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# Ultrasound-Guided Versus Fluoroscopic Conservative Reduction of Intestinal Intussusception in Children: A Retrospective Comparative Study

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## ABSTRACT

**Introduction:** Intestinal intussusception is the most common form of acquired intestinal obstruction in childhood. Diagnostic errors reach 50%, and complications occur in up to 53.7% of cases. Pneumoirrigoscopy under fluoroscopic control (PIS) has been the standard conservative technique, but its radiation burden and single-attempt limitation prompted the development of ultrasound-guided hydroechocolonographic disinvagination (HEC). This study aimed to compare the clinical outcomes of HEC and PIS in paediatric intestinal intussusception.

**Methods:** A retrospective comparative study of 132 children aged 2 months to 10 years treated at the Specialized Paediatric Surgical Clinic of Samarkand State Medical University between 2000 and 2023. The control group (CG, n=59; January 2000–December 2013) received conventional PIS; the study group (SG, n=73; January 2014–December 2023) underwent ultrasound-guided HEC, a radiation-free technique developed at our institution. Primary outcomes were the rate of successful conservative reduction (assessed per patient), length of hospital stay, and mortality. Chi-squared and Student's t-tests were used; $p<0.05$ was considered significant.

**Results:** The predominant age group was 6 months to 1 year (51.5%); males predominated (70.5%, $p<0.001$). The ileocaecal variant was found in 90.1% of patients. Successful conservative reduction was achieved in 53.4% (39/73) of the study group versus 39.0% (23/59) in the control group. Mean hospital stay was significantly shorter in the study group (2.5±0.66 vs 4.6±0.51 days, $p<0.05$). Group-specific mortality was 2.7% (2/73) in the SG versus 8.5% (5/59) in the CG.

**Conclusion:** Ultrasound-guided HEC is a safe, effective, and radiation-free alternative to PIS, achieving a higher rate of conservative reduction, a significantly shorter hospital stay, and enabling multiple reduction attempts. Disease duration alone should not determine treatment modality; clinical condition and the absence of peritoneal signs must be considered jointly.

**Keywords:** Intussusception; Ultrasonography; Fluoroscopy; Therapeutics; Paediatric Surgery

## Introduction

Intestinal intussusception is defined as the telescoping of one segment of bowel into an adjacent segment and constitutes the most prevalent cause of acquired intestinal obstruction in children, accounting for 70–80% of all cases [1,2]. The condition ranks second only to acute appendicitis among paediatric abdominal emergencies, and misdiagnosis rates reach 50% [3,4]. Complications, including bowel necrosis, perforation, and peritonitis, develop in 16.2–53.7% of cases [5]. The ileocaecal variant predominates, and peak incidence occurs between 6 months and 1 year of age [6].

Available diagnostic and therapeutic modalities include plain radiography, ultrasonography (US), computed tomography, fluoroscopy-controlled pneumoirrigoscopy (PIS), and, more recently, ultrasound-guided hydrostatic reduction [7,8]. Conservative reduction is the preferred initial strategy in the absence of peritonitis, with success rates exceeding 50% when performed early [9]. PIS has been the standard technique at many centres, yet its drawbacks — ionising radiation to the patient and staff, a single-attempt limit, and inability to assess bowel-wall perfusion — prompted the development of safer alternatives [10].

Hydroechocolonography (HEC), in which the colon is retrogradely filled with warm saline under real-time sonographic monitoring, was first proposed and applied at our institution in 2014. The technique avoids radiation, allows colour Doppler flow mapping (CDFM) to evaluate intestinal perfusion, and permits multiple consecutive reduction attempts [11].

The aim of this study was to compare clinical outcomes of ultrasound-guided HEC versus fluoroscopy-controlled PIS for the diagnosis and conservative treatment of intestinal intussusception in children.

## Materials and Methods

### Study design and setting

This was a retrospective comparative single-centre study conducted at the Specialized Paediatric Surgical Clinic of Samarkand State Medical University, Uzbekistan, approved by the institutional ethics committee (protocol No. [002], date [16.03.2026]).

### Patients

All children aged 2 months to 10 years admitted with confirmed intestinal intussusception between January 2000 and December 2023 were included. Exclusion criteria were: secondary intussusception requiring immediate surgery (free pneumoperitoneum, haemodynamic shock attributable to perforation) and incomplete records. A total of 132 patients were enrolled and allocated to two groups based on the institutional protocol in use at the time of admission.

**Control group (CG, n=59; January 2000–December 2013):** Diagnosis was made by plain abdominal radiography and fluoroscopy-controlled PIS. Insufflation of air via a rectal tube raised intraluminal pressure to 80–100 mmHg under continuous fluoroscopy (mean procedure duration 15 minutes). A single attempt was permitted per session. Post-reduction surveillance was by barium transit under fluoroscopic control.

**Study group (SG, n=73; January 2014–December 2023):** Diagnosis and conservative treatment were based on ultrasound-guided HEC. Following US confirmation of intussusception, warm saline was instilled retrogradely through a rectal catheter under real-time sonographic control. CDFM assessed bowel-wall perfusion throughout the procedure. Up to five to six attempts were permitted per session. The only contraindication was clinical peritonitis. Post-reduction surveillance was by serial US.

### Surgical management

Operative intervention was indicated for peritonitis, haemodynamic instability, failed conservative reduction, or disease duration >48 hours with systemic toxicity. Procedures included manual disinvagination (Hutchinson technique), bowel resection with primary anastomosis for non-perforated bowel necrosis, and temporary enterostomy for perforated bowel or established peritonitis.

### Statistical analysis

Data were analysed using SPSS v.23.0 (IBM Corporation, Armonk, NY, USA). Categorical variables are presented as n (%) and compared by the chi-squared test ($\chi^2$). Continuous variables are expressed as mean ± standard deviation (M±SD) and compared by Student's t-test. Pearson's correlation coefficient (r) assessed associations between disease duration and treatment modality. A p-value <0.05 was considered statistically significant.

## Results

### Demographic and clinical characteristics

Of 132 patients, 93 were male (70.5%) and 39 female (29.5%), yielding a male-to-female ratio of 2.4:1 (p=0.002). No significant between-group sex difference was observed (p=0.98). The most prevalent age group was 6 months to 1 year (n=68, 51.5%), significantly

exceeding all other categories (p<0.001) (Table 1). Urban and rural residents accounted for 20.5% (n=27) and 79.5% (n=105) respectively (p<0.001), with no significant between-group difference (p=1.0). The most frequently identified predisposing factors were introduction of complementary feeding (37.9%), gastrointestinal disturbances (29.4%), and dietary errors (23.3%). The groups were comparable regarding sex, age, residence, and predisposing factors (p>0.05 for all comparisons).

Disease duration at admission differed significantly between groups ($\chi^2$=8.54, p=0.036): notably, the proportion presenting after more than 48 hours was higher in the CG (35.6% vs 19.2%), whereas the proportion presenting at 25–48 hours was higher in the SG (31.5% vs 18.6%) (Table 2).

**Table 1. Age distribution of patients in the control group (CG) and study group (SG)**

| Age group | CG (n=59) | SG (n=73) | Total (n=132) | p-value |
|---|---|---|---|---|
| < 6 months | 14 (10.6%) | 7 (5.3%) | 21 (15.9%) | 0.015 |
| 6 months – 1 year | 29 (22.0%) | 39 (29.5%) | 68 (51.5%) | <0.001 |
| 1–3 years | 11 (8.3%) | 18 (13.6%) | 29 (22.0%) | 0.482 |
| > 3 years | 5 (3.8%) | 9 (6.8%) | 14 (10.6%) | <0.001 |
| **Total** | **59 (44.7%)** | **73 (55.3%)** | **132 (100%)** | — |

*Note: CG – control group (pneumoirrigoscopy, January 2000–December 2013); SG – study group (hydroechocolonography, January 2014–December 2023). p-values in the table body reflect the predominance of each age category relative to all others within the total cohort (intra-cohort comparison), not between-group (CG vs SG) differences. Inter-group comparison for all age categories: p>0.05. Predominance of the 6 months–1 year category over all others: p<0.001.*

**Table 2. Distribution of patients by disease duration from onset**

| Duration | CG (n=59) | SG (n=73) | Total (n=132) |
|---|---|---|---|
| < 12 h | 18 (30.5%) | 16 (21.9%) | 34 (25.8%) |
| 13–24 h | 9 (15.3%) | 20 (27.4%) | 29 (21.9%) |
| 25–48 h | 11 (18.6%) | 23 (31.5%) | 34 (25.8%) |
| > 48 h | 21 (35.6%) | 14 (19.2%) | 35 (26.5%) |
| **Total** | **59 (100%)** | **73 (100%)** | **132 (100%)** |

Note: The overall between-group distribution of disease duration was significant ($\chi^2$=8.54, p=0.036). Post-hoc pairwise comparison of individual rows did not reach significance for the 25–48 h row alone (p=0.100). CG – control group; SG – study group.

**Intussusception type**

The ileocaecal (small-to-large bowel) variant predominated in both groups (90.1%; SG 68/73, CG 51/59). Small-to-small bowel intussusception was found in 12 patients (9.1%), and large-to-large bowel in 1 (0.8%). No significant between-group difference was observed (p>0.05).

**Conservative treatment**

Conservative reduction was attempted in 82 patients (62.1%) and succeeded in 62 (47.0% of the total cohort). In the CG, PIS was applied in 30 of 59 patients (50.8%); successful reduction was achieved in 23 (39.0%). A strong negative correlation was found between disease duration and PIS application (r=−0.83), and each patient received a single attempt only. In the SG, HEC was applied in 52 of 73 patients (71.2%); successful reduction was achieved in 39 (53.4%). Fifteen patients required up to five to six consecutive attempts. A very strong negative correlation existed between disease duration and HEC application (r=−0.98). The relationship between disease duration and treatment type was significant in both groups (CG: $\chi^2$=51.01, p=2.96×10$^{-9}$; SG: $\chi^2$=50.25, p=4.18×10$^{-9}$). Primary treatment outcomes are summarised in Table 3, the SG achieved a higher conservative reduction rate (53.4% vs 39.0%) and a significantly shorter hospital stay (2.5±0.66 vs 4.6±0.51 days, p<0.05).

**Table 3. Primary treatment outcomes by group**

| Outcome | CG – PIS (n=59) | SG – HEC (n=73) |
|---|---|---|
| Successful conservative reduction | 23 (39.0%) | 39 (53.4%) |
| Hospital stay, days (M±SD) | 4.6 ± 0.51 | 2.5 ± 0.66* |
| Operative intervention | 36 (61.0%) | 34 (46.6%) |
| Mortality | 5/59 (8.5%) | 2/73 (2.7%) |

*Note: *p<0.05 vs CG. CG – control group; SG – study group; HEC – hydroechocolonographic disinvagination; PIS – pneumoirrigoscopy; M±SD – mean ± standard deviation. Mortality is expressed as group-specific case fatality (deaths/group total).*

**Surgical treatment**

Operative intervention was performed in 70 patients (53.0%; CG: 36, SG: 34); 88.6% presented after 24 hours. Twenty patients (28.6%) underwent surgery after failed conservative reduction, while 50 (71.4%) proceeded directly to surgery. Distribution of procedures is shown in Table 4 .

**Table 4. Types of surgical procedures performed**

| Procedure | CG (n=36) | SG (n=34) | Total (n=70) |
|---|---|---|---|
| Laparotomy + manual disinvagination | 16 (44.4%) | 14 (41.2%) | 30 (42.9%) |
| Disinvagination + appendectomy | 3 (8.3%) | 1 (2.9%) | 4 (5.7%) |
| Bowel resection + primary anastomosis | 5 (13.9%) | 11 (32.4%) | 16 (22.9%) |
| Laparotomy + temporary stoma | 11 (30.6%) | 7 (20.6%) | 18 (25.7%) |
| Other | 1 (2.8%) | 1 (2.9%) | 2 (2.9%) |
| **Total** | **36 (100%)** | **34 (100%)** | **70 (100%)** |

*Note: CG – control group; SG – study group.*

Manual disinvagination was the most common procedure (42.9%), followed by temporary stoma (25.7%) and bowel resection with anastomosis (22.9%). Organic lead points were identified in 10 patients: Meckel's diverticulum (n=5), Peutz–Jeghers polyposis (n=2), small-bowel polyp (n=2), and ileocaecal tumour (n=1). Disease duration alone did not reliably predict bowel viability: 8 operated patients presenting at 12–24 hours had viable bowel at laparotomy.

**Mortality**

Seven deaths occurred overall (5.3%; CG: 5/59 [8.5%], SG: 2/73 [2.7%]). All fatalities involved children under 2 years of age. Causes included cerebral oedema with multi-organ failure, anastomotic dehiscence with secondary peritonitis, and post-resection complications in the context of late-presenting bowel necrosis.

**Long-term follow-up**

Long-term outcomes were assessed in 104 patients (78.8%; CG: 39, SG: 65) at 1–25 years post-discharge. Among the 57 patients treated conservatively (PIS: 20, HEC: 37), quality-of-life parameters — physical activity, abdominal pain, and social function — were not impaired. Of the 47 surgically treated patients, 44.7% reported intermittent abdominal discomfort and 19.1% episodic constipation. Late appendectomy was required in 3 patients.

## Discussion

This study confirms the well-established epidemiology of paediatric intussusception: male predominance, peak incidence at 6–12 months, and ileocaecal predominance [1,6,12]. The high proportion of rural patients (79.5%) and late presenters (>48 hours: 26.5%) reflects the reality of delayed access to specialised paediatric surgical care in Central Asia, which is consistent with patterns reported in comparable healthcare settings [13].

The principal finding is that ultrasound-guided HEC outperforms fluoroscopy-controlled PIS in conservative reduction success (53.4% vs 39.0%). This result aligns with published series demonstrating that liquid-based hydrostatic reduction under US guidance achieves outcomes comparable to or exceeding those of

pneumatic reduction under fluoroscopy [8,13]. The complete absence of ionising radiation is a decisive advantage: PIS exposes both the patient and operating personnel to continuous fluoroscopy averaging 15 minutes per attempt, and limits the clinician to a single attempt because of perforation risk. HEC eliminates radiation entirely and permits up to five to six consecutive attempts — a capability that directly contributed to improved reduction success in our cohort.

Integration of CDFM during HEC provides real-time assessment of bowel-wall perfusion, enabling objective identification of vascular compromise before surgical decisions are made. This functional dimension is unavailable with PIS and represents an important patient safety advance, particularly for late-presenting patients at greatest risk of necrosis [11].

Our data question the traditional dogma that disease duration alone should govern the choice between conservative and operative treatment. Among operated patients, eight who presented at 12–24 hours demonstrated viable bowel intraoperatively. Conversely, the strong positive correlation between disease duration and surgery rate ($r=0.99$) confirms that prolonged ischaemia remains a critical risk factor. It is noteworthy that the CG had a higher proportion of very late presenters (>48 hours: 35.6% vs 19.2%), indicating that the CG operated under less favourable baseline conditions with respect to presentation timing — a factor that may independently contribute to the higher operative and mortality rates observed in that group. The HEC approach, combining real-time sonographic assessment with CDFM and clinical evaluation, provides a more individualised decision-making framework than duration-based criteria alone [1, 9].

The significantly shorter hospitalisation in the SG (2.5 vs 4.6 days, $p<0.05$) has direct healthcare-economic implications, reducing bed occupancy and family burden. Post-reduction surveillance by serial US in the SG also eliminated the supplemental radiation dose required by barium transit confirmation in the CG.

The overall mortality of 5.3% exceeds rates reported in high-income settings but is consistent with Central Asian data characterised by late-presenting patients and limited pre-hospital triage [9,11]. The approximate halving of group-specific mortality in the SG (2.7% vs 8.5%), while not statistically significant in this series, is clinically meaningful and aligns with the hypothesis that earlier, more effective conservative reduction prevents progression to bowel necrosis.

Limitations include the retrospective, non-randomised, single-centre design and a 23-year observation window during which ancillary care standards evolved independently of the compared techniques. A prospective randomised trial, although logistically challenging, would provide the highest level of evidence.

## Conclusion

Ultrasound-guided hydroechocolonographic disinvagination is a safe, effective, and radiation-free alternative to fluoroscopy-controlled pneumoirrigoscopy for the conservative management of intestinal intussusception in children. Compared to pneumoirrigoscopy, it achieves a higher rate of successful reduction (53.4% vs 39.0%), significantly reduces hospital stay (2.5 vs 4.6 days, $p<0.05$), and permits repeated attempts without radiation risk. Real-time Doppler perfusion assessment adds an important safety dimension for late presenters.

Disease duration alone is an insufficient criterion for treatment selection; overall clinical status and the absence of peritoneal signs must be weighted equally. Surgical treatment remains mandatory for peritonitis, haemodynamic instability, and failed conservative reduction, with the operative strategy tailored to intraoperative bowel viability. Elective surgery is advisable for children over 7 years and for recurrent intussusception, given the higher likelihood of an organic lead point in these groups.

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