# Cross-Sectional Imaging Instead of Colonoscopy

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Recently, cross-sectional imaging techniques have been increasingly shown as reliable tools for assessing Inflammatory bowel diseases (IBD) activity. While computed tomography (CT) is hampered by radiation risks, routine implementation of magnetic resonance enterography (MRE) for close monitoring is limited by its costs, low availability and long examination time. Novel magnetic resonance imaging (MRI)-based techniques, such as diffusion-weighted imaging (DWI), can overcome some of these weaknesses and have been shown as valuable options for IBD monitoring. Bowel ultrasound (BUS) is a noninvasive, highly available, cheap, and well accepted procedure that has been demonstrated to be as accurate as CS and MRE for assessing and monitoring disease activity in IBD. Furthermore, as BUS can be quickly performed at the point-of-care, it allows for real-time clinical decision making.

bowel ultrasound | inflammatory bowel disease | cross-sectional imaging

## 1. Introduction

Inflammatory bowel diseases (IBD), such as Crohn's disease (CD) and ulcerative colitis (UC), are chronic, recurrent and progressive inflammatory gastrointestinal disorders that can lead to invalidating complications [1][2]. Therapeutic strategies aiming merely at controlling symptoms have been demonstrated to fail in modifying the natural course of these diseases. Thus, there has been a shift towards a treat-to-target approach based on a tight control of the disease activity with close monitoring of intestinal inflammation through objective interval assessments and therapy optimization whenever the therapeutic targets are not met [3]. This strategy has been proven able to impact on the disease course, improving long-term outcomes in IBD patients [4]. Colonoscopy (CS) is the gold standard for assessing disease activity and severity in IBD [5][6]. Nevertheless, CS cannot entirely assess and quantify the small bowel disease extension and detect any transmural and extramural CD activity, including complications such as fistulas and abscesses [7]. In addition, it is an expensive and invasive procedure with the risk, although low, of bowel perforation, and its repetition over time is poorly tolerated by patients [8][9]. These limitations make CS an unsuitable tool for the frequent and repetitive monitoring required by the treat-to-target strategy. Hence, noninvasive, cost-effective and easy-to-use options are strongly needed for the routine care.

In the last few years, the use of cross-sectional imaging techniques for IBD assessment has significantly grown. Computed tomography enterography (CTE) has been proven to have high accuracy for the detection of small bowel disease extension and complications in CD, but its use is limited by radiation exposure [10][11]. Magnetic

resonance enterography (MRE) is currently the recommended procedure for evaluating the small bowel and complications in CD, and it has been suggested as a potential alternative to CS for the assessment of both UC and ileo-colonic CD [6][12][13]. However, standard MRE is costly, time-consuming and not promptly accessible; in addition, it requires bowel preparation and the intravenous injection of gadolinium as a contrast agent, which carries the risk of adverse events such as allergic reactions and nephrogenic systemic fibrosis, and, therefore, it can be scarcely accepted by patients [14]. New magnetic resonance imaging (MRI)-based techniques can represent an added value in the monitoring of IBD, overcoming some limitations of conventional MRE and providing further information. Among these, diffusion-weighted imaging (DWI) has demonstrated good accuracy and reliability, but lacks an adequate standardization of DWI scanners and procedures [15]. In addition to CT and MRE, bowel ultrasound (BUS) is an inexpensive, noninvasive, readily available and well tolerated procedure that does not require either bowel preparation or contrast agent and can be performed at the point-of-care [16]. It is as valuable as CS and MRE for detecting disease activity and complications in IBD [17].

# 2. Crohn's Disease

## 2.1. Cross-Sectional Imaging Techniques in Crohn's Disease

In CD, the inflammation typically develops transmurally, resulting in destructive complications such as strictures, fistulas, and abscesses, requiring surgery over time in about half of patients [1]. Cross-sectional imaging techniques, including CTE, MRE and BUS, are required to assess and monitor the entire disease burden, including the small bowel and transmural locations, as indicated by the European Crohn's and Colitis Organization (ECCO) and the European Society of Gastrointestinal and Abdominal Radiology (ESGAR) latest guidelines [6][17].

## 2.2. Computed Tomography Enterography for the Assessment of Disease Activity and Complications

Several data are available on the accuracy of CTE in assessing disease activity and complications in CD. In a systematic review by Panes et al., according to the high-quality standards required, 69 relevant prospective studies were included [10]. CTE was demonstrated as a valuable tool for assessing CD activity (overall sensitivity and specificity of 81% and 88%, respectively) and for detecting stricturing and/or penetrating complications (sensitivity and specificity higher than 80%) [10]. Furthermore, a meta-analysis performed by Horsthuis et al. showed that CTE has high accuracy in detecting CD (mean per-patient sensitivity and specificity were 84% and 95%, respectively; mean per-bowel-segment sensitivity and specificity were 68% and 90%, respectively) [18].

## 2.3. Magnetic Resonance Enterography

### 2.3.1. Assessment of Disease Activity and Complications

Horsthuis et al. in their meta-analyses reported MRE as reliable both for the diagnosis of suspected CD (both mean per-patient sensitivity and specificity were 93%; mean per-bowel-segment sensitivity and specificity were 70% and

94%, respectively) and for grading CD activity (per-patient and per segment accuracy grading were 84% and 67–82%, respectively) [18][19].

Moreover, MRE has been demonstrated to be accurate for assessing CD activity (sensitivity 80% and specificity 82%) and for identifying fistulas, abscesses and strictures (sensitivity and specificity were 76% and 96%, 86% and 93%, and 89% and 94%, respectively) as reported by Panes et al. in their systematic review [10]. Unlike CTE, MRE is a radiation-free procedure, suitable for frequent restaging and monitoring young CD patients over the time. Hence, it currently represents the gold standard investigation for assessing small bowel CD presence and extension as well as transmural and extramural characteristics and complications [6]. Furthermore, MRE has a shorter recovery time and is considered more acceptable by CD patients in comparison to CS (88% vs. 60%, $p < 0.001$) [14].

### 2.3.2. Monitoring and Prediction of Outcomes

A prospective study evaluated the accuracy of MRE in monitoring treatment responses in CD [20]. MRE was shown to identify ulcer healing (MaRIA score < 11) and mucosal healing (MH) (MaRIA score < 7) with 83% and 90% of accuracy, respectively [20].

## 2.4. Diffusion Weighted Imaging

### 2.4.1. Assessing Disease Activity

Diffusion-weighted imaging (DWI) is a magnetic resonance (MR)-based technique that analyzes water molecules' motion in the extracellular and intracellular compartments to provide image contrast. It can be performed without the need for intravenous administration of gadolinium-based contrast agent. Due to restricted microscopic diffusion of water molecules, a high enhancement diffusion signal and a low apparent diffusion coefficient (ADC) value have been detected in inflamed bowel segments in IBD patients and allowed the identification of active CD [15].

### 2.4.2. Monitoring Patients

Thierry et al. conducted a prospective study on 96 CD patients undergoing DWI-MR before and after biological therapy [21]; at the same time, CS was also performed in a subgroup of 20 patients [21]. The total and the segmental Nancy score significantly correlated with the total and the segmental CDEIS ($r = 0.60$, $p < 0.0001$; and $r = 0.63$, $p < 0.0001$, respectively) [21].

## 2.5. Other New Magnetic Resonance Imaging-Based Techniques

Magnetization transfer (MT) is a novel MRI technique that provides contrast between protons in free water molecules and protons in large macromolecules, such as collagen, without the administration of any intravenous contrast agent. The MT signal of a specific tissue can be quantified by the MT ratio, which increases along with the increase in collagen in that tissue. MT-based MR may, therefore, estimate the relative amount of fibrosis in a tissue [22]. The development of bowel wall strictures occurs in about 30% of CD patients and this complication requires

medical, endoscopic or surgical therapy depending on the nature of the stricture. However, while strictures can be accurately diagnosed by both CS and cross-sectional imaging techniques (BUS, CTE, MRE), no diagnostic investigation has been proved efficient to discriminate the nature of the stricture (mainly fibrotic or mainly inflammatory) and to establish the degree of fibrosis in the bowel wall [10][23].

# 3. Ulcerative Colitis—Cross-Sectional Imaging Techniques in Ulcerative Colitis

In order to achieve proper disease control, in UC patients, tight and close monitoring of intestinal inflammation is also required [3]. Besides the improvement of symptoms, including rectal bleeding and loose stools, MH, defined by a Mayo endoscopic subscore of 0 to 1, is designated as the target of treatment [3]; indeed, the achievement of MH in UC has been found to be associated with long-term clinical remission and decreased need for surgery and corticosteroid therapy [4]. CS is currently the gold standard procedure for the assessment of MH in UC [5].

In recent years, the use of cross-sectional imaging techniques, including CTE, MRE and US, is increasingly rising in UC.

## 3.1. Computed Tomography Enterography and Magnetic Resonance Enterography for Assessing Disease Activity

CTE has been shown to have a moderate accuracy in assessing disease activity in UC [24]. A comparison study showed that CTE findings moderately correlated with UC severity ($r$ = 0.612) defined by endoscopic evaluation [24]. Johnson et al. reported that CTE in UC patients detected colonic inflammation with an overall sensitivity of 74% [25]; of note, moderate and severe diseases were identified with a sensitivity of 93% [25]. Similar to what has been said for its role in CD, the use of CTE, despite reduced costs and high availability, is limited by radiation exposure, especially for monitoring young patients over the disease course. Thus, CTE is the technique of choice to detect acute complications, such as toxic megacolon, bowel perforation, intra-abdominal complications and post-operative leaks [26].

## 3.2. Diffusion Weighted Imaging

### 3.2.1. Assessing Disease Activity

Very recently, DWI-MR has emerged as a highly accurate tool in detecting colonic inflammation in UC [27]. An observational study, carried out on the accuracy of DWI-MR imaging for assessing disease activity in 35 UC patients without oral/rectal preparation and fasting demonstrated that the endoscopic activity was accurately identified by a segmental Nancy score > 1 (sensitivity 89.4%, specificity 86.7%, AUROC, 0.92; $p$ = 0.0001) [27]. The segmental and total Nancy scores agreed with the segmental and total modified endoscopic Baron scores ($r$ = 0.659, $p$ < 0.0001; and $r$ = 0.813, $p$ = 0.0001, respectively) [27].

### 3.2.2. Monitoring of Disease

A recent study on a UC cohort evaluated the accuracy of the DWI Nancy score in assessing MH, defined by a Mayo endoscopic subscore of 0 to 1, and the treatment response in a subgroup of subjects with active UC. MH was reliably detected by a Nancy score < 7 (sensitivity 75%, specificity 67%, AUROC 0.72; $p = 0.0063$) [28]. The Nancy score has been shown to have good reliability (ICC 0.63) [28].

## 3.3. Bowel Ultrasound

### 3.3.1. Assessing Disease Activity

Even if less investigated than in CD, recent data support the role of BUS in the management of UC patients. BUS has great accuracy in detecting colonic inflammation in UC (sensitivity and specificity of 90% and 96% per-patient analysis, and 74% and 93% per segment analysis, respectively) as endorsed by meta-analysis [18].

### 3.3.2. Predicting Outcomes and Monitoring

As concerns the ability of BUS to predict clinical outcomes, Parente et al. found that a severe BUS score (BWT > 6 mm and the presence of BWF) after three months of steroid therapy was predictive of a severe endoscopic activity at 15 months (OR 9.1) [29].

Furthermore, MUC was shown to have a predictive value on UC course in both the short and the long period [30]. Indeed, a very recent study on UC patients, investigating BUS assessments in a follow-up period of at least one year, identified a MUC > 6.2 as an independent predictor of need for treatment escalation at 12 months (OR 5.95; $p < 0.020$) [30].

## References

1. Torres, J.; Mehandru, S.; Colombel, J.-F.; Peyrin-Biroulet, L. Crohn’s disease. Lancet 2017, 389, 1741–1755.
2. Ungaro, R.; Mehandru, S.; Allen, P.B.; Peyrin-Biroulet, L.; Colombel, J.F. Ulcerative colitis. Lancet 2017, 389, 1756–1770.
3. Turner, D.; Ricciuto, A.; Lewis, A.; D’Amico, F.; Dhaliwal, J.; Griffiths, A.M.; Bettenworth, D.; Sandborn, W.J.; Sands, B.E.; Reinisch, W.; et al. STRIDE-II: An Update on the Selecting Therapeutic Targets in Inflammatory Bowel Disease (STRIDE) Initiative of the International Organization for the Study of IBD (IOIBD): Determining Therapeutic Goals for Treat-to-Target strategies in IBD. Gastroenterology 2021, 160, 1570–1583.
4. Colombel, J.-F.; D’Haens, G.; Lee, W.-J.; Petersson, J.; Panaccione, R. Outcomes and Strategies to Support a Treat-to-target Approach in Inflammatory Bowel Disease: A Systematic Review. J. Crohn’s Colitis 2019, 14, 254–266.

5. Magro, F.; Gionchetti, P.; Eliakim, R.; Ardizzone, S.; Armuzzi, A.; Barreiro-de Acosta, M.; Burisch, J.; Gecse, K.B.; Hart, A.L.; Hindryckx, P.; et al. Third European evidence-based consensus on diagnosis and management of ulcerative colitis. Part 1: Definitions, Diagnosis, Extra-intestinal Manifestations, Pregnancy, Cancer Surveillance, Surgery, and Ileo-anal Pouch Disorders. J. Crohn's Colitis 2017, 11, 649–670.
6. Gomollón, F.; Dignass, A.; Annese, V.; Tilg, H.; Van Assche, G.; Lindsay, J.O.; Peyrin-Biroulet, L.; Cullen, G.J.; Daperno, M.; Kucharzik, T.; et al. 3rd European Evidence-based Consensus on the Diagnosis and Management of Crohn's Disease 2016: Part 1: Diagnosis and Medical Management. J. Crohn's Colitis 2017, 11, 3–25.
7. Louis, E.; Collard, A.; Oger, A.F.; Degroote, E.; El Yafi, F.A.N.; Belaiche, J. Behaviour of Crohn's disease according to the Vienna classification: Changing pattern over the course of the disease. Gut 2001, 49, 777–782.
8. Lohsiriwat, V. Colonoscopic perforation: Incidence, risk factors, management and outcome. World J. Gastroenterol. 2010, 16, 425–430.
9. Noiseux, I.; Veilleux, S.; Bitton, A.; Kohen, R.; Vachon, L.; Guay, B.W.; Rioux, J.D. Inflammatory bowel disease patient perceptions of diagnostic and monitoring tests and procedures. BMC Gastroenterol. 2019, 19, 1–11.
10. Panes, J.; Bouzas, R.; Chaparro, M.; García-Sánchez, V.; Gisbert, J.P.; Martínez de Guereñu, B.; Mendoza, J.L.; Paredes, J.M.; Quiroga, S.; Ripollés, T.; et al. Systematic review: The use of ultrasonography, computed tomography and magnetic resonance imaging for the diagnosis, assessment of activity and abdominal complications of Crohn's disease. Aliment. Pharmacol. Ther. 2011, 34, 125–145.
11. Desmond, A.N.; O'Regan, K.; Curran, C.; McWilliams, S.; Fitzgerald, T.; Maher, M.M.; Shanahan, F. Crohn's disease: Factors associated with exposure to high levels of diagnostic radiation. Gut 2008, 57, 1524–1529.
12. Rimola, J.; Rodriguez, S.; Garcia-Bosch, O.; Ordas, I.; Ayala, E.; Aceituno, M.; Pellise, M.; Ayuso, C.; Ricart, E.; Donoso, L.; et al. Magnetic resonance for assessment of disease activity and severity in ileocolonic Crohn's disease. Gut 2009, 58, 1113–1120.
13. Ordás, I.; Rimola, J.; García-Bosch, O.; Rodríguez, S.; Gallego, M.; Etchevers, M.J.; Pellisé, M.; Feu, F.; González-Suárez, B.; Ayuso, C.; et al. Diagnostic accuracy of magnetic resonance colonography for the evaluation of disease activity and severity in ulcerative colitis: A prospective study. Gut 2013, 62, 1566–1572.
14. Miles, A.; Bhatnagar, G.; Hallian, S.; Gupta, A.; Tolan, D.; Zealley, I.; Taylor, S.A.; METRIC Investigators. Magnetic resonance enterography, small bowel ultrasound and colonoscopy to diagnose and stage Crohn's disease: Patient acceptability and perceived burden. Eur. Radiol. 2019, 29, 1083–1093.

15. Pouillon, L.; Laurent, V.; Pouillon, M.; Bossuyt, P.; Bonifacio, C.; Danese, S.; Deepak, P.; Loftus, E.; Bruining, D.H.; Peyrin-Biroulet, L. Diffusion-weighted MRI in inflammatory bowel disease. Lancet Gastroenterol. Hepatol. 2018, 3, 433–443.
16. Bryant, R.V.; Friedman, A.B.; Wright, E.K.; Taylor, K.M.; Begun, J.; Maconi, G.; Maaser, C.; Novak, K.L.; Kucharzik, T.; Atkinson, N.S.S.; et al. Gastrointestinal ultrasound in inflammatory bowel disease: An underused resource with potential paradigm-changing application. Gut 2018, 67, 973–985.
17. Maaser, C.; Sturm, A.; Vavricka, S.R.; Kucharzik, T.; Fiorino, G.; Annese, V.; Calabrese, E.; Baumgart, D.C.; Bettenworth, D.; Borralho Nunes, P.; et al. ECCO-ESGAR guideline for diagnostic assessment in IBD Part 1: Initial diagnosis, monitoring of known IBD, detection of complications. J. Crohn's Colitis 2019, 13, 144–164.
18. Horsthuis, K.; Bipat, S.; Bennink, R.J.; Stoker, J. Inflammatory Bowel Disease Diagnosed with US, MR, Scintigraphy, and CT: Meta-analysis of Prospective Studies. Radiology 2008, 247, 64–79.
19. Horsthuis, K.; Bipat, S.; Stokkers, P.C.F.; Stoker, J. Magnetic resonance imaging for evaluation of disease activity in Crohn's disease: A systematic review. Eur. Radiol. 2009, 19, 1450–1460.
20. Ordas, I.; Rimola, J.; Rodríguez, S.; Paredes, J.M.; Martínez-Pérez, M.J.; Blanc, E.; Arévalo, J.A.; Aduna, M.; Andreu, M.; Radosevic, A.; et al. Accuracy of Magnetic Resonance Enterography in Assessing Response to Therapy and Mucosal Healing in Patients with Crohn's Disease. Gastroenterology 2014, 146, 374–382.e1.
21. Thierry, M.-L.; Rousseau, H.; Pouillon, L.; Girard-Gavanier, M.; Baumann, C.; Lopez, A.; Danese, S.; Laurent, V.; Peyrin-Biroulet, L. Accuracy of Diffusion-weighted Magnetic Resonance Imaging in Detecting Mucosal Healing and Treatment Response, and in Predicting Surgery, in Crohn's Disease. J. Crohn's Colitis 2018, 12, 1180–1190.
22. Pazahr, S.; Blume, I.; Frei, P.; Chuck, N.; Nanz, D.; Rogler, G.; Patak, M.; Boss, A. Magnetization transfer for the assessment of bowel fibrosis in patients with Crohn's disease: Initial experience. Magma Magn. Reson. Mater. Phys. Biol. Med. 2012, 26, 291–301.
23. Rieder, F.; Latella, G.; Magro, F.; Yuksel, E.S.; Higgins, P.D.; Di Sabatino, A.; de Bruyn, J.R.; Rimola, J.; Brito, J.; Bettenworth, D.; et al. European Crohn's and Colitis Organization topical review on prediction, diagnosis and management of fibrostenosing Crohn's disease. J. Crohn's Colitis 2016, 10, 873–885.
24. Andersen, K.; Vogt, C.; Blondin, D.; Beck, A.; Heinen, W.; Aurich, V.; Häussinger, D.; Mödder, U.; Cohnen, M. Multi-detector CT-colonography in inflammatory bowel disease: Prospective analysis of CT-findings to high-resolution video colonoscopy. Eur. J. Radiol. 2006, 58, 140–146.
25. Johnson, K.T.; Hara, A.K.; Johnson, C.D. Evaluation of colitis: Usefulness of CT enterography technique. Emerg. Radiol. 2009, 16, 277–282.

26. Deepak, P.; Axelrad, J.E.; Ananthakrishnan, A.N. The Role of the Radiologist in Determining Disease Severity in Inflammatory Bowel Diseases. Gastrointest. Endosc. Clin. N. Am. 2019, 29, 447–470.
27. Oussalah, A.; Laurent, V.; Bruot, O.; Bressenot, A.; Bigard, M.A.; Régent, D.; Peyrin-Biroulet, L. Diffusion-weighted magnetic resonance without bowel preparation for detecting colonic inflammation in inflammatory bowel disease. Gut 2010, 59, 1056–1065.
28. Laurent, V.; Naudé, S.; Vuitton, L.; Zallot, C.; Baumann, C.; Girard-Gavanier, M.; Peyrin-Biroulet, L. Accuracy of Diffusion-weighted Magnetic Resonance Colonography in Assessing Mucosal Healing and the Treatment Response in Patients with Ulcerative Colitis. J. Crohn's Colitis 2016, 11, 716–723.
29. Parente, F.; Molteni, M.; Marino, B.; Colli, A.; Ardizzone, S.; Greco, S.; Sampietro, G.M.; Gallus, S. Bowel Ultrasound and Mucosal Healing in Ulcerative Colitis. Dig. Dis. 2009, 27, 285–290.
30. Allocca, M.; Dell'Avalle, C.; Furfaro, F.; Craviotto, V.; Zilli, A.; D'Amico, F.; Peyrin-Biroulet, L.; Fiorino, G.; Danese, S. OP21 Predictive value of Milan Ultrasound Criteria in Ulcerative Colitis: A prospective observational cohort study. J. Crohn's Colitis 2021, 15, S020–S021.