pneumatic reduction**

Pneumatic reduction was attempted in 26 of the 45 cases (58%), and of these 26 attempts, only 9 were successful (35%). Three of these 9 had radiographic evidence of bowel obstruction, and 6 did not have evidence of bowel obstruction. One case was complicated by bowel perforation, and the other 16 had failed reduction attempts. Patient number 35 initially presented without bowel obstruction, and an attempt to pneumatically reduce the obstruction was made, but was unsuccessful. The following day bowel obstruction was present on abdominal x-ray, and the intussusception was

pneumatically reduced. The patient then re-developed the intussusception and bowel obstruction the day after, and was taken for surgical reduction where necrotic bowel was identified. This case, despite the one successful pneumatic reduction attempt, was classified as a failed reduction, as surgery ultimately had to be performed.

### **3.2.7 Surgery**

36 of the 45 study patients (80%) underwent surgical reduction, of which 17 had prior unsuccessful pneumatic reductions. The other 19 cases did not have pneumatic reduction attempts, and it is assumed that these patients had contraindications to pneumatic reduction such as perforation, shock, peritonitis, or were clinically too ill.

22 of these 36 patients (61%) who underwent surgical reduction were found to have necrotic bowel, and 23 of these 36 patients (64%) had bowel resection. 8 did not have necrotic bowel nor bowel resection. 5 of the 36 patients did not have documentation in their discharge summary regarding whether necrotic bowel was found, or bowel resection was performed.

### **3.3 The proportion of children with intussusception who had evidence of bowel obstruction on initial baseline abdominal radiograph**

The percentage of children who had evidence of bowel obstruction on the baseline AXR was 80% (95% confidence interval: 65-90%).

### 3.4 The failure rate of pneumatic reduction in patients with and without evidence of bowel obstruction, and the association between these two variables

**Table 3.1** Association of radiographic evidence of bowel obstruction with pneumatic reduction outcomes

Attempted pneumatic reductions (NSR) (26/45)			
Cases with SBO on AXR		Cases without SBO on AXR	
Successful NSR	Failed NSR	Successful NSR	Failed NSR
18/26		8/26	
3/18 (17%)	15/18 (83%)	6/8 (75%)	2/8 (25%)

The sample size of the patients with attempted pneumatic reduction was n=26, which did not meet sample size requirements for the detection of a large effect size. However, there was a significant, strong, association between evidence of bowel obstruction (or not) and the success/failure of the pneumatic reduction (Fisher's exact test;  $p=0.0077$ , phi coefficient=0.56). The failure rate of pneumatic reduction in patients with evidence of bowel obstruction was 83% (15/18) (95% CI: 59-96%). The failure rate of pneumatic reduction in patients without evidence of bowel obstruction was 25% (2/8) (95% CI: 3-65%).

There was a significant, strong, association between evidence of bowel obstruction (or not) and the success/failure/non-attempt of the pneumatic reduction (Fisher's exact test;  $p=0.0007$ , phi coefficient=0.58). The failure/non-attempt rate of pneumatic

reduction in patients with evidence of bowel obstruction was 92% (33/36) (95% CI: 78-98%). The failure/non-attempt rate of pneumatic reduction in patients without evidence of bowel obstruction was 33% (3/9) (95% CI: 7-70%).

### **3.5 The association between the radiological presence or absence of bowel obstruction and necrotic bowel found at surgery**

The number of patients with necrotic bowel at surgery was 31 (n=31), therefore the sample size requirements for the test of association were met. The prevalence of necrotic bowel in patients with evidence of bowel obstruction was 75% (21/28) (95% CI: 55-89%). The prevalence of necrotic bowel in patients without evidence of bowel obstruction was 33% (1/3) (95% CI: 1-91%). There was no significant association between evidence of bowel obstruction (or not) and the presence/absence of necrotic bowel as found during surgery (Fisher's exact test;  $p=0.19$ ).

### **3.6 The association between the radiological presence/absence of bowel obstruction and blood CRP and WCC levels**

CRP levels: 73% of the data are missing; therefore, we cannot use this variable for further analysis.

WCC levels: 58% of the data are missing; therefore, we cannot use this variable for further analysis.

## **4. DISCUSSION**

### **4.1 Results in context**

#### **4.1.1 Descriptive analysis**

From an initial database of 150 patients, only 45 patients could be used in the study. Due to this decrease in sample size, the third study aim of determining associations between radiological evidence of bowel obstruction and pneumatic reduction outcomes, CRP and WCC levels could not be met, as a larger sample size was needed to give sufficient statistical power to draw correct conclusions from the data. The study has therefore become a descriptive analysis, and will unfortunately not be able to detect significant associations if they exist, which could develop intussusception protocols as was intended.

The variables on which a descriptive analysis was performed included age at presentation, duration of symptoms, presence or absence of bowel obstruction on initial baseline abdominal X-ray, pneumatic reduction attempts and outcome, and surgical management of these patients. Between group comparisons and associations were made, however due to missing data the sample sizes were too small to determine large, medium or small effects. The only association that could be made (ie. sample size was met), was the association between the radiological presence or absence of bowel obstruction and necrotic bowel found at surgery.

The median age at presentation of the study population was 7 months, which, despite this study having a small sample size, is similar to studies conducted on larger sample sizes, such as Justice et al. (study population of 191 patients, with median age of 7

months), Kaiser et al. (study population of 244 patients, with median age of 8.2 months), and Tareen et al. (study population of 256 patients, with median age of 7 months)(4, 11, 21).

The median duration of symptoms prior to hospital presentation was 2 days, with 83% of patients having had symptoms for 3 days or less. This is in contrast to another study conducted in South Africa by Venter et al., which showed that 70.6% of patients in their study presented after 72hours of symptom onset. Despite generalised thinking that patients in a South African public health service setting present quite late, presentation times in our study population were comparable to first world study centres. Kaiser et al., and Tareen et al., demonstrated percentages of 69% and 79% respectively, with regards to the percentage of patients presenting within the first 48 hours (4, 21). This outcome, however, may be an inaccurate representation of our study population, as 36% of the data on duration of symptoms was missing.

Radiographic evidence of bowel obstruction was present in 80% of the patients in this study. This was a much higher percentage when compared to studies included in the literature search. Gorenstein et al., McDermott et al., Stephenson et al., and Blane et al., had percentages between 35% and 48% (3, 13, 27, 28).

Two variables, presenting symptoms and laboratory data, had levels of missing data that exceeded 30% and 50% respectively; therefore, the results could not be interpreted reliably.

#### **4.1.2 Associations**

##### **4.1.2.1 The association between the outcomes of pneumatic reduction and evidence of bowel obstruction**

As mentioned previously, a sample size of 26 is too small to be able to detect significant associations if they exist.

Due to this small sample size resulting in an inability to make statistically sound group comparisons, an assumption was made that those patients who did not have a pneumatic reduction attempt were likely too ill for the procedure, and would therefore have, with high probability, failed the pneumatic reduction attempt. If this assumption is made, then an adequate sample size of  $n=45$  could be used.

Using the Fisher's exact test, there was a significant, slightly stronger, association between evidence of bowel obstruction (or not) and the success/failure-non-attempt of the pneumatic reduction in the larger study sample of 45 patients. A p value of 0.0007, and a phi coefficient of 0.58 were obtained, compared to the p value of 0.0077 and phi coefficient of 0.56 when a sample size of 26 was used.

Compared to international studies, our pneumatic reduction failure rate with evidence of bowel obstruction was much higher. The range of failure rates in these international studies however was broad, starting from 32% and reaching 76%. This is most likely due to the variation in many of the factors in each study population, which could affect the outcome of non-surgical reduction. This demonstrates the fact that multiple variables need to be taken into account to predict a failed pneumatic

reduction, and radiographic evidence of bowel obstruction alone may not be predictive.

#### **4.1.2.2 The association between the radiological presence or absence of bowel obstruction and necrotic bowel found at surgery**

The number of patients with necrotic bowel at surgery was 31 (n=31), which did meet the sample size requirements. Using Fisher's exact test, no significant association between evidence of bowel obstruction (or not) and the presence/absence of necrotic bowel as found during surgery was found (p-value =0.19).

Even though the sample was adequate in size to conduct the Fisher's test, it still may be too small to detect such an association if it does exist. Furthermore, the sample is again biased, because we have not included those who did not have surgery.

#### **4.1.2.3 The association between the radiological presence or absence of bowel obstruction and blood CRP and WCC levels**

The missing data exceeded 30%, therefore these variables could not be analysed.

## **4.2. Limitations of the current study**

### **4.2.1 Limited by its retrospective nature**

The findings in this study were dependent on the admitting clinician taking necessary blood samples and requesting appropriate radiological imaging, the discharging clinician creating an accurate and detailed summary of patient treatment plans and outcomes, and the hospital X-ray filing system (correct filing which impacts the ability to retrieve baseline abdominal X-rays). This resulted in limited data availability, which led to a dramatic (over two thirds) reduction in the sample size, from an initial 150 patients to 45 patients. This significantly altered the direction and outcome of the study, as statistically significant associations could not be detected, which were needed to assist in protocol development at the study base hospitals. Of the patient cases that were available for the study, poor data quality was another factor, which limited the power of this study.

A lack of consistency in protocols for patient data capturing and patient management at individual centres and across centres, both in paediatric surgery and radiology, also contributed to the limited data availability.

### **4.2.2 Limited by experience and expertise**

The third reader in this study was a radiology registrar, the subjective opinion of whom was given equal weighting compared to the other readers, both paediatric radiology consultants. The third reader may have therefore under or over called bowel obstruction on the initial baseline abdominal radiographs due to lack of experience. Another area of this study which may have had limited expertise, is the

procedure of pneumatic reduction. Having only one paediatric radiology consultant at each base hospital, most pneumatic reductions are performed by general radiology consultants, some of whom may lack experience in this technique.

#### **4.2.3 Limited by subjective evaluation of whether bowel obstruction is present or not on abdominal radiographs**

There is no objective radiographic grading system to determine whether bowel obstruction is present or not in children. This therefore limits accuracy in determining the presence and severity of this finding.

### **4.3. Future applications**

#### **4.3.1 Conduct a prospective study**

This will enable the researcher to collect data without having to rely on external people or factors. Firstly, every possible intussusception case should have their baseline abdominal radiograph reported by the radiologist, whether the patient is for conservative management (pneumatic reduction) or surgery. In this way, all intussusception cases go through the radiology department. They will be excluded from the study if intussusception is not confirmed radiologically or surgically.

The radiologist reporting the abdominal radiograph will also fill in a data collection sheet (Appendix D) if intussusception is proven. This will include the patients name, hospital number, presenting symptoms and duration thereof, detailed abdominal radiograph and ultrasound findings, blood results, and treatment choices and outcomes.

This data sheet together with the abdominal X-ray should then be kept in the radiology department.

A radiological intussusception management flow chart can also be given to the radiology registrars to standardise patient care, and ensure that correct imaging is performed (see Appendix E).

This standardisation in patient management can be done in collaboration with the paediatric surgery team, in order to create an applicable clinical protocol to feed into the radiological algorithm.

#### **4.3.2 Conduct a collaborative study**

One way of collecting a substantial sample size would be to combine the samples from other tertiary hospitals around the country. This would then possibly result in a sample size that would be able to detect significant associations, if they exist, which could then be used in developing protocols at our academic institutions. This could be performed as either a prospective or retrospective study.

## 5. CONCLUSION

A retrospective study was conducted to determine the proportion of children with intussusception who have evidence of bowel obstruction on their baseline abdominal radiograph, and the failure rate of pneumatic reduction in patients with and without evidence of bowel obstruction. The study also sought to determine if associations exist between radiological presence or absence of bowel obstruction, and pneumatic reduction outcome, necrotic bowel found during surgery, and CRP and WCC levels.

The international literature on this topic of paediatric intussusception revealed varying opinions on what should and should not be regarded as absolute and relative contraindications to pneumatic reduction. The above research questions attempted to shed light on the above associations, to guide protocol development regarding pneumatic reduction of intussusception cases in our hospitals.

80% of the intussusception cases in the study had bowel obstruction on baseline abdominal X-ray, and the failure rate of pneumatic reduction in patients with bowel obstruction was 83%, whereas the failure rate of pneumatic reduction in patients without bowel obstruction was only 25%. Due to the small study sample however, significant associations were unable to be made, if they existed. This unfortunately prevented the third objective of this study from being met.

This study has shown that the failure rate of pneumatic reduction is much higher in patients with bowel obstruction. This finding justifies further investigation to establish whether a strong association exists between pneumatic reduction outcome and bowel

obstruction, which will be helpful in drawing up evidence based protocols at our base hospitals.

Intussusception remains a common cause of morbidity, and analysis of this entity can only improve patient management and care. Therefore, despite this study being unable to achieve its last objective, it may be a stepping stone to further research, which can only expand our knowledge and lead to better practice.

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## Appendix A: Ethics Clearance Certificate



R14/49 Dr Parusha Pillay

### HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL) CLEARANCE CERTIFICATE NO. M140855

**NAME:** Dr Parusha Pillay  
**(Principal Investigator)**

**DEPARTMENT:** Radiology  
Chris Hani Baragwanath Academic Hospital  
Charlotte Maxeke Johannesburg Academic Hospital

**PROJECT TITLE:** Radiological Bowel Obstruction as a Predictor of  
Failed Pneumatic Reduction in Paediatric Ileo-Colic  
Intussusception

**DATE CONSIDERED:** 29/08/2014

**DECISION:** Approved unconditionally

**CONDITIONS:**

**SUPERVISOR:** Dr Linda Tebogo Hlabangana

**APPROVED BY:**   
Professor P Cleaton-Jones, Chairperson, HREC (Medical)

**DATE OF APPROVAL:** 01/10/2014

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

#### DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.**

Principal Investigator Signature \_\_\_\_\_

Date \_\_\_\_\_

**PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES**

## Appendix B: Data Collection Sheet For Reader

PATIENT	Bowel Obstruction present on AXR (Yes/No)
1 ab	
2 ab	
3 ab	
4 ab	
5 ab	
6	
7 ab	
8 ab	
9 ab	
10 ab	
11 ab	
12	
13 ab	
14	
15 ab	
16 ab	
17 ab	
18 ab	
19	
20	
21	
22	
23	
24	
25 ab	
26 ab	
27	
28 ab	
29 ab	
30 ab	
31 ab	
32	
33 ab	
34 ab	
35 ab	
35 cd	
35 ef	
36	
37	
38	
39 ab	
40 ab	
41	
42	
43 ab	
44	
45	

## Appendix C: Final Data Collection Sheet

	AXR FINDINGS	OUTCOME PNEUMATIC REDUCTION			PRIMARY SURGICAL REDUCTION	SYMPTOMS	BLOOD RESULTS
PATIENT	Bowel Obstruction present (2/3 or 3/3 readers conclusions)	Reduced	Not reduced	Perforated			
1							
2							
3							

## Appendix D: Future Study Data Collection Sheet

### INTUSSUSCEPTION DATA COLLECTION SHEET

PATIENT NAME \_\_\_\_\_

HOSPITAL NUMBER \_\_\_\_\_

AGE IN MONTHS \_\_\_\_\_

DATE OF ADMISSION \_\_\_\_/\_\_\_\_/\_\_\_\_

SYMPTOMS \_\_\_\_\_

SYMPTOM DURATION \_\_\_\_\_

ADMISSION BLOOD RESULTS CRP \_\_\_\_ WCC \_\_\_\_

ADMISSION ABDOMINAL RADIOGRAPH (Please print film and place in dedicated intussusception X-ray box in paediatric sonar room for further evaluation)

	YES	NO
Dilated loops of bowel	<input type="checkbox"/>	<input type="checkbox"/>
Air fluid levels	<input type="checkbox"/>	<input type="checkbox"/>
Free air	<input type="checkbox"/>	<input type="checkbox"/>
Soft tissue mass	<input type="checkbox"/>	<input type="checkbox"/>
Paucity of gas	<input type="checkbox"/>	<input type="checkbox"/>
Other findings	_____	

which quadrant?

ADMISSION ULTRASOUND (if performed)

	YES	NO
Pseudo-kidney sign	<input type="checkbox"/>	<input type="checkbox"/>
Doughnut sign	<input type="checkbox"/>	<input type="checkbox"/>
Colour flow in intussusception	<input type="checkbox"/>	<input type="checkbox"/>
Free fluid	<input type="checkbox"/>	<input type="checkbox"/>
Other findings	_____	

### PNEUMATIC REDUCTION

	YES	NO
Performed	<input type="checkbox"/>	<input type="checkbox"/>
Successful	<input type="checkbox"/>	<input type="checkbox"/>
Complicated	<input type="checkbox"/>	<input type="checkbox"/>
If successful, at what pressure? 80mmHg <input type="checkbox"/> 100mmHg <input type="checkbox"/> 120mmHg <input type="checkbox"/>		
If complicated, what complication? _____		

### SURGERY

	YES	NO
Performed	<input type="checkbox"/>	<input type="checkbox"/>
Primary reduction method	<input type="checkbox"/>	<input type="checkbox"/>
Post failed pneumatic reduction	<input type="checkbox"/>	<input type="checkbox"/>
Necrotic bowel	<input type="checkbox"/>	<input type="checkbox"/>
Perforation	<input type="checkbox"/>	<input type="checkbox"/>
Lead point	<input type="checkbox"/>	<input type="checkbox"/>
Other findings	_____	
Referring clinicians contact details _____		

## Appendix E: Radiological Intussusception Management Flow Chart

