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DOPPLEROGRAPHIC EVALUATION OF INTESTINAL WALL BLOOD FLOW IN CHILDREN WITH ACUTE INTESTINAL OBSTRUCTION





Otamuradov Furqat Abdukarimovich[1], Vohobov Nodir Safarovich[1], Kurbaniyazov Bakhodir Zafarjonovich[2]
1 - Termez Branch of Tashkent State Medical University, Republic of Uzbekistan, Termez;
2 - Samarkand State Medical University, Republic of Uzbekistan, Samarkand

БОЛАЛАРДА ЎТКИР ИЧАК ТУТИЛИШИДА ИЧАК ДЕВОРИ ҚОН ОҚИМИНИ ДОППЛЕРОГРАФИК БАҲОЛАШ

Отамурадов Фуркат Абдукаримович[1], Вохобов Нодир Сафарович[1], Курбаниязов Баходир Зафаржонович[2]
1 - Тошкент давлат тиббиёт университети Термиз филиали, Ўзбекистон Республикаси, Термиз ш.;
2 - Самарқанд давлат тиббиёт университети, Ўзбекистон Республикаси, Самарқанд ш.

ДОППЛЕРОГРАФИЧЕСКАЯ ОЦЕНКА КРОВОТОКА В СТЕНКЕ КИШКИ ПРИ ОСТРОЙ КИШЕЧНОЙ НЕПРОХОДИМОСТИ У ДЕТЕЙ

Отамурадов Фуркат Абдукаримович[1], Вохобов Нодир Сафарович[1], Курбаниязов Баходир Зафаржонович[2]
1 - Термезский филиал Ташкентского государственного медицинского университета, Республика Узбекистан, г. Термез;
2 - Самаркандский государственный медицинский университет, Республика Узбекистан, г. Самарканд

e-mail: nodirvohobov@gmail.com

Резюме. *Мақсад: болаларда орттирилган ўткир ичак тутилишида прогнозга асосланган дифференциал алгоритм натижаларини анъанавий тактика билан солиштириш. Материал ва усуллар: бир марказли амбиспектив когортда прогностик баллни 6 ва 12 соатда режали қайта ҳисоблаш билан алгоритм бўйича даволанган 82 нафар бола (асосий гуруҳ) 104 нафар боладан иборат тарихий назорат гуруҳи билан таққосланди; гуруҳлар бирорта бошланғич белги, шу жумладан хавф гуруҳлари тақсимоти бўйича фарқ қилмади (p = 0,917). Натижалар: алгоритм операция қилинганлар улушини 41,3 дан 25,6% гача (p = 0,025), ичак резекцияси частотасини 22,1 дан 4,9% гача (шанслар нисбати 0,18; p < 0,001) ва қабулдан кейин 24 соатдан кечиктирилган операцияларни 16,3 дан 3,7% гача (p = 0,006) камайтирди. Асоратлар 15,4 дан 6,1% гача камайди (p = 0,047), ўлим қайд этилмади, анастомоз чоки етишмовчилиги назоратдаги учтага қарши кузатилмади. Лапароскопия операция қилинган болаларнинг 81,0% ида биринчи аралашув бўлди (назоратда 55,8%), операциягача бўлган медиана вақт эса 14,2 дан 7,0 соатга қисқарди. Битта резекциянинг олдини олиш учун даволаш зарур бўлган болалар сони олтитани, резекция учун Мантел–Хензел шанслар нисбати 0,13 ни ташкил этди (p = 0,001). Хулоса: балл асосидаги алгоритм стационарда бўлиш муддатини узайтирмаган ҳолда даволашни эрта кам инвазив аралашув томон хавфсиз равишда силжитади.*

Калит сўзлар: *ўткир ичак тутилиши, болалар, прогностик балл, ичак резекцияси, лапароскопия, дифференциал тактика.*

Abstract. *Aim: to compare the outcomes of a prognosis-based differentiated algorithm with conventional tactics in children with acquired acute intestinal obstruction. Materials and methods: a single-centre ambispective cohort compared a main group of 82 children managed by an algorithm with scheduled recalculation of a prognostic score at 6 and 12 hours against a historical control group of 104 children; the groups did not differ in any baseline feature, including the distribution of risk groups (p = 0.917). Results: the algorithm cut the operated share from 41.3% to 25.6% (p = 0.025), the bowel-resection rate from 22.1% to 4.9% (odds ratio 0.18; p < 0.001) and operations later than 24 hours from admission from 16.3% to 3.7% (p = 0.006). Complications fell from 15.4% to 6.1% (p = 0.047), with no deaths and no anastomotic leaks against three in controls. Laparoscopy was the first procedure in 81.0% versus 55.8% of operated children, and the median time to surgery shortened from 14.2 to 7.0 hours. The number needed to treat to prevent one resection was six, and the Mantel–Haenszel odds ratio for resection was 0.13 (p = 0.001). Conclusion: a score-driven algorithm safely shifts management toward early minimally invasive intervention without lengthening hospital stay.*

Keywords: *acute intestinal obstruction, children, prognostic score, bowel resection, laparoscopy, differentiated tactics.*

Background. In children, acquired intestinal obstruction arises from intussusception, postoperative adhesions and luminal obturation, and each form permits an attempt at non-operative resolution. The pivotal question of management is when to stop that attempt and operate, because delay converts a reversible obstruction into ischaemia and resection. In a historical control group managed by conventional tactics, 41.3% of children were operated, 22.1% underwent bowel resection and 16.3% were operated later than 24 hours from admission, with 1.9% mortality - a pattern that defines the target for improvement.

Conventional management answers the timing question from the bedside impression of the surgeon on duty. That impression integrates experience in a way no rule reproduces, but it varies between shifts and between levels of training, and it is formed once rather than revised on a schedule. Two opposite errors follow: an operation performed on an obstruction that would have resolved, and an operation performed after the wall has lost viability. The first adds anaesthesia, access trauma and the risk of new adhesions; the second costs bowel length and its lifelong consequences for digestion.

The structure of obstruction is age-dependent: intussusception dominates in the first years of life, adhesive obstruction leads from the age of four years [4], and obturation is rarer and more evenly spread. This age pattern orders the diagnostic search but does not resolve the common problem of timing, which applies across forms and which conventional, judgment-based management handles inconsistently between shifts.

Predictive work in the field. The predictive literature on childhood obstruction has grown dense, yet stops short of a tested algorithm. In the meta-analysis of Kim et al. (38 studies, 40,133 cases) a symptom duration under 24 hours favoured successful reduction (odds ratio 3.81), whereas age under one year (0.385), rectal bleeding (0.252) and ascites on ultrasound (0.127) favoured failure [3]; Wondemagegnehu et al. reported a comparable picture in 174 children with a reduction success of 81.6% [5]. For resection, Xia et al. (660 children, 218 resections) identified C-reactive protein (odds ratio 4.79) and intussusception location (12.65) and reached 78.3% sensitivity and 71.9% specificity [6], while Yu et al. (547 children) combined symptom duration, C-reactive protein, white-cell count and ascites into a nomogram with a concordance index of 0.871 [7].

In adhesive obstruction, Hyak et al. (258 admissions in 202 children) reported urgent operation in 12% and successful non-operative management in 54%, with age under one year raising the need for surgery (odds ratio 3.71) and delay beyond 48 hours doubling resection, from 15.3% to 32.6% [2]. These studies converge on prediction but stop before a management loop: most address a single form, are validated by random split rather than over time, and are not embedded in an algorithm whose effect on outcomes has been measured. The present work closes that gap by recalculating a score and acting on it, which is why its comparison is framed as a treatment effect rather than as a statement of diagnostic accuracy.

What such models share is a design that ends at the moment of prediction. A probability computed once on admission describes the child as found, not as the child becomes over the next hours, and obstruction is a process whose decisive change - the loss of wall perfusion - may occur after that single measurement. Embedding a score in a schedule of recalculations turns the estimate into a trajectory and makes it actionable, which is the step the present study set out to test.

The aim of this study was to measure the clinical effect of an algorithm driven by a six-item prognostic score against conventional tactics in children with acquired acute intestinal obstruction.

Materials and methods. The work followed a single-centre, ambispective, non-randomised cohort design with historical control at the pediatric surgery department of Termez State Medical Institute, across three consecutive stages: retrospective derivation of a prognostic score, its temporal validation, and prospective evaluation of a differentiated algorithm. Over the study period 310 children presented with acute intestinal obstruction; 82 (26.5%) were excluded, and 228 children aged 1 month to 18 years entered the study.

The present analysis compares a historical control group of 104 children (2020–2023) managed by conventional tactics with a main group of 82 children (second half of 2025–2026) managed by the differentiated algorithm; a validation group of 42 children served the preceding score-validation stage. The protocol was approved by the local ethics committee (protocol No. 8 of 18 September 2023). Across the whole cohort boys numbered 138 (60.5%), intussusception accounted for 55.3%, adhesive obstruction for 37.3% and obturation for 7.5% of cases; the wide spread of body weight across the 1 month–18 year range required weight-based dosing of fluids, contrast and laparoscopy parameters.

On admission every child underwent examination, a complete blood count with the neutrophil-to-lymphocyte index, lactate measurement and colour-Doppler ultrasound; the on-call surgeon computed the prognostic score within the first 1–2

hours. The six items of the score are reduced or absent blood flow in the intestinal wall, peritoneal signs and lactate at or above 2.5 mmol/L, each worth two points, and symptom duration beyond 24 hours, a neutrophil-to-lymphocyte index at or above 5.0 and a free fluid layer thicker than 10 mm, each worth one point, giving a maximum of nine points and three risk bands.

The score was recalculated at 6 hours, at 12 hours if observation continued and off-schedule on deterioration, a rise moving the child to a higher risk group and changing tactics. Hydrostatic reduction was performed under ultrasound control, and laparoscopy at an age- and weight-adjusted pneumoperitoneum pressure, with atraumatic reduction of the intussusceptum and assessment of bowel viability after reduction. Resection was performed for a clearly non-viable segment, with the extent of resection and the method of restoring continuity decided intraoperatively.

Outcomes were the operated share, the bowel-resection rate, late surgery, complications graded by Clavien–Dindo [1], mortality, the first-line approach and the time to surgery. Statistical processing used the Pearson χ^2, Fisher and Fisher–Freeman–Halton tests for categorical variables, the Student t-test and Mann–Whitney U-test for continuous variables, binary logistic regression with multiple imputation, ROC analysis, 1000-fold bootstrap validation, the Hosmer–Lemeshow test, Mantel–Haenszel analysis and the Kaplan–Meier method, in SPSS Statistics 26.0 and R 4.4.2; $p < 0.05$ was taken as significant.

The groups were balanced at baseline, including the distribution of risk groups, which underpins the validity of the outcome comparison (Table 1).

Results. Across every main outcome the algorithm outperformed conventional tactics (Table 2, Fig. 1). The operated share fell from 41.3% to 25.6% ($p = 0.025$) and the bowel-resection rate from 22.1% to 4.9% (odds ratio 0.18; $p < 0.001$), an absolute risk reduction of 17.2% - six children treated by the algorithm prevent one resection. Operations later than 24 hours from admission dropped from 16.3% to 3.7% ($p = 0.006$), and the median time to surgery shortened from 14.2 to 7.0 hours. Laparoscopy was the first procedure in 81.0% versus 55.8% of operated children, and primary laparotomy fell from 18.3% to 4.9%.

Stratification by risk group showed that the benefit was not an artefact of case mix: within strata the odds of surgery were 2.6-fold lower and the odds of resection almost 8-fold lower in the main group (Mantel–Haenszel odds ratio for resection 0.13; $p = 0.001$). The largest gain appeared in the intermediate-risk group, where 20.0% versus 52.6% of children were operated. In the high-risk group the operated share was comparable (82.4% in the main group versus 75.0% in controls), yet resection within it fell from 54.2% to 23.5%: earlier surgery in high-risk children did not add interventions but allowed operating before ischaemia became irreversible. In the low-risk group 34 of 35 children (97.1%) recovered without surgery and none required resection.

The safety profile improved in parallel (Table 3). Complications fell from 15.4% to 6.1% ($p = 0.047$), with no anastomotic leaks in the main group against three in controls and no deaths against two. Among operated children the complication rate did not differ (23.8% versus 27.9%), so the overall fall followed from fewer operations and resections rather than from safer surgery. Hospital stay was unchanged (6.4 versus 6.5 days), because score recalculation at 6 and 12 hours required longer monitoring in non-operated children, and the 12-month recurrence rate did not differ significantly (5.3% versus 12.8%; $p = 0.101$).

Table 1. Baseline risk-group distribution in the control (CG) and main (MG) groups

Risk group	CG (n = 104), %	MG (n = 82), %
Low	40.4	42.7
Intermediate	36.5	36.6
High	23.1	20.7

Note: between-group comparison p = 0.917.

Table 2. Main treatment outcomes in the control (CG) and main (MG) groups

Outcome	CG (n = 104)	MG (n = 82)	p
Operated children, %	41.3	25.6	0.025
Bowel resection, %	22.1	4.9	< 0.001
Surgery later than 24 h, %	16.3	3.7	0.006
Complications (Clavien–Dindo), %	15.4	6.1	0.047
Mortality, %	1.9	0	-
Laparoscopy as first procedure, %	55.8	81.0	-
Primary laparotomy, %	18.3	4.9	-
Median time to surgery, h	14.2	7.0	-

Note: significance was not reported in the source manuscript for the outcomes marked with a dash.

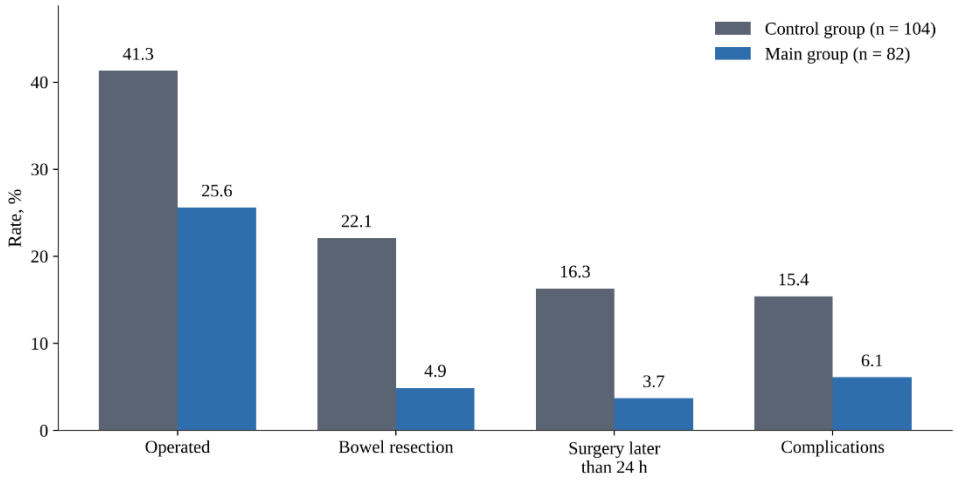


Fig. 1. Main treatment outcomes: conventional versus algorithm-based tactics

Table 3. Safety outcomes in the control (CG) and main (MG) groups

Outcome	CG (n = 104)	MG (n = 82)	p
Complications, %	15.4	6.1	0.047
Anastomotic leak, n	3	0	-
Mortality, %	1.9	0	-
12-month recurrence, %	12.8	5.3	0.101
Hospital stay, days (M ± SD)	6.5 ± 3.4	6.4 ± 2.7	-

Note: significance was not reported in the source manuscript for the outcomes marked with a dash.

Table 4. Risk-stratified tactics by obstruction form

Risk group	Intussusception	Adhesive obstruction
Low	Up to 3 controlled hydrostatic reductions	Conservative treatment with contrast test ≤ 24 h
Intermediate	One reduction, then laparoscopy on failure	Reassessment of effect at 6–12 h
High	Early laparoscopic revision without reduction	Urgent surgery

Tactics by risk band and obstruction form. The algorithm acted along two axes at once: the risk group set how aggressively to move toward surgery, and the obstruction form set which action that meant (Table 4). A one-dimensional rule cannot make that distinction, because the same risk level calls for repeated hydrostatic reduction in intussusception and for a timed contrast test in adhesive obstruction.

Structure of obstruction by age. Intussusception made up 95.1% of cases in the first year of life and 80.8% at 1–3 years, falling to 36.5% at 4–7 years and 7.4% in adolescents, while adhesive obstruction rose from 4.9% in the first year to 57.7% at 4–7 years and 65.7% at 8–12 years and led from the age of four; the share of an organic lead point in intussusception rose from 2.6% to 66.7%, which shifts diagnostic suspicion in older children.

Discussion. The gains align with the direction of predictive work in the field while adding what that work lacked - a tested management loop. Yu et al. [7] and Xia et al. [6] built resection-prediction tools, and Kim et al. summarised predictors of failed reduction [3]; the present algorithm converts such prediction into scheduled decisions with score recalculation, and its effect persisted after stratification, indicating a genuine treatment effect rather than case selection. The mechanism is temporal: by shortening the median time to surgery from 14.2 to 7.0 hours, the algorithm reaches high-risk children before ischaemia becomes irreversible, which explains why the operated share in the high-risk group was unchanged while resection within it fell by more than half.

The direction of this finding matches the adhesive-obstruction data of Hyak et al., where delay beyond 48 hours doubled the resection rate [2]. The threshold used here is tighter - 24 hours - and the comparison concerns a cohort in which late operation was already uncommon in absolute terms, which suggests that the relationship between delay and bowel loss holds well below the intervals examined in adult practice.

The architecture matters as much as the score. Recalculating the score at 6 and 12 hours converts a single admission snapshot into a trajectory, so a child whose obstruction is progressing is moved to a higher-risk tactic before the clinical picture becomes overt. Pairing the risk axis with the form axis - intussusception, adhesive, obturation - lets the same

risk level prescribe different actions. The gain concentrated in the intermediate-risk band, which is precisely where judgment-based management is least reproducible: low-risk children are observed and high-risk children are operated under any reasonable rule, whereas the intermediate band is where a scheduled reassessment replaces an impression.

Unchanged hospital stay despite fewer operations reflects the longer monitoring that score recalculation requires in non-operated children, a reasonable trade for a lower resection burden. The absence of anastomotic leaks and deaths in the main group, together with an unchanged complication rate among operated children, locates the safety benefit in avoided operations rather than in altered operative technique. The shift of first-line management toward laparoscopy, from 55.8% to 81.0% of operated children, works in the same direction, since earlier intervention is more often feasible through ports than through a laparotomy performed on a distended abdomen.

The low-risk band deserves separate comment. Thirty-four of 35 low-risk children in the main group recovered without surgery and none lost bowel, which answers the safety question that any de-escalating rule must answer: a score used to withhold an operation is only as good as the children it keeps out of theatre. Read together with the negative predictive value of the underlying score, this result supports using the low band as an explicit permission to continue non-operative management rather than as a mere absence of alarm signs.

Limitations include the single-centre design, the historical control that exposes the comparison to secular change in care, and the modest size of the main group, which widens confidence intervals for subgroup estimates. The control and main groups were treated in different calendar periods, so improvements in anaesthesia, imaging availability and perioperative care cannot be separated from the effect of the algorithm itself; the stability of the effect after stratification argues against case mix but not against secular trend. Multicentre prospective testing is needed to confirm transportability.

The strengths of the study are the combination of clinical, laboratory and Doppler features in a single tool, temporal validation on an independent sample and the explicit link between risk and tactics. Beyond the clinical effect, the approach carries an organisational benefit: the six score items are available in any pediatric surgical unit without extra equipment, the calculation takes the on-call surgeon one to two minutes, and the reproducibility of the decision reduces the dependence of outcome on the experience of a particular shift. This transportability matters most at district level, where late presentation of obstruction is more common and a dedicated pediatric emergency surgeon may not be on every shift. Future work should pursue external multicentre validation and a prospective assessment of the approach on long-term outcomes, including recurrence and growth-related sequelae of bowel loss.

The weight structure of the underlying score also informs practice: two points attach to signs that directly reflect ischaemia and its systemic response, and one point to background and duration, so a single late presentation does not by itself mandate surgery while impaired wall perfusion moves a child toward early intervention. This balance guards against both of the opposing errors that judgment-based management tends to make.

Conclusion. A prognosis-based differentiated algorithm lowered the operated share from 41.3% to 25.6%, the bowel-resection rate from 22.1% to 4.9% and late operations from 16.3% to 3.7%, while shifting first-line management toward laparoscopy and abolishing mortality, without lengthening hospital stay. The score-driven approach suits any pediatric surgical unit that can obtain a blood count, lactate and Doppler ultrasound on admission.

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ДОППЛЕРОГРАФИЧЕСКАЯ ОЦЕНКА КРОВОТОКА В СТЕНКЕ КИШКИ ПРИ ОСТРОЙ КИШЕЧНОЙ НЕПРОХОДИМОСТИ У ДЕТЕЙ

Отамурадов Ф.А., Вохобов Н.С., Курбаниязов Б.З.

Резюме. *Цель: сравнить результаты дифференцированного алгоритма, основанного на прогнозе, с традиционной тактикой у детей с приобретённой острой кишечной непроходимостью. Материал и методы: в одноцентровой амбиспективной когорте основную группу из 82 детей, которых вели по алгоритму с плановым пересчётом прогностического балла через 6 и 12 часов, сравнили с историческим контролем из 104 детей; группы не различались ни по одному исходному признаку, включая распределение групп риска (p = 0,917). Результаты: алгоритм снизил долю оперированных с 41,3 до 25,6% (p = 0,025), частоту резекции кишки - с 22,1 до 4,9% (отношение шансов 0,18; p < 0,001) и долю операций позже 24 часов от поступления - с 16,3 до 3,7% (p = 0,006). Осложнения снизились с 15,4 до 6,1% (p = 0,047), летальных исходов и несостоятельности анастомоза не было против двух и трёх в контроле. Лапароскопия стала первым вмешательством у 81,0% оперированных против 55,8%, медиана времени до операции сократилась с 14,2 до 7,0 часа. Число больных, которых необходимо пролечить для предотвращения одной резекции, составило шесть, отношение шансов резекции по Мантелю–Хензелю - 0,13 (p = 0,001). Выводы: алгоритм, управляемый балльной шкалой, безопасно смещает лечение в сторону раннего малоинвазивного вмешательства, не удлиняя сроки госпитализации.*

Ключевые слова: *острая кишечная непроходимость, дети, прогностическая шкала, резекция кишки, лапароскопия, дифференцированная тактика.*