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CONSENSUS/GUIDELINES

Imaging techniques for assessment of inflammatory bowel disease: Joint ECCO and ESGAR evidence-based consensus guidelines

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Abstract

The management of patients with IBD requires evaluation with objective tools, both at the time of diagnosis and throughout the course of the disease, to determine the location, extension, activity and severity of inflammatory lesions, as well as, the potential existence of complications. Whereas endoscopy is a well-established and uniformly performed diagnostic examination, the implementation of radiologic techniques for assessment of IBD is still heterogeneous; variations in technical aspects and the degrees of experience and preferences exist across countries in Europe. ECCO and ESGAR scientific societies jointly elaborated a consensus to establish standards for imaging in IBD using magnetic resonance imaging, computed tomography, ultrasonography, and including also other radiologic procedures such as conventional radiology or nuclear medicine examinations for different clinical situations that include general principles, upper GI tract, colon and rectum, perineum, liver and biliary tract, emergency situation, and the postoperative setting. The statements and general recommendations of this consensus are based on the highest level of evidence available, but significant gaps remain in certain areas such as the comparison of diagnostic accuracy between different techniques, the value for therapeutic monitoring, and the prognostic implications of particular findings.

Contents

1. Objective of the consensus and methodology

The idiopathic inflammatory bowel diseases (IBD) comprise two types of chronic intestinal disorders: Crohn's disease (CD) and ulcerative colitis (UC). Accumulating evidence suggests that IBD results from an inappropriate inflammatory response to intestinal microbes in a genetically susceptible host. The management of patients with IBD requires evaluation with objective tools, both at the time of diagnosis and throughout the course of the disease, to determine the location, extension, activity and severity of inflammatory lesions, as well as, the potential existence of complications. This information is crucial to select appropriate therapeutic strategies in a particular patient, and has prognostic implications.

Whereas endoscopy is a well-established and uniformly performed diagnostic examination, the implementation of radiologic techniques for assessment of IBD is still heterogeneous; variations in technical aspects and the degrees of experience and preferences exist across countries in Europe. This reality led to the recognition among members of ECCO and ESGAR scientific societies that practical guidance for the use or cross-sectional imaging in IBD is needed, and that convergence of knowledge in the fields of IBD and radiology was necessary to provide the best evidence-based recommendations. This joint ECCO–ESGAR project was started on 2010, and developed during 2011 and 2012 to generate a consensus on imaging in IBD. The consensus organizing committee was made up by three members of ESGAR (AL, JS, ST) and three members of ECCO (YB, JP, WR) providing a broad national diversity.

The aim of the project was to establish standards for imaging in IBD using magnetic resonance imaging (MRI), computed tomography (CT), ultrasonography (US), and including also other radiologic procedures such as conventional radiology or nuclear medicine examinations, but not endoscopy, although

considerations on the relative value of endoscopy and radiology in different clinical settings are provided in the consensus.

The strategy to develop the consensus involved 5 steps:

1. The consensus organizing committee identified 7 main topics on the use of imaging in IBD that included:
   1. Overview. General principles. Technical aspects. Scores. Radiation safety.
   2. Upper GI tract (including esophagus, stomach, duodenum) & small bowel.
   3. Colon and rectum, CD and UC including severe colitis.
   4. Perineum including anus, genital tract.
   5. Liver and biliary tract.
   6. Emergency situation (acutely ill patients to be treated/investigated within 24 h).
   7. Special situations: postoperative setting, cancer surveillance, and ileoanal pouch.

Uniform questions were addressed for each topic, taking into consideration the procedures available; patient acceptance, tolerability, complications; costs in Europe; definitions of elementary abnormalities, value for diagnosis, value for detection of inflammation (activity) and bowel damages; value for detection of complications, value for therapeutic monitoring and prognostication; information needed for the gastroenterologist, and positioning of imaging techniques in a diagnostic algorithm. A working group was created for each topic composed of gastroenterologists (ECCO members) and radiologists (ESGAR members). Participants were asked to answer the questions based on evidence from the literature as well as their experience.

ECCO participants were selected by the Guidelines' Committee of ECCO (GuiCom) among responders to an open call (see acknowledgements and www.ecco-ibd) on the basis of their publication record and a personal statement. ESGAR participants were selected by the governing Board of the society.

2. The working groups performed a systematic literature search of their topic with the appropriate key words using Medline/Pubmed and the Cochrane database, as well as their own files. The evidence level (EL) was graded according to the 2011 review of the Oxford Centre for Evidence Based Medicine.[1]
3. Revised statements on their topic were then written by the Chairs, based on answers from their working party, as well as the literature evidence and were circulated first among their working group and then among all participants.
4. All working groups met in Vienna on January 2012 to approve the final version of each statement. Technically this was done by projecting the statements and revising them on screen until a consensus was reached. Consensus was defined as agreement by >80% of participants, termed a Consensus Statement and numbered for convenience in the document. Two members of the European Association of Nuclear Medicine (JM-C, AS) were integrated as participants in the consensus project at this stage.
5. The final document on each topic was written by the Chairs in conjunction with their working party. Consensus statements in bold are followed by comments on the evidence and opinion. Statements are intended to be read in context with qualifying comments and not read in isolation. The final text was edited for consistency of style by Andrea Laghi and Julián Panés before being circulated and approved by the participants.

2. General principles. Technical aspects. Radiation safety

2.1. General principles

> ECCO–ESGAR statement 2A
> Radiological imaging techniques are complementary to endoscopic assessment. Cross-sectional imaging offers the opportunity to detect and stage inflammatory, obstructive and fistulizing CD and is fundamental at first diagnosis to stage disease and to monitor follow-up [EL 1].

The diagnosis IBD is based on a combination of endoscopic, histological, radiological, and/or biochemical investigations as a single gold standard is missing.[2] For suspected IBD, ileocolonoscopy and biopsies from the terminal ileum as well as from each colonic segment are the first line procedures to establish the diagnosis.[2] CD may affect segments of the small bowel beyond the reach of ileocolonoscopy, may hamper the advance of the scope due to strictures or may be complicated by extra-mural lesions of the intestine or in the perineal region (including fistulas and abscesses) not amenable to endoscopic visualization. Thus, cross-sectional imaging techniques are an important adjunct to endoscopic assessment, to allow a complete and sensitive staging of the small bowel and perineum with the unique advantage to assess mural and extramural disease.[3]

The applications of cross-sectional imaging techniques in IBD are manifold. In cases of suspected CD cross-sectional imaging of the small bowel is recommended to detect, stage and classify disease behavior.[2,3] In established CD it assists to select treatment, to assess response and to quantify tissue damage.[3,4] In perianal fistulizing CD it complements the examination under anesthesia by an experienced surgeon. In suspected UC with a discontinuous endoscopic appearance of colonic inflammation cross-sectional imaging should be considered to exclude small bowel inflammation indicating the differential diagnosis with CD.[2]

2.2. Technical aspects

2.2.1. Ultrasonography

> ECCO–ESGAR statement 2B
> US is a well-tolerated and radiation-free imaging technique, particularly for the terminal ileum and the colon. Examinations are impaired by gas-filled bowel and by large body habitus [EL 2].
> US is also a technique to guide interventional procedures (e.g., abscess drainage) [EL 2].

US is non-invasive, does not impart ionizing radiation, and is well tolerated and accepted by patients. Bowel

examination may be hampered by air, the volume of which may be reduced by recommending the patient to fast at least 6 h before the examination. The use of laxative and non-flatulent preparations is not required before routine abdominal ultrasound.[5]

Specific preparations with the oral administration of intraluminal contrast can improve image quality and diagnostic accuracy.[6] Oral intake is generally better accepted by patients than techniques using small bowel intubation, and non-absorbable fluid should be used to reduce the volume needed.[6]

US for IBD requires high-frequency (5–17 MHz) linear array probes to increase spatial resolution and to allow adequate assessment of bowel diameter and of the recognizable 5-layer wall pattern.[7] A systematic approach to search for intestinal wall abnormalities is recommended including four scanning positions in the upper and lower, right and left abdominal quadrants. The ileocecal region, sigmoid and often ascending and descending colon are adequately visualized in most patients. The proximal ileum and jejunum can be difficult to assess due to multiple overlying bowel loops and deep pelvic location, whereas the study of transverse colon is challenging because of its variable anatomy, and the rectum for accessibility.

Contrast-enhanced US (CEUS) may improve diagnostic accuracy and diagnostic confidence in detecting inflammatory activity.[8,9]

Ultrasound is a validated technique to guide interventional procedures. For example percutaneous or transrectal abscess drainage under sonographic guidance has a high technical success rate of 96%.[10–12] Moreover, ultrasound can be useful to detect and drain pyogenic liver abscess.[11,13] and is also suitable to guide insertion of intravenous lines, particularly in pediatric patients.[14]

Demonstration and communication of the extent of abnormality and comparison between studies at clinical/radiology/nuclear medicine conference are generally easier with other imaging modalities, such as CT and MRI.

2.2.2. Computed tomography

ECCO–ESGAR statement 2C
CT of the abdomen and pelvis in order to assess the small intestine and colon requires luminal distension, and intravenous contrast administration. Radiation exposure is the major limitation. CT can be used to guide interventional procedures (e.g. abscess drainage) [EL 2].

CT of the small intestine and colon is performed using a multidetector-row scanner able to cover the required anatomical region within a single breath-hold. Rapid image acquisition minimizes motion and peristaltic artifacts. Imaging protocol includes thin detector collimation and slice thickness (in order to benefit from multiplanar reformats).[15–17]

The use of intravenous injection of contrast medium is important for the assessment of bowel wall enhancement pattern and mesenteric vessels.[16,18,19] Bowel distension is a fundamental requisite for any imaging method of the small intestine, since collapsed bowel loops can either hide lesions or simulate pathological wall thickenings.[20–22] Luminal distension can be achieved with enteric contrast agents, either positive or neutral. Neutral contrast agents, which possess X-ray attenuation similar to water, are preferred for most of the clinical indications.[23–25] To minimize absorption, water is usually mixed with high molecular size compounds which do not alter water density and taste, such as polyethylene glycol (PEG), mannitol, sugar alcohols or sorbitol. Positive contrast agents are usually a mixture of barium sulfate (1–2%) or iodinated contrast agents (2–3%). In IBDs positive enteral agents are preferred for the evaluation of perforations or fistulas.[26,27]

Enteric contrast agents can be administered orally (CT enterography) or injected through a naso-jejunal tube (CT enteroclysis). CT enterography is faster, less demanding for radiologists and has superior patient acceptance compared with enteroclysis. CT enterography provides good distension of mid-terminal ileum, but offers limited distention of the jejunum.[25] Diagnostic performances are similar in CD, although CT enteroclysis has higher specificity, but also a slightly higher radiation burden because of the additional exposure associated with naso-jejunal tube placement under fluoroscopy guidance.[25]

Radiation exposure is the major limitation of CT, particularly in patients undergoing repeated examinations.[28,29] The use of new dose reduction techniques, like adaptive statistical iterative reconstruction, should be recommended especially in younger patients.[28,29]

CT is also useful to guide interventional procedures such as percutaneous drainage of intraabdominal abscess or pyogenic liver abscess.[11] Although use of surgery remains common in such patients, radiologically (CT) guided nonsurgical therapy is of increasing importance.[30–34]

2.2.3. Magnetic resonance imaging

ECCO–ESGAR statement 2D
MRI of the small bowel and colon requires fast imaging techniques and luminal distension [EL 2]. MR enterography/enteroclysis has similar diagnostic accuracy and similar indications to CT, but with the major advantage of not imparting ionizing radiation [EL 1].

MRI of the small bowel and colon requires fast sequences, able to acquire T1- and T2-weighted images within a single breath hold, and limiting motion and peristaltic artifacts.[20-21] The use of intravenous injection of contrast medium is mandatory for the assessment of bowel wall enhancement pattern and mesenteric vessels.

Diffusion-weighted imaging is feasible in UC and CD, even without bowel preparation, and has utility for detecting colonic inflammation.[35,36] The inclusion of small bowel motility evaluation may increase lesion detection rate compared with static MRE alone.[37,38]

Similarly to CT, enteric contrast agents can be administered orally (MR enterography) or injected through a naso-jejunal tube (MR enteroclysis).[39] Enteric contrast agents can be classified according to the action on the signal intensity of bowel lumen into positive, negative and biphasic agents. The use of positive agents has been largely abandoned, and currently both biphasic and negative contrast agents are widely used.[40] Biphasic contrast agents include several non-absorbable iso-osmolar solutions [poly-ethylene glycol or mannitol solutions], which produce a negative effect on T1-weighted and a positive effect on T2-weighted images ("water-like" effect), providing satisfactory dilation of the small bowel without side effects, excluding mild laxation. Negative contrast agents, made of a superparamagnetic non-absorbable solution of iron oxide particles, markedly reduce the signal of the intestinal lumen, both on T1 and T2 weighted images ("black lumen" effect).[41–44]

Pelvic MRI using high resolution T2-weighted images and contrast-enhanced T1-weighted images is the imaging modality of choice for the evaluation of perianal disease, fistula, and adjacent abscesses; it is superior to anal endosonography, CT or surgical evaluation for showing disease extent.[45,46]

CT and MRI have a similar diagnostic accuracy for imaging IBD.[47,48] CT has greater availability and is less time consuming than MRI.

2.2.4. Nuclear medicine techniques

ECCO–ESGAR statement 2E
NM procedures especially WBC scintigraphy are an alternative to cross-sectional imaging for evaluation of disease activity and extension in specific situations [EL 2].
Radiation exposure is the major limitation of NM procedures [EL 2].
PET/CT with FDG is poorly specific for inflammation and for assessing disease activity [EL 3].

Scintigraphy with radiolabeled leukocytes (WBC) is useful in the diagnosis of IBD, and in particular to evaluate disease extension and activity.[49–58] A normal scan makes the presence of active IBD very unlikely.[49–58] WBC scintigraphy explores the whole intestine in a single image and with relatively low radiation exposure (2–4 mSv/exam)[59] so may be particularly suited to the investigation of children.[53,60]

WBC scintigraphy has demonstrable utility in the follow-up and for evaluating response to treatment, particularly in patients with UC.[50,52] After surgery, it can be used to differentiate between disease relapse and fibrotic tissue.[61,62]

In some countries WBC scintigraphy is substituted with the anti-granulocyte monoclonal antibody scintigraphy. However, the latter showed lower sensitivity and specificity than labeled leucocyte scintigraphy for evaluation of IBD.[49]

The role of PET/CT with FDG has not yet been clearly established.[63–65]

2.2.5. Barium contrast radiology

ECCO–ESGAR statement 2F
Small bowel follow-through and enteroclysis have high accuracy for mucosal abnormality and are widely available. They are less able to detect extramural complications and are contraindicated in high grade obstruction and perforation. Radiation exposure is a major limitation [EL 2].

Barium contrast examinations are long established for small bowel evaluation and are in widespread use[66] using either SBFT or SBE techniques. SBFT may be augmented by pneumocolon to produce double contrast imaging.[67] SBE is inherently more invasive with tube placement resulting in a higher radiation exposure compared with SBFT.[68] Although the radiation exposure for barium studies is lower than for CT, it is nevertheless a significant exposure for adults[69] and children[70] particularly where repeated examinations are performed. Moreover, excessive fluoroscopy time and number of abdominal radiographs can result in actual doses that are equivalent to CT.[70] Both techniques have acceptable accuracy in the depiction of strictures and ulceration related to CD compared with other techniques[71–73] and to date have acted as a benchmark for comparison with other modalities.[47] Direct comparison indicates superiority of SBFT over SBE for detection of mucosal detail and fistula.[74] Extramural complications including internal fistulas may be identified[75] but other extramural complications such as abscess are not reliably demonstrated compared with other modalities.[76] Wide availability and low cost are advantages but barium is contraindicated in high-grade obstruction and bowel perforation, which limits the role of this modality in patients with acute presentation. While other imaging modalities have advantages, SBFT remains an acceptable method of small bowel assessment where access to other techniques is limited.

2.2.6. Plain film radiology

ECCO–ESGAR statement 2G
Plain films have a role in the assessment of specific emergency cases [EL 3].

Plain abdominal radiographs have been routinely used in the assessment of patients with IBD for many years. However the status of plain film radiography in the triage of patients with the acute abdomen is diminishing in favor of US and CT[77] particularly with the development of low dose CT techniques.[78,79] Data on the accuracy of plain films is limited to small series. Furthermore conclusions are conflicting both in terms of accuracy for assessment of the distribution and severity of colitis (by assessment of the extent of fecal residue, dilatation and wall thickening)[80–82] and for locating and defining the etiology of small bowel obstruction (by detection of small bowel dilatation).[83–85] Plain abdominal and chest radiographs may detect perforation but cannot determine the

cause and have a lower sensitivity than CT for abscess and intra-abdominal free gas.[86–88]

Plain films have no role in the routine assessment of non-emergency clinical presentations due to their failure to adequately assess the distribution or activity of disease. Where out of hours access to other imaging modalities services is limited, plain films can help direct clinical decision-making in the acute setting. However where findings are equivocal, other more accurate imaging modalities should be used, in particular where radiographs fail to demonstrate abnormalities in a patient with high clinical suspicion of an acute abdominal complication related to known IBD.

2.3. Radiation exposure

ECCO–ESGAR statement 2H
High radiation exposure and earlier age of exposure both increase the risk of radiation-induced cancer [EL 2].
Independent predictors of increased radiation exposure in IBD patients are: diagnosis of CD, need of steroids, IBD related surgery, increasing severity, upper gastrointestinal tract involvement, the first year following diagnosis and young age of disease onset [EL 2].

Repeated CT examinations, particularly in children and young patients, may expose those individuals to an increased life-time radiation-induced cancer risk.[89,90] The chronically progressive nature of IBD which results in intestinal damage, hospitalizations, surgery and the screening for infections or disease complications determines higher levels of annual and total diagnostic radiation exposure particularly due to use of CT in patients with CD and UC.[91] Patients with CD have a higher cumulative radiation exposure than patients with UC.[92] According to a recent meta-analysis the pooled prevalence of IBD patients receiving potentially harmful levels of radiation (defined as $\geq$50 mili-Sieverts, mSv), was 8.8% (11.1% and 2% for CD and UC, respectively). IBD-related surgery and corticosteroid use were significant risk factors with pooled adjusted odds ratios of 5.4 (95% CI 2.6–11.2) and 2.4 (95% CI 1.7–3.4) respectively.[93] Other factors noted to be associated with a high cumulative effective dose were age <17 years at diagnosis, the first year after diagnosis, upper gastrointestinal tract disease, penetrating disease, use of infliximab and multiple surgeries.[17,94]

In clinical practice the appropriateness of CT use should be scrutinized, particularly in young patients and when alternative modalities with acceptable accuracy are available.[90]

Low-dose CT examinations (<2 mSv) are now possible due to the development of new techniques based on adaptive statistical iterative reconstruction method. Iterative methods allow significant radiation dose reduction without sacrificing image quality as compared with filtered back projection alone.[15,29,95]

2.4. Availability of techniques

ECCO–ESGAR statement 2I
CT, US and SBFT are generally more available and less expensive than MRI and scintigraphy [EL 4].

Unfortunately availability is still currently limited to a few diagnostic centers,[3,29] although as dissemination occurs, the role of CT in IBD may be reviewed.

Availability of equipments and expertise of interpreting personnel are generally greater for CT, US and SBFT in comparison with MRI and WBC scintigraphy. The major limitation of WBC scintigraphy is the limited availability.

3. Upper GI tract & small bowel

3.1. Techniques for examination of upper GI and small bowel

ECCO–ESGAR statement 3A
SBE, SBFT, US, CT, MRI and WBC scintigraphy are able to detect signs of Crohn's disease [EL 1].
US, CT, and MRI have a high and comparable diagnostic accuracy at the initial presentation of terminal ileal CD [EL 1].
SBE and SBFT have an acceptable accuracy for mucosal disease but are less accurate for mural disease and extramural complications [EL 3].

ECCO–ESGAR statement 3B
US, CT, MRI and WBC scintigraphy can be used to assess disease activity in Crohn's disease of the terminal ileum [EL 1].
MRI, CT and WBC scintigraphy are able to explore the entire length of the small bowel whereas US has a more limited coverage [EL 4].

3.1.1. Small bowel enteroclysis (SBE) and small bowel follow-through (SBFT)

Historically, SBE and SBFT examinations have been the standard radiologic approaches used to assess patients with suspected or established CD. Radiologic findings include irregular thickening and alteration of the circular folds, narrowing of the bowel lumen with presence of ulcerations, loop adhesions or separation because of wall thickening and mesenteric inflammatory infiltration.[96]

SBE has been shown to be highly accurate, with 95% sensitivity and 96.5% specificity in diagnosing small bowel disease using MR enteroclysis as reference standard.[97] In severe cases of CD with clinical suspicion of septic complications such as abdominal mass or fever, the accuracy of SBE for

detecting internal fistulas and intra-abdominal abscesses, was 80.3% against a reference standard of intraoperative findings.[75]

Some investigators have compared SBFT with SBE studies and reported comparable results.[98] In a prospective study, it was concluded that SBFT is safer, preferred by patients, and is less likely to miss gastroduodenal disease compared to SBE. A normal SBFT obviated the need to perform SBE.[74] However, other researches have suggested that SBE is more accurate than SBFT at detecting early mucosal lesions.[99–100] Both methods provide only limited and indirect information in regard to the state of the bowel wall and extraluminal extension of CD. Although barium imaging manages to accurately detect the location and extension of CD, it is not as accurate as other radiologic imaging modalities in providing information on extraluminal manifestations.[76,101]

3.1.2. Ultrasound

US diagnosis of CD relies on several features, but primarily on the detection of increased bowel wall thickness, which is considered the most common and constant US finding in CD.[102] The importance of this sign for the accuracy of US diagnosis of CD has been evaluated in several studies and sensitivities of 75–94% with specificities of 67–100% have been reported.[103–105] In a meta-analysis of seven prospective and appropriately designed studies (five case control and two cohort studies), it was shown that when >3 mm cut-off level was applied for abnormality in wall thickness, the sensitivity and specificity of US in the diagnosis of CD were 88 and 93%, while when a cut-off level of >4 mm was used, sensitivity was 75% and specificity 97%.[106] In a recent systematic review,[36] the overall per-patient sensitivity of US for the diagnosis of CD was 85% (95% CI 83–87%). Overall per patient specificity derived from studies reporting this metric was 98% (95% CI 95–99%).

The use of intraluminal orally administered contrast agents, such as iso-osmolar polyethylene glycol solution at a dose ranging from 500 to 800 ml, has also been proposed to better define CD. While the use of intraluminal contrast appears to reduce intraobserver variability and increase sensitivity in defining disease extension, location and intestinal complications in patients with established CD, its value in the early diagnosis of CD has not been proven.[107,108]

3.1.3. Computed tomography

The accuracy of CT (either CT enteroclysis or CT enterography) for diagnosing CD in patients with a suspected diagnosis has been investigated in several prospective studies. A good correlation has been shown between CT and histopathology results in regard to inflammatory changes (Spearman's $r = 0.7$, $P < 0.0001$), but no details were provided for signs of fibrostenosis.[109] CT variables associated with inflammation were mucosal enhancement, wall thickness, comb sign, and presence of enlarged lymph nodes (P values 0.04, 0.04, <0.0001, and 0.016, respectively). Solem et al. reported the results of a prospective, blinded randomized controlled trial that compared the utility of four primary small-bowel imaging modalities: CT, ileocolonoscopy, capsule endoscopy (SBCE) and SBFT as diagnostic tools for CD. The researchers aimed to administer all four tests to 41 patients with known or suspected small-bowel CD over a 4-day period.[73] Of the 41 patients enrolled, only 26 underwent all four tests. Sensitivity was not significantly different between the techniques (83% for SBCE, 67% for CT and ileocolonoscopy, and 50% for SBFT). Specificity was significantly lower in SBCE (53%) than in all other tests (100%, $P < 0.05$ for all). The authors concluded that a combination of at least two diagnostic techniques (preferably ileocolonoscopy plus CT) should be implemented as first-line diagnostic assessment of small-bowel CD. In addition small bowel radiological imaging, preferably using CT or MRI, is needed prior to SBCE because of the high frequency of asymptomatic stenosis in suspected or known CD patients, risking capsule retention, and because these techniques can also detect extraluminal complications.[73,110,111]

3.1.4. Magnetic resonance imaging

MRI allows for an accurate assessment of the small bowel without radiation exposure, making this imaging tool ideally suited to the CD population given their age and need for repeated imaging.

MRI changes associated with the presence of inflammation include wall thickening, wall hyper-enhancement after injection of MRI contrast medium, presence of wall edema, and presence of ulcers, as well as extramural changes such as presence of comb sign, fat stranding and enlarged lymph nodes.[112] A systematic review reported per-patient sensitivity and specificity of MRI for the diagnosis of CD as 78% (95% CI 67–84%) and 85% (95% CI 76–90%) respectively.[36]

3.1.5. Nuclear medicine

The use of radiolabeled WBC scintigraphy provides information about the presence of an inflammatory process in the small and large bowel as well as its extent.[58] Leucocytes are labeled in vitro using 99mTc-HMPAO or 111In-oxine, and the technique entails a low radiation exposure. 99mTc-HMPAO is the first option due to the highest availability and lower radiation burden.[113] The accumulation of labeled leukocytes identifies the presence of active disease within the bowel or other complications such as fistulae or abscess.[56,57,114]

FDG-PET/CT might be used for early therapy follow-up particularly in non-complicated IBD eligible for biological treatment. Nevertheless, while preliminary literature data suggest that PET/CT with FDG has a clinical value in adults and pediatric patients, there is at present not enough evidence to support its use in clinical practice.[49,63,64,115]

3.1.6. Comparison of SBE, SBFT, US, CT, MRI and scintigraphy

In a recent study, SBFT, CT and MRI were compared and appeared to be equally accurate in the identification of active inflammation in the small intestine. Although the sensitivity values of CT (89%) and MRI (83%) were slightly higher than those of SBFT (67%–72%) with regard to active terminal ileitis, these differences were not significant.[76]

A meta-analysis comparing the accuracies of US, MRI, scintigraphy, CT, and PET for diagnosis in patients with suspected or known IBD, mainly CD,[47] showed that mean sensitivity estimates for the diagnosis of IBD on a per-patient basis were high and not significantly different among the imaging modalities (90%, 93%, 88%, and 84% for US, MRI, WBC scintigraphy, and CT, respectively). Mean

per-patient specificity estimates were 96% for US, 93% for MRI, 85% for leucocyte scintigraphy, and 95% for CT; the only significant difference in values was that between scintigraphy and US (P = 0.009). Mean per-bowel-segment sensitivity estimates were lower: 74% for US, 70% for MRI, 77% for WBC scintigraphy, and 67% for CT. Mean per-bowel-segment specificity estimates were 93% for US, 94% for MRI, 90% for WBC scintigraphy, and 90% for CT. CT proved to be significantly less sensitive and specific compared with WBC scintigraphy (P = 0.006) and MRI (P = 0.037). There were no studies selected in which the accuracy of PET for the diagnosis of IBD was assessed. The authors concluded that no significant differences in diagnostic accuracy among US, CT, MRI and WBC scintigraphy were observed.

3.2. Assessment of stenotic lesions

ECCO–ESGAR statement 3C
US, CT and MRI and SBE / SBFT have a high sensitivity and specificity for the diagnosis of stenosis affecting the small bowel [EL 2].
Diagnostic accuracy of MRI and CT for stenosis is based on the use of luminal contrast. In partially obstructing stenosis, enteroclysis may provide higher sensitivity than enterography [EL 2].
Cross-sectional imaging using CT, US, MRI [EL 2] and WBC scintigraphy [EL 3] may assist in differentiating between predominantly inflammatory or fibrotic strictures [EL 5].

The definition of a stenosis may be relatively simple for an endoscopist who can record the inability or difficulty to advance the endoscope through a narrowing of the bowel lumen. Unfortunately, such an assessment is not the same for imaging and the definition of stenosis has varied in different studies. Stenosis is usually defined as a thickening of the bowel wall with a narrowing of the small bowel lumen, and some definitions include also the presence of the dilation above of the narrowing.[2,116] Others rank bowel stenosis as high grade (80%–100% narrowing of normal lumen), intermediate (60%–80%), low grade (50%–60%) and absent (0–50%).[117]

SBFT and SBE show a low albeit significant correlation with surgical findings in identifying the number, localization, and extension of stenosis. These examinations may identify small bowel obstruction, but cannot depict the cause, indicating additional diagnostic work up often based on MRI or CT.[2] In addition they have a considerably lower sensitivity for the detection of small bowel and extraluminal complications compared to CT or MRI.[73,109,116,118]

In experienced hands, bowel US is an accurate technique for detection of small bowel stenosis, especially high grade stenosis that may be candidates for surgery.[116] Based on the pooled data of three studies using surgery as reference standard, the sensitivity of US was 79% and specificity was 92%.[36]

Use of oral contrast agents can improve the accuracy of US in detecting the presence and number of small-bowel stenoses (sensitivity increased from 74% to 89% in one study),[116] but it is generally not necessary in patients with symptomatic obstruction.

In two studies comparing CT with ileocolonoscopy and capsule endoscopy, the sensitivity of CT for the detection of stenoses was 92% and specificity 100%.[73,111] Two additional studies using endoscopy and surgery as a reference standard[119,120] reported a sensitivity of 85% and 90%, respectively and both a specificity of 100%.

Direct comparison of CT and MRI for diagnosis of stenosis in a study with 44 patients showed also a similar sensitivity (85% vs. 92%) and specificity (100% vs. 90%).[119] Pooled results of seven studies with adequate reference standard (endoscopy and/or surgery), showed that the sensitivity of MRI for diagnosis of stenosis was 89% and specificity 94%.[36] Better distension was achieved with MR enteroclysis than with MR enterography resulting in a higher sensitivity (100 versus 86%, respectively) and specificity (100% versus 93%) for detecting stenosis, though the difference was not significant.[39]

When performing CT or MRI before capsule endoscopy, between 27 and 40% of patients are excluded from capsule endoscopy due to the identification of a stenosis.[111,121]

Over and above diagnosing the presence of a stenosis, determining the relative inflammatory and fibrous component of a stenosis may be helpful for guiding therapy.

The perfusion of the intestinal wall involved in CD can effectively be studied with CEUS Dynamic evaluation of the bowel wall enhancement using CEUS can be performed with high temporal resolution and has been reported to correlate with the inflammatory activity in the intestinal wall in some studies,[122] although not in others.[123]

In a study evaluating CT classification of lesion type using histopathology of surgical specimens as reference standard,[109] it was shown that wall thickness, parietal enhancement, comb's sign and the presence of enlarged lymph nodes were correlated with the presence of inflammatory lesions, and it was only the presence of a stenosis that was associated with fibrotic changes in the intestinal wall. The study did not provide any means to differentiate between inflammatory and fibrous components of a stenotic lesion. Another study that compared CT findings with histology stated that small bowel stenoses, without CT findings of inflammation do not predict the presence of fibrosis. Therefore, CT criteria cannot be used to predict the presence of fibrous component in a stenotic lesion.[124]

A recent study evaluated the value of MRI findings in small bowel CD in correlation with 52 surgical pathology specimens.[118] The MRI signs significantly associated with the presence of fibrosis were wall thickness, T2 hyperintensity, comb sign and fistula. However, these findings were not reproduced in another study, in which no correlation was found between wall thickness and T2 hyper intensity with fibrosis, although in that study a layered enhancement pattern was common in fibrostenotic segments.[125] Overall, in contrast with well-established MRI criteria for determining presence and severity of inflammation no validated criteria have been established to reliably determine the

fibrotic component of stenotic small bowel lesions based on MRI.

3.3. Assessment of penetrating lesions

ECCO–ESGAR statement 3D
US, CT, and MRI have a high accuracy for the assessment of penetrating complications (i.e., fistula, abscess) [EL 1] and for monitoring disease progression [EL 4].
For deep-seated fistulas MRI and CT are preferable to US [EL 4].
US and CT are widely available and facilitate early abscess drainage [EL 4].
WBC scintigraphy may provide useful information when cross sectional imaging is inconclusive for detecting abscesses [EL 3].

ECCO–ESGAR statement 3E
MRI demonstrates high agreement with conventional radiology (i.e. SBE and SBFT) and CT for the diagnosis of superficial and transmural abnormalities. MRI is superior to conventional radiology for assessing the extramural manifestations, and has the advantage over CT of avoiding radiation exposure [EL 2].

3.3.1. Fistula

At the time of diagnosis 15.5% of patients with CD have penetrating lesions (fistulas, phlegmons or abscesses).[126] In a systematic review, pooled results of four US studies for the diagnosis of fistulizing lesions, using surgery (in three studies) and barium studies, surgery, or/and colonoscopy (in one study) as reference standard, showed a sensitivity of 74% and specificity of 95%.[36] The largest study, using surgery as reference standard, included 128 patients with 119 internal fistulas. US showed a sensitivity of 71% and specificity of 96%.[75] In this study, US and SBE had the same accuracy for the detection of internal fistulas (85%). Using the combination of US and SBE, and also considering the presence of fistulae when revealed by at least one method, the sensitivity in diagnosing this complication rose to 90%. The addition of oral contrast agents, does not improve the accuracy of US for the detection of internal fistulas.[108] US may be used for detection of extramural complications of CD, although if CT or MRI is available, they are preferable for the detection of intra-abdominal fistulas.[2]

The sensitivity of CT for the diagnosis of fistulas has been reported in a systematic review. This showed that, based on the pooled results of five studies with surgery and endoscopy as reference standard, the sensitivity was 70% and specificity 97%.[36] Two studies although not meeting the selection criteria of this systematic review, used surgical findings as the reference standard and reported higher accuracies for diagnosis of fistulas. In one of these studies including 44 patients, the sensitivity, specificity, and accuracy of CT for the detection of small bowel fistula were 77.8%, 86.8%, and 85.1%, respectively.[109] The other study included 36 patients, the presence or absence of a fistula was correctly determined by CT in 94%.[127]

The key role of cross-sectional imaging for assessment of penetrating complications of CD is demonstrated in a retrospective study including 56 patients, showing that in half of the patients with penetrating complications of CD, there was no suspicion of a fistula or abscess at pre-CT clinical assessments, with 79% of these patients subsequently receiving new medical therapy or undergoing surgical or percutaneous intervention based on the detection of penetrating CD on CT.[128]

MRI is highly accurate for the detection of abscesses, fistulae and inflammatory infiltrates in CD.[129,130] Pooled results of four studies with adequate reference standard (endoscopy and/or surgery) showed a sensitivity of MRI for the diagnosis of fistulas of 76% and specificity of 96%.[36] Other studies on MRI for diagnosing intra-abdominal fistulas have been published,[76,118,131–133] but only one used surgical findings as the reference standard.[118] Detection of small-bowel fistula by MRI had a sensitivity, specificity, and accuracy of 88%, 93%, and 91%, respectively, but the authors did not differentiate between abscess and fistula.[118] MRI actually appears to be the most efficient tool to detect intra-abdominal fistulas, and CT and MRI are the recommended techniques for detection of extramural complications of CD.[2]

A WBC scintigraphy has no indication for the diagnosis and characterization of fistulae.

3.3.2. Abscess

Pooled results in a systematic review of three US studies for the diagnosis of abscesses using surgery as a reference standard reported a sensitivity of 84% and a specificity of 93%, although US accuracy has been reported to be highly related to disease location in CD.[36] In clinical practice, if an intra-abdominal abscess or deep-seated fistula is suspected, US should be used only if CT or MRI is not available or in children in whom other methods are less feasible.

CT and US showed an overall high and comparable accuracy in the detection of intra-abdominal abscesses, although CT showed a slightly greater positive predictive value than US. CT has been reported to determine the exact location and extent of an abscess with great reliability. Only two studies had surgery as reference standard for detection of extra-enteric lesions on CT,[75,109]. One study showed that for the detection of intra-abdominal abscesses the sensitivity, specificity, and accuracy of CT compared with surgical findings were 85.7%, 87.5%, and 87.2%, respectively.[75] In another prospective study, intra-abdominal abscesses were found intra-operatively in 22 patients and sensitivity of CT for the diagnosis of abscesses was 85% and specificity 95%.[109] Because of its accuracy, ability to detect penetrating complications of CD, and high availability, CT is in clinical practice the most useful imaging modality to detect intra-abdominal abscesses in CD.

Only three studies used surgery as the reference standard to assess the accuracy of MRI in detection of an abscess.[76,118,132] Sensitivity ranged from 86% to 100% and specificity from 93% to

100%. These studies were limited because two included fewer than five patients with intra-abdominal abscess[76,131] and the third did not differentiate abscess from fistula.[134] Pooling the results of these three studies showed a sensitivity of MRI for the detection of abscesses of 86% and a specificity of 93%.[36] The access to MRI remains limited in some countries and image acquisition and analysis still takes longer than for CT (although recent developments have decreased the image acquisition time to 15–30 min). These reasons may limit the use of MRI as a first line examination to detect intra-abdominal abscess in CD.

Labeled leukocyte scintigraphy can help in the localization of abscesses when the other methods have been inconclusive.

3.4. Upper GI lesions

ECCO–ESGAR statement 3F
Contrast studies or cross sectional imaging can be used to detect upper GI strictures [EL 4].

The prevalence of CD involving the upper gastrointestinal (GI) tract is low compared with ileal and colonic disease. Approximately 10%–15% of patients have associated upper GI lesions.[135] Esophageal CD has been shown to affect the distal third of the esophagus alone in 80%, the middle and lower third in 15%, and the entire esophagus in 5%.

Data on imaging in esophageal CD is sparse and sizeable series are lacking, with essentially absent data for the stomach. Cross sectional imaging may reveal ulcers or strictures in oesophageal CD but superficial lesions are difficult to detect, underscoring the importance of endoscopy in the diagnosis of oesophageal CD. Endoscopy with tissue biopsy is useful to exclude other common esophageal disorders. The most commonly described findings on endoscopy include aphthous ulcers, superficial erosions, and late stage development of stricture and cobblestoning of the mucosa.[136]

One study discussed inflammatory conditions of the esophagus[137] where diagnosis was made with endoscopy, barium studies, CT scan and a biopsy. Recently, the presence of an esophagobronchial fistula formation in a patient with CD was described in a case report.[138] The authors indicated barium swallow as the initial test of choice to identify esophagobronchial fistulae.

3.5. Global bowel damage

New tools, such as the Lémann score, have been proposed and are in the process of validation. This score measures damage resulting from inflammatory, stenosing or penetrating lesions, as well as that resulting from permanent loss of intestine after surgery[4] The score would allow measuring the cumulative bowel damage at a specific time in a patient's history, measuring the progression of bowel damage over time in cohorts of patients and in clinical trials. It would facilitate identification of patients with CD at high (or low) risk of rapid damage progression, and compare the effects of treatment strategies on the progression of bowel damage.

3.6. Monitoring therapeutic responses

ECCO–ESGAR statement 3G
Cross sectional imaging, in particular MRI, can be used for monitoring therapeutic response. However, there is a delayed timeline as compared to clinical or endoscopic changes [EL 3].

Mucosal healing has been associated with sustained clinical remission, and reduced rates of hospitalization and surgery. CD is a transmural process, so full-thickness small bowel healing or remodeling could be important end points. However, only few studies have explored how radiologic parameters of active inflammation change over time during medical therapy.

3.6.1. Ultrasonography

A prospective study was carried out on 15 patients with CD, using small intestine contrast ultrasound (SICUS) to assess changes caused by anti-inflammatory treatment and its relationship with the clinical and biological response.[139] The parameters were measured before and after 6-month anti-inflammatory treatment. In 13 patients the slope of the enhancement curve and the area under the enhancement curve were significantly lower after anti-inflammatory treatment ($P < 0.05$) with a significant correlation with the Crohn's disease activity index (CDAI) score (=0.85, $P < 0.05$). However, changes in US findings were not compared with another objective measure of lesion severity, namely endoscopy.

Another prospective study was carried out on 24 consecutive patients with CD, using US to assess changes induced by anti-TNF therapy and its relationship with the clinical and biological response.[140] The parameters were measured one week prior to the induction treatment and two weeks after. The anti-TNF therapy caused a significant reduction in the thickness of the bowel wall ($P = 0.005$) and Doppler flow ($P = 0.02$), leading to the disappearance of US changes in 50% of the patients. However, sonographic normality was only achieved in five out of 17 (29%) patients with a clinical and biological response, and could not differentiate between those with and without clinical and biological response ($P = 0.27$). This study also lacked an established gold standard for assessment of mucosal healing. Although the overall data seems promising, US is not ready to be used in clinical practice for assessment of therapeutic responses.

3.6.2. Computed tomography

A recent retrospective study of 63 patients with CD who underwent CT before and at variable time lengths after initiation of infliximab showed that resolution of lesions can be centripetal (from the ends inward) and that up to

25% of patients who respond to treatment have complete normalization of what was abnormal small bowel.[141] Poor to fair correlation was found between CT features of response and improved clinical symptoms (kappa 0.26), improved endoscopic appearance (kappa 0.07), and reduction of CRP (kappa 0.30). When comparing responders (complete and partial) with nonresponders, only the presence of "comb sign" on the index CT was predictive of radiologic response (P = 0.024).

3.6.3. Magnetic resonance imaging

Various studies have shown responsiveness of MRI lesions or indexes to therapeutic interventions. A study in 18 patients prospectively assessed the effect of 6 month adalimumab treatment with moderate-severe stricturing ileal CD.[142] Before and 6 months after the beginning of adalimumab treatment, patients underwent ileocolonoscopy and MRE. MRE activity index was of 7.11 ± 1.18 and 5.1 ± 2.22, respectively. Improvement in inflammatory parameters was observed both in relation to the MRE activity index (P = 0.003) and the SES-CD score (P = 0.0005), compared with 6 months before. Authors conclude that MRE activity index could be helpful for assessment of healing of inflammatory lesions.

3.6.4. Positron emission tomography

CD strictures usually represent a continuum of active inflammation, muscular hypertrophy, and fibrosis: all are present, in varying degrees, in any particular stricture.[109] Most strictures (defined as luminal narrowing with prestenotic dilation) will have some imaging findings of inflammation, but these imaging findings do not correlate with reversibility of the stricture. Combined PET–CT enterography may overcome this weakness because poor uptake of the PET tracer FDG may predict failure of medical therapy.[143] Although a study of inflammatory and fibrotic strictures demonstrated a range of FDG uptake, patients with predominant fibrosis had lower FDG uptake.[144]

4. Colon and rectum, CD and UC excluding cancer

Most studies employing US, MRI and/or CT for assessment of IBD activity included CD patients with small bowel rather than colonic disease. Moreover, not all studies describe disease location, activity and severity. Different designs, samples (often small) and technical aspects confound observed differences between techniques. In the present section, only studies comparing imaging findings to a reliable reference standard (endoscopy and/or surgery) in patients with both suspected and established IBD are considered.

4.1. Diagnosis of colonic inflammation

ECCO–ESGAR statement 4A
MRI, CT and US imaging are an adjunct to endoscopy for diagnosis of colonic IBD. MRI and CT have higher sensitivity for examining locations difficult to access by US [EL 2].

ECCO–ESGAR statement 4B
The performance of imaging depends on the type of colitis and severity [EL 1].
Transabdominal US and MRI have a high accuracy for assessing the activity and severity of Crohn' s colitis [EL:1b, RG:A]; the performance in UC is less clear and the role of CT for distinguishing quiescent from active colonic IBD is currently not defined.
White blood cell scintigraphy can detect colon inflammation and can be used as an additional technique [EL 2].

The accuracy of cross-sectional imaging techniques for the assessment of disease activity and severity is high, and sufficient to guide clinical decisions in the majority of clinical circumstances. Direct and indirect comparisons of the relative accuracy of US, CT and MRI for diagnosis of disease activity and severity both in UC and in CD show that the techniques provide similar sensitivities and specificities overall.[47,146-156] However, accuracy of each technique may vary depending on the location of the colonic segments being analyzed.[152-155]

4.1.1. Ultrasonography

The role of US to assess activity has been most extensively investigated for small bowel CD. When considering colonic CD, US is most accurate in the sigmoid/descending colon, followed by the caecum/ascending, and transverse colon, while accuracy for rectal disease is poor.[151,158]

A systematic review of 6 studies investigating US for assessment of ileo-colonic CD found sensitivities ranging from 63% to 100% and specificities from 77% to 100%.[106] A study using a heterogeneous case mix (48 CD, 23 UC, 3 unclassified colitis, 44 controls),[156] reported high sensitivity, specificity and accuracy for high resolution sonography when assessing CD activity (per-patient basis: 94%, 67% and 93%; per-segment basis: 80%, 67% and 80%, respectively). It has been suggested that contrast-enhanced Doppler US may assess CD inflammatory activity within colonic strictures impassable by endoscopy.[159–161] A comparable accuracy was shown by CEUS and Doppler US, although correlation with CDAI was strongest for CEUS than for US.[8] Several studies found significant correlations in CD severity between US (using wall thickness) and colonoscopy,[8,9,116,132,153,162-165] barium contrast[132,169] CT/MRI, surgery or histology.[8,151]

Some studies reported good correlations between various clinical and endoscopic activity indices and severity of colonic lesions as assessed by hydrocolonic sonography,[68] but these findings have not always been reproduced; other studies found weak or no correlation between CD severity as assessed by US and several clinical and hematochemical parameters of inflammation.[116,132,145,151,153,155,164]

Because UC involves the mucosa continuously from the rectum, colonoscopy with biopsy is the reference standard for assessment of disease extent, activity, and severity. Nevertheless, in experienced hands, US is an alternative, particularly in patients not requiring biopsy and/or with severe comorbidities. In 4 studies assessing the diagnostic

accuracy of US (74 patients), sensitivities ranged from 48% to 100% and specificities from 82% to 90%.[166] Current evidence indicates that in UC diagnostic accuracy of US is also related to disease site, as sensitivity is high for sigmoid/descending colonic disease (reaching 97%),[151] but low for rectal disease.[167] The utility of US for assessing activity has been assessed in a study including 38 IBD patients (12 UC) and 6 controls,[155] the mean colonic wall thickness was 3.2 mm in both CD and UC, being higher in moderately (n = 46; $P < 0.001$) or severely inflamed bowel (n = 20; $P < 0.001$) compared to normal segments (n = 58). However, these studies frequently depend on specifically experienced sonographers and may not be generalizable.

4.1.2. Computed tomography

The diagnostic utility of CT in CD colitis was investigated in 3 studies including 85 patients.[119,168,169] Sensitivity and specificity for activity ranged from 60% to 90% and from 90% to 100%, respectively. Lowest sensitivity was achieved when luminal contrast was omitted.[119] One study compared CT-colonography and high-resolution video-endoscopy[168]; the colonic wall thickness on CT correlated with the presence of ulceration ($r = 0.69$, $P < 0.01$), active CD ($r = 0.81$, $P = 0.001$), pseudopolyps ($r = 0.72$, $P = 0.01$) and fistulae ($r = 0.77$, $P = 0.002$) at endoscopy. Increased vascularity correlated with mucosal inflammation ($r = 0.72$, $P < 0.01$) while no correlation was found between CDAI and any CT finding.[168] A role for CT colonography (virtual colonoscopy) has been proposed to assess postoperative recurrence, although the observed false negative rate supports continued use of colonoscopy,[170] unless strictures are impassable.

Few studies have investigated CT to assess UC, finding an overall sensitivity of 74% when using CT enterography to detect colonic inflammation.[171,172] Although preliminary studies in small samples[173,174] report good correlation between disease extent by colonoscopy and PET/CT (κ 55%; $P = 0.02$), further studies are needed. A study of CT in 21 patients,[168] found loss of haustration, a rigid bowel wall, and bowel thickness were moderately correlated with UC severity ($r = 0.612$). Overall, the limited available data using CT or CT colonography in UC does not demonstrate adequate diagnostic performance[175,176] and colonoscopy remains the reference standard. Indications for CT are currently restricted to patients with impassable stenoses or severe comorbidities where colonoscopy is contraindicated.[176]

4.1.3. Magnetic resonance imaging

MRI may provide useful information in colonic CD, including wall thickening, presence of ulcers, depth of mural penetration, edema, loss of haustration, polyps, and extraluminal findings/complications, although mild disease may not be detected.[150] 13 studies investigated colitis activity using an appropriate reference standard.[133,146,148–150,152,154,157,169,177–181] Per-patient analysis[133,152,157,178–180] found high sensitivity and specificity, ranging from 78% to 100% and from 46% to 100%, respectively. On a per-segment analysis,[146,148–150,154,166,169,177,181] sensitivity and specificity ranged from 55 to 87% and from 84% to 98% respectively.[166] The sensitivity and specificity of MRI were investigated in 8 studies using colonoscopy as reference standard.[146,148–150,166,179–181] Overall, good correlation was found between endoscopic severity and MRI findings, which was higher with luminal distension.[148,166,181] Significant correlation was observed between MRI and endoscopic activity indices in 5/6 studies (ranging from $r = 0.34$ to $r = 0.85$).[148,149,153,179–181] In 3 of these, an MRI activity index significantly correlated with the endoscopic activity index, including both qualitative[148] and quantitative indices.[149,150] In 4 studies describing a segmental analysis,[148–150,179] 768 segments were analyzed, of which 230 were active (29%). High correlation between endoscopic activity and MRI ($P < 0.001$) was reported.[148,149,179] All studies found no or very weak correlation between MRI findings and both clinical and endoscopic indices of inflammation or alterations in biomarkers.[117,131,133,150,153,177,179,180] However, a total MRI score (MR-score-T) did correlate with both a simplified endoscopic activity score ($r = 0.539$, $P < 0.001$) and with the CDAI ($r = 0.367$; $P < 0.004$).[148] Overall, MRI may be useful to assess CD colitis after incomplete colonoscopy, in patients not requiring biopsy, or those with severe co-morbidities, and where extraluminal complications are suspected.[117,131,133,146,148–150,177–181]

Findings of initial studies suggesting that MRI may be valuable for assessment of UC,[182,183] were later substantiated in larger studies.[184–188] Indeed, various studies reported higher sensitivity for MRI in UC (58.8%–68%) than CD (31.6%–40%).[146,189] In a larger study,[148] the accuracy of diffusion-weighted (DWI) MRI for colitis was also greater in UC (n = 35) than CD (n = 61) ($P < 0.003$). A segmental MRI score (MR-score-S) > 1 had a sensitivity and specificity of 89% and 86% when compared with endoscopic assessment of inflammation (AUC 0.920, $P < 0.0001$). For CD, a MR-score-S > 2 detected inflammation with a sensitivity and specificity of 58% and 84% (AUC = 0.779, $P < 0.0001$). MRI performs better in moderate-to-severe UC[190] than in mild disease.

4.1.4. Other techniques

Scintigraphy with radiolabeled leucocytes is a valid option to cross-sectional imaging to demonstrate disease activity in CD. A normal scan makes very unlikely the presence of active disease with high accuracy.[51,56,191]

4.2. Diagnosis of colonic complications

4.2.1. Penetrating complications

> ECCO–ESGAR statement 4C
> US, CT, and MRI are useful for detection of penetrating complications of the colon, although accuracy of these techniques for this type of lesions is less well defined than for assessment of colonic inflammatory changes [EL 2].

This section is devoted to complications mostly related to colonic CD, including fistula, abscesses and stenosis. Only studies reporting results for colonic lesions and with an adequate reference standard (i.e. endoscopy and/or surgery) are considered.

Three studies investigating US for diagnosis of fistulizing complications[75,132,192] found sensitivities ranging from 71% to 87%, with specificities ranging from 90% to 100%. Only one

study investigating CT for diagnosis of fistulas used an adequate reference standard, finding sensitivity and specificity of 68% and 91% respectively.[75] The diagnostic utility of MRI for intraabdominal colonic fistulas was determined in three studies,[131–133] reporting sensitivities between 71% and 100%, and specificities from 92% to 100%. In the only study reporting results separately for colonic and small bowel segments, similar sensitivity, specificity and overall accuracy were found for all segments.[131]

Various studies have compared the performance of different cross-sectional imaging modalities. The diagnostic accuracy of CT and US for diagnosis of intra-abdominal fistulas complicating CD was similar in a study using a surgical reference standard: sensitivity and specificity were 68% and 91% for CT compared with 87% and 91% respectively for US.[75] In another study using a combination of endoscopy, barium studies, CT, and surgery as reference standard, 17 cases with enteroenteric fistulas were identified.[132] US and MRI detected 14 (82%) and 12 (70%) fistulas respectively. Specificity and accuracy were 100% and 90% for US versus 92% and 80% for MRI.

The value of US for the detection of abscesses was assessed in three studies using a surgical reference standard,[75,131,192] finding sensitivities ranging from 81% to 100%, with specificities of 92% to 94%. One study found that intra-abdominal abscesses were correctly detected in 9/9 patients and excluded in 22/24 patients (sensitivity 100%, specificity 92%).[192] The higher accuracy reported in this study may be due, at least partly, to patient selection by excluding cases with lesions in anatomic areas that are difficult to assess by US, in particular the stomach, the deep pelvis, and the rectum.

The value of CT to detect intra-abdominal abscesses in patients with CD colitis was investigated by two studies from the same group[75,162] showing sensitivities of 86 to 100% and specificities of 95 to 100%. Two similar studies using MRI[131,179] found sensitivities of 75% and 86%, and specificities of 91% and 93%.

A comparison of US and CT[75] found that abscesses were correctly detected in similar proportions (US 91%, CT 86%), although overall accuracy was higher for CT (92%) than for US (87%) because of US false-positives. Both methods missed only deep abscesses: five by US in the entire series (three interloop, one mesenteric, and one appendicular) and three by CT (two interloop and one mesenteric). The combination of CT and US did not significantly improve the diagnostic accuracy overall.

4.2.2. Detection of stenosis

ECCO–ESGAR statement 4D
Contrast enema or cross sectional imaging can be used to diagnose and assess colonic strictures and accuracy is improved with colonic distension [EL 2].

Two studies found that US had high diagnostic accuracy for detection of small bowel and colonic stenosis,[192,193] with sensitivities of 75% and 100%, and specificities of 93% and 90%. In the single study reporting small bowel and colonic findings separately, US sensitivity was not significantly affected by the site of stenosis.[193]

None of the four studies investigating the utility of CT for assessment of stenosis, and using an appropriate reference standard, provided data regarding colonic stenoses.[73,111,120,152] Based on the high accuracy of CT for detecting small bowel stenosis (sensitivity 85% to 93%, specificity 100%) it is plausible that CT may be useful for similar colonic lesions.

Four studies investigated the utility of MRI for the detection of colonic stenosis in CD,[131,133,179,194] with sensitivities ranging from 75% to 100%, and specificities from 91% to 100%.

At the time of writing, there is no direct comparison of cross sectional imaging techniques for diagnosis of colonic strictures.

4.2.3. Limitations of selected studies

Studies using a surgical reference standard will have a spectrum bias towards more severe intestinal complications in CD, and likely overestimate diagnostic sensitivity, due to the presence of more severe lesions, and diagnostic specificity due to a higher prevalence of lesions in the operated population.

Comparisons of diagnostic accuracy are also limited by different diagnostic thresholds and criteria across studies; standard definitions for individual complications from a radiologic perspective for each of the available techniques are elusive. Such definitions would facilitate comparisons across studies and overall conclusions. Some recent progress has been made in this regard for US and CT; standard definitions are currently being developed for MRI.

4.3. Value for therapeutic monitoring

ECCO–ESGAR statement 4E
MRI is accurate for therapeutic monitoring in colonic Crohn's disease [EL 2]; the accuracy of other modalities is not well defined.

Mucosal healing has emerged as an important treatment goal for patients with inflammatory bowel disease. Various studies have assessed the value of cross sectional imaging techniques for therapeutic monitoring in CD, using US,[108,167,195] and CT,[196] although the terminal ileum was also assessed in these studies, and results are not reported separately for colonic disease.

The utility of US for assessing activity and drug response has been compared with colonoscopy,[108,167,195] with high concordance (weighted κ between 0.76 and 0.90). US may also provide prognostic information; moderate/severe US scores at 3 months were associated with increased endoscopic activity at 15 months (OR 5.2; 95% CI 1.6–17.6 and OR 9.1; 95% CI 2.5–33.5, respectively).[167]

The value of CT was assessed in a retrospective North American study including 63 patients with CD receiving infliximab.[196] Of 105 lesions, 21 (20%) were colonic. Poor to fair correlation was found between CTE features of response

and improved clinical symptoms (kappa 0.26), improved endoscopic appearance (kappa 0.07), and reduction of CRP (kappa 0.30). When comparing responders (complete and partial) with nonresponders, only the presence of "comb sign" on the index CTE was predictive of radiologic response (P = 0.024).[196] Preliminary results of ongoing studies show that MRI has a high accuracy for monitoring therapeutic responses using endoscopy as a reference standard, in terms of responsiveness and reliability.

5. Perineum including anus, genital tract

5.1. Assessment of perianal disease

ECCO–ESGAR statement 5A
MRI is the most accurate diagnostic imaging test for perianal CD with accuracy surpassing examination under anesthesia, and is recommended during the initial diagnosis unless there is a need for immediate drainage of sepsis [EL 1].
Endosonography (with or without hydrogen peroxide) is superior to clinical examination and is an alternative to MRI [EL 2].

The diagnosis and classification of perianal disease are often reached using a combination of both clinical and imaging findings. Examination under anesthesia (EUA) in the hands of an experienced surgeon has been considered the gold standard in the assessment of perianal CD as it provides opportunity for both full staging and treatment such as drainage of sepsis and placement of non-cutting setons.[197] Many comparative studies have been performed evaluating US and MRI in the diagnosis of perianal CD fistulae,[198–209] pouchitis and urogenital complications. Both US (with and without hydrogen peroxide) and MRI are able to identify and classify fistulous tracts with good accuracy. The diagnostic accuracy of MRI ranges from 80 to 100% in most reported studies. The diagnostic accuracy of endoanal US (EUS) is variable and in general ranges from 50 to 100%. In general endoanal probes are utilized, although studies using alternative approaches such as transperineal have reported high sensitivity.[210]

Schwartz et al.,[46] in a prospective blinded study comparing EUA, MRI and EUS demonstrated a diagnostic accuracy of 91%, 87% and 91% respectively with 100% accuracy when any 2 of the tests were combined. A larger prospective clinical trial comparing preoperative digital rectal examination, US and body-coil MRI showed MRI to be superior to US for abscess detection, which in turn was superior to clinical examination (85%, 75% and 33% sensitivity respectively). Good data exists demonstrating that MRI may correctly change surgical management in patients with perianal CD.[198,211] Given its non-invasive nature, MRI should precede simple diagnostic EUA unless there is a need for immediate drainage of sepsis. Although endoscopic US has been found to have high diagnostic accuracy,[46] its use may be limited by luminal stenoses and transvaginal and transperineal US techniques may be more useful in this instance.[212]

The perianal disease activity index (PDAI)[214] is a clinical scoring system which has been used and validated in clinical studies both at diagnosis and to measure treatment response. CDAI measures intestinal and extraintestinal manifestations of CD and as such is not accurate in assessment of perianal disease specifically.[215] The fistula drainage assessment has been used in several clinical trials of medical therapy,[216–219] but is very much investigator dependent and has not been validated in large studies. A single retrospective study has evaluated the PDAI scoring system, where high scores predicted short term surgical outcome, but this has not since been validated.[220] MRI classifications of fistula severity have been proposed such as the system published by Van Assche et al.,[221] but have limited use so far outside formal clinical trials.

There is no single widely accepted and validated severity clinical scoring system for perianal fistula in CD. Both the PDAI and fistula drainage assessment may be used to measure fistula activity in clinical trials.

ECCO–ESGAR statement 5B
Undetected or untreated fistulae extensions and abscesses are the major cause of treatment failure. Imaging, particularly using MRI, is highly accurate in detecting such complications and for treatment planning [EL 1].

Full and accurate staging of perianal fistulae complicating CD is essential for therapeutic planning and ultimately achieving optimal clinical outcomes. Data suggest that the finding of rectal inflammation and or stenosis has prognostic implications and is relevant in determining the treatment approach. Rectal inflammation often indicates the presence of complex fistulae and associated complications such as abscesses.[2] Often endoscopic examination of the rectum and colon is needed to determine the presence of macroscopic inflammation and/or anal stenosis and is useful for planning treatment of perianal CD.

Undiagnosed extensions and abscesses are the major cause of recurrent disease after attempted surgical cure.[199] Furthermore, full knowledge of the presence of these complicating abscesses and extensions is required before appropriate deployment of medical therapy, particularly with anti-TNF.[222]

Good evidence is available to inform use of investigations for staging and detection of complications prior to therapy. Notably two prospective and blinded studies have evaluated the effect of preoperative MRI on clinical outcome after surgical treatment for perianal fistula disease.[198,199] Both studies showed that MRI revealed additional and clinically relevant information to the surgeon performing EUA. Recurrence rates after fistula surgery are improved if the findings of preoperative MRI are used to inform the surgical approach. US also has high reported accuracy for detecting complications of perianal CD[46,223–225] and may also be useful in treatment planning, particularly in non-recurrent disease. Use of US may be restricted due to patient discomfort, and the field of view is less than external coil MRI. Comparative prospective data using a robust outcome based reference standard suggests that MRI is superior to US for detecting complicating

abscesses[226] and in general use is preferred in CD, especially in recurrent or suspected complex disease.

5.2. Assessment of therapeutic responses in perianal disease

ECCO–ESGAR statement 5C
MRI and endosonography are both superior to simple clinical evaluation at assessing treatment response, particularly for detecting residual abscesses, and either should be considered prior to significant changes in, or cessation of, surgical or medical therapy [EL 2].

The definition for fistula healing in the literature is varied, and there is no consensus on when a first or definitive evaluation of fistula healing should be performed.[215] The PDAI[214] has been validated in patients undergoing treatment with antibiotics and azathioprine and has been used as a secondary end point for infliximab trial for the closure of perianal fistulae.[214] Subsequent trials on biologics and immunomodulators have used physical examination using gentle finger compression to assess whether drainage occurred to define a primary end point of >50% reduction in the number of draining fistulae on two or more consecutive study visits.[218,222,227] There are no studies to compare the reproducibility of this method to that of the PDAI.

MRI is increasingly used to assess fistula healing, particularly during medical therapies.[221,228,229] Various MRI classifications have been proposed, including the Van Assche score[221] which considers the number of fistulae, localization, extensions, T2 hyperintensity, abscesses and rectal involvement. Changes in contrast enhancement have also been proposed as a means to monitor fistula activity.[208]

There is no consensus on when the first or definitive evaluation of fistula healing should be performed. It has been shown that fistulae may reopen after cessation of therapy and studies using MRI findings as a more stringent endpoint of deep fistula healing suggest that MRI[221,222,229] and endoanal US[224,230] may be useful for identification of fistulae that show external closure but retain an internal fistula tract. This suggests that imaging assessment of deep healing is superior to simple clinical evaluation, although long-term comparative studies are lacking. Direct comparisons between MRI and endoanal ultrasound are also lacking although use of MRI is more clinically widespread.

5.3. Urogenital complications

ECCO–ESGAR statement 5D
In urogenital CD, clinical examination, EUA, MRI, CT and ultrasound may all be used. Contrast studies have a diminishing role [EL 4].

Many imaging modalities including MRI, fluoroscopy, CT and US may be employed for diagnosis of urogenital complications such as entero-vaginal and entero-vesical fistulae. There remains a lack of controlled data in this field with little evidence to recommend one technique over another. Small series report successful use of MRI in detecting pouch related complications such as fistula and leaks.[213]

US and MRI are superior to clinical examination in classifying fistulae and their findings should inform final classification. Clinical examination should be supplemented with imaging and/or EUA for full and accurate fistula classification.

5.4. Anorectal disease

ECCO–ESGAR statement 5E
The role of imaging in anorectal stricturing or carcinomatous transformation is limited to staging of confirmed disease and assessing the severity of known stricture [EL 4].
Confirmation of CD related anorectal malignancy should be made using established clinical, endoscopic and histopathological criteria [EL 4].

Long term complications of perianal CD include the development of luminal stenosis and anal carcinoma. The limited available evidence suggests that imaging is insensitive for diagnosis of carcinoma,[231–233] and use is limited to staging of confirmed disease. Confirmation of carcinomatous transformation in the context of chronic CD related fistulation should be made using established clinical and histopathological criteria. Both MRI and US have been used in the context of staging anal cancer although the larger anatomical coverage afforded by MRI suggests that it should be used as first line.[234] Clinical evaluation and conventional endoscopic techniques remain first line for detection luminal stenosis.

6. Liver and biliary tract

6.1. Non-invasive radiological techniques

ECCO–ESGAR statement 6A
Ultrasound is the first-line non-invasive imaging procedure in the work up of elevated liver enzymes and to differentiate intra- from extra-hepatic cholestasis [EL 1].
Magnetic resonance cholangiopancreatography (MRCP) should be considered in patients with unexplained cholestasis if ultrasound and laboratory results are non-diagnostic [EL 1].
Endoscopic ultrasound (EUS) is an alternative to MRCP for evaluation of distal biliary tract obstruction [EL 2].

Elevated liver or cholestatic enzymes in IBD should be further investigated.[235] If drug induced liver toxicity is unlikely,

primary sclerosing cholangitis (PSC) should be considered. Other hepatobiliary diseases more frequently observed in IBD than in normal controls including non-alcoholic fatty liver, non-alcoholic steatohepatitis, gallstone disease, reactivation of hepatitis B, primary biliary cirrhosis and liver cirrhosis should also be considered.

US is usually the initial diagnostic step to exclude intra- and extrahepatic cholestasis or lesions within the liver as US is sensitive and specific, relatively inexpensive and non-invasive.[236–238] CT is associated with radiation exposure, is highly specific and has moderate sensitivity for the detection of bile duct narrowing and choledocholithiasis.[239] ERCP has been considered to be the gold standard for imaging of the biliary tract. However, because of potential complications it should be restricted to selected cases. MRCP has been shown to be a safe alternative to ERCP in many cases and has similar sensitivity and specificity in detecting bile duct abnormalities.[240,241]

EUS is equivalent to MRCP in detecting common bile duct abnormalities.[242–244] In endoscopic units with good experience with this method, EUS may therefore be used instead of MRCP for detection of bile duct stones and other lesions that cause extrahepatic obstruction. Therefore, when the requirement of intervention is unclear, MRCP or EUS should be performed first, in order to avoid ERCP.[245,246]

6.2. Endoscopic retrograde cholangiopancreatography

ECCO–ESGAR statement 6B
Diagnostic endoscopic retrograde cholangiopancreatography (ERCP) should be reserved for highly selected cases in patients with normal high quality MRCP, but high suspicion for PSC, when cytology is required or in patients with contraindications for MRI due to high complication rate [EL 2].
ERCP should also be reserved for patients where a therapeutic procedure is anticipated such as stenting or balloon dilatation [EL 2].

For many years ERCP has been considered to be the gold standard to detect PSC. In recent years many studies have confirmed that MRCP has similar diagnostic value as ERCP in detecting PSC.[241,247–249] Sensitivity for detection of small duct PSC may be slightly higher in ERCP even though MRCP is almost as accurate as ERCP.[241,248] Recent meta-analysis shows that MRCP has excellent accuracy (area under the curve of 0.91) in the diagnosis of PSC which supports that initial MRCP with negative results followed by ERCP would be a cost-effective approach to diagnosing PSC.[241] MRCP should therefore be first line procedure and ERCP should be restricted for highly selected cases. Differentiating benign strictures in PSC from cholangiocarcinoma is still a diagnostic challenge.[246] In a prospective study for evaluation of bile duct strictures comparing ERCP, MRCP, CT and EUS, sensitivity and specificity relating to bile duct strictures for diagnosis of malignancies are 85%/75% for ERCP, 85%/71% for MRCP, 77%/63% for CT and 79%/62% for EUS.[250] However, ERCP may be associated with significant complications such as bleeding after sphincterotomy in 2%, pancreatitis in 3–5%, cholangitis in 1% and procedure related mortality in about 0.4%.[251–253] ERCP should therefore be restricted to cases with extrahepatic obstruction with need for endoscopic intervention, when intraductal ultrasound, histology or cytology is required.[254–259] Other reasons to perform ERCP may be contraindications for MRI. Patients with established PSC should undergo regular screening in order to detect abnormalities of the biliary tract suspicious for hepatobiliary malignancies in particular cholangiocarcinoma. First line diagnostic procedures to follow up patients with PSC are ultrasound and MRCP.[260] Bile duct strictures and progressive marked dilatations in patients with PSC are suspicious for cholangiocarcinoma and should be further investigated with ERCP for cytology, histology and eventually intraductal US.[257,258]

6.3. Ultrasound-guided liver biopsy

ECCO–ESGAR statement 6C
Ultrasound guided liver biopsy should be considered for diagnosis of small duct PSC and other liver diseases in patients with otherwise unexplained intrahepatic cholestasis, normal high quality MRCP or ERCP and inconclusive laboratory work up [EL 3].

In patients with otherwise unexplained intrahepatic cholestasis, normal high quality MRCP or ERCP and a negative AMA test a liver biopsy should be considered for diagnosis of small duct PSC and other liver diseases. Patients with small duct PSC have biochemical and histological features compatible with PSC while having a normal cholangiogram.[260,261] In a large multicenter trial small duct PSC was associated with IBD in about 80%.[262] 78% of these patients had UC, 21% had CD. Small duct PSC appears to be a distinct form of hepatobiliary disorders in IBD patients which can only by diagnosed by histopathological features and with better prognosis than PSC.[263–265]

7. Emergency situations

7.1. Gastrointestinal bleeding

ECCO–ESGAR statement 7A
Diagnosis and management of gastrointestinal hemorrhage remain a domain of endoscopy. If the bleeding cannot be located by endoscopy CT or catheter angiography should be performed, unless the patient requires immediate surgery [EL 1].

Gastrointestinal bleeding is a common cause for hospital admission that results in significant morbidity for patients affected by IBD. Identifying the source of bleeding

can be difficult since many patients bleed intermittently or stop bleeding spontaneously. With the continued advances in endoscopic technology, colonoscopy and gastroduodenoscopy have become not only diagnostic but also a useful therapeutic tools in the management of acute gastrointestinal bleeding (GIB) in stable patients. Despite the lack of IBD specific studies, colonoscopy performed within the first 24 h of admission may result in a definitive diagnosis in up to 96% of patients.[266,267]

After standard endoscopy, in the setting of obscure gastrointestinal bleeding double balloon enteroscopy (DBE) might be the initial test to perform.[268] According to a recent metanalysis DBE seems to have similar diagnostic performances as capsule endoscopy (CE), with the main advantage to be also an interventional procedure.[269]

CE is superior to push enteroscopy for diagnosing clinically significant small bowel pathology in patients with occult gastrointestinal bleeding; a recent metaanalysis reported the yield for CE and push enteroscopy of 63% and 28% respectively.[270]

Diagnosis and management of acute gastrointestinal hemorrhage in IBD patients have been mainly investigated in retrospective studies and case series.

The most recent study included 123 patients with gastrointestinal hemorrhage of obscure origin that was investigated with capsule endoscopy (CE) in combination with multidetector CT. The study showed integrating the procedures improved the diagnosis, but that for CD lesions, CE was superior to CT in diagnostic value.[271]

Despite the lack of IBD specific studies on the value of CT in acute gastrointestinal bleeding, a recent prospective study evaluated the accuracy of this technique for detection and localization of acute massive gastrointestinal bleeding, using angiography as reference standard, showing that overall patient-based accuracy for detection of acute GI bleeding was 88.5%.[272]

7.2. Toxic megacolon

ECCO–ESGAR statement 7B
In acute, severe colitis a plain abdominal radiograph is an acceptable first study to detect toxic megacolon defined by a mid transverse colonic dilation >5.5 cm. In equivocal or selected cases CT could be used as the primary imaging modality to screen for complications (e.g. perforation, abscess, thrombosis, ischemia) that require emergency surgery. Toxic megacolon is also predicted by the extent of small bowel and gastric distension in most patients with severe colitis [EL 3].

Toxic megacolon represents a serious complication of mainly inflammatory or infectious conditions of the colon, commonly associated with IBD, i.e., UC or ileocolonic CD.[273]

Diagnosis is made by clinical evaluation for systemic toxicity and imaging studies. Detection of colonic dilatation greater than 5.5 cm by means of plain abdominal X-ray is still the most established radiological criterion of toxic megacolon. However, other radiological signs, such as increased small bowel gas, persistent small bowel distension and distension of the stomach, mucosal islands, colonic dilatation and colonic deep ulceration, may predict the failure of medical therapy in patients with severe colitis, together with a higher risk of developing toxic megacolon and the need for colectomy.[274–278]

Small case series showed that in patients with toxic megacolon, CT scan and transabdominal intestinal ultrasound may be promising alternatives providing additional information.[279,280] In particular, CT scan is potentially an important tool in the diagnosis of abdominal complications including toxic megacolon, perforation or ascending pylephlebitis. A study observed that among 18 patients with toxic megacolon (4 with underlying UC) in 4 CT scan found abdominal complications missed clinically and on plain abdominal films.[279] However, larger clinical studies are warranted to assess the diagnostic benefit of radiological studies in the assessment of toxic megacolon.

7.3. Acute abdominal pain

ECCO–ESGAR statement 7C
Abdominal ultrasound and plain X-ray should be considered in all patients with acute abdominal pain and established IBD. CT should be considered in patients with suspected perforation and negative or inconclusive first line studies [EL 2].

Spontaneous free perforation is a rare but often serious event in the clinical course of CD, and may be a result of severe inflammatory lesions or a superimposed malignant process, i.e., adenocarcinoma or lymphoma. It is estimated that approximately 1–15% of patients with CD will present with a free perforation initially or eventually in their disease course.[281,282]

The early diagnosis of this condition is an important determinant of survival. A study by Hattori et al. including 10 CD patients with free perforations showed that CT scan was significantly more sensitive than plain radiography for detecting free air in the abdomen at the time of perforation.[283] However, a retrospective review of CT scans enrolling 76 patients with various diseases (including 5 CD patients) with proven alimentary tract perforation showed that CT scan yielded 65 true-positive and 11 false-negative cases, including 1 CD patient with mesenteric phlegmon and obstruction and concluded that CT is a valuable method for intestinal perforation but with a sensitivity of 85.5%.[284]

It should be taken into account that frequently in CD patients, intestinal perforation presents as a perintestinal abscess that may be detected by cross sectional imaging methods such as US, MRI or CT. A

recent systematic review showed that in this context the three techniques have a high accuracy for identification of fistulas, abscesses and stenosis (sensitivities and specificities > 0.80), although US has false positive results for abscesses.[36]

7.4. Post-operative complications

ECCO–ESGAR statement 7D
Acute postoperative complications in IBD patients (e.g. anastomotic leaks, abscesses, intestinal intussusception, mesenteric vein thrombosis, obstruction) should be initially investigated by CT or ultrasound followed by immediate CT if negative or equivocal. Fluoroscopic studies are also effective for assessing anastomotic leaks, in particular distal anastomotic leaks [EL 4].

Anastomotic leaks after intestinal surgery may be easily diagnosed on clinical grounds due to their characteristic presentation in the post operative period. However, sometimes this complication has no definitive signs and symptoms, and correct and prompt diagnosis by the radiologist is necessary for successful management.

Although few studies have been designed to assess the detection of these complications in CD patients, most of the available data is derived from the surgical literature.[285]

A prospective database of two colorectal surgeons carried out over a 10-year period, showed that anastomotic leaks are frequently diagnosed late in the postoperative period and often after initial hospital discharge. In this study CT scan was the preferred diagnostic modality when imaging is required.[286]

On the other hand, other studies showed that most postoperative CT features overlap between patients with and without clinically important anastomotic leaks and that CT studies performed on patients shortly after abdominal surgery are not definitive. A negative CT study does not rule out postoperative lower gastrointestinal tract leak.[287,288]

Ileal-pouch-anal anastomosis (IPAA) surgery preserves fecal continence for improved quality of life in patients who require proctocolectomy for treatment of intractable IBD. The main acute complication of IPAA includes anastomotic leak and abscesses. Leaks from the blind end of the pouch and the pouch-anal anastomosis often result in pelvic abscesses.

The detection of this complication is possible using transrectal and transperineal US, although usually CT or MRI scanning is required to delineate the full extent of the complication and guide drainage.[289,290] In this regard, pelvic abscess associated with anastomotic leak in patients with IPAA can be drained using either transanal or CT-guided approach. Both are equally effective although there is a risk of fistula induction at the drainage site after a CT-guided drainage.[291]

8. Special situations not emergencies: postsurgery, cancer surveillance, ileoanal pouch

8.1. Post-surgical recurrence

ECCO–ESGAR statement 8A
US, CT, MRI, SBFT and WBC scintigraphy detect recurrence of CD after ileocolonic resection and are complementary to endoscopy [EL 2].
US, CT, MRI, SBFT and WBC scintigraphy can be useful as a follow-up method in patients after small bowel surgery [EL 2].

Recurrence of CD after surgical intervention is a diagnostically and therapeutically challenging condition. Several imaging modalities are available to reliably diagnose post surgical recurrence including US, SICUS, SBFT, CT enteroclysis or enterography including virtual colonoscopy, MRI enteroclysis or MRI enterography, SBCE and WBC scintigraphy.

Several authors had formerly emphasized the value of abdominal US in the postoperative follow-up and confirmed the observation of the bowel wall thickening as an indicator for recurrence.[292–295] SICUS has shown an excellent correlation with the endoscopic Rutgeerts' score (P = 0.0001; r = 0.67) reaching 87.5% accuracy for detecting CD recurrence[296] and is considered to be superior to standard abdominal US in detecting postoperative CD recurrence after ileocecal resection.[297] Bowel wall thickening was defined by thickness of more than 3.5 mm. SICUS prediction of recurrence was found to be correct in 100% of cases and confirmed by endoscopy[297] These results were confirmed in two additional studies[298,299] who determined sensitivity, specificity, positive and negative predictive values to be 61.5% (95% IC: 41 79%), 96% (95% IC: 78 100%), 94%, and 71%, respectively.

SBFT should only be used if cross-sectional imaging techniques are not available or very specific clinical questions apply. SBFT or enteroclysis is able to visualize the presence, extent and pattern of CD recurrence after ileo-colonic resection, although providing a radiation exposure to the patient.[300]

CT enterography or enteroclysis is an alternative to endoscopy for assessing postoperative recurrence of CD activity.[301] Evidence for the value of CT enterography has also been shown.[302] CT colonography has been tested for assessing the postoperative recurrence of CD with inconclusive results due to false negative findings. It does however represent an alternative to conventional colonoscopy in noncompliant postsurgical patients with a rigid stenosis which does not allow passage of the endoscope.[170]

MRI enteroclysis or enterography may be an alternative to endoscopy as a diagnostic tool in post-surgical recurrence evaluation in CD patients.[142,303] Similar to the endoscopic Rutgeerts' score for assessing post-surgical recurrence, one study showed an objective evaluation using an MRI based index of activity and severity for post-surgical recurrence. This score achieved a high correlation with the endoscopic

index allowing differentiation between mild and severe lesions[304] and predicting the risk of clinical post-surgical recurrence in CD patients.[305]

Although the Rutgeerts' score has been used to evaluate the efficacy of several drugs, there is lack of information whether mural healing changes seen by cross-sectional imaging techniques are in parallel to the endoscopical mucosal healing.

Scintigraphy with 99mTc-HMPAO or 111 In-oxide labeled leucocytes (or white blood cells WBC scintigraphy) has been reported as an alternative non-invasive technique for the detection of recurrence of intestinal inflammation in CD patients.[306–309] It is able to provide information about the localization, extent and severity of a disease recurrence. Limitations of WBC scintigraphy are its relatively low specificity due to the high frequency of false positive findings.[300] Investigations on the usefulness of WBC scintigraphy in assessing the early postoperative recurrence of CD are sparse[62,140]

8.2. Evaluation of the ileoanal pouch

ECCO–ESGAR statement 8B
Either Pelvic MRI or CT is recommended in suspicion of ileoanal pouch septic complications [EL3b; RG C] or CD of the pouch [EL 4].
Pouchography can assess functional disorders, pouch strictures, afferent limb syndrome, pouch fistulae and pouch leakage [EL 3].

Ileo-anal (IA) pouch is a well-established option for patients who require surgery for UC. Despite excellent functional results the short and long-term outcomes of IPAA are determined by the occurrence of complications. These may be directly related to the performed surgery or occur over the long-term. Immediate postsurgical complications include leakage, abscess formation, pelvic sepsis and fistula formation. More chronic disorders following IPAA are pouchitis, cuffitis, irritable pouch syndrome, pouch stricture, pouch sinus, afferent loop syndrome or small bowel obstruction.[310] Recurrence of CD may occur within the pouch. Following surgery, up to 40% of patients have a single episode of pouchitis[311] within 12 months, a nonspecific inflammatory condition at the ileal pouch reservoir, whereas 19% to 5% experience intermittent episodes and chronic pouchitis.[312–314] In addition to pouch endoscopy, diagnostic imaging modalities are essential to help distinguish inflammatory from non-inflammatory conditions and to identify extraluminal complications which require immediate interventions.

Therefore, cross-sectional imaging modalities such as CT- and MRE and MRI of the pelvis are key imaging modalities.

Functional assessment of mechanical disorders related to the pouch such as pouch stricture, afferent loop syndrome and obstruction can be successfully addressed with functional radiographic techniques such as pouchography and defecography. The choice of the most appropriate imaging modality depends on the clinically suspected disorder, local expertise and availability. Inflammatory and infectious complications are best addressed with CT and MRI.[315,316]

Pelvic MRI can be used to assess recurrence of CD of pouch. Pelvic CT and MRI showed high accuracy for detecting IA inflammatory complications. Further larger series are needed to confirm their utility and determine whether cross sectional techniques may be helpful for differentiating pouchitis from CD recurrence.

Barium-enhanced radiography (pouchography) is accepted for diagnosis of inflammatory complications of IA pouch as well as for non-inflammatory conditions.

Despite a limited number of studies assessing the postoperative outcome of IPAA with these techniques, both CT and MRI are advocated to be useful in detecting mural inflammatory changes. In one study[315] mural and extramural inflammatory lesions were found in 7 of 9 patients with clinical suspicion of complicated ileoanal pouch confirmed by histology. From these 7 patients, 2 had normal mucosa at endoscopy. In another study a sensitivity of 78% and specificity of 96% for detecting ileoanal pouch complications (fistula, abscess or pouchitis) were observed; CT had a higher sensitivity than pouchography for the detection of inflammatory IPAA complications because extraluminal complications cannot readily be assessed with pouchography.[316] It is important to emphasize that transmural inflammation of the pouch detected on imaging is not necessarily due to CD, as it can also be seen in chronic pouchitis. It has been suggested that asymmetric pouchitis may indicate ischemia in contrast to CD of the pouch or chronic pouchitis.[317] Transmural disease and wall thickening in the setting of IPAA are not pathognomonic of CD. Transmural inflammation shown by imaging or histopathology can be seen in both CD and chronic antibiotic-refractory pouchitis.[318]

A correlation of CT, MRI, pouch endoscopy and retrograde pouchography findings with the clinical outcome found a reasonable accuracy for diagnosis of strictures, fistulas, sinuses and pouch leaks with all methods.[213] CT had the lowest accuracy for small bowel strictures (74%), and MRI for pouch sinuses (68%). A combination of 2 imaging tests increased the accuracy of diagnosis to 100%.

The afferent limb syndrome, defined as the obstruction of afferent bowel loop at the junction of the pouch, can be diagnosed by imaging techniques[290]; barium enema or CT enterography can be used for the diagnosis of inflammatory or fibrostenotic CD of the pouch. Finally, it is important to emphasize that transabdominal ultrasonography is poor at evaluating IA pouch complications due to their typically deep location in the pelvis and inherent difficulty in visualization.

8.3. Neoplastic lesions

ECCO–ESGAR statement 8D
CT colonography or virtual colonoscopy is not an alternative to colonoscopy in patients with proven IBD for assessment of neoplastic lesions. However, it is useful to detect cancer in clinical situations where colonoscopy cannot be performed (e.g. strictures) [EL 2].

There is no evidence that virtual colonoscopy by CT or MRI may be of utility for surveillance of colorectal cancer in patients with CD or UC. Considering the underlying inflammatory changes of the intestinal wall leading to permanent abnormalities such as pseudopolyps, and the fact that a significant portion of dysplastic lesions are flat at endoscopy, it is conceivable that with current cross-sectional imaging techniques both the number of false positive diagnosis and the miss-rate for these lesions would be high. Therefore, follow-up by periodical endoscopy including chromoendoscopy is recommended for screening of dysplasia at least for UC.[319–321] There are no specific trials for CD but epidemiological data suggest that patients with CD colitis have similar incidences of colorectal cancer as of patients with UC.[322,323] Therefore, in CD colitis a similar cancer surveillance algorithm should be applied.

In patients with CD the risk for small bowel adenocarcinoma is increased with a relative risk up to 159.[324–326] Cumulative risks of 0.2% at 10 years and 2.2% at 25 years for CD patients with small bowel disease at diagnosis have been observed.[147,327]

9. Implementation of recommendations

The statements and general recommendations of this consensus are based on the highest level of evidence available, but significant gaps remain in certain areas such as the comparison of diagnostic accuracy between different techniques, the value for therapeutic monitoring, and the prognostic implications of particular findings.

Local expertise may have a significant influence on the accuracy, and this is an additional factor to take into consideration, although implementation of the techniques that have shown the best diagnostic accuracy by properly designed studies using reference standard (evidence levels 1 and 2), should be procured in every IBD reference center.

Finally, the costs incurred by different techniques have not been considered for every patient situation. These costs are highly variable between European countries, which makes it difficult to factor this aspect into the recommendations. Judicious considerations integrating the available evidence, patient condition and costs are essential for the best use of imaging techniques in IBD.

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