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Pneumatic Reduction of Intussusception in Pediatric Population: A Descriptive Observational Study

Dr. Arjun Pawar[1], Dr. Vidyanand Deshpande[2], Dr. Urvee Parekh[3], Dr. Anish Adak[4]

[1]MBBS, MS (General Surgery), MCH (Pediatric Surgery)
Email: *drarjunpawar[at]gmail.com*

[2]MBBS, MS (General Surgery), MCH (Pediatric Surgery)
Email: *drvidyananddeshpande[at]gmail.com*

[3]MBBS, MS (General Surgery) Junior Resident – Third Year
Email: *urveeparekh1999[at]gmail.com*

[4]MBBS, MS (General Surgery) Junior Resident-Second Year
Email: *anishadak19[at]gmail.com*

Abstract: ***Background: Intussusception is the most common cause of intestinal obstruction in infants and young children. Delayed diagnosis and treatment may result in bowel ischemia, perforation, sepsis, and mortality. Over recent decades, pneumatic reduction has become the preferred first-line non-operative treatment modality in hemodynamically stable children because of its high success rate and minimally invasive nature. Aim: To evaluate the efficacy and safety of pneumatic reduction in pediatric intussusception and to analyze clinical characteristics, management patterns, complications, and outcomes in a regional healthcare setting. Methods: This retrospective observational descriptive study was conducted across multiple private hospitals in Sambhaji Nagar, Maharashtra, India, from May 2020 to December 2025. A total of 107 children aged 0–15 years with ultrasonographically confirmed intussusception were included. Hemodynamically stable patients without gross abdominal distension underwent pneumatic reduction under fluoroscopic guidance using controlled air insufflation with intraluminal pressure maintained below 120 mmHg. Data regarding demographic profile, type of intussusception, management modality, treatment outcome, complications, and mortality were analyzed using descriptive statistical methods. Results: Among 107 children, 62 (57.9%) were males and 45 (42.1%) were females, with a male-to-female ratio of 1.37:1. Ileo-colic intussusception was the most common type, observed in 95 cases (88.8%). Pneumatic reduction was attempted in 80 children and achieved successful radiological reduction in 78 cases, corresponding to a success rate of 97.5% (95% confidence interval: 91.3%–99.7%). Two patients (2.5%) developed bowel perforation requiring surgical intervention. Conservative management was sufficient in 15 cases (14.0%), while surgery was required in 10 patients (9.3%). No mortality was recorded. Conclusion: Pneumatic reduction demonstrated favorable outcomes as a minimally invasive first-line treatment modality in selected hemodynamically stable pediatric patients with intussusception. Early diagnosis, appropriate patient selection, and adherence to standardized pressure-controlled techniques significantly reduce the need for surgery and improve clinical outcomes.***

Keywords: Intussusception; Pneumatic reduction; Pediatric intestinal obstruction; Ileo-colic intussusception; Non-operative management

1. Introduction

Intussusception is defined as the telescoping of a proximal segment of the intestine into an adjacent distal bowel segment, resulting in venous congestion, bowel wall edema, intestinal ischemia, and possible perforation if left untreated. It is the most common cause of intestinal obstruction in infants and young children, particularly between 3 and 18 months of age.1 The reported incidence ranges from 1 to 4 cases per 1,000 live births, with a consistent male predominance observed worldwide. Delayed diagnosis and treatment continue to contribute significantly to morbidity and mortality, especially in developing countries.2

Most pediatric intussusceptions are idiopathic in origin and are believed to be associated with hypertrophied Peyer's patches following viral infections. Pathological lead points such as Meckel's diverticulum, intestinal polyps, duplication cysts, and lymphomas are more frequently identified in older children. Approximately 85–90% of cases are ileo-colic in type, followed by ileo-ileal and colo-colic variants.3

Clinically, children commonly present with intermittent colicky abdominal pain, vomiting, abdominal distension, irritability, and passage of red currant jelly stools. However, the classical triad is present in less than half of patients. Advanced cases may demonstrate abdominal tenderness, guarding, bowel ischemia, perforation, or sepsis. Ultrasonography has emerged as the imaging modality of choice because of its high sensitivity, specificity, rapid availability, and absence of radiation exposure. The characteristic "target" or "doughnut" sign confirms the diagnosis in most cases.4

Historically, surgical intervention was considered the standard treatment for intussusception. Subsequently, hydrostatic reduction using barium or saline enemas under fluoroscopic or ultrasonographic guidance gained popularity as a non-operative treatment option. Although hydrostatic reduction is effective, it may be associated with longer procedural duration, fluid leakage, hypothermia, and risk of peritoneal contamination in the event of bowel perforation.5

Pneumatic reduction using controlled air insufflation has increasingly become the preferred treatment modality because of its high success rates, shorter procedure duration, reduced radiation exposure, improved visualization, and lower risk of contamination during perforation. Previous

studies have demonstrated success rates ranging between 70% and 90% in experienced centers.6 In addition, pneumatic reduction is cost-effective and particularly useful in resource-limited healthcare settings because of minimal equipment requirements.

Despite increasing evidence supporting pneumatic reduction as the preferred first-line management strategy, variations in practice continue to exist, particularly in peripheral and private healthcare institutions. Furthermore, regional outcome data evaluating the efficacy and safety of pneumatic reduction in pediatric populations remain limited in India.7

The present study was conducted to evaluate the clinical characteristics, management approaches, and outcomes of pediatric intussusception treated predominantly with pneumatic reduction in multiple private hospitals in Sambhaji Nagar, Maharashtra. The study also aims to contribute regional data supporting evidence-based treatment protocols for pediatric intussusception.

2. Objectives of the Study

Primary Objective

- To evaluate the efficacy and safety of pneumatic reduction as a primary treatment modality for pediatric intussusception.

Secondary Objectives

- To determine the success rate of pneumatic reduction in children with intussusception.
- To assess the proportion of patients requiring conservative management, hydrostatic reduction, or surgical intervention.
- To analyze the distribution of different types of intussusception among the study population.
- To document procedure-related complications and mortality associated with pneumatic reduction.

3. Materials and Methods

Study Design

This was a retrospective observational descriptive study.

Study Setting and Duration

The study was conducted across four private hospitals in Sambhaji Nagar, Maharashtra, India, over a period of nearly five years from May 2020 to December 2025. All participating centers followed a standardized pneumatic reduction protocol using fluoroscopic guidance and controlled intraluminal pressure limited to 120 mmHg. Procedures were performed by experienced pediatric surgeons and radiologists trained in pneumatic reduction techniques.

Study Population

The study included pediatric patients diagnosed with intussusception during the study period. A total of 107 children fulfilling the eligibility criteria were included in the final analysis. Diagnosis was confirmed by ultrasonography in all cases.

Inclusion Criteria

- Children aged 0–15 years.
- Ultrasonographically confirmed intussusception.
- Hemodynamically stable at presentation.
- Absence of significant abdominal distension.

Exclusion Criteria

- Acute intestinal obstruction with gross abdominal distension.
- Suspected bowel gangrene or toxic clinical presentation.
- Preoperatively identified pathological lead point on ultrasonography or CT scan.
- Excessive gaseous distension interfering with fluoroscopic visualization.
- Long-segment intussusception with rectally palpable mass.
- Ileo-ileal intussusception diagnosed on ultrasonography.
- Evidence of compromised bowel vascularity on Doppler study.

Pneumatic Reduction Technique

Eligible patients underwent pneumatic reduction under general anesthesia in the operating room. A well-lubricated Foley catheter was inserted rectally under fluoroscopic C-arm guidance. Depending on patient age, 10–20 mL of normal saline was instilled into the catheter balloon to achieve an adequate seal.

Controlled air insufflation was delivered through a pressure-monitored system equipped with an aneroid pressure gauge. Radiation exposure was minimized using intermittent fluoroscopy during the procedure. Intraluminal pressure was carefully maintained below 120 mmHg throughout the procedure. Successful reduction was confirmed fluoroscopically by visualization of reflux of air into the terminal ileum. A maximum of three reduction attempts were permitted before the procedure was considered unsuccessful.

Management Protocol

Children unsuitable for pneumatic reduction or those with unsuccessful reduction underwent conservative management or surgical intervention depending on clinical status. Conservative management included bowel rest, intravenous fluids, serial abdominal examinations, observation, and repeat ultrasonography when indicated. Hydrostatic reduction was selectively performed in a limited number of patients based on clinical judgment and facility availability.

Data Collection

Clinical records were reviewed to obtain information regarding:

- Age
- Sex
- Type of intussusception
- Management modality
- Outcome of pneumatic reduction
- Complications
- Requirement for surgery
- Mortality

Outcome Measures

Primary outcome measures included:
- Success rate of pneumatic reduction
- Requirement for surgical intervention

Secondary outcome measures included:
- Procedure-related complications
- Mortality

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using descriptive statistical methods. Continuous variables were expressed as mean ± standard deviation or range, while categorical variables were expressed as frequencies and percentages. Success rates and complication rates were calculated with corresponding percentages and confidence intervals where appropriate. As this was a descriptive observational study without comparative groups, inferential statistical comparisons were not performed.

Ethical Considerations

Institutional ethical approval was obtained prior to commencement of the study. The requirement for informed consent was waived because of the retrospective anonymized nature of data collection. Patient confidentiality was maintained by anonymizing all records and excluding personally identifiable information from the analysis.

4. Results

A total of 107 children diagnosed with intussusception were included in the study. The age range varied from 6 months to 6 years. Male children constituted the majority of cases.

Table 1: Demographic Profile of Study Participants (N = 107)

Variable	Number	Percentage (%)
Male	62	57.9
Female	45	42.1
Total	107	100

The study demonstrated a male predominance with a male-to-female ratio of approximately 1.37:1.

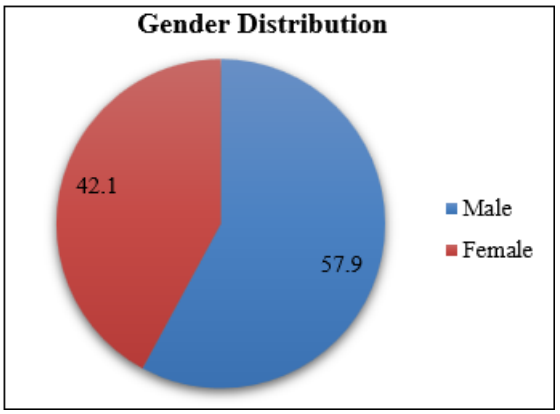

Figure 1: Gender Distribution

Table 2: Type of Intussusception (N = 107)

Type of Intussusception	Number of Cases	Percentage (%)
Ileo-colic	95	88.8
Other types*	12	11.2
Total	107	100

*Other types included ileo-ileal and colo-colic intussusception.

Ileo-colic intussusception represented the overwhelming majority of cases.

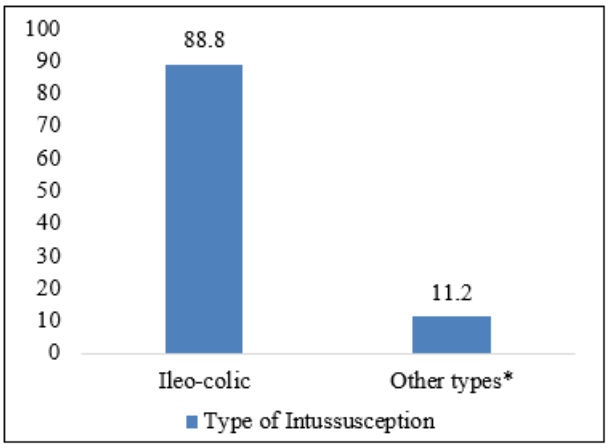

Figure 2: Type of Intussusception

Table 3: Management Modality (N = 107)

Management Type	Number of Cases	Percentage (%)
Pneumatic reduction	80	74.8
Conservative management	15	14
Surgical management	10	9.3
Hydrostatic reduction	2	1.9
Total	107	100

Pneumatic reduction was the predominant management modality used in this study.

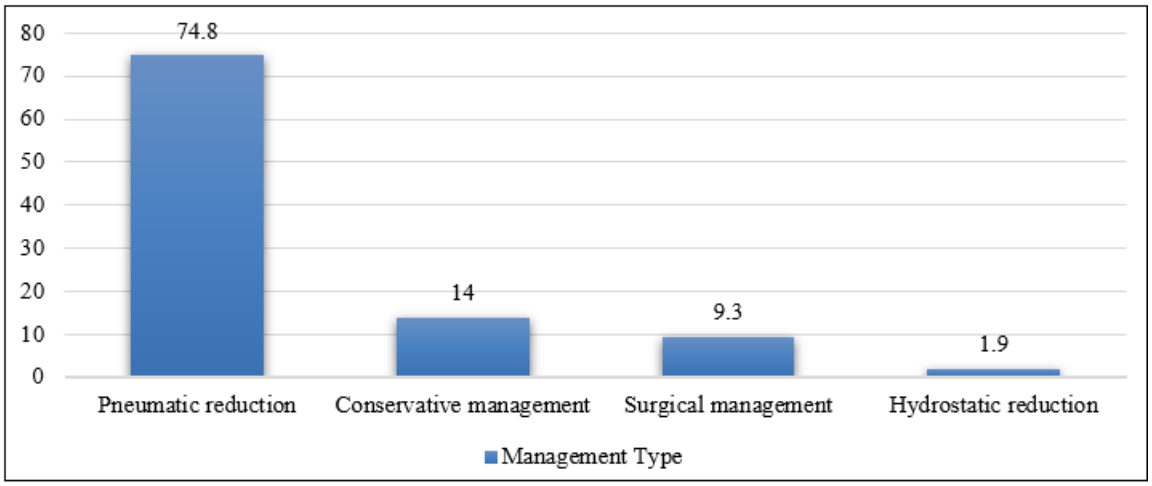

Figure 3: Management of Modality

Table 4: Outcome Distribution Among Study Participants (N = 107)

Outcome	Number of Cases
Successful pneumatic reduction without surgery	78
Pneumatic reduction complicated by perforation requiring surgery	2
Conservative management	15
Primary surgical management	10
Hydrostatic reduction	2

Clinical success without requirement for surgery was achieved in 78 of 80 children who underwent pneumatic reduction, corresponding to a success rate of 97.5%.

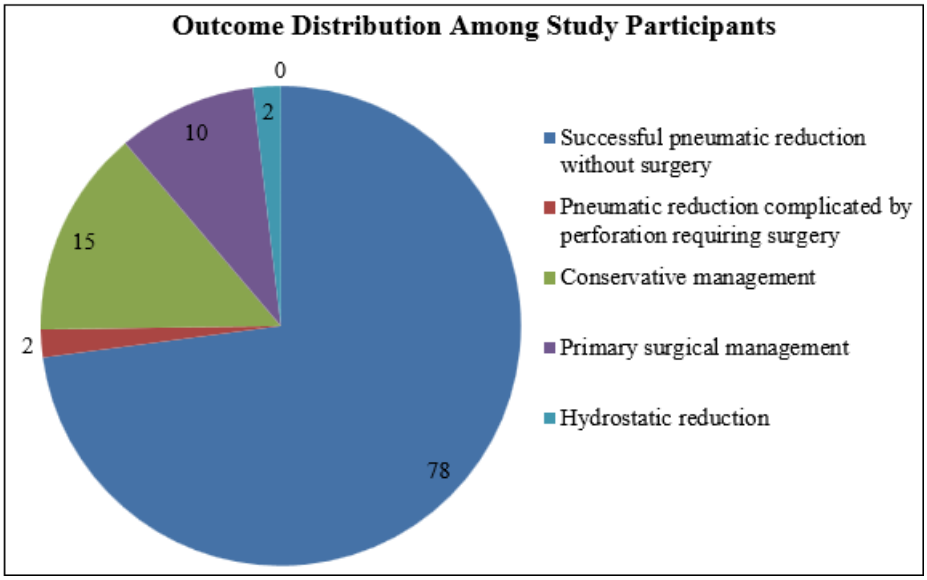

Figure 4: Outcome of Pneumatic reduction

Table 5: Complications and Mortality

Parameter	Observation
Procedure-related perforation	2- 80
Mortality	0

Two children developed bowel perforation during pneumatic reduction and subsequently underwent surgical management with favorable postoperative recovery. No mortality was recorded during the study period.

5. Discussion

Intussusception remains one of the most common abdominal emergencies encountered during infancy and early childhood. Delayed diagnosis and treatment may lead to bowel ischemia, necrosis, perforation, sepsis, and mortality.1 Over the past several decades, management strategies have evolved considerably from primary surgical intervention toward minimally invasive non-operative reduction techniques.

The present study evaluated the efficacy and safety of pneumatic reduction in 107 pediatric patients diagnosed with intussusception. The findings demonstrate that pneumatic reduction is an effective and safe first-line treatment modality in carefully selected hemodynamically stable children.

A male predominance was observed in the present study, with 62 males (57.9%) and 45 females (42.1%), resulting in a male-to-female ratio of approximately 1.37:1. Similar gender distributions have been reported in previous epidemiological studies, which consistently demonstrate higher incidence rates among male children.5 The age distribution in this cohort, ranging from 6 months to 6 years, also corresponds closely with the established peak incidence of intussusception occurring between 3 and 18 months of age.1

Ileo-colic intussusception accounted for 95 cases (88.8%) in the current study, which is consistent with previous pediatric literature reporting ileo-colic involvement in approximately 85–90% of cases.9 The predominance of ileo-colic intussusception is attributed to the anatomical and physiological characteristics of the ileocecal region, including abundant lymphoid tissue and active intestinal peristalsis.

Pneumatic reduction was performed in 80 children (74.8%) and achieved successful radiological reduction in 78 patients, corresponding to a success rate of 97.5%. The procedure-related perforation rate was 2.5%, while mortality was absent. These findings compare favorably with previously published success rates ranging from 70% to 90% in experienced pediatric centers.6,9

The high success rate observed in the present study may be attributed to early diagnosis, careful patient selection, controlled intraluminal pressure monitoring, and fluoroscopic guidance during the procedure. Exclusion of clinically advanced cases with bowel gangrene, vascular compromise, significant abdominal distension, or long-segment intussusception may also have contributed to the favorable outcomes and should be considered while interpreting the results.

Only 10 children (9.3%) required surgical intervention. This surgical rate falls within the range reported by previous studies and highlights the effectiveness of timely non-operative management in reducing unnecessary laparotomies.9 Avoidance of surgery is associated with shorter hospital stay, reduced postoperative morbidity, lower healthcare costs, and decreased psychological stress for both patients and caregivers.

Procedure-related bowel perforation occurred in 2 children (2.5%) undergoing pneumatic reduction. Both patients were successfully managed surgically without mortality. Previous studies have demonstrated that careful pressure monitoring with intraluminal pressures maintained below 120 mmHg significantly reduces the risk of perforation.6 The low complication rate observed in this study supports the safety of standardized pneumatic reduction protocols.

Hydrostatic reduction was utilized in only 2 cases (1.9%), reflecting the increasing preference for pneumatic reduction in contemporary pediatric surgical practice. Hydrostatic reduction nevertheless remains an established alternative modality in selected patients. In the present cohort, pneumatic reduction demonstrated practical advantages including shorter procedural duration, improved fluoroscopic visualization, lower risk of fluid contamination during perforation, reduced procedure-related hypothermia, and easier pressure regulation.

The absence of mortality in the present study is encouraging and aligns with outcomes reported in centers emphasizing early diagnosis and prompt intervention. Mortality associated with intussusception has declined substantially over recent decades and is now largely confined to delayed presentations complicated by bowel necrosis, perforation, or septic shock.

The findings of this study are particularly relevant in resource-limited healthcare settings. Pneumatic reduction is cost-effective, requires minimal consumables, and can be safely implemented using protocol-based training in appropriately equipped centers. Wider adoption of structured pneumatic reduction techniques may substantially reduce the need for surgery and improve clinical outcomes in pediatric intussusception. This study also represents one of the larger regional datasets from private-sector hospitals in Maharashtra evaluating standardized pneumatic reduction outcomes in children.

6. Conclusion

Intussusception remains a common pediatric surgical emergency requiring early diagnosis and timely intervention to prevent serious complications. The present study demonstrated that pneumatic reduction is a safe, effective, and minimally invasive first-line treatment modality in hemodynamically stable children.

Clinical success without requirement for surgery was achieved in 97.5% of attempted pneumatic reductions, with a low complication rate and no mortality. Only a small proportion of patients required surgical intervention, primarily because of clinical instability or procedure-related perforation.

Compared with hydrostatic reduction and primary surgical management, pneumatic reduction offers several practical advantages, including shorter procedural duration, improved pressure control, better fluoroscopic visualization, reduced risk of fluid contamination, and decreased hospital stay.

Early diagnosis, appropriate patient selection, and adherence to standardized pressure-controlled reduction techniques are essential for optimizing clinical outcomes and minimizing the need for surgical intervention in pediatric intussusception.

7. Limitations of the Study

The retrospective observational design of the study may introduce selection and documentation bias. Detailed comparative statistical analysis between management modalities was limited because of the relatively small number of hydrostatic reduction and surgical cases.

Long-term follow-up and recurrence rates were not comprehensively assessed, and recurrence data were unavailable in several patients because of the retrospective

multicenter design. Additionally, the high success rate observed in this study may partly reflect strict exclusion criteria that excluded clinically advanced or complicated cases unsuitable for pneumatic reduction.

Future prospective multicenter studies with larger sample sizes and long-term follow-up are recommended to provide stronger evidence regarding predictors of successful reduction, recurrence rates, and long-term outcomes.

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