TITLE

Role of bowel ultrasound in the management of postoperative Crohn's disease

RUNNING TITLE

Ultrasound in postoperative Crohn’s disease

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Key words

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Abstract:

The use of biological and immunosuppressive therapy in Crohn’s disease (CD) changed favorably the course of the disease and is currently suggested in the prevention of clinical recurrence. Symptomatic exacerbation is a feature of the natural course of the disease. Endoscopic recurrence may occur earlier than clinical manifestations and its rate is still high ever since the first year after surgery. The severity of mucosal lesions is highly predictive of a new flare of the disease so that the early detection of recurrence warrants strong therapeutic changes or a closer monitoring of the case.

Endoscopy is at present the gold-standard technique for the diagnosis and grading of recurrence severity, but is poorly accepted by patients for its inva0siveness.

A simple and easy repeatable examination able to detect early signs of recurrence could be useful in the follow-up as an alternative or as a backing in the choice of the right timing for endoscopy in questionable cases.

The use of bowel ultrasound (B-US) in the management of CD has grown in the past twenty years. Its accuracy in the real time detection of the disease and its complications, known since the 80's, together with the non-invasiveness, low cost and wide availability of the technique have influenced the extension of its clinical use in many referral centers in Europe. The latest generation of ultrasound scanners allows a precise and reproducible morphological assessment of the intestinal tract and the surrounding tissues and enables a complete evaluation of the disease.

This review analyzes the literature history about B-US in the diagnosis of postoperative recurrence of CD and outlines the clinical implications of its use.

Published works confirm a very good accuracy of B-US in the diagnosis of CD recurrence compared to endoscopy, also in the early phase. B-US shows a good correlation with Rutgeert’s score grading, but does not prove significant association with CRP or CDAI values.

A wider use of B-US in the daily practice could allow to set a prompt diagnosis and an earlier and targeted treatment, probably sparing more invasive tests.

Core Tip

In the recent years, after the introduction of new drugs, prevention of recurrence is one of the emerging issues in the management of Crohn’s disease because a more aggressive and earlier therapy is supposed to change the clinical course of the disease. Endoscopy, that is presently the standard reference for the diagnosis, is not well tolerated by patients. To asses pre-clinical signs of recurrence a non-invasive alternative is needed: MRI shows accurate results but with high costs and low availability. B-US can detect early specific signs of recurrence. Advantages, limits and clinical implications of the technique are discussed below.

Introduction

The therapeutic management of CD patients is an open challenge. The correct use of steroids, antibiotics, immunomodulators and biological therapies requires an appropriate timing in the decision making process. From this point of view an early diagnosis of postoperative recurrence is extremely important in order to identify patients with a more aggressive course and to address the correct therapeutic choice. Recurrence is endoscopically present in around 70% of patients at 1 year after surgery. Early endoscopic signs of recurrence have been detected even three months after surgery and severity of mucosal lesions is highly predictive of future clinical manifestations of the disease [1,2].

Endoscopy is at present the gold-standard for the diagnosis of recurrence but less invasive, repeatable techniques would fit better to follow the evolution of chronic disease if they showed comparable results. The use of Computed Tomography (CT) should be limited because of its biological invasiveness while Magnetic Resonance (MR) can not be carried out routinely for its substantial costs and inadequate availability.

Starting from the first reports in the 80’s on the possibility of detecting inflammatory bowel diseases using ultrasounds, the role of this technique in characterizing Inflammatory Bowel Disease (IBD) in terms of extension, activity and complications compared to radiology or endoscopy has steadily increased [3-8].

In the last decade the continuous improvement in ultrasound technology enabled a better definition of the bowel wall morphology. The addition of color-power doppler, oral or intravenous contrast to advanced US technical equipment made it possible to distinguish fibrotic from inflammatory involvement of the intestinal tract, phlegmons from abscesses and to select a portion of patients at increased surgical risk or with optimal response to new pharmacological approaches [9-13].

Advantages and limits of the technique and the technical aspects of potential impact on clinical practice are discussed below.

Literature analysis

All the studies available in literature define post-surgical US recurrence as an increased bowel wall thickness at the anastomosis level and the majority of them correlates US findings with endoscopy. Major obstacles to a correct interpretation of the literature are due to a significant heterogeneity in the studies' design (different reference standards and variability in the timing of procedures), in technical aspects (different cut-offs for bowel wall thickness, BWT) and in the use of additional technical equipment (Power Doppler, Enteral or Intravenous Contrast Agents).

Since 1986 Di Candio et al. described the possibility of detecting post-surgical recurrence using transabdominal US compared to contrast radiography and endoscopy. His pioneering work on 32 patients showed a good sensitivity (82%) and an excellent specificity (100%) of the technique with an overall accuracy of 93.7%. In this study the possibility to distinguish between inflammatory and neoplastic lesions is shown through a structural study of bowel wall, paying particular attention to the integrity of its layers [14].

In 1998 Andreoli studied the US detection rate of CD recurrence in 47 patients who underwent terminal ileum resection for Crohn's disease using endoscopy at the anastomotic site as gold standard. Bowel US sensitivity was 81%, specificity 86% and the overall accuracy 83%. The authors suggest to perform US in case of clinical suspected recurrence, reserving ileocolonscopy to negative or uncertain cases [15].

In 2001 and 2004 two studies have been published on the role of ultrasonography in the detection of recurrence after conservative surgery (strictureplastic and/or miniresections) [16,17 ]. Thickness and echopattern (the sequence of layers that constitute the sonographic appearance of the intestinal wall) of the diseased wall were considered before and 6 months after surgery in patients with ileal stictures in order to understand if these characteristics and their postoperative behavior have a prognostic value. Both thickness and echopattern, in different measure, are relevant in order to reliably predict recurrence (hazards ratio 8.8 and 4.1 respectively).

A possible role of US as a predictor of endoscopic recurrence has been evaluated by Orlando in 2006[18]. Looking for the best calprotectin cut-off to assess recurrence, 50 resected patients were studied with US and fecal calprotectin every three months after surgery. Endoscopy was performed at one year. US sensitivity with a 5 mm BWT cut-off was 26% and specificity 90%. The best calprotectin cut-off value to predict the highest numbers of endoscopic recurrences was > 200 mg/L (sensitivity 63% and specificity 75%). Considering such a high specificity of US, the authors suggest that a positive ultrasound 3 months after surgery, may be an indication to colonoscopy. In case of US negative, faecal calprotectin with a cut-off value of 200 mg/L could be a useful tool in order to decide if performing colonoscopy in asymptomatic patients.

In the study of Biancone et al. Bowel US was performed with oral contrast (small intestine contrast ultrasound – SICUS) [19]. Twenty-two asymptomatic patients, prospectively followed after surgery, underwent clinical controls every 3 months and SICUS, WCE and colonoscopy 1 year after surgery. Seventeen patients underwent all the 3 procedures. SICUS showed 100% sensitivity, 0% specificity (16 TPs, 1 FP), whereas WCE 100% sensitivity, 100% specificity (16 TPs, 1 TN). The small serie was then split in smaller subgroups. Considering only neo-terminal ileum recurrence and excluding patients in which disease was limited to the anastomosis the sensibility was 86% and specificity 33 %. In a very small subgroup (10 patients) SICUS and WCE were performed at 3, 6 and 12 months. SICUS identified four of the nine WCE positive at month 3. At month 6, eight of the nine WCE positive were detected by SICUS. No significant correlation between BWT and Rutgeert’s score was found.

A part of a long term prospective follow up study on severity of CD recurrence after ileal resection published in 2010 by Pallotta et al. reports on 58 CD patients scheduled to SICUS and ileocolonoscopy at 6 months regular intervals after surgery [20]. Ileocolonoscopy was performed within 2 weeks from SICUS. Bowel wall thickness at the anastomosis site was measured and it correlated with the anastomotic recurrence degree sec. Rutgeerts. SICUS could detect extension of intramural lesions even in patients with tight anastomotic stenosis.

In 2010, Onali performed a longitudinal prospective study in 25 patients 3 years after surgery using oral contrast US and obtaining a very good correlation between SICUS and endoscopy. The correspondence of SICUS detected lesions with Rutgeert’s grade was moderate and the attempt of identifying a bowel wall thickness value predictive for clinical recurrence did not reach statistical significance [21].

Between 2006 and 2010 other four prospective studies comparing US performance with endoscopy have been published [22-25]. In these studies sensitivity varies from 79 to 92% and specificity from 20 to 95%. In two of them oral contrast was used [23-24]. For all of them ileocolonoscopy was the reference standard and bowel wall thickness (>3 mm) the only pathological feature considered. In one paper Doppler findings were considered, slightly strengthening the accuracy only in moderate-severe recurrence and with no impact on recurrence detection [25]. Bowel wall thickness was compared with Rutgeerts’ score obtaining a good correlation between ultrasonographic findings and endoscopic lesions. Using a cut-off of 5 mm for bowel wall thickness mild from severe disease can be distinguished. No significant correlations between Crohn’s disease activity index (CDAI) and SICUS where found [24], while SICUS showed a higher sensitivity and specificity in detecting recurrence compared to CRP and CDAI values [23] .

The use of intravenous contrast enhancement ultrasonography (CEUS) to emphasize B-US findings was reported by Paredes et al. in a study on postoperative recurrence of Crohn's disease [26]. The sample size of the study is consistent (60 patients) and the interval between ileocolonoscopy and CEUS was 3 days only. The study considered bowel wall thickness (cut-off 3-5 mm recurrence present, >5 mm moderate-severe), color doppler vascularity (subjectively graded) and CEUS. The authors quantify ultrasonographic activity, with a software processing of the difference in brightness of contrast enhancement maximum uptake and the baseline and worked out a US activity score that correlates with Rutgeert’s degree of severity. B-US sensitivity rises with CEUS from 89.8% to 98% while specificity keeps 81%.

In the same year Cammarota et al. published the largest retrospective study on the subject and investigate in particular the possible predictive role of BWT on surgical recurrence. All the patients included (196) were followed for 114 months on average and the rate of surgical recurrence was 20.4%. Bowel US was performed 6-15 months after surgery; bowel wall thickness >3 mm was predictive of surgical recurrence. Moreover the authors describe an increased percentage of surgical recurrence in higher values of BWT at 1 year after surgery [27].

Conclusion

Several studies have been performed on bowel ultrasound and post-surgical recurrence in Crohn’s disease. Although most of them have a small sample size and different study designs, a very good correspondence between US and ileocolonoscopy is reported even in the early stages after surgery [18,24]. Bowel wall thickness is the main US parameter in the detection of recurrence. The majority of the studies compare ultrasonografic with endoscopic findings and BWT values >3 mm shows, except in two cases [18-19] , high percentage of sensibility and specificity (until 100% both) in identifying recurrence [14,15,20-26] . Some studies demonstrate also a correlation between BWT values (> 5 mm) and Rutgeert’s score severe disease grade [19-24].

Few studies consider the echopattern performance before and after surgery in addition to bowel wall thickness [16-17]. Morphological alterations of the echopattern are a relevant parameter in the follow-up of Crohn's disease, and a good correspondence of different echopatterns with histologic findings has been shown [28]. Moreover the predictive value of different echopatterns on the relative risk of surgical treatment and the normalization of the echopattern after biologic therapy have been reported [9, 13]. Despite the positive data supporting its use, this technique is not widespread and its use is substantially limited to some European countries. The main criticism raised by some authors is the supposed low reproducibility of the method.

Ultrasonography is by definition a subjective technique and its employement in the study of ileum and colon may be particularly difficult considering the scarcity of repere points, the high anatomical variability expecially in post-surgical patients and the presence of gas in the bowel which implies the use of graduated pressure to display the deepest loops. On this issue (the reproduciblity of B-US in the evaluation of Crohn' disease) a multicenter study has been performed which brought together gastroenterologists sonographers and radiologists from six referral centers for inflammatory bowel diseases, including our group. We found in different clinical settings of Crohn's disease a good k value concerning BWT (K= 0.72–1) and the presence of complications (K= 0.81–1) [29].

The performance of the examination, blinded, sequentially conducted by different operators, was preceded by a long theoretical comparison that led to the choice of parameters to be measured and methods of detection.

The results of this experience, combined with the well known positive characteristics of ultrasound (optimal tolerance, low invasiveness, low costs, wide availability) and the comparable accuracy values of B-US, CT and MRI in different controlled settings of Crohn's disease attest B-US as an added value in the clinical management of IBD [30, 32].

In our opinion features needed for a correct use of B-US are an adequate learning curve, a good clinical knowledge in inflammatory bowel diseases and the basics of ultrasound technique. The use of B-US should be included in pathways of clinical management at different levels in the management of inflammatory bowel diseases (screening IBS-IBD, therapy monitoring, follow up of complications, emergency, young children) because it raises an efficient clinical work up and reduces the use of more expensive and invasive tests with similar results in terms of clinical impact[31, 32].

It is conceivable that new technologies can improve the correspondence between imaging and bowel wall morphology in intestinal inflammation. A wider confrontation among experienced operators on this and other interesting US paramethers in B-US would be desirable.

REFERENCES

1. **Rutgeerts P**, Geboes K, Vantrappen G, Beyls J, Kerremans R, Hiele M.et al. Predictability of the postoperative course of Crohn’s disease. Gastroenterology 1990;99:956–63. PMID:2394349
2. **Olaison G**, Smedj K, Sjodahl R. Natural course of Crohn’s disease after ileo-cecal resection: Endoscopically visualised ileal ulcers preceding symptoms. Gut 1992;33:331–5. PMID:1568651 doi.org/10.1136/gut.33.3.331 S
3. **Sonnenberg A**, Erckenbrecht J, Peter P, Niederau C. Detction of Crohn’s disease by ultrasound. Gastroenterology. 1982 Aug;83(2):430-4.PMID:7084620
4. **Hata J**, Haruma K, Suenaga K, et al. Ultrasonographic assessment of inflammatory bowel disease. Am J Gastroenterol. 1992;87:443–447. PMid:1553931
5. **Maconi G**, Parente F, Bollani S, Cesana B, Bianchi Porro G. Abdominal ultrasound in the assessment of extent and activity of Crohn's disease: clinical significance and implication of bowel wall thickening. Am J Gastroenterol. 1996 Aug;91(8):1604-9.PMID:8759670
6. **Maconi G**, Bollani S, Bianchi Porro G. Ultrasonographic detection of intestinal complications in Crohn's disease Dig Dis Sci. 1996 Aug;41(8):1643-8.PMID:8769293 doi.org/10.1007/BF02087914
7. **Parente** F, Maconi G, Bollani S, Anderloni A, Sampietro G, Cristaldi M, Franceschelli N, Bianco R, Taschieri AM, Bianchi Porro G. Bowel ultrasound in assessment of Crohn's disease and detection of related small bowel strictures: a prospective comparative study versus x ray and intraoperative findings.Gut. 2002 Apr;50(4):490-5 PMID:1188906 doi.org/10.1136/gut.50.4.490
8. **Fraquelli M**, Colli A, Casazza G, Paggi S, Colucci A, Massironi S, Duca P, Conte D. Role of US in detection of Crohn disease: meta-analysis. *Radiology* 2005; 236: 95-101 PMID:15987966 doi.org/10.1148/radiol.2361040799
9. **Rigazio C**, Ercole E, Laudi C, Daperno M, Lavagna A, Crocella L, Bertolino F, Viganò L, Sostegni R, Pera A, Rocca R. “Abdominal bowel ultrasound can predict the risk of surgery in Crohn's disease: Proposal of an ultrasonographic score” Scand J Gastroenterol. 2009;44(5):585-93. PMID:19148846 doi:10.1080/00365520802705992.
10. **Castiglione F**, de Sio I, Cozzolino A, Rispo A, Manguso F, Del Vecchio Blanco G, Di Girolamo E, Castellano L, Ciacci C, Mazzacca G. “Bowel wall thickness at abdominal ultrasound and the one-year-risk of surgery in patients with Crohn's disease” Am J Gastroenterol. 2004 Oct;99(10):1977-83. PMID:15447760 doi.org/10.1111/j.1572-0241.2004.40267.x
11. **Ripollés T**, Rausell N, Paredes JM, Grau E, Martínez MJ, Vizuete J. Effectiveness of contrast-enhanced ultrasound for characterisation of intestinal inflammation in Crohn's disease: a comparison with surgical histopathology analysis J Crohns Colitis. 2013 Mar;7(2):120-8 doi:10.1016/j.crohns.2012.03.002. Epub 2012 Apr 5.PMID: 22483566
12. **Calabrese E**, Zorzi F, Onali S, Stasi E, Fiori R, Prencipe S, Bella A, Petruzziello C, Condino G, Lolli E, Simonetti G, Biancone L, Pallone F. Accuracy of small-intestine contrast ultrasonography, compared with computed tomography enteroclysis, in characterizing lesions in patients with Crohn's disease. Clin Gastroenterol Hepatol. 2013 Aug;11(8):950-5. doi: 10.1016/j.cgh.2013.01.015. Epub 2013 Jan 29. PMID: 23375998
13. **Moreno N**, Ripollés T, Paredes JM, Ortiz I, Martínez MJ, López A, Delgado F, Moreno-Osset E. Usefulness of abdominal ultrasonography in the analysis of endoscopic activity in patients with Crohn's disease: Changes following treatment with immunomodulators and/or anti-TNF antibodies. J Crohns Colitis. 2014 Mar 7. PMID: 24613399 pii: S1873-9946(14)00056-7. doi: 10.1016/j.crohns.2014.02.008.
14. **Di Candio** G. Mosca F, Campatelli A, Bianchini M, D’Elia F, Dellagiovanpaola C. “Sonographic detection of postsurgical recurrence of Crohn's disease” American Journal of Radiology 1986; 146: 523-526 PMID:3511636
15. **Andreoli A**. Cerro P, Falasco G, Giglio LA, Prantera C. “ Role of ultrasonography in the diagnosis of postsurgical recurrence of Crohn's disease” Am J Gastroenterol. 1998 Jul;93(7):1117-21. [doi.org/10.1111/j.1572-0241.1998.00340.x](http://dx.doi.org/10.1111/j.1572-0241.1998.00340.x) PMID:9672341
16. **Maconi G**, Sampietro GM, Cristaldi M, Danelli PG, Russo A, Bianchi Porro G, Taschieri AM Preoperative characteristics and postoperative behavior of bowel wall on risk of recurrence after conservative surgery in Crohn's disease: a prospective study. Ann Surg. 2001 Mar;233(3):345-52. PMID:11224621 doi.org/10.1097/00000658-200103000-00007
17. **Parente F**, Sampietro GM, Molteni M, Greco S, Anderloni A, Sposito C, Danelli PG, Taschieri AM, Gallus S, Bianchi Porro G. Behaviour of the bowel wall during the first year after surgery is a strong predictor of symptomatic recurrence of Crohn's disease: a prospective study. Aliment Pharmacol Ther. 2004 Nov 1;20(9):959-68. [doi.org/10.1111/j.1365-2036.2004.02245.x](http://dx.doi.org/10.1111/j.1365-2036.2004.02245.x) PMID:15521843
18. **Orlando A**. Modesto I, Castiglione F, Scala L, Scimeca D, Rispo A, Teresi S, Mocciaro F, Criscuoli V, Marrone C, Platania P, De Falco T, Maisano S, Nicoli N, Cottone M. “The role of calprotectin in predicting endoscopic post-surgical recurrence in asymptomatic Crohn's disease: a comparisopn with ultrasound”. Eur Rev Med Pharmacol Sci. 2006 Jan-Feb;10(1):17-22. PMID:16494106
19. **Biancone** L, Calabrese E, Petruzziello C, Onali S, Caruso A, Palmieri G, Sica GS, Pallone F. Wireless capsule endoscopy and small intestine contrast ultrasonography in recurrence of Crohn’s disease. Inflamm Bowel Dis. 2007 Oct;13(10):1256-65. PMID:17577246 doi.org/10.1002/ibd.20199
20. **Pallotta N**, Giovannone M, Pezzotti P, Gigliozzi A, Barberani F, Piacentino D, Hassan NA, Vincoli G, Tosoni M,Covotta A, Marcheggiano A, Di Camillo M, Corazziari E. “Ultrasonographic detection and assessment of the severity of Crohn's disease recurrence after ileal resection” Gastroenterology 2010; 10: 69-80 doi: 10.1186/1471-230X-10-69. PMID:20594291
21. **Onali S**. E. Calabrese, C. Petruzziello, F. Zorzi, G.S. Sica, E. Lolli, M. Ascolani, G. Condino , F. Pallone, L. Biancone “Endoscopic vs ultrasonographyc findings related to Crohn's Disease recurrence: A prospective longitudinal study at 3 years” Journal of Crohn's and Colitis 2010; 4: 319-328 doi.org/10.1016/j.crohns.2009.12.010 PMid:21122521
22. **Rispo A**. Bucci L, Pesce G, Sabbatini F, de Palma GD, Grassia R, Compagna A, Testa A, Castiglione F. “Bowel Sonography for the diagnosis and Grading of Postsurgical Recurrence of Crohn's Disease” Inflamm Bowel Dis. 2006 Jun;12(6):486-90.PMID:16775492 doi.org/10.1097/00054725-200606000-00007
23. **Castiglione F**. Bucci L, Pesce G, De Palma GD, Camera L, Cipolletta F, Testa A, Diaferia M, Rispo A. “Oral Contrast-Enhanced Sonography for the Diagnosis and Grading of Postsurgical Recurrence of Crohn's Disease” Inflamm Bowel Dis. 2008 Sep;14(9):1240-5. doi: 10.1002/ibd.20469. PMID:18398896
24. **Calabrese E**, Petruzziello C, Onali S, Condino G, Zorzi F, Pallone F, Biancone L. “Severity of Postoperative Recurrence in Crohn's disease: Correlation Between Endoscopic and Sonographic Findings” Inflamm Bowel Dis. 2009 Nov;15(11):1635-42. doi: 10.1002/ibd.20948.PMID:19408327
25. **Paredes JM**, Ripollés T, Cortés X, Reyes MD, López A, Martínez MJ, Moreno-Osset Eet al. “Non-invasive diagnosis and grading of post postsurgical endoscopic recurrence in Crohn's disease. Usefulness of abdominal ultrasonography and 99mTc-hexamethylpropylene amineoxime-labelled leucocyte scintigraphy”. Journal of Crohn's and Colitis 2010; 4: 537-545 doi: 0.1016/j.crohns.2010.03.002. PMID:21122557
26. **Paredes JM**, Ripollés T, Cortés X, Moreno N, Martínez MJ, Bustamante-Balén M, Delgado F, Moreno-Osset E. “Contrast-enhanced ultrasonography: Usefulness in the assessment of postoperative recurrence of Crohn's disease” J Crohns Colitis. 2013 Apr 1;7(3):192-201. doi: 10.1016/j.crohns.2012.03.017. Epub 2012 Apr 26. PMID:22542055
27. **Cammarota T**. Davide Giuseppe Ribaldone, Andrea Resegotti, Alessandro Repici, Silvio Danese, Gionata Fiorino, Antonino Sarno,Daniela Robotti, Paola Debani, Giovanni Bonenti, Rinaldo Pellicano, Alida Andrealli, Nicoletta Sapone, Daniele Simondi, Francesca Bresso & Marco Astegiano et al. “Role of bowel ultrasound as a predictor of surgical recurrence of Crohn's disease” Scandinavian Journal of Gastroenterology 2013; 48: 552-555. doi.org/10.3109/00365521.2013.777774 PMid:23477675
28. **Maconi G**, Carsana L, Fociani P, Sampietro GM, Ardizzone S, Cristaldi M, Parente F, Vago GL, Taschieri AM, Bianchi Porro G. Small bowel stenosis in Crohn's disease: clinical, biochemical and ultrasonographic evaluation of histological features. Aliment Pharmacol Ther. 2003 Oct 1;18(7):749-56. PMID: 14510749
29. **Fraquelli M**, Sarno A, Girelli C, Laudi C, Buscarini E, Villa C, Robotti D, Porta P, Cammarota T, Ercole E, Rigazio C, Senore C, Pera A, Malacrida V, Gallo C, MaconiG. Reproducibility of bowel ultrasonography in the evaluation of Crohn's disease. Dig Liver Dis. 2008 Nov;40(11):860-6. doi: 10.1016/j.dld.2008.04.006. Epub 2008 Jun 25. PMID:18583205
30. **Maconi** G, Radice E, Greco S, Bezzio C, Bianchi Porro G. Transient small-bowel intussusceptions in adults: significance of ultrasonographic detection. Clin Radiol. 2007 Aug;62(8):792-7. Epub 2007 May 18. PMID: 17604770
31. **Panes J**, Bouzas R, Chaparro M, García-Sánchez V, Gisbert JP, Martínez de Guereñu B, Mendoza JL, Paredes JM, Quiroga S, Ripollés T, Rimola J. “Sistematyc review: the use of ultrasonography, computed tomography and magnetic resonance imaging for the diagnosis, assessment of activity and abdominal complications of Crohn's disease” Alimentary Pharmacology and Therapeutics 2011; 34: 125-145 doi.org/10.1111/j.1365-2036.2011.04710.x PMid:21615440
32. **Panes** [**J**](http://www.ncbi.nlm.nih.gov/pubmed?term=PanesJ%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Bouhnik Y](http://www.ncbi.nlm.nih.gov/pubmed?term=BouhnikY%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Reinisch W](http://www.ncbi.nlm.nih.gov/pubmed?term=ReinischW%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Stoker J](http://www.ncbi.nlm.nih.gov/pubmed?term=StokerJ%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Taylor SA](http://www.ncbi.nlm.nih.gov/pubmed?term=TaylorSA%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Baumgart DC](http://www.ncbi.nlm.nih.gov/pubmed?term=BaumgartDC%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Danese S](http://www.ncbi.nlm.nih.gov/pubmed?term=DaneseS%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Halligan S](http://www.ncbi.nlm.nih.gov/pubmed?term=HalliganS%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Marincek B](http://www.ncbi.nlm.nih.gov/pubmed?term=MarincekB%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Matos C](http://www.ncbi.nlm.nih.gov/pubmed?term=MatosC%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Peyrin-Biroulet L](http://www.ncbi.nlm.nih.gov/pubmed?term=Peyrin-BirouletL%5BAuthor%5D&cauthor=true&cauthor_uid=23583097),[Rimola J](http://www.ncbi.nlm.nih.gov/pubmed?term=RimolaJ%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Rogler G](http://www.ncbi.nlm.nih.gov/pubmed?term=RoglerG%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [van Assche G](http://www.ncbi.nlm.nih.gov/pubmed?term=vanAsscheG%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Ardizzone S](http://www.ncbi.nlm.nih.gov/pubmed?term=ArdizzoneS%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Maccioni F](http://www.ncbi.nlm.nih.gov/pubmed?term=MaccioniF%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Bali MA](http://www.ncbi.nlm.nih.gov/pubmed?term=BaliMA%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Bellini D](http://www.ncbi.nlm.nih.gov/pubmed?term=BelliniD%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Biancone L](http://www.ncbi.nlm.nih.gov/pubmed?term=BianconeL%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Castiglione F](http://www.ncbi.nlm.nih.gov/pubmed?term=CastiglioneF%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Ehehalt R](http://www.ncbi.nlm.nih.gov/pubmed?term=EhehaltR%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Grassi R](http://www.ncbi.nlm.nih.gov/pubmed?term=GrassiR%5BAuthor%5D&cauthor=true&cauthor_uid=23583097),[Kucharzik T](http://www.ncbi.nlm.nih.gov/pubmed?term=KucharzikT%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), , [Maconi G](http://www.ncbi.nlm.nih.gov/pubmed?term=MaconiG%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Magro F](http://www.ncbi.nlm.nih.gov/pubmed?term=MagroF%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Martín-Comín J](http://www.ncbi.nlm.nih.gov/pubmed?term=Martín-ComínJ%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Morana G](http://www.ncbi.nlm.nih.gov/pubmed?term=MoranaG%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Pendsé D](http://www.ncbi.nlm.nih.gov/pubmed?term=PendséD%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Sebastian S](http://www.ncbi.nlm.nih.gov/pubmed?term=SebastianS%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Signore A](http://www.ncbi.nlm.nih.gov/pubmed?term=SignoreA%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Tolan D](http://www.ncbi.nlm.nih.gov/pubmed?term=TolanD%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Tielbeek JA](http://www.ncbi.nlm.nih.gov/pubmed?term=TielbeekJA%5BAuthor%5D&cauthor=true&cauthor_uid=23583097),[Weishaupt D](http://www.ncbi.nlm.nih.gov/pubmed?term=WeishauptD%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Wiarda B](http://www.ncbi.nlm.nih.gov/pubmed?term=WiardaB%5BAuthor%5D&cauthor=true&cauthor_uid=23583097), [Laghi A](http://www.ncbi.nlm.nih.gov/pubmed?term=LaghiA%5BAuthor%5D&cauthor=true&cauthor_uid=23583097). Imaging techniques for assessment of inflammatory bowel disease: joint ECCO and ESGARevidence-based consensus guidelines. [J Crohns Colitis.](http://www.ncbi.nlm.nih.gov/pubmed/?term=Imaging+techniques+for+assessment+of+inflammatory+bowel+disease%3A+Joint+ECCO+and+ESGAR+evidence-based+consensus+guidelines)2013 Aug;7(7):556-85. doi: 10.1016/j.crohns.2013.02.020. Epub 2013 Apr 11.