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述评 EDITORIAL

进一步提高经腹超声评估炎症性肠病的水平

刘 畅, 徐辉雄

刘畅, 徐辉雄, 同济大学附属第十人民医院超声医学科 上海市 200072
徐辉雄, 教授, 主任医师, 主要从事超声造影、超声介入和三维超声的研究.
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通讯作者: 徐辉雄, 教授, 主任医师, 博士生导师, 200072, 上海市延长中路301号, 同济大学附属第十人民医院超声医学科. xuhuixiong@hotmail.com
电话: 021-6630753
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Transabdominal ultrasound for diagnosis of inflammatory bowel disease

Chang Liu, Hui-Xiong Xu

Chang Liu, Hui-Xiong Xu, Department of Medical Ultrasound, Tenth People's Hospital of Tongji University, Shanghai 200072, China
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Correspondence to: Hui-Xiong Xu, Professor, Chief Physician, Department of Medical Ultrasound, Tenth People's Hospital of Tongji University, 301 Yanchang Middle Road, Shanghai 200072, China. xuhuixiong@hotmail.com
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Abstract

Inflammatory bowel disease (IBD) is a chronic inflammatory disease, including Crohn's disease and ulcerative colitis. Patients with IBD need life-time treatment because the disease is characterized by alternating periods of remission and exacerbation. In recent years, the incidence of IBD has been increasing in China. Compared with magnetic resonance imaging (MRI) and computed tomography (CT), transabdominal ultrasound has many advantages such as real-time scanning, easy handling, no radiation, and low cost, representing the optimal modality for diagnosing IBD. A meta-analysis has showed that ultrasound is comparable to CT or MRI in evaluation of IBD. Contrast-enhanced ultrasound is capable of detecting microcirculation perfusion of the intestinal wall, and ultrasound elastography is able to assess the stiffness of the intestinal wall. Both of them have great potential in the diagnosis of IBD and will further improve diagnostic performance.

Key Words: Inflammatory bowel disease; Crohn's disease; Ulcerative colitis; Transabdominal ultrasound; Contrast-enhanced ultrasound; Ultrasound elastography

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摘要

炎症性肠病(inflammatory bowel disease, IBD)是一种慢性炎症性疾病, 主要包括克罗恩病和溃疡性结肠炎. 其活动期与缓解期反复交替, 需要终身治疗. 近年来, 我国IBD的发病率呈持续上升的趋势. 相对于核磁共振成像(magnetic resonance imaging, MRI)和计算机断层扫描(computed tomography, CT), 经腹超声具有无创、无放射学、操作简便、价廉、患者依从性高等特性, 成为IBD检查的理想工具. Meta分析结果证实, 经腹超声用于评估IBD, 诊断价值与CT、MRI等检查相近. 近年来出现的超声造影技术能反映病变肠段的微循环灌注, 而超声弹性成像能反映病变肠段的软硬水平, 二者在IBD的诊断和评估中具有潜在的临床价值, 能进一步提高超声评估IBD的水平.

关键词: 炎症性肠病; 克罗恩病; 溃疡性结肠炎; 经腹超声; 超声造影; 弹性成像

核心提示: 超声作为一种简便易行的方法, 在炎症性肠病(inflammatory bowel disease, IBD)的诊

■背景资料
炎症性肠病(inflammatory bowel disease, IBD)的诊断主要依靠临床表现、内镜检查和组织学活检. 影像学检查如核磁共振成像(magnetic resonance imaging, MRI)和计算机断层扫描(computed tomography, CT)以及超声(ultrasound, US)在IBD的疾病诊断、活动性评估、并发症的检测、治疗后的疗效评估等方面发挥着日益重要的作用.

■同行评议者
潘秀珍, 教授, 主任医师, 福建省立医院消化科

■应用要点
经腹超声具有无创、无放射学、操作简便、价廉、患者依从性高等特性，成为IBD检查的理想工具.

断中可以媲美增强CT及核磁共振成像(magnetic resonance imaging), 超声新技术的出现进一步丰富了超声检查的手段, 从形态、功能、微循环灌注、质地等多个不同角度提供了IBD患者肠道的病变信息. 因此可以预计超声检查在IBD的诊断中可以发挥不可替代的作用, 进一步提高超声(ultrasound, US)诊断IBD的水平、规范和普及US在IBD中的应用十分重要.

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0 引言

炎症性肠病(inflammatory bowel disease, IBD)是一类病因尚不明确的以肠道免疫功能紊乱为主的慢性非特异性炎症性疾病, 主要包括克罗恩病(Crohn's disease, CD)和溃疡性结肠炎(ulcerative colitis, UC)[1]. 近年来随着生活方式的改变和认识水平的提高, IBD的发病率逐年上升. IBD的诊断主要依靠临床表现、内镜检查和组织学活检[2]. 影像学检查如核磁共振成像(magnetic resonance imaging, MRI)和计算机断层扫描(computed tomography, CT)以及超声(ultrasound, US)在IBD的疾病诊断、活动性评估、并发症的检测、治疗后的疗效评估等方面发挥着日益重要的作用[3]. US因具有无创、无辐射、操作方便、价廉、容易掌握、准确性高、患者依从性好等优点, 近年来越来越多受到关注[4].

1 病理和临床表现

IBD主要发生于青壮年, 男女发病率无明显差异[5], UC和CD的临床表现有较多重叠, 不易鉴别. 在病理上, UC是一种慢性非特异性结肠炎症, 病变主要累及结肠黏膜和黏膜下层, 范围多自远端结肠开始, 逆行向近端发展, 甚至累及全结肠和近端回肠. 而CD是一种慢性肉芽肿性炎症, 病变可累及整个肠道, 以末段回肠和邻近结肠为主, 呈穿壁性炎症, 多节段性、非对称性分布. UC临床主要表现 为腹痛、腹胀、腹泻、黏液脓血便等消化系统症状, 同时可伴有消瘦、贫血、低蛋白血症及水电解质紊乱等全身表现和多种肠外表现. CD临床主要表现为腹痛、腹泻、腹部包块、肠梗阻及肛门直肠周围病变等消化系统症状、体征, 可伴有发热、营养障碍等全身性表现和肠外多个系统损害等[6].

2 超声扫查及表现

近年来, US检查成为临床应用于IBD诊断的重要手段之一[7]. 检查前一晚常规禁食, 并开始口服不可吸收的无回声对比剂(常用复方聚乙二醇电解质)进行肠道准备, 以充盈肠腔、减少肠腔内气体和肠蠕动.

检查时常规先用经腹凸阵探头(频率一般为2-5 MHz)自右下腹开始顺时针方向扫查, 依次扫查回盲部、升结肠、横结肠、降结肠及乙状结肠, 最后再回到脐周观察余下肠段. 必要时还需经会阴或经直肠扫查观察肛周或直肠病变. 在确定需重点观察的肠段后, 再切换至高频探头(频率一般为7.5-10.0 MHz)仔细观察[8].

超声观察内容一般包括病变部位、累及肠段长度、肠壁厚度、肠壁层次、肠壁回声、肠管蠕动、肠管周围脂肪组织、肠周淋巴结、肠周及腹腔积液以及并发症情况(肠瘘、瘘管、脓肿、肠腔狭窄、梗阻等). 正常肠壁超声可显示5层结构, 从内到外依次为高回声黏膜层(或黏膜与肠腔界面), 低回声黏膜肌层, 高回声黏膜下层, 低回声肌层, 高回声浆膜层[9,10].

CD活动期最常见的超声表现包括: (1)肠壁增厚(≥4 mm), 病变肠段各层次间结构模糊或消失, 尤其以黏膜下层增厚及回声增高明显; (2)肠壁僵硬, 结肠袋消失; (3)深溃疡形成, 黏膜下层的高回声界限中断; (4)肠腔狭窄、脓肿及瘘管形成等; (5)肠周脂肪增厚回声增高、肠周淋巴结肿大[11]. 以肠壁厚度≥4 mm判断CD活动期, 敏感度为75%, 特异度为97%. 在随诊病例中, 建议以肠壁厚度≥4 mm作为判断复发的依据[12].

CD活动期也伴随着肠壁微血管增多、用Limberg分级法半定量评估肠壁能量多普勒所见可用于区分活动期与缓解期[13]. Limberg分型如下: 0型, 正常肠壁; Ⅰ型, 肠壁增厚; Ⅱ型, 肠壁增厚并有较短的血管出现; Ⅲ型, 肠壁增厚并出现较长的血管; Ⅳ型, 肠壁增厚且出现能与肠系膜相连的长血管. 病变肠段能量多普勒分级越高, 表示疾病越活跃. 一般认为Ⅰ、Ⅱ型代表缓解期, Ⅲ、Ⅳ型代表活动期.

UC活动期最常见的超声表现也是肠壁增厚[14], 但因为病变主要局限于黏膜层和黏膜下层, 肠壁层次基本保持正常, 其肠壁血流信号增加及肠系膜淋巴结肿大情况不如CD.

采用高频US, Rodgers等[15]报道在CD患者中检出并发症如肠腔狭窄、肠瘘、脓肿等的敏感度、特异度、阳性预测值、阴性预测值分别

为0.86、0.90、0.83、0.92; 0.78、0.95、0.86、0.91; 0.90、0.99、0.90、0.99. 近期的Meta分析结果发现, 经腹超声对IBD的诊断性能等同于CT和MRI[16].

3 影像学比较

3.1 多层螺旋CT检查 近年来, 随着多层螺旋计算机断层扫描(multislice spiral computed tomography, MSCT)技术的不断进步和工作站图像重建软件的发展, MSCT为IBD的诊断提供了更多、更有价值的信息[17]. 常规的CT平扫和增强对小肠病变显示效果较差, 而CT小肠灌肠造影(computed tomography enterography, CTE)检查能很好地观察肠壁厚度并评估整个腹部病变情况[18].

UC的CT表现: (1)肠壁增厚. 肠壁厚度平均为7.8 mm, 增厚的肠壁为连续性改变, 病变段肠壁的厚度大致均匀, 表现为对称性的改变, 或有分层现象, 表现为“靶征”或“双晕征”; (2)黏膜面的改变. 黏膜面多发小溃疡和炎性息肉, 运用合理的窗宽、窗位, 可清楚显示出结肠腔内黏膜面锯齿状凹凸不平的改变, 而非病变区的黏膜面则是光滑的; (3)肠管形态的改变. 可见病变区肠腔变细等表现; (4)肠系膜改变. 病变区肠系膜密度升高、模糊, 同时伴有系膜血管束的边缘不清[19].

CD的CT表现: (1)肠壁增厚. 口服对比剂后肠壁平均厚度>4 mm即为增厚, 通常为11-13 mm; (2)肠壁强化程度增加. CD活动期增强CT动脉期和静脉期肠壁均较邻近正常肠壁强化程度增加, 以静脉期更明显; (3)肠系膜血管改变, 表现为血管束扭曲、扩张、增多, 称为“木梳征”; (4)并发症表现. 可见肠管周围蜂窝组织炎、炎性肿块、脓肿、瘘管和肠梗阻等[20,21].

3.2 MRI检查 随着MRI设备软、硬件发展和肠道对比剂的应用, 肠道MRI影像质量有了很大提高, 对IBD诊断的敏感性和特异性不亚于CT[22].

UC的MRI表现主要有: 肠壁增厚[23]、肠壁的异常强化、病灶周围多发淋巴结和结肠皱襞减少. UC急性期由于黏膜和黏膜下层肿胀, 使MR T1和T2加权成像均呈高信号; 慢性期结肠壁在T1和T2加权成像上均呈低信号[24,25].

CD的MRI表现包括: (1)病变肠壁因炎性充血致肠壁强化幅度增加, 据此可准确反映病变范围, 且炎性肠壁的增强程度与炎性程度密切相关, 中-重度炎症肠壁的血管通透性大, 因此其较正常和轻度炎症的肠壁强化更明显; (2)肠壁厚度>4 mm, 可与周围蜂窝织炎黏连、融合而边界不清, 开始时常表现为偏心性肠壁增厚, 随着病变的进展也可表现为肠壁环形增厚; (3)多节段性病变或跳跃性病变, 表现为多个肠段的肠壁增厚和强化幅度增加, 其间隔为正常厚度和正常强化的肠段[26].

MRI无电离辐射的优点使其更适于年轻患者的长期观察随访, 在临床上具有好的应用前景. 但目前MRI对IBD活动性的定量评估尚无统一标准, 制定一个统一的量化标准还需多中心大样本研究. 此外, MRI的局限性如检查费用昂贵、耗时较长且有较多禁忌证如体内金属植入物、幽闭恐惧症等也限制了其广泛应用.

有学者将MRI与US评估CD范围及活动性分别做了对比, 发现US诊断的敏感性(91%)、特异性(98%)及准确性(95%)均高于MRI(分别为83%、97%、91%); 两种方法对回盲部病变的敏感性均较高(分别为100%和93%); 对于瘘管的检测, US的敏感性、特异性、准确性分别为82%、100%、90%, 而MRI则为70%、92%、80%[27].

MRI和CT有一个共同的局限, 检查前都必须要求患者口服大量的造影剂, 患者依从性较差[28]; 造影剂应用于肾功能不全的患者有所限制[29].

4 US应用进展

4.1 超声造影检查 超声造影(contrast-enhanced ultrasound, CEUS)是近年来出现的一种新技术, 他通过经外周静脉注射超声造影剂, 采用造影剂特异性成像的成像技术, 示踪显示造影剂在血管及微循环内的运行情况[30]. 目前临床常用的造影剂为SonoVue, 为包裹六氟化硫气体的微泡, 微泡外壳的主要成分为磷脂. CEUS能显著提高对低速血流以及微小血管的显示能力, 近年来广泛用于炎症性肠病的诊断和评估[31].

4.1.1 判断活动性: 从CEUS增强形态学上观察, CD患者CEUS可观察到4种模式, 分别为: 模式1: 肠壁全层高增强; 模式2: 肠壁内层高增强(黏膜层、黏膜肌层及黏膜下层); 模式3: 仅黏膜下层高增强; 模式4: 肠壁无增强, 其中模式3、4主要见于非活动期患者, 模式1、2主要见于活动期患者. 以此来判断病变的活动性敏感性为93.5%, 特异性为93.7%(以肠镜及活检结果为金标准).

也有学者采用CEUS定量的方法来判断CD的活动性, CEUS峰值强度增高及达峰时间(time-

同行评价
本文立题有依据, 述评内容集中, 结果明确, 具有一定指导意义.

to-peak, TTP)较短通常提示活动期, 反之则为非活动期[32]. CEUS定量方法与Limberg分型及肠壁厚度有较好的相关性[33]. 也有学者使用了另外一种定量的方法(E/W比率, E为增强层的主要厚度, 和W为整个肠壁的厚度)并将CEUS的结果和通过克罗恩病活动性指数测量的临床活动性作比较. 结果发现E/W比率和克罗恩病活动性指数呈正相关. 活动期(CDAI>150)E/W比率明显比非活动期(CDAI<150) E/W比率高.

在UC患者中, Serra等[34]也发现CEUS峰值强度与UC炎症程度呈正相关, 而TTP/峰值强度比值则与炎症程度呈负相关, 提示CEUS定量分析可用于评估UC活动性[10].

4.1.2 炎性包块定性: CD患者常合并肠周炎性包块, 主要包括肠周蜂窝织炎及脓肿形成[35]. 两者在临床上的处理方法各异, 脓肿常需外科引流, 盲目采用生物治疗方法有导致败血症的风险[36]; 而蜂窝织炎则以内科治疗为主. 常规US鉴别脓肿及蜂窝织炎较困难, 而CEUS鉴别二者较易. 脓肿在CEUS上一般表现为无增强, 而蜂窝织炎CEUS动脉期为高增强.

4.1.3 肠腔狭窄评估: CD患者肠腔狭窄发生率为12%-54%[37], 肠腔狭窄可导致患者生活质量下降. 狭窄可为纤维性、炎性或兼而有之. 炎性狭窄为主者多采用内科治疗, 而纤维性狭窄者多采用内镜下气囊扩张或外科治疗[12]. 因此, 鉴别肠腔狭窄的性质对临床决定治疗方案十分重要. 结肠镜为诊断肠腔狭窄的金标准[38], 但到达小肠部位的狭窄较困难. 常规超声对判断狭窄性质价值有限, 而CEUS则具有独特的优势[39,40]. Lauenstein等[41]认为狭窄段肠壁黏膜下层明显增强表明严重的血管化, 应考虑为炎性狭窄; 炎性狭窄病程较长者可表现为全肠壁增强. 纤维性狭窄尽管也可出现全肠壁增强, 但增强多首先从肠壁外层或肠周血管开始. 此外, 炎性狭窄者通常增强程度较高, 而纤维性狭窄者增强程度较弱.

4.1.4 评估疗效: Gourtsoyiannis等[42]采用CEUS定量方法分析了药物治疗前后CD患者肠壁增强的曲线下面积, 发现对药物治疗有效者的CEUS时间强度曲线下面积明显低于对药物治疗无效者, 提示CEUS可用于前瞻性预测药物治疗的疗效. 此外, CEUS也可用于外科手术后吻合口的随访和复发的监测[43].

4.2 超声弹性成像 超声弹性成像(ultrasound elastography, UE)是近年来出现的另一种超声成像新技术[43], 他通过施加外力或通过超声探头发射声波, 推动组织发生形变, 通过检测形变来反映组织的软硬度[44]. 因此, 他与CEUS技术反映组织的微循环灌注不同, 反映的是组织的另外一个重要特征-即组织弹性[45].

Del Vescovo等[46]较早探讨了实时UE在CD中的应用, 结果发现实时UE可用来区分狭窄的肠段与正常肠段. Lasocki等[47]也发现在UC患者中, 实时UE与肠镜表现密切相关, 实时UE并可用来预测UC患者对药物治疗的反应. 但UE在IBD中的应用还需积累更多经验.

5 结论

超声作为一种简便易行的方法, 在IBD的诊断中可以媲美增强CT及MRI, 超声新技术如CEUS和UE等技术的出现进一步丰富了超声检查的手段[48], 从形态、功能、微循环灌注、质地等多个不同角度提供了IBD患者肠道的病变信息[49]. 因此可以预计超声检查在IBD的诊断中可以发挥不可替代的作用, 进一步提高US诊断IBD的水平、规范和普及US在IBD中的应用十分重要.

6 参考文献

1 中华医学会消化病学分会炎症性肠病协作组. 对我国炎症性肠病诊断治疗规范的共识意见. 现代消化及介入诊疗 2008; 13: 139-145

2 刘畅, 徐辉雄, 徐晓蓉, 吴剑, 张一峰, 郭乐杭, 孙丽萍, 徐军妹, 王帅, 刘媛媛, 刘琳娜. 经腹超声检查在克罗恩病中的应用. 影像诊断与介入放射学 2012; 21: 446-449

3 Neye H, Ensberg D, Rauh P, Peitz U, Mönkemüller K, Treiber G, Klauck S, Malfertheiner P, Rickes S. Impact of high-resolution transabdominal ultrasound in the diagnosis of complications of Crohn's disease. *Scand J Gastroenterol* 2010; 45: 690-695 [PMID: 20235899 DOI: 10.3109/00365521003710190]

4 Panes J, Bouhnik Y, Reinisch W, Stoker J, Taylor SA, Baumgart DC, Danese S, Halligan S, Marincek B, Matos C, Peyrin-Biroulet L, Rimola J, Rogler G, van Assche G, Ardizzone S, Ba-Ssalamah A, Bali MA, Bellini D, Biancone L, Castiglione F, Ehehalt R, Grassi R, Kucharzik T, Maccioni F, Maconi G, Magro F, Martín-Comín J, Morana G, Pendsé D, Sebastian S, Signore A, Tolan D, Tielbeek JA, Weishaupt D, Wiarda B, Laghi A. Imaging techniques for assessment of inflammatory bowel disease: joint ECCO and ESGAR evidence-based consensus guidelines. *J Crohns Colitis* 2013; 7: 556-585 [PMID: 23583097 DOI: 10.1016/j.crohns.2013.02.020]

5 Gaitini D, Kreitenberg AJ, Fischer D, Maza I, Chowers Y. Color-coded duplex sonography compared to multidetector computed tomography for the diagnosis of crohn disease relapse and complications. *J Ultrasound Med* 2011; 30: 1691-1699 [PMID: 22124005]

6 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; 7: 120-128 [PMID: 22483566 DOI: 10.1016/j.crohns.2012.03.002]
7 De Franco A, Di Veronica A, Armuzzi A, Roberto I, Marzo M, De Pascalis B, De Vitis I, Papa A, Bock E, Danza FM, Bonomo L, Guidi L. Ileal Crohn disease: mural microvascularity quantified with contrast-enhanced US correlates with disease activity. *Radiology* 2012; 262: 680-688 [PMID: 22157203 DOI: 10.1148/radiol.11110440]
8 Quaia E, Cabibbo B, De Paoli L, Toscano W, Poillucci G, Cova MA. The value of time-intensity curves obtained after microbubble contrast agent injection to discriminate responders from non-responders to anti-inflammatory medication among patients with Crohn's disease. *Eur Radiol* 2013; 23: 1650-1659 [PMID: 23306710 DOI: 10.1007/s00330-012-2754-1]
9 Girlich C, Schacherer D, Jung EM, Klebl F, Huber E. Comparison between quantitative assessment of bowel wall vascularization by contrast-enhanced ultrasound and results of histopathological scoring in ulcerative colitis. *Int J Colorectal Dis* 2012; 27: 193-198 [PMID: 21847545 DOI: 10.1007/s00384-011-1300-y]
10 Migaleddu V, Scanu AM, Quaia E, Rocca PC, Dore MP, Scanu D, Azzali L, Virgilio G. Contrast-enhanced ultrasonographic evaluation of inflammatory activity in Crohn's disease. *Gastroenterology* 2009; 137: 43-52 [PMID: 19422826 DOI: 10.1053/j.gastro.2009.03.062]
11 Quaia E. Contrast-enhanced ultrasound of the small bowel in Crohn's disease. *Abdom Imaging* 2013; 38: 1005-1013 [PMID: 23728306]
12 Stidham RW, Xu J, Johnson LA, Kim K, Moons DS, McKenna BJ, Rubin JM, Higgins PD. Ultrasound elasticity imaging for detecting intestinal fibrosis and inflammation in rats and humans with Crohn's disease. *Gastroenterology* 2011; 141: 819-826.e1 [PMID: 21784048 DOI: 10.1053/j.gastro.2011.07.027]
13 Ishikawa D, Ando T, Watanabe O, Ishiguro K, Maeda O, Miyake N, Nakamura M, Miyahara R, Ohmiya N, Hirooka Y, El-Omar EM, Goto H. Images of colonic real-time tissue sonoelastography correlate with those of colonoscopy and may predict response to therapy in patients with ulcerative colitis. *BMC Gastroenterol* 2011; 11: 29 [PMID: 21453450 DOI: 10.1186/1471-230X-11-29]
14 Onali S, Calabrese E, Petruzziello C, Zorzi F, Sica G, Fiori R, Ascolani M, Lolli E, Condino G, Palmieri G, Simonetti G, Pallone F, Biancone L. Small intestine contrast ultrasonography vs computed tomography enteroclysis for assessing ileal Crohn's disease. *World J Gastroenterol* 2012; 18: 6088-6095 [PMID: 23155337 DOI: 10.3748/wjg.v18.i42.6088]
15 Rodgers PM, Verma R. Transabdominal ultrasound for bowel evaluation. *Radiol Clin North Am* 2013; 51: 133-148 [PMID: 23182513 DOI: 10.1016/j.rcl.2012.09.008]
16 Cosnes J, Gower-Rousseau C, Seksik P, Cortot A. Epidemiology and natural history of inflammatory bowel diseases. *Gastroenterology* 2011; 140: 1785-1794 [PMID: 21530745 DOI: 10.1053/j.gastro.2011.01.055]
17 Ardizzone S, Bianchi Porro G. Inflammatory bowel disease: new insights into pathogenesis and treatment. *J Intern Med* 2002; 252: 475-496 [PMID: 12472908]
18 Pizarro TT, Pastorelli L, Bamias G, Garg RR, Reuter BK, Mercado JR, Chieppa M, Arseneau KO, Ley K, Cominelli F. SAMP1/YitFc mouse strain: a spontaneous model of Crohn's disease-like ileitis. *Inflamm Bowel Dis* 2011; 17: 2566-2584 [PMID: 21557393 DOI: 10.1002/ibd.21638]
19 Peyrin-Biroulet L, Loftus EV, Colombel JF, Sandborn WJ. The natural history of adult Crohn's disease in population-based cohorts. *Am J Gastroenterol* 2010; 105: 289-297 [PMID: 19861953 DOI: 10.1038/ajg.2009.579]
20 Adler J, Swanson SD, Schmiedlin-Ren P, Higgins PD, Golembeski CP, Polydorides AD, McKenna BJ, Hussain HK, Verrot TM, Zimmermann EM. Magnetization transfer helps detect intestinal fibrosis in an animal model of Crohn disease. *Radiology* 2011; 259: 127-135 [PMID: 21324841 DOI: 10.1148/radiol.10091648]
21 Holtmann MH, Neurath MF. Anti-TNF strategies in stenosing and fistulizing Crohn's disease. *Int J Colorectal Dis* 2005; 20: 1-8 [PMID: 15459771]
22 Calabrese E. Bowel ultrasound for the assessment of Crohn's disease. *Gastroenterol Hepatol* (N Y) 2011; 7: 107-109 [PMID: 21475417]
23 Dietrich CF. Significance of abdominal ultrasound in inflammatory bowel disease. *Dig Dis* 2009; 27: 482-493 [PMID: 19897964 DOI: 10.1159/000233287]
24 Astegiano M, Bresso F, Cammarota T, Sarno A, Robotti D, Demarchi B, Sostegni R, Macchiarella V, Pera A, Rizzetto M. Abdominal pain and bowel dysfunction: diagnostic role of intestinal ultrasound. *Eur J Gastroenterol Hepatol* 2001; 13: 927-931 [PMID: 11507357]
25 Parente F, Greco S, Molteni M, Cucino C, Maconi G, Sampietro GM, Danelli PG, Cristaldi M, Bianco R, Gallus S, Bianchi Porro G. Role of early ultrasound in detecting inflammatory intestinal disorders and identifying their anatomical location within the bowel. *Aliment Pharmacol Ther* 2003; 18: 1009-1016 [PMID: 14616167]
26 Borthne AS, Abdelnoor M, Rugtveit J, Perminow G, Reiseter T, Kløw NE. Bowel magnetic resonance imaging of pediatric patients with oral mannitol MRI compared to endoscopy and intestinal ultrasound. *Eur Radiol* 2006; 16: 207-214 [PMID: 15942733]
27 Panés J, Bouzas R, Chaparro M, García-Sánchez V, Gisbert JP, Martínez de Guereñu B, Mendoza JL, Paredes JM, Quiroga S, Ripollés T, Rimola J. Systematic review: the use of ultrasonography, computed tomography and magnetic resonance imaging for the diagnosis, assessment of activity and abdominal complications of Crohn's disease. *Aliment Pharmacol Ther* 2011; 34: 125-145 [PMID: 21615440 DOI: 10.1111/j.1365-2036.2011.04710.x]
28 Parente F, Greco S, Molteni M, Anderloni A, Sampietro GM, Danelli PG, Bianco R, Gallus S, Bianchi Porro G. Oral contrast enhanced bowel ultrasonography in the assessment of small intestine Crohn's disease. A prospective comparison with conventional ultrasound, x ray studies, and ileocolonoscopy. *Gut* 2004; 53: 1652-1657 [PMID: 15479688]
29 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; 14:

1240-1245 [PMID: 18398896 DOI: 10.1002/ibd.20469]
30 Epifanio M, Baldisserotto M, Spolidoro JV, Gaiger A. Grey-scale and colour Doppler sonography in the evaluation of children with suspected bowel inflammation: correlation with colonoscopy and histological findings. *Clin Radiol* 2008; 63: 968-978 [PMID: 18718226 DOI: 10.1016/j.crad.2008.02.009]
31 Drews BH, Barth TF, Hänle MM, Akinli AS, Mason RA, Muche R, Thiel R, Pauls S, Klaus J, von Boyen G, Kratzer W. Comparison of sonographically measured bowel wall vascularity, histology, and disease activity in Crohn's disease. *Eur Radiol* 2009; 19: 1379-1386 [PMID: 19184036 DOI: 10.1007/s00330-008-1290-5]
32 Di Sabatino A, Fulle I, Ciccocioppo R, Ricevuti L, Tinozzi FP, Tinozzi S, Campani R, Corazza GR. Doppler enhancement after intravenous levovist injection in Crohn's disease. *Inflamm Bowel Dis* 2002; 8: 251-257 [PMID: 12131608]
33 Rapaccini GL, Pompili M, Orefice R, Covino M, Riccardi L, Cedrone A, Gasbarrini G. Contrast-enhanced power doppler of the intestinal wall in the evaluation of patients with Crohn disease. *Scand J Gastroenterol* 2004; 39: 188-194 [PMID: 15000283]
34 Serra C, Menozzi G, Labate AM, Giangregorio F, Gionchetti P, Beltrami M, Robotti D, Fornari F, Cammarota T. Ultrasound assessment of vascularization of the thickened terminal ileum wall in Crohn's disease patients using a low-mechanical index real-time scanning technique with a second generation ultrasound contrast agent. *Eur J Radiol* 2007; 62: 114-121 [PMID: 17239555]
35 Kunihiro K, Hata J, Manabe N, Mitsuoka Y, Tanaka S, Haruma K, Chayama K. Predicting the need for surgery in Crohn's disease with contrast harmonic ultrasound. *Scand J Gastroenterol* 2007; 42: 577-585 [PMID: 17454878]
36 Maconi G, Sampietro GM, Sartani A, Bianchi Porro G. Bowel ultrasound in Crohn's disease: surgical perspective. *Int J Colorectal Dis* 2008; 23: 339-347 [PMID: 18188575 DOI: 10.1007/s00384-007-0418-4]
37 Kratzer W, von Tirpitz C, Mason R, Reinshagen M, Adler G, Möller P, Rieber A, Kächele V. Contrast-enhanced power Doppler sonography of the intestinal wall in the differentiation of hypervascularized and hypovascularized intestinal obstructions in patients with Crohn's disease. *J Ultrasound Med* 2002; 21: 149-157; quiz 158-159 [PMID: 11833871]
38 Sinha R, Murphy P, Hawker P, Sanders S, Rajesh A, Verma R. Role of MRI in Crohn's disease. *Clin Radiol* 2009; 64: 341-352 [PMID: 19264177 DOI: 10.1016/j.crad.2008.08.006]
39 Villa C, Pompili G, Franceschelli G, Munari A, Radaelli G, Maconi G, Cornalba GP. Role of magnetic resonance imaging in evaluation of the activity of perianal Crohn's disease. *Eur J Radiol* 2012; 81: 616-622 [PMID: 21316171 DOI: 10.1016/j.ejrad.2011.01.046]
40 Kayhan A, Oommen J, Dahi F, Oto A. Magnetic resonance enterography in Crohn's disease: Standard and advanced techniques. *World J Radiol* 2010; 2: 113-121 [PMID: 21160577 DOI: 10.4329/wjr.v2.i4.113]
41 Lauenstein TC, Schneemann H, Vogt FM, Herborn CU, Ruhm SG, Debatin JF. Optimization of oral contrast agents for MR imaging of the small bowel. *Radiology* 2003; 228: 279-283 [PMID: 12750457]
42 Gourtsoyiannis N, Papanikolaou N, Grammatikakis J, Maris T, Prassopoulos P. MR enteroclysis protocol optimization: comparison between 3D FLASH with fat saturation after intravenous gadolinium injection and true FISP sequences. *Eur Radiol* 2001; 11: 908-913 [PMID: 11419161]
43 Cosgrove D, Harvey C. Clinical uses of microbubbles in diagnosis and treatment. *Med Biol Eng Comput* 2009; 47: 813-826 [PMID: 19205774 DOI: 10.1007/s11517-009-0434-3]
44 Messaris E, Chandolias N, Grand D, Pricolo V. Role of magnetic resonance enterography in the management of Crohn disease. *Arch Surg* 2010; 145: 471-475 [PMID: 20479346 DOI: 10.1001/archsurg.2010.68]
45 Shrot S, Konen E, Hertz M, Amitai MM. Magnetic resonance enterography: 4 years experience in a tertiary medical center. *Isr Med Assoc J* 2011; 13: 172-177 [PMID: 21608339]
46 Del Vescovo R, Sansoni I, Caviglia R, Ribolsi M, Perrone G, Leoncini E, Grasso RF, Cicala M, Zobel BB. Dynamic contrast enhanced magnetic resonance imaging of the terminal ileum: differentiation of activity of Crohn's disease. *Abdom Imaging* 2008; 33: 417-424 [PMID: 17639383]
47 Lasocki A, Pitman A, Williams R, Lui B, Kalade AV, Farish S. Relative efficacy of different MRI signs in diagnosing active Crohn's disease, compared against a histological gold standard. *J Med Imaging Radiat Oncol* 2011; 55: 11-19 [PMID: 21382184 DOI: 10.1111/j.1754-9485.2010.02223.x]
48 Ha CY, Kumar N, Raptis CA, Narra VR, Ciorba MA. Magnetic resonance enterography: safe and effective imaging for stricturing Crohn's disease. *Dig Dis Sci* 2011; 56: 2906-2913 [PMID: 21688128 DOI: 10.1007/s10620-011-1781-0]
49 Lawrance IC, Welman CJ, Shipman P, Murray K. Correlation of MRI-determined small bowel Crohn's disease categories with medical response and surgical pathology. *World J Gastroenterol* 2009; 15: 3367-3375 [PMID: 19610137]

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