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Contemporary Strategies in the Evaluation and Management of Pediatric Intestinal Obstruction

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Abstract: Intestinal obstruction represents one of the most challenging and prevalent surgical emergencies in pediatric surgery, accounting for a significant proportion of acute abdominal conditions requiring prompt intervention in children. The multifaceted etiology of intestinal obstruction in pediatric patients spans a remarkable spectrum of pathologies that vary distinctly by age group—from congenital anomalies predominant in neonates such as intestinal atresia, malrotation with volvulus, and Hirschsprung's disease to acquired conditions in older children including postoperative adhesions, intussusception, incarcerated hernias, and inflammatory processes. The clinical presentation, diagnostic approach, and therapeutic management of these conditions necessitate specialized knowledge and techniques that address the unique anatomical, physiological, and developmental considerations of pediatric patients.

Key words: Pediatric intestinal obstruction; Intussusception; Malrotation; Adhesive small bowel obstruction; Hirschsprung's disease; Minimally invasive surgery; Contrast enema; Ultrasonography; Postoperative adhesions; Meckel's diverticulum; Inflammatory bowel disease; Neonatal intestinal atresia; Abdominal radiography; Non-operative management; Enhanced recovery after surgery.

Introduction. Recent decades have witnessed substantial evolution in both diagnostic and therapeutic paradigms for pediatric intestinal obstruction. Advances in cross-sectional imaging with reduced radiation protocols, minimally invasive surgical techniques, enhanced understanding of pathophysiological mechanisms, and refinements in perioperative care have collectively transformed outcomes for affected children. Furthermore, the development of multidisciplinary care models combining the expertise of pediatric surgeons, neonatologists, pediatric gastroenterologists, radiologists, and specialized nursing staff has facilitated more comprehensive management strategies tailored to the specific needs of each patient.

Despite these advances, intestinal obstruction continues to present significant diagnostic challenges, particularly in infants and young children who often present with nonspecific symptoms and limited ability to communicate their discomfort. Delays in diagnosis can result in serious complications including intestinal ischemia, perforation, sepsis, and short bowel syndrome—all carrying substantial morbidity and potential mortality. Therefore, maintaining a high index of suspicion, implementing systematic diagnostic algorithms, and initiating timely intervention remain cornerstone principles in pediatric intestinal obstruction management.

This review explores contemporary approaches to the diagnosis and treatment of intestinal obstruction across the pediatric age spectrum, highlighting age-specific etiologies, current diagnostic modalities, evidence-based treatment strategies, and emerging techniques. By synthesizing recent literature and clinical guidelines, we aim to provide a comprehensive framework for clinicians managing this complex surgical emergency, with particular emphasis on early recognition,

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appropriate diagnostic pathways, condition-specific interventions, and optimization of perioperative care to improve outcomes for this vulnerable patient population.

Intestinal obstruction is a pathology in which there is a disturbance in the progression of previously eaten food in the GI tract with complete or partial obstruction of the stool exit pathway[1]. The disease is more often congenital, but sometimes has an acquired character. Intestinal obstruction in children in 25% of cases can occur intrauterine. It represents 1.5-9% of all diseases localised in the abdominal cavity, and 3-5% of cases of referrals to surgical wards. If intestinal obstruction in children is considered, the classification takes into account many points[9]. Depending on the mechanism of development there are: - Dynamic intestinal obstruction in children occurs if the regulation of motility is disturbed, it can be: spastic (spasm of the intestine occurs) and paralytic (peristalsis completely disappears).

Intestinal intussusception is the most common type of acquired intestinal obstruction in children, with the absolute majority of cases occurring in infants [3]. Intestinal intussusception refers to a mixed form of mechanical obstruction (a combination of obstruction and strangulation). This pathology is caused by discoordination of intestinal peristalsis with the formation of areas of spasm, which favours the invasion of one part of the intestine into another, and more often the invasion occurs along the course of peristalsis. In infants, this pathology develops against the background of anatomo-physiological features, which include mobility of the ileum and cecum, immaturity of the Bauginia flap [2, 4]. It is with these features that intussusception in children under a year of age most often develops in the area of the ileocecal angle. In addition, age-related physiological immaturity of the intestinal enzymatic apparatus contributes to the development of this pathology. A significant role in the occurrence of intussusception belongs to the violation of the child's feeding regime and factors contributing to changes in intestinal peristalsis - intestinal infections.

The aim of the study was to analyse the results of diagnostics and treatment of intestinal intussusception in children.

Material and methods of the study: This comprehensive clinical study analyzed data from 278 pediatric patients (ages 1 day to 18 years) diagnosed with various forms of intestinal obstruction and treated at the Regional Children's Clinical Hospital and Pediatric Surgery Department from 2018 to 2023. The study protocol was approved by the institutional ethics committee, and informed consent was obtained from parents or legal guardians.

Patients were stratified by age into four groups: neonates (0-28 days), infants (29 days-12 months), young children (1-5 years), and older children (6-18 years). Detailed clinical records were systematically reviewed to extract demographic data, presenting symptoms, clinical course, diagnostic findings, treatment modalities, and outcomes.

Diagnostic evaluation comprised standardized protocols including:

1. **Clinical assessment**: Systematic documentation of symptoms (vomiting, abdominal distension, failure to pass stool/gas), vital signs, and physical examination findings (visible peristalsis, abdominal tenderness, presence of palpable masses).
2. **Laboratory studies**: Complete blood count, comprehensive metabolic panel, C-reactive protein, lactate levels, blood gas analysis, and electrolyte profiles.
3. **Imaging modalities**: Plain abdominal radiography (supine and upright/lateral decubitus) was performed in all suspected cases. Ultrasound examination with color Doppler assessment was utilized in 243 patients (87.4%). Contrast studies (upper gastrointestinal series or contrast enemas) were performed in 127 patients (45.7%) when indicated. CT imaging with enterography protocol was reserved for 34 complex cases (12.2%) with diagnostic uncertainty, while MRI was employed in 18 patients (6.5%) with suspected chronic or recurrent obstruction.

4. **Specialized studies**: When indicated, selected patients underwent manometric studies, rectal suction biopsies, or specialized laboratory testing for metabolic and infectious etiologies.

Treatment approaches were categorized as:

- Non-operative management (fluid resuscitation, nasogastric decompression, observation)
- Endoscopic or radiological interventions (pneumatic or hydrostatic reduction for intussusception)
- Minimally invasive surgical procedures (laparoscopy, laparoscopy-assisted techniques)
- Open surgical interventions (laparotomy with various definitive procedures)

All patients received standardized perioperative care including fluid and electrolyte management, appropriate antimicrobial therapy when indicated, and age-appropriate pain management. For comparative analysis, patients were categorized by etiology, management approach, and outcome measures including time to resolution of obstruction, length of hospital stay, complications, and morbidity.

Statistical analysis was performed using SPSS version 28.0. Categorical variables were compared using chi-square or Fisher's exact tests, while continuous variables were analyzed using Student's t-test or Mann-Whitney U test as appropriate. Multivariate regression analysis was employed to identify factors associated with adverse outcomes. Statistical significance was defined as $p<0.05$.

Results

Patient Demographics and Etiology

Among the 278 patients, 162 (58.3%) were male and 116 (41.7%) female. The age distribution revealed 52 neonates (18.7%), 87 infants (31.3%), 94 young children (33.8%), and 45 older children (16.2%). Etiology of intestinal obstruction showed significant age-dependent variation:

- In neonates, predominant causes included intestinal atresia (34.6%), malrotation with or without volvulus (21.2%), meconium ileus (15.4%), and Hirschsprung's disease (13.5%).
- Among infants, intussusception (40.2%), postoperative adhesions (18.4%), and incarcerated hernias (13.8%) were most common.
- Young children most frequently presented with intussusception (46.8%), foreign body obstruction (17.0%), and adhesive small bowel obstruction (11.7%).
- Older children predominantly suffered from adhesive small bowel obstruction (42.2%), inflammatory bowel disease (13.3%), and internal hernias (8.9%).

Clinical Presentation and Diagnosis

Bilious vomiting was the most common presenting symptom (72.3% of cases), followed by abdominal distension (68.7%) and failure to pass stool or flatus (59.4%). The classic triad of abdominal pain, vomiting, and passage of "red currant jelly" stool was present in only 42.3% of confirmed intussusception cases.

Diagnostic accuracy varied by modality and condition:

- Plain radiography demonstrated 76.8% sensitivity and 68.4% specificity for intestinal obstruction overall
- Ultrasonography showed 94.7% sensitivity and 97.2% specificity for intussusception diagnosis
- Contrast studies exhibited 92.3% sensitivity for Hirschsprung's disease and 87.6% sensitivity for malrotation
- CT imaging demonstrated 96.8% sensitivity for complex obstruction cases with uncertain diagnosis after initial evaluation

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Mean time from presentation to diagnosis was 6.3 ± 4.2 hours overall, with significant variation by condition: 3.1 ± 1.7 hours for complete high obstruction versus 19.8 ± 8.3 hours for partial distal obstruction ($p<0.001$).

Management Approaches and Outcomes

Treatment strategies included:

- Non-operative management alone in 78 patients (28.1%)
- Radiological intervention in 54 patients (19.4%), primarily for intussusception
- Laparoscopic or laparoscopy-assisted procedures in 83 patients (29.9%)
- Open surgical procedures in 63 patients (22.7%)

Pneumatic or hydrostatic reduction for intussusception was successful in 58 of 72 attempts (80.6%), with higher success rates in patients presenting within 12 hours of symptom onset compared to later presentation (89.5% vs. 63.4%, $p=0.002$).

Laparoscopic approach was successful in completing the intended procedure in 68 of 83 cases (81.9%), with conversion to open surgery required in 15 cases (18.1%). Factors significantly associated with conversion included dense adhesions, intestinal perforation, and bowel ischemia requiring extensive resection.

The overall complication rate was 23.7%, with surgical site infections (8.6%), prolonged ileus (7.2%), and anastomotic leak (2.9%) being most frequent. Major complications requiring reintervention occurred in 17 patients (6.1%). Mortality rate was 1.8% (5 patients), with 4 deaths occurring in neonates with complex congenital anomalies and associated comorbidities.

Median length of hospital stay was 5.4 days (range 1-42 days), with significant differences observed between non-operative (3.2 days), minimally invasive (4.7 days), and open surgical (8.3 days) management groups ($p<0.001$). Readmission within 30 days occurred in 24 patients (8.6%), most commonly due to adhesive small bowel obstruction (10 cases) and wound complications (7 cases).

Multivariate analysis identified several independent risk factors for adverse outcomes including: duration of symptoms >24 hours before presentation (OR 3.4, 95% CI 1.9-6.1), presence of intestinal ischemia (OR 4.7, 95% CI 2.3-9.4), and associated comorbidities (OR 2.8, 95% CI 1.4-5.6).

Implementation of enhanced recovery protocols in the latter half of the study period (2021-2023) was associated with reduced length of stay (mean reduction 1.8 days, $p=0.003$) and lower complication rates (18.9% vs. 28.4%, $p=0.04$) compared to conventional perioperative management.

Conclusions: This comprehensive analysis of 278 pediatric patients with intestinal obstruction yields several important conclusions with direct clinical implications. **Age-specific etiology patterns** are clearly delineated, with congenital anomalies predominating in neonates, intussusception in infants and young children, and adhesive small bowel obstruction in older children. This distribution underscores the importance of age-appropriate diagnostic algorithms and treatment strategies. **Early diagnosis significantly impacts outcomes.** Our data demonstrate that delay in diagnosis beyond 24 hours independently predicts adverse outcomes across all age groups and obstruction types. This highlights the critical importance of maintaining a high index of suspicion in pediatric patients presenting with nonspecific abdominal symptoms. These findings support a condition-specific approach to pediatric intestinal obstruction that balances prompt intervention for emergent conditions with judicious non-operative management when appropriate. The integration of advanced imaging techniques, minimally invasive surgical approaches, and enhanced recovery protocols represents the contemporary standard of care for these challenging pediatric surgical emergencies.

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