Current Endoscopic Scoring Systems in Inflammatory Bowel Disease: Strengths and Limitations

Jeffery M. Venner, MD, MSc[a,b], Charles N. Bernstein, MD[a,b,*]

KEYWORDS

• Endoscopy assessment • Interobserver agreement • Disease activity
• Mucosal healing

KEY POINTS

- Endoscopic scoring schemas were derived to assess disease activity in Crohn's disease and ulcerative colitis, not to make the diagnosis of inflammatory bowel disease (IBD).
- Available endoscopic scoring schemas each have their own strengths and weaknesses, largely dictated by their complexity (or ease of use) and population from which they were derived.
- Interobserver agreement in the endoscopic assessment of IBD is fair at best.
- Novel technologies and artificial intelligence utilizing prospective cohorts are needed to improve the diagnosis and assessment of disease states seen in IBD.

INTRODUCTION

Endoscopy is a fundamental tool for the diagnosis and management of inflammatory bowel disease (IBD). Endoscopy can help with the differentiation between IBD and other inflammatory and infectious disorders of the gastrointestinal tract and is required for staging disease activity, biopsy acquisition for histology, dysplasia surveillance, and surgical sparing interventions such as balloon dilation of fibrostenotic strictures.

Adolf Kussmaul is credited with the invention of the first rigid gastroscopy in 1868,[1] but since then, various flexible endoscopic imaging modalities have been developed. These include high-definition white light, chromoendoscopy and narrow band imaging, confocal laser endomicroscopy, and endocytoscopy. In select patients with small bowel Crohn's disease (CD), balloon-assisted enteroscopy, and video capsule endoscopy (CE) can be particularly helpful. The current standard-of-care goal for IBD treatment is endoscopic healing. Confirmation of endoscopic healing is prudent because

[a] University of Manitoba IBD Clinical and Research Centre, Winnipeg, Manitoba, Canada; [b] Department of Internal Medicine, Max Rady College of Medicine, University of Manitoba, Winnipeg, Manitoba, Canada
* Corresponding author. 804F-715 McDermot Avenue, Winnipeg, Manitoba, R3E 3P4, Canada.
E-mail address: charles.bernstein@umanitoba.ca

Gastrointest Endoscopy Clin N Am 35 (2025) 19–39
https://doi.org/10.1016/j.giec.2024.04.014
giendo.theclinics.com

symptoms poorly correlate with disease activity[2–4] and are not disease-specific. Furthermore, there are data to support histology assessment as a treatment target, as those in endoscopic remission with active microscopic disease have an increased risk of disease relapse and development of dysplasia compared to those without microscopic disease.[5] We avoid the term mucosal healing since it is ambiguous, as histology is also an assessment of the mucosa. The term mucosal healing will become more ambiguous if other technologies, such as confocal laser endoscopy, are found to be clinically useful.

The endoscopist's description of endoscopic findings in IBD is paramount to patient care: it supports the diagnosis and grading of disease activity (severity). While there are no formalized endoscopic scoring criteria for diagnosing ulcerative colitis (UC) or CD, there is the assessment of disease activity. Endoscopic scoring systems provide information that help make therapeutic decisions, assess response to therapy, and allow for objective communication to patients and other clinicians. As outlined later, many scoring systems used in IBD were derived out of the need to assess response to therapy in a clinical trial.

In this review, we discuss the role of endoscopy with regard to pertinent endoscopic scoring systems (or schema), their strengths and weaknesses, and how upcoming technological advancements may address pitfalls in present-day endoscopic assessment.

OVERVIEW: ENDOSCOPIC DIAGNOSIS AND ASSESSMENT

During the initial assessment of patients suspected of having IBD, ileocolonoscopy with targeted biopsies is the gold standard diagnostic modality. Additional or follow-up endoscopic evaluation such as repeat colonoscopy, gastroscopy, or video CE will be dependent on the patient's diagnosis, disease course, expert opinion, local practices, and society guidelines. The correct diagnosis of CD versus UC is made approximately 90% of the time when clinical and endoscopic assessment are completed by a gastroenterologist with training in IBD.[6,7] The diagnostic accuracy is unknown when the assessment is made by endoscopists external to gastroenterology or gastroenterologists who do not frequently see patients with IBD. Making the correct endoscopic diagnosis of CD or UC is based on several endoscopic patterns. Classically described lesions in CD include rectal sparing with skip lesions, small bowel involvement, fistulas, and strictures. On the other hand, rectal involvement with deep ulcers is a hallmark of poor prognosis CD. Continuous inflammatory changes extending proximally from the rectum to a characteristic sharp demarcation of inflamed to uninvolved colonic mucosa are suggestive of UC.

There are, however, well-known caveats in the endoscopic appearance of CD and UC. Approximately 80% of patients with CD will have small bowel involvement. However, where small bowel involvement is limited to the terminal ileum, care must be taken to differentiate Crohn's colitis with ileitis versus backwash ileitis seen in pancolonic UC. Certain extraintestinal manifestations of IBD, such as primary sclerosing cholangitis (PSC) that is associated with UC, may help with the diagnosis but are not 100% specific. Furthermore, in cases of PSC, UC can be paradoxically right-sided predominant.[8] In patients with left-sided UC, patchy inflammation in the cecum referred to as a cecal patch is well described[9] but can be mistaken for a CD skip lesion. The mucosa in patients with partially treated UC can also have a patchy appearance.[10] These are several examples where UC may be misdiagnosed as CD. When the clinician is unable to commit to diagnosis of CD or UC, the patient may receive a label of IBD unclassified (IBDU). Unsurprisingly, most patients who are

labeled as IBDU have disease limited to the colon,[11] as significant small bowel or upper GI tract involvement would likely receive a CD label.

It must be noted that IBD endoscopic scoring schemas were not designed or validated for making the diagnosis of UC or CD. They were derived to assess disease activity and response to treatment in patients already diagnosed with IBD.

ENDOSCOPIC SCORING IN CROHN'S DISEASE

The more commonly used endoscopic scoring systems in CD are outlined later. There are several, mostly older scoring systems of note. However, these have not extensively made their way through the research literature or clinical practice, nor have they been validated.[12–16] As described later, most endoscopic scoring systems in CD do not account for disease proximal to the terminal ileum, thus underassessing approximately 5% to 10% of all cases of CD.

Crohn's Disease Endoscopic Index of Severity

The CD Endoscopic Index of Severity (CDEIS) is a complex, composite scoring system that assesses superficial and deep ulcers, as well as the proportion of bowel involved with other endoscopic lesions (eg, pseudopolyps, erythema, swollen mucosa, aphthoid ulceration, and stenosis) in each colonic segment and the terminal ileum (**Table 1**).[17] Thus, the CDEIS considers disease extent. Furthermore, the CDEIS was validated in a second prospective cohort.[17] However, only 35% of endoscopists in the discovery set and 38% in the validation set intubated the ileum (and ~75% in each group made it the level of the cecum).[17] While assessment of the proximal colon and small bowel may have been inhibited by fibrostenotic disease in some patients, the lack of endoscopic assessment reduces validity of the CDEIS in these respective areas.

There are various cutoffs or endpoints described in the literature. Endoscopic remission is defined as CDEIS <6, ≤4, or <3, and endoscopic improvement is a reduction from baseline greater than 5, ≥5, ≥3, or ≥75%, depending on the study.[18] Thus, there is disagreement on what might be considered appropriate healing or response to therapy.

As demonstrated in **Table 1**, the CDEIS is impractical for daily clinical use. It requires significant training and dedicated time during endoscopy. Despite its complexity, interobserver agreement was surprisingly high for both the discovery and validation sets (intraclass correlation coefficient [ICC] 0.96 and 0.81, respectively).[17] One should not expect high concordance in an otherwise complex, subjective scoring system. In the original CDEIS study,[17] two endoscopists scored each endoscopy at the same time in the same room, the endoscopists were similar between the discovery and validation sets, and they underwent training before the studies—a practice not akin to daily clinical care. Similar high ICCs have been replicated, but again in a setting where endoscopists were considered, CDEIS experts and received retraining.[19] In a multicenter trial of certolizumab in CD, endoscopy videos were reassessed by pairs of central readers.[20] The ICC of the CDEIS scores from the paired central readers was 0.6 (at week 0 post-treatment), 0.74 (week 10), and 0.81 (week 54). The study demonstrated positive response to certolizumab as per the CDEIS; thus, interobserver agreement improved as the CDEIS score improved (ie, as endoscopic assessment normalized and became simpler) and central readers gained experience throughout the study period. The study did not assess interobserver agreement between central and local readers, which would have been much more informative.

Table 1
Crohn's Disease Endoscopic Index of Severity, shown with an example

	Rectum	Sigmoid and Left Colon	Transverse Colon	Right Colon	Ileum	Segment Sum
Deep ulceration (12 if present, 0 if absent)	0	12	0	0	0	12
Superficial ulceration (6 if present, 0 if absent)[a]	0	0	0	6	6	12
Surface involved by disease (0–10 cm)[b,c]	0	10	0	8	6	24
Ulcerated surface (0–10 cm)[b]	0	6	0	8	6	20
					Total sum of all segments (A) =	68
					Number (N) of segments explored =	5
					Segment sum (A) divided by number (N) of segments explored (B) =	68 ÷ 5 = 13.6
					Quote 3 if ulcerated stenosis anywhere, 0 if absent (C) =	3
					Quote 3 if nonulcerated stenosis anywhere, 0 if absent (D) =	0
					Total CDEIS = B+ C + D =	16.6

[a] Superficial ulceration does not include aphthous ulcers.
[b] Percentage of segmental surfaces involved is calculated by positioning a cross on two 10 cm linear analog scales, between 0 (no lesion or ulceration) and 10 (100% involved with lesions or ulceration).
[c] Includes assessment of 9 lesions: pseudopolyps, healed ulceration, frank erythema, frankly swollen mucosa, aphthoid ulceration, superficial or shallow ulceration, deep ulceration, nonulcerated stenosis, ulcerated stenosis (stenosis is defined as difficult or impossible to pass with adult colonoscope).

Simple Endoscopic Score for Crohn's Disease

The simple endoscopic score for CD (SES-CD) was derived to simplify the complexity of the CDEIS while still accounting for disease extent.[21] There are 4 empirically chosen variables (presence and size of ulcers, extent of ulcerated surface, extent of affected surface, and presence and type of stenosis) that each receive a score from 0–3, and each segment of colon and ileum receives a score for each variable (**Fig. 1**, **Table 2**). The SES-CD is the sum of each variable score in each bowel segment. Derivation of the SES-CD included a prospective validation cohort.[21]

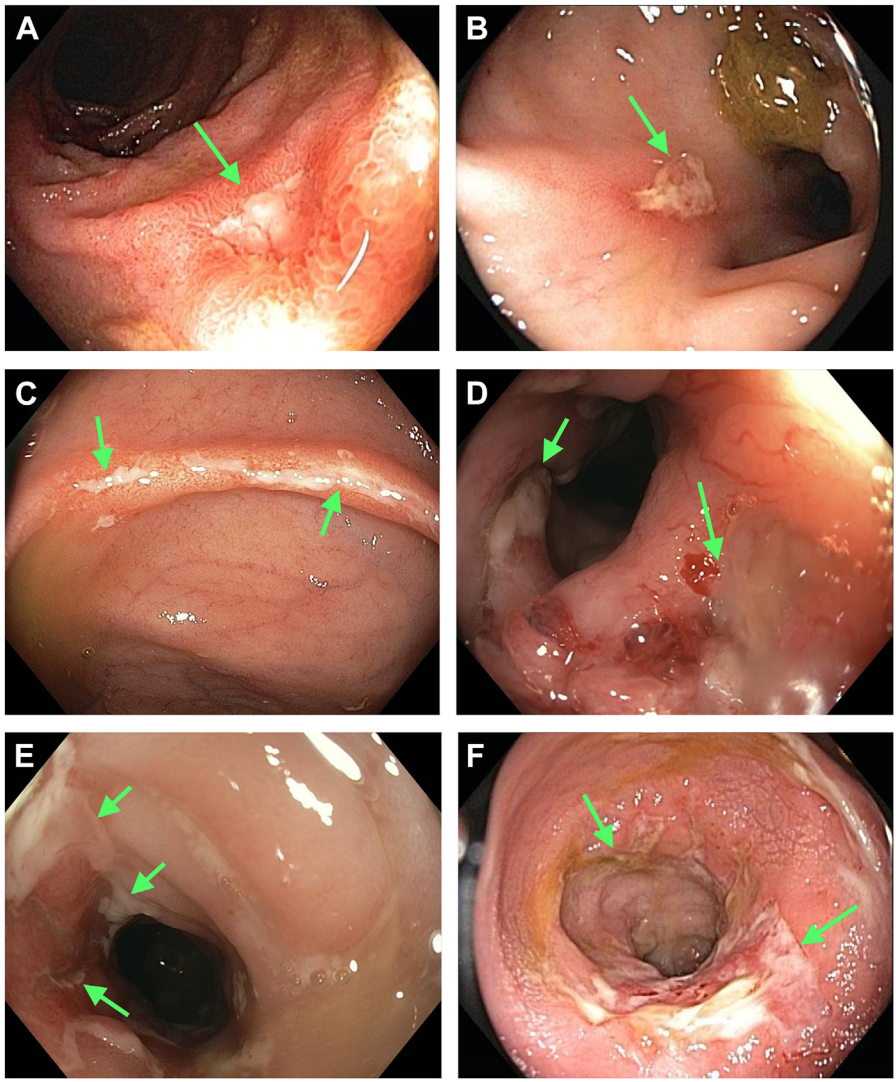

Fig. 1. Example colonoscopy images demonstrating features assessed by the simple endoscopic score for Crohn's disease (SES-CD). (*A*) Aphthous ulcer less than 0.5 cm (*arrow*), (*B*, *C*) ulcers 0.5 to 2.0 cm (*arrows*), (*D*, *E*) ulcers greater than 2 cm (*arrows*), and (*F*) ulcers of various sizes (>0.5 cm, *arrows*) with associated narrowing that could be passed with the colonoscope.

Table 2
Simple endoscopic score for Crohn's disease, shown with an example

	Ileum	Right Colon	Transverse Colon	Left Colon	Rectum	Segment Sum
Presence and size of ulcers (0–3) • 0: no ulcers • 1: aphthous 0.1–0.5 cm • 2: large 0.5–2.0 cm • 3: >2 cm	2	1	0	2	0	5
Extent of ulcerative surface (0–3) • 0: not affected • 1: <10% • 2: 10%–30% • 3: >30%	2	1	0	2	0	5
Extent of affected surface (0–3) • 0: not affected • 1: <50% • 2: 50%–75% • 3: >75%	2	1	0	2	0	5
Presence and type of narrowing (0–3) • 0: none • 1: single, can be passed • 2: multiple, can be passed • 3: cannot be passed	1	0	0	0	0	1
					Total SES-CD =	16

To estimate the CDEIS from the SES-CD: CDEIS = 0.76 (SES-CD) + 0.29.

The SES-CD correlated with the CDEIS (Spearman's correlation coefficient r = 0.90), and the CDEIS can be estimated from the SES-CD: CDEIS = 0.76 (SES-CD) + 0.29. The SES-CD was weakly correlated with the CD activity index (CDAI, r = 0.39), IBD quality of life (r = −0.30), and C-reactive protein (CRP, r = 0.47).[21] Thus, the SES-CD likely adds information in addition to readily available clinical variables but offers simpler endoscopic assessment than the CDEIS.

Unlike the CDEIS, patients with prior surgical resections were included in both the SES-CD development and validation cohorts.[21] However, assessment at the anastomotic site was purposely ignored. Thus, neither the SES-CD nor CDEIS is appropriate for assessing disease at anastomotic sites.

In order to calculate interobserver agreement, select endoscopies (~50% of the discovery set and 30% of the validation set) had a second investigator simultaneously observing the ileocolonoscopy. Interobserver agreement was high to perfect for the individual SES-CD lesions (kappa coefficient 0.8–1.0) and the total SES-CD score (ICC 0.98).[21] However, the paired investigators may have been influenced by each other and knowledge of the patients' histories. The case-mix was overrepresented by disease that was in remission or was mild, thus making it more likely to result in good interobserver agreement. Selection bias and limited challenge bias may have also had a role since a minority of endoscopies had a second investigator.

Rutgeerts Score and the Modified Rutgeerts Score

The Rutgeerts score (RS) was developed to assess for the recurrence of CD in patients with ileocolonic resection and anastomosis.[22] The RS is a 5 point score

(i0–i4), as shown in **Table 3**. Advanced RS (i3 and i4) is associated with clinical recurrence and the need for further surgery.[22]

There has been debate over the implications of ulcers at the ileocolonic anastomosis, considering that gastric anastomotic ulcers are well described and thought to be secondary to postsurgical ischemia. Thus, if postsurgical ischemia contributes to anastomotic ulcers, the accuracy and predictive value of the RS will be reduced. The Modified RS was subsequently derived, further delineating i2 lesions (**Table 3**): i2a, lesions confined to the anastomosis with or without ≤5 aphthous ulcers in the ileum and i2b, greater than 5 aphthous ulcers in the ileum with normal mucosa in between, with, or without anastomotic lesions.[23] This is an important distinction, as compared to i2a, patients with i2b lesions are more likely to progress to i3 or i4 and are more likely to require subsequent surgery.[24] Furthermore, retrospective analysis suggests that if patients with i2b lesions receive medical treatment initiation or escalation, the risk of clinical relapse, stricture dilation, or surgical intervention is equal to that of those with i2a lesions.[25] Nonetheless, despite the relatively favorable prognosis of i2a lesions, it is not well explained why those with ileocolonic resection and anastomosis for other indications (eg, colon cancer) have a relatively lower prevalence of anastomotic ulcers than those with CD i2a lesions.[26] Thus, i2a lesions cannot solely be attributed to ischemia and likely do represent a component of active CD.

CAPSULE ENDOSCOPY TO ASSESS SMALL BOWEL CROHN'S DISEASE

Video CE enables clinicians to noninvasively view the entire small bowel, with generally improved lesion detection over push enteroscopy, small bowel barium radiography, and computerized tomography enterography (or enteroclysis).[27–30] However, CE is contraindicated in patients with suspected or known stenosis (or at least in those without a successful patency capsule study). Also of note, CE cannot definitively distinguish other causes of enteropathy (nonsteroidal anti-inflammatory drugs [NSAIDs], tuberculosis) from CD, and the small bowel scoring schemas described later have only been validated in those with a preceding diagnosis of CD. Therefore, CE does have its limitations.

Lewis Score

To use the Lewis score (LS), the small bowel is divided into tertiles based on transit time (a method previously derived from the assessment of NSAID-induced enteropathy[31]),

Table 3
Rutgeerts score and modified Rutgeerts score

Score	Endoscopic Description	Modified Rutgeerts (i2 Modifier)
i0	No lesion in the neoterminal ileum	
i1	≤5 ulcers in the neoterminal ileum	
i2	>5 aphthous ulcers with normal intervening mucosa, skip areas of larger lesions, or lesions confined to the ileocolonic anastomosis	i2a: Isolated anastomotic ulcers and/or ≤5 isolated aphthous ulcers in the ileum i2b: >5 ulcers in the neoterminal ileum with normal intervening mucosa, with or without anastomotic lesions
i3	Diffused aphthous ileitis and diffusely inflamed neoterminal ileum	
i4	Diffuse inflammation with large ulcers, nodules, and/or narrowing in the neoterminal ileum	

and each tertile is assessed for empirically derived descriptors of villous edema and ulcers.[32] Additionally, the presence of stenosis is assessed, independent of the tertiles. The LS is the sum of the worst-affected tertile plus the stenosis score (**Table 4**, **Fig. 2**). The actual score values assigned for each parameter were derived using a computational optimization program and empirical assignment.[32] Four CE readers were trained on 10 studies with lesions thumbnail to ensure agreement. Subsequent reading of 34 CE studies resulted in an interobserver agreement (kappa coefficient) of 0.48 for villous appearance, 0.66 for ulcer assessment, and 0.58 for stenosis.[32] As **Table 4** indicates, calculation of the LS is complex, but some CE software can calculate the LS for the reader.

The LS was validated in a follow-up retrospective study in patients with known CD without recent exposure to NSAIDs.[33] Patients with a history of stricturing or penetrating disease were excluded. Interobserver agreement was high for the global LS between one of 3 CE readers and a single central reader (ICC 0.79–0.97).[33] However, the study population was overrepresented with normal mucosa or only mild changes. While it should be standard-of-care to exclude patients with stricturing disease from CE (or at least not without a patency capsule first), such exclusions invalidate CE to assess the full spectrum of stenotic phenotypes.

Capsule Endoscopy Crohn's Disease Activity Index

The capsule endoscopy CD activity index (CECDAI) is another validated CE scoring schema for small bowel CD.[34] The CECDAI is simpler to use and calculate compared to the LS. In the CECDAI, 3 empirically chosen lesions (inflammation, disease extent, and narrowing) are graded in each of 2 bowel segments (proximal and distal), as determined by small bowel transit time of the capsule (**Table 5**).[34] Calculation of the total CECDAI is shown in **Table 5**.

Interobserver agreement (kappa coefficient) for the total CECDAI in the original study was 0.87 and was 0.66 in a follow-up multicenter, prospective validation study.[34,35] However, the 3 individual lesions had lower kappa coefficients (range

Table 4
Lewis score for video capsule endoscopy assessment of small bowel Crohn's disease

Parameter	Number	Longitudinal Extent[a]	Descriptor
Villous appearance (worst-affected tertile)	Normal: 0 Edematous: 1	Short segment: 8 Long segment: 12 Whole tertile: 20	Single: 1 Patchy: 14 Diffuse: 17
Ulcer (worst-affected tertile)	None: 0[b] Single: 3[b] Few: 5[b] Multiple: 10[b]	Short segment: 5 Long segment: 10 Whole tertile: 15	<¼: 9[c] ¼–½: 12[c] >½: 18[c]
Stenosis (whole study)	None: 0 Single: 14 Multiple: 20	Ulcerated: 24 Nonulcerated: 2	Traversed: 7 Not traversed: 10

Lewis score = score of worst-affected tertile [(villous parameter × extent × descriptor) + (ulcer number × extent × size)] + stenosis.

If the cecum is not reached, the small bowel transit time is calculated on the last imaged obtained.

[a] Longitudinal extent: short segment less than 10% of tertile, long segment 11% to 50% of tertile, whole tertile greater than 50% of tertile.

[b] Ulcer number: single = 1, few = 2 to 7, multiple ≥8.

[c] Ulcer descriptor (size): proportion of capsule picture filled by the largest ulcer.

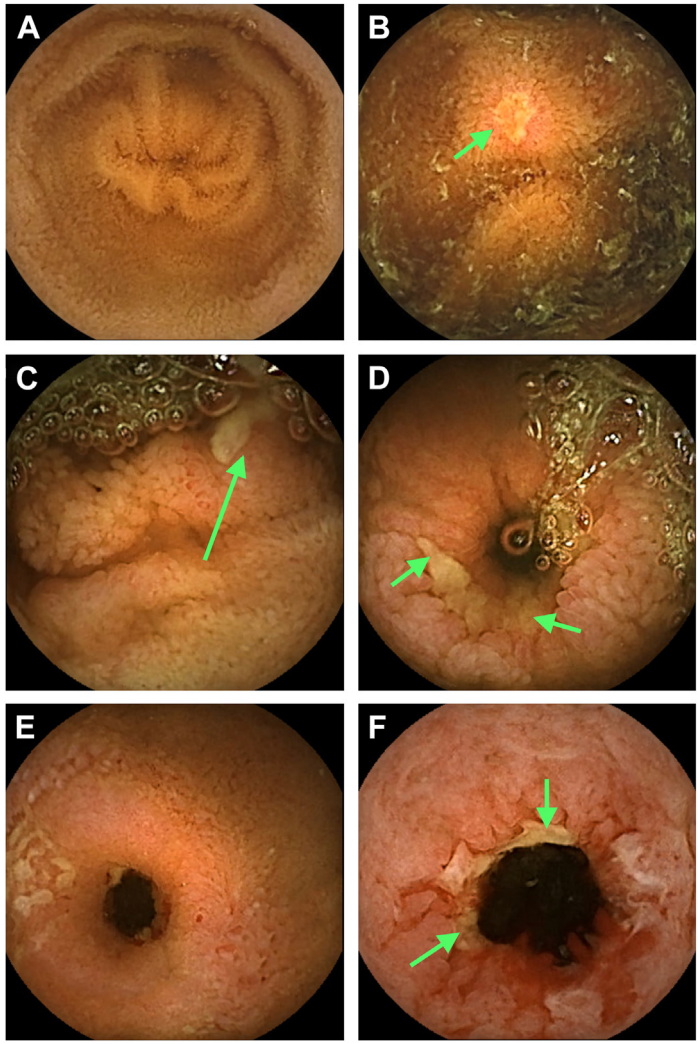

Fig. 2. Example video capsule endoscopy images demonstrating features assessed by the Lewis score. (*A*) Image of normal small bowel, (*B*) aphthous ulcer (*arrow*), (*C*, *D*) short segments of villous edema and small ulcers (*arrows*), (*E*) nonulcerated stenosis, and (*F*) ulcerated (*arrows*) stenosis that was traversed by the capsule.

0.25–0.57).[34] This indicates that there is inflated agreement in the total score, since CE readers got to the final score through different subscoring.

ENDOSCOPIC SCORING IN ULCERATIVE COLITIS

The first endoscopic scores in UC assessed focal disease activity but did not account for disease extent. Truelove and Witts published the first description of endoscopic features of UC in 1955, their score consisted of 5 descriptive endoscopic features—normal, near normal, improved, unchanged, or worse—that were used to assess response to treatment.[36] The Baron score,[37] Powell-Tuck sigmoidoscopic score,[38]

Table 5
Capsule endoscopy Crohn's disease activity index

Parameter (Lesion)	Score	Descriptor
(A) Inflammation score	0	None
	1	Mild-to-moderate edema/hyperemia/denudation
	2	Severe edema/hyperemia/denudation
	3	Bleeding, exudate, aphthae, erosion, small ulcer <0.5 cm
	4	Moderate ulcer 0.5–2.0 cm, pseudopolyp
	5	Large ulcer >2.0 cm
(B) Extent of disease score	0	No disease, normal
	1	Focal disease (single segment is involved)
	2	Patchy disease (2–3 segments are involved)
	3	Diffuse disease (>3 segments are involved)
(C) Narrowing (stricture)	0	None
	1	Single (passed)
	2	Multiple (passed)
	3	Obstruction (nonpassage)

Total score = ([A1 × B1] + C1) + ([A2 × B2] + C2).
A1, B1, C1 = scores for proximal segment; A2, B2, C2 = scores for distal segment.
If the cecum is not reached, the small bowel transit time is calculated on the last imaged obtained.

and Sutherland endoscopic subscore[39] are largely based on the degree of mucosal friability and bleeding. The modified Baron score and Rachmilewitz endoscopic index include friability, bleeding, vascular pattern, granularity, hyperemia, and ulcerations.[40,41] The Mayo endoscopic subscore (MES),[42] described in more detail below, was developed in 1987 and due to its simplicity has been one of the most frequently used endoscopic activity scores in clinical trials. None of the aforementioned endoscopic scores have been validated.

Mayo Endoscopic Subscore

The MES is part of a composite scoring system, the Mayo score, also known as the 16 point disease activity index, that consists of four, 4 point subscores: stool frequency, rectal bleeding, physician global assessment, and the MES. The 4 points within the MES correspond to normal, mild, moderate, and severe (**Table 6**, **Fig. 3**A–D). Each point is based on the presence or absence of a combination of 6, subjective observations, including friability, erosions, vascular patter, erythema, ulceration, and spontaneous bleeding. The MES was developed for use in the ASACOL trial,[42] and the MES was based on flexible proctosigmoidoscopy, not a complete colonoscopy. Owing to its relative simplicity, it has been used in numerous clinical trials and is the most commonly used endoscopic scoring system in clinical practice.[43–49]

An MES of 1 (mild disease) is often considered an endpoint for endoscopic remission in large clinical trials,[43–48] yet data suggest that an MES 1 is associated with a higher risk of disease relapse than an MES of 0.[50,51] This causes ambiguity in what is to be considered endoscopic remission using the MES.

The MES has a reported interobserver agreement (kappa coefficient) of 0.5 in the literature,[52–55] which equates to fair agreement. However, agreement is inflated from a retrospective study design and selection bias, where a limited number of videos and images are picked from a database, thus potentially missing the full spectrum of disease and avoiding ambiguous phenotypes that are seen in real clinical practice. The MES also lacks granularity: it is not clear whether a particular MES score needs

Table 6
Mayo endoscopic subscores for ulcerative colitis

Score	Description
Mayo endoscopic subscore (MES)	
0	Normal or inactive disease
1	Mild disease: erythema, decreased vascular pattern, mild friability
2	Moderate disease: marked erythema, absent vascular pattern, friability, erosions
3	Severe disease: spontaneous bleeding, ulceration

Colonic segment	Evaluated (0 or 1)[a]	Inflamed (0 or 1)[b]	MES[c]
Modified MES (MMES)			
Rectum	1	1	2
Sigmoid	1	1	3
Descending colon	1	1	2
Transverse colon	1	1	1
Ascending colon	1	0	0
Total	5	4	8
Maximal extent (dm)[d] = 6			
Extended modified score (EMS) = maximal extent × MES = 8 × 6 = 48			
Modified Mayo endoscopic subscore (MMES) = EMS ÷ Segments (N) with MES >0 = 48 ÷ 4 = 12			

[a] Evaluated, 1 if segment was either partially or completely evaluated.
[b] Inflamed, 1 if the MES for this segment was greater than 0.
[c] MES, as per the original score, evaluated for the endoscopically most severely inflamed part.
[d] Maximal extent, measured in decimeters during withdrawal.

to have all descriptive criteria present or any of the listed criteria (see **Table 6**), and the MES does not provide direction on how to assess disease extent or how to handle colonic segments with different MES scores.

Modified Mayo Endoscopic Subscore

The modified MES (MMES) assesses the same lesions as the MES but each segment of the colon separately (see **Table 6**).[56] Thus, the MMES considers disease extent, a feature not in the original MES. The MMES correlates with other assays of the inflammatory burden (eg, CRP, fecal calprotectin, and the Geboes score). However, the MMES has not been routinely used in large clinical trials, where the MES is still standard assessment, and other than disease extent the MMES is prone to the same weakness as the MES.

Ulcerative Colitis Endoscopic Index of Severity

The UC endoscopic index of severity (UCEIS) was the first validated endoscopic score to be applied to patients with UC.[57,58] It assesses 3 lesions, vascular pattern (3 points), bleeding (4 points), and erosions and ulcers (4 points; **Table 7**), thus making it relatively simple to implement. Additionally, since the UCEIS contains a greater range of scores than the MES, changes in endoscopic disease activity can be detected earlier than changes in MES following treatment,[59] implying that treatment effects or flare can be detected sooner.

Since water immersion or water exchange has become standard colonoscopic techniques, some of the UCEIS scores have likely been rendered obsolete. For example,

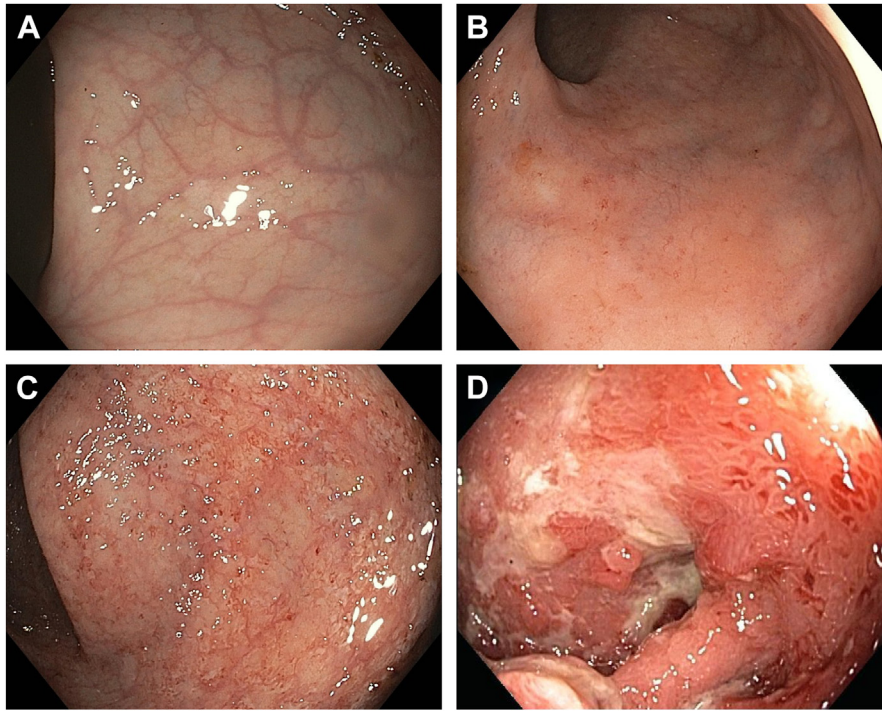

Fig. 3. Example colonoscopy images demonstrating grades of the Mayo endoscopic subscore (MES). (*A*) MES = 0, normal-appearing mucosa in a patient with UC in endoscopic remission, note lack of erythema and erosions with a well-defined vascular patter. **(*B*)** MES = 1, mild disease, erythema with a decreased vascular pattern. (*C*) MES = 2, moderate disease, erythema with erosions. (*D*) MES = 3, severe disease, spontaneous bleeding with ulcerations.

bleeding subscore 2 requires coagulated blood on the mucosa surface that can be washed away (see **Table 7**)—a feature that may be missed when ample water is used over air or carbon dioxide insufflation.

While the UCEIS has been validated, it was derived using select database videos from flexible sigmoidoscopies. Furthermore, video segments demonstrating contact friability were removed from the validation process, since this endoscopic feature caused confusion among endoscopists—it had the lowest intraobserver and interobserver agreement (kappa coefficient 0.33 and 0.23, respectively) of all features assessed.[57] The validation study boasted fair interobserver agreement (kappa coefficient ~0.5) on the overall UCEIS as well as on the individual 3 endoscopic lesions.[58] However, it must be noted that this degree of agreement was achieved following rigorous training, and endoscopists who did not pass the training were disqualified from partaking in the study. Thus, the UCEIS may not be validated for the full spectrum of disease seen in clinical practice since its derivation was exposed to significant selection bias.

Ulcerative Colitis Colonoscopic Index of Severity

The UC colonoscopic index of severity (UCCIS) assesses 4 lesions, vascular pattern, granularity, ulceration, and bleeding and friability distributed over 14 points (**Table 8**) that were deemed to have the best interobserver agreement (Lin's concordance correlation coefficient 0.31–0.81) from a total of 10 candidate endoscopic lesions.[60] Advantages

Table 7
Ulcerative colitis endoscopic index of severity

Descriptor[a]	Likert Scale	Definition
Vascular pattern	Normal (1)	Normal vascular pattern with arborization of capillaries clearly defined or with blurring or patchy loss of capillary margins.
	Patchy obliteration (2)	Patchy obliteration of vascular pattern.
	Obliterated (3)	Complete obliteration of vascular pattern.
Bleeding	None (1)	No visible blood.
	Mucosal (2)	Some spots or streaks of coagulated blood on the surface of the mucosa ahead of the scope, which can be easily washed away.
	Luminal mild (3)	Some free liquid blood in the lumen.
	Luminal moderate or severe (4)	Frank blood in the lumen ahead of the endoscope or visible oozing from mucosa after washing intraluminal blood or visible oozing from hemorrhagic mucosa.
Erosions and ulcers	None (1)	Normal mucosa, no visible erosions or ulcers.
	Erosions (2)	Tiny ($\leq$5 mm) defects in the mucosa of a white or yellow color with a flat edge.
	Superficial ulcer (3)	Larger (>5 mm) defects in the mucosa, which are discrete fibrin-covered ulcers in comparison with erosions, but remain superficial.
	Deep ulcer (4)	Deeper excavated defects in the mucosa, with a slightly raised edge.

[a] Score most severe lesions.

of the UCCIS is that it was derived on assessment of the entire colon (rather than just the proctosigmoid colon) using a prospective cohort, and it has been validated.[60,61]

However, assessment of UCCIS lesions was carried out on select, shortened video clips from colonoscopies of prospectively enrolled patients. Thus, UCCIS scores and interobserver agreement are founded on the most optimal video clips chosen by a single study investigator. Suboptimal bowel preparations were excluded. Assessors of

Table 8
Ulcerative colitis colonoscopic index of severity

Lesion	Score	Definition
Vascular patter	0	Normal, clear vascular pattern
	1	Partially visible vascular pattern
	2	Complete loss of vascular pattern
Granularity	0	Normal, smooth, and glistening
	1	Fine
	2	Course
Ulceration	0	Normal, no erosion or ulcer
	1	Erosions or pinpoint ulcerations
	2	Numerous shallow ulcers with mucopus
	3	Deep, excavated ulcerations
	4	Diffusely ulcerated with >30% involvement
Bleeding/friability	0	Normal, no bleeding, no friability
	1	Friable, bleeding to light touch
	2	Spontaneous bleeding

the video clips were almost identical across both the discovery and validation studies; thus, recency of training and familiarity of the UCCIS will increase agreement. While the UCCIS was derived from assessment of the entire colon, application of the score cannot provide information on the extent of disease (see **Table 8**).

ENDOSCOPIC SCORING OF THE ILEAL POUCH

Proctocolectomy with ileal pouch–anal anastomosis (IPAA) is often the preferred surgical choice for patients with refractory UC and UC-associated neoplasia. Inflammatory and structural conditions of the pouch are common, with subsequent pouch excision or diversion in up to 10% of cases.[62,63] Pouchitis is the most common complication, with an estimated 20% to 40% incidence within 1 year of an IPAA[64] and 80% 30 year cumulative probability.[65] The differential diagnoses of pouchitis are broad and are poorly understood. These include microbial-associated (chronic antibiotic-dependent, chronic antibiotic-refractory, or infectious), inflammatory-associated (Crohn's-like disease, PSC-associated), and others (idiopathic, cuffitis, or ischemic). This makes endoscopic assessment difficult, from both a diagnostic perspective and in the staging of disease activity.

Pouchitis Disease Activity Index

The pouchitis disease activity index (PDAI) is a 22 point composite score containing clinical, endoscopic, and histology subscores.[66] The lesions assessed on endoscopy include edema, granularity, friability, loss of vascular patter, mucous exudate, and ulcers (**Table 9**). The PDAI correctly identified pouchitis in a small prospective cohort of patients with an IPAA in the setting of UC.[66] In a phase 4 double-blind, randomized trial in patients with recurrent or refractory pouchitis with a history of UC, treatment with vedolizumab resulted in significant improvement in the modified PDAI (histology subscore was excluded in this study).[67] Like several of the aforementioned scores, the PDAI does not account for disease extent and is not useful in differentiating the cause of pouchitis or directing treatment. The PDAI, or variations of the PDAI, is the most commonly used scoring assessments for pouchitis.[49] Others exist, but they are similar in their design and lesions assessed.[68] The PDAI has also been adapted for use in the assessment of cuffitis.[69]

DIVERSION-ASSOCIATED BOWEL DISEASE

Jejunostomy, ileostomy, or colostomy with fecal diversion is a temporary or permanent measure for the treatment of disease in a distal segment of bowel (eg, for management of perianal CD, following total colectomy for medically refractory UC or as

Table 9
Pouchitis disease activity index, endoscopic criteria

Criteria	Score
Edema	1
Granularity	1
Friability	1
Loss of vascular pattern	1
Mucous exudate	1
Ulceration	1

Diagnosis of pouchitis defined as $\geq$7 points, but includes clinical and histologic criteria.[66]

palliative measure for an obstructing lesion). Diversion-associated bowel disease is a mucosal inflammatory phenomenon of the diverted rectum (Hartmann's pouch), colon, or ileal pouch, experienced by upward of 70% to 90% of patients, but seems to be more prevalent in those with underlying IBD.[70] There are no endoscopic scoring systems designed to assess inflammation in this condition or to help differentiate IBD from diversion-associated bowel disease.

DISCUSSION

There are several scoring schemas available for use in CD and UC. These enable clinicians to communicate objectively with patients and other clinicians, and they are required for assessing outcomes in large clinical trials. Despite this, no single system has been universally adapted into clinical practice and research. The MES and RS are more commonly used since they are easy to implement. However, they do not permit comprehensive, fully validated, assessment of the entire bowel and force patients into ordinal scores, missing the full spectrum of disease. Complex scoring schemas that allow for more extensive disease assessment, such as the SES-CD and UCCIS, require substantial training, experience, and time.

Comprehensive assessment of the small bowel remains a problem in CD. The LS and CECDAI that are derived using CE have not gained widespread use in clinical practice or clinical trials. Furthermore, the LS and CECDAI have limited utility in assessing advanced fibrostenotic or fistulizing disease due to safety concerns. Scores that assume transit through different thirds of the small bowel are equivalent are based on a flawed premise, where even a mild narrowing may slow transit in the segment proximal to it. CE is not able to differentiate CD from other causes of enteropathy with certainty (eg, NSAIDs or tuberculosis).

All endoscopic scoring schemas have been derived to assess disease activity and they are not suitable for resolving cases of diagnostic ambiguity: IBD versus other causes of inflammation and differentiation of CD versus UC versus IBDU. Diagnostic terms that include "unclassified," "unknown," "indeterminate," or "borderline" are ambiguous; they represent poorly understood phenotypes or disease states and are labels that must be resolved.

Diagnostic platforms are judged on precision and accuracy. Precision is the reproducibility of the assessment, while accuracy is the degree to which the assessment reflects the true disease state. Endoscopic assessment relies on pattern recognition, based on experience taught from generation to generation. However, this is imprecise since endoscopist opinions and experience differ.[55] This contributes to reduced reproducibility—variation between observers assessing the mucosa. Variation is not the fault of the expert, but rather an inherent feature. Referral to an experienced gastroenterologist for ambiguous or dubious cases (eg, central reads) is not evidence-based, rather it is eminence-based. This practice eliminates interobserver variation and may improve adherence to an endoscopic scoring schema but does not improve accuracy.

Accuracy will be impaired from selection bias and limited challenge bias. Selection bias results from retrospectively "cherry-picking" endoscopic videos or images from a database. In its extreme, this leads to limited challenge bias, where the most severe phenotype is compared to normal or healthy tissue. Derivation of an endoscopic score on limited phenotypes—limiting assessment to the proctosigmoid colon and exclusion of poor-quality videos, poor bowel preparation, postsurgical anatomy, advanced disease (eg, fibrostenotic, fistulizing), and ambiguous phenotypes (eg, IBDU)—misses the full spectrum of disease in a given population. Ignoring lesions that cause confusion among endoscopists, such as contact friability, will reduce interobserver variation

but also contributes to bias and possibly negates a poorly understood phenotype—*the baby is thrown out with the bathwater*.

In their current state, we do not believe confocal laser endomicroscopy, endocytoscopy, or histology will improve mucosal assessment of disease activity or resolve dubious diagnoses. The routine use of histology scoring schema is not standard across many centers and they are subject to the same pitfalls as endoscopy. International variation in assessment of histology lesions has been well documented, is underrecognized, and difficult to improve.[71,72] Histology scores have fair interobserver agreement at best,[73–75] and evidence suggests that agreement for individual histology lesions is worse.[72] This implies that agreement on the total score (MES, SES-CD, Geboes, Nancy, and so forth) is driven somewhat by chance, since how endoscopists or pathologists arrived at the same final answer may be different and therefore incorrect.

The use of artificial intelligence (AI; eg, machine learning, deep learning) in IBD has recently been reviewed in detail.[76] There have been many retrospective studies looking at AI for the diagnosis of IBD or assessment of endoscopic disease activity. However, there are lack of prospective, multicenter trials.[76] Endoscopic scoring schema will not be improved by AI if the algorithms incorporate the aforementioned flaws: all phenotypes and disease states (eg, IBDU, infectious colitis, poor bowel preparation) need to be included. Therefore, agreement between AI and the flawed conventional diagnostic systems (eg, MES or histology) is neither expected nor desirable, since AI-based assessment should be an improvement over the current gold standard, not a replica of it.

Moving forward, diagnosis of IBD and assessment of disease activity are likely to incorporate a multidimensional approach: clinician opinion (endoscopy and histology) combined with high-throughput assays (eg, genetic, gene expression, microbiome assessment). Output from diagnostic platforms must be continuous (expressed as probabilities, derived from machine learning classifiers), not ordinal, and considers all phenotypes and confounders of the disease of interest.

CLINICS CARE POINTS

- Diagnosis of CD or UC is made on the basis of a combination of factors, but not on the basis of any endoscopic scoring system. Scoring systems are not validated for use outside of IBD or in ambiguous disease states (eg, IBDU).
- Endoscopic scoring systems in IBD should be used to objectively communicate information to patients and to other clinicians and to assess response to treatment.
- Each IBD endoscopic scoring system has its own advantages and pitfalls, and there is no single system that is more supported by the literature than another. Each clinician should use the one(s) they feel most comfortable using.
- Some endoscopy software will help calculate endoscopic scores. This can be particularly helpful in a busy clinical setting.
- New endoscopic technologies that use AI are likely to become available in the coming years. Clinicians should be aware of what they will offer over the current gold standard.

DISCLOSURE

Dr C. N. Bernstein has consulted to and served on advisory boards for Abbvie, Canada; Amgen, Canada; Bristol Myers Squibb, Canada; Eli Lilly, Canada; JAMP Pharmaceuticals; Janssen, Canada; Pendopharm, Canada; Pfizer Canada; Sandoz, Canada;

and Takeda and has received unrestricted educational grants from AbbVie, Canada; Boston Scientific; Bristol-Myers Squibb, Canada; Janssen, Canada; Organon, Canada; Pfizer, Canada; and Takeda, Canada. He has been on the speaker's bureau of Abbvie Canada, Janssen, Canada, Pfizer, Canada, and Takeda, Canada. He has received research grants from Abbvie, Canada, Amgen, Canada, Pfizer Canada, and Sandoz, Canada and contract grants from Janssen.

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