A UK evidence based guideline for the acute management of paediatric intussusception

BSPR Intussusception Working Group

Introduction

Background

Intussusception is the most common single cause of an abdominal surgical emergency in the infant population. Intussusception is the invagination of a portion of proximal bowel (intussusceptum) into the adjacent distal bowel (intussuscipiens). This can lead to intestinal obstruction, bowel ischaemia, necrosis and perforation. The aetiology is idiopathic in 90% of cases with a peak incidence at 6-18 months of age [1]. The putative mechanism is hyperplasia of the mucosa associated lymphoid tissue in response to immune activation that may be subclinical. The condition has historically been found to occur more commonly in males [1] and in older children is more likely to be precipitated by pathological 'lead point' such as a polyp or inverted Meckel's diverticulum [2].

The presenting symptoms / signs of intussusception are those of obstruction and gastrointestinal ischemia. These are summarised in figure 1.

Pathogenesis	Symptom / sign
Intestinal obstruction	Colicky abdominal pain
	Vomiting
	Abdominal distension/mass
Gut ischemia	Lethargy
	Pallor
	Rectal bleeding

Management of uncomplicated intussusception usually involves resuscitation, imaging based diagnostic confirmation followed by intervention primarily by pressurised enema reduction of the intussusception. Intussusception with suspected perforation, bowel necrosis or failed enema reduction requires surgical intervention. This will be either manual reduction and/or segmental bowel resection.

The British Society of Paediatric Radiology (BSPR) first published guidelines in 2003. These were primarily based on an earlier review of available evidence published in 1999 [3], but have subsequently been withdrawn. A recent retrospective national audit of radiological management of intussusception in the UK demonstrated that most centres still broadly follow the original guidelines but there appears to be a lack standardisation of equipment and personnel [4]. The national reduction rate reported by this audit was 71% and a similar prospective study in 2012 found a lower rate of 61% [5]. There was a wide variation in the reduction rate between centres (38 – 90%) and number of cases performed per centre (range 0–31/yr). These figures suggest outcomes below the best in the contemporary international literature [6, 7].

Aims

The BSPR Intussusception Working Group (IWG) seeks to address the lack of standardisation and variability in performance in the management of intussusception. The terms of reference are to develop new evidence based guidelines for the investigation and management of intussusception with the longer-term goal of standardising practice and improving outcomes.

Methods

The working group is composed of experienced UK paediatric radiologists and paediatric surgeons invited to contribute to a putative new national guideline. The following subdivisions for the proposed guideline allowed for detailed review.

Diagnosis	
Technique (radiological)	• Equipment
	• Pressure transmission medium Pneumatic vs hydrostatic
	• Pressures
	• Monitoring modality
	• Delayed repeat enemas
	• Sedation/anaesthesia
	• Personnel
Reduction rates	• Definition
	• Target reduction rates
Perforation rates	

Two reviewers independently performed literature review for each topic and their findings collated. The whole IWG reviewed the provisional recommendations at the time of BSPR's annual meeting (Oxford, UK; November 2014). Following discussion and further review if the evidence and recommendations the guidelines were agreed and finalised. The level of supporting evidence for each topic and grade of recommendation were agreed [8]. Whilst the best available evidence has been the basis of the guideline, the practical application of the final guideline was an essential consideration to make it relevant and applicable to current UK practice.

1 Diagnosis

1.1 Abdominal Ultrasound:

The investigation of choice for diagnosis of intussusception is abdominal ultrasound (US). This has consistently shown almost 100% sensitivity and specificity of 80-100% [9-15] (Level 1c). The 'target' or 'doughnut sign' in transverse section and the pseudo-kidney sign on longitudinal views are diagnostic. US has the benefit of being relatively cheap and non-invasive with no associated radiation exposure. Adequate training and experience are essential prerequisites for an operator dependent investigation such as this.

Full US examination of the abdomen/pelvis is essential, particularly as the diagnostic threshold has lowered, in order to detect other potential diagnoses. A focused examination of an intussusception, when detected, should assess for potentially prognostic features. Absent or reduced blood flow (colour Doppler) in the intussusception has been shown to predict ischaemia and is associated with significantly lower reduction rates [16-19] (Level 3b). Trapped fluid between the intussusceptum and intussuscipiens has also been associated with significantly lower reduction rates [20, 21] (Level 3b). Nonetheless, reduction rates of 26% and 31% have been reported in the presence of trapped fluid between bowel walls and absent colour Doppler flow respectively [17, 22] (Level 4). Neither of these radiological signs are therefore absolute contraindications to attempted non-operative reduction in a haemodynamically stable patient without evidence of perforation or peritonitis.

Ultrasound also has the advantage of the potential ability to identify pathological lead points [2, 20]. Again, whilst the presence of large lymph nodes and other lead points has been shown to reduce reduction rates, they are not necessarily absolute contra-indications to attempted non-operative reduction [2, 23] (Level 4).

The accuracy and detail of US for diagnosis and assessment of intussusception is operator dependant but sensitivity approaches 100%. In one study this has been specifically demonstrated in 3-4th year radiology residents following initial generic training in (adult) sonography [15] (Level 1c). More recently, accuracy and image quality have improved with the use of high frequency, high resolution linear transducers [24].

Recommendation 1.1

US is the modality of choice for the initial investigation of suspected paediatric intussusception

Grade A

US features such as absent colour Doppler flow or internal trapped fluid may be useful for predicting the likelihood of successful non-operative reduction but are not contraindications to attempted non-operative reduction in selected clinically stable patients

Grade C

1.2 Abdominal radiograph (AXR)

The sensitivity of the plain radiograph in suspected intussusception depends upon the clinical context and whether assessing single or combined imaging features. Individual features such as

sparse small bowel gas have been reported to have a sensitivity of 89% [25]. Absent caecal gas is may have similarly high sensitivity rates and negative predictive values [26, 27]. More modest sensitivity was found for features such as soft tissue mass, present in 68% of cases [28] (Level 3b).

Some signs on AXR may be more specific for intussusception and are potentially of greater diagnostic utility. The 'crescent sign' in the transverse colon is considered by some to be pathognomonic [29], although there is a reported 7% false positive rate [28]. The 'target sign' (alternating rings of fat and soft tissue density) has a reported 85% specificity [28, 30] (Level 3b).

The selective use of the AXR in cases of suspected intussusception has previously been recommended as part of routine work up. If the clinical likelihood of intussusception is low, an AXR may be indicated in order to assess for other pathologies [31] and although it is anecdotally overused for this indication, it may have a role in assessing for contra-indications for attempted non-operative reduction, specifically the presence of free intraperitoneal gas [24] (Level 3b/4).

Recommendation 1.2

The routine use of AXR is not recommended in the diagnosis of suspected paediatric intussusception

Grade C

Plain radiography should be considered if intestinal perforation is suspected in the absence of any indication for immediate operative intervention

Grade C

1.3 Contrast enema

Contrast enema had been the gold standard diagnostic modality for intussusception in the UK until the early 1980s. This modality has the dual advantage of diagnostic and therapeutic efficacy. The diagnostic accuracy is high and en par with US [24, 31, 32].

With the improvement in US equipment, the invasive nature of contrast enema has made it less popular, especially as the investigation threshold has lowered to reduce missed or delayed diagnosis. The wider use of US has improved outcomes overall for intussusception but a consequently higher true negative rate in investigated cases of suspected intussusception.

The use of fluoroscopy in the diagnosis of intussusception has the disadvantage of radiation exposure without the accessibility of AXR as well as the inability to demonstrate many alternative pathologies that US can detect [29, 31, 33].

In current and anticipated future practice, fluoroscopic diagnosis cannot be recommended as a first line investigation although some authors suggest it for cases equivocal on US examination.

Recommendation 1.3

Contrast enema for diagnosis of paediatric intussusception is not recommended given the diagnostic accuracy and non-invasive nature of US

Grade B/C

1.4 Other diagnostic modalities

Other imaging modalities and operative diagnosis are not indicated on account of limited access (MR), relative cost or potential morbidity in cases negative for intussusception (MR, CT, operative). Immediate operative exploration is, of course, indicated in some cases and following negative investigations for intussusception for the identification of other pathologies that may present in a similar fashion.

2 Radiological Reduction Technique

Before attempting non-operative reduction the patient with suspected intussusception should be assessed by a clinician experienced in the care acutely unwell children and ideally specifically of children with intussusception. In the UK, this is almost invariably a paediatric surgeon although often requiring interinstitutional transfer. Patients should be triaged and resuscitated at the first point of contact with health services and prior to any intervention. A full history and systematic examination should be performed unless there is an immediate indication for (operative) intervention prior to diagnostic imaging in which case follow abbreviated goal directed approach

On confirming the diagnosis, the suitability for attempted non-operative reduction must be assessed. The decision to proceed is best made jointly between the primary clinical team and radiologist

All patients proceeding to attempted non-operative reduction must have intravenous access, adequate monitoring and supervision by an appropriate clinician and assistant(s) **in addition** to the interventionist

Parents should have the opportunity to give informed consent for the procedure according to local practice including a discussion of the potential risks of the procedure and occasional need for emergent surgery in case of iatrogenic perforation or failed non-operative reduction

2.1 Air vs Hydrostatic reduction

Non-operative intussusception reduction using various pressure transmission media per rectum is well described. These include liquids (barium, water-soluble contrast and saline) and gases (air or CO_2 most commonly). A retrograde head of pressure sufficient to reduce the intussusception is generated and reduction is both monitored and confirmed using some form of imaging. Fluoroscopy, US and direct (operative) visualisation are all appropriate and established approaches.

Historically, barium salt suspensions were used and provide excellent contrast for monitoring reduction and high efficacy for successful reduction. The consequences of barium peritonitis in the event of perforation has limited more recent use of these media. The deleterious effect of barium perforation was demonstrated in early experimental models and perforation by air rather than barium or other liquid contrast causes less morbidity [34, 35] (Level 4). Routine clinical data suggest longer hospital stays for those perforating with barium enema [36, 37] (Level 4). Water soluble (hypertonic) contrast media are used in some centres [38] and crystalloid (isotonic) solutions have been used with US as the monitoring modality in others [39].

Pneumatic reduction has the advantage of being cleaner and quicker to perform than liquid enema, although negative contrast fluoroscopy can be more difficult to follow than liquid contrast fluoroscopy. Air results in less peritoneal soiling following perforation than liquid contrast but there is a risk of rapidly developing high-pressure pneumoperitoneum. Pressure release valves on all equipment and the ability to decompress tension pneumoperitoneum are essential [40, 41] (Level 5).

Comparison of reduction rates with each of the available methods is much discussed in the literature, including in other national guidelines [33, 38] but high level supporting evidence is very

limited to non-existent. Randomised trials comparing hydrostatic and pneumatic reduction consistently report higher reduction rates for pneumatic reduction [39, 42] (Level 1b) as do smaller retrospective comparative studies concur [43, 44] (Level 2b/3b). Many retrospective series and audits of practice also report good reduction rates with pneumatic reduction. Overall reported pneumatic reduction rates vary from 54-95% with a mean of around 86% [5-7, 39, 42, 45-73] (Level 3b/4). The degree of reported variation and the heterogeneity in reporting methods are all causes for concern in making firm recommendations or meaningful comparisons [7].

On the other hand, many retrospective studies and institutional series show similarly efficacy with hydrostatic reduction including several large studies that utilise US as the means of monitoring the reduction [11, 74-98]. Hydrostatic reduction with US control appears to be gaining in popularity but is not currently routine practice in the UK.

2.1.1 Perforation Rate

Perforation is a principal iatrogenic complication that should be considered in the selection of the pressure transmission medium for non-operative reduction. The cause of perforation during attempted non-operative reduction is multifactorial: gut ischemia, pre-existing (potentially concealed) perforation, patient and technical factors. Several clinical features have been associated with an increased risk of perforation including the duration of symptoms and age [99, 100]. The reduction technique and maximum pressure applied, unsurprisingly, have an effect on perforation rates [33, 37, 101]. Perforations seen at lower pressures support the hypothesis that the mechanical effect of transmural pressure that leads to perforation is not the sole factor and intuitively the characteristics and acute condition of the affected bowel must be a significant factor.

It has been suggested that higher spikes in intra-luminal pressures with pneumatic reduction may lead to an increase in the risk of perforation compared to hydrostatic reduction and the highest reported figures have been in studies employing pneumatic reduction [63, 99, 102-104] (Level 2b/3b) with only 3 hydrostatic studies reporting a >2% incidence of perforation [39, 97, 105] (Level 2a/4). A recent comprehensive review suggests contemporary perforation rates are generally low (<1%) for both pneumatic and hydrostatic reduction [33]. A meta-analysis performed during the development of Japanese national guidelines concurs, but suggests pneumatic reduction has a slightly higher perforation rate (0.76% vs 0.37%) [38]. Of concern in the UK, the most recent national audit found a perforation rate >2% overall [4]. Oddly, the largely unknown (at the time) Chinese experience [106] suggests equivalent rates (<0.25%) of perforation to hydrostatic methods are achievable for pneumatic reduction. The generalisability of this series to current Western practice is uncertain particularly given the incidence and therefore individual experience afforded in that setting at that time.

Surveys of practice from North America, Europe and the United Kingdom have shown a trend away from hydrostatic and towards pneumatic reduction [3, 4, 107-110]. The most recent national audit of UK practice in 2012 found all centres reported using pneumatic reduction almost exclusively [4].

Recommendation 2.1

Air enema reduction is the technique of choice in the UK for attempted non-operative reduction of paediatric intussusception

Grade B

2.2 Reduction monitoring modality

Fluoroscopic visualisation of reduction attempts in real time is by far the commonest surveillance modality. This obviously involves radiation exposure but there is limited literature documenting the actual exposure for intussusception reduction.

Older studies report long exposure times and high radiation doses. This is sometimes due to the use of fluoroscopy as both a diagnostic and therapeutic modality [61, 111, 112]. A more recent study (2014) reports more contemporary exposure levels with a mean screening time of 53s and mean Dose Area Product (DAP) of 11.4cGycm^2 in a centre using principally US diagnosis and pneumatic reduction [113]. Measures taken to reduce radiation dose were tight collimation, copper shields, digital imaging (last image displays etc), low frequency pulsed fluoroscopy, strict training and protocols for fluoroscopy in children and specifically intussusception.

The use of US for monitoring during reduction eliminates any radiation exposure and is common practice in some parts of Europe and the rest of the world. This is well documented for hydrostatic reduction and more recently for pneumatic reduction. Whilst the concept of US guided reduction is appealing, there is concern with regards to the ease of identification of perforation using sonography and also the relative technical difficulty of screening the reduction with US [33, 38] particularly in the context of a low caseload for individual interventionists in nearly all settings.

There are however, several series of US monitored hydrostatic [75, 76, 78, 80, 114] and pneumatic [52, 62, 115] reduction modalities reporting comparable outcomes (>90% efficacy) to fluoroscopically monitored reduction (fluid reduction (level 2b/4), air reduction (level 3b/4).

Whilst the results of these studies need to be taken in to consideration, especially given the reduction in radiation exposure potentially on offer, so does the lack of experience in the UK for US monitored reduction. This lack of experience and ongoing concerns about the identification of perforation with US mean that at present US cannot be routinely supported in the UK as the monitoring modality. A randomised trial would be very useful, especially given current attempts to reduce radiation exposure in children, but would be challenging for this condition and type of intervention. Harmonisation and better reporting infrastructure in the UK would facilitate such studies and are a longer-term goal of the IWG.

Recommendation 2.2

Fluoroscopy should be used to monitor for perforation and confirm successful air enema reduction of intussusception with the following precautions employed to minimise radiation exposure:

A dedicated paediatric fluoroscopy machine and presets for all cases
The lowest possible dose setting that allows satisfactory visualisation
Pulsed screening with a low frame rate, e.g. as low as 1.56/s appears satisfactory [113]
Intermittent rather than continuous screening during the procedure
Collimation to include diaphragms, right lower quadrant and the intussusception itself

Grade C

Consideration should be made for evaluating US as a monitoring modality in a controlled study within the UK context

2.3 Equipment

There is a wide variety of equipment used for hydrostatic and pneumatic reduction from basic hand pumped air systems and gravity fed fluid systems to more complex designs that utilise a pressurised air supply, a gauge to control maximum pressure and automatic cut off valves aimed at improving the safety of the system. Our search only found one commercially available basic pneumatic system [http://www.grimedical.com/shiels_intussusception.htm].

The literature is scant on the specifics of equipment used for reduction. There are several descriptions of basic equipment configurations principally targeted at resource poor settings and using hand pumped air systems [53, 116, 117].

The most recent UK audit [4] demonstrated a lack of standardisation of equipment used in the UK. Broadly, equipment was divided into hand pumped and pressurised air systems. There was no significant difference between reduction rates in each group.

During discussion at the working group it was felt that standardisation of equipment may be useful across the UK to maximise safety, reduction rates and to facilitate training across centres for what is a relatively rare condition [118].

Recommendation 2.3

UK centres should continue to use current familiar equipment but moves towards standardisation of equipment and techniques has potential benefits

Grade D

2.4 Pressures

Pressures used for reduction were initially based on the early descriptions of barium enema [119] and later in the 1980s with the early reports of air enema [43, 120]. Hydrostatic reduction pressures refer directly to the height of the column of fluid used this was extrapolated on the introduction of air as the principal transmission medium. Early descriptions using 120mmHg as the maximum pressure [71] reported excellent reduction rates (91%) with a low perforation rate (0.08%). As a result, the trend has continued for using 120mmHg as the maximum pressure with several series reporting similarly good results [33]. There is little high level evidence for the correlation between pressure and reduction rates, presumably due to the fact that the reducibility of an intussusception is not simply related to the pressure applied but to other factors such as the state of the bowel, configuration of the intussusception and applied time/pressure profile to hypothesise a few. This is also true for the factors determining the risk of perforation. In all but a fully automated system, the interventionist will be an additional complex confounding variable.

In the UK, the original BSPR guideline suggested a standardised graded approach beginning with 80mmHg increasing towards a maximum of 120mmHg. A maximum of 3 attempts of up to 3min each was suggested but was based purely on the historical descriptions of hydrostatic reduction. These related in part to the perceived tolerance of the child and subsequent concerns regarding

radiation exposure. There is no direct evidence to support the use of 3 attempts for 3min each and the optimal approach to non-operative reduction is yet to be defined. Other guidelines provide similar recommendations for example starting pressures of 80mmHg up to 120mmHg with air enema in Japan [38] and 3 attempts of up to 5min at 80-120mmHg in the US [121].

In 22/27 UK centres [4], 19/22 used 120mmHg as the maximum pressure, 2/22 used 130mmHg and one centre allowed pressures up to 180mmHg. The Japanese national guideline [38] included data suggesting some centres are using maximum pressures over 200mmHg. And similar deviations have been reported in the US with pressures up to and above 140mm Hg used in some centres [122].

With these reports of excellent reduction rates and acceptably low perforation rates, most using 120mmHg as the maximum pressure applied, it is difficult to suggest higher pressures are routinely necessary. There is however, no evidence to suggest that higher pressures are not safe and their use on a case by case basis has been suggested [123]. There is arguably much room for improvement in our understanding of the mechanics of transrectal fluidic reduction given the low level of sophistication in the pressure monitoring equipment, generally poor documentation and the importance of transmural as opposed to simply intraluminal pressure.

Recommendation 2.4

The current recommendation of 3 attempts for 3min at 120mmHg is consistent with established practice and has a relatively good safety and efficacy profile

Grade D

This recommendation should not be viewed as proscriptive provided complications are audited Greater sophistication in measurement and further study are needed in this area

Grade D

2.5 Personnel

The personnel involved in intussusception reduction vary in different parts of the world according to the different expertise of professionals in different countries and health service setup [38, 121, 124].

When considering the personnel required, the following should be considered: adequate patient resuscitation, expertise in diagnosis and non-operative intervention, safety principles during reduction and facility to manage complications. Good decision-making is critical concerning attempted non-operative reduction and abandoning such attempts in order to achieve the best outcomes.

In the UK, intussusception care has been centralised to units with paediatric surgical and anaesthetic specialists [3, 4] owing to the relative rarity of the condition and with the aim of ensuring complications can be managed safely and promptly.

Most patients are admitted via the emergency department directly or on transfer from a referring secondary care unit. Here it should be possible be feasible to safely assess and resuscitate even the sickest patients. Diagnostic imaging is usually performed by a specialist radiologist prior to any non-operative intervention. Subsequent planning and delivery of reduction is more variable. The

recent UK audit [4] found that in the majority of responding UK centres (21/22), reduction is led by a consultant paediatric radiologist but in only 12 centres is it routine practice for a paediatric surgery registrar to be present at all reduction attempts [4]. In one centre where reduction was not routinely lead by a consultant (radiologist or surgeon) the published reduction rate in their series was above 80% [109]. In the surveyed centres, the reported reduction rates were significantly higher where surgeons were routinely present at non-operative reduction attempts. The positive influence of surgeon presence at reduction is supported by other series [125].

Despite the low incidence of perforation and other complications in the developed world literature, there is still concern about the safety of non-operative reduction and ability of the personnel involved to manage complications such as perforation and haemodynamic instability [40, 126, 127]. Training of all staff involved is as important as documented procedures or protocols for the management of intussusception [128, 129].

In the UK, radiologists do not routinely complete advance paediatric life support (APLS) training and typically have limited experience of resuscitating acutely unwell children. Intussusception can make even children with viable/salvageable bowel unstable. By analogy to the situation in the operating theatre, a dedicated clinician to monitor and respond to the condition of the child in addition to the primary interventionist is a wise precaution. Extending the analogy, other professionals facilitate the primary intervention and should be seen as desirable if not essential:

Recommendation 2.5

Personnel present at intussusception reduction include:

Interventionist	Usually a (paediatric) radiologist: performs and monitors the reduction attempt
Radiographer	Imaging control if fluoroscopy is the monitoring modality
Clinical supervisor	Usually a paediatric surgeon: monitors the child and with the interventionist oversees the reduction attempt
Assistant	Often also performed by a paediatric surgeon: principally ensures adequate rectal access, positioning and maintains seal
Patient carer	Paediatric nurse: directly monitors and delivers supportive interventions to the patient as directed by clinical supervisor
Grade C/D	

2.6 Delayed Repeat Non-Operative Reduction

Also and more commonly referred to as delayed repeat enema (DRE), a second or further attempts at non-operative reduction in a stable child where there has been some progress has gained recent popularity as an acceptable method for increasing the non-operative reduction rate . Delayed attempts at non-operative reduction prior to operative intervention are not a new concept [130,

131] but have been championed by some centres and have become acceptable to the mainstream as more evidence (largely case series) has been published [55, 131-135]. The definition of a delayed attempt is not clear but should be seen as distinct from repeated attempts at the same session within a time frame of minutes. The decision to opt for a delayed repeat enema should be made jointly between interventionist and primary clinical team based on clinical and radiological parameters as well as progress during the initial non-operative reduction attempt (Level 5).

Recommendation 2.6

Delayed repeat attempts at non-operative reduction can be considered in stable patients with favourable imaging and progress at the first attempt

Grade C

Delayed repeat attempts can be considered in all stable patients with progress at the first attempt

Grade D

2.7 Adjuncts for non-operative reduction

Non-operative reduction is typically performed in an awake child typically at a preverbal stage of development and limited active cooperation with both diagnostic examination and intervention. This can prove challenging for the interventionist and potentially distressing to the patient. Strong analgesia, sedation and general anaesthesia have all been used in an effort to alleviate distress and potentially facilitate reduction. Muscle relaxants and pharmacological adjuncts such as glucagon are used infrequently in an effort to facilitate reduction.

Prophylactic antibiotics are frequently administered prior to attempted radiological reduction although the overall risk of perforation is low and the incidence of significant bacterial translocation in the absence of ischaemic/necrotic bowel is unknown and likely to be of similarly low incidence.

The evidence for all of these adjuncts is both limited and generally of poor quality. Strong recommendations cannot therefore be made but their use (aside from antibiotic prophylaxis) is limited in the UK and so are not recommended for routine use. Antibiotic prophylaxis although likely unnecessary in the vast majority of cases is also likely to be of limited potential harm even allowing for antibiotic overuse consequences given the absolute rate of intussusception in the population. The high rates of reduction potentially achievable without any adjuncts suggest that any additional benefit may be both limited and difficult to demonstrate objectively (see comments on reduction rates/complications.

2.7.1 Analgesia/Sedation/General Anaesthesia/Muscle relaxants

Benzodiazepines are the most frequently used sedative (aside from the sedative effects occurring as a by-product of strong analgesics). Although contemporary series [136] and older literature [137] propose a positive effect of sedation on success of non-operative reduction there has been no prospective or robust evaluation and in the first case other potentially active agents were used as premedication. The situation is confounded by dual actions of some of the agents for example

producing sedation (facilitating the intervention) and smooth muscle relaxation (potentially reducing the resistance to reduction) [138]. Preclinical work (which incidentally is the likely origin of the 120mmHg pressure limit) has suggested a possible increased rate of perforation under sedation presumably due to an imbalance of intra and extra-luminal pressure without active abdominal contraction/Valsalva under deep sedation/anaesthesia [139, 140]. Delayed repeat non-operative reduction attempts have been postulated as the basis of successful reductions under general anaesthetic as opposed to any positive effect of anaesthesia (Section 2.6).

Despite various references [3, 4, 38, 107, 108, 121, 122, 141] to the use of muscle relaxants (almost always benzodiazepines) there is only one small and purportedly randomised study (n=32) that specifically addresses the efficacy of muscle relaxation as an adjunct to non-operative reduction [142]. The best estimates of perforation rate are around 1% for air enema and less for liquid enema making this the study greatly under powered to detect any increase in the incidence of perforation. It also excluded many cases that would be considered more advanced but nonetheless appropriate for attempted non-operative reduction giving a more favourable patient group.

2.7.2 Glucagon

Largely of historic interest, glucagon is seldom used in modern practice and has rarely even been commented upon since the 1990s. It is used for its smooth muscle relaxant effect and no other mechanism has been suggested for older reports of efficacy. There do not appear to be any high quality studies of its efficacy and only 2 randomised studies both of which are old (1980s) and use hydrostatic reduction. One has too low control success rate to be representative today although it was run as double blind [143] and the other was larger and more representative but unblinded and showed no significant difference with glucagon [144].

2.7.3 Antibiotics

Perhaps surprisingly, there have been no direct comparisons of antibiotic prophylaxis in the non-operative management of intussusception. In routine practice, prophylaxis will usually be given for operative reduction even though it may not strictly be necessary and is extrapolated from general use in gastrointestinal surgery where in paediatrics at least it is an extrapolation and pragmatic intervention. Also surprising is the relatively low rate of routine antibiotic use in several surveys both in the UK and internationally and over the various eras of contemporary practice from the 1990s onwards [3, 4, 107, 108, 122, 130, 141]. This would seem an ideal area for a randomised study however it is probably not one likely to produce a significant improvement in practice given the relatively low rate of infective complications even in complicated cases (a large number needed to treat expected) and by reasonable extrapolation from other similar conditions and interventions.

Recommendation 2.7

No firm recommendations can be made but given the lack of evidence of harm in centres that do not routinely administer antibiotics local policy should be agreed considering the following:

Selective use in patients likely to have more advanced disease (late presentation, resuscitation requirement) where perforation/surgical resection more likely
Ready availability of appropriate antibiotics for immediate administration in the event of perforation where they are not given routinely

Grade D

2.8 Operative Management

When non-operative management fails or in the presence of certain complications of the condition or non-operative intervention emergent surgery is indicated to avoid or mitigate perforation and/or bowel ischaemia. Traditionally this is by transverse laparotomy but reports of minimally invasive approaches using alternative incisions (for example [145]) or laparoscopy are neither as unique nor as contemporary as might be expected (for example as [146]) with references to at least diagnostic use of laparoscopy dating to at least the 1980s. The evidence base as with much of this field is poor comprising a majority of case reports and varying case series usually analysed retrospectively and in single centres. There are variations in the technique including single incision laparoscopy [147] and laparoscopic visualisation of hydrostatic reduction [148] as with imaging guided approaches.

The outcome after operative reduction depends on the technique used in terms of procedure specific complications (adhesions, wound complications, anastomotic leak/stenosis). The incidence would not be expected to differ greatly from those in other GI surgery in an adequately resuscitated child or equivalent physiological status. The second factor is the condition of the bowel at reduction where this is possible/performed although generally the appearance and immediate recovery are good indicators of viability given the low rate of late complications after simple reduction of intussusception (by any means). As manual reduction affords greater control, more borderline bowel can be reduced and there are anecdotal and case reports of segmental stricture.

Laparoscopic approaches have traditionally been viewed as counter to the principles of open reduction but there is no high level evidence that either approach is superior. A recent systematic review concludes [149] laparoscopy is an effective and safe method for reduction of intussusception based on 10 retrospective studies (Level 2B) including 276 patients. The reduction rate was 70% however (as will be discussed in section 3.1), without any data on the preoperative management (attempted non-operative reduction) and a relatively low rate of ischaemic bowel requiring resection the included studies may overestimate the utility and safety of the laparoscopic approach. There is undoubtedly publication bias but this was not assessed in this review. Although the authors claim the grade of recommendation is C this is perhaps an overestimate of the validity of the data presented.

Recommendation 2.8

No firm recommendations can be made but the operative technique should be one with which the surgeon is familiar and minimise additional risks of the operative approach given the low background risk of complications in unperforated intussusception

Grade C/D

2.9 Other management options

No other well-established management options apart from extracorporeal manual reduction were found by this review group in the preparation of the guidance. Extracorporeal manual reduction has an even weaker evidence base than the principal methods described so far and therefore cannot be recommended. Indeed any other modifications or novel approaches ideally require a better research and monitoring infrastructure for this condition, which in the UK would have to be on a national, multicentre and ideally whole population basis. The IWG supports the establishment of a clinical network and support infrastructure to this end as an absolute prerequisite for progress in the management of intussusception in the UK.

3 Outcomes

There is a lack of contemporaneous reporting systems in the health care systems the review group is familiar with and the composition of the literature suggests the majority of audit is retrospective or based on routinely collected data. In the latter case it is overwhelmingly used to survey for post vaccination incidence of intussusception. The best estimates of outcomes therefore are derived from predominantly retrospective case series, often small or collected over long periods of time in single centres [7].

3.1 Reduction Rates

It is surprising that there is an almost complete lack of discussion of the definition of the 'reduction rate' nor of the biases inherent in the selective reporting of case series. The greatest discrepancy is in the division of operative and non-operative cases in published series, which are frequently presented in complete isolation or at least with no clear indication of the management of the whole population presenting to the reporting centre. This continues to be an issue in recent publications (for example [150]) despite some discussion following a paper on the subject by members of the IWG [4, 7, 109, 151, 152] and a handful of series referencing the paper [153, 154] it has not been widely adopted and the proposed solution was not even considered by 2 of the 3 citing studies [155, 156].

In brief, the predominant reporting pattern is to simply calculate success with non-operative reduction in the cases for which it was attempted. Given the primary rate of surgery can be greater than 1/3 and perhaps 30% of cases might require surgery eventually this leaves significant potential for bias in the reported rate of success with non-operative techniques. The proposal is that the reported reduction rate should be the proportion of all intussusceptions that could have been reduced without any subsequent need for bowel or lead point resection (so called 'composite reduction rate' or CoRR). In doing so, fluctuations in success due to case mix (late presentation, pathological lead points) are compensated and case selection for attempted non-operative reduction is accounted for in the performance statistic for the given population [7].

Until the whole population of patients with intussusception is considered in any analysis, the results and reported performance will remain biased and firm conclusions cannot be drawn even from superficially high-level evidence from randomised trials and meta-analyses.

Recommendation 3.1

Reporting of reduction rates should be standardised and minimise selection bias in particular

The Composite Reduction Rate (CoRR) is suggested as an appropriate primary performance statistic for intussusception

Grade C

3.2 Radiation Exposure

Recommendation 3.2 (as per 1.2 & 2.2)

The routine use of AXR is not recommended in the diagnosis of suspected paediatric intussusception

Grade C

Fluoroscopy should be used to monitor for perforation and confirm successful air enema reduction

The following precautions should be employed to minimise radiation exposure:

Dedicated paediatric fluoroscopy machine and presets for all cases
Lowest possible dose setting that allows satisfactory visualisation
Pulsed screening with a low frame rate, e.g. as low as 1.56/s appears satisfactory [157]
Intermittent rather than continuous screening during the procedure
Collimation to include diaphragm, right lower quadrant and the intussusception itself

Grade C

3.3 Complications

Complications following the prompt management of intussusception are fortunately rare even where the condition is complicated by gut ischaemia or perforation. Deaths in children who present to hospital (as was the case in the last century [158]) have largely disappeared thanks to improved diagnostic imaging and greater awareness. The principal complications can be grouped as surgical (wound complications, anastomotic failure and rarely ischaemic stricture that can occur in unresected bowel), radiation (cumulative dose of any ionising radiation) and perforation during attempted reduction. Good estimates for this condition specifically have not been produced but they are not generally considered major. Perforation may be iatrogenic or may be revealed in a non-viable segment of bowel when it is reduced (when it could be considered a consequence of disease).

Based on several large series [6] the rate of perforation with air enema is considered to be approximately 1% although one of the largest series ever reported (China, 1986) suggested this rate could be much lower at ~0.1% [106]. This would place it at approximately the same level as the accepted rate for hydrostatic reduction.

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