ORIGINAL ARTICLE

Safety and Feasibility of Laparoscopic Reduction of Intussusception in Infants and Children After Failure of Pneumatic Reduction

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Abstract

Background: ***One of the most frequent reasons why children have intestinal obstruction is intussusception. The rate of success for pneumatic reduction is high. Pneumatic reduction failure is most frequently caused by the existence of a pathological leading point. There is still debate regarding laparoscopy after unsuccessful pneumatic reduction.***

Aim: ***To assess laparoscopy's safety and viability following a failed pneumatic reduction of intussusception.***

Patients and method: ***This prospective study was conducted on children and infants who had non-complicated intussusception. Over the course of a year, from July 2023 to June 2024, it was carried out at the pediatric surgical department at Al-Azhar University Hospitals. The patients were managed with pneumatic reduction. Then, after a failed reduction, laparoscopy was decided. The study collected data encompassing patient profiles, preoperative and operative variables, early postoperative complications, duration of hospitalization, and the length of the follow-up period.***

Results: ***Twenty patients with an average age of 9.65 ± 3.44 months were involved in the study. There were nine females (45%) and eleven males (55%) with a mean body weight of 9.65 ± 3.44 kg. Ileocolic intussusception was found in 11 cases (55%), ileocecal intussusception in 7 cases (35%), and negative exploration in 2 cases (10%) during laparoscopic exploration. After surgery, the average time to begin oral feeding was 1.38 ± 0.79 days. Hospital stays lasted an average of 2.44 ± 1.21 days.***

Conclusion: ***With a comparatively short operating time and hospital stay, laparoscopy after unsuccessful pneumatic reduction for pediatric intussusception may be a safe and practical choice.***

Keywords: Laparoscopy; Pneumatic reduction; Intussusception; Children

1. Introduction

In children under five years old, idiopathic intussusception is one of the most frequent causes of intestinal blockage.[1] With an average success rate of 80%, non-operative treatment for intussusception is regarded as the first line of treatment. This includes saline enema guided by ultrasound or pneumatic reduction utilizing air guided by fluoroscopy.[2] Pneumatic reduction with fluoroscopic monitoring has become more and more popular. It is a very effective alternative to hydrostatic reduction and has other benefits, such as lower cost and a lower risk of perforations. About 10–20% of cases require surgery after failed enema reduction, hemodynamic instability, and/or peritonitis.[3]

Initially employed as a diagnostic tool following unsuccessful hydrostatic reduction, laparoscopy evolved to include laparoscopic-assisted hydrostatic reduction and is now utilized as a definitive treatment approach.[4] Nevertheless, the use of laparoscopic techniques for managing intussusception after failed pneumatic reduction remains controversial, with limited publications in English-language literature. This study aims to assess the efficacy of laparoscopy following unsuccessful pneumatic reduction of intussusception, examining factors such as safety, feasibility, duration of surgery, intraoperative challenges, rate of conversion to open procedures, length of hospital stay, postoperative complications, and recurrence rates.

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2. Patients and methods

A prospective non-comparative case series was conducted on infants and children exhibiting symptoms and signs of intussusception. The study took place in the pediatric surgery department at Al-Azhar University Hospitals over a 12-month period from July 2023 to June 2024. The Faculty of Medicine's ethics committee at Al-Azhar University approved the study protocol. After a comprehensive explanation of the procedure's steps and purpose, written informed consent was obtained from the participants' parents.

All infants and children within the age of enrollment (3 months - 5 Years) who presented with non-complicated intussusception and underwent failed pneumatic reduction were included in this study. Patients aged < 3 months or > 5 years, patients with successful non-operative reduction, patients who underwent laparoscopy from the start or laparoscopic-assisted hydrostatic reduction, and patients who had relative or absolute contraindications for laparoscopy were excluded from this study.

Every patient underwent a comprehensive medical history assessment, thorough physical examination, and standard laboratory tests (including CBC, PT, PTT, INR, blood gas analysis, and serum electrolyte measurements). Preoperative diagnostic procedures included an upright abdominal X-ray to rule out perforation, as well as an abdominal and pelvic ultrasound to determine the location and dimensions of the mass.

Protocol of therapy

Pneumatic Reduction

In the operating room, with the patient under general anesthesia and positioned supine, a lubricated Foley's catheter 18 was introduced into the child's rectum. The catheter's balloon was then inflated using 20-30 ml of normal saline. To seal against air escape, the child's buttocks were secured together with adhesive tape. Under fluoroscopy, an initial control film was taken to assess bowel gas distribution. Then, insufflating air into the colon was started by manually squeezing the hand pump slowly and intermittently to avoid exceeding the pressure of 80-120 mmHg, while gently pulling the catheter against the perineum to prevent air leak. The progress of air was observed on the monitor until the mass fully disappeared and air freely returned to the small intestine in the central abdominal region, signifying a successful and complete reduction procedure. It is worth noting that at the initiation of insufflation, the colon arch sign appeared clinically on the patient's abdomen, which means a circumscribed, inflated colon before the success of reduction; however, the disappearance of this sign and centralization of air in the abdomen indicate successful reduction (Figure 1). If air failed to reflux into the small bowel, a total of three trials, five minutes each, with five minutes rest in between, were consumed before deciding on failed reduction and shift to laparoscopy. Before starting sterilization and draping, a bedside pelvi-abdominal ultrasound was done in the OR by a radiologist to ensure the presence of a mass and to detect its position to decide the arrangement of ports.

Figure 1. Shows disappearance of colon arch signand centralization of air in the abdomen indicate successful reduction

Laparoscopic Reduction

Following sterilization and draping, with the patient's position maintained, a 5-mm umbilical port was created using an open Hasson technique to establish pneumoperitoneum. Initial abdominal insufflation was set at 8–10 mmHg pressure, with a flow rate of 1.5 l/min. Laparoscopic exploration was used to confirm the mass's location. Two additional 5-mm working ports were positioned. The patient's size and mass position determined where they were located. For manipulation, two nontraumatic wide-jaw bowel graspers were employed. In order to reduce intussusception, the surgeon's right hand milked the intussusceptum from the distal bowel while the surgeon's left hand gently pulled. A bowel inspection was done before the end of the procedure to exclude the presence of a lead point or perforation. After complete reduction, abdominal deflation and port site closure were performed. In cases of failed reduction or no progress for a median of 45 minutes, conversion to laparotomy via vertical extension of the umbilical incision and manual reduction was done.

Discharge and follow-up:

The child was discharged from the hospital after he/she tolerated oral feeding. Parent education about the possibility of recurrence of the intussusception and the importance of being aware to return to the emergency department early if similar picture of previous attack recurred. The authors of this article were the surgical team and concerned physicians for follow-up. Follow-up was done at the outpatient clinics of Al-Azhar

University hospitals to exclude postoperative complications (e.g., recurrence, wound infections, port site hernia). Frequency of follow-up visits was 1week, 1month, 3 months, 6 months, and 1 year.

Statistical analysis

The statistical analysis program SPSS (Statistical Package for Social Science [SPSS] [version 21] [IBM Corp., released 2012]) was used to gather and enter data into a computer. When the probability of error was less than 5% ($P < 0.05$), the results were deemed statistically significant.

3. Results

138 patients diagnosed to have intussception were presented to department of pediatric surgery over 12 months from July 2023 to June 2024. 7 cases were presented with symptoms and signs of peritonitis. These patients were transferred directly to OR after resuscitation. Remaining 131 patients were managed with pneumatic reduction under GA in OR. Successful pneumatic reduction encountered in 111 patients. Failed pneumatic reduction were encountered in 20 patients who were managed after that by laparoscopy. There were 11 males with (55%) and 9 females (45%) included in this study with age ranging from 5 to 18 months, and a mean body weight of 9.65 ± 3.44 kg [Table 1]. Gastroenteritis was found to be the most noted predisposing factor for intussusception, followed by Upper respiratory tract (URT) infection. It took an average of 1.79 ± 0.99 days from the start of symptoms to the diagnosis. Different presenting symptoms were encountered, with bleeding per rectum was the predominant symptom encountered. It was noted in 18 patients (90%) followed by vomiting, paroxysmal cry and abdominal pain in 16 patients (80%). On examinations, fever, dehydration, abdominal distension, palpable mass, and red currant jelly stool were encountered. The most elicited sign was the red currant jelly stool. It was encountered in 18 patients (90%). Low grade fever was the least observed sign, 3 patients (15 %), [Table 1].

Analysis of preoperative data showed that the mean total leukocytic count was 11.12 ± 3.61 thousands/cm., mean hemoglobin level was 9.41 ± 1.16 g/dl., while the mean pH value of blood gases was 7.37 ± 0.07, [Table 2].

Air fluid levels in erect anterior posterior plain abdominal X-ray was found in 6 patients (30%). Preoperative abdominal ultrasound showed the pathognomonic target sign for intussusception. It was encountered in all abdominal regions with the predominant site was right Iliac fossa in 7 patients (35%) of patients, and the least encountered site was epigastric in 2 patients (10%). Mean maximal diameter of the mass, measured by ultrasound was 4.55 ± 0.78 cm [Table 2].

Laparoscopic exploration of 20 cases (100%) after failed pneumatic reduction revealed ileocolic intussusception in 11 cases (55%), ileocecal intussusception in 7 cases (35%) and negative exploration in 2 cases (10%). Of the 18 cases (90%) showed presence of intussusception by laparoscopic evaluation, 14 patients (70%) underwent complete reduction of intussusception laparoscopy, while 4 patients (20%) converted to open due to intraoperative difficulties, 3 of them (15%) were due to tight intussusception and 1 case (5%) was due to ilial perforation. The mean time for laparoscopically managed patients was 46.63 ± 12.34 min, [Table 3].

Of 14 patients completed laparoscopically (100%), 11 patients (78.6%) had no intraoperative complications, while 2 patients (14.3%) had colonic serosal tears, and 1 patient (7.1%) had ileal serosal tear during trial of reduction, however all 14 cases were completed laparoscopically. Post-operative complications were encountered in 2 cases (14.30%), prolonged post-operative ileus and recurrence were found in 1 patient for each (7.15%). Ileus was managed conservatively by good hydration and electrolytes administration. Recurrence was encountered within the 1st week postoperative and was managed successfully by pneumatic reduction, [Table 3].

In laparoscopically managed cases, patients resumed oral feeding after an average of 1.38 ± 0.79 days post-surgery, with a mean hospital stay duration of 2.44 ± 1.21 days. The average follow-up period extended to 7.20 ± 1.51 months, as detailed in [Table 3]. Statistical analysis, presented in [Table 4], showed no significant associations between the success of laparoscopic reduction and factors such as patient age, time elapsed since symptom onset, or the dimensions of the mass.

Table 1. Demographic and Clinical assessment data of the study population (n = 20)

	NO.	%
SEX		
• MALE	11	55.0
• FEMALE	9	45.0
AGE		
• MIN. – MAX.	5.0 – 18.0	
• MEAN ± SD.	9.65 ± 3.44	
BODY WEIGHT		
• MIN. – MAX.	5.50 – 11.0	
• MEAN ± SD.	7.83 ± 1.69	
PREDISPOSING FACTORS		
• GASTROENTERITIS	14	
• URT. INFECTION	6	

ONSET OF SYMPTOM		
• MIN. – MAX.	0.75 – 5.00	
• MEAN ± SD.	1.79 ± 0.99	
SYMPTOMS VARIANTS:		
ABDOMINAL PAIN	16	80.0
BLEEDING PER RECTUM	18	90.0
VOMITING		
• NO	4	20.0
• BILIOUS	3	15.0
• NON-BILIOUS	13	65.0
SIGNS		
• FEVER (LOW GRADE)	3	15.0
• DEHYDRATION	4	20.0
• ABDOMINAL DISTENTION	14	70.0
• PALPABLE MASS	14	70.0
• RED CURRANT JELLY STOOL	18	90.0

Table 2. Preoperative data of the study population (n = 20)

	NO.	%
LABORATORY		
TLC		
• MIN. – MAX.	6.40 – 18.80	
• MEAN ± SD.	11.12 ± 3.61	
HB		
• MIN. – MAX.	7.50 – 11.60	
• MEAN ± SD.	9.41 ± 1.16	
PH		
• MIN. – MAX.	7.27 – 7.49	
• MEAN ± SD.	7.37 ± 0.07	
AIR FLUID LEVELS		
• NO	14	70.0
• YES	6	30.0
TARGET SIGN SITE		
• RIGHT ILIAC FOSSA	7	35.0
• RIGHT LUMBER	3	15.0
• RIGHT HYPOCHONDRIUM	5	25.0
• EPIGASTRIC	2	10.0
• LEFT HYPOCHONDRIUM	3	15.0
	Min. – Max.	Mean ± SD.
TARGET SIGN SIZE PER CM		
• MIN. – MAX.	3.0 – 6.0	
• MEAN ± SD.	4.55 ± 0.78	

Table 3. Operative, intraoperative, postoperative data of patients underwent laparoscopy

	NO.= 20	%
OPERATIVE FINDINGS		
• ILEOCOLIC	11	55.0
• ILEOCECAL	7	35.0
• NEGATIVE EXPLORATION	2	10.0
OPERATIVE DETAILS		
SUCCESSFUL LAP. REDUCTION	14	70.0
NEGATIVE EXPLORATION	2	10.0
CONVERSION TO OPEN		
• TIGHT INTUSSUSCEPTION	3	15.0
• ILEAL PERFORATION	1	5.0
	No.= 14	%
TIME OF OPERATION		
• MIN. – MAX.	28.0 – 66.0	
• MEAN ± SD.	46.63 ± 12.34	
INTRAOPERATIVE COMPLICATIONS		
• NO	11	78.6
• COLONIC SEROSAL TEAR	2	14.3
• ILEAL SEROSAL TEAR	1	7.1
POST-OPERATIVE COMPLICATIONS		
• RECURRENCE	1	7.15
• POSTOPERATIVE ILEUS	1	7.15
FOLLOW UP/ MONTHS		
• MIN. – MAX.	6.0 – 9.0	
• MEAN ± SD.	7.20 ± 1.51	
POST OP. ORAL FEEDING/DAYS		
• MIN. – MAX.	1.0 – 4.0	
• MEAN ± SD.	1.83 ± 0.79	
HOSPITAL STAY/DAYS		
• MIN. – MAX.	2.0 – 6.0	
• MEAN ± SD.	2.44 ± 1.21	

Table 4. Relation between outcome of laparoscopy and age of the patients, time lag after onset of symptoms, and target sign size (n=18)

	SUCCESSFUL LAPAROSCOPIC REDUCTION		P VALUE
	No (n = 4)	Yes (n = 14)	
AGE			
• MEAN ± SD.	7.75 ± 2.75	10.13 ± .50	0.226
• MEDIAN (MIN. – MAX.)	7.50(5.0 – 11.0)	10.0(5.0 – 18.0)	
ONSET OF SYMPTOM			
• MEAN ± SD.	2.63 ± 1.60	1.58 ± 0.71	0.122
• MEDIAN (MIN. – MAX.)	2.0(1.50 – 5.0)	1.50(0.75 – 3.0)	
TARGET SIGN SIZE			
• MEAN ± SD.	5.13 ± 1.03	4.41 ± 0.66	0.249
• MEDIAN (MIN. – MAX.)	5.25(4.0 – 6.0)	4.50(3.0 – 6.0)	

4. Discussion

Literature has shown that prompt reduction during bowel blood flow obstruction is crucial for saving strangulated intussusception and reducing the need for extensive bowel resection.[5-6] Pneumatic enema reduction has emerged as the primary treatment for intussusception, boasting a success rate of up to 90% .[7]

Many researchers have advocated for the use of minimally invasive techniques to prevent the need for laparotomy.[8-10] However, there is a lack of comprehensive reviews in English literature regarding the safety and effectiveness of these minimally invasive approaches for treating pediatric intussusception. This study sought to evaluate the efficacy and feasibility of using laparoscopic reduction in pediatric cases where pneumatic reduction had failed.

The study protocol involved performing laparoscopic exploration after unsuccessful air enema reduction, instead of immediately resorting to laparotomy. This approach offers the benefit of allowing for the detection of injuries to bowel segments away from the intussusceptum, which may result from air enema reduction attempts, as well as the identification of other abdominal issues and potential lead points. In this research, laparoscopy was selected following failed air enema reduction due to the high rate of conversion from laparoscopy to laparoscopy-assisted mini-open reduction or laparotomy, reported to be 71.8% in previous studies that initiated treatment with laparoscopic reduction.[11-12] In contrast, Yang et al.[13] suggested

that a more liberal use of laparoscopic intervention for intussusception could effectively lower the risk of intestinal resection, thus showing promising outcomes for patients with this condition. Their study reported a notably shorter operation time and lower rate of conversion to open surgery in the group that began with laparoscopy (LIBERAL group) compared to the group that underwent laparoscopy after pneumatic reduction. This finding contradicts the results of the present study, which demonstrated a high success rate for pneumatic reduction of intussusception, even for masses located in or beyond the transverse colon, without any time delay between pneumatic reduction and laparoscopic exploration. Moreover, due to the high volume of cases (about 100 pneumatic reductions per year), the surgical team has developed significant expertise in non-surgical reduction techniques, reserving laparoscopic exploration for only the most complex cases.

The age of the children with intussusception in the current study ranged from 5 months to 18 months. Several studies have reported the same age range.[14-15] However, Nguyen et al.[16] reported a wider age range of 2–134 months.

In the current study, there was no significant relationship between age and laparoscopic reduction outcome. However, Nguyen et al.[16] reported that older patient age was associated with a higher success rate of laparoscopic reduction. Older patients are more likely to tolerate pneumoperitoneum and have more intra-abdominal space for successful laparoscopic reduction. With a male-to-female ratio of 1.2:1, this study revealed a male predominance in terms of gender distribution. Kaiser et al.[17] and Zhao et al.[18] reported a male-to-female ratio of 2:1, which was somewhat higher than this. The smaller number of instances in the current study or the racial variables could be the cause of this discrepancy.

Different presentations were observed among the patients included in this study. More than one symptom was observed. Vomiting and abdominal pain were observed in 80% of the patients. This result is consistent with the findings of Zhao et al.[18] They reported vomiting and abdominal pain in 70.9% and 87.1% of the patients, respectively. Rectal bleeding was reported in 90% of the cases in this study, compared to 64.5% and 70% in Zhao et al. [18]. Abdominal mass and fever were found in 70% and 15% of cases, respectively, in the current study. This is consistent with the value of 66.1% in Zhao et al.[18]

The average duration between the start of symptoms and surgery in this study was 1.79 ± 0.99 days. The results of Zhao et al.[18] are comparable to this one. Before surgery, they reported a median duration of symptoms of 0.71. They found no correlation between the success rate of laparoscopic reduction and the onset of symptoms. This outcome aligns with the current study's findings.

The present investigation found that 55% of patients had ileocolic target signs, while 35% had ileocecal signs. These observations are in line with Li et al.[11] who reported the ascending colon as the most frequent location.

The current study revealed a 20% conversion rate from laparoscopic to open surgery. The primary reasons for conversion were tight intussusception (15%) and perforation (5%). These findings align with those of Zhao et al.[18] and Kia et al.[19], who reported conversion rates of 17.7% and 12.5%, respectively. In contrast, Nguyen et al.[16] noted higher conversion rates of 48% and 72%.

Examination of the intussusceptum's leading edge in the four conversion cases in the current study showed that 75% were situated distal to the splenic flexure of the colon. This observation corresponds with Zhao et al.[18], who found that 45% of intussusception conversion cases occurred in this area.

Additionally, Kanglie et al.[20] and Jamshidi et al.[14] reported spontaneous reduction of ileocolic intussusception following unsuccessful pneumatic reduction in approximately 10% and 15% of cases, respectively. This is consistent with the current study, where 10% of cases experienced spontaneous reduction and yielded negative results during laparoscopic exploration.

The incidence of intraoperative complications was 21.4% in the form of serosal tears, 14.3% colonic, and 7.1% ileal serosal tears, which is consistent with the findings of Zhao et al.[18] who reported that intraoperative complications were 19.4%.

In this study, the average duration of laparoscopic reduction procedures was 46.63 ± 12.34 minutes, aligning with the results reported by Nguyen et al.[16] who observed a mean operative time of 32 ± 17 minutes. Similarly, the current study's findings are in agreement with those of Zhao et al.[18] and Jamshidi et al.[14] who documented operative times spanning from 40 to 145 minutes and 24 to 184 minutes, respectively.

In terms of postoperative complications, this study documented a recurrence rate of 7.1%, which is in line with existing literature. This finding is comparable to the 4.9% recurrence rate reported by Zhao et al.[18] and the 7.2% rate observed by Nguyen et al.[16] Notably, the current study did not encounter any instances of port site wound infection, mirroring the results of Zhao et al.[18] However, while Zhao et al.[18] reported a 3.2% occurrence of port site hernias, the present study

found no such cases, marking a divergence in outcomes between the two investigations.

In this study, patients began oral feeding within the initial four days, with an average time of 1.83 ± 0.79 days. This result is comparable to the findings of Zhao et al.[18] and Jamshidi et al.[14] who reported that postoperative oral feeding started between 1.0 and 6.0 days, and 1.0-4.0 days, respectively. Additionally, the average length of postoperative hospitalization was 2.44 ± 1.21 days, which is in line with Jamshidi et al.[14] who noted a mean postoperative hospital stay of four days.

During pneumatic reduction, the colon sign that occurs at the initiation of inflation (i.e., a well-circumscribed inflated colon) before the success of reduction has been observed. The disappearance of this sign and the centralization of air in the abdomen have been shown to indicate a successful pneumatic reduction. A review of the English literature revealed that this has not been published as a finding during pneumatic reduction, so it is unique to the current study. It is hypothesized that this sign may be utilized as a guide during pneumatic reduction in cases where fluoroscopic guidance is unavailable; however, this hypothesis requires validation through further research.

This study encountered several limitations, including its confinement to a single center, a restricted number of participants, and a comparatively brief postoperative monitoring duration of 6-12 months. Consequently, it is advised that subsequent research endeavors involve multiple institutions, encompass a larger cohort, and extend the follow-up period to better evaluate long-term outcomes.

4. Conclusion

With a reasonable operating time and a respectable conversion rate, laparoscopy after unsuccessful pneumatic reduction may be regarded as a feasible and secure method for treating uncomplicated primary intussusception in pediatric patients.

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