European Journal of Radiology 85 (2016) 268–273

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Editorial musings

CT enterography: Diagnostic value of 4th generation iterative reconstruction algorithm in low dose studies in comparison with standard dose protocol for follow-up of patients with Crohn's disease

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ARTICLE INFO

Article history:
Received 1 July 2015
Received in revised form 7 October 2015
Accepted 14 October 2015

Keywords:
Crohn's disease
CT-Enterography
Computed tomography dose index
Iterative reconstruction
Dose length product

ABSTRACT

Purpose: To compare radiation dose, image quality and diagnostic performance of low dose CT enterography (CTE) protocol combined with iterative reconstruction algorithm (iDose[4]) with standard dose CTE in follow-up of patients with known Crohn's disease (CD).
Materials and method: Thirty-six patients (12 females), with CD underwent a low-dose CTE scan during single venous phase on 256 MDCT scanner, with the following parameters: 120 kV, automated mAs dose-modulation, slice thickness 2 mm and iDose[4] iterative reconstruction algorithm. A control group of thirty-seven patients underwent standard dose CTE examination on the same CT scanner. Two radiologists, blinded to clinical and pathological findings, independently evaluated in each scan, HU values in bowel wall and any presence of CD activity features and disease complications. Image noise and diagnostic quality were evaluated using a 4-point scale. Dose-length product (DLP) and CT-dose-index (CTDI) were recorded and data from both examinations were compared and statistically analyzed.
Results: Low-dose CTE protocol showed high diagnostic quality in assessment of Crohn's disease obtaining significantly ($p \leq 0.001$) lower values of DLP and CTDI (604.98 mGy*cm and 12.29 mGy) as compared to standard dose examinations (974.85 mGy*cm and 19.71 mGy), with an overall dose reduction of 37.6%. Noise resulted slightly higher in iDose[4] images (SD = 15.97) than in standard dose ones (SD = 13.61) but this difference was not statistically significant ($p = 0.064$).
Conclusion: Low-dose CTE combined with iDose[4] reconstruction algorithm offers high quality images with significant reduction of radiation dose, and therefore can be considered a useful tool in the management of CD patients, considering their young age and the frequent imaging follow-up required.

1. Introduction

Crohn's disease (CD) is a chronic granulomatous inflammatory disease that occurs predominantly in young people. CD can affect any part of the gastrointestinal tract-but most commonly involves the distal ileum or the colon [1]. Diagnosis of CD at baseline and for relapses is mainly based on a combination of clinical, laboratory and histological data, which are able to identify the different clinic phenotypes of this disease according to age at diagnosis, location, behavior and severity [2]. Distinguishing different patterns of disease is important to manage better medical and surgical therapy and to investigate the influence of genetic and environmental factors [3].

Imaging plays a crucial role not only in diagnosis but also for follow-up and management of patients with CD [4]. The small-bowel follow-through (SBFT) has been largely replaced by CT enterography (CTE), firstly introduced by Raptopoulos in 1997 and ha now become the imaging technique of choice for CD [5]. CTE consists of the administration of a large volume of neutral or low density contrast agent in order to distend the bowel lumen, combined with the administration of intravenous contrast to obtain mural enhancement of pathologic segments [6]. This technique provides information about intestinal and extra-intestinal pathology and demonstrates a significant impact on the management of the patient [3]. Notwithstanding this, the increased use of CTE in

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http://dx.doi.org/10.1016/j.ejrad.2015.10.011
0720-048X/

clinical routine is a source of concern for the risk of cancer development related to radiation exposure, since patients are often young and will likely undergo multiple imaging studies due to the relapsing nature of this chronic disease [4].

Although, Magnetic Resonance Imaging (MRI) provides similar diagnostic accuracy to CT, while avoiding radiation exposure, it presents several limitations as a first-line imaging method [7]: lower spatial and temporal resolution, longer acquisition time, higher cost and greater variability in examination quality [8]. So there is an increased interest in evaluating any available radiation dose reduction strategies [9].

One of the most widely reported techniques is to lower the tube voltage, but this is often affected by excessive noise with degradation of image quality and therefore of diagnostic performance [8]. The filtered back projection (FBP) technique represents an efficient process for image production but it requires a slightly higher dose for the acquisition of CT images. Iterative reconstruction (IR) algorithms, on the other hand, allow scanning at a lower dose while providing images with noise characteristics comparable to high-dose scanning [1,10].

The aim of this study was to compare the standard-dose CTE protocol with low-dose CTE, obtained with iterative reconstruction algorithm (iDose^4), in patients with Crohn's disease, in terms of image quality, diagnostic performance and delivered radiation dose.

2. Materials and methods

2.1. Study population

The study protocol was approved by our institutional review board, and informed consent was obtained from each patient.

We prospectively evaluated a total of 36 patients (12 females; mean age, 53 years) with proven Crohn's disease and with known or suspicion of relapse who underwent a low-dose CTE examination on a 256-slice scanner (iCT; Brilliance, Philips Medical System, Eindhoven, The Netherlands) from February 2012 to February 2014. We evaluated a control group of 37 patients (13 females; mean age, 49 years) who underwent a standard-dose CTE study on the same scanner.

The inclusion criteria were: (a) biopsy proven CD with clinical suspicion of relapse, (b) Crohn's disease activity index [CDAI] >150 and (c) at least one elevated acute phase reactant (erythrocyte sedimentation rate [ESR] or C-reactive protein [CRP] active >5 mg/dL). The exclusion criteria were: (a) renal insufficiency (estimated glomerular filtration rate, eGFR < 30 ml/min/1.73m^2), (b) documented adverse reaction to iodinated contrast material and (c) pregnancy.

All the patients were followed-up at the Gastroenterology department and were under pharmacologic treatment (i.e., azathioprine, oral corticosteroid, mesalazine and infliximab). Of the 73 patients, 23 had undergone a previous surgical resection (7/23 resection of colon and small intestine, 9/23 ileal resection, 6/23 colon resection and 1 rectal resection), due to CD complications mainly represented by bowel stricturing or penetrating disease.

2.2. CT technique: scanning parameters and oral contrast medium administration

For the study group, the scanning parameters were: tube voltage 120 kV, mAs determined by *x*-, *y*- and *z*-axis dose modulation, iDose^4 iterative reconstruction algorithm (level 4), collimation 128 × 0,650, pitch = 0.977, rotation time = 0.75 s, thickness 2 mm, matrix 512 and field of view (FOV) 350 mm. For the control group we used a standard-dose CTE protocol combined with FBP reconstruction with the following acquisition parameters: tube voltage 120 kV, tube current 200 mAs (for patients weighing less than 60 kg) and 300 mAs (for patients weighing between 61 and 90 kg), collimation 128 × 0,650, pitch = 0.977, rotation time = 0.75 s, thickness 2 mm, matrix 512; FOV 350 mm.

In order to obtain sufficient bowel distension for a better wall evaluation, patients were orally administered a solution of Polyethylene glycol (PEG) in 1500 mL of water, 45 min prior to scanning: 500 mL over the first 15 min and two further 500-mL aliquots 25 and 15 min prior to scanning, respectively [7].

CT scans were obtained from the dome of the liver to the level of the perineum to cover the entire course of the intestine. Images were acquired with the patient in the prone position in order to disperse the small bowel loops.

Intravenous contrast material (Xenetix 350; Guerbet, Aulnay, France) was power injected in an antecubital vein at a rate of 2.5–3.5 ml/s, with a double syringe injector (Medrad Stellant, Pittsburgh, PA, USA). The volume of the contrast agent was calculated on the basis of patient's body weight. Scanning was performed after a 70-s delay, during portal venous phase, as it provides acceptable enhancement of the bowel wall and surrounding structures including the mesenteric fat and terminal mesenteric vessels and allows detection of extraintestinal complications [3].

2.3. Image analysis and measurements

2.3.1. Qualitative analysis

Two radiologists, with 10 years and 4 years of experience in abdominal imaging respectively, analyzed the images of the MDCT protocols independently and in a blinded manner. In both series qualitative visual image analysis was assessed by recording, on a template, the subjective assessment of image quality and the presence of mural and extramural findings as well as complications of Crohn's disease. Both axial images and coronal reformations were analyzed, in accordance with the European guidelines on quality criteria for abdominal CT examinations [1].

Image quality was assessed subjectively using a 4-point scale compared with the quality of routine abdominal CTE (1) images inadequate for diagnosis; (2) images worse than routine examinations but interpretable; (3) images similar to routine examinations; (4) images better than routine examinations.); a score of ≥3 was considered acceptable [8].

The radiological features evaluated as disease localization in the bowel wall were [11]: thickening, increased enhancement and stratification (bilaminar or trilaminar appearance). The extraluminal features and complications evaluated were: the enlargement of mesenteric lymph nodes, fat stranding (focally increased inhomogeneous attenuation in the peri-enteric fat), regional dilation of vasa recta (comb sign), small-bowel obstruction, abscesses, fistulas and free abdominal fluid. Active disease was defined by the presence of mural thickening, increased enhancement and stratification along with peri-visceral inflammatory changes (fat stranding and vascular congestion) [11].

2.3.2. Quantitative analysis

Quantitative image analysis was defined using noise index (NI) and signal to noise ratio (SNR). Noise index was determined by standard deviation (SD of mean CT number), placing a rounded region-of-interest (ROI) in the subcutaneous fat and in the liver parenchyma on three different slices, both on the low-dose and on the standard-dose CT data sets. The signal to noise ratio (SNR) was calculated in each scan for the two groups, by dividing the mean attenuation values (HU) of the liver and abdominal fat respectively for the standard deviation (SD) [12].