ORIGINAL ARTICLE

# COMPARISON OF IMMATURE GRANULOCYTE VALUES AND C-REACTIVE PROTEIN IN PREDICTING HOSPITALIZATION AMONG PATIENTS PRESENTING TO THE EMERGENCY DEPARTMENT WITH ABDOMINAL PAIN

## Karın Ağrısı ile Acil Servise Başvuran Hastalarda Hospitalizasyonu Öngörmede İmmatür Granülosit Değerleri ve C-Reaktif Proteinin Karşılaştırılması

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## ABSTRACT

**Objective:** Immature granulocyte count (IGc) and percentage (IG%) are emerging inflammatory markers, yet their early prognostic value in undifferentiated abdominal pain in the emergency department (ED) remains unclear. In this study we aimed to compare the predictive performance of IGc, IG%, and C-reactive protein (CRP) for hospitalization and surgical intervention.

**Material and Methods:** This prospective observational study included adult ED patients presenting with abdominal pain. Predictive accuracy was assessed using ROC analysis with AUC values compared by the DeLong test. Independent predictors of hospitalization were identified using multivariable logistic regression adjusted for IG levels, CRP and key clinical variables.

**Results:** A total of 526 patients were analyzed. Hospitalized patients had higher CRP, IG count, and IG% levels (all p<0.001). CRP showed the strongest predictive value for hospitalization (AUC=0.728), while IG count (AUC=0.673) and IG% (AUC=0.619) demonstrated limited performance. All markers were elevated in surgically treated patients but showed poor discriminatory ability. In multivariable analysis, CRP and IG count remained independent predictors of hospitalization, whereas IG% did not retain significance.

**Conclusion:** Although the prognostic value of IG percentage remained limited, the absolute IG count appeared to be an independent risk factor when considered alongside CRP and clinical findings. However, none of the markers-IG%, IG count, or CRP reliably identified patients requiring surgery, emphasizing the continued need for comprehensive clinical assessment and imaging in ED abdominal pain management.

**Keywords:** *Immature Granulocyte Count, Immature Granulocyte Percentage, C-Reactive Protein, Abdominal Pain*

## ÖZET

**Amaç:** İmmatür granülosit sayısı (IGc) ve yüzdesi (IG%), yeni gelişen inflamatuvar belirteçler arasında yer almakla birlikte, acil serviste ayırıcı tanısı konmamış karın ağrısında erken dönemdeki prognostik değerleri hâlâ belirsizdir. Bu çalışmada IGc, IG% ve C-reaktif protein (CRP) düzeylerinin hospitalizasyon ve cerrahi müdahale gereksinimini öngörmedeki performanslarını karşılaştırmak amaçlanmıştır.

**Gereç ve Yöntemler:** Bu prospektif gözlemsel çalışmaya karın ağrısı ile başvuran yetişkin acil servis hastaları dahil edilmiştir. Öngörü doğruluğu ROC analizi ile değerlendirilmiş ve AUC değerleri DeLong testi ile karşılaştırılmıştır. Hospitalizasyonun bağımsız belirleyicileri, IG düzeyleri, CRP ve temel klinik değişkenler ile ayarlanan çok değişkenli lojistik regresyon analizi ile belirlenmiştir.

**Bulgular:** Toplam 526 hasta analiz edilmiştir. Hastaneye yatırılan hastaların CRP, IG sayısı ve IG% düzeyleri anlamlı olarak daha yüksektir (tümü p<0,001). Hospitalizasyonu öngörmede en güçlü belirteç CRP olmuştur (AUC=0,728). IG sayısı (AUC=0,673) ve IG% (AUC=0,619) ise daha sınırlı performans göstermiştir. Cerrahi tedavi uygulanan hastalarda tüm belirteçler yüksek seyretmiş olsa da ayırıcı performansları zayıf kalmıştır. Çok değişkenli analizde CRP ve IG sayısı hospitalizasyonun bağımsız belirleyicileri olarak kalırken, IG% anlamlılığını korumamıştır.

**Sonuç:** IG yüzdesinin prognostik değeri sınırlı görünmekle birlikte, IG sayısı CRP ve klinik bulgularla birlikte değerlendirildiğinde bağımsız bir risk faktörü olarak ortaya çıkmıştır. Ancak IG%, IG sayısı ve CRP'nin hiçbiri cerrahi gereksinimini güvenilir biçimde öngörememiştir. Bu durum, acil serviste karın ağrısı yönetiminde kapsamlı klinik değerlendirme ve görüntülemenin önemini sürdürdüğünü göstermektedir.

**Anahtar Kelimeler:** *İmmatür Granülosit Sayısı, İmmatür Granülosit Yüzdesi, C-Reaktif Protein, Karın Ağrısı*

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## INTRODUCTION

Abdominal pain is a common reason for emergency department (ED) visits, accounting for approximately 5-10% of presentations, with etiologies ranging from benign conditions to acute abdominal emergencies requiring urgent intervention (1). Common causes include appendicitis, biliary tract diseases, pancreatitis, ileus, gastrointestinal perforation, and urinary tract disorders.

Inflammation plays a central role in many abdominal conditions, and numerous inflammatory markers-such as white blood cell count, the neutrophil-to-lymphocyte ratio, the platelet-to-lymphocyte ratio, and C-reactive protein (CRP)-have been extensively studied (2). More recently, the immature granulocyte count (IG) and IG percentage (IG%) have emerged as early inflammatory markers obtainable from routine complete blood count analyzers (3). IGs are normally absent in peripheral blood except during pregnancy and the neonatal period; however, cytokine-driven bone marrow activation in acute inflammation can lead to their premature release (4-6). Several studies suggest that IG levels may rise earlier than conventional inflammatory markers, indicating potential prognostic value.

Nearly all etiologies of abdominal pain involve an inflammatory response; however, most IG-related studies have focused on patients with established diagnoses (7). In contrast, ED clinicians must make rapid decisions before diagnostic clarity is achieved. Despite increasing interest in IG-based markers, no study has evaluated their independent predictive value for hospitalization among adults presenting to the ED with undifferentiated abdominal pain. Furthermore, it remains unclear whether the IG percentage or the absolute IG count provides superior prognostic information.

The primary aim of this study was to compare the predictive performance of IG parameters and CRP for hospitalization among ED patients presenting with abdominal pain. A secondary aim was to assess their ability to predict the need for surgical intervention and to determine whether the IG percentage or the absolute IG count serves as the more informative marker.

## MATERIAL AND METHODS

This prospective, observational, single-center study was conducted at a tertiary hospital with approval from the local ethics committee (AEŞH-EK1-2023-356) between 01 October 2023 and 31 March 2024. Written informed consent was obtained from all participants. All patients presenting to the ED with abdominal pain during the study period were evaluated. The diagnostic and management plans determined by the treating physicians were not altered. Demographic characteristics, presenting symptoms, and laboratory results of eligible patients were systematically recorded using standardized case report forms. Additionally, the time required to complete the diagnostic process, the final diagnosis, hospitalization status (ward or intensive care unit), and clinical outcomes-including emergency surgical intervention or discharge-were documented.

During the study period, 1,099 adult patients presented to the ED with abdominal pain (ICD codes R10.0-R10.4). Of these, 573 patients were excluded due to pregnancy; medical conditions known to affect IG levels (such as hematological or rheumatological diseases, concurrent infections, or treatments including granulocyte colony-stimulating factors, glucocorticoids, or other immunosuppressive agents); impaired capacity to provide informed consent (e.g., unconsciousness, dementia, or Alzheimer's disease); or refusal to undergo laboratory testing or treatment.

Sample size estimation was performed based on the expected effect size for comparing clinical and laboratory characteristics between hospitalized and non-hospitalized patients. Assuming a medium effect

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size (Cohen's f =0.3), a significance level (α) of 0.05, and a power of 90%, a minimum of 492 participants was required. This calculation was performed using the G*Power 3.1 software package (2).

All statistical analyses were performed using the Jamovi statistical software (version 2.6.26, Sydney, Australia). Descriptive statistics are presented as counts and percentages for categorical variables, while continuous variables are expressed as mean ± standard deviation for normally distributed data, and as median (interquartile range 25-75%) for non-normally distributed data. The normality of continuous variables was assessed using both visual methods (histograms and probability plots) and analytical tests (Kolmogorov-Smirnov and Shapiro-Wilk tests). Comparisons between independent groups were performed using the Mann-Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the predictive performance of the studied markers, and the DeLong test was used to compare the area under the curve (AUC) values. Cut-off values for the markers were determined using the Youden index. Independent predictors of hospitalization were identified using multivariable logistic regression adjusted for IG levels, CRP, and key clinical variables. Variables included in the model were age, sex, hypertension, diabetes, fever, oxygen saturation, abdominal pain localization, CRP, and either IG count or IG percentage. Model calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test. Statistical significance was defined as $p<0.05$, and all effect estimates were reported with 95% confidence intervals.

## RESULTS

During the study period, a total of 1,099 patients presented to the ED with abdominal pain. After excluding with incomplete data, 526 patients who met the inclusion criteria were included in the final analysis. The median age of the study population was 44 years (IQR: 29-58), and 40.7% were male. The most common comorbidities were hypertension (20%), diabetes mellitus (13.5%), and coronary artery disease (7.4%).

In the majority of patients, abdominal pain was localized to the periumbilical region (38%), followed by the epigastric region (17.1%) and the right lower quadrant (11.8%). The onset of pain was acute (within the previous 24 hours) in 54.2% of the cases. Upon evaluation in the ED, the most frequent final diagnosis was nonspecific abdominal pain (32.1%), followed by urinary tract pathologies (23.4%), acute gastroenteritis (10.1%), and gastritis (10.1%). More than 80% of the patients were discharged. A total of 74 patients required urgent surgical intervention (14%). The general characteristics and outcomes of the study population are summarized in Table 1.

**Table 1.** General characteristics, final diagnosis and outcome of the patients

| **Variables** | **Median (IQR 25-75) / n (%)** |
|---|---|
| Age (year) | 44 (29-58) |
| **Gender** | |
| Female | 312 (59.3%) |
| Male | 214 (40.7%) |
| **Comorbidities** | |
| Hypertension | 105 (20%) |
| Diabetes mellitus | 71 (13.5%) |

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**Table 1.** Continued

| | |
|---|---|
| Coroner artery disease | 39 (7.4%) |
| Congestive heart deficiency | 24 (4.6%) |
| Chronic kidney disease | 14 (2.7%) |
| Other | 145 (27.6%) |
| Vital parameters | |
| Systolic blood pressure, mmHg | 125 (113-134) |
| Diastolic blood pressure, mmHg | 72 (63-80) |
| Pulse/minute | 84 (76-91) |
| Body temperature, °C | 36.0 (36.0-36.0) |
| Oxygen saturation, % | 98 (96-99) |
| Localization of the abdominal pain | |
| Periumbilical | 200 (38%) |
| Epigastric | 90 (17.1%) |
| Right upper quadrant | 62 (11.8%) |
| Right lower quadrant | 60 (11.4%) |
| Suprapubic | 38 (7.2%) |
| Right flank | 27 (5.1%) |
| Left flank | 24 (4.2%) |
| Left lower quadrant | 22 (4.2%) |
| Left upper quadrant | 3 (0.6%) |
| Symptom onset time | |
| <24 hour | 285 (54.2%) |
| 1-3 days | 193 (36.7%) |
| 3-7 days | 48 (9.1%) |
| Laboratory parameters | |
| Glucose, mg/dL | 101 (91-120) |
| Creatinine, mg/dL | 0.79 (0.66-0.93) |
| Amylase | 61 (45-77) |
| Lipase | 30 (23-41) |
| C-Reactive protein, mg/L | 6 (2-23) |
| Hemoglobin, g/dL | 13.8 (12.5-15.2) |
| WBC, $10^9$/L | 9.4 (7.6-11.6) |
| Neutrophil count, 109/L | 6.2 (4.6-8.5) |
| Neutrophil percentage, % | 67 (58-76) |
| Lymphocyte count, 109/L | 2.0 (1.4-2.8) |

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**Table 1.** Continued

| | |
|---|---|
| Lymphocyte percentage, % | 23 (14-31) |
| Immature granulocyte count, $10^9$/L | 0.03 (0.02-0.05) |
| Immature granulocyte percentage, % | 0.3 (0.3-0.4) |
| Final diagnosis at the emergency department | |
| Urinary system infections | 123 (23.4%) |
| Acute gastroenteritis | 53 (10.1%) |
| Gastritis | 53 (10.1%) |
| Cholelithiasis | 39 (7.4%) |
| Acute appendicitis | 26 (4.9%) |
| Pancreatitis | 15 (2.9%) |
| Hernias | 12 (2.3%) |
| Choledocholithiasis/cholangitis | 12 (2.3%) |
| Acute cholecystitis | 10 (1.9%) |
| Ileus | 10 (1.9%) |
| Tubovarian abscess | 3 (0.6%) |
| Ectopic pregnancy | 1 (0.2%) |
| Non-specific | 169 (32.1%) |
| Emergency department outcome | |
| Ward admission | 94 (17.9%) |
| Intensive care unit admission | 8 (1.5%) |
| Discharge | 424 (80.6%) |
| Need for surgery | |
| Urgent surgery | 76 (14.4%) |
| Elective surgery | 95 (18.1%) |
| None | 355 (67.5%) |

*Data given as median (inter quartile range 25-75) or number (percentage).
WBC: White blood cell

When hospitalized and discharged patients were compared, the median age was higher in the hospitalized group (52 vs. 41 years), and male predominance was more evident among hospitalized patients. All comorbid conditions were more common in the hospitalized group. Among the vital parameters, systolic blood pressure and oxygen saturation were lower in hospitalized patients (122 vs. 125 mmHg and 97% vs. 98%, respectively), whereas body temperature was higher. Right lower quadrant pain was significantly more common among hospitalized patients. Regarding final diagnoses, urinary tract infections and gastroenteritis were predominant among discharged patients, whereas acute appendicitis, pancreatitis, and ileus were more frequently observed in hospitalized patients. Demographic characteristics, vital signs, pain localization, and final diagnoses of the hospitalized and discharged patients are summarized in Table 2.

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**Table 2.** General characteristics and final diagnosis of hospitalized and discharged patients

| **Variables** | **Hospitalized (n=102)** | **Discharged (n=424)** | **p value** |
|---|---|---|---|
| Age (year) | 52 (36-68) | 41 (29-56) | <0.001 |
| **Gender** | | | |
| Male | 56 (54.9%) | 158 (37.3%) | 0.001 |
| Female | 46 (45.1%) | 266 (62.7%) | |
| **Comorbidities** | | | |
| Hypertension | 32 (31.4%) | 73 (17.2%) | **0.001** |
| Diabetes mellitus | 25 (24.5%) | 46 (10.8%) | **<0.001** |
| Coroner artery disease | 18 (17.6%) | 21 (5%) | **<0.001** |
| Congestive heart deficiency | 13 (12.7%) | 11 (2.6%) | **<0.001** |
| Chronic kidney disease | 8 (7.8%) | 6 (1.4%) | **0.002** |
| **Vital parameters** | | | |
| Systolic blood pressure, mmHg | 122 (105-135) | 126 (115-134) | **0.027** |
| Diastolic blood pressure, mmHg | 74 (62-80) | 71 (63-80) | 0.961 |
| Pulse /minute | 85 (76-93) | 84 (76-91) | 0.327 |
| Body temperature, °C | 36.0 (36.0-37.0) | 36.0 (36.0-36.0) | **<0.001** |
| Oxygen saturation, % | 97 (95-99) | 98 (96-99) | **0.001** |
| **Localization of the abdominal pain** | | | |
| Periumbilical | 39 (38.2%) | 161 (38.0%) | 0.961 |
| Epigastric | 6 (5.9%) | 84 (19.8%) | **<0.001** |
| Right upper quadrant | 21 (20.6%) | 41 (9.7%) | **0.002** |
| Right lower quadrant | 29 (28.4%) | 31 (7.3%) | **<0.001** |
| Suprapubic | 1 (1%) | 37 (8.7%) | **0.007** |
| Right flank | 1 (1%) | 26 (6.1%) | **0.034** |
| Left flank | 1 (1%) | 23 (5.4%) | 0.062 |
| Left lower quadrant | 4 (3.9 %) | 18 (4.2%) | |
| Left upper quadrant | 0 | 3 (0.7%) | |
| **Final diagnosis at the emergency department** | | | |
| Urinary system infections | 1 (1%) | 122 (28.8%) | **<0.001** |
| Acute gastroenteritis | 1 (1%) | 52 (12.3%) | **<0.001** |
| Gastritis | 0 | 53 (12.5%) | |
| Cholelithiasis | 1 (1%) | 38 (9%) | **0.006** |
| Acute appendicitis | 25 (24.5%) | 1 (0.2%) | **<0.001** |
| Pancreatitis | 15 (14.7%) | 0 | |

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**Table 2.** Continued

| | | | |
|---|---|---|---|
| Hernias | 1 (1%) | 11 (2.6%) | 0.477 |
| Choledocholithiasis/cholangitis | 9 (8.8%) | 3 (0.7%) | <0.001 |
| Acute cholecystitis | 7 (6.9%) | 3 (0.7%) | <0.001 |
| Ileus | 10 (9.8%) | 0 | |
| Tubovarian abscess | 3 (2.9%) | 0 | |
| Ectopic pregnancy | 1 (1%) | 0 | |
| Non-specific | 28 (27.5%) | 141 (33.3%) | 0.260 |

*Data given as median (inter quartile range 25-75) or number (percentage).
**Mann-Whitney U test, chi-square test and Fischer Exact test were used in group comparisons.

Hospitalized patients had significantly higher levels of CRP, IG count, and IG percentage compared with discharged patients (p<0.001 for all comparisons). However, when the predictive performance of these markers for hospitalization was evaluated, CRP demonstrated acceptable discriminative ability with an AUC of 0.728, whereas the predictive performance of IG count and IG percentage was fair (AUC =0.673 and 0.619, respectively). The DeLong test revealed no statistically significant difference between the AUC values of IG count and CRP (AUC difference: -0.055; 95% CI: -0.125 to 0.015; p=0.124). The cut-off value of CRP for predicting hospitalization was determined as 13.8 mg/L, with a sensitivity of 69% and specificity of 71%. For IG count, the optimal cut-off value was $0.04x10^9$/L, yielding a sensitivity of 66% and specificity of 62%.

Similarly, patients requiring surgery exhibited significantly higher levels of CRP, IG count, and IG percentage compared with discharged patients (p<0.001, p<0.001, and p=0.002, respectively). However, the predictive performance of these markers was poor, with AUC values of 0.616 for CRP, 0.603 for IG count, and 0.580 for IG percentage. Paired comparisons using the DeLong test revealed no statistically significant differences among these AUCs. The cut-off values for CRP and IG count were determined as 13 mg/L and $0.04x10^9$/L, respectively; however, their diagnostic accuracy remained low. For IG percentage, the optimal cut-off value was 0.4%, but its discriminative ability was similarly limited (Tables 3 and 4, Figure 1).

**Table 3.** Comparison of C-reactive protein and immature granulocyte levels according to hospitalization status and surgical requirement

| | **Hospitalization status** | | | **Surgical requirement** | | |
|---|---|---|---|---|---|---|
| | Hospitalized (n=102) | Discharged (n=424) | p value | Yes (n=171) | No (n=355) | p value |
| CRP | 22 (6-85) | 5 (2-17) | <0.001 | 12 (3-50) | 5 (2-18) | <0.001 |
| IGc | 0.04 (0.03-0.07) | 0.03 (0.02-0.04) | <0.001 | 0.04 (0.02-0.06) | 0.03 (0.02-0.04) | <0.001 |
| IG% | 0.4 (0.3-0.5) | 0.3 (0.2-0.4) | <0.001 | 0.4 (0.3-0.5) | 0.3 (0.2-0.4) | 0.002 |

CRP; C-reactive protein, IGc: Immature granulocyte count, IG%: Immature granulocyte percentage
** Data given as median (inter quartile range 25-75), Mann-Whitney U test was used.

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**Table 4.** Cut-off values of CRP and immature granulocyte levels and their predictive value for hospitalization and requirement for surgery

| | | Cut-off | AUC (95% CI) | SEN (95% CI) | SPE (95% CI) | PPV (95% CI) | NPV (95% CI) |
|---|---|---|---|---|---|---|---|
| **Hospitalization** | CRP | 13.8 | 0.728 (0.670-0.785) | 0.69 (0.59-0.77) | 0.71 (0.66-0.75) | 0.36 (0.32-0.41) | 0.90 (0.88-0.93) |
| | IGc | 0.04 | 0.673 (0.611-0.734) | 0.66 (0.57-0.75) | 0.62 (0.57-0.67) | 0.29 (0.26-0.36) | 0.88 (0.85-0.91) |
| **Surgical requirement** | CRP | 13 | 0.616 (0.565-0.668) | 0.50 (0.42-0.57) | 0.69 (0.64-0.74) | 0.44 (0.38-0.49) | 0.74 (0.71-0.77) |
| | IGc | 0.04 | 0.603 (0.551-0.656) | 0.54 (0.47-0.62) | 0.62 (0.57-0.67) | 0.41 (0.36-0.46) | 0.74 (0.70-0.77) |

CRP: C-reactive protein, IGc: Immature granulocyte count, AUC: Area under curve, SEN: Densitivity, SPE: Specificity, PPV: Positive predictive value, NPV: Negative predictive value, CI: Confidence interval

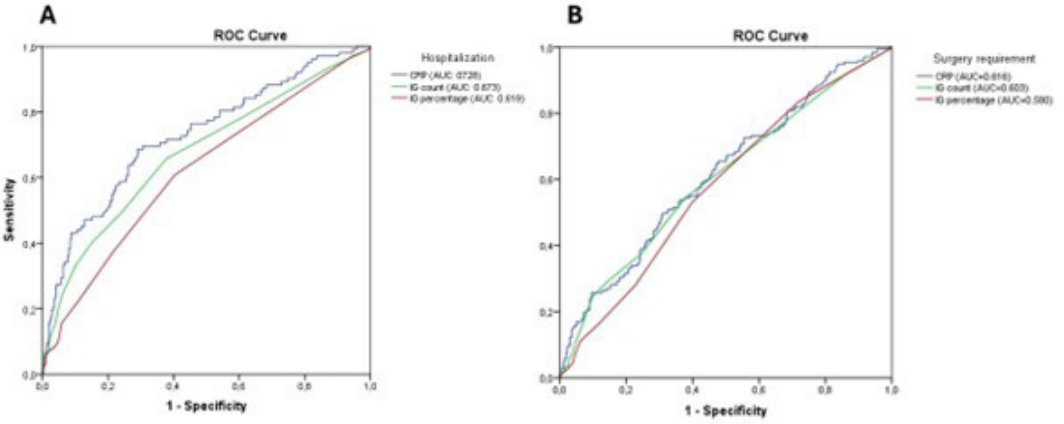


**Figure 1.** A) The predictive values (AUC) of CRP, IG count, and IG percentage for hospitalization were 0.728, 0.673, and 0.619, respectively. Pairwise comparisons using the DeLong test showed no significant difference between CRP and IG count (p=0.124), while significant differences were observed between CRP and IG percentage (p=0.003) and between IG count and IG percentage (p=0.003). B) The predictive values (AUC) of CRP, IG count, and IG percentage for surgery requirement were 0.616, 0.603, and 0.580, respectively. Pairwise comparisons using the DeLong test showed no significant difference between CRP and IG count (p=0.687), between CRP and IG percentage (p=0.268) or between IG count and IG percentage (p=0.120)

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In the multivariable logistic regression model incorporating IG count (Model A), CRP ≥13.8 mg/L (OR: 3.82, 95% CI: 2.14-6.83; p<0.001), IG count ≥0.04 x$10^9$/L (OR: 1.85, 95% CI: 1.10-3.31; p=0.021), and right lower quadrant (RLQ) abdominal pain (OR: 8.15, 95% CI: 4.10-16.2; p<0.001) were independently associated with hospitalization. Male sex was associated with a lower likelihood of discharge, indicating a higher hospitalization rate among men (OR: 0.57, 95% CI: 0.34-0.95; p=0.032). The model demonstrated good explanatory power (McFadden $R^2$=0.232; AIC=417). In contrast, in Model B, where IG percentage replaced IG count, CRP ≥13.8 mg/L (OR: 4.07, 95% CI: 2.28-7.25; p<0.001) and RLQ pain (OR: 8.79, 95% CI: 4.40-17.6; p<0.001) remained strong independent predictors, whereas IG percentage ≥0.4% did not retain independent significance (OR: 1.45, 95% CI: 0.85-2.52; p=0.157). Model performance was slightly inferior to Model A (McFadden $R^2$=0.225; AIC =421) (Table 5).

**Table 5.** Comparison of multivariable logistic regression models predicting hospitalization

| Predictor | Model A OR (95% CI) | p value | Model B OR (95% CI) | p value |
|---|---|---|---|---|
| CRP ≥13.8 mg/L | 3.82 (2.14-6.83) | <0.001 | 4.07 (2.28-7.25) | <0.001 |
| IG count ≥0.04×$10^9$/L | 1.85 (1.10-3.31) | 0.021 | - | - |
| IG percentage ≥0.4% | - | - | 1.45 (0.85-2.52) | 0.157 |
| RLQ pain | 8.15 (4.10-16.2) | <0.001 | 8.79 (4.40-17.6) | <0.001 |
| Male sex | 0.57 (0.34-0.95) | 0.032 | 0.56 (0.33-0.95) | 0.031 |
| Fever ≥37.5°C | 7.55 (0.76-75.1) | 0.096 | 7.15 (0.75-68.1) | 0.100 |
| $SpO_2$ <97% | 1.56 (0.82-2.93) | 0.178 | 1.66 (0.87-3.14) | 0.127 |
| Hypertension | 1.13 (0.53-2.40) | 0.760 | 1.09 (0.51-2.32) | 0.815 |
| Diabetes mellitus | 1.37 (0.70-2.68) | 0.393 | 1.49 (0.75-2.96) | 0.272 |
| Age (per year) | 0.98 (0.96-1.00) | 0.084 | 0.98 (0.96-1.01) | 0.134 |
| Model performance | | | | |
| McFadden $R^2$ | 0.232 | - | 0.225 | - |
| AIC | 417 | - | 421 | - |

Model A includes IG count (≥0.04 ×$10^9$/L), whereas Model B incorporates IG percentage (≥0.4%). Both models were adjusted for age, sex, hypertension, diabetes mellitus, fever, oxygen saturation, and right lower quadrant abdominal pain. Odds ratios (OR) with 95% confidence intervals (CI) are presented. Model performance was assessed using McFadden's $R^2$ and Akaike Information Criterion (AIC).
CRP: C-reaktif protein, RLQ: Right lower quadrant, IG: Immature granulocytes, $SpO_2$: Saturation of peripheral oxygen

## DISCUSSION

This study compared the predictive performance of IG parameters and CRP for hospitalization and surgical intervention in ED patients with undifferentiated abdominal pain. While all three markers were significantly elevated in hospitalized patients, CRP demonstrated the strongest discriminative ability in ROC analysis. Crucially, multivariable logistic regression analysis revealed that absolute IG count, but not IG percentage, remained an independent predictor of hospitalization after adjusting for CRP and clinical

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variables. This finding suggests that the absolute IG count provides a superior prognostic value over its percentage counterpart in this patient population. Conversely, none of the biomarkers, including CRP and IG count, demonstrated sufficient diagnostic accuracy for identifying patients requiring surgical intervention, thereby underscoring the continued necessity of comprehensive clinical assessment and imaging for surgical decision-making.

Abdominal pain remains one of the most common and diagnostically challenging presentations in the ED, owing to its broad differential diagnosis that spans benign to life-threatening conditions (8). Rapid and reliable risk stratification is therefore essential to guide diagnostic testing, prioritize imaging, and determine the need for hospitalization. Although inflammatory markers-particularly CRP-have historically supported clinical decision-making in this context, most laboratory parameters used in isolation provide only modest discriminatory value and are insufficient as standalone tools for triaging undifferentiated abdominal pain (9,10). In line with prior studies, our findings confirm that CRP demonstrates moderate predictive accuracy for hospitalization, as reflected by an AUC of 0.728. Although IG parameters may rise earlier in the inflammatory cascade, CRP reflects a more integrated and sustained hepatic acute-phase response, which may explain its greater stability and discriminatory performance in heterogeneous ED populations. The optimal cut-off values identified in our study (CRP ≥13.8 mg/L, IG count ≥0.04 x$10^9$/L) are clinically feasible thresholds that may support early triage decisions; however, their performance requires validation in external cohorts.

The most novel finding of our study is the clear distinction between the prognostic utility of absolute IG count and IG percentage in the evaluation of undifferentiated abdominal pain. Immature granulocytes are released from the bone marrow in response to systemic inflammatory stimulation, and prior research suggests that IG parameters-particularly IG %-may rise earlier than traditional inflammatory markers, potentially enabling early recognition of inflammatory processes (6,11). However, several studies have also reported that the diagnostic and prognostic accuracy of IG% is generally inferior to that of CRP (12,13). Our results are in line with these observations: although both IG% and absolute IG count were significantly associated with hospitalization in univariable analysis, only the absolute IG count (≥0.04x$10^9$/L) retained significance as an independent predictor in the multivariable model (OR 1.85, p=0.021), whereas IG percentage did not demonstrate an independent effect (p=0.157). Moreover, Model A-which incorporated absolute IG count-demonstrated superior explanatory performance compared with Model B including IG percentage, as reflected by a higher McFadden $R^2$ and a lower AIC. This performance gap likely reflects fundamental biological differences between the two parameters: IG percentage may fluctuate with variations in total leukocyte count, while absolute IG count more directly represents bone marrow activation and the true magnitude of the inflammatory response. Collectively, these findings, supported by prior literature indicating the stronger prognostic value of absolute IG count in inflammatory and infectious conditions, suggest that absolute IG count may be a more robust and clinically meaningful parameter than IG percentage for capturing the intensity of the inflammatory response and for risk stratification of patients presenting with undifferentiated abdominal pain in the ED (6,11). The superior performance of the absolute IG count (IGC) in our multivariable model may be explained by fundamental hematologic principles. Unlike IG%, which is mathematically influenced by fluctuations in the total leukocyte count, the absolute IGC reflects the true number of circulating immature granulocytes and provides a more direct indicator of bone marrow activation. Consequently, IGC is less susceptible to misleading changes related to leukocytosis or leukopenia, making it a more stable marker of inflammatory stress. This mechanistic rationale aligns with previous studies reporting that absolute IGC demonstrates better diagnostic and prognostic performance than IG% in inflammatory and infectious conditions (14,15).

Besides biomarker-related findings, our multivariable model also revealed an unexpected association related to patient characteristics. Interestingly, male sex emerged as a protective factor for hospitalization in our multivariable model (OR 0.57), a finding that diverges from prior literature reporting worse outcomes among men with severe abdominal and surgical conditions (16,17). This association in our cohort may reflect differences in the etiologic distribution of abdominal pain-particularly the higher prevalence of gynecologic or diagnostically uncertain presentations among women-as well as potential sex-related biases in

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clinical decision-making, wherein female patients may be hospitalized more frequently for observation when diagnostic uncertainty exists (18).

Beyond hospitalization outcomes, we also evaluated the ability of these biomarkers to predict surgical intervention. Notably, neither IG-based parameters nor CRP provided adequate discriminatory power for identifying patients who required surgical intervention in our cohort, consistent with their modest AUC values in this subgroup. This may be partly explained by the limited pathophysiologic specificity of systemic inflammatory markers in abdominal pain, where surgical and non-surgical etiologies frequently produce overlapping inflammatory profiles. This limited performance echoes previous findings; for instance, Mathews et al. reported that IG % did not confer additional diagnostic value beyond CRP elevation and left shift when differentiating acute from perforated appendicitis (19). Such observations highlight the inherent complexity of decision-making in patients presenting with abdominal pain and emphasize that these biomarkers, while useful adjuncts, are insufficient as standalone indicators to guide surgical management (20). Consequently, comprehensive clinical evaluation-supported by appropriate imaging-remains indispensable for determining the need for operative intervention.

The findings of this study carry important implications for ED practice and future research. Clinically, the absolute IG count-rather than IG percentage-may serve as a useful adjunctive marker in the early evaluation of patients presenting with undifferentiated abdominal pain, particularly when interpreted in conjunction with CRP and key clinical findings. Although none of the markers demonstrated sufficient accuracy to independently guide hospitalization or surgical decision-making, the absolute IG count may help identify patients who require closer monitoring or expedited diagnostic workup. The optimal cut-off thresholds identified in this study (CRP ≥13.8 mg/L and IG count ≥0.04 x$10^9$/L) are readily applicable in clinical practice, provided that clinicians avoid relying on them in isolation and continue to incorporate physical examination, serial assessments, and appropriate imaging. Future studies should validate these findings across diverse, multicenter populations and evaluate the utility of dynamic, serial measurements to better characterize the temporal behavior of IG and CRP. Additionally, integrating these biomarkers with imaging findings, structured clinical scoring tools, and machine learning–based predictive models may enhance early risk stratification. Further investigation is also warranted to determine whether the absolute IG count provides meaningful incremental value in specific diagnostic entities such as appendicitis, bowel obstruction, or intra-abdominal infections.

A major strength of this study is its prospective design and the inclusion of a truly undifferentiated abdominal pain population, which closely reflects real-world ED practice. Unlike previous research focusing on patients with established diagnoses, our study evaluates IG-based markers at the earliest point of presentation, providing valuable insight into their utility during initial triage. Additionally, the systematic and standardized data collection process minimized measurement bias, while the head-to-head comparison of IG percentage, absolute IG count, and CRP under the same clinical conditions offers a robust evaluation of their relative prognostic performance. The study population reflects the heterogeneous, symptom-based presentations commonly encountered in ED practice, enhancing the real-world relevance of the findings.

This study has several limitations. First, although the data were prospectively collected, the single-center design may limit the generalizability of our findings to different emergency care settings. Second, while the exclusion of patients with conditions known to affect IG parameters was necessary to reduce confounding, it may restrict the applicability of our results to broader ED populations in which such comorbidities are common. Third, we evaluated IG parameters and CRP only at initial presentation; serial or dynamic measurements could have provided additional insight into their temporal behavior and prognostic value. Fourth, although our multivariable model incorporated key clinical variables, imaging findings and other advanced diagnostic parameters-which are essential components of decision-making for hospitalization and surgical intervention-were not included. Additionally, because our hospital has a dedicated emergency unit for gynecological emergencies, patients presenting to that unit were not included in this study. Although missingness was addressed through listwise exclusion, future studies may benefit from multiple imputation methods to minimize potential bias. These limitations should be considered when interpreting the findings of this study.

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## CONCLUSION

In this prospective study of adults presenting to the ED with undifferentiated abdominal pain, the absolute IG count demonstrated superior prognostic value compared with the IG percentage and emerged as an independent predictor of hospitalization, whereas the IG percentage did not retain statistical significance. Although the prognostic value of IG percentage remained limited, the absolute IG count appeared to be an independent risk factor when considered in conjunction with CRP and clinical findings. Although CRP remained the strongest laboratory marker overall, neither CRP nor IG-based parameters exhibited adequate discriminatory performance to identify patients requiring surgical intervention. These findings highlight the limited standalone utility of inflammatory biomarkers in the early evaluation of acute abdominal pain and reinforce the essential role of comprehensive clinical assessment and appropriate imaging. The absolute IG count may serve as a useful adjunctive marker to support early risk stratification and guide further diagnostic evaluation in this heterogeneous patient population. However, its clinical role is best understood as supportive rather than determinative, reinforcing the primacy of comprehensive clinical evaluation.

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