Scientific Research Publishing

Open Journal of Gastroenterology, 2025, 15(5), 247-257
https://www.scirp.org/journal/ojgas
ISSN Online: 2163-9469
ISSN Print: 2163-9450

The Correlation between Clinico-Endoscopic Activity and Fecal Calprotectin in IBD

Hynd Hedda[1,2], Hindi Chikhani[1,2], Wafae Hammoumi[1,2], Asmae Lamine[1,2], Maria Lahlali[1,2], Nada Lahmidani[1,2], Amine El Mekkaoui[1,2], Mounia El Yousfi[1,2], Dafr-Allah Benajah[1,2], Sidi Adil Ibrahimi[1,2], Mohammed El Abkari[1,2], Hakima Abid[1,2]

[1]Hepato-Gastroenterology Department, Hassan II University Medical Center, Fez, Morocco
[2]Faculty of Medicine, Dentistry and Pharmacy, Sidi Mohammed Ben Abdellah University, Fez, Morocco
Email: hynd.hedda@usmba.ac.ma

How to cite this paper: Hedda, H., Chikhani, H., Hammoumi, W., Lamine, A., Lahlali, M., Lahmidani, N., El Mekkaoui, A., El Yousfi, M., Benajah, D.-A., Ibrahimi, S.A., El Abkari, M. and Abid, H. (2025) The Correlation between Clinico-Endoscopic Activity and Fecal Calprotectin in IBD. *Open Journal of Gastroenterology*, **15**, 247-257.
https://doi.org/10.4236/ojgas.2025.155024

Received: March 29, 2025
Accepted: May 19, 2025
Published: May 22, 2025

Abstract

Introduction: Endoscopy is the gold standard examination for evaluating the activity of inflammatory bowel diseases (IBD). However, it remains an invasive procedure with a significantly high cost. Many studies have focused on the study of non-invasive markers, particularly fecal calprotectin (FC), in monitoring inflammatory activity in IBD. **Objective:** The aim of this study is to comparatively evaluate the correlation between biological markers, including FC, and clinical scores with endoscopic findings in assessing inflammatory activity in IBD. **Materials and Methods:** This is a retrospective, analytical study conducted in the Hepato-Gastroenterology Department of Hassan II University Medical Center, Fez, over a period of two years. It includes all patients with IBD who were followed in the department and who underwent clinical, biological (measuring FC and CRP), and endoscopic evaluation through ileocolonoscopy. The latter is based on the SES-CD for Crohn's disease and the Mayo endoscopic subscore for ulcerative colitis. **Results:** We collected data on 111 patients in our study, with 49 followed for ulcerative colitis (UC) and 62 for Crohn's disease. The female/male sex ratio is 1.36. The average age of our patients was 40.6 years. Based on endoscopic activity, patients are divided into two groups: Group I (n = 46), consisting of patients in endoscopic remission, and Group II (n = 65), consisting of patients with active disease endoscopically. Patients in Group I were predominantly in clinical remission (89%) compared to those in Group II (70%), without a significant difference (P = 0.274). The average CRP level was higher in Group II (21 mg/l [57 - 800]) compared to Group I (11 mg/l [57 - 800]), without a significant difference in this case (p = 0.098). The average fecal calprotectin level was significantly higher (p = 0.001) in patients in Group II (253 µg/g [57 - 800]) compared to those in Group I (135.7 µg/g [19.5 - 192]). In our study, we determined a

threshold of 157 μg/g to detect endoscopically active IBD with a sensitivity of 86.2% and specificity of 63%. **Conclusion:** In our series, FC shows a good correlation with endoscopic activity. Therefore, it constitutes an alternative method that allows for extending intervals between control endoscopies, thus reducing the cost of managing IBD.

Keywords

IBD, Fecal Calprotectin, Clinical Activity, Endoscopic Activity

1. Introduction

Chronic Inflammatory Bowel Diseases (IBD) comprise two main entities: Crohn's disease (CD) and ulcerative colitis (UC), grouped under the same nosological framework due to several common features (epidemiological, diagnostic, therapeutic, and evolutionary) [1]. They present diagnostic challenges and, more importantly, therapeutic difficulties due to their chronic nature and unpredictable progression, which is often complicated by complications [2]. Current treatment aims to achieve clinical, biological, and especially endoscopic remission (mucosal healing) and even histological remission. This requires an accurate assessment of mucosal inflammation severity to determine the appropriate therapeutic strategy [3].

While endoscopy is the gold standard for an objective evaluation of disease activity and mucosal healing, it remains an invasive method, with limited availability, poor patient tolerance, and relatively high cost [4]. Therefore, several biomarkers have been studied, including fecal calprotectin (FC), to clarify their roles in diagnosing and assessing IBD activity [5]. In the physiological state, the fecal concentration of calprotectin is approximately six times higher than in plasma, leading to the concept that the measurement of this biomarker is likely to be a sensitive and specific marker of gastrointestinal inflammation. Compared to its serum concentration, the level in the stool is better correlated with the infiltration of the intestinal mucosa by neutrophilic polymorphonuclear cells, and thus it is increased in patients with IBD.

The objective of this study is to comparatively evaluate the correlation between biological markers, including FC, and clinical scores with endoscopy in assessing inflammatory activity in IBD within a Moroccan population.

2. Patients and Methods

This is a retrospective analytical study conducted at the Hepato-Gastroenterology Department of Hassan II University Medical Center, Fez, spanning a two-year period and including patients followed for diagnosed IBD based on clinical, biological, morphological, endoscopic, and histological data.

1) Inclusion Criteria:

- Patients followed for uncomplicated IBD.
- Patients who underwent endoscopic evaluation and fecal calprotectin measurement with an interval not exceeding one month.
- No age or sex limitations.

2) Exclusion Criteria:

- IBD with superinfection (Salmonella, Shigella, Campylobacter, positive C. difficile toxins A + B, cytomegalovirus).
- Colorectal cancer.
- Indeterminate colitis.
- Inability to collect fecal samples.
- Regular intake of aspirin and/or non-steroidal anti-inflammatory drugs (NSAIDs) (more than two tablets per week).

3) Study Protocol:

- All patients are followed in a specialized IBD consultation.
- We developed a data collection form to gather information via patient's electronic records, including demographic data (age and sex), year of IBD diagnosis, history of ileal or colonic surgery, lesion topography, Montreal classification, treatment modalities, clinical activity assessment, hemoglobin (Hb), platelet count, CRP, fecal calprotectin, and endoscopic evaluation.
- The clinical activity of the disease is assessed using the Harvey Bradshaw Index (HBI) score for Crohn's disease or the Mayo clinical score for ulcerative colitis (UC). Inactive disease is defined by an HBI < 4 or a Mayo clinical score < 2. Above these thresholds, the disease is defined as active.
- Fecal calprotectin is measured using the ELISA technique, and its values are expressed in μg/g.
- Endoscopic evaluation is performed by a senior endoscopist, calculating the CDEIS score for Crohn's disease and the Mayo endoscopic score for ulcerative colitis. Endoscopic remission is defined by a CDEIS score < 4 or a Mayo endoscopic score < 2; beyond these thresholds, the disease is defined as endoscopically active. Patients are divided into two groups: those in endoscopic remission (Group I) and those with endoscopic activity (Group II).

The sample size was determined using a power analysis to ensure that the study had sufficient power to detect a significant difference in outcomes. Considering a significance level of 0.05 and a power of 80%, we estimated that we would need at least 111 participants.

Our limitations in sampling: Selection Bias: Participants were recruited from a single hospital and a specific geographic region, which may also introduce bias if the characteristics of this population do not reflect those of other groups.

3. Results

During the period of our study, we collected data from 111 patients with inflammatory bowel disease (IBD), including 62 with Crohn's disease (CD) and 49 with ulcerative colitis (UC). The average age of our patients was 40.6 years, with a slight female predominance (sex ratio F/M of 1.36). The extent of the disease was de-

scribed according to the Montreal classification: for Crohn's disease: L1: Ileal (41.3%), L2: Colonic (27.5%), L3: Ileocolonic (31%), and for UC: Rectal (3%), Left-sided colitis (47%), and Pancolitis (35.2%).

The phenotype of patients with Crohn's disease, according to the Montreal classification, was as follows: B1, inflammatory in 62.9%; B2, stricturing in 29%; B3, penetrating in 8%; p, perianal manifestation in one patient only.

For UC, the severity of the disease is classified as mild in 30.6%, moderate in 22.4%, and severe in 12.2%; Table 1 summarizes the characteristics of the patients.

Table 1. Patients' characteristics.

	Crohn's Disease	Ulcerative Colitis
Average Age	34.1	39.8
Sexe ratio F/H	1.5	1.13
Smoking	5	4
Duration of Disease	6 ± 2.4	6.7 ± 4.3
Surgical history	21	0
Activity disease:		
HBI	3.8 ± 2.5	
Clinical Mayo Score		1.7 ± 1.5
Extent (Montreal):		
Ileal	23 (37.5%)	-
Colonic	17 (27%)	-
Ilecolonic	22 (35.5%)	-
Upper digestive involvement	0 (0%)	-
Rectitis	-	20 (40.8%)
Left-sided Colitis	-	8 (16.3%)
Pancolitis	-	21 (42.8%)
Ongoing Treatment:		
5ASA	7	26
Corticosteroids	4	2
Azathioprine	19	15
6-Mercaptopurine	16	2
Methotrexate	3	0
Anti TNF alpha	12	7
Hemoglobine (g/dl)	12.3	11.5
Platelets (cells/mm^3)	310,000	235,000
Albumin (g/l)	35	41
CRP (mg/l)	18 [4 - 34]	22 [3 - 55]
Fecal calprotectin (µg/g)	212 (19.5 - 800)	193.1 (21 - 800)
Endoscopic Activity:		
(CDEIS. Mayo Endoscopic)		
Remission	46.7%	34.6%
Active	53.2%	65.3%

The mean fecal calprotectin level in our series was 203 µg/g (Figure 1).

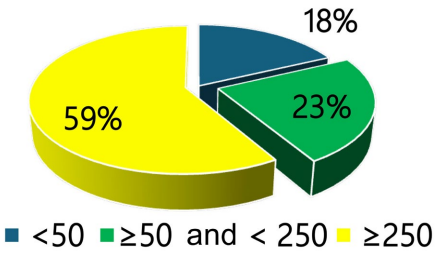

Figure 1. Distribution of patients according to the fecal calprotectin level.

- **Endoscopic Data:**

According to endoscopic activity, patients are divided into two groups: Group I (n = 46), consisting of patients in endoscopic remission, and Group II (n = 65), comprising those with active disease endoscopically.

Patients in Group I were predominantly in clinical remission (89%) compared to patients in Group II (70%), with this difference not being significant (P = 0.274). In Group II, the mean CRP level was higher at 21 mg/L compared to the mean level in Group I (11 mg/L), but this was not significant (p = 0.098).

The mean fecal calprotectin level was significantly (p = 0.001) higher in patients from Group II at 253 µg/g [57 - 800] than in those from Group I, in endoscopic remission at 135.7 µg/g [19.5 - 192].

Table 2 presents the clinical and biological data observed in both groups, as well as the correlation of these parameters with endoscopy.

Table 2. Clinical and biological data of the two groups according to endoscopic activity.

	Endoscopic remission (Groupe I)	Endoscopically active disease (Groupe II)	P
Clinical activity:			
-Remission	89.1%	70.7%	P = 0.247
-Active	10.9%	29.3%	
Hb (g/dl)	12.9 ± 1.9	12.6 ± 1.7	P = 0.182
Platelets (Cells/mm^3)	218,000 ± 40,000	239,000 ± 32,000	P = 0.201
CRP (mg/l)	11 [3 - 45]	21[3 - 55]	P = 0.098
Fecal calprotectin (µg/g)	135.7 [19.5 - 192]	253 [57 - 800]	P = 0.001

Based on the ROC curve, different threshold values of the CF were studied. Thus, we determined the threshold that maximizes the sensitivity and specificity of the evaluation of inflammatory activity at 157 µg/g, with a sensitivity of 86.2% and a specificity of 63%. The negative predictive value is 71.8%, and the positive predictive value is 72.7%. However, it should be noted that the area under the curve was 0.767 with a 95% confidence interval [0.671 - 0.863], p < 0.001. This makes it a moderately informative diagnostic test (Figure 2).

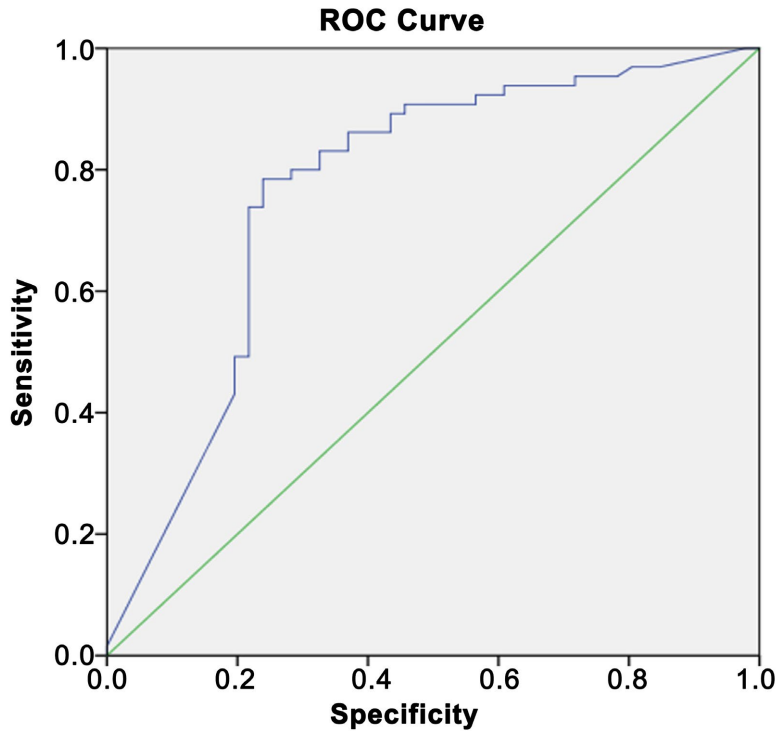

Figure 2. ROC curve for the evaluation of endoscopic activity. The area under the curve (AUC) was 0.767 with a 95% CI [0.671 - 0.863], $p < 10^{-3}$.

During the follow-up, it was observed that patients with clinical remission (N = 87) and those who experienced a clinical relapse (N = 16) had a higher calprotectin level compared to those (N = 71) who did not relapse (mean rate 239 µg/g versus 105). The average time to clinical relapse is 2.6 months over a follow-up period of 9 months.

4. Discussion

The diagnosis and follow-up of patients with inflammatory bowel disease (IBD) are often complex and vary significantly from patient to patient: some patients may remain in remission for years with minimal treatment, while others experience chronic and recurrent progression with frequent flares despite aggressive treatment [6].

Nowadays, the optimal therapeutic target for modifying the natural history of the disease should no longer be just clinical remission, but rather mucosal healing [7] [8].

While endoscopy has been and still is an essential examination in the management of IBD, at various stages of its natural history, its invasive nature and cost have motivated the search for non-invasive markers that could replace it [6].

These markers must first be well correlated with endoscopic and histological scores and be accessible, thus playing a role at different times in the management of IBD: during diagnosis, in the event of a possible flare under treatment, in predicting medium-term response, and when a therapeutic change is discussed [3].

Clinical scores and serum inflammatory markers, particularly CRP, are widely used, despite their poor specificity for identifying mucosal inflammatory activity [9] [10].

Fecal calprotectin (FC) has recently emerged as an effective and non-invasive marker for detecting inflammation in the gastrointestinal tract, with several clinical applications in the management of inflammatory bowel diseases (IBD) [5]:

1) Differentiating between inflammatory bowel diseases (IBD) and functional gastrointestinal disorders (FGD):

The clinical presentation of irritable bowel syndrome can closely mimic that of IBD [11]. Several studies have highlighted the usefulness of fecal calprotectin (FC) in differentiating between FGD and organic disease. One of the largest studies, which included 602 patients with abdominal symptoms, showed that an FC threshold of 50 μg/g had a sensitivity of 89% and a specificity of 79% for identifying an organic etiology [12].

2) Monitoring the activity of inflammatory bowel diseases (IBD):

Numerous studies have shown a significant correlation between fecal calprotectin levels and endoscopic findings in Crohn's disease (CD) and ulcerative colitis (UC). This strong correlation between fecal calprotectin and the endoscopic activity of the disease gives it an important role in diagnosing the activity of CD [8].

a) The correlation of fecal calprotectin with endoscopic activity of inflammatory bowel diseases (IBD):

Compared to clinical scores (HBI, Mayo score), C-reactive protein (CRP), hemoglobin, or white blood cell count in the blood, fecal calprotectin is the parameter most closely correlated with endoscopic activity in IBD [5]. The correlation of fecal calprotectin with endoscopy and histology is greater than that of clinical activity indices, which are primarily based on subjective data. Therefore, fecal calprotectin can be used to detect subclinical inflammatory activity in asymptomatic patients [5].

In ulcerative colitis (UC), Schoepfer *et al.* reported that endoscopic disease activity was well correlated with fecal calprotectin ($R = 0.834$) [11].

In Crohn's disease (CD), a reliable surrogate marker for intestinal inflammation is even more important than in UC, as silent intestinal inflammation in asymptomatic patients is associated with severe disease complications. Reflecting this silent inflammation, fecal calprotectin may be elevated in 60% to 70% of asymptomatic individuals with CD [13] [14].

In another recent study involving 115 patients with CD, Lobato'n *et al.* demonstrated that using a threshold of 274 μg/g, fecal calprotectin was closely correlated with endoscopic disease activity, accurately predicting endoscopic remission (CDEIS < 3), with an area under the receiver operating characteristic curve (AUC) of 0.935.

Moreover, the correlation of fecal calprotectin with the endoscopic activity of the disease appears to be better for colonic involvement than for ileal involvement

[11].

In our study, we determined a threshold of 157 µg/g with a sensitivity of 86.2% and a specificity of 63% for detecting endoscopically active inflammatory bowel diseases (IBD). Thus, fecal calprotectin is considered the best predictive marker of endoscopic activity compared to CRP, circulating leukocytes, and the Crohn's Disease Activity Index (CDAI) [15].

b) Evaluating therapeutic response:

Fecal calprotectin is also used in monitoring therapeutic responses in inflammatory bowel diseases (IBD); thus, several studies have assessed the value of fecal calprotectin as a treatment response marker [5].

A decrease in calprotectin levels parallels mucosal healing, indicating a good response to treatment. Conversely, persistent high levels of fecal calprotectin suggest treatment resistance [5].

Rapid decreases in fecal calprotectin among patients receiving anti-TNF antibodies were significantly correlated with endoscopic remission [16] [17].

In a more recent prospective Italian study involving 43 patients with Crohn's disease (CD), fecal calprotectin appeared to be both a biological marker of therapeutic efficacy (significant decrease in fecal calprotectin in clinically responsive patients to infliximab) and an indicator of sustained response (below a threshold value of 168 µg/g, $P = 0.0001$), as well as mucosal healing at one year (below a threshold value of 121 µg/g, $P = 0.0001$) [18].

c) Evaluating the risk of relapse:

The potential role of fecal calprotectin in predicting relapse risk in inflammatory bowel diseases (IBD) has been well studied by several authors [6].

Tibble *et al.* concluded in a study involving 80 patients with clinically inactive IBD for 1 to 4 months (43 with Crohn's disease and 37 with ulcerative colitis) that patients with a fecal calprotectin level above 250 µg/g had a 13-fold higher risk of relapse within 12 months, with respective sensitivity and specificity of 90% and 83% [19].

Later, Costa and colleagues conducted a similar study to determine if the predictive value of calprotectin differs between Crohn's disease and ulcerative colitis. They found a non-significant doubling of the relapse risk in Crohn's disease and a significant 14-fold increase in the relapse risk in ulcerative colitis for those in clinical remission with fecal calprotectin > 150 µg/g [20].

Overall, these studies indicate that fecal calprotectin is a promising marker for predicting relapses in IBD. It appears to be more accurate for predicting relapses in ulcerative colitis and Crohn's disease with colonic involvement, making it a powerful tool in the monitoring and management of IBD [21].

d) The interest in the postoperative setting:

Inflammatory bowel diseases are chronic conditions, and despite advances in medical therapy, a significant number of patients still require surgery [7].

In ulcerative colitis (UC), following colectomy, the patient is assumed to be cured, whereas in Crohn's disease (CD), surgery is not curative, and the disease

often recurs [7].

Several studies have evaluated the role of fecal calprotectin (FC) in predicting postoperative relapse. In a multicenter trial involving 86 asymptomatic patients with CD who underwent ileocolic resection, it was shown that FC levels were significantly higher in those with endoscopic recurrence compared to those in remission. The optimal threshold to predict endoscopic recurrence was found to be 100 µg/g [21].

Receiver operating characteristic (ROC) curves indicated that the sensitivity, specificity, and negative predictive value (NPV) for predicting postoperative disease recurrence were 95%, 54%, and 93%, respectively. This high NPV can help avoid unnecessary endoscopies in asymptomatic patients [21].

In a study conducted by Yamamoto *et al.*, maintaining an FC level below 140 µg/g postoperatively was correlated with endoscopic remission, yielding a negative predictive value of 91%. Conversely, an increase in FC above 140 µg/g was predictive of endoscopic relapse during follow-up (6 out of 8 patients, or 75%) [22].

3) Limitations of fecal calprotectin (FC):

Although FC is a reliable marker for detecting and evaluating intestinal inflammation, it has certain limitations:

- **False positives:** Elevated FC levels can occur in other situations such as gastrointestinal infections, certain inflammatory conditions (microscopic colitis, eosinophilic colitis, autoimmune enteropathies, celiac disease), polyps, and colorectal cancers [5].
- **Intra-individual variability:** Several authors have noted considerable daily variability in FC levels within the same patient, which may be due to differences in diet or physical activity.
- **Lack of a consensus threshold:** To date, there is no agreed-upon threshold for the various applications of fecal calprotectin in IBD. While the most frequently used thresholds range from 50 to 200 µg/g, there is no standardization [5].
- **Inability to distinguish between Crohn's disease and ulcerative colitis:** FC does not provide the ability to differentiate between these two conditions [21].

4) The medico-economic aspect:

The use of fecal calprotectin testing has allowed for the selection of patients who do not require comprehensive evaluations for organic disease, consequently significantly reducing healthcare costs [22].

In the context of inflammatory bowel diseases (IBD) postoperatively, the use of fecal calprotectin to determine which patients require endoscopy could reduce the number of colonoscopies by 47% [23].

5. Conclusions

Fecal calprotectin (FC) is an interesting marker for identifying patients with atypical digestive symptoms who may require further examinations to investigate organic disease.

FC is more closely correlated with endoscopic activity in inflammatory bowel diseases (IBD) than other non-invasive markers such as C-reactive protein (CRP) and clinical activity.

It also serves as a useful marker for monitoring therapy and for the early detection of relapses in IBD. Currently, its measurement is increasingly integrated into daily practice for assessing endoscopic activity, enabling the selection of patients who are candidates for endoscopy and thus reducing the cost of managing IBD.

However, further efforts are needed to establish thresholds for the various clinical applications of FC in the context of IBD.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Sairenji, T., Collins, K.L. and Evans, D.V. (2017) An Update on Inflammatory Bowel Disease. *Primary Care*: *Clinics in Office Practice*, **44**, 673-692. https://doi.org/10.1016/j.pop.2017.07.010

[2] Flynn, S. and Eisenstein, S. (2019) Inflammatory Bowel Disease Presentation and Diagnosis. *Surgical Clinics of North America*, **99**, 1051-1062. https://doi.org/10.1016/j.suc.2019.08.001

[3] Ma, C., Battat, R., Khanna, R., Parker, C.E., Feagan, B.G. and Jairath, V. (2019) What Is the Role of C-Reactive Protein and Fecal Calprotectin in Evaluating Crohn's Disease Activity? *Best Practice & Research Clinical Gastroenterology*, **38**, Article ID: 101602. https://doi.org/10.1016/j.bpg.2019.02.004

[4] Spiceland, C.M. and Lodhia, N. (2018) Endoscopy in Inflammatory Bowel Disease: Role in Diagnosis, Management, and Treatment. *World Journal of Gastroenterology*, **24**, 4014-4020. https://doi.org/10.3748/wjg.v24.i35.4014

[5] Manceau, H., Chicha-Cattoir, V., Puy, H. and Peoc'h, K. (2017) Fecal Calprotectin in Inflammatory Bowel Diseases: Update and Perspectives. *Clinical Chemistry and Laboratory Medicine* (*CCLM*), **55**, 4014-4020. https://doi.org/10.1515/cclm-2016-0522

[6] Lichtenstein, G.R., Hanauer, S.B. and Sandborn, W.J. (2009) Management of Crohn's Disease in Adults. *The American Journal of Gastroenterology*, **104**, 465-483. https://doi.org/10.1038/ajg.2008.168

[7] Berni Canani, R., Terrin, G., Rapacciuolo, L., Miele, E., Siani, M.C., Puzone, C., *et al.* (2008) Faecal Calprotectin as Reliable Non-Invasive Marker to Assess the Severity of Mucosal Inflammation in Children with Inflammatory Bowel Disease. *Digestive and Liver Disease*, **40**, 547-553. https://doi.org/10.1016/j.dld.2008.01.017

[8] Papi, C., Fascì-Spurio, F., Rogai, F., Settesoldi, A., Margagnoni, G. and Annese, V. (2013) Mucosal Healing in Inflammatory Bowel Disease: Treatment Efficacy and Predictive Factors. *Digestive and Liver Disease*, **45**, 978-985. https://doi.org/10.1016/j.dld.2013.07.006

[9] Cushing, K. and Higgins, P.D.R. (2021) Management of Crohn Disease. *JAMA*, **325**, 69-80. https://doi.org/10.1001/jama.2020.18936

[10] Turkay, C. and Kasapoglu, B. (2010) Noninvasive Methods in Evaluation of Inflammatory Bowel Disease: Where Do We Stand Now? An Update. *Clinics*, **65**, 221-231. https://doi.org/10.1590/s1807-59322010000200015

[11] Otte, M.L., Lama Tamang, R., Papapanagiotou, J., Ahmad, R., Dhawan, P. and Singh,

A.B. (2023) Mucosal Healing and Inflammatory Bowel Disease: Therapeutic Implications and New Targets. *World Journal of Gastroenterology*, **29**, 1157-1172. https://doi.org/10.3748/wjg.v29.i7.1157

[12] Sipponen, T. and Kolho, K. (2014) Fecal Calprotectin in Diagnosis and Clinical Assessment of Inflammatory Bowel Disease. *Scandinavian Journal of Gastroenterology*, **50**, 74-80. https://doi.org/10.3109/00365521.2014.987809

[13] Sipponen, T., Savilahti, E., Kolho, K., Nuutinen, H., Turunen, U. and Färkkilä, M. (2008) Crohn's Disease Activity Assessed by Fecal Calprotectin and Lactoferrin: Correlation with Crohn's Disease Activity Index and Endoscopic Findings. *Inflammatory Bowel Diseases*, **14**, 40-46. https://doi.org/10.1002/ibd.20312

[14] Sipponen, T. and Kolho, K. (2010) Faecal Calprotectin in Children with Clinically Quiescent Inflammatory Bowel Disease. *Scandinavian Journal of Gastroenterology*, **45**, 872-877. https://doi.org/10.3109/00365521003782389

[15] Schoepfer, A.M., Beglinger, C., Straumann, A., Trummler, M., Vavricka, S.R., Bruegger, L.E., *et al.* (2010) Fecal Calprotectin Correlates More Closely with the Simple Endoscopic Score for Crohn's Disease (SES-CD) than CRP, Blood Leukocytes, and the CDAI. *American Journal of Gastroenterology*, **105**, 162-169. https://doi.org/10.1038/ajg.2009.545

[16] Dhaliwal, A., Zeino, Z., Tomkins, C., Cheung, M., Nwokolo, C., Smith, S., *et al.* (2014) Utility of Faecal Calprotectin in Inflammatory Bowel Disease (IBD): What Cut-Offs Should We Apply? *Frontline Gastroenterology*, **6**, 14-19. https://doi.org/10.1136/flgastro-2013-100420

[17] Wagner, M., Peterson, C.G., Ridefelt, P., Sangfelt, P. and Carlson, M. (2008) Fecal Markers of Inflammation Used as Surrogate Markers for Treatment Outcome in Relapsing Inflammatory Bowel Disease. *World Journal of Gastroenterology*, **14**, 5584-5589. https://doi.org/10.3748/wjg.14.5584

[18] Guidi, L., Marzo, M., Andrisani, G., Felice, C., Pugliese, D., Mocci, G., *et al.* (2014) Faecal Calprotectin Assay after Induction with Anti-Tumour Necrosis Factor A Agents in Inflammatory Bowel Disease: Prediction of Clinical Response and Mucosal Healing at One Year. *Digestive and Liver Disease*, **46**, 974-979. https://doi.org/10.1016/j.dld.2014.07.013

[19] Tibble, J.A., Sigthorsson, G., Bridger, S., Fagerhol, M.K. and Bjarnason, I. (2000) Surrogate Markers of Intestinal Inflammation Are Predictive of Relapse in Patients with Inflammatory Bowel Disease. *Gastroenterology*, **119**, 15-22. https://doi.org/10.1053/gast.2000.8523

[20] Costa, F. (2005) Calprotectin Is a Stronger Predictive Marker of Relapse in Ulcerative Colitis than in Crohn's Disease. *Gut*, **54**, 364-368. https://doi.org/10.1136/gut.2004.043406

[21] Ikhtaire, S., Shajib, M.S., Reinisch, W. and Khan, W.I. (2016) Fecal Calprotectin: Its Scope and Utility in the Management of Inflammatory Bowel Disease. *Journal of Gastroenterology*, **51**, 434-446. https://doi.org/10.1007/s00535-016-1182-4

[22] Yamamoto, T., Shimoyama, T., Umegae, S. and Matsumoto, K. (2016) Serial Monitoring of Faecal Calprotectin for the Assessment of Endoscopic Recurrence in Asymptomatic Patients after Ileocolonic Resection for Crohn's Disease: A Long-Term Prospective Study. *Therapeutic Advances in Gastroenterology*, **9**, 664-670. https://doi.org/10.1177/1756283x16646562

[23] Wright, E.K., Kamm, M.A., De Cruz, P., Hamilton, A.L., Ritchie, K.J., *et al.* (2015) Measurement of Fecal Calprotectin Improves Monitoring and Detection of Recurrence of Crohn's Disease after Surgery. *Gastroenterology*, **148**, 938-947.e1.