ECCO-ESGAR Topical Review on Optimizing Reporting for Cross-Sectional Imaging in IBD

Torsten Kucharzik[a*], Jeroen Tielbeek[b*], Dan Carter[c], Stuart A. Taylor[d], Damian Tolan[e], Rune Wilkens[f], Robert V Bryant[g], Christine Hoeffel[h], Isabelle De Kock[i], Christian Maaser[j], Giovanni Maconi[k], Kerri Novak[l], Søren R. Rafaelsen[m], Martina Scharitzer[n], Antonino Spinelli[o#], Jordi Rimola[p#]

[*] Both authors contributed equally to the work

[#] Both authors contributed equally to the work

[a] Department of Gastroenterology, Klinikum Lüneburg, University of Hamburg, Bögelstr. 1, 21339 Lüneburg, Germany

[b] Department of Radiology, Spaarne Gasthuis, Boerhaavelaan 22, Haarlem, the Netherlands; Department of Radiology and Nuclear Medicine, Amsterdam UMC, University of Amsterdam, Meibergdreef 9, Amsterdam, the Netherlands

[c] Department of Gastroenterology, Chaim Sheba Medical Center, Tel Hasomher, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

[d] Centre for Medical Imaging, University College London, London, UK

[e] Radiology Department, St James's University Hospital, Leeds Teaching Hospitals NHS Trust, Beckett Street, Leeds, UK

[f] Gastrounit, Division of Medicine, Hvidovre University Hospital, Copenhagen, Denmark. & Copenhagen Centre for Inflammatory Bowel Disease in Children, Adolescents and Adults, University of Copenhagen, Hvidovre Hospital, Copenhagen, Denmark.

[g] Department of Gastroenterology, The Queen Elizabeth Hospital, Adelaide, South Australia

[h] Department of Abdominal Radiology, CHU Reims and CRESTIC, URCA, 51100 Reims, France

[i] Department of Radiology, Ghent University Hospital, Ghent, Belgium

[j] Outpatient Department of Gastroenterology, Department of Geriatrics, Klinikum Lüneburg,

University of Hamburg, Bögelstr. 1, 21339 Lüneburg, Germany

[k] Gastroenterology Unit, “Luigi Sacco” University Hospital, Milan, Italy

[l] Department of Radiology and Medicine, Division of Gastroenterology, University of Calgary, Alberta, Canada.

[m] Department of Radiology, University Hospital of Southern Denmark, Vejle, Denmark

[n] Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Vienna, Austria

[o] Department of Biomedical Sciences, Humanitas University, Via Rita Levi Montalcini 4, 20090, Pieve Emanuele, Milan, Italy; IRCCS Humanitas Research Hospital-, via Manzoni 56, 20089 Rozzano, Milan, Italy, Division of Colon and Rectal Surgery

[p] IBD unit, Radiology Department, Hospital Clínic Barcelona, Barcelona, Catalonia-Spain.

Correspondence address: Torsten Kucharzik, Department of Gastroenterology, Klinikum Lüneburg, University of Hamburg, Bögelstr. 1, 21339 Lüneburg; e-mail: Torsten.Kucharzik@klinikum-lueneburg.de

Key Words: inflammatory bowel disease (IBD), cross-sectional imaging, magnetic resonance imaging (MRI), intestinal ultrasound (IUS), endoanal ultrasonography (EAUS), transperineal ultrasonography (PUS), reporting

Abstract

Background and Aims: Diagnosis and follow up of patients with inflammatory bowel disease [IBD] requires cross-sectional imaging modalities, such as intestinal ultrasound [IUS], magnetic resonance imaging [MRI], and computed tomography [CT]. The quality and homogeneity of medical reporting are crucial to ensure effective communication between specialists and to improve patient care. The current topical review addresses optimized reporting requirements for cross-sectional imaging in IBD.

Methods: An expert consensus panel consisting of gastroenterologists, radiologists, and surgeons convened by the ECCO in collaboration with ESGAR performed a systematic literature review covering the reporting aspects of MRI, CT, IUS, endoanal ultrasonography, and transperineal ultrasonography in IBD. Practice position statements were developed utilizing a Delphi methodology incorporating two consecutive rounds. Current practice positions were set when ≥80% of the participants agreed on a recommendation.

Results: Twenty-five practice positions were developed, establishing standard terminology for optimal reporting in cross-sectional imaging. Assessment of inflammation, complications, and imaging of perianal CD are outlined. The minimum requirements of a standardized report, including a list of essential reporting items, have been defined.

Conclusions: This topical review offers practice recommendations to optimize and homogenize reporting in cross-sectional imaging in IBD.

1. Introduction

An interdisciplinary, multi-professional approach involving gastroenterologists, radiologists, and surgeons is crucial to ensure the optimal management of patients with inflammatory bowel disease [IBD]. Cross-sectional imaging in IBD, including intestinal ultrasound [IUS], magnetic resonance imaging [MRI], and computed tomography [CT], have emerged as appropriate and effective imaging methods in IBD patients. Such methods are used for diagnosis, assessment of disease activity and severity, and to detect complications and monitor disease course.[1] Mural and extramural disease manifestations beyond the reach of the endoscope can be visualized and determined. In the recent European Crohn's and Colitis Organization [ECCO] and European Society of Gastroenterology and Abdominal Radiology [ESGAR] [ECCO-ESGAR] joint diagnostic guideline, the utility of cross-sectional imaging modalities, including the diagnostic management of perianal Crohn's disease [CD] and pouch complications, has been established.[2] In addition, different societies have previously suggested technical standards and definitions of parameters for cross-sectional imaging.[3-6] Currently, there is no consensus guidance on reporting findings of cross-sectional imaging that encompasses MRI, CT, IUS, endoanal ultrasonography [EAUS], and transperineal ultrasonography [PUS] in IBD.

The optimization and standardization of imaging reporting is currently an unmet need and would facilitate the comparison between different reports and communication between the different specialties involved in IBD. The current review identifies standardized parameters and suggests how to report and how to characterize CT, MRI, and IUS findings. The core elements of this review describe the imaging parameters of inflammation and intra- and extramural complications of IBD in a standardized manner. This review provides an overview of the current literature, suggests vital data for each reporting type, and proposes possible strategies to optimize and standardize reporting quality of cross-sectional imaging in IBD. The consensus agreement was made by a large interdisciplinary panel of experts to optimally address this important clinical need in daily practice. Similarities and differences in reporting between MRI/CT and IUS were identified and addressed.

The target audience of this review includes IBD specialists, gastroenterologists, radiologists, surgeons, and paediatricians.

2. Methods

Under the leadership of ECCO and ESGAR and the oversight of the ECCO Guideline Committee, an open call for a topical review on optimizing reporting for cross-sectional imaging was announced to

all ECCO and ESGAR members. Sixteen individuals were selected based on their expertise, accomplishments, and commitment. Working group leadership was balanced between ECCO and ESGAR representatives. The project was divided into four different working groups covering the following: 'assessment of inflammation', 'assessment of complications', 'MRI for the use of perianal CD and pouch', and 'IUS for the use of perianal CD'. The latter two were merged in the final manuscript into one section on 'assessment and reporting of perianal CD and pouch complications'. The working groups consisted of gastroenterologists [members of the International Bowel Ultrasound Group; IBUS], surgeons, and radiologists and were well balanced between ECCO and ESGAR members.

Each working group performed a systematic literature search of their topics using Medline/Pubmed and Embase and Cochrane database in addition to their own files [see supplementary file]. Based on the literature, each working group discussed the literature and drafted current practice positions and supporting text. Provisional practice position statements, including supporting text, were then posted on a guideline platform with subsequent online voting by all participants. The working group members then met over a final web-based video conference in March 2021 to discuss and vote on the updated statements and recommendations. A consensus was defined as agreement by ≥80% of participants, termed a current practice position. The workgroup leader and their working party wrote the final document on their topic. Statements should be read in context with supporting comments and tables and not in isolation. The final manuscript was critically reviewed by the guideline committee and governing board members not involved in the guideline panel. The final manuscript was edited for consistency of style before being circulated and approved by the consensus group participants.

The final manuscript is divided into the following three main sections: assessment of inflammation in IBD, assessment of complications, and assessment of perianal CD and pouch complications.

3. Current Practice Positions

3.1. General aspects

Current practice position 1

Reporting of findings should be structured to improve communication to clinicians, ensure inclusion of all important disease features, and improve report structure and reproducibility.

A minimum standard terminology should be provided for quality reporting on cross-sectional imaging to ensure quality and effective communication. The report should be electronic and describe technical aspects, including MRI and CT platforms, ultrasound [US] equipment, and probes utilized for the examination. General disease aspects include information about disease characteristics, including phenotype, clinical disease activity, symptoms, an indication of the procedure, and current treatment. For perianal CD examination, perianal inspection and digital anorectal examination should be provided. Other aspects that should be mentioned include fasting status, bowel preparation, and use of contrast medium [if applicable]. In IUS, the extent of examination [point-of-care examination vs complete assessment of the small and large bowel] should be described.

Current practice position 2

The examination quality should be reported together with any impact on diagnostic confidence.

A suboptimal scan and any impact on reader confidence should be reported. For a description of the main findings, validated scores for disease activity may be used. For MRI, partially validated scoring systems, such as the MaRIA Score, London score, Clermont Score, MEGS, and simplified MaRIA score are available to assess disease activity.[7-11] However, most scores are used in research studies to quantify change in disease activity but are optional in a standard report. For IUS, different activity scores have been suggested for CD and ulcerative colitis [UC].[12, 13] IUS scores are used in the research setting mainly and are not expected as part of routine clinical practice in general. While digital-imaging storage of MRI

or CT findings is standard, storage for IUS findings is less frequent and depends on the operator facilities. However, electronic IUS photo [and cine loop] storage and documentation of pathology is required to ensure quality and transparency. For IUS, all pathological segments should be documented in longitudinal and cross-sectional with cine-loop sweeps that include the whole pathology originating at non-pathological margins. Vascularization should also be documented with colour Doppler imaging cine loops.

Key quality indicators for a report in cross-sectional imaging [MRI/CT/IUS/EAUS/PUS] are listed in Table 1.

Table 1: Key quality indicators for a good report in cross-sectional imaging

Pre-procedure features

- Indication
- Disease characteristics [phenotype, current symptoms, current and former treatment, surgical history]
- Fasting period

Technical features

- Modality/Machine specification [MRE/CTE, IUS]
- Probes [IUS, PUS, EAUS]
- Device settings
- **Specific features for MRE/CTE**
    - Oral contrast volume ingested for MRI or CT enterography [minimum 500 ml]
    - Bowel distension [optimal/suboptimal/insufficient]
    - Antiperistalsis drugs administered, dose and route of administration
    - Scan coverage [in case of MRI/CT, this should include an abdominal and pelvic examination, including perianal area]
    - Missing segment(s) due to previous surgery
- **Specific features for IUS**
    - Use of i.v. contrast medium [type, volume]
    - Use of oral contrast [type, volume]

Intra-procedure features*

- Examination extent [point of care examination or complete bowel/abdominal scan]
- Technical limitations
    - Intestinal gas or faeces [MRE/CT, IUS]
    - Motion artefacts [MRE/CT]:
        - Peristaltic motility
        - Breathing
        - Foreign bodies [e.g., prosthesis]
    - Body status

    - Obesity [IUS]
    - Lack of fat space between bowels [MRI]
- Disease activity [optional activity scores][#]
- Complications of disease[#]
- Extraintestinal findings
- Examination quality/diagnostic confidence

Post-procedure features

- Conclusion [including treatment response, if any]
- Follow-up
- Imaging storage location

* See Table 4 for perianal CD

[#] See Table 2 for detailed disease activity and complications reporting

3.2. Assessment and reporting of inflammation

3.2.1. General aspects

Current practice position 3

The number and anatomical location of intestinal segments with imaging findings of mural inflammation should be reported, including skip lesions. An estimate of the total affected length and length of all individual pathological areas of the small bowel is preferred. Segment(s) exhibiting the most severe mural inflammation should be reported in detail to guide therapeutic decision making.

Disease extent, including all involved colonic segment(s) and an estimate of small-bowel length, is commonly reported [13-17]. There is no consensus on how to categorize disease length for ileal disease, and an approximate estimation in cm is thus recommended. Estimates of length lack a strong association with endoscopic disease activity and is a poor individual marker for disease activity/response in CD [13, 16]. However, most imaging [11, 13, 18-21] and endoscopic scores for CD are based on the sum of individual segmental activity scores; thus, length is a part of some validated, cumulative activity scores contributing to overall disease burden. Location of involved intestinal segments is also essential for disease classification (e.g., Montreal classification) to facilitate

consistent reassessment utilizing the same/or different imaging/endoscopic modalities to establish treatment response. Both MRE or CTE and IUS are equally accurate at detecting small bowel disease. In contrast, colonic disease is slightly less accurately identified by all three modalities,[22] and should be reported on a segmental basis only.

3.2.2. Parameters assessing inflammation – Bowel wall thickness

Current practice position 4

Thickness of the most involved small bowel and/or colonic segment, defined as bowel wall thickness (BWT), should be measured and reported. A threshold of 3 mm is the recommended cut-off for presence of mural inflammation for both small and large bowel.

BWT is the most consistent individual parameter reported when assessing intestinal inflammation in IBD[4, 12]. Normal BWT as observed on IUS is considered < 2 mm (excluding rectum and duodenum)[23]. BWT measurement on MRI enterography (MRE) or CT enterography (CTE) should ideally be measured in a distended bowel segment, on either T2 or contrast-enhanced T1 sequences. Non-distended bowel may lead to over-estimation of inflammation and should be avoided as representative sections. Different BWT cut-offs (2-7 mm) have been utilized as a threshold for disease presence to optimize disease detection[12, 22, 24-27]. The most common cut-off is 3 mm,[12] and expert consensus [4, 28, 29] now recommends 3 mm cut-off as a reasonable compromise between sensitivity and specificity for disease detection in both the small and large bowel, with increasing BWT reflecting increasing severity in most scores. In special situations, colonic BWT may differ, as BWT between 2-3 mm has shown to detect Mayo 1 changes in UC [30]. Up to 4 mm can be seen in the sigmoid colon with concomitant diverticulosis, and 4 mm is used as the sigmoid colon threshold by some [27]. BWT has been shown to exhibit high reliability with ICC up to ICC=0.96 (95%CI 0.94-9.98) for IUS [19] and ICC=0.87 (0.82-0.90) for MRE experts [31]. BWT measured with IUS and MRE is also reliable compared to histology [32]. Several scores include BWT measured continuously [19-21, 33] without categorization of activity levels, and is thus recommended. Definition of explicit BWT cut-off levels to differentiate activity into categories like mild, moderate, and severe lack consensus. Given the co-existence of acute inflammation and chronic changes in the bowel wall, BWT alone may not best

reflect disease activity. Thus additional activity parameters should be considered[32]. Other imaging parameters are needed to grade disease activity accurately (see also Table 2).

3.2.3. Parameters assessing inflammation – Mural changes

Current practice position 5

Given the contribution to assessing transmural inflammatory activity, detailed mural changes should be reported and include ulceration(s) and oedema, shown on IUS as disruption of bowel wall stratification and increased intramural T2 signal on MRE. Restricted diffusion (MRE) is supportive but a nonspecific sign of active inflammation.

In addition to BWT, other cross-section imaging features of the bowel wall, like oedema and intramural ulcers, have shown an association with disease activity and should be reported when present. Ulcers seen on IUS are described as transverse linear, focal hypoechoic regions crossing wall layers (focal loss of bowel wall stratification [BWS] and ulcer presence is associated with more severe inflammation (Figure 1) [32, 34, 35]. However, this has not been shown consistently [17]. Mural oedema may cause unequivocal disruption of BWS, but confirmatory studies correlating with histopathology are needed. Reliability for BWS is moderate [19, 36]. Loss of haustration is strongly associated with active endoscopic disease in UC with fair to substantial reliability[30]. Increased hyperintensity on T2-weighted MR images (usually reported as mural oedema) and ulcerations (seen as small focal disruptions in the intraluminal surface of the distended bowel) are associated with severe inflammation highly predictive of endoscopic ulcerations (Figure 2) [11, 33, 37-39]. Restricted diffusion should be interpreted as absent or present when mural hyperintensity is present on high b-value images. The interpretation of DWI in conjunction with ADC maps will reduce the over-estimation of restricted diffusion due to the T2-shine-through effect [40]. Given the high rate of false-positive lesions[41], restricted DWI should be considered as a supportive feature on MRI when other unequivocal findings of mural inflammation are present.

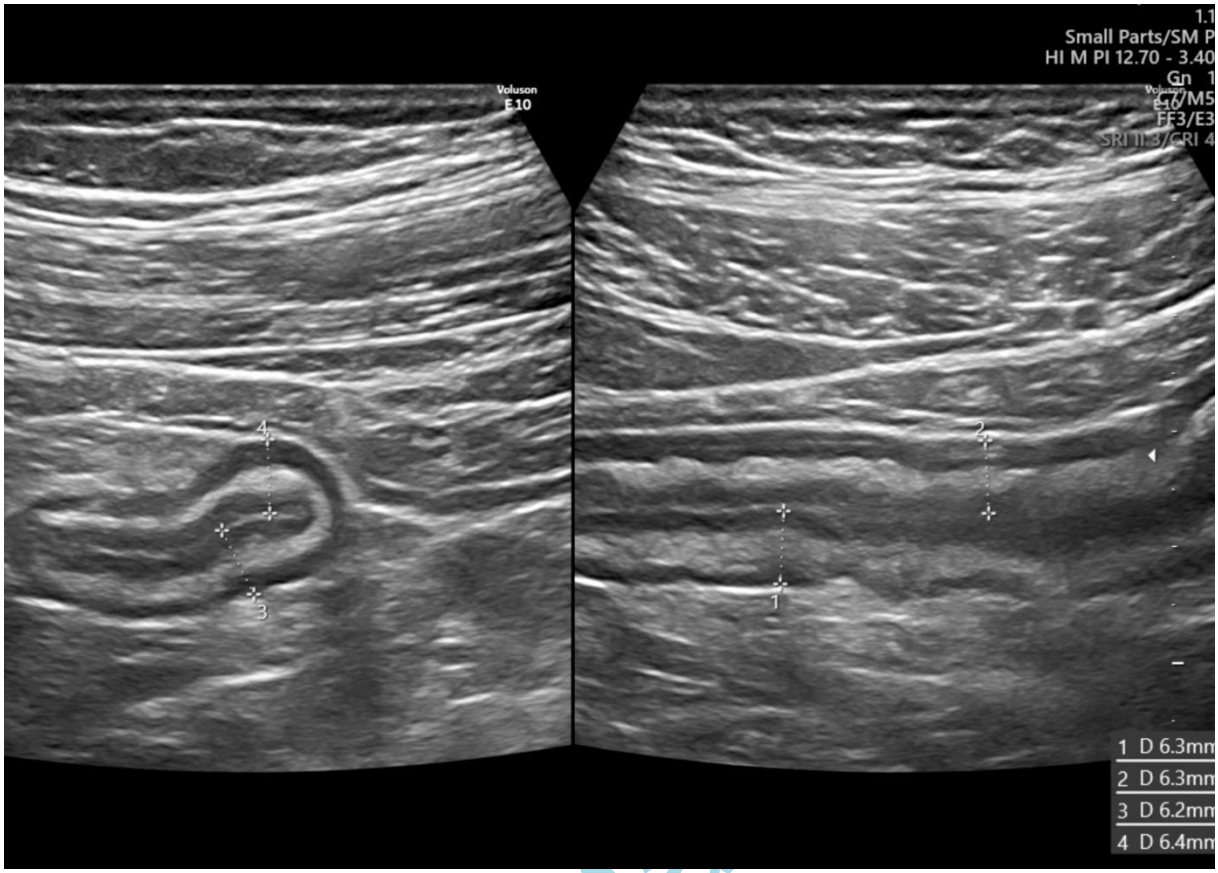

Figure 1A – see figure legend at the end of the manuscript

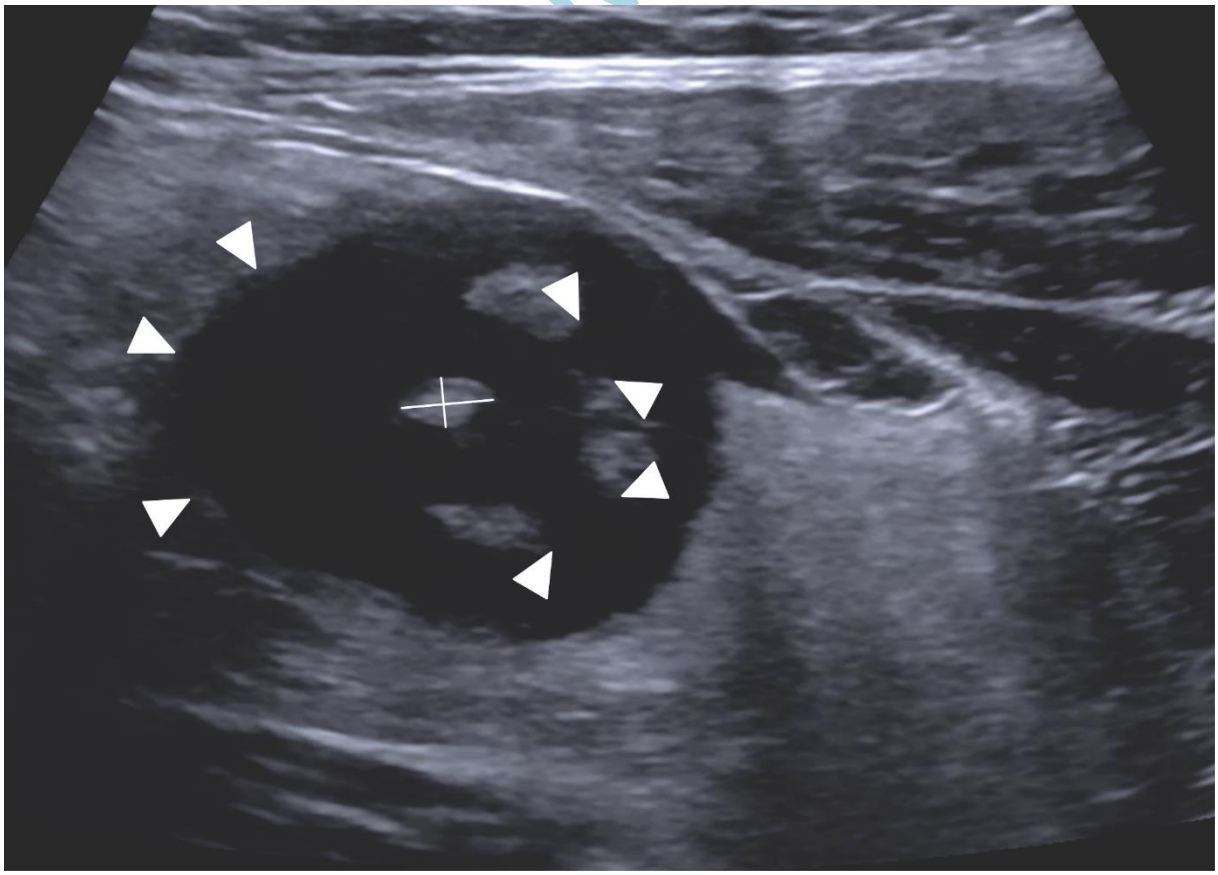

Figure 1B – see figure legend at the end of the manuscript

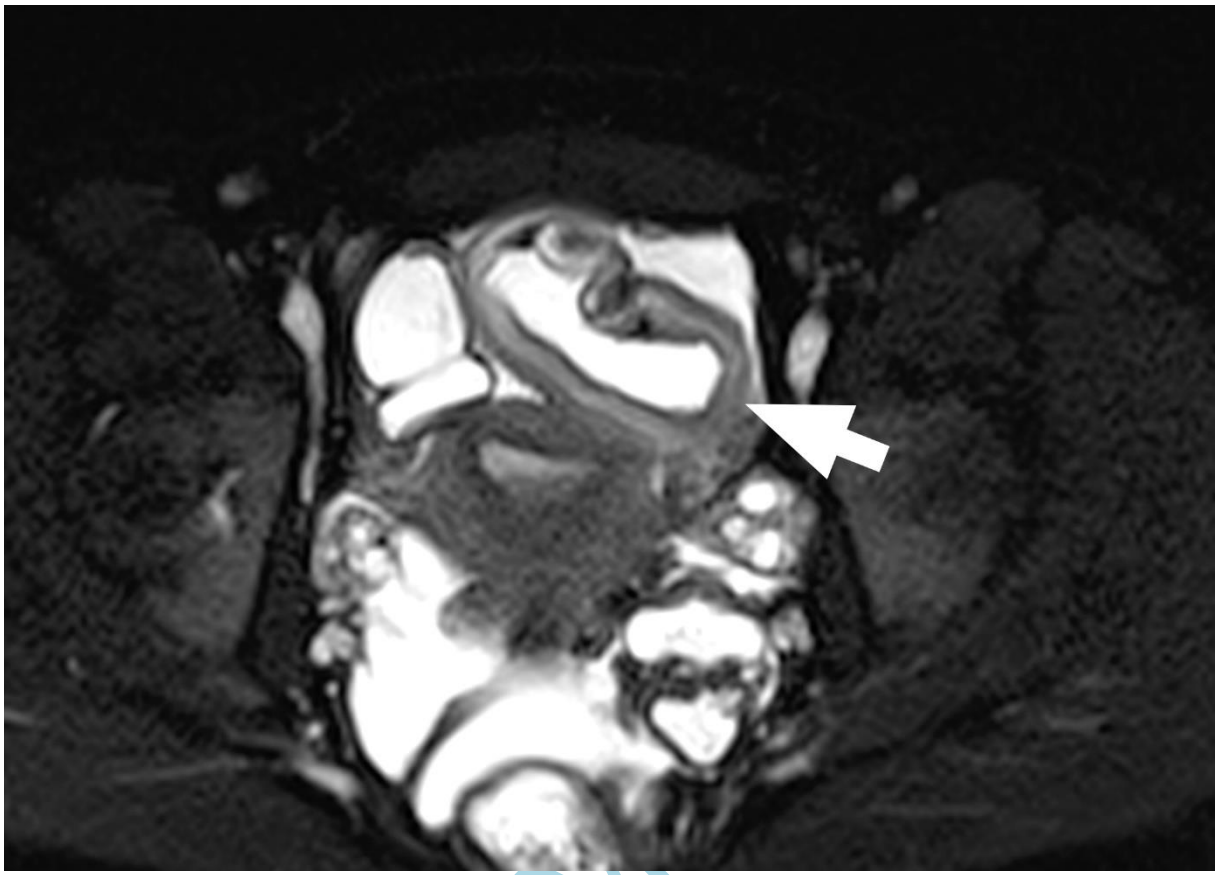

Figure 2A – see figure legend at the end of the manuscript

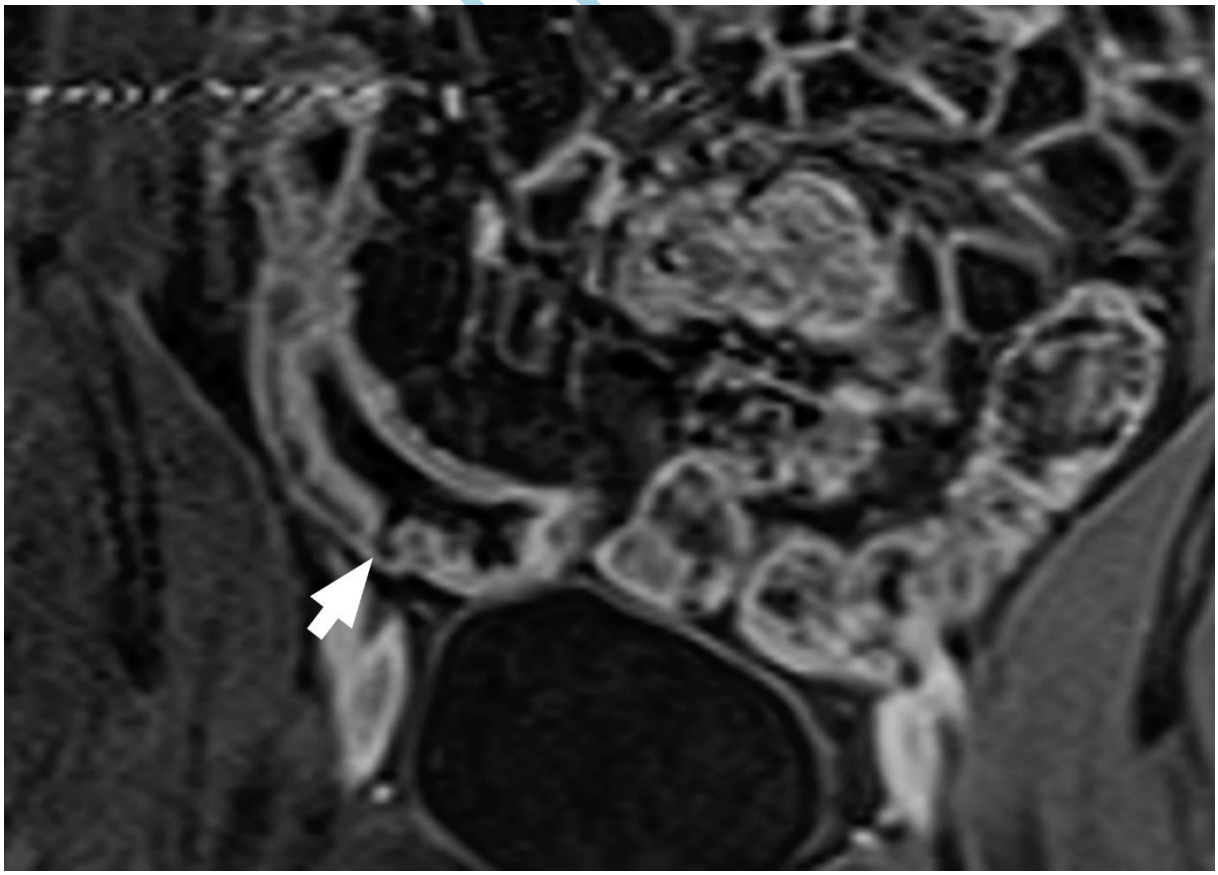

Figure 2B – see figure legend at the end of the manuscript

3.2.4. Parameters assessing inflammation – Vascularisation

Current practice position 6

Intestinal vascularization should be assessed by a semi-quantitative grading of intra- and extramural blood flow in abnormal bowel segments (colour Doppler on IUS). For MRE/CT, a qualitative impression of increased contrast hyperenhancement should be reported.

Intestinal hyperaemia is an important reportable finding, as neo-angiogenesis occurs with progressive inflammation, and thus is a known significant contributor to activity [Figure 3].[12, 42, 43] Varying scores used to semi-quantitatively grade signals seen with low-flow setting [4–7 m/s] on colour Doppler correlate with either histologic or endoscopic disease activity.[44-47] The site of greatest BWT is assessed to determine the presence of short- and long-segment signals that can extend into the mesentery.[15, 19, 28] Moderate-to-excellent reliability has been demonstrated [κ=0.60–0.93].[13, 19, 48] However, little consensus exists regarding which semi-quantitative scoring system is preferred, but intra- and extramural blood-flow grading should be reported when present. The comb sign,[49] defined as engorgement of perienteric vasculature [regional dilation of the vasa recta][50] or mesenteric comb sign, can be supportive and its reporting optional.

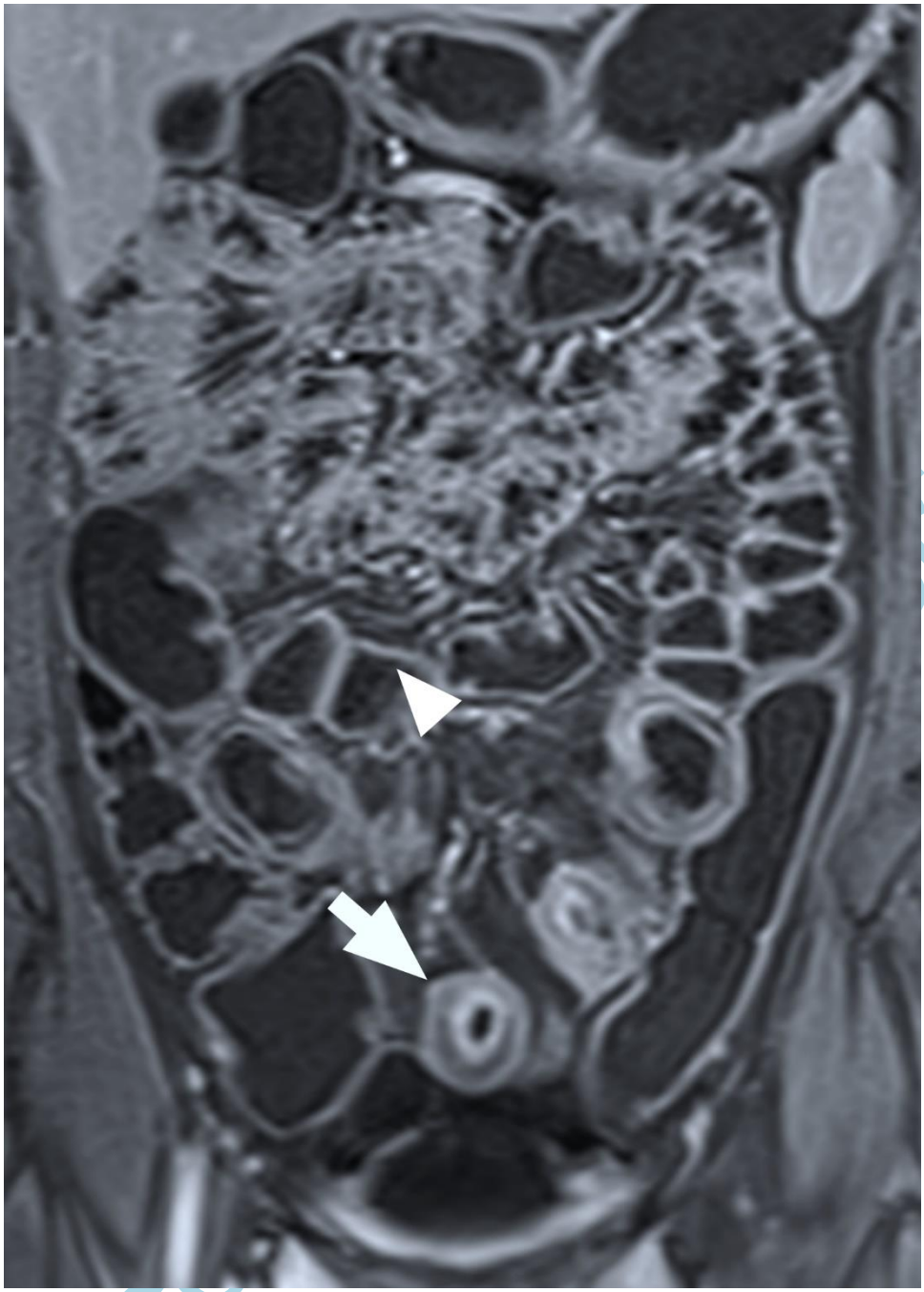

Figure 3A – see figure legend at the end of the manuscript

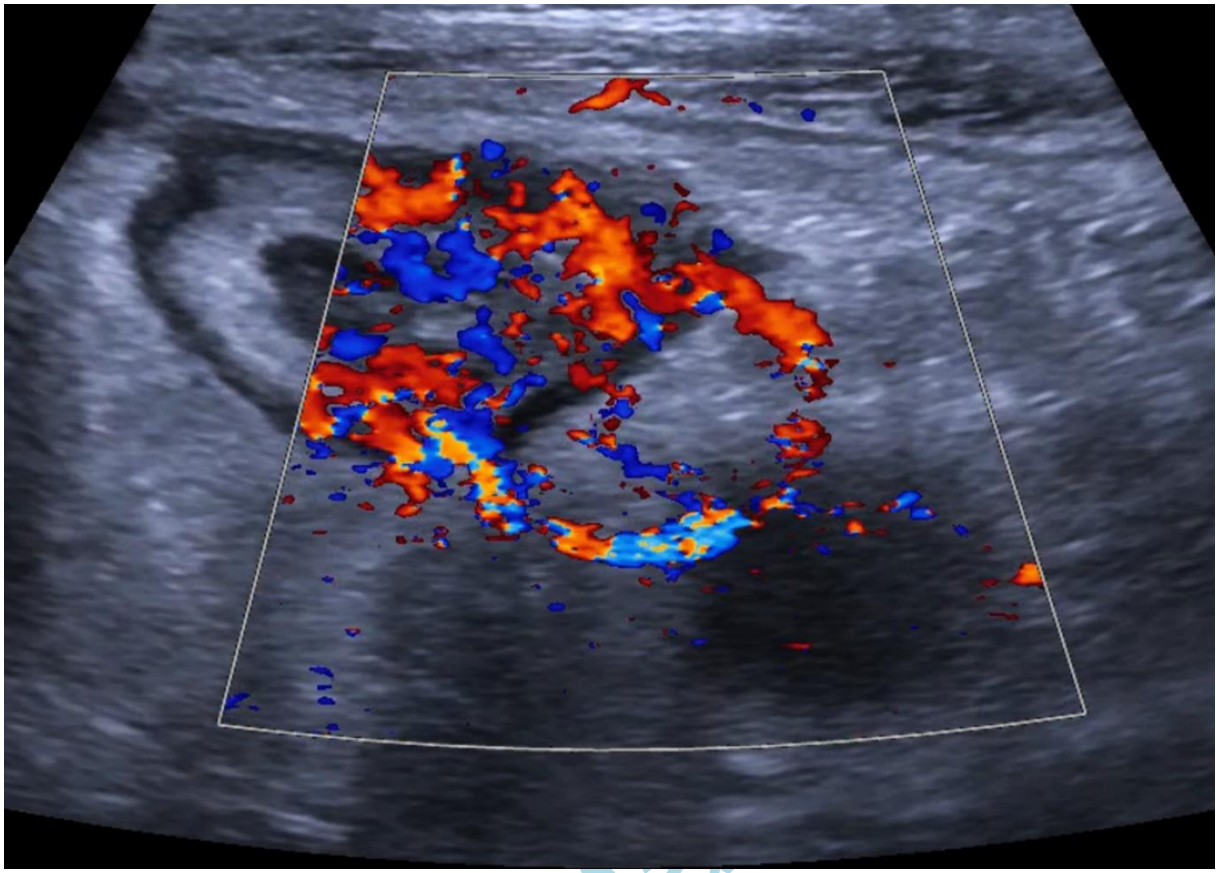

Figure 3B – see figure legend at the end of the manuscript

3.2.5. Parameters assessing inflammation – Perienteric inflammatory changes

Current practice position 7

The presence and location of perienteric inflammatory changes and mesenteric adipocyte proliferation [creeping fat] should be reported. Although non-specific, enlarged mesenteric lymph nodes can occur adjacent to transmural inflammation and thus may be supportive of disease activity and may be reported.

Perienteric inflammation or fat stranding is observed as abnormally increased attenuation in the mesentery and causes loss of the typical sharp interface between the intestinal wall and mesentery, which can be associated with regional or mesenteric free fluid or oedema.[11] Perienteric inflammation is associated with more severe inflammation[11, 39] and should be reported. Alternatively, another entity called 'creeping fat' reflects an increased volume of mesenteric fat surrounding [wrapping around] an inflamed intestinal segment, usually present on the anti-

mesenteric aspect of the bowel.[11] Creeping fat may be associated with poorer disease outcome. [51] Currently, there is no consensus on the number or size of regional lymph nodes to be associated with mural inflammation. Unequivocal detection of regional enlarged lymph nodes can be supportive of active inflammation, although the impact on therapeutic decisions is equivocal. [52]

3.2.6. Parameters assessing inflammation – Adjunctive acquisition techniques

Current practice position 8

If used, adjunctive acquisition techniques such as contrast-enhanced US or motility assessment may also be helpful in further characterizing transmural pathology and should be reported.

The reliability of largely subjectively graded parameters has not yet been established, and motility, compressibility, or submucosal changes have not been included in any existing activity index.[12, 42] Small-bowel motility and potentially its compressibility have the potential to reflect changes in disease activity states.[12] Reduced motility detected with cine loops captured after 4–6 hours of fasting correlates well with disease activity on MRE[53] and has been included in some activity scores.[54] Very little has been reported on small-bowel compressibility and its contribution to chronic versus active inflammation; thus, its significance is similarly uncertain.[12] Contrast-enhanced IUS is a promising tool in the evaluation of IBD. However, the available studies are mainly small single-centre studies, and standardization is largely lacking.[55]

3.2.7. Monitoring disease activity

Current practice position 9

For follow-up examinations, reporting should focus on changes from the previous examination and should be categorized as transmural remission or significant transmural response, stable disease, or progression of inflammation. Changes in responsive features, including BWT, colour Doppler signal, BWS [IUS], ulcers, oedema [MRE], and perienteric inflammatory changes, should guide treatment response categorization.

Transmural remission is now increasingly acknowledged as an entity with better long-term outcomes than response assessed by endoscopy and should be used instead of transmural healing.[56] Precise definitions of overall therapeutic response, therapeutic targets, or endpoints in imaging studies on IBD are generally lacking and warrant further characterization [Table 2].

Different imaging features, including BWT, vascularization, stratification, creeping fat [IUS, MRE], ulcers, fat stranding, and oedema [MRE] are responsive after medical therapeutic intervention and should be used to categorize treatment efficacy. Therapeutic response should be assessed, focusing on changes from the previous examination. Response can be classified as transmural remission [normalization of all features], response (unequivocal improvement in imaging features but persistent features of inflammation [parameters described in position 2–4 provide guidance]), stable from earlier examination, or progression [increase in parameters of inflammation, new segments inflamed, presence of CD-related complications, or combinations thereof].

Intestinal segments affected by active inflammation may revert to a normal mucosal appearance on endoscopy but exhibit residual transmural disease, notably mural thickness or mural fatty deposition, which may coexist with or without imaging features of inflammation reporting false-positive findings of active disease.[57, 58] Sacculation in the anti-mesenteric border is another sequela of CD as consequence of gut shortening along the mesenteric border.

Although some authors[59] have utilized a reduction in inflammation length to categorize treatment response, this usually parallels intra- and extramural inflammation changes. Currently, it is uncertain if this is associated with clinical outcome.

3.2.8. Postoperative recurrence

Current practice position 10

Imaging evidence of post-operative disease activity, including notation regarding resected bowel segments, presence of disease activity, and post-operative complications should be reported. Post-operative recurrence is detected and graded by parameters outlined in positions 4–6.

Post-operative recurrence at the site of the anastomosis can be assessed by cross-sectional imaging. Ileocolonoscopy remains the gold standard utilizing Rutgeert's classification.[60] Several studies have

assessed the ability of IUS to detect any recurrence, with sensitivity ranging from 90–100% and specificity 20–93% using BWT between 3–3.5 mm as a threshold. When using BWT cut-offs at 4.5–5 mm [IUS] or 4 mm (in small intestinal contrast ultrasonography [SICUS]), the modalities exhibit a sensitivity and specificity of 74–93% and 77–96% for categorizing severe recurrence [i3-i4], respectively.[14, 61-64]

In a study by Sailer et al.,[65] MRE revealed post-operative recurrence and achieved substantial agreement between MR score and Rutgeert's score [κ=0.67] and almost perfect agreement [κ=0.84] for MR to predict low- and high-grade recurrence.

Table 2: Relevant findings for assessing inflammation and complications

<table>
<tr><th>Findings to be assessed on a segment basis</th><th>Extension/ localization of the disease</th><th>Overall interpretation</th></tr>
<tr><td>Abnormal bowel:
- Thickness*
- Ulceration(s)
- Oedema#
- Vascularization
- Perienteric inflammatory changes</td><td>Terminal or neo-terminal ileum$^{\pi}$
Distal ileum$^{\pi}$
Proximal small bowel$^{\pi}$
Individual colonic segments</td><td rowspan="3">Initial diagnosis
- No evidence of active disease
- Evidence of active disease ± complications

Follow-up examination
Treatment response
- Transmural remission
- Significant transmural response
- Stable disease
- Progression of disease
Status of complications</td></tr>
<tr><td>Adjunctive techniques:
- Motility
- Restricted diffusion</td></tr>
<tr><td colspan="2">Complications
- Stricture^
- Fistula and/or sinus$^{\alpha}$
- Mesenteric mass/abscess$^{¥}$
- Vascular complications$^{\infty}$</td></tr>
</table>

* Measured in millimetres

Oedema is shown on IUS as extensive disruption of bowel wall stratification and increased intramural T2 signal on MRE

[π] An estimate of the total affected length and length of all individual pathological areas of small bowel should be reported in centimeters

[^] location, number, length, signs of inflammation, relationship to a surgical anastomosis, and presence and degree of dilated upstream should be reported

[α] site of origin, involved organs [e.g. entero-enteric, entero-vesical], classification [simple vs complex] and relationship to strictures should be reported

[¥] location, dimensions, and feasibility of image-guided drainage [for abscess] should be reported

[∞] on CT and MRE, mesenteric venous thrombosis, collateral pathways/varices should be reported

3.3. Assessment and reporting of complications

3.3.1. Stricturing Crohn's disease

Current practice position 11

The number, location, and length of intestinal strictures should be reported, together with the relationship to a surgical anastomosis if present. The degree of upstream luminal dilatation and wall thickness and the presence and severity of accompanying active inflammation within a stricture should be reported, including the presence of fistulae. Any suspicion of neoplasm should be reported.

Up to half of patients with CD disease develop a stricture.[66] Most strictures contain both inflammatory and fibrotic components, and the predominance of one over another informs optimal therapy.[67] Cross-sectional imaging and IUS are accurate in identification of intestinal strictures,[4, 68] although there is ambiguity as to the appropriate definition. Luminal narrowing accompanied by unequivocal dilatation [upstream bowel segment ≥3 cm] has been proposed [Figure 4], and fixed luminal narrowing alone, without upstream dilatation, may best be reported as a probable stricture on cross-sectional imaging to limit false-positive findings.[4, 69, 70] However, the prerequisite for upstream dilatation likely reduces sensitivity for stricture detection and does consider omission of oral contrast [common in IUS].[71-75] Using IUS, stricture detection may be enhanced by real-time evaluation of the movement of intestinal contents and bowel motility.[76]

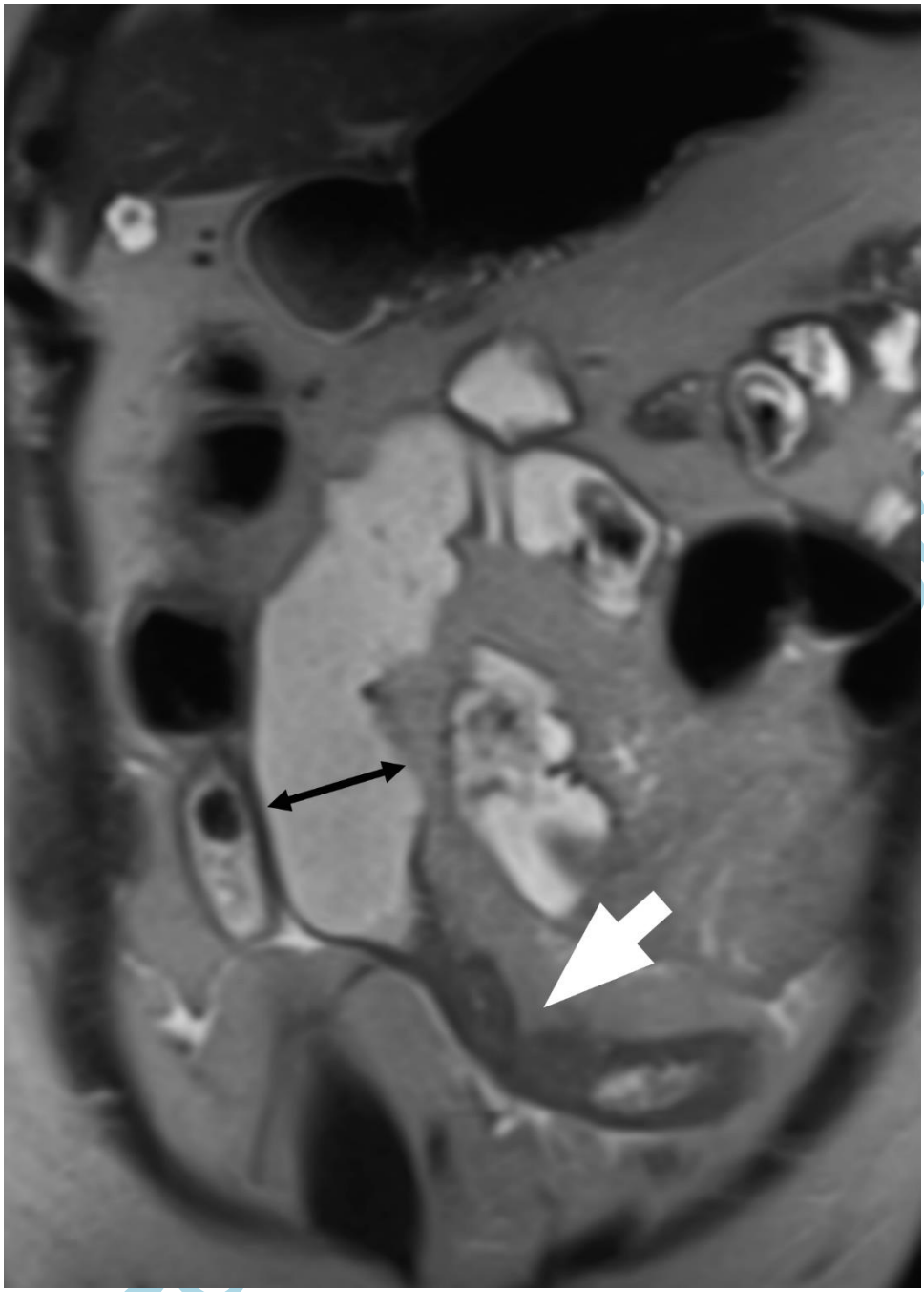

Figure 4A – see figure legend at the end of the manuscript

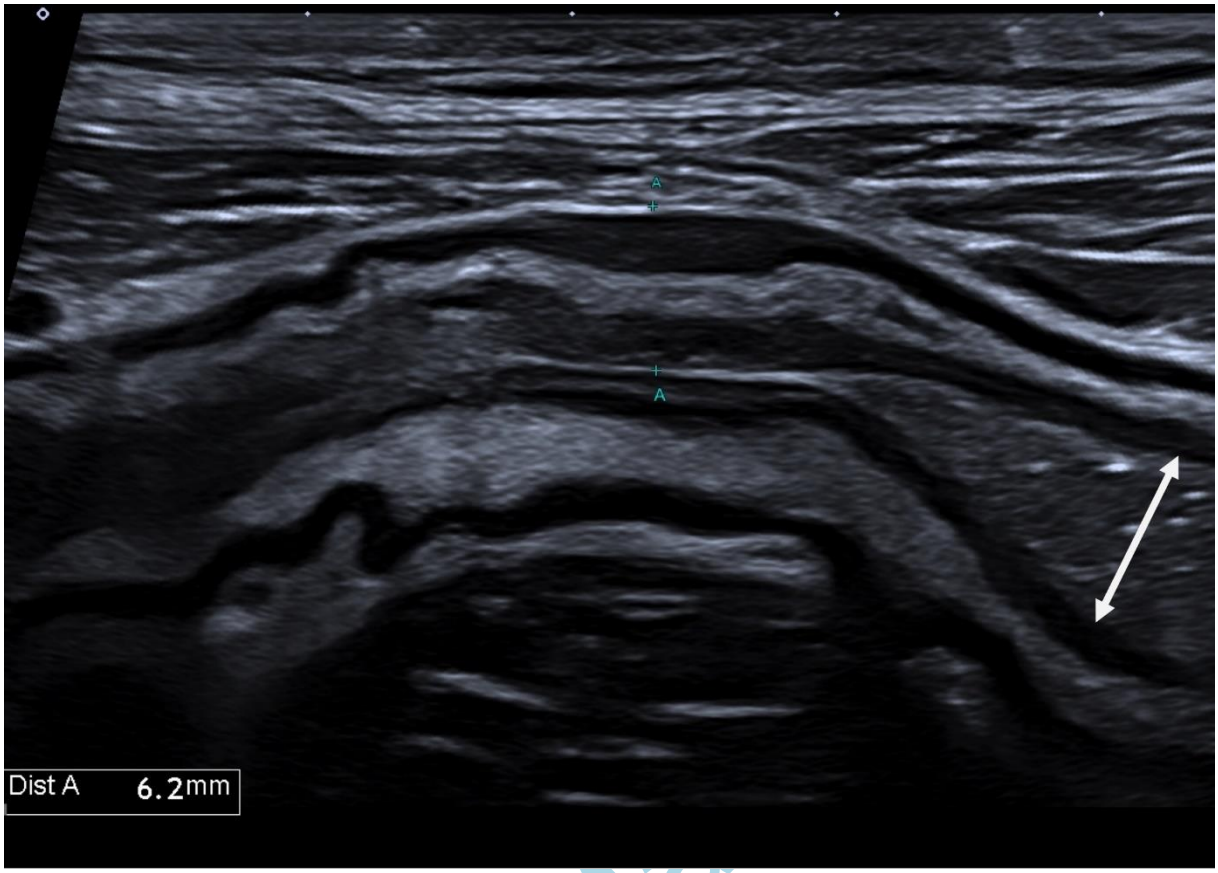

Figure 4B – see figure legend at the end of the manuscript

The presence and degree of upstream dilatation should be reported to inform the risk of complications and need for surgery,[71-75, 77, 78] along with multiplicity, location, length, relationship to anatomical landmarks [such surgical anastomosis or ileo-caecal valve, or both], and BWT. An attempt to report the relative contribution of inflammation and fibrosis within a stricture should be made, recognizing that both are usually present. Penetrating complications, such as fistulae, should be reported.[70, 79] Follow up of intestinal strictures can be used to measure treatment response by reporting on upstream dilatation and features of inflammation.[72, 74] Emerging modalities may assist in determining the degree of fibrosis, including shear-wave elastography and contrast-enhanced IUS, delayed gadolinium enhancement, magnetization transfer, and motility MR imaging.[80] Features suggestive of potential malignancy, particularly in the setting of a new stricture on a background of longstanding poorly controlled disease, should be described. If present, asymmetry, nodularity, and soft-tissue extension should be reported.[81, 82]

3.3.2. Penetrating Crohn's disease

Current practice position 12

Fistulae should be differentiated as simple or complex and their location described by their intestinal origin and the adjacent structures to which they connect. Sinus tracts as blind-ending tubular structures should be reported as early signs of penetrating disease. In addition, the relationship of penetrating disease to inflamed bowel segments or strictures should be reported.

Transmural inflammation can lead to various penetrating complications, including sinuses, fistulae, mesenteric inflammation, and abscesses.[83] Sinus tracts are blind-ending bowel-wall defects arising from the serosal surface, extending into the perienteric mesentery without connecting to another structure.[84] A simple fistula is a single extra-enteric tract that connects to another bowel segment, the cavity of another organ, or the skin surface [Figure 5], whereas a complex fistula consists of multiple extra-enteric tracts involving multiple structures, often showing an asterisk or star configuration.[85, 86] The fistula type, site of origin, and involved organ [e.g. enteroenteric, enterocutaneous, enterovesical] should be described. Enterovesical, enteroureteral, or enterobiliary fistulae are at increased risk of septic complications and may require urgent surgery.[87]

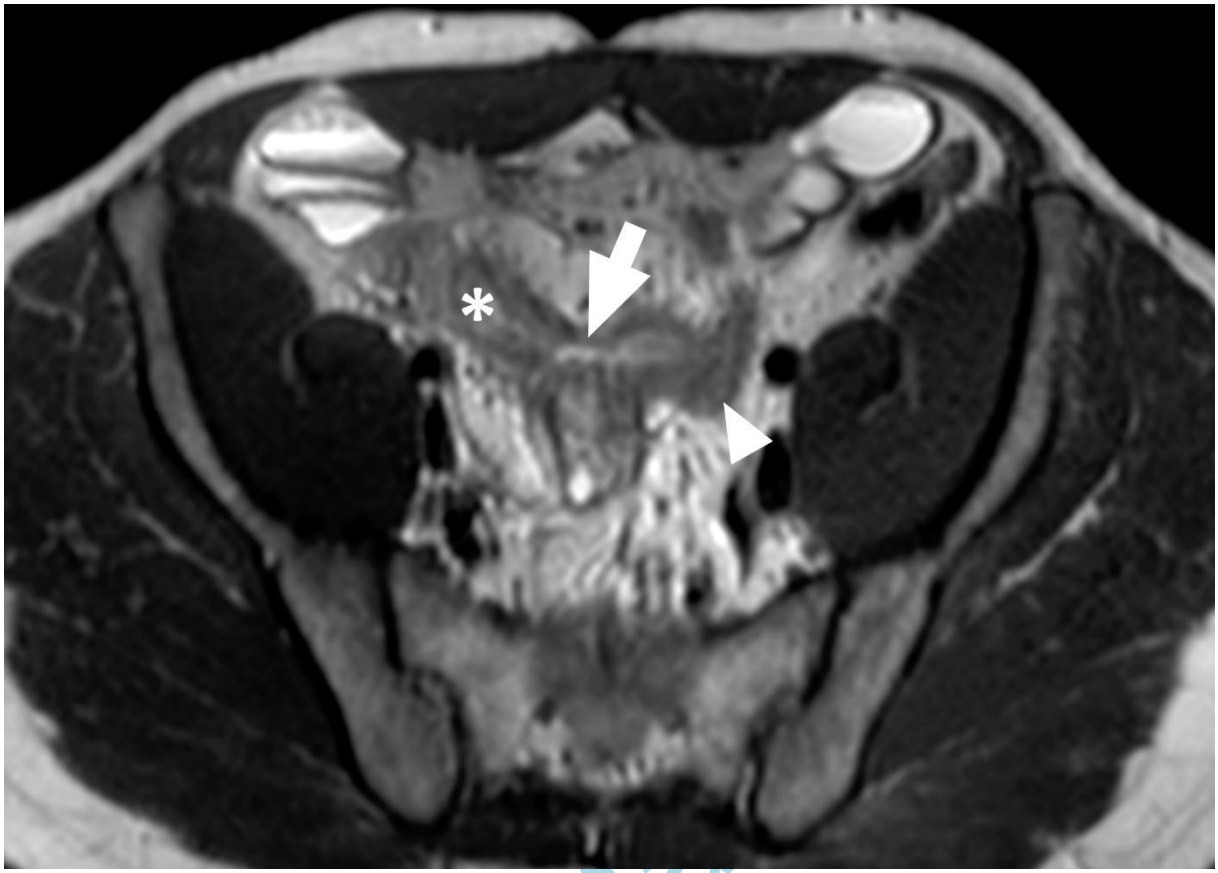

Figure 5A – see figure legend at the end of the manuscript

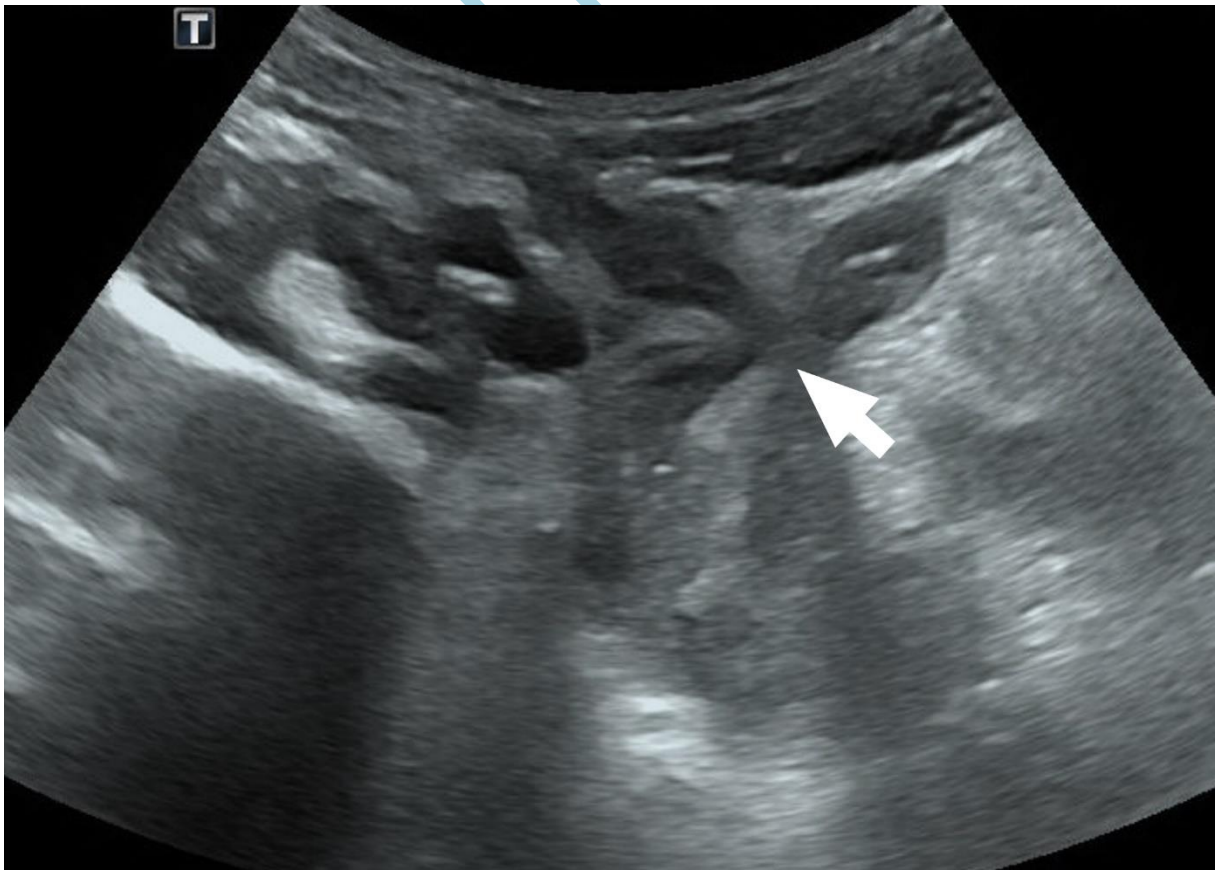

Figure 5B – see figure legend at the end of the manuscript

On cross-sectional imaging, sinus tracts and fistulae manifest as tubular structures arising from the bowel wall with fluid, air content, or both exhibiting peripheral contrast enhancement. Sonographically, they appear as hypoechoic duct-like structures with or without internal gaseous artifacts and a cross-sectional lumen diameter <2 cm, which is a differentiating feature from a perienteric abscess.[28] The administration of intravenous contrast medium may increase sonographic sensitivity.[88] On MRI, sinus or fistulous tracks may have central high-signal intensity on T2-weighted images and restricted diffusion.[89] After healing, fistulae may have low signal on T2-weighted images with minimal enhancement.

Penetrating disease tends to develop in a high-pressure region in the mid or proximal part of strictures with transmural inflammation.[79, 90] Bowel segments with imaging findings of inflammation, stenosis, or both should be carefully evaluated for the presence of penetrating disease.[91] Prestenotic dilatation may be absent due to decompression through a proximal fistula and 'a stricture is likely present' may be reported.[4] Fistulae should not be mistaken for peritoneal adhesions, the latter being thinner with later contrast enhancement.[92]

Current practice position 13

The clinical care team should be immediately notified of the presence of free perforation. The presence or otherwise of any inflammatory mass or abscess should be documented in all imaging reports, including the dimensions, enteric location and, if applicable, relationship to adjacent intra-abdominal organs and structures. In the case of an abscess, the estimated dimensions of the fluid content should be provided along with the technical feasibility of image-guided drainage.

Penetrating disease and toxic megacolon may be associated with free perforation into the peritoneal cavity.[93] CT is highly sensitive for detecting extraluminal free gas and is the examination of choice if this is clinically suspected.[94] Extraluminal gas may also be visualized as extraluminal low signal on MRE and echogenic reflections on US. All modalities may depict discontinuity, thickening, or both in the intestinal wall, and reactive mesenteric changes associated with free perforation.[94] Free perforation should be communicated immediately to the clinical care team.

The term inflammatory mass is generally preferred over 'phlegmon'.[4] On IUS, a mesenteric inflammatory mass typically appears as an ill-defined hypoechoic mass without a definable wall and usually has detectable internal colour Doppler signal.[95] An abscess contains hypoechoic fluid, an [often irregular] defined wall, and peripheral Doppler signal in the wall. Contrast-enhanced US may aid in the differentiation between a mesenteric mass and abscess, with the former demonstrating central enhancement.[95] On MRI and CT, a mesenteric mass typically manifests as ill-defined perienteric mesenteric increased signal or attenuation, respectively, without fluid content [Figure 6]. Conversely, an abscess shows the signal or attenuation characteristics of fluid and does not conform to the normal peritoneal reflections [unlike free fluid].[96] Rim enhancement after intravenous contrast is typical and restriction is usual on diffusion-weighted imaging.[70] The location and size of inflammatory masses and abscesses should be noted in the imaging report. In the case of an abscess, the estimated volume of fluid content and the feasibility of image-guided drainage should also be noted.[97, 98]

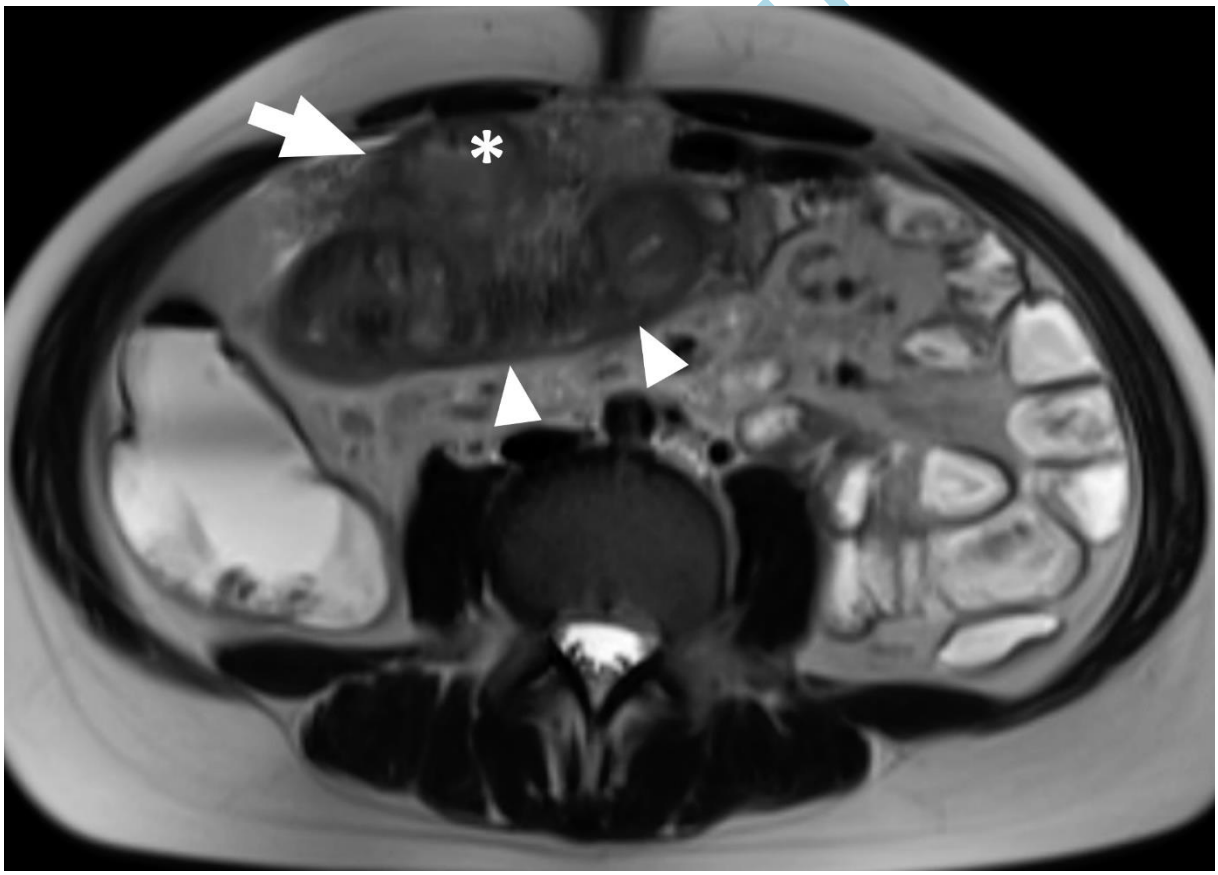

Figure 6A – see figure legend at the end of the manuscript

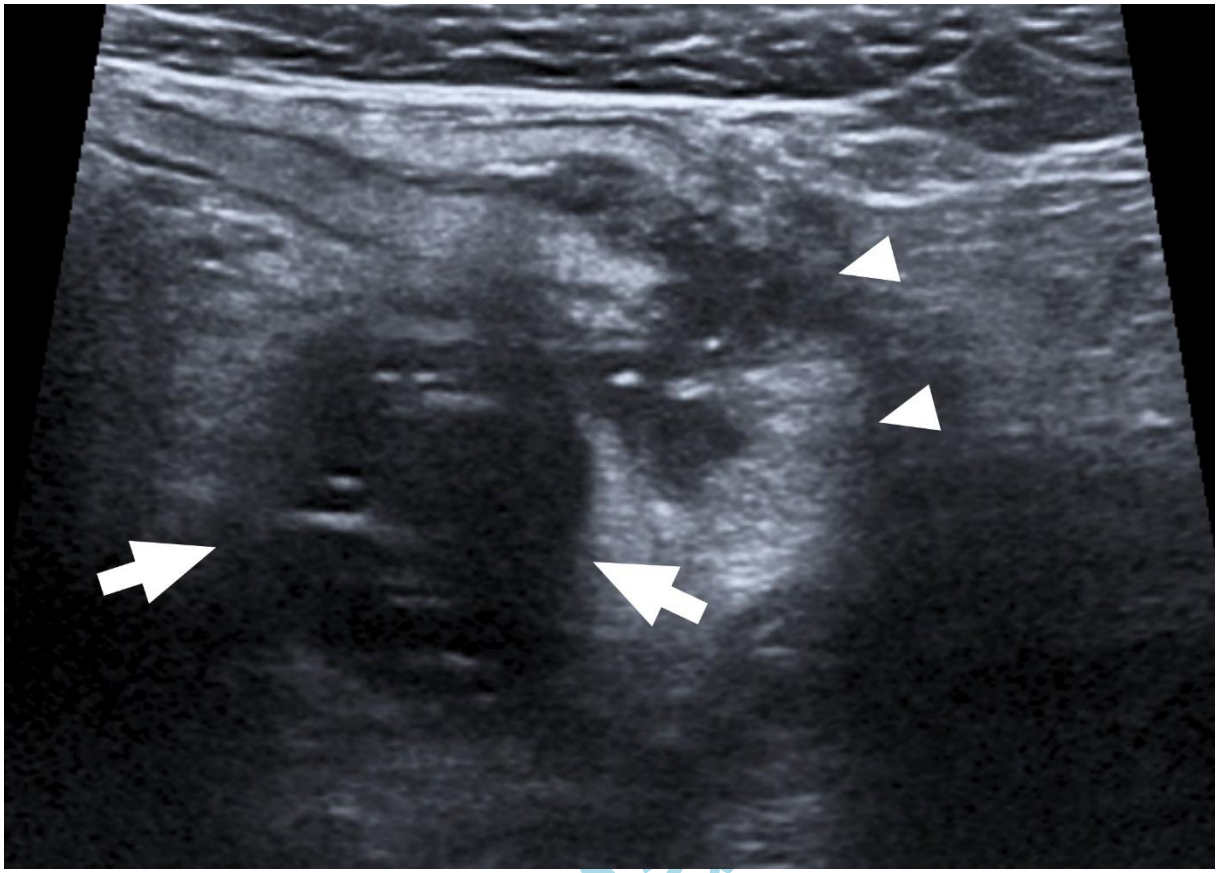

Figure 6B – see figure legend at the end of the manuscript

3.3.3. Image-guided interventions

Current practice position 14

Decisions around image-guided interventions in IBD should be made after multidisciplinary team discussion. The procedure report should include detailed information, including clinical status and indication, full technical details of the intervention, and instructions for post-procedure aftercare.

Percutaneous image-guided Seldinger's drainage techniques[99-101] are a less invasive alternative to surgical drainage for intra-abdominal or pelvic collections that may develop spontaneously or as postoperative complications.[102] [103] CT-guided percutaneous drainage is indicated for deep intra-abdominal or pelvic collections and allows for the optimal visualization of retroperitoneal structures.[104] US-guided percutaneous drainage is usually preferred for more superficial collections

and abscesses. It avoids the use of ionizing radiation and is particularly indicated for paediatric interventions.[105-107]

A multidisciplinary team, including radiologists, colorectal surgeons, and gastroenterologists should discuss the use of image-guided intervention on a case-by-case basis.

Image-guided percutaneous drainages are moderate-risk interventions.[108] The most common complication is the damage of surrounding tissues and vessels, and consequent haemorrhage [109].

The safety and efficacy of image-guided intervention relies on appropriate work up and pre-procedural planning. Reports should include complete information about the indication and clinical presentation. If the abscess is due to a postoperative complication, the time interval between surgery and onset should be indicated, as this may influence the intervention outcome.[110] The report should detail any abnormalities in coagulation status and platelets and include exposure to antithrombotic medications.[111]

Detailed technical information should be provided, including patient positioning, drainage approach [for example transgluteal vs transabdominal], use of hydrodissection, and type and calibre of the catheter.

Reports on transluminal intervention [for example, transgastric or transrectal] should include the type of pre-interventional preparation and type and make of the echoendoscope. The presence of any fistula should be reported, as this may affect the outcome.[112]

All intervention reports should also include details of sedation [if used] and instructions for patient aftercare, including haemodynamic monitoring, bed rest, and cessation of eating or drinking. Instructions for post-procedural antibiotic treatment, if needed, should be stated. The report should include the volume of aspirate and instructions for catheter care, such as free drainage, flushing, or aspiration.

3.3.4. Other complications

Current practice position 15

Short-term postsurgical complications such as leak, abscess, or bowel obstruction should be reported for all intestinal anastomoses. The presence or absence of toxic megacolon and associated

complications should be reported in all cases of acute colitis. The presence of vascular complications, such as mesenteric portal venous occlusion, varices, or bleeding should be reported.

IBD is associated with a higher risk of both acute and chronic mesenteric venous thromboembolism, particularly when active.[113] Compensatory collateral pathways or small-bowel varices suggest chronic mesenteric venous occlusion, and peripheral vascular stenoses or intraluminal filling defects should be identified, which typically occur in the vascular territory of the inflamed segment(s).[4]

Severe gastrointestinal bleeding is a rare complication of IBD, most commonly originating from the ileum and colon.[114] Multi-phase CT, including arterial-phase acquisition, may identify the enteric source.[52, 115]

For the assessment of possible anastomotic strictures, BWT and prestenotic dilation should be interpreted with caution, as post-surgical changes may fail to recede.[2] Anastomotic insufficiency may present late in the postoperative period and may present with atypical clinical features. Leaks should be suspected by the presence of localized fluid and gas around the anastomosis [typically diagnosed with CT], although imaging features may overlap with normal post-operative appearances, particularly early post-surgery.[116] Use of oral contrast may be useful when leaks are suspected. An apparently negative CT in the postoperative period does not exclude gastrointestinal tract leaks.[2, 68]

Extraenteric tracks originating from the anastomosis should raise suspicion for a postoperative leak as well as primary fistulizing CD.[4]

Short-bowel syndrome causing intestinal failure is defined as a total small intestinal length <150–200 cm and may develop from repeated intestinal resection.[117] Estimating the remnant bowel length by CTE or MRE has been shown to be largely adequate for clinical use.[118]

Toxic megacolon, a potentially fatal complication of IBD, is characterized by total or segmental nonobstructive colonic dilation and systemic toxicity.[119] Abdominal X-ray or CT are usually first-line investigations, although imaging signs such as colonic dilatation >6 cm, mural thinning [<2 mm], and air-fluid levels with abnormal haustral colonic dilation pattern may also be seen on MRI and US.[120, 121] Immediate reporting of colonic perforation, ascending pylephlebitis, and colonic wall ischemia is necessary to prevent delayed surgical treatment.[2, 121, 122]

3.4. Assessment and reporting of perianal Crohn's disease and pouch complications

3.4.1. Perianal Crohn's disease - Initial diagnosis

Current practice position 16

At initial diagnosis, fistula reports should include a comprehensive description of key findings in a structured format, including 1) number of fistulae/sinuses/abscesses, 2) Park's classification for each fistula, 3) description of all complex fistula features, and 4) assessment of anal sphincter integrity.

MRI, endoanal ultrasound [EAUS], and perineal US [PUS] are possible modalities for imaging of perianal fistulae and abscesses in CD, according to local availability and expertise. Fistula imaging reports for MRI and US should include all relevant information for clinical decision making with a reliable structure.[5, 123, 124] Since these are potentially challenging examinations, reporting in a clear format with defined criteria for reporting abnormalities with consistent terminology is necessary, particularly as repeat examinations may be needed.

Fistulae typically have a single internal opening connected to a single external opening. Occasionally, a single primary fistula track may have multiple internal openings; in this case, it is recommended that this fact is stated along with the number and location of internal openings and the same applies to multiple external openings. Multiple fistula tracks may occasionally also share a single internal opening. In this case, it is recommended that this fact is stated along with the location of the internal opening and the same applies to shared external openings.[6]

Fistulae should be summarized as either simple or complex.[6] Complex features are defined as multiple fistulae [>1], high fistulae [high transsphincteric, supra- or extrasphincteric], any extensions or collections, and involvement of other organs [genitourinary or musculoskeletal]. [125] Other observed disease complications should also be described [proctitis, pouchitis, hidradenitis suppurativa, osteomyelitis, or malignancy].

Each fistula should be reported according to Park's classification,[126] using a clock-face terminology and the quadrant [e.g. left or right side, anterior or posterior] and described with reference to its distance to the skin [e.g. mainly superficial or deep route], its length [in cm], and maximum diameter [in mm], if possible. Intersphincteric fistulae track along the intersphincteric plane between the

internal and external anal sphincters and may extend into the superficial part of the external anal sphincter but should not cross the full thickness. Transphincteric fistulae track across the anal sphincter muscle. High transsphincteric fistulae cross the upper two thirds of the anal sphincter to the ischioanal fossa, while low transsphincteric fistulae cross the lower third of the anal sphincter [i.e. external sphincter]. Suprasphincteric fistulae originate in the anal canal but bypass the anal sphincter complex by passing superiorly above the level of the anorectal junction before traversing the levator muscle and the ischioanal fossa to the external opening. Extrasphincteric fistulae originate in rectum and bypass the sphincter complex by crossing the levator muscles.

The height of the internal opening in the anal canal may be difficult to define precisely due to variation of anal-canal length from person to person and shorter length in women. The puborectalis muscle and external sphincter form a single functional unit of striated muscle around the anal canal. For guidance, the anal canal on imaging is considered to extend from the anal verge [which on US and MRI can be estimated as the most caudal extent of the subcutaneous external sphincter][6] up to the uppermost fibres of the puborectalis muscle. This distance may be segmented into equal thirds on MRI assessment. In US, the lower third is considered to be where the EAS is visible, the middle third is where the IAS and the EAS are seen together, and the upper third is where the puborectalis is seen. The anatomical positions of the internal and the external openings should be described with 'clock face' nomenclature and relative wall of the anal canal [anterior, posterior, left and right] and according to its location in the anal canal [upper third, mid third, or lower third of the canal].

In case of a complex fistula, the extensions should be reported and described along with correspondent location and length. A 'horseshoe' extension is defined radiologically as a semilunar region of sepsis that spreads in the horizontal plane on either side of an internal opening to involve two or more adjacent quadrants. Horseshoe extensions may be ischioanal, intersphincteric, or supralevator.[6] EAUS and PUS have limitations in imaging complex and high fistulae, including the exclusion of abscesses. Pelvic MRI should be recommended in any uncertain cases.[127] The diameter of the fistula or its extent should be measured at its widest point.[6] Collections of fluid in extensions with diameter >10 mm should be specifically highlighted, as these are frequently described as 'abscesses' and may require surgical intervention for drainage before commencement of medical therapy.[2]

It is acknowledged that in practice the location of abnormalities can vary between supine MRI or EAUS/PUS and surgical positioning at EUA [e.g., lithotomy position] with respect to clock-face position. The height of an abnormality in the anal canal and distance from anal verge and imaging

locations should be considered indicative. Similarly, seton identification may be difficult on MRI depending on which sequences are performed and the content of the fistula.

The presence of ongoing perianal sepsis can be related to partial drainage by a seton, and therefore cases of partial drainage of fistula tracts and extensions should be mentioned.

Specific ultrasonographic signs may help discriminate CD from cryptoglandular fistulae, which include bifurcation of the fistulae, widening of the fistulae, presence of debris in the fistula tract, and presence of a hypoechogenic rim with a surrounding hyperechoic region around abscesses and fistula;[128] these signs should be mentioned if present. Assessment of sphincter integrity is an important part of the imaging evaluation of anal structure,[6] especially in cases in which surgery is being considered. 3D-EAUS can be helpful but is not considered mandatory.[6, 129, 130]

An interval of at least 4 weeks is recommended for examinations performed after first presentation requiring acute perianal surgery.[6]

Since a proportion of CD patients will have symptoms of suspected perianal fistula and small-bowel disease at initial presentation, it is desirable to combine bowel and pelvic assessment by combining intestinal and pelvic MRI or IUS with EAUS or PUS for fistula to allow that the procedures can be done in a single visit.

Unless underlying fistulae or abscesses are clinically suspected, imaging is not recommended for characterizing inflammatory anorectal strictures, deep anal ulcers, anal fissures, and perianal skin tags.

Structured reporting has been proposed previously for perianal fistulizing CD.[5, 124] Structured reports have advantages of improved satisfaction of the referring clinician and increased reporting of important positive and negative findings to guide management.

Table 3 summarizes the inflammatory lesions related to perianal CD that are potentially assessable by pelvic MRI or US and their definitions.

Table 3: Perianal CD - Definitions of abnormalities	
Subject	Definition
Fistula	Tracts connecting the anus or rectum and the perianal skin or other organs[6]
Complex fistula	High fistula or with one or more of the following characteristics: extensions, multiple external openings, complicated by an abscess, urogenital involvement, or anorectal stricture[2]
Sinus	Blind-ending tract without both an external and internal opening[131]
Abscess [or collection]	US: hypo-anechoic structures [>10 mm], containing echoic fluid and sometimes gas bubbles, with posterior echo enhancement and internal echoes[127] MRI: >10 mm fluid signal component in the cavity of a collection;[6] exhibits rim enhancement after contrast
Fistula type: Intersphincteric	Fistula between the internal and external sphincter[132, 133]
Transphincteric	Fistula crossing the anal sphincter muscle. A high transsphincteric fistula crosses the upper two thirds of the anal sphincter [mainly puborectal muscle, upper part external sphincter] to the ischioanal fossa, while a low transsphincteric fistula crosses the lower third of the anal sphincter [i.e., external sphincter][132, 133]
Suprasphincteric	Fistula passing upward in the intersphincteric plane to a point above the puborectalis muscle where it tracks laterally and caudally into the ischioanal fossa[132, 133]
Extrasphincteric	Fistula not originating in the anal canal and sphincter complex that passes directly from the rectum to the perineal skin through the ischioanal fossa[132, 133]
Superficial	Fistula that involves the distal anal canal and does not involve the anal sphincters[124]
Recto- or anovaginal	Hypoechoic tract [US] or high-signal/enhancing or low-signal structure between the rectum or anus and vagina [MRI][127]
Internal opening	Defect in the internal anal sphincter and the subepithelial space[134, 135]
External opening	Visible external opening to the skin surface[6, 136]
Extension	An additional secondary tract or branch of a fistula, which may be blind

	ending or connect to other organs or skin[6]
Abscess type: Superficial	A subcutaneous abscess lying directly beneath the skin
Perianal	A subcutaneous abscess close to the anal verge.
Ischioanal	An abscess that passes through the external anal sphincter into the ischioanal space
Intersphincteric	An abscess lying between the internal and external sphincter muscles
Intralevator	An abscess lying within the levator muscle
Suprasphincteric	An abscess lying in the supralevator space
Horseshoe	A semilunar region of sepsis that spreads in the horizontal plane either side of an internal opening, to involve two or more adjacent quadrants affecting the ischioanal, intersphincteric, or supralevator compartments.[6]

A recommended template has been provided that includes the main components for a structured report for MRI or US evaluation [Table 4].

Table 4. Key quality indicators for a good report in perianal CD

Baseline imaging reporting template for patients with perianal manifestations of IBD.
Fistula reporting descriptors:
Number of separate fistulae present:
Complexity: Simple / Complex
For each fistula:
Fistula type: superficial / intersphincteric / transphincteric / suprasphincteric / extrasphincteric
Seton visible: no / yes
Internal opening: [clock face position - relative to anal canal] __ o'clock
Internal opening: distance from anal verge [cm] * OR anal canal lower third / mid third / upper third / lower rectum
External opening: [clock face position - relative to anal verge] __ o'clock / not applicable [blind ending]
External opening: distance from anal verge [cm]

External opening position: perineum / gluteal / vagina / labia / scrotum / penis / other / blind ending

Extension: none / single, unbranched / single, branched / multiple

Additional fistula descriptors: [free text]

For each extension:

Extension form: blind ending / to skin / to other organ [free text]

Extension: linear intersphincteric / horseshoe-shaped intersphincteric / infralevator / supralevator/ transphincteric

Extension position: [clock face - relative to anal canal or rectum] __ o'clock

Extension end position: perineum / ischioanal fossa / levator / mesorectum / presacral space / gluteal / vagina / labia / scrotum / penis / other

Abscess/collection present [>10 mm]: no / yes: ___ mm

Additional extension descriptors: [free text]

For each Abscess:

Abscess/collection position: [clock face - relative to anal canal or rectum] __ o'clock

Abscess/collection position: horseshoe intersphincteric / infralevator / supralevator perineum / blind ending/ gluteal / vagina / labia / scrotum / penis

Additional abscess descriptors: [free text]

Other disease complications present: yes / no

Rectal wall / pouch wall thickening: no / yes

Proposed diagnosis: Proctitis / Pouch complication / Hidradenitis Suppurativa / Suspicion of osteomyelitis / Suspicion of malignancy

Additional complication descriptors: [free text]

Anal sphincter integrity and scarring:

Internal sphincter intact: no/yes

Angle of defect_____ position of defect_____

External sphincter intact: no/yes

Angle of defect: _____ position of defect: _____

Puborectalis intact: no/yes

angle of defect: _____ position of defect: _____

Description of sphincter abnormalities present: [free text]

****Baseline fistula activity on MRI assessment [the most active fistula present]***

Hyperintensity on T2: [absent/mild]/high

Post-contrast enhancement of primary tract: [absent/mild]/high

Activity Category:

- Predominant fluid/pus filled [>50%] - hyperintense T2 and rim enhancement
- Predominant granulation tissue [>50%] - hyperintense T2 and diffuse enhancement
- Predominant fibrosis [>50%] - absent or mild signal intensity T2 and post contrast

Conclusion and recommendations: [free text]

3.4.2. Perianal CD - Fistula activity

Current practice position 17

An overall assessment of fistula activity should be reported on MRI.

Fistula MRI activity scoring systems rely on a combination of an assessment of T2 hyperintensity and T1 enhancement following gadolinium contrast to allow differentiation of fluid or pus in the fistula from granulation tissue or fibrosis, as fluid or pus do not enhance.[137-139] This distinction can alter patient management, including whether surgical intervention is needed and the urgency of this intervention, particularly in cases with complex disease at presentation.

The assessment of fistula MRI signal intensity is typically subjective, which is a recognized limitation. As detailed scoring systems are impractical for routine use, an approach using a dichotomous categorization may discriminate absent/mild signal [representing inactive disease or fibrosis] from high signal [active inflammation]. Mild is considered to be a slight increase in signal intensity but less than that of nearby, in-plane vessels. High is a tract showing equal or greater signal hyperintensity than nearby in-plane vessels.[137] The most active fistula should be assessed and allocated to one of the following three categories for future comparison: predominant fluid/pus filled [>50%], hyperintense T2 and rim enhancement; predominant granulation tissue [>50%], hyperintense T2 and diffuse enhancement; and predominant fibrosis [>50%], absent or mild signal intensity T2 and post contrast.[137]

The data regarding evaluation of perianal disease activity using US are limited. Mean grey-scale tone value at EAUS was found to be significantly lower in patients with active than in those with inactive perianal disease.[140]

3.4.3. Anovulvar and rectovaginal fistulas

Current practice position 18

Anovulvar or rectovaginal fistulas should be reported separately and described with respect to the position of internal opening [anus/rectum], track, and vaginal or vulvar opening [left, right]

Rectovaginal fistulae require specific treatment and a multidisciplinary approach. Rectovaginal fistulae can be defined using MRI, EAUS,[141, 142] or PUS; transvaginal US should be considered as part of US assessment for the best definition of vulvar or vaginal openings.[134]

3.4.4. Perianal CD with abscess

Current practice position 19

Abscess description of should include anatomic location, size, presence of horseshoe abscess, and relation to fistula

Abscesses should be reported according to their anatomic location.[135] A perianal abscess is a simple anorectal abscess. Intersphincteric abscesses are located in the intersphincteric plane between the internal and external sphincters. Ischioanal abscesses penetrate through the external anal sphincter into the ischioanal space [Figure 7]. Supralevator abscesses are superior to the intersphincteric plane in the supralevator space. The size of the abscess should be reported at its largest diameter in two perpendicular planes. Presence of a horseshoe abscess has already been described and should be reported and defined with its horizontal plane spread [Figure 8]. Any anatomical relations with fistulae should be reported as above. Increased vascularity on US colour Doppler and altered perfusion in contrast-enhanced US may assist in the distinction of a non-vascularized abscess from inflammatory phlegmon.[143-145]

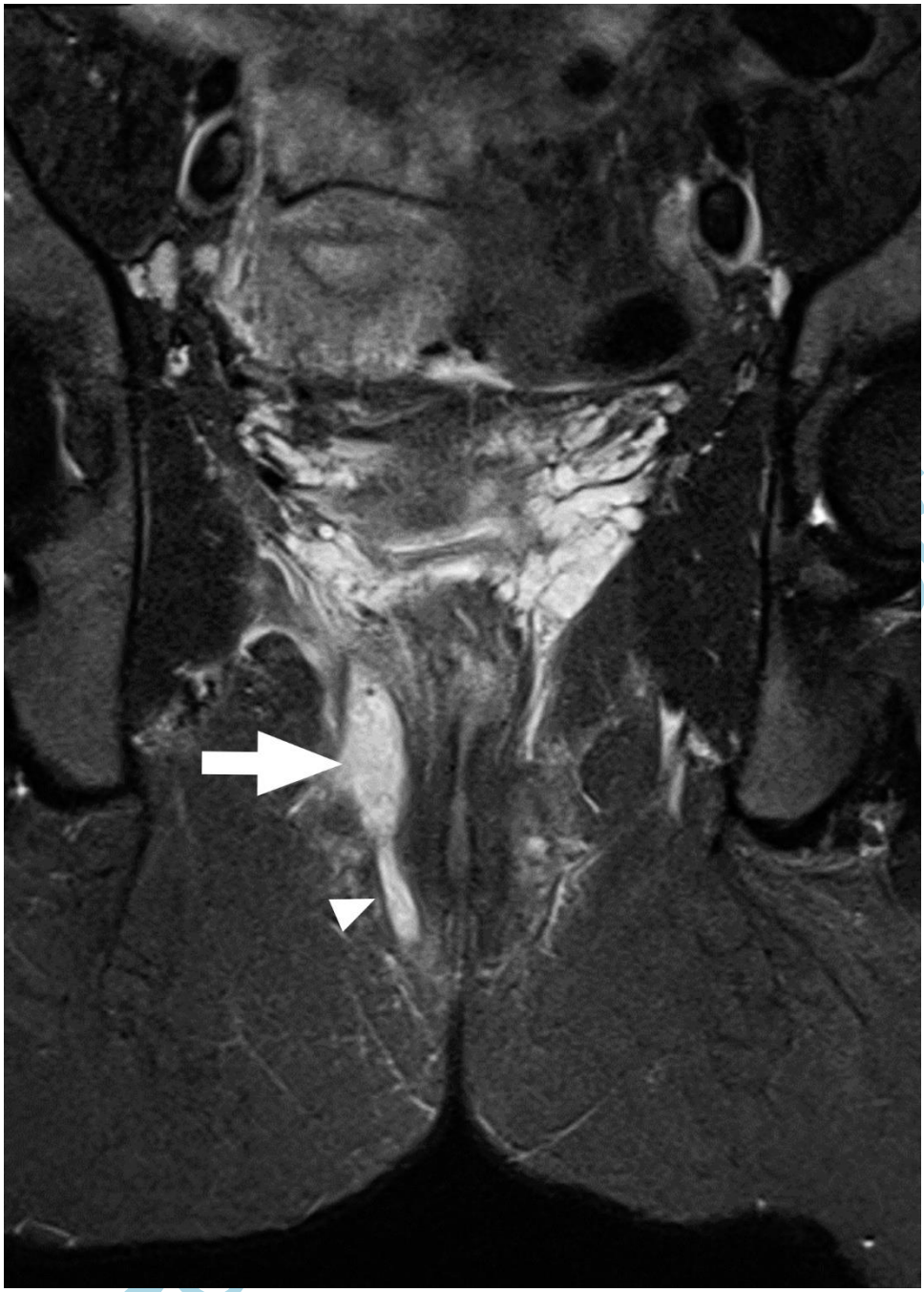

Figure 7A – see figure legend at the end of the manuscript

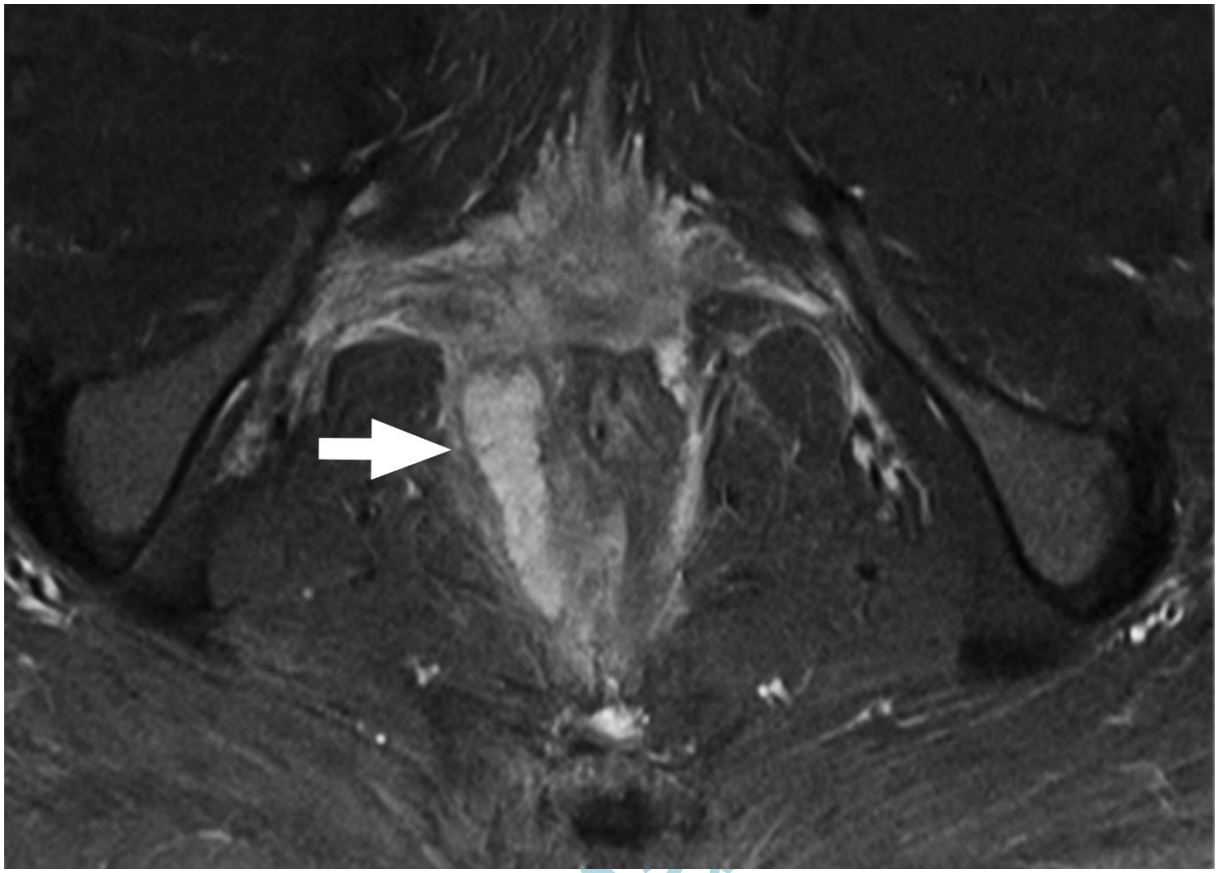

Figure 7B – see figure legend at the end of the manuscript

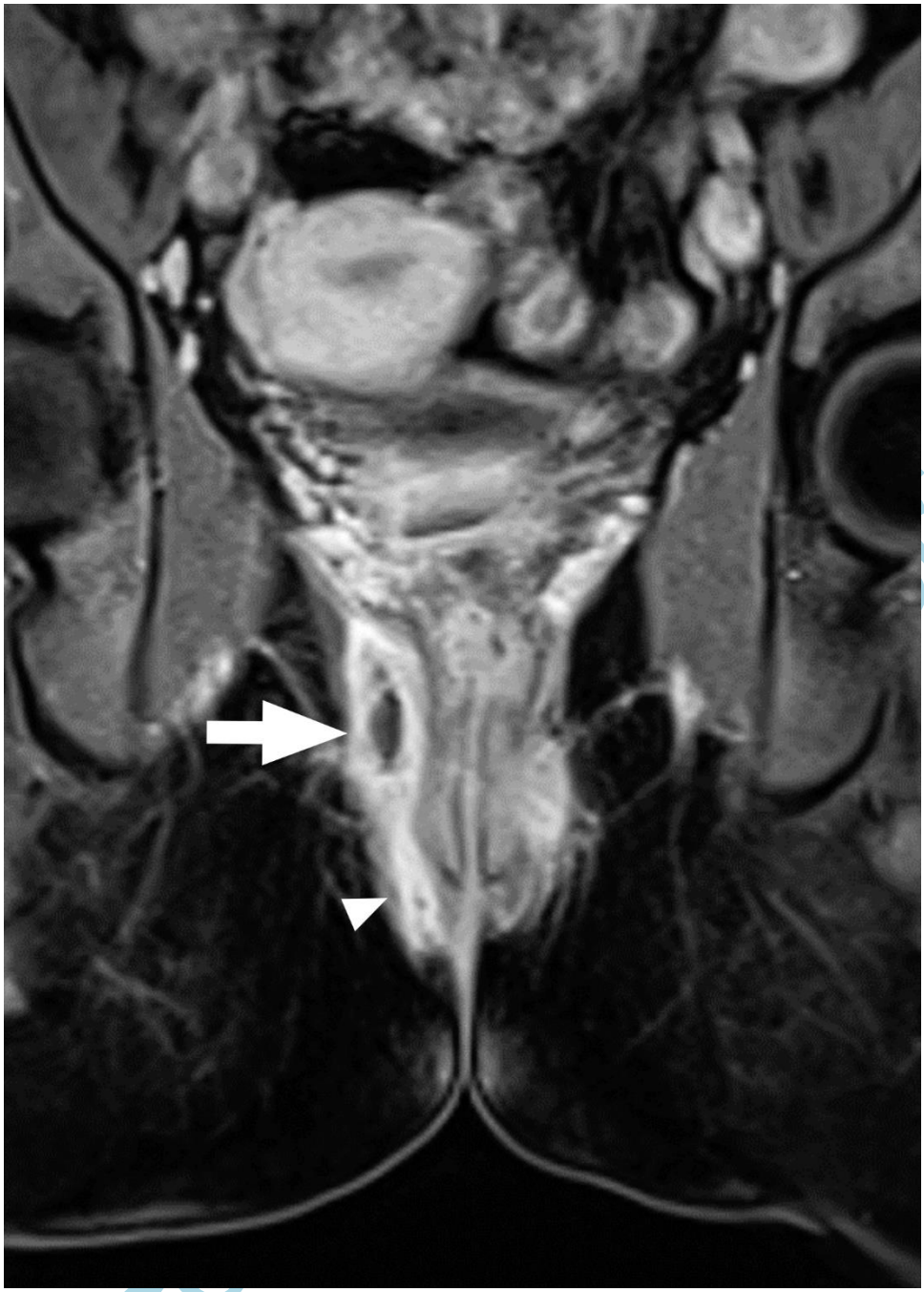

Figure 7C – see figure legend at the end of the manuscript

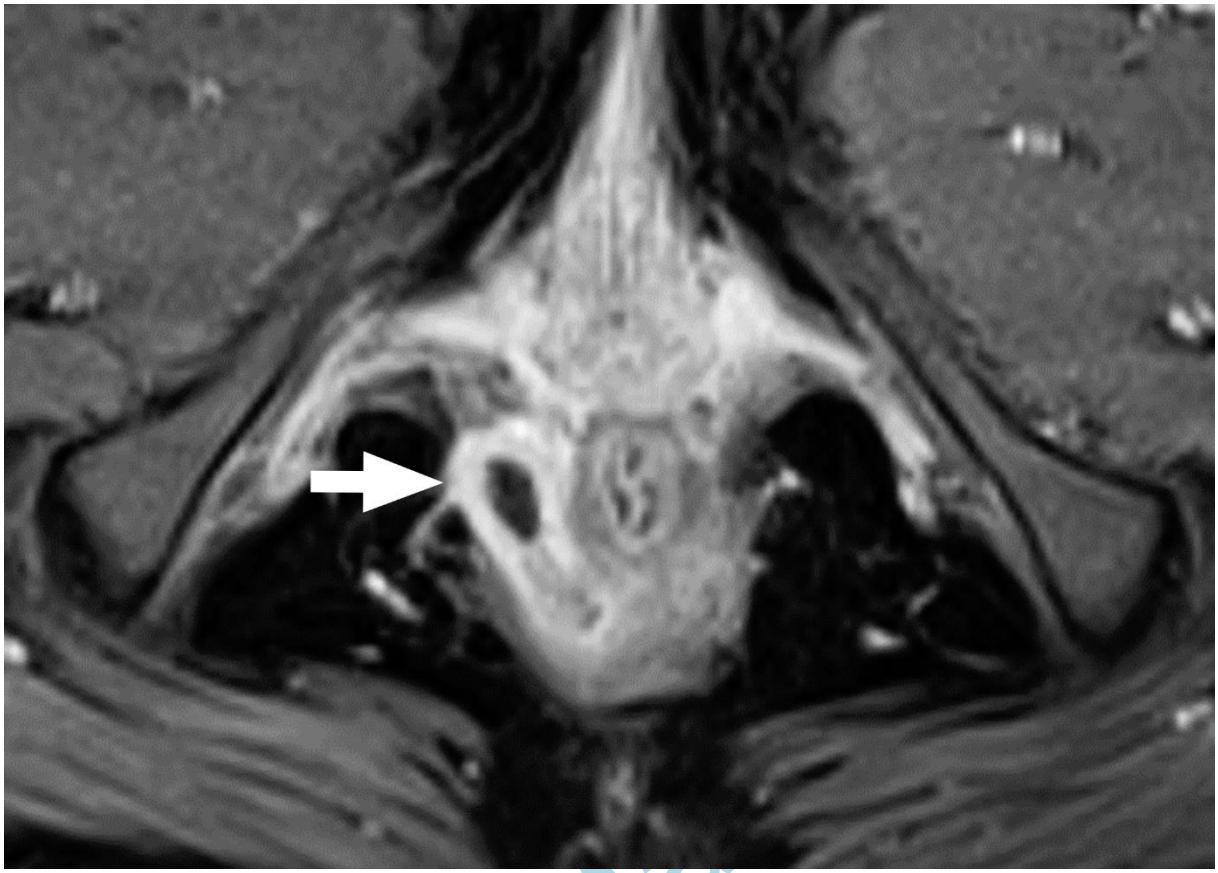

Figure 7D – see figure legend at the end of the manuscript

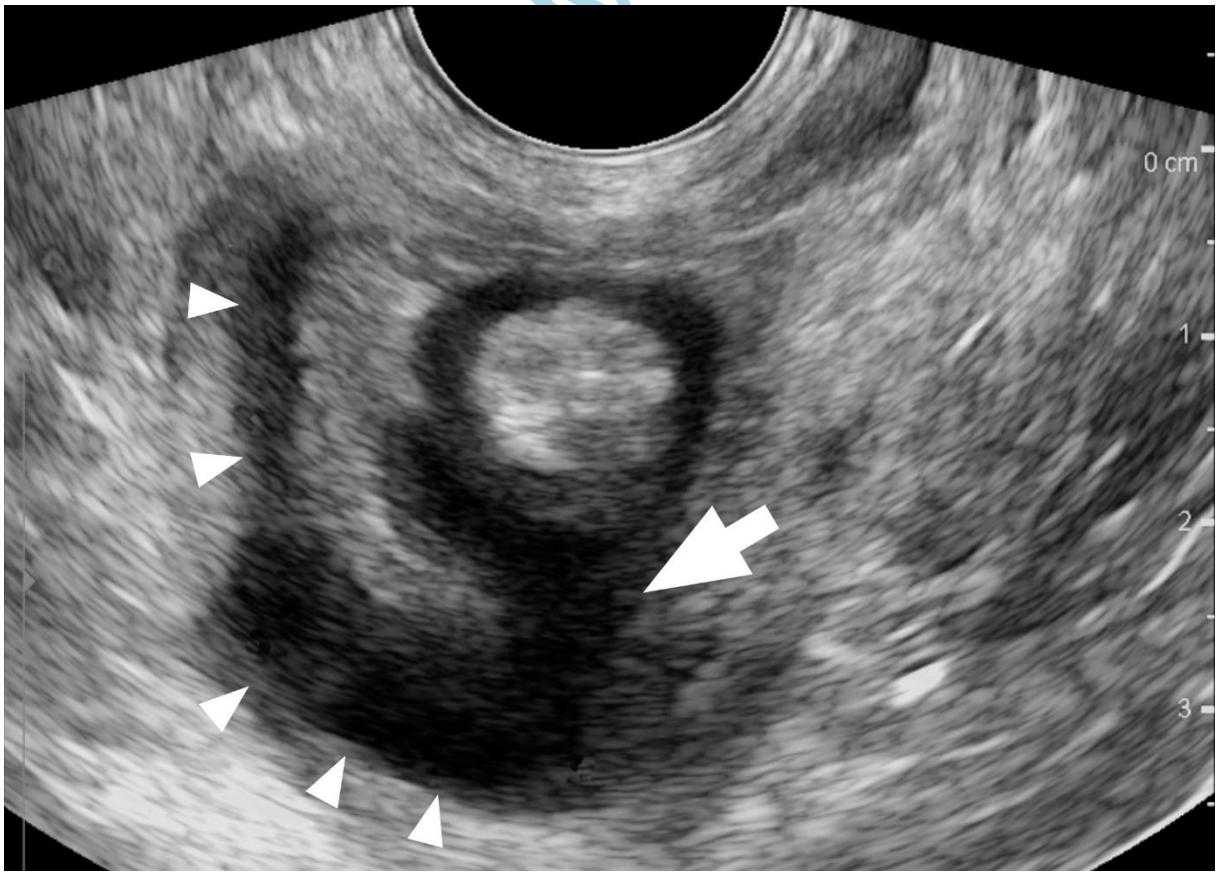

Figure 8 – see figure legend at the end of the manuscript

3.4.5. Proctitis in perianal CD

Current practice position 20

Any signs of proctitis should be included in the report, as this may influence patient management.

Proctitis may be associated with perianal fistulae in CD. Although the literature is limited, there is a strong correlation with MRI features and endoscopic disease activity. There is high interobserver agreement for increased rectal wall thickness [>9 mm, considered abnormal vs ≤6 mm, considered normal], rectal mural fat, and mesorectal features, including perimural T2 signal, perimural enhancement, creeping fat, and mesorectal lymph nodes >5 mm.[146] When any of these signs are present, they should be included in reports to prompt clinical evaluation and endoscopic assessment, as the therapeutic options and prognosis for perianal fistulae are altered in the presence of proctitis.[147]

Rectal wall thickness can be measured using EAUS and PUS. Vascularity can be measured using Doppler ultrasonography in PUS, as an association between rectal wall thickness and colour Doppler signal to endoscopic and histological score has been reported.[148, 149] Therefore, reporting of rectal wall thickness and vascularity together where an abnormal distal rectal wall [thickening > 4 mm] is detectable on US is recommended.

It should be noted that proctitis cannot be excluded based on cross-sectional imaging findings alone.

3.4.6. Perianal CD – treatment response

Current practice position 21

Response assessment reports for perianal fistulae in CD should include evaluation of the following items: number of separate fistula tracts; length of active fistula tract; fistula extension; and number and size of any prior collection. MRI changes in T2 signal intensity and post-contrast enhancement should be reported. Presence of seton, postoperative changes, or both, should also be described.

Although there is no clear definition of radiological healing, imaging features suggestive of treatment response include reduction in fistula length, reduction in number of fistula tracts, and reduction in

fistula extensions and collections. Specific MRI parameters include low T2 signal intensity within the tract [indicating fibrosis], presence of bright enhancing granulation tissue or progressively enhancing fibrosis within the tract on T1WI after gadolinium contrast administration, and reduction in size of any prior collection. [5, 6, 123, 124] The presence of a draining seton or changes due to prior fistula surgery should also be mentioned in the report.[5]

A 'partial response' on MRI indicates an overall decrease in disease and filling of the remaining tracts [at least one] with granulation tissue. Resolved collections and fibrotic tracts indicate 'complete response'. Progression of any one feature of fistula activity indicates 'Progressive disease', while no interval change indicates stable disease [Table 5].

Table 5 - Assessment of treatment response of perianal fistulizing CD on MRI using a structured approach

	STABLE DISEASE	**RESPONSE**		**PROGRESSIVE DISEASE** *
		Partial	*Complete*	
Number of separate fistulae present	No change	↓	↓	↑
Length of the active component of fistula tract	No change	↓	↓	↑
Fistula extension	No change	↓	↓	↑
Collection size	No change	↓	Absent	↑ or new collection
Hyperintensity on T2	No change	Bright signal — Granulation tissue	Dark signal — Fibrosis	Bright signal — Fluid /pus
Post-contrast enhancement	No change	Present [bright diffuse] — Granulation tissue	Present [mild diffuse] — Fibrosis	Rim enhancement — Fluid /pus

*An increase in any one of the items listed should be considered as 'progressive disease' regardless of improvement of the other features

MRI activity scoring systems, such as the Van Assche index, modified Van Assche index, and Novel MRI index for fistulizing Crohn's disease [MAGNIFI-CD] have been proposed for the evaluation of disease severity and combine morphological findings [e.g. number and length of fistula tracts] and the presence of signs of inflammation [e.g. T2 hyperintensity, T1 enhancement following gadolinium contrast].[137-139] While these MRI-based activity indices are potential tools for assessment of treatment response, the validity of these indices should be further investigated to fully determine their clinical applicability.[146, 147] Furthermore, MRI scoring systems are generally time consuming and require experienced radiologists, thus complicating implementation in everyday practice. Nevertheless, these indices may serve as a useful reminder of imaging features that may be described in the report.[124]

Patients in clinical remission [defined as closure of external opening, no fistula drainage, or both] may have persistent underlying fistula tracts on MRI and thus be at risk for early relapse and need for prolonged treatment.[150-152] This suggests that MRI healing may have considerable clinical significance, given its prognostic implications for long-term response to biological therapy.[123] Future research should focus on comparing the long-term outcomes of patients who achieve MRI healing with those who achieve only clinical remission.

The role of novel MRI sequences, such as diffusion-weighted imaging, dynamic contrast enhanced MRI, and magnetization transfer MRI as imaging biomarkers in assessment of early treatment response should be further explored.[150, 153, 154] These sequences may serve as imaging biomarkers, as they provide functional information by measuring tissue changes occurring at the molecular level. This may be useful in early evaluation of treatment response, particularly response to biological therapy.[150]

US parameters for response assessment are similar to those of pre-treatment evaluation. The number of fistulae [and corresponding length and extension] and size of any collection should be carefully assessed and measured prior to and after treatment to monitor effectiveness. Although there is no clear definition of radiological healing, imaging features indicating favourable treatment response include reduction in fistula length, reduction in number of fistula tracts, reduction in fistula extension, and reduction in size of any prior collection [155-160].

3.4.7. Perianal CD-related malignancy

Current practice position 23

Reports should highlight any features of anorectal carcinoma or a potential malignant mass in a fistulous track that requires additional investigation.

Patients with long-standing IBD are at a greater risk of malignant anorectal transformation in fistulous tracts [present >10 years].[161-164] Clinical diagnosis is challenging and a single negative biopsy does not exclude a diagnosis of cancer. Pelvic MRI may contribute to the diagnosis in screening at-risk CD patients.[162, 165] Features suggestive of mucinous adenocarcinoma arising in a fistula include a multiloculated mass with marked hyperintensity on T2-weighted MRI and progressive mesh-like internal enhancement.[162, 165]

3.4.8. Hidradenitis Suppurativa

Current practice position 24

If present, imaging features of hidradenitis suppurativa should be reported on CT and MRI and differentiated from perianal fistulizing disease.

CD is rarely associated with hidradenitis suppurativa [HS], and HS may precede CD. CD with HS is more active with an increased risk of permanent stoma.[166] CT and MRI findings of both perineal diseases overlap.[167, 168] However, bilaterality, subcutaneous oedema and granulomas, and with the location in the sacro gluteal and anterior/inguinal areas suggest HS. Predominance of features in the perianal area and rectal wall thickening favour the diagnosis of CD, in case one of the diseases is not already known.[169, 170]

Since US is often performed by a clinician, perianal skin lesions such as HS, folliculitis, and pilonidal cysts should be reported using clock-face nomenclature and described on US, including size and maximum depth in the skin. Other relevant abnormalities should also be reported [e.g., lymph node, Bartholin gland cysts, or inflammation].

3.4.9. Pouch and pouch complications

Current practice position 25

A description of pre-pouch ileum and pouch-wall inflammation [pouchitis] and its complications, such as anastomotic leakage, fistula, sinus tracks, collections, and anal or ileal strictures, should be reported when present on pelvic MRI or CT.

Pouch-related symptoms may be directly related to the surgery or may occur over the long term. Immediate postoperative complications include leakage, abscess formation, pelvic sepsis, fistula formation, and mesenteric venous thrombosis. More chronic disorders following IPAA include pouchitis, cuffitis, irritable pouch syndrome, pouch stricture, pouch sinus, afferent loop syndrome, or small-bowel obstruction. According to the current ECCO/ESGAR diagnostic guideline, pouch-related symptoms, including pouchitis, should be initially evaluated by endoscopy with biopsies.[2]

If pouch-related symptoms cannot be explained by pouchoscopy, pelvic MRI or CT should be performed, even though little is known regarding the utility of MRI and CT in postoperative pouch evaluation.[171-178] US does not have a significant role in the evaluation of pouch complications due to limited access to the affected bowel segment.

CT should be restricted to emergency cases or if MRI is unavailable because of radiation safety. [179] Description of the imaging findings for pelvic MRI or CT is provided in Table 6. How current imaging relates to prior studies should be reported where available. The radiological report should always include clinical details. Reporting and interpretation of the findings of complicated pouchitis should include the suspicion of potential misdiagnosis and need for further evaluation of CD.[171]

Table 6: Dataset on MRI/CT reporting on pouchitis and pouch complications

Imaging findings	Description/definition	Comment	Conclusion
Anastomotic leakage	Anastomotic dehiscence of the pouch or more frequently the pouch-anal anastomosis[173, 178]	Leakage may result in a sinus tract, fistula, or collection/ abscess	Reporting on pouch complications by pelvic MRI or CT should include description of anastomotic leakage, fistula, sinus tracks, collections, and small-bowel obstruction/anastomotic
Fistula	Arises from pouch or anastomosis or small bowel Describe type of fistula,	Usually associated with increased mesenteric fat adjacent to the	

	including pouch-anus, pouch-vagina, pouch-bladder, enterocutaneous[173, 178]	fistula tract Anatomical location should be described	stricture/anal stenosis [4, 171-173]
Sinus track	Wall defect that extends the pouch wall, anastomosis, or small bowel but not to adjacent organs[173, 178]		
Collection/abscess	Peripouch fluid collection with rim enhancement, internal air, or both	May be difficult to distinguish from leak in postoperative setting Anatomical location and maximal diameter should be described	
Small-bowel obstruction/anastomotic stricture/anal stenosis	Narrowing of the lumen Increased bowel-wall thickness Prestenotic dilatation [173, 178]	Small-bowel obstruction site, anal anastomosis, and ileal pouch anastomosis should be described	
Pouchitis	MRI/CT: Thickening of the bowel wall Increased peripouch fat Inflammatory changes in the fat	MRE findings correlate with the pouch endoscopic findings with high sensitivity and positive predictive value for pouchitis[176]	Pouchitis should usually be determined by endoscopic pouch evaluation[2] If pelvic MRI or CT is performed, signs of pouchitis should be described
Additional findings	e.g. osteomyelitis		

4. Summary

The current topical review establishes various core elements required for reporting cross-sectional imaging in IBD. Optimal recording ensures quality assurance and improves communication between different specialities. A large consensus was reached to establish 25 current practice positions with an interdisciplinary team of 16 experts. Commonly accepted terminology for MRI/CT and IUS, as suggested in this topical review among gastroenterologists, surgeons, and radiologists, meets a high standard of care and will further improve management of IBD patients.

This work also identified unmet clinical needs that require future clinical research and development. Standardizing descriptions of various pathological findings in cross-sectional imaging will need further research and discussion. In particular, validated disease activity scores are warranted that are suitable for clinical practice. Intensified and standardized training modules should be offered to support standardization of these imaging techniques in daily clinical use.

It is hoped that the current recommendations will provide valuable tools for the daily care of IBD patients. Many open questions still exist, particularly for utilizing scoring systems. Therefore, this topical review does not have the strength of either a guideline recommendation or a position paper statement but will act as a basis for further research and consensus development in this area.

Disclaimer

The ECCO Topical Review Projects are based on an international consensus process. Any decision about the use and interpretation of any diagnostic modality are a matter for the individual clinician and should not be based exclusively on the ECCO Topical Review content. ECCO and/or any of its staff members and/or consensus contributor may not be held liable for any information published in good faith in the ECCO Topical Reviews.

Topical review coordinators: **Torsten Kucharzik**, GE, ECCO, IBUS, GuiCom; **Jordi Rimola**, ES, ESGAR, **Antonino Spinelli**, IT, ECCO, GuiCom, **Jeroen Tielbeek**, NL, ESGAR

Working group 'assessment of inflammation'; leader: **Rune Wilkens**, DK, ECCO, IBUS members: **Jordi Rimola**, ES, ESGAR; **Søren Rafaelsen**, DK, ESGAR; **Kerri Novak**, CA, ECCO, IBUS

Working group 'assessment of complications'; leader: **Stuart Taylor**, UK, ESGAR, members: **Antonino Spinelli**, IT, ECCO; **Martina Scharitzer**, AT, ESGAR; **Robert Bryant**, AU, ECCO

Working group 'MRI to assess perianal Crohn's disease and pouch'; leader: **Damian Tolan**, UK, ESGAR, members: **Torsten Kucharzik**, GE, ECCO, IBUS; **Isabelle de Kock**, BE, ESGAR; **Christine Hoeffel**, FR, ESGAR

Working group 'EAUS/PUS to assess perianal Crohn's disease'; leader: **Dan Carter**, IS, ECCO, IBUS, members: **Jeroen Tielbeek**, NL, ESGAR; **Giovanni Maconi**, IT, ECCO, IBUS; **Christian Maaser**, GE, ECCO, IBUS

Funding

The work was initiated and funded by the European Crohn's and Colitis Organisation [ECCO] and supported by the European Society of Gastrointestinal and Abdominal Radiology [ESGAR].

Conflict of interest

ECCO has diligently maintained a disclosure policy of potential conflicts of interests [CoI]. The CoI declaration is based on a form used by the International Committee of Medical Journal Editors [ICMJE]. The CoI disclosures are open to public scrutiny on the ECCO website

[https://www.ecco-ibd.eu/about-ecco/ecco-disclosures.html], providing a comprehensive overview of the authors' potential CoI.

Acknowledgements

The authors thank the ECCO office, in particular Dauren Ramankulov, for his constant support in the development of this topical review. The authors also thank Torsten Karge from the user group-clinical guidelines services for his valued assistance during the online voting and establishing the reference list.

Author contributions

This manuscript is a joint expert consensus activity. Hence all authors participated sufficiently, intellectually or practically, to take public responsibility for the article's content, including the concept, design, data interpretation, and writing of the manuscript. All authors approved the final version of the manuscript.

Figure legends

Figure 1. Bowel wall stratification. Composite image from terminal ileum with increased bowel wall thickness [Figure 1A] seen on intestinal ultrasound [cross-section on left side and longitudinal in right side] showing preserved bowel wall stratification. Cross-section image ultrasound from a different patient [Figure 1B] shows a total disruption of bowel wall stratification of the descending colon from on the left-side image [arrowheads], and focal disruption on the right-side image [pairs of arrowheads]. The lumen is indicated with two lines.

Figure 2. Transmural changes associated with more severe inflammation detected with magnetic resonance enterography include ulceration [arrow in Figure 2A, seen as small focal disruptions in the intraluminal surface of the distended bowel] and bowel oedema [arrow in Figure 2B, seen as increased intramural signal on fat-saturated T2 sequences].

Figure 3. Bowel wall thickness and vascularization. Post-contrast fat-saturated T1 sequences [Figure 3A] shows moderate bowel wall thickening with bowel wall hyperenhancement [arrow] compared with normal thickness in the uninvolved segments [arrowhead]. Cross-section image ultrasound from a different patient with active Crohn's disease [Figure 3B] shows a thickened terminal ileum with high-colour Doppler signal intensity within and extending outside the bowel wall. These findings are consistent with active inflammatory small-bowel Crohn's disease.

Figure 4. Sticturing small bowel Crohn's disease. Coronal T2-weighted MRI image [Figure 4A] reveals a long mid ileal stricture [arrow] with dilated upstream small bowel [double arrow]. The stricture shows mural thickening and increased T2 signal, consistent with active disease.

Ultrasound image from a different patient [Figure 4B] shows an ileal stricture with mural thickening [measured at 6.2 mm] with preservation of the sonographic bowel wall layers. Small-bowel luminal contents are visualized upstream [double arrow].

Figure 5. Fistulizing Crohn's disease. Axial T2-weighted MRI image [Figure 5A] reveals a patent fluid containing simple fistula [long arrow] between the terminal ileum [asterix] and a more proximal ileal loop [arrowhead]. The involved small bowel is thickened with increased T2-weighted signal, consistent with active disease. Intestinal ultrasound image from a different patient [Figure 5B] shows a subtle ileo-ileal simple fistula without gas or fluid content [arrow].

Figure 6. Crohn's disease extraluminal complications. Axial T2-weighted MRI image [Figure 6A] demonstrates a mesenteric inflammatory mass [arrow] adjacent to an actively inflamed ileal loop [arrowhead]. The inflammatory mass has a small fluid component [asterix] and eventually formed an abscess. Ultrasound image from a different patient [Figure 6B] shows a small abscess [arrows] adjacent to an actively inflamed ileal loop [arrowheads].

Figure 7. Perianal fistula seen on pelvic MRI of a patient with colonic Crohn's disease with new perianal symptoms. Coronal and axial images on fat-saturated T2 sequences [Figures 7A and 7B] and post-contrast fat-saturated T1 sequences [Figures 7C and 7D] show a complex right transsphincteric fistula [arrowheads] with a 10-mm abscess in the roof of the right ischiorectal fossa prior to examination under anaesthesia. The abscess is high signal on fat-saturated T2 sequences [arrow in Figures 7A and 7B] with rim enhancement on post-contrast fat-saturated T1 sequences and central low signal related to the fluid component of the collection [arrow in Figures 7C and 7D].

Figure 8. Perineal ultrasound image of a patient with Crohn's disease [Figure 7A] shows a transphincteric fistula [arrow] with an associated horseshoe abscess [arrowheads].

References

1. Panes J, Bouzas R, Chaparro M, 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;34:125-45.
2. Maaser C, Sturm A, Vavricka SR, et al. ECCO-ESGAR Guideline for Diagnostic Assessment in IBD Part 1: Initial diagnosis, monitoring of known IBD, detection of complications. J Crohns Colitis 2019;13:144-164.
3. Grand DJ, Guglielmo FF, Al-Hawary MM. MR enterography in Crohn's disease: current consensus on optimal imaging technique and future advances from the SAR Crohn's disease-focused panel. Abdom Imaging 2015;40:953-64.
4. Bruining DH, Zimmermann EM, Loftus EV, Jr., et al. Consensus Recommendations for Evaluation, Interpretation, and Utilization of Computed Tomography and Magnetic Resonance Enterography in Patients With Small Bowel Crohn's Disease. Gastroenterology 2018;154:1172-1194.
5. Thipphavong S, Costa AF, Ali HA, et al. Structured reporting of MRI for perianal fistula. Abdominal Radiology 2018;44:1295-1305.
6. Halligan S, Tolan D, Amitai MM, et al. ESGAR consensus statement on the imaging of fistula-in-ano and other causes of anal sepsis. European radiology 2020;30:4734-4740.
7. Rimola J, Rodriguez S, Garcia-Bosch O, et al. Magnetic resonance for assessment of disease activity and severity in ileocolonic Crohn's disease. Gut 2009;58:1113-20.
8. Steward MJ, Punwani S, Proctor I, et al. Non-perforating small bowel Crohn's disease assessed by MRI enterography: derivation and histopathological validation of an MR-based activity index. Eur J Radiol 2012;81:2080-8.
9. Hordonneau C, Buisson A, Scanzi J, et al. Diffusion-weighted magnetic resonance imaging in ileocolonic Crohn's disease: validation of quantitative index of activity. Am J Gastroenterol 2014;109:89-98.
10. Makanyanga JC, Pendse D, Dikaios N, et al. Evaluation of Crohn's disease activity: initial validation of a magnetic resonance enterography global score (MEGS) against faecal calprotectin. Eur Radiol 2014;24:277-87.
11. Ordás I, Rimola J, Alfaro I, et al. Development and Validation of a Simplified Magnetic Resonance Index of Activity for Crohn's Disease. Gastroenterology 2019;157:432-439.e1.
12. Goodsall TM, Nguyen TM, Parker CE, et al. Systematic Review: Gastrointestinal Ultrasound Scoring Indices for Inflammatory Bowel Disease. J Crohns Colitis 2021;15:125-142.
13. Sævik F, Eriksen R, Eide GE, et al. Development and Validation of a Simple Ultrasound Activity Score for Crohn's Disease. Journal of Crohn's & colitis 2021;15:115-124.
14. Calabrese E, Petruzziello C, Onali S, et al. Severity of postoperative recurrence in crohn's disease: Correlation between endoscopic and sonographic findings. Inflammatory Bowel Diseases 2009;15:1635-1642.
15. Lu C, Gui X, Chen W, et al. Ultrasound Shear Wave Elastography and Contrast Enhancement. Inflammatory Bowel Diseases 2017;23:421-430.

16. Messadeg L, Hordonneau C, Bouguen G, et al. Early Transmural Response Assessed Using Magnetic Resonance Imaging Could Predict Sustained Clinical Remission and Prevent Bowel Damage in Patients with Crohn's Disease Treated with Anti-Tumour Necrosis Factor Therapy. Journal of Crohn's and Colitis 2020;14:1524-1534.
17. Ripollés T, Rausell N, Paredes JM, et al. Effectiveness of contrast-enhanced ultrasound for characterisation of intestinal inflammation in Crohn's disease: A comparison with surgical histopathology analysis. Journal of Crohn's and Colitis 2013;7:120-128.
18. Novak KL, Kaplan GG, Panaccione R, et al. A Simple Ultrasound Score for the Accurate Detection of Inflammatory Activity in Crohn's Disease. Inflammatory Bowel Diseases 2017;23:2001-2010.
19. Novak KL, Nylund K, Maaser C, et al. Expert Consensus on Optimal Acquisition and Development of the International Bowel Ultrasound Segmental Activity Score [IBUS-SAS]: A Reliability and Inter-rater Variability Study on Intestinal Ultrasonography in Crohn's Disease. Journal of Crohn's & colitis 2021;15:609-616.
20. Ripollés T, Poza J, Suarez Ferrer C, et al. Evaluation of Crohn's Disease Activity: Development of an Ultrasound Score in a Multicenter Study. Inflammatory Bowel Diseases 2020;27:145-154.
21. Ordás I, Rimola J, Rodríguez S, 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.
22. Taylor SA, Mallett S, Bhatnagar G, et al. Diagnostic accuracy of magnetic resonance enterography and small bowel ultrasound for the extent and activity of newly diagnosed and relapsed Crohn's disease (METRIC): a multicentre trial. The Lancet Gastroenterology & Hepatology. Volume 3. S.A. Taylor, 2018:548-558.
23. Nylund K, Hausken T, Ødegaard S, et al. Gastrointestinal Wall Thickness Measured with Transabdominal Ultrasonography and Its Relationship to Demographic Factors in Healthy Subjects. Ultraschall in der Medizin - European Journal of Ultrasound 2012;33:E225-E232.
24. Hallé E, Azahaf M, Duveau N, et al. Radiological Response Is Associated with Better Outcomes and Should Be Considered a Therapeutic Target in Crohn's Disease. Digestive Diseases and Sciences 2019;65:2664-2674.
25. Horsthuis K, Bipat S, Bennink RJ, et al. Inflammatory Bowel Disease Diagnosed with US, MR, Scintigraphy, and CT: Meta-analysis of Prospective Studies. Radiology 2008;247:64-79.
26. Kucharzik T, Wittig BM, Helwig U, et al. Use of Intestinal Ultrasound to Monitor Crohn's Disease Activity. Clinical Gastroenterology and Hepatology 2017;15:535-542.e2.
27. Maaser C, Petersen F, Helwig U, et al. Intestinal ultrasound for monitoring therapeutic response in patients with ulcerative colitis: results from the TRUST&UC study. Gut 2020;69:1629-1636.
28. Maconi G, Nylund K, Ripolles T, et al. EFSUMB Recommendations and Clinical Guidelines for Intestinal Ultrasound (GIUS) in Inflammatory Bowel Diseases. Ultraschall in der Medizin - European Journal of Ultrasound 2018;39:304-317.
29. Goodsall TM, Jairath V, Feagan BG, et al. Standardisation of intestinal ultrasound scoring in clinical trials for luminal Crohn's disease. Aliment Pharmacol Ther 2021;53:873-886.

30. Bots S, Nylund K, Löwenberg M, et al. Intestinal Ultrasound to Assess Disease Activity in Ulcerative Colitis: Development of a novel UC-Ultrasound Index. Journal of Crohn's and Colitis 2021.
31. Tielbeek JAW, Bipat S, Boellaard TN, et al. Training readers to improve their accuracy in grading Crohn's disease activity on MRI. European Radiology 2014;24:1059-1067.
32. Wilkens R, Hagemann-Madsen RH, Peters DA, et al. Validity of Contrast-enhanced Ultrasonography and Dynamic Contrast-enhanced MR Enterography in the Assessment of Transmural Activity and Fibrosis in Crohn's Disease. Journal of Crohn's and Colitis 2017;12:48-56.
33. Buisson A, Joubert A, Montoriol PF, et al. Diffusion-weighted magnetic resonance imaging for detecting and assessing ileal inflammation in Crohn's disease. Alimentary Pharmacology & Therapeutics 2013;37:537-545.
34. Bhatnagar G, Quinn L, Higginson A, et al. Observer agreement for small bowel ultrasound in Crohn's disease: results from the METRIC trial. Abdominal radiology (New York) 2020;45:3036-3045.
35. Kunihiro K, Hata J, Haruma K, et al. Sonographic detection of longitudinal ulcers in Crohn disease. Scandinavian Journal of Gastroenterology 2004;39:322-326.
36. Calabrese E, Kucharzik T, Maaser C, et al. Real-time Interobserver Agreement in Bowel Ultrasonography for Diagnostic Assessment in Patients With Crohn's Disease: An International Multicenter Study. Inflammatory Bowel Diseases 2018;24:2001-2006.
37. Oussalah A, Laurent V, Bruot O, et al. Diffusion-weighted magnetic resonance without bowel preparation for detecting colonic inflammation in inflammatory bowel disease. Gut 2010;59:1056-1065.
38. Rimola J, Rodriguez S, Garcia-Bosch O, et al. Magnetic resonance for assessment of disease activity and severity in ileocolonic Crohn's disease. Gut 2009;58:1113-1120.
39. Steward MJ, Punwani S, Proctor I, et al. Non-perforating small bowel Crohn's disease assessed by MRI enterography: Derivation and histopathological validation of an MR-based activity index. European Journal of Radiology 2012;81:2080-2088.
40. Dohan A, Taylor S, Hoeffel C, et al. Diffusion-weighted MRI in Crohn's disease: Current status and recommendations. Journal of Magnetic Resonance Imaging 2016;44:1381-1396.
41. Kim K-J, Lee Y, Park SH, et al. Diffusion-weighted MR Enterography for Evaluating Crohn's Disease. Inflammatory Bowel Diseases 2015;21:101-109.
42. Bots S, Nylund K, Löwenberg M, et al. Ultrasound for Assessing Disease Activity in IBD Patients: A Systematic Review of Activity Scores. Journal of Crohn's and Colitis 2018;12:920-929.
43. Ripollés T, Martínez MJ, Paredes JM, et al. Crohn Disease: Correlation of Findings at Contrast-enhanced US with Severity at Endoscopy. Radiology 2009;253:241-248.
44. Esteban J, Maldonado L, Sanchiz V, et al. Activity of Crohn's disease assessed by colour Doppler ultrasound analysis of the affected loops. European Radiology 2001;11:1423-1428.
45. Moreno N, Ripollés T, Paredes JM, et al. Usefulness of abdominal ultrasonography in the analysis of endoscopic activity in patients with Crohn's disease: Changes following treatment with immunomodulators and/or anti-TNF antibodies. Journal of Crohn's and Colitis 2014;8:1079-1087.

46. Ripollés T, Paredes JM, Martínez-Pérez MJ, et al. Ultrasonographic Changes at 12 Weeks of Anti-TNF Drugs Predict 1-year Sonographic Response and Clinical Outcome in Crohn's Disease. Inflammatory Bowel Diseases 2016;22:2465-2473.
47. Sasaki T, Kunisaki R, Kinoshita H, et al. Doppler ultrasound findings correlate with tissue vascularity and inflammation in surgical pathology specimens from patients with small intestinal Crohn's disease. BMC research notes 2014;7:363-363.
48. De Voogd F, Wilkens R, Gecse K, et al. A Reliability Study: Strong Inter-Observer Agreement of an Expert Panel for Intestinal Ultrasound in Ulcerative Colitis. Journal of Crohn's and Colitis 2021.
49. Meyers MA, McGuire PV. Spiral CT demonstration of hypervascularity in Crohn disease: "vascular jejunization of the ileum" or the "comb sign". Abdominal Imaging 1995;20:327-332.
50. Ordás I, Rimola J, García-Bosch O, et al. Diagnostic accuracy of magnetic resonance colonography for the evaluation of disease activity and severity in ulcerative colitis: a prospective study. Gut 2012;62:1566-1572.
51. Rimola J, Fernandez-Clotet A, Capozzi N, et al. Pre-treatment magnetic resonance enterography findings predict the response to TNF-alpha inhibitors in Crohn's disease. Aliment Pharmacol Ther 2020;52:1563-1573.
52. Taylor SA, Avni F, Cronin CG, et al. The first joint ESGAR/ ESPR consensus statement on the technical performance of cross-sectional small bowel and colonic imaging. Eur Radiol 2017;27:2570-2582.
53. Menys A, Puylaert C, Tutein Nolthenius CE, et al. Quantified Terminal Ileal Motility during MR Enterography as a Biomarker of Crohn Disease Activity: Prospective Multi-Institution Study. Radiology 2018;289:428-435.
54. Girometti R, Zuiani C, Toso F, et al. MRI Scoring System Including Dynamic Motility Evaluation in Assessing the Activity of Crohn's Disease of the Terminal Ileum. Academic Radiology 2008;15:153-164.
55. Serafin Z, Białecki M, Białecka A, et al. Contrast-enhanced Ultrasound for Detection of Crohn's Disease Activity: Systematic Review and Meta-analysis. Journal of Crohn's & colitis 2016;10:354-362.
56. Wilkens R, Novak KL, Maaser C, et al. Relevance of monitoring transmural disease activity in patients with Crohn's disease: current status and future perspectives. Therapeutic advances in gastroenterology 2021;14:17562848211006672-17562848211006672.
57. Castiglione F, Imperatore N, Testa A, et al. One-year clinical outcomes with biologics in Crohn's disease: transmural healing compared with mucosal or no healing. Alimentary Pharmacology & Therapeutics 2019;49:1026-1039.
58. Rimola J, Alfaro I, Fernández-Clotet A, et al. Persistent damage on magnetic resonance enterography in patients with Crohn's disease in endoscopic remission. Alimentary Pharmacology & Therapeutics 2018;48:1232-1241.
59. Deepak P, Fletcher JG, Fidler JL, et al. Radiological Response Is Associated With Better Long-Term Outcomes and Is a Potential Treatment Target in Patients With Small Bowel Crohn's Disease. American Journal of Gastroenterology 2016;111:997-1006.
60. Rutgeerts P, Geboes K, Vantrappen G, et al. Predictability of the postoperative course of Crohn's disease. Gastroenterology 1990;99:956-963.

61. Castiglione F, Bucci L, Pesce G, et al. Oral contrast-enhanced sonography for the diagnosis and grading of postsurgical recurrence of Crohn's disease. Inflammatory Bowel Diseases 2008;14:1240-1245.
62. Martínez MJ, Ripollés T, Paredes JM, et al. Intravenous Contrast-Enhanced Ultrasound for Assessing and Grading Postoperative Recurrence of Crohn's Disease. Digestive Diseases and Sciences 2019;64:1640-1650.
63. Onali S, Calabrese E, Petruzziello C, et al. Endoscopic vs ultrasonographic findings related to Crohn's Disease recurrence: A prospective longitudinal study at 3years. Journal of Crohn's and Colitis 2010;4:319-328.
64. Paredes JM, Ripollés T, Cortés X, et al. Contrast-enhanced ultrasonography: Usefulness in the assessment of postoperative recurrence of Crohn's disease. Journal of Crohn's and Colitis 2013;7:192-201.
65. Sailer J, Peloschek P, Reinisch W, et al. Anastomotic recurrence of Crohn's disease after ileocolic resection: comparison of MR enteroclysis with endoscopy. European Radiology 2008;18:2512-2521.
66. Louis E, Collard A, Oger AF, et al. Behaviour of Crohn's disease according to the Vienna classification: changing pattern over the course of the disease. Gut 2001;49:777-82.
67. Rimola J, Capozzi N. Differentiation of fibrotic and inflammatory component of Crohn's disease-associated strictures. Intest Res 2020;18:144-150.
68. Panes J, Bouhnik Y, Reinisch W, et al. Imaging techniques for assessment of inflammatory bowel disease: joint ECCO and ESGAR evidence-based consensus guidelines. J Crohns Colitis 2013;7:556-85.
69. Rieder F, Bettenworth D, Ma C, et al. An expert consensus to standardise definitions, diagnosis and treatment targets for anti-fibrotic stricture therapies in Crohn's disease. Aliment Pharmacol Ther 2018;48:347-357.
70. Guglielmo FF, Anupindi SA, Fletcher JG, et al. Small Bowel Crohn Disease at CT and MR Enterography: Imaging Atlas and Glossary of Terms. Radiographics 2020;40:354-375.
71. Bossuyt P, Debeuckelaere C, Ferrante M, et al. Risk Stratification for Surgery in Stricturing Ileal Crohn's Disease: The BACARDI Risk Model. J Crohns Colitis 2018;12:32-38.
72. Bouhnik Y, Carbonnel F, Laharie D, et al. Efficacy of adalimumab in patients with Crohn's disease and symptomatic small bowel stricture: a multicentre, prospective, observational cohort (CREOLE) study. Gut 2018;67:53-60.
73. Chaudhry NA, Riverso M, Grajo JR, et al. A Fixed Stricture on Routine Cross-sectional Imaging Predicts Disease-Related Complications and Adverse Outcomes in Patients with Crohn's Disease. Inflamm Bowel Dis 2017;23:641-649.
74. Schulberg JD, Wright EK, Holt BA, et al. Magnetic resonance enterography for predicting the clinical course of Crohn's disease strictures. J Gastroenterol Hepatol 2020;35:980-987.
75. Stocker D, King MJ, El Homsi M, et al. Luminal narrowing alone allows an accurate diagnosis of Crohn's disease small bowel strictures at cross-sectional imaging. J Crohns Colitis 2020.
76. Bryant RV, Friedman AB, Wright EK, et al. Gastrointestinal ultrasound in inflammatory bowel disease: an underused resource with potential paradigm-changing application. Gut 2018;67:973-985.

77. Flint A, Chaudhry NA, Riverso M, et al. Effective communication of cross-sectional imaging findings in Crohn's disease: comparing conventional EMR reporting to a published scoring system. Abdom Radiol (NY) 2018;43:1798-1806.
78. Allocca M, Bonifacio C, Fiorino G, et al. Efficacy of tumour necrosis factor antagonists in stricturing Crohn's disease: A tertiary center real-life experience. Dig Liver Dis 2017;49:872-877.
79. Orscheln ES, Dillman JR, Towbin AJ, et al. Penetrating Crohn disease: does it occur in the absence of stricturing disease? Abdom Radiol (NY) 2018;43:1583-1589.
80. Allocca M, Fiorino G, Bonifacio C, et al. Noninvasive Multimodal Methods to Differentiate Inflamed vs Fibrotic Strictures in Patients With Crohn's Disease. Clin Gastroenterol Hepatol 2019;17:2397-2415.
81. Weber NK, Fletcher JG, Fidler JL, et al. Clinical characteristics and imaging features of small bowel adenocarcinomas in Crohn's disease. Abdom Imaging 2015;40:1060-7.
82. Radmard AR, Amouei M, Kooraki S, et al. Potential MR Enterography Features to Differentiate Primary Small Intestinal Lymphoma from Crohn Disease. American Journal of Roentgenology 2020;215:864-873.
83. Magro F, Langner C, Driessen A, et al. European consensus on the histopathology of inflammatory bowel disease. J Crohns Colitis 2013;7:827-51.
84. Rees MA, Dillman JR, Anton CG, et al. Inter-radiologist agreement using Society of Abdominal Radiology-American Gastroenterological Association (SAR-AGA) consensus nomenclature for reporting CT and MR enterography in children and young adults with small bowel Crohn disease. Abdom Radiol (NY) 2019;44:391-397.
85. Herrmann KA, Michaely HJ, Zech CJ, et al. Internal fistulas in Crohn disease: magnetic resonance enteroclysis. Abdom Imaging 2006;31:675-87.
86. Braithwaite KA, Alazraki AL. Use of the star sign to diagnose internal fistulas in pediatric patients with penetrating Crohn disease by MR enterography. Pediatr Radiol 2014;44:926-31.
87. Sampietro GM, Casiraghi S, Foschi D. Perforating Crohn's disease: conservative and surgical treatment. Dig Dis 2013;31:218-21.
88. Bollegala N, Griller N, Bannerman H, et al. Ultrasound vs Endoscopy, Surgery, or Pathology for the Diagnosis of Small Bowel Crohn's Disease and its Complications. Inflamm Bowel Dis 2019;25:1313-1338.
89. Kaushal P, Somwaru AS, Charabaty A, et al. MR Enterography of Inflammatory Bowel Disease with Endoscopic Correlation. Radiographics 2017;37:116-131.
90. Rieder F, Zimmermann EM, Remzi FH, et al. Crohn's disease complicated by strictures: a systematic review. Gut 2013;62:1072-84.
91. Baker ME, Fletcher JG, Al-Hawary M, et al. Interdisciplinary Updates in Crohn's Disease Reporting Nomenclature, and Cross-Sectional Disease Monitoring. Radiol Clin North Am 2018;56:691-707.
92. Leyendecker JR, Bloomfeld RS, DiSantis DJ, et al. MR enterography in the management of patients with Crohn disease. Radiographics 2009;29:1827-46.
93. Goldstone RN, Steinhagen RM. Abdominal Emergencies in Inflammatory Bowel Disease. Surg Clin North Am 2019;99:1141-1150.
94. Shin D, Rahimi H, Haroon S, et al. Imaging of Gastrointestinal Tract Perforation. Radiol Clin North Am 2020;58:19-44.

95. Ripollés T, Martínez-Pérez MJ, Paredes JM, et al. Contrast-enhanced ultrasound in the differentiation between phlegmon and abscess in Crohn's disease and other abdominal conditions. Eur J Radiol 2013;82:e525-31.
96. Tolan DJ, Greenhalgh R, Zealley IA, et al. MR enterographic manifestations of small bowel Crohn disease. Radiographics 2010;30:367-84.
97. Patil SA, Cross RK. Medical versus surgical management of penetrating Crohn's disease: the current situation and future perspectives. Expert Rev Gastroenterol Hepatol 2017;11:843-848.
98. Dietrich CF, Lorentzen T, Appelbaum L, et al. EFSUMB Guidelines on Interventional Ultrasound (INVUS), Part III - Abdominal Treatment Procedures (Short Version). Ultraschall Med 2016;37:27-45.
99. Duszak RL, Jr., Levy JM, Akins EW, et al. Percutaneous catheter drainage of infected intra-abdominal fluid collections. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000;215 Suppl:1067-75.
100. Richards RJ. Management of abdominal and pelvic abscess in Crohn's disease. World J Gastrointest Endosc 2011;3:209-12.
101. Feagins LA, Holubar SD, Kane SV, et al. Current strategies in the management of intra-abdominal abscesses in Crohn's disease. Clin Gastroenterol Hepatol 2011;9:842-50.
102. Clancy C, Boland T, Deasy J, et al. A Meta-analysis of Percutaneous Drainage Versus Surgery as the Initial Treatment of Crohn's Disease-related Intra-abdominal Abscess. J Crohns Colitis 2016;10:202-8.
103. Worley GHT, Segal JP, Warusavitarne J, et al. Management of early pouch-related septic complications in ulcerative colitis: a systematic review. Colorectal Dis 2018;20:O181-O189.
104. Allen BC, Barnhart H, Bashir M, et al. Diagnostic accuracy of intra-abdominal fluid collection characterization in the era of multidetector computed tomography. Am Surg 2012;78:185-9.
105. Ulitzsch D, Nyman MK, Carlson RA. Breast abscess in lactating women: US-guided treatment. Radiology 2004;232:904-9.
106. Cardinal E, Bureau NJ, Aubin B, et al. Role of ultrasound in musculoskeletal infections. Radiol Clin North Am 2001;39:191-201.
107. Gervais DA, Brown SD, Connolly SA, et al. Percutaneous imaging-guided abdominal and pelvic abscess drainage in children. Radiographics 2004;24:737-54.
108. Jaffe TA, Nelson RC. Image-guided percutaneous drainage: a review. Abdom Radiol (NY) 2016;41:629-36.
109. Lagana D, Carrafiello G, Mangini M, et al. Image-guided percutaneous treatment of abdominal-pelvic abscesses: a 5-year experience. Radiol Med 2008;113:999-1007.
110. Okita Y, Mohri Y, Kobayashi M, et al. Factors influencing the outcome of image-guided percutaneous drainage of intra-abdominal abscess after gastrointestinal surgery. Surg Today 2013;43:1095-102.
111. Patel IJ, Davidson JC, Nikolic B, et al. Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. J Vasc Interv Radiol 2012;23:727-36.
112. Akinci D, Ergun O, Topel C, et al. Pelvic abscess drainage: outcome with factors affecting the clinical success. Diagn Interv Radiol 2018;24:146-152.

113. Violi NV, Schoepfer AM, Fournier N, et al. Prevalence and clinical importance of mesenteric venous thrombosis in the Swiss Inflammatory Bowel Disease Cohort. AJR Am J Roentgenol 2014;203:62-9.
114. Podugu A, Tandon K, Castro FJ. Crohn's disease presenting as acute gastrointestinal hemorrhage. World J Gastroenterol 2016;22:4073-8.
115. Yoon W, Jeong YY, Shin SS, et al. Acute massive gastrointestinal bleeding: detection and localization with arterial phase multi-detector row helical CT. Radiology 2006;239:160-7.
116. Power N, Atri M, Ryan S, et al. CT assessment of anastomotic bowel leak. Clin Radiol 2007;62:37-42.
117. Fuglestad MA, Thompson JS. Inflammatory Bowel Disease and Short Bowel Syndrome. Surg Clin North Am 2019;99:1209-1221.
118. Cheng W, Zhang S, Wang J, et al. Three-dimensional CT enterography versus barium follow-through examination in measurement of remnant small intestinal length in short bowel syndrome patients. Abdom Radiol (NY) 2018;43:2955-2962.
119. Autenrieth DM, Baumgart DC. Toxic megacolon. Inflamm Bowel Dis 2012;18:584-91.
120. Smith RL, Taylor KM, Friedman AB, et al. Systematic Review: Clinical Utility of Gastrointestinal Ultrasound in the Diagnosis, Assessment and Management of Patients With Ulcerative Colitis. J Crohns Colitis 2020;14:465-479.
121. Desai J, Elnaggar M, Hanfy AA, et al. Toxic Megacolon: Background, Pathophysiology, Management Challenges and Solutions. Clin Exp Gastroenterol 2020;13:203-210.
122. Gan SI, Beck PL. A new look at toxic megacolon: an update and review of incidence, etiology, pathogenesis, and management. Am J Gastroenterol 2003;98:2363-71.
123. Lee T, Yong E, Ding NS. Radiological outcomes in perianal fistulizing Crohn's disease: A systematic review and meta-analysis. JGH open : an open access journal of gastroenterology and hepatology 2019;4:340-344.
124. Sheedy SP, Bruining DH, Dozois EJ, et al. MR Imaging of Perianal Crohn Disease. Radiology 2017;282:628-645.
125. Sandborn WJ, Fazio VW, Feagan BG, et al. AGA technical review on perianal Crohn's disease. Gastroenterology 2003;125:1508-30.
126. Parks AG, Gordon PH, Hardcastle JD. A classification of fistula-in-ano. British Journal of Surgery 1976;63:1-12.
127. Maconi G, Tonolini M, Monteleone M, et al. Transperineal Perineal Ultrasound Versus Magnetic Resonance Imaging In the Assessment of Perianal Crohn's Disease. Inflammatory Bowel Diseases 2013;19:2737-2743.
128. Zbar AP, Horesh N, Bucholtz V, et al. Are there specific endosonographic features in Crohn's patients with perianal fistulae? Journal of Crohn's and Colitis 2013;7:490-496.
129. Albuquerque A. Endoanal ultrasonography in fecal incontinence: Current and future perspectives. World journal of gastrointestinal endoscopy 2015;7:575-581.
130. Rao SSC. Advances in Diagnostic Assessment of Fecal Incontinence and Dyssynergic Defecation. Clinical Gastroenterology and Hepatology 2010;8:910-919.e2.
131. Fazio VW. Complex Anal Fistulae. Gastroenterology Clinics of North America 1987;16:93-114.
132. Garcés-Albir M, García-Botello SA, Espi A, et al. Three-dimensional endoanal ultrasound for diagnosis of perianal fistulas: Reliable and objective technique. World journal of gastrointestinal surgery 2016;8:513-520.

133. Stewart LK, McGee J, Wilson SR. Transperineal and Transvaginal Sonography of Perianal Inflammatory Disease. American Journal of Roentgenology 2001;177:627-632.
134. Maconi G, Ardizzone S, Greco S, et al. Transperineal Ultrasound in the Detection of Perianal and Rectovaginal Fistulae in Crohn's Disease. The American Journal of Gastroenterology 2007;102:2214-2219.
135. Rizzo JA, Naig AL, Johnson EK. Anorectal Abscess and Fistula-in-Ano: Evidence-Based Management. Surgical Clinics of North America 2010;90:45-68.
136. Nevler A, Beer-Gabel M, Lebedyev A, et al. Transperineal ultrasonography in perianal Crohn's disease and recurrent cryptogenic fistula-in-ano. Colorectal Disease 2013;15:1011-1018.
137. Hindryckx P, Jairath V, Zou G, et al. Development and Validation of a Magnetic Resonance Index for Assessing Fistulas in Patients With Crohn's Disease. Gastroenterology 2019;157:1233-1244.e5.
138. Samaan MA, Puylaert CAJ, Levesque BG, et al. The development of a magnetic resonance imaging index for fistulising Crohn's disease. Alimentary Pharmacology & Therapeutics 2017;46:516-528.
139. Van Assche G. Magnetic resonance imaging of the effects of infliximab on perianal fistulizing Crohn's disease. The American Journal of Gastroenterology 2003;98:332-339.
140. Losco A, Viganò C, Conte D, et al. Assessing the activity of perianal Crohn's disease: Comparison of clinical indices and computer-assisted anal ultrasound. Inflammatory Bowel Diseases 2009;15:742-749.
141. Rosenshein NB, Genadry RR, Woodruff JD. An anatomic classification of retovaginal septal defects. American Journal of Obstetrics and Gynecology 1980;137:439-442.
142. Stoker J, Rociu E, Schouten WR, et al. Anovaginal and Rectovaginal Fistulas. American Journal of Roentgenology 2002;178:737-741.
143. Di Nardo R, Drudi FM, Marziale P, et al. [Role of color Doppler echography in the visualization of perianal fistulae with injections of physiologic solutions]. Radiol Med 2000;100:235-9.
144. Dietrich CF. Significance of Abdominal Ultrasound in Inflammatory Bowel Disease. Digestive Diseases 2009;27:482-493.
145. Piscaglia F, Nolsøe C, Dietrich C, et al. The EFSUMB Guidelines and Recommendations on the Clinical Practice of Contrast Enhanced Ultrasound (CEUS): Update 2011 on non-hepatic applications. Ultraschall in der Medizin - European Journal of Ultrasound 2011;33:33-59.
146. Horsthuis K, Ziech MLW, Bipat S, et al. Evaluation of an MRI-based score of disease activity in perianal fistulizing Crohn's disease. Clinical Imaging 2011;35:360-365.
147. van Rijn KL, Lansdorp CA, Tielbeek JAW, et al. Evaluation of the modified Van Assche index for assessing response to anti-TNF therapy with MRI in perianal fistulizing Crohn's disease. Clinical Imaging 2020;59:179-187.
148. Ellrichmann M, Wietzke-Braun P, Dhar S, et al. Endoscopic ultrasound of the colon for the differentiation of Crohn's disease and ulcerative colitis in comparison with healthy controls. Alimentary Pharmacology & Therapeutics 2014;39:823-833.
149. Sagami S, Kobayashi T, Aihara K, et al. Transperineal ultrasound predicts endoscopic and histological healing in ulcerative colitis. Alimentary Pharmacology & Therapeutics 2020;51:1373-1383.

150. Gallego JC, Echarri A. Role of magnetic resonance imaging in the management of perianal Crohn's disease. Insights into imaging 2018;9:47-58.
151. Gecse KB, Sebastian S, Hertogh Gd, et al. Results of the Fifth Scientific Workshop of the ECCO [II]: Clinical Aspects of Perianal Fistulising Crohn's Disease—the Unmet Needs. Journal of Crohn's and Colitis 2016;10:758-765.
152. Thomassin L, Armengol-Debeir L, Charpentier C, et al. Magnetic resonance imaging may predict deep remission in patients with perianal fistulizing Crohn's disease. World journal of gastroenterology 2017;23:4285-4292.
153. Pinson C, Dolores M, Cruypeninck Y, et al. Magnetization transfer ratio for the assessment of perianal fistula activity in Crohn's disease. European Radiology 2016;27:80-87.
154. Ziech MLW, Lavini C, Bipat S, et al. Dynamic Contrast-Enhanced MRI in Determining Disease Activity in Perianal Fistulizing Crohn Disease: A Pilot Study. American Journal of Roentgenology 2013;200:W170-W177.
155. Ardizzone S, Maconi G, Colombo E, et al. Perianal Fistulae Following Infliximab Treatment. Inflammatory Bowel Diseases 2004;10:91-96.
156. Guidi L, Ratto C, Semeraro S, et al. Combined therapy with infliximab and seton drainage for perianal fistulizing Crohn's disease with anal endosonographic monitoring: a single-centre experience. Techniques in Coloproctology 2008;12:111-117.
157. Rasul I, Wilson SR, MacRae H, et al. Clinical and Radiological Responses after Infliximab Treatment for Perianal Fistulizing Crohn's Disease. American Journal of Gastroenterology 2004;99:82-88.
158. Spradlin NM, Wise PE, Herline AJ, et al. A Randomized Prospective Trial of Endoscopic Ultrasound to Guide Combination Medical and Surgical Treatment for Crohn's Perianal Fistulas. The American Journal of Gastroenterology 2008;103:2527-2535.
159. West RL, van der Woude CJ, Hansen BE, et al. Clinical and endosonographic effect of ciprofloxacin on the treatment of perianal fistulae in Crohn's disease with infliximab: a double-blind placebo-controlled study. Alimentary Pharmacology & Therapeutics 2004;20:1329-1336.
160. Schwartz DA, White CM, Wise PE, et al. Use of Endoscopic Ultrasound to Guide Combination Medical and Surgical Therapy for Patients With Crohn's Perianal Fistulas. Inflammatory Bowel Diseases 2005;11:727-732.
161. Barral M, Hoeffel C, Boudiaf M, et al. Rectal cancer in inflammatory bowel diseases: MR imaging findings. Abdominal Imaging 2014;39:443-451.
162. Hama Y, Makita K, Yamana T, et al. Mucinous Adenocarcinoma Arising from Fistula in Ano: MRI Findings. American Journal of Roentgenology 2006;187:517-521.
163. Iesalnieks I, Gaertner WB, Gla H, et al. Fistula-associated anal adenocarcinoma in Crohn's disease. Inflammatory Bowel Diseases 2010;16:1643-1648.
164. Shwaartz C, Munger JA, Deliz JR, et al. Fistula-Associated Anorectal Cancer in the Setting of Crohn's Disease. Diseases of the Colon & Rectum 2016;59:1168-1173.
165. Zhu X, Zhu T-S, Ye D-D, et al. Magnetic resonance imaging findings of carcinoma arising from anal fistula: A retrospective study in a single institution. World journal of clinical cases 2020;8:5159-5171.

166. Peyrin-Biroulet L, Loftus EV, Jr., Tremaine WJ, et al. Perianal Crohn's disease findings other than fistulas in a population-based cohort. Inflammatory bowel diseases 2012;18:43-48.
167. Griffin N, Williams AB, Anderson S, et al. Hidradenitis Suppurativa. Diseases of the Colon & Rectum 2014;57:762-771.
168. Monnier L, Dohan A, Amara N, et al. Anoperineal disease in Hidradenitis Suppurativa : MR imaging distinction from perianal Crohn's disease. European Radiology 2017;27:4100-4109.
169. Bouchard D, Brochard C, Vinson-Bonnet B, et al. How to manage anal ulcerations and anorectal stenosis in Crohn's disease: algorithm-based decision making. Techniques in Coloproctology 2019;23:353-360.
170. Deckers IE, Benhadou F, Koldijk MJ, et al. Inflammatory bowel disease is associated with hidradenitis suppurativa: Results from a multicenter cross-sectional study. Journal of the American Academy of Dermatology 2017;76:49-53.
171. Nadgir RN, Soto JA, Dendrinos K, et al. MRI of complicated pouchitis. AJR Am J Roentgenol 2006;187:W386-91.
172. Seggerman RE, Chen MY, Waters GS, et al. Radiology of Ileal Pouch–Anal Anastomosis Surgery. American Journal of Roentgenology 2003;180:999-1002.
173. Crema MD, Richarme D, Azizi L, et al. Pouchography, CT, and MRI features of ileal J pouch-anal anastomosis. AJR Am J Roentgenol 2006;187:W594-603.
174. Huang C, Remzi F, Dane B, et al. Reporting Templates for Magnetic Resonance Imaging and Water Soluble Contrast Enema in Patients with Ileal Pouch Anal Anastomosis: Experience from a Large Referral Center. AJR Am J Roentgenol 2020.
175. Tonolini M, Campari A, Bianco R. Ileal pouch and related complications: spectrum of imaging findings with emphasis on MRI. Abdom Imaging 2011;36:698-706.
176. Sahi KS, Lee KS, Moss A, et al. MR Enterography of the Ileoanal Pouch: Descriptive Radiologic Analysis With Endoscopic and Pathologic Correlation. AJR Am J Roentgenol 2015;205:W478-84.
177. Broder JC, Tkacz JN, Anderson SW, et al. Ileal Pouch–Anal Anastomosis Surgery: Imaging and Intervention for Post-operative Complications. RadioGraphics 2010;30:221-233.
178. Tang L, Cai H, Moore L, et al. Evaluation of endoscopic and imaging modalities in the diagnosis of structural disorders of the ileal pouch. Inflamm Bowel Dis 2010;16:1526-31.
179. Desmond AN, O'Regan K, Curran C, et al. Crohn's disease: factors associated with exposure to high levels of diagnostic radiation. Gut 2008;57:1524-9.