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Effects of General Anesthesia on the Success Rate of Pneumatic Reduction in the Treatment of Intussusception

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Abstract

Background: Intussusception is one of the most frequent reasons for intestinal obstruction in young children, which needs to be treated immediately. When it comes to non-operative reduction, there is no gold standard. Our goal was to look into how general anesthesia affected the success rate of pneumatically reduced intussusception guided by fluoroscopy.

Methods: This prospective study was done throughout the time between January 2023 and January 2024 by collaboration between the Pediatric Surgery Unit and Diagnostic Radiology Departments, Al-Azhar University Hospital, New Damietta, Egypt. Under general anesthesia, pneumatic reduction guided by fluoroscopy was performed on all intussusception patients. Children with pathologic lead points discovered by ultrasonography, those with symptoms of intestinal perforation or peritonitis, and those who were hemodynamically unstable were excluded. Statistical analysis of the obtained data was done using the SPSS program (version 20).

Results: In all, 34 children between the ages of 3-28 months, pneumatic reduction under general anesthesia was successful in 32 individuals (94.1% overall). On the first trial, the intussusception was succeeded in 26 patients; on the second try, it was reduced in 5 patients, and in the third, in 1 patient. In two cases, the intussusception failed after three successive trials. One of them was diagnosed as an extended intussusception mass, which was later surgically confirmed, and the other was an appendico-cecal intussusception. During the reduction efforts, there was no bowel perforation or death reported.

Conclusion: As a first-line therapy for pediatric intussusception, fluoroscopy-guided PR under GA is straightforward, risk-free, and successful, with no complications or mortalities.

Keywords: Fluoroscopy, Intussusception, General anesthesia, Pneumatic reduction

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Introduction

Intussusception is the most prevalent cause of intestinal obstruction in babies and children, which is also likely the second most common cause of acute abdominal pain in children under the age of six, behind constipation (1, 2).

The illness presents clinically as frequent crying fits, a palpable lump in the abdomen, discomfort in the abdomen, distention in the abdomen, and thick, bloody stools. Although there are several potential etiologies for intussusception, idiopathic causes are most frequently identified (3). Maintaining intestinal integrity, avoiding complications,

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↑What is "already known" in this topic:
Intussusception is the most prevalent cause of intestinal obstruction in babies and children, which is also likely the second most common cause of acute abdominal pain in children under the age of six, behind constipation.

→What this article adds:
Pneumatic reduction of intussusception under general anesthesia guided by fluoroscopy is a well-tolerated, straightforward, safe, and successful procedure with a high success rate and no complications. It can be used as the primary nonsurgical treatment for pediatric intussusception.

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and reducing mortality are all dependent on an early diagnosis and prompt treatment of intussusception. Treatment options for intussusception range from operative to non-operative techniques (4).

Non-operative reduction therapies, either hydrostatic or pneumatic reduction under imaging guidance, with greater usage of fluoroscopy since it is a highly helpful, reproducible, affordable and accessible technology, may be easily employed for early management of intussusception (3).

General anesthesia (GA) and sedation have unknown benefits for the reduction operation, and different institutions utilize them in very different ways (5, 6).

Therefore, the aim of this study was to evaluate how general anesthesia affected the success rates of pneumatic reduction in intussusception in children.

Methods

This prospective study involved *34* patients aged 3 to 28 months who presented with intussusception diagnosed by plain X-ray and ultrasonography. The study was conducted between January 2023 and January 2024 in collaboration with the pediatric surgery unit and the diagnostic radiology departments of Al-Azhar University Hospital, New Damietta, Egypt. An informed consent was obtained from all parents of patients involved in the study. The study was authorized by the local ethical committee of Al-Azhar University Hospital.

Inclusion and exclusion criteria

Patients between the ages 3-28 months old who were hemodynamically stable, showed no evidence of peritonitis either clinically or radiologically and had symptoms lasting less than 24 hours were included in the research, and hemoglobin was tuned to guarantee at least 10 g/dl While, we excluded patients who had significant abdominal distention, signs of peritonitis, shock that is difficult to correct with intravenous hydration, symptoms that persisted for more than 24 hours, or imaging results that suggested a pathologic lead point, perforation, or suspected necrosis.

Implementation method

All patients had their complete histories taken, with special attention paid to age, gender, presenting symptoms (e.g., colitis, bleeding in the rectum, vomiting), feeding solid foods, history of upper respiratory tract infection, history of gastroenteritis, history of prior similar attacks, type of management, and postoperative notes and complications.

Upon admission to the Emergency room, all patients suspected of having intussusceptions underwent a comprehensive history and physical examination to evaluate their overall health. Resuscitation was accomplished by inserting an intravenous line, a nasogastric tube, and administering fluid treatment and antibiotics.

Imaging evaluation

Patients were sent for a plain abdominal X-ray (A GE compact, GE OCE Medical system was utilized for the C-arm), an abdominal ultrasonography (General Electric corporation (GE) health care model GE Logic P6 ultrasound equipment with a 10–12 MHz high-frequency linear probe), We are searching for thickening of the colonic wall, color flow, trapped or free fluid, small bowel blockage, and expansion of the mesenteric nodes. Also, laboratory tests (complete blood count, blood urea, serum creatinine, prothrombin time and INR and serum electrolytes) were performed.

Resuscitation after confirmation of the diagnosis

Once the patient's overall state stabilized, the definite therapy began a few minutes after the ultrasound test confirmed the diagnosis. The child was prohibited from eating, and resuscitation began with intravenous fluids, antibiotics (Metronidazole, 7.5 mg/kg body weight/dose every eight hours), a nasogastric tube, and a urethral catheter. The antibiotics were administered in two separate doses. Complete blood count, urea, creatinine, and serum electrolytes were measured. When an electrolyte imbalance was detected, it was corrected. After the patient received complete resuscitation and produced 1-2 milliliters of urine per kilogram of body weight per hour, the diagnosis was verified using abdominal ultrasonography in the radiological unit. Enough arrangements were in place to ensure prompt surgery in the case of a failure bowel reduction or perforation.

Regardless of the treatment plan, a cross-matched blood sample, prothrombin time, and INR were done for every patient, and the parent or legal guardian of each patient provided written informed consent to participate in the study.

Technique of general anesthesia

All children received intravenous midazolam (0.05 mg/kg) for sedation 30 minutes prior to being separated from their parents. Basic hemodynamic monitoring, including arterial blood pressure, heart rate (HR), oxygen saturation, and electrocardiogram (ECG), was set up in the operating room. Every surgical procedure was carried out under general anesthesia, which was brought on by either IV propofol (2 mg/kg) or sevoflurane inhalation, depending on the anesthetist's option. After administering a muscle relaxant (IV atracurium 0.5 mg/kg), a non-cuffed endotracheal tube of the appropriate size was placed. In addition to sevoflurane (2–4%) administered in an air/oxygen combination utilizing regulated mechanical ventilation (FiO_2 = 50%), anesthesia was maintained by intravenous fentanyl (1 mcg/kg).

Pneumatic reduction technique:

Using a modified air insufflation device, patients underwent pneumatic reduction using air insufflations (Figure 1). Patients who met the exclusion criteria or who had attempted pneumatic reduction but failed were operated on.

The patients were positioned in the left lateral decubitus position on the operation table. The free end of the nasogastric tube was inserted into a kidney dish containing saline kept at the same level as the patient. In order to keep the balloon as low as feasible, 18–20 Fr. Foley's catheter was placed into the rectum while under general anesthesia and guided by a C-arm or fluoroscopy. The balloon was inflated with 25–30 ml of normal saline. A nurse assisted in taping the patient's buttocks together while he was in his

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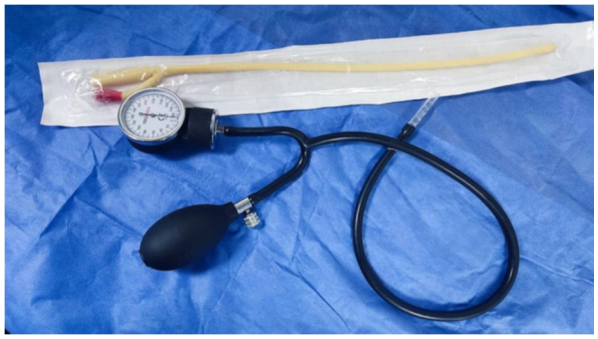

Figure 1. Modified air insufflation device

posture. The air insufflation device was attached to the opposite end of the catheter. For younger newborns and the first reduction attempt, the maximum air pressure was 100 mmHg; for older infants and the second and third reduction tries, the pressure was up to 120 mmHg. By progressively compressing the inflated bulb and maintaining a pressure of between 60 and 120 mmHg, the air was pushed into the colon.

Throughout the procedure, the reduction process was monitored by C-arm and fluoroscopy. By the ileo-caecal junction, the increasing intra-colonic pressure will progressively lessen intussusceptibility. Once there are adequate clinical and radiological characteristics of complete reduction of intussusceptions, the procedure is stopped.

Clinical evidence of the success reduction included a sharp drop in pressure, air bubbles in the kidney dish filled with saline, and a burst of feces following catheter balloon deflation. While radiological evidence proved the effective reduction of intussusceptions, plain abdominal X-rays demonstrated the demarcation of the whole colon and terminal ileum with gases in some patients, providing further proof. Other ultrasound criteria for successful reduction following deflation of air included the disappearance of the intussuscepted, a single concentric ring representing the swollen terminal ileum rather than multiple concentric rings of intussusceptions, and a sharp change in bowel wall thickness between the proximal normal ileum and the swollen terminal ileum on longitudinal axis scanning. (7).

After that, the patient was returned to the surgical ward, where they were kept under observation, and any complications were noted for a period of 48 to 72 hours.

For children whose initial reduction failed, one or two further reduction trials were conducted. Each trial lasts for 3 minutes. The manifestations of a failed reduction and the need for surgical intervention were the high resistance to air insufflations and the persistence of the mass by fluoroscopy, confirmed by ultrasonography later on.

Upon the eradication of all intussusception manifestations, patients were released to their homes, taking oral nutrition without throwing up; having a typical bowel movement, and the mass's ultrasound-detector disappearance.

Statistical analysis

The statistical software SPSS (Statistical Package for the Social Science: SPSS Inc., Chicago, IL, USA) version 20 was used for all statistical computations. For parametric data, the quantitative data were expressed as mean ± SD (standard deviation), and for non-parametric data, as a range. Frequencies and relative percentages were used to express the qualitative data. The homogeneity of the operation done, the month and season of presentation, the pathologic lead point, the gender, and the localization of intussusception were assessed using the One-Sample Chi-Square and Binomial tests. Every statistical comparison was conducted using a two-tailed test, where a *P*-value of less than 0.05 indicated a significant difference.

Results

34 patients (20 boys and 14 girls) were diagnosed with intussusception during the study period with mean age of 13.22 months at the time of diagnosis. Regarding presenting symptoms, 85.3% presented with vomiting, 64.7% present with abdominal pain, and 55.9% present with rectal bleeding. Interestingly, 14 (41.2%) of enrolled cases presented with a classic clinical triad (abdominal pain, rectal bleeding and palpable mass) (Table 1).

Sonographic findings of enrolled cases were evidence of small bowel obstruction (76.5%), colonic wall thickness (>10 mm) (67.6%), presence of additional abnormalities (trapped fluid between the intussusceptum and intussusception, ascites, absence of color flow, and presence of mesenteric nodal enlargement; 41.2%). During pneumatic reduction, the mean of maximum pressure applied was 85.66 mmHg. The success rate of reduction recorded was 32 (94.1%) of cases; 26 (76.5%) of them showed success reduction from the first attempt, 5 (14.7%) successes from the second attempt and only one case (2.9%) successes from the third attempt. The remaining two cases of failed processes (5.9%); the first case involved an 18-month-old girl who presented with an extended intussusception mass that was not reducible using the pneumatic reduction method. Following an unsuccessful pneumatic reduction, this diagnosis was also made during surgery. Extended mass excision and end-to-end anastomosis were done on this patient. Additionally, surgical exploration was conducted on a male infant who had presented with appendico-cecal intussusception. The intussusception was manually reduced, and an appendicectomy was performed. The current study recorded neither perforation nor mortality (Figure 2; Table 2).

Discussion

For children younger than six years old, intussusceptions are the second most prevalent cause of acute stomach pain

Table 1. Patients' characteristics and symptoms

Variable	Characteristics	Value
Age / months	Mean± SD	13.22±4.15
	3 – 6 months	2 (5.9%)
	7 – 12 months	7 (20.6%)
	13 – 18 months	12 (35.3%)
	19 – 24 months	8 (23.5%)
	25 – 28 months	5 (14.7%)
Gender	Male	20 (58.8%)
	Female	14 (41.2%)
Symptoms	Vomiting	29 (85.3%)
	Abdominal pain	22 (64.7%)
	Rectal bleeding	19 (55.9%)

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and the most common cause of bowel obstruction (1). The children in our study ranged in age from 3 to 28 months at the time of reduction, with a mean age of 13.22±4.15 weeks. Several researchers reported the same age range (8-10). However, older studies (11, 12) reported a wider age range from 16 days to 12 years. But, 75% of instances happen during the first two years of life, and 90% happen during the first three years of life. The male-to-female ratio was 1.4:1, which is similar to the ratio reported by literature (1, 4, 13).

Abdominal pain, distention, palpable abdominal mass, bloody and sticky stools, and continuous crying attacks are some of the disease's clinical signs (14). Although 85.3% of enrolled children presented with vomiting, 64.7% present with abdominal pain, and 55.9% present with rectal bleeding. Interestingly, 14 (41.2%) of enrolled cases presented with a classic clinical triad (abdominal pain, rectal bleeding and palpable mass). This result is consistent with

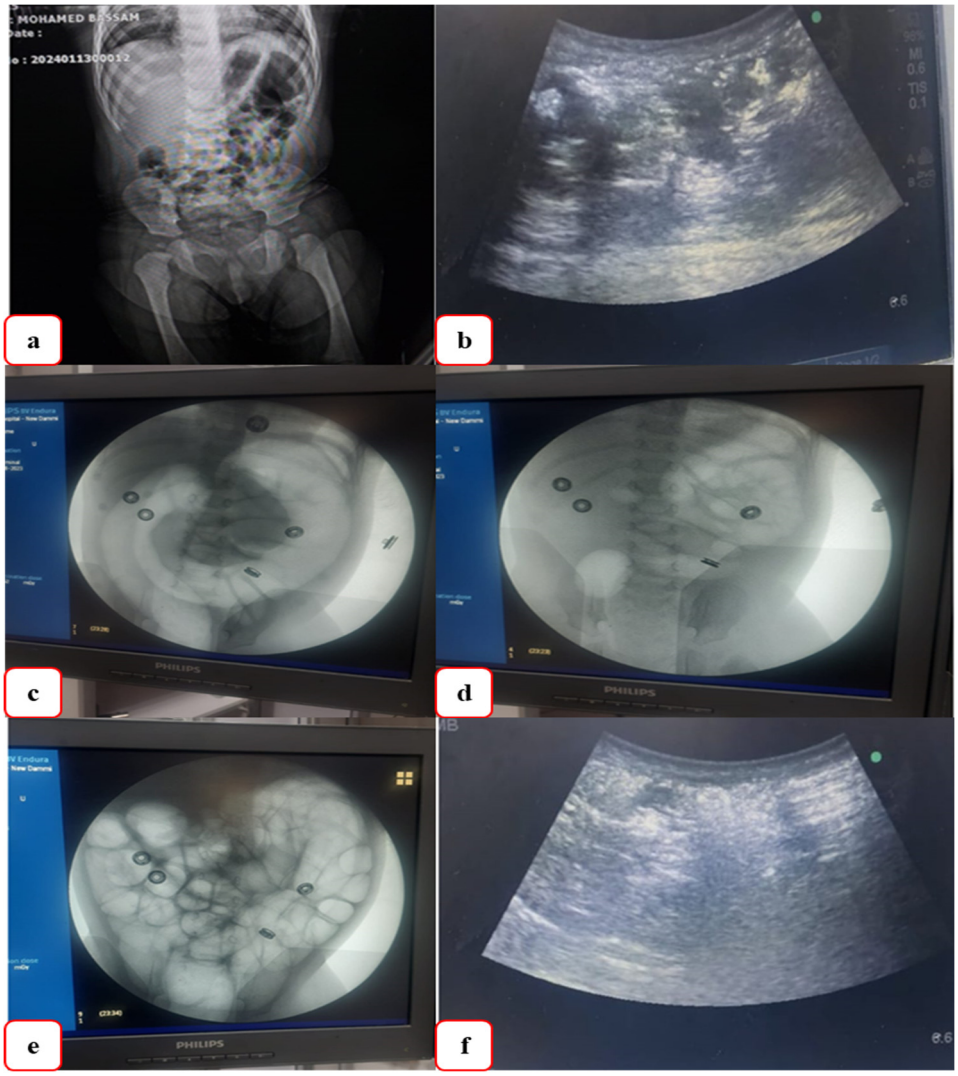

Figure 2. Radiological diagnosis and follow-up of male child with intussusception. a) X-ray abdomen's erect position shows target sign, crescent sign and absent liver edge sign with bowel obstruction. b) Ultrasound image shows target sign of intussusception. c,d and e) Fluoroscopic serial images for pneumatic reduction process of intussusception. F) Reduction was confirmed by ultrasound post reduction shows complete reduction.

Table 2. Sonographic findings and details of pneumatic reduction

Variable	Characteristics	Value N(%)
Sonographic findings	Small bowel obstruction	26 (76.5%)
	Colonic wall thickness	23 (67.6%)
	Enlargement of lymph node	14 (41.2%)
	Trapped fluid	6 (17.6%)
	Ascites	4 (11.8%)
	Absence of color flow	1 (2.9%)
Applied maximum pressure (mean± SD)	mmHg	85.66±16.78
Outcome	Success reduction after 1st attempt	26 (76.5%)
	Success reduction after 2nd attempts	5 (14.7%)
	Success reduction after 3rd attempts	1 (2.9%)
	Failed reduction	2 (5.9%)

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other studies' findings, with vomiting being the most common symptom (8, 15). However, colicky abdominal discomfort has been described as the most prevalent symptom in certain studies (4, 16). There exists a possibility that the discrepancy in presenting symptoms is associated with the illness stage or the hospital admission date. The baby's knees are brought up to his chest as a result of the abdominal discomfort caused by intussusception.

Successful pneumatic reduction was achieved in 32 patients (94.1%), similar in range of 51%-97.7% from the past studies (1, 3, 4, 10, 14, 17-19) and higher than (33% to 50%) (20, 21). This might be because some of the patients in their study were subjected to ineffective pneumatic pressures (less than 80 mmHg).

During pneumatic reduction, 26 of the cases (76.5%) showed success reduction from the first attempt, which is closer to that reported by the others Gamal et al. (22) (85%), Arsalan et al. (23) (91%), Kritsaneepaiboon et al. (17) (76%), but much higher than Salman et al. (1) (30%). The last study's poor success rate of first attempt reduction could be attributed to a number of factors, including the type of intussusceptions, younger ages (less than three months), longer symptom duration (more than two days), and low starting pressure. They raised the pressure to 120 mmHg on the second try, which resulted in a better success rate of 35.7% which is greater than that reported by the current study (14.7%), Dahab et al. (24) (12%) and Ahmed et al. (25) (15.3%). This can be explained by the initial low pressure employed in the first attempt. Our study's third attempt success rate was 2.9%, which was comparable to what the other researchers had reported by Gamal et al. (22) (3.5%), Arsalan et al. (23) (2.1%), Kritsaneepaiboon et al. (17) (3.4%), and Hassan et al. (26) (2.8%).

Although the ideal interval between attempts of pneumatic reduction is unknown, practitioners typically wait anywhere from 15 minutes to several hours (27). The supposed explanation is that in cases with residual intussusception, reducing the intussusception partially on the first try enhances venous drainage and lessens gut wall edema (28).

The increased success rate of reduction in the current study could be attributed to the fact that pneumatic reduction has been used more frequently at our institution with better skill and experience; also, the equipment employed in our study was an advancement over that which was available in earlier series. Furthermore, this may be due to the procedure of pneumatic reduction in the current study done under general anesthesia (GA). While pneumatic reduction has gained popularity as a therapy option, different institutions and geographical areas use different protocols when applying this technique (29). The use of anesthetic medications, their benefits, and potential side effects are some contentious topics (18).

Some authors (5, 6, 30) believe that the use of sedation and GA improves the reduction rate, possibly by smooth muscle relaxation. No research has measured the level of pain during reduction objectively, but based on comparisons with colonoscopy, where the intestine is likewise enlarged with gas and children typically need sedation, it is thought to be uncomfortable (4).

By reducing the child's physical discomfort and mental stress, as well as the anxiety of the parents, the administration of sedatives like midazolam, ketamine, fentanyl, propofol, diazepam, and chloral hydrate may improve the procedure's success rates, shorten its duration, and minimize radiation exposure. It may also help to relax the abdominal and gastrointestinal smooth muscles (18, 29, 31). Another benefit of general anesthesia is that it protects the airway better and allows for quick surgery when necessary (5, 30).

Purenne et al. (6) demonstrated that, in contrast to sedation, the success rate of reduction by air enema rose when the procedure was carried out under general anesthesia. But when surgery was necessary, the anesthesia was kept in place, and the patient was moved to the operating room. They carried out the treatment in the radiology suite.

The American Academy of Pediatrics does not specifically address the prevention of intussusception, although it recommends the use of psychological, pharmacological, and physical measures to lessen pain and discomfort for children undergoing diagnostic and therapeutic procedures (32). Furthermore, analgesia is not mentioned in UK recommendations relating to intussusception. Additionally, assessments of the degree of pain and discomfort experienced during intussusception have not been documented. The emergence of hospital guidelines that suggest analgesia as part of general care may be reflected in Australian practice patterns (4).

The success rate of PR was evaluated between patients who underwent deep sedation and general anesthesia by Khorana et al. (8). They showed that there was no discernible difference in the two groups' baseline characteristics. Both groups' success rates were identical at 88.0%. They found that the success rates for deep sedation and general anesthesia were comparable. If the non-operative strategy fails, general anesthesia should be explored in high-risk cases to enable the changeover to surgical therapy in the same setting. The effectiveness of reduction is further increased by the proper course of care and sedative procedure. Furthermore, Hailemariam et al. (29), in their systematic analysis, showed that, in comparison to not using any sedation, sedation improved the success of enema reduction. Nonetheless, the success rate was similar for individuals under non-general anesthesia (minimal, moderate, or severe sedation) and general anesthesia.

On the other hand, according to some authors, the use of GA has been associated with a decreased reduction rate because it hinders the child's ability to complete the Valsalva maneuver while straining. They think the Valsalva technique is beneficial because it lowers the colonic transmural pressure gradient and raises intraluminal pressure, which enhances the efficacy of enema therapy and guards against perforation (19, 28). According to other studies, sedatives require a team of committed, experienced personnel to watch over the intussusception-affected youngsters during the treatment, which has an impact on resources (18).

One disadvantage of using GA for the reduction method is the possibility of delayed and repeated attempts at intussusception reduction (33). When the reduction operation is carried out under general anesthesia, surgery typically follows an unsuccessful effort, so it is not possible to attempt

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delayed repeated tries. Surgery is utilized again if an unsuccessful attempt is not immediately followed by a delayed try, which is not ideal considering the growing knowledge of the possible morbidity linked to GA in youngsters (34). The requirement for an anesthesiologist to be on hand for radiologic reduction by enema is another significant disadvantage of utilizing GA. This requirement may not always be met, which could cause the treatment to take longer (18).

Even while more and more doctors and parents are requesting the use of sedatives during enema reduction, there are still some issues with this practice. Fear of a higher perforation rate and/or the potential for covert perforation symptoms is one of the causes (35). Sedation, on the other hand, is thought to lower patient resistance during pneumatic reduction, which in turn lowers peak pressures and the chance of perforation (35, 36). Furthermore, crying kids throughout the treatment make it harder to see problems (35).

Our findings are supported by a recent systematic review (19) of 849 propofol-based sedation for reducing intussusception in children, where the incidence of intestinal perforation was 0.6%. The current study reported no perforation rate, which was consistent with a published rate of less than 1% (35). In a similar vein, Yeoh et al. (37) found that 65.8% of Australian children who received opioid analgesia within two hours of reduction did not experience any perforations.

Although Hailemariam et al. (29) reported no statistically significant difference in the risk of perforation when minimizing intussusception with sedation, the treatment can be made safer by carefully selecting patients who are eligible for sedation based on their clinical condition and imaging results (35).

Conclusion

Pneumatic reduction of intussusception under general anesthesia guided by fluoroscopy is a well-tolerated, straightforward, safe, and successful procedure with a high success rate and no complications. It can be used as the primary nonsurgical treatment for pediatric intussusception.

For delayed attempts performed in the operating room, general anesthesia can be saved for the maximum number of youngsters who will benefit from the non-surgical reduction.

To assess the possibility of long-term negative effects of radiation and general anesthesia on a child's development, more research is advised.

Authors' Contributions

"Conceptualization, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; methodology, S.E, M.E, A.A and E.A.; software, O.R., A.S., R.E., M.E, A.A, R.A., H.E.; validation, O.R., A.S., R.E., M.E, A.A, R.A., H.E and E.A..; formal analysis, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; investigation, S.E, M.E, A.A and E.A; data curation, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; writing—original draft preparation, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; writing—review and editing, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; visualization, S.E, O.R., A.S., R.E., M.E, A.A, R.A., H.E. and E.A.; supervision, S.E, and E.A.; project administration, S.E, and E.A. All authors have read and agreed to the published version of the manuscript.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of DAMIETTA FACULTY OF MEDICINE, Al-Azhar University (IRB 00012367 and date of approval)." for studies involving humans.

The study protocol was reviewed and approved by the committee of the institutional review board in the faculty of medicine, approval number (IRB 00012367).

Acknowledgment

None.

Conflict of Interests

The authors declare that they have no competing interests.

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