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Pathological lead points in surgically treated pediatric ileocolic intussusception: A 17-year single-center cohort study

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Abstract

Purpose: Pathological lead points (PLPs) are an important cause of pediatric intussusception, but their clinical characteristics and associated factors remain incompletely characterized in surgically treated children. This study aimed to describe the etiologies of PLPs and compare demographic, clinical, laboratory, operative, and postoperative characteristics between children with and without PLPs undergoing surgery for ileocolic intussusception.

Methods: This retrospective single-center cohort study included 83 children who underwent surgery for ileocolic intussusception at a tertiary pediatric surgical center.

Results: PLPs were identified in 15.7%. Meckel's diverticulum (MD) was the most common lesion (9/13, 69.2%). Patients with PLPs were older (median, 82.0 vs. 17.5 months), had a longer symptom duration before presentation (51.0 vs. 17.0 hours), and had higher leukocyte counts (17.1 vs. 11.7 × 10^9/L). Bowel resection was performed in all 13 children with PLPs and in 12/70 children without PLPs (17.1%). In the primary multivariable model, increasing age was consistently associated with PLP status (adjusted odds ratio [OR] per month, 1.06; 95% confidence interval [CI], 1.02–1.11; $p < 0.001$). Higher leukocyte count was also associated with PLP status (adjusted OR, 1.21; 95% CI, 1.01–1.52; $p = 0.034$), although this association was less stable in the influence-based sensitivity analysis.

Conclusions: Among children undergoing surgery for ileocolic intussusception, PLPs were identified in 15.7%, most commonly MD. Older age was the most consistent factor associated with PLP status. These exploratory findings characterize a selected surgical population and should not be used to guide the choice between operative and nonoperative management.

Introduction

Intussusception is a leading cause of intestinal obstruction in infants and young children and requires prompt diagnosis and treatment [1,2]. Ileocolic intussusception is the predominant form in children, and most cases occur during the first two years of life [3-7]. Although image-guided enema reduction is the preferred initial treatment for most children without contraindications, some patients require surgical intervention because of failed reduction, bowel compromise, or an underlying pathological lead point (PLP) [8-10].

Most pediatric intussusceptions are idiopathic, whereas a smaller proportion is associated with structural lesions that serve as PLPs. These include Meckel's diverticulum (MD), intestinal polyps, duplication cysts, and benign or malignant neoplasms [11-14]. MD is among the most frequently reported PLPs in children [14,13]. The likelihood of an underlying PLP increases with age, making its consideration particularly relevant in older children presenting with intussusception [11,12,15]. Identifying a PLP has implications for management because enema reduction may be unsuccessful and operative treatment may be required to address both the intussusception and the underlying lesion [10,12].

Recognizing a PLP before surgery remains difficult, and the clinical and laboratory features associated with PLPs have varied across studies [12,10,16]. Evidence specifically characterizing children who undergo surgery for ileocolic intussusception is also affected by differences in patient selection and treatment pathways. A better understanding of the clinical and laboratory characteristics associated with PLP status may help inform preoperative assessment, although such associations require cautious interpretation in small cohorts.

This study compared demographic characteristics, clinical presentation, laboratory findings, operative management, and postoperative outcomes between children undergoing surgery for ileocolic intussusception with and without a PLP. We also explored factors independently associated with PLP status in this surgically treated cohort.

Materials and Methods

Study design and patients

This retrospective cohort study included consecutive patients younger than 18 years who underwent surgery for ileocolic intussusception at the Department of Pediatric Surgery, Clinical Center University of Sarajevo (CCUS), Bosnia and Herzegovina, between January 2009 and December 2025. Potentially eligible patients were identified through the hospital's electronic database using the International Classification of Diseases, Tenth Revision (ICD-10) code K56.1.

Patients were excluded if intussusception was successfully reduced nonoperatively, resolved spontaneously, occurred in the setting of previous abdominal surgery, or was documented in incomplete medical records.

The study was authorized by the local institutional review board (Institute for Scientific Research and Development of the CCUS, reference no. 51-45-1-3082/24). The requirement for informed consent was waived because of the retrospective study design.

Data collection and definitions

The following variables were extracted from medical records: age, sex, season of presentation, duration of symptoms, presenting symptoms, leukocyte count, C-reactive protein (CRP) concentration, intraoperative findings, surgical procedure, postoperative complications, length of hospital stay, and clinical outcome.

Leukocyte count and CRP concentration were taken from the initial laboratory assessment at hospital presentation.

Patients were classified according to intraoperative findings as having ileocolic intussusception with or without a PLP. In patients who underwent manual reduction without bowel resection, the absence of a PLP was determined by systematic intraoperative inspection and palpation of the reduced bowel.

For descriptive analyses, age was categorized as follows: infants, younger than 12 months; toddlers, 12–35 months; preschool children, 36–71 months; school-aged children, 72–143 months; and adolescents, 144–215 months.

Bloody stool was defined as the passage of grossly bloody or characteristic currant-jelly stool. Symptom duration was calculated as the interval between symptom onset and hospital presentation and expressed in hours. Neurological manifestations were defined as documented abnormalities at presentation, including lethargy, decreased responsiveness, irritability, hypotonia, or episodes of unresponsiveness.

Operative management was classified as manual reduction or bowel resection with primary anastomosis, according to intraoperative findings and the assessment of bowel viability. Total hospital stay was calculated from admission to discharge, and postoperative hospital stay from surgery to discharge.

A favorable clinical outcome was defined as discharge without death or major postoperative complications. Superficial surgical site infection was considered a minor complication and did not preclude a favorable clinical outcome; therefore, these categories were not mutually exclusive.

Statistical analysis

The distribution of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms and quantile–quantile plots. Approximately normally distributed variables were summarized as mean ± standard deviation (SD) and compared using the independent-samples t test. Non-normally distributed variables were summarized as median and interquartile range (IQR) and compared using the Mann–Whitney U test. Categorical variables were presented as frequencies and percentages and compared using Pearson's chi-square test or Fisher's exact test, as appropriate.

A multivariable logistic regression model was fitted to explore factors independently associated with pathological lead point (PLP) status. Given the small number of patients with PLPs, Firth's penalized maximum-likelihood logistic regression was used to reduce small-sample bias and address potential separation. Candidate predictors were age, sex, symptom duration, and leukocyte count. Associations were expressed as odds ratios (ORs) with 95% confidence intervals (CIs).

Multicollinearity was assessed using variance inflation factors (VIFs). The assumption of linearity in the logit for continuous predictors was evaluated using restricted cubic spline functions. Model discrimination was assessed by receiver operating characteristic (ROC) analysis and the area under the curve (AUC), while model fit was summarized using McFadden's pseudo-R^2. These measures were calculated in the study cohort; no external validation was performed.

An influence-based sensitivity analysis was performed to assess the effect of the two most influential observations on the regression estimates. Both observations were excluded simultaneously, and the

Firth penalized logistic regression model was refitted to examine changes in the estimated coefficients. The two observations were identified based on their influence on the estimated regression coefficients.

All statistical tests were two-sided, and p values <0.05 were considered statistically significant. Analyses were performed using R statistical software, version 4.5.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient characteristics and clinical presentation

A total of 83 children who underwent surgery for ileocolic intussusception during the study period were included. No identifiable PLP was found in 70 patients (84.3%), whereas 13 (15.7%) had a PLP (Table 1). Overall, 59 patients (71.1%) were male and 24 (28.9%) were female, giving a male-to-female ratio of 2.5:1. Sex distribution did not differ between groups (p = 1.000).

Children with PLPs were older than those without PLPs, with median ages of 82.0 months (IQR, 47.0–109.0) and 17.5 months (IQR, 8.0–29.0), respectively (p < 0.001). The distribution across age categories also differed significantly between groups (p < 0.001). Most children without PLPs were infants or toddlers, whereas school-aged children and adolescents accounted for a greater proportion of PLP-associated cases.

Vomiting was reported in 70 patients (84.3%), including all 13 children with PLPs and 57 of 70 children (81.4%) without PLPs (p = 0.205). Bloody stool occurred in 33 patients (39.8%), including 7 of 13 children (53.8%) with PLPs and 26 of 70 (37.1%) without PLPs (p = 0.258). A palpable abdominal mass was documented in 7 patients (8.4%); the difference between groups was not statistically significant (15.4% vs. 7.1%; p = 0.301).

The classic triad of paroxysmal abdominal pain, vomiting, and bloody stool was present in 23 of 83 patients (27.7%). It was more frequent among patients with PLPs than among those without PLPs (7/13 [53.8%] vs. 16/70 [22.9%], respectively; Fisher’s exact test, p = 0.039).

Neurological manifestations were documented in five patients (6.0%), all of whom were in the group without PLPs; none of the 13 children with PLPs had neurological manifestations (p = 1.000). Lethargy was the most common neurological manifestation. In one patient, neurological symptoms were the only initial presenting feature before abdominal ultrasonography established the diagnosis.

Duration of symptoms and laboratory findings

Median symptom duration before hospital presentation was longer among children with PLPs than among those without PLPs: 51.0 hours (IQR, 16.0–56.0) versus 17.0 hours (IQR, 11.0–32.0; p = 0.007) (Table 1). The distribution of symptom duration categories also differed significantly between groups (p

= 0.025). Symptoms had been present for more than 24 hours in 9 of 13 children (69.2%) with PLPs and 23 of 70 (32.9%) without PLPs.

The median leukocyte count was higher in children with PLPs than in those without PLPs (17.1 × 10^9/L [IQR, 13.5–18.6] vs. 11.7 × 10^9/L [IQR, 9.2–16.1]; p = 0.011). Median CRP concentration was also higher in the PLP group, but the difference was not statistically significant (12.6 mg/L [IQR, 10.4–48.2] vs. 8.3 mg/L [IQR, 2.8–18.6]; p = 0.073).

Operative management and postoperative outcomes

Operative management differed significantly according to PLP status (p < 0.001). Manual reduction was performed in 58 of 70 children (82.9%) without PLPs and in none of the children with PLPs. Bowel resection with primary anastomosis was performed in 25 patients (30.1%), including all 13 children with PLPs and 12 of 70 children (17.1%) without PLPs (Table 1).

Total hospital stay was longer among children with PLPs than among those without PLPs, with median durations of 9.0 days (IQR, 8.0–10.0) and 7.0 days (IQR, 5.0–8.0), respectively (p < 0.001). Postoperative hospital stays showed the same pattern: 9.0 days (IQR, 8.0–10.0) in the PLP group and 7.0 days (IQR, 5.0–8.0) in the group without PLPs (p < 0.001).

No postoperative deaths or major complications were recorded. A favorable clinical outcome, defined as discharge without death or major postoperative complications, was documented in 81 patients (97.6%), including 69 of 70 patients (98.6%) without PLPs and 12 of 13 (92.3%) with PLPs. Two patients (2.4%) developed a superficial surgical site infection, one in each group. These infections were classified as minor complications and did not preclude a favorable clinical outcome.

Etiology of pathological lead points

Among the 13 children with PLPs, MD was the most common lesion (9/13, 69.2%). Burkitt lymphoma was identified in two patients (15.4%). Gastric heterotopia and a Peutz–Jeghers-type hamartomatous polyp were each identified in one patient (7.7%) (Table 2).

Multivariable analysis of factors associated with pathological lead points

Firth's penalized logistic regression was used to explore factors associated with PLP status. Age, sex, leukocyte count, and symptom duration were included as candidate predictors. No evidence of substantial multicollinearity was observed (all variance inflation factor values <1.4). Restricted cubic spline analysis showed no statistically significant evidence of nonlinearity among continuous predictors (overall test for nonlinearity, p = 0.356).

Increasing age was independently associated with PLP status (adjusted odds ratio [OR] per month, 1.06; 95% confidence interval [CI], 1.02–1.11; p < 0.001). Higher leukocyte count was also associated with PLP status in the primary model (adjusted OR, 1.21; 95% CI, 1.01–1.52; p = 0.034). Neither sex nor symptom

duration was independently associated with PLP status. For symptom duration, the adjusted OR was 1.03 (95% CI, 1.00–1.08; p = 0.080).

The model had an apparent area under the receiver operating characteristic curve (AUC) of 0.90 (95% CI, 0.78–1.00) and a McFadden's pseudo-R^2 of 0.745. These estimates were obtained in the same cohort used to fit the model.

In the influence-based sensitivity analysis, the two most influential observations were excluded simultaneously and the model was refitted. The association between age and PLP status remained consistent, whereas the association with leukocyte count was less stable.

Discussion

In this cohort of children undergoing surgery for ileocolic intussusception, PLPs were identified in 15.7% of patients. Children with PLPs were older and had a longer duration of symptoms before presentation than those without PLPs. Higher leukocyte counts were associated with PLP status in the primary multivariable model, although this association was less stable in influence-based sensitivity analysis. Bowel resection was also more frequent among children with PLPs.

PLPs were identified in 15.7% of our surgically treated cohort. Published estimates of PLP prevalence in pediatric intussusception range from 0.3% to 20%, reflecting differences in study populations and methods of case ascertainment [15]. The prevalence observed in our study should be interpreted in the context of its restriction to children who required surgery and should not be extrapolated to the broader population of children with intussusception.

The distribution of PLP etiologies in our cohort is consistent with the recognized spectrum of structural causes of pediatric intussusception. MD was the predominant PLP, accounting for 9 of 13 cases (69.2%). Burkitt lymphoma accounted for two cases, while gastric heterotopia and a Peutz–Jeghers-type hamartomatous polyp were each identified in one patient. MD is widely recognized as the most common PLP in children, although the relative frequency of individual lesions varies with age and the characteristics of the study population [11-14,17]. The two cases of Burkitt lymphoma also illustrate the range of underlying pathology that may be encountered in older children presenting with intussusception [18].

Age was the most consistent factor associated with PLP status in our cohort. The median age was substantially higher among children with PLPs than among those without PLPs (82.0 vs. 17.5 months). This pattern is consistent with the established age distribution of pediatric intussusception: idiopathic cases predominate in infancy and early childhood, whereas structural LPs are encountered more frequently in older children [11,12,15]. Clinically, older age should therefore increase suspicion for an underlying structural abnormality, particularly when the presentation is atypical.

The clinical presentation of intussusception varies with age and symptom duration, ranging from nonspecific gastrointestinal symptoms to the classic triad of paroxysmal abdominal pain, vomiting, and bloody stool [7,19,20]. In our cohort, 27.7% of patients presented with the complete triad. This proportion was close to that reported by Das et al. (25.6%) [20], although higher than the 9.3% reported by Park and Cho [19]. The triad was more frequent among children with PLPs than among those without PLPs (53.8% vs. 22.9%). However, direct comparisons of the frequency of the complete triad according to PLP status are scarce, and the small number of PLP cases in our cohort limits the interpretation of this difference.

No significant difference in seasonal distribution was observed between children with and without PLPs ($p = 0.413$). Although cases were most frequent in summer in the overall cohort, season was not associated with PLP status in this study.

Higher leukocyte counts were associated with PLP status in the primary multivariable model, although this association was less consistent in the influence-based sensitivity analysis. In contrast, the association with increasing age remained stable. In contrast, the association with increasing age remained stable. These findings should be interpreted cautiously because only 13 patients had PLPs, limiting the reliability of multivariable estimates despite the use of Firth's penalized logistic regression [21,22]. The model's apparent discriminatory performance (AUC, 0.90; 95% CI, 0.78–1.00) was assessed in the same cohort used to fit the model and was not independently validated. Therefore, the model should not be regarded as a clinically validated prediction tool [23].

Children with PLPs had a longer duration of symptoms before presentation and more frequently underwent bowel resection than children without PLPs. Intermittent symptoms or partial spontaneous reduction may contribute to delayed recognition in some children with structural lesions, while prolonged bowel compromise may increase the risk of ischemia and resection. Braun et al. and Wong et al. [10,24] reported similar associations between PLPs, delayed presentation, failed reduction, and bowel resection. However, symptom duration was not independently associated with PLP status in our multivariable model, suggesting that the observed difference in symptom duration may partly reflect age or other clinical factors. The higher frequency of bowel resection should also be interpreted in the context of the need to manage the underlying lesion and the condition of the affected bowel; this comparison does not establish that PLP status independently predicts bowel resection.

This study has several limitations. Its retrospective, single-center design is susceptible to selection and information bias. Because the cohort included only surgically treated children, the findings cannot be generalized directly to children whose intussusception was successfully managed by image-guided reduction. The small number of PLP cases limited the precision of the multivariable estimates and increased the risk of overfitting despite Firth penalization. In the influence-based sensitivity analysis, the association between age and PLP status remained consistent, whereas the association with leukocyte count was less stable. The model was not externally validated. Finally, the 17-year study period encompassed changes in institutional management, with image-guided reduction becoming the

preferred first-line treatment for stable children without perforation or peritonitis. This change may have influenced the characteristics of the surgically treated cohort over time.

Conclusion

In conclusion, in this single-center cohort of children undergoing surgery for ileocolic intussusception, PLPs were identified in 15.7% of patients, with MD being the most common cause. Children with PLPs were older and had a longer duration of symptoms before presentation. Increasing age was the most consistent factor associated with PLP status in the multivariable analysis, whereas the association with leukocyte count was less stable. These exploratory findings require confirmation in larger, preferably multicenter cohorts. The results apply to surgically treated patients and should not be extrapolated to all children with intussusception.

Declarations

Contributions

ZZ: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. MM: Validation, Formal analysis, Data curation. UG: Validation, Formal analysis, Data curation. AJ: Validation, Formal analysis, Data curation. NZ: Validation, Formal analysis, Data curation. SV: Writing – review & editing, Supervision, Formal analysis, Data curation, Conceptualization.

Ethics declarations

Conflict of interest

Una Glamočija is an employee of Bosnalijek d.d., Sarajevo, but the employer has no role in design or results of the current study. Other authors declare no competing interests.

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Tables

Table 1. Demographic, clinical, laboratory, and operative characteristics of children undergoing surgery for ileocolic intussusception, according to pathological lead point status.

Parameter	All patients (n=83)	No pathologic lead point (n=70)	Pathologic lead point (n=13)	p-value
Age, months*	**19.0 (8.0, 39.0)**	**17.5 (8.0, 29.0)**	**82.0 (47.0, 109.0)**	**<0.001**
Age, categories‡				**<0.001**
Infants	30 (36.1%)	28 (40.0%)	2 (15.4%)	
Toddlers	32 (38.6%)	31 (44.3%)	1 (7.7%)	
Preschool children	9 (10.8%)	7 (10.0%)	2 (15.4%)	
School-aged children	9 (10.8%)	4 (5.7%)	5 (38.5%)	
Adolescents	3 (3.6%)	0 (0.0%)	3 (23.1%)	
Sex, male‡	59 (71.1%)	50 (71.4%)	9 (69.2%)	1.000
Season‡				0.413
Autumn	13 (15.7%)	11 (15.7%)	2 (15.4%)	
Winter	22 (26.5%)	16 (22.9%)	6 (46.2%)	
Spring	20 (24.1%)	18 (25.7%)	2 (15.4%)	
Summer	28 (33.7%)	25 (35.7%)	3 (23.1%)	
Vomiting‡	70 (84.3%)	57 (81.4%)	13 (100.0%)	0.205
Bloody stool‡	33 (39.8%)	26 (37.1%)	7 (53.8%)	0.258
Palpable mass‡	7 (8.4%)	5 (7.1%)	2 (15.4%)	0.301
Classic triad‡	23 (27.7%)	16 (22.9%)	7 (53.8%)	**0.039**
Neurological manifestations‡	5 (6.0%)	5 (7.1%)	0 (0.0%)	1.000
Duration of symptoms, hours*	**18.0 (13.0, 47.0)**	**17.0 (11.0, 32.0)**	**51.0 (16.0, 56.0)**	**0.007**
Duration of symptoms, categorical‡				**0.025**
< 12 hours	18 (21.7%)	18 (25.7%)	0 (0.0%)	
12–24 hours	33 (39.8%)	29 (41.4%)	4 (30.8%)	
> 24 hours	32 (38.6%)	23 (32.9%)	9 (69.2%)	
Leukocyte count, × 10^9/L*	**12.5 (9.6, 17.1)**	**11.7 (9.2, 16.1)**	**17.1 (13.5, 18.6)**	**0.011**

C-reactive protein, mg/L*	9.1 (3.0, 25.9)	8.3 (2.8, 18.6)	12.6 (10.4, 48.2)	0.073
Surgery type‡				**<0.001**
Manual reduction	58 (69.9%)	58 (82.9%)	0 (0.0%)	
Bowel resection	25 (30.1%)	12 (17.1%)	13 (100.0%)	
Length of stay, days*				
Total	7.0 (6.0, 8.0)	7.0 (5.0, 8.0)	9.0 (8.0, 10.0)	**<0.001**
Postoperative	7.0 (5.0, 8.0)	7.0 (5.0, 8.0)	9.0 (8.0, 10.0)	**<0.001**
Postoperative outcomes‡				
Favorable clinical outcome	81 (97.6%)	69 (98.6%)	12 (92.3%)	0.290
Superficial surgical site infection	2 (2.4%)	1 (1.4%)	1 (7.7%)	

Continuous variables are presented as *median (Q1–Q3) and were compared using the Mann–Whitney U test. Categorical variables are presented as n (%) and were compared using Pearson's chi-square test or Fisher's exact test, as appropriate.

‡Percentages are calculated within each study group.

Classic triad: paroxysmal abdominal pain, vomiting, and bloody stool.

Total hospital stay was calculated from admission to discharge, and postoperative hospital stay from surgery to discharge.

Favorable clinical outcome was defined as discharge without death or major postoperative complications. Superficial surgical site infection was classified as a minor complication and did not preclude a favorable clinical outcome.

Statistically significant p values ($p < 0.05$) are shown in bold.

Table 2. Histopathological diagnoses of pathological lead points in the study cohort

Pathological lead point with microscopic confirmation	n (%)	Median age (months)	Sex, male/female, n	Bowel resection, n/N
Meckel's diverticulum	9 (69.2%)	80	6/3	9/9
Burkitt lymphoma	2 (15.4%)	83	2/0	2/2
Gastric heterotopia	1 (7.7%)	193	1/0	1/1
Peutz–Jeghers-type hamartomatous polyp	1 (7.7%)	71	0/1	1/1

Figures

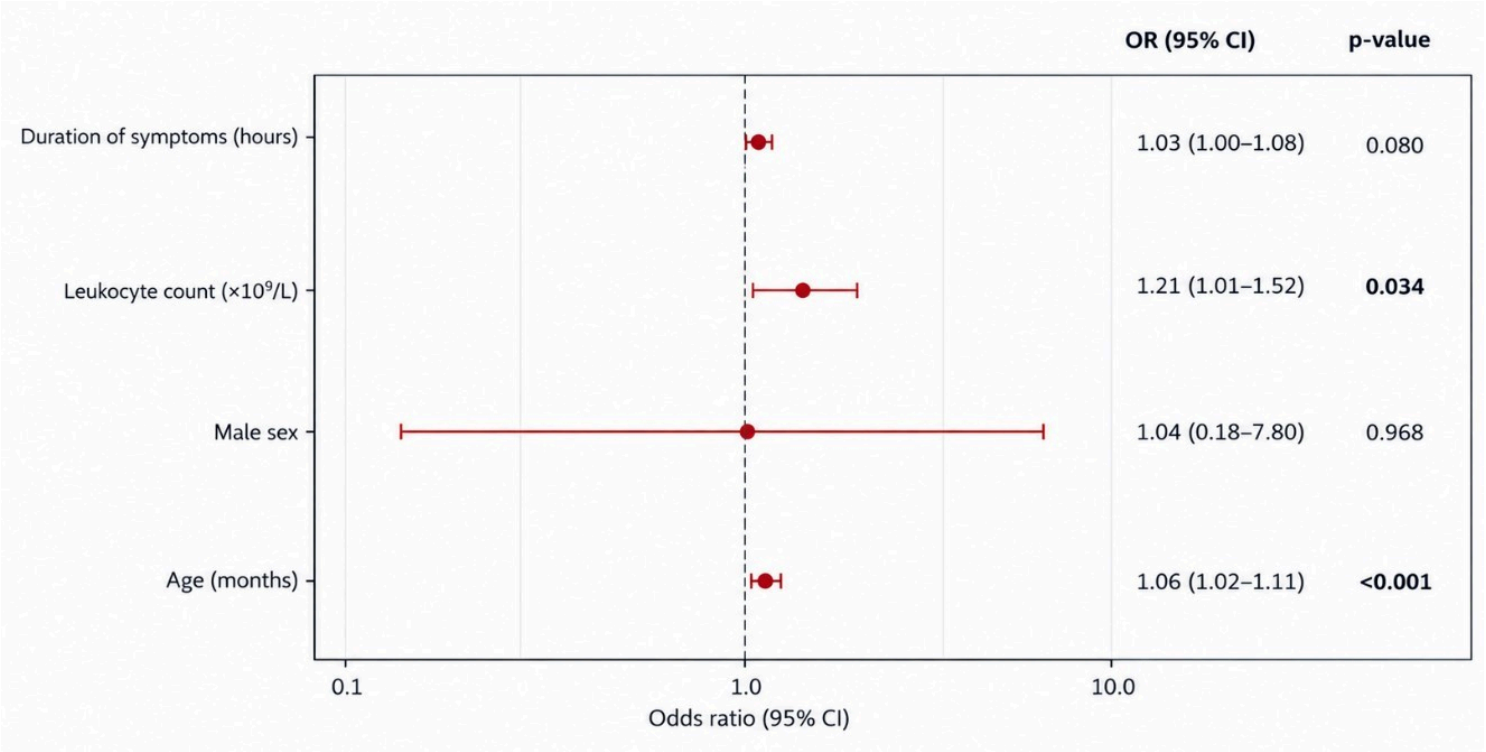


Figure 1

Forest plot of multivariable logistic regression estimates for factors associated with pathological lead point status.

Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) from the Firth penalized logistic regression model. The x-axis is shown on a logarithmic scale. The vertical dashed line indicates an OR of 1.00.