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The role of CT Colonography in the assessment of inflammatory bowel Diseases patients

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A B S T R A C T

Inflammatory bowel disease (IBD), including Crohn's disease (CD) and Ulcerative Colitis (UC), is characterized by chronic inflammation of the gastrointestinal tract, and its long-standing course significantly elevates the risk of colorectal cancer (CRC), primarily arising from dysplastic lesions. While regular surveillance by colonoscopy is well established for UC patients, guidelines for CD remain uncertain.

Computed Tomographic Colonography (CTC) offers a minimally invasive alternative for evaluating the colon, particularly in cases where colonoscopy is incomplete or contraindicated. Although not commonly utilized in IBD management, CTC provides substantial advantages in identifying complications such as fistulas, strictures, and colonic neoplasms. Additionally, it offers anatomical detail, which is crucial for surgical planning and decision-making.

In this review we aim to demonstrate the usefulness of CTC in selected IBD cases, particularly in patients for whom colonoscopy is not feasible, and to show how its integration into clinical practice enhances decision-making and provides crucial insights into disease complications.

1. Introduction

Inflammatory bowel disease (IBD) refers to a group of chronic, relapsing conditions of the gastrointestinal tract characterized by underlying inflammation. The two major subtypes of IBD are Crohn's disease (CD) and ulcerative colitis (UC), both of which involve persistent inflammation of the gastrointestinal tract [1],[2]. While both conditions share this chronic inflammatory nature, they differ significantly in anatomical distribution and pathophysiology: UC is restricted to the colon and rectum, presenting with continuous superficial inflammation starting from the rectum, whereas CD can involve any segment of the gastrointestinal tract and is marked by transmural, discontinuous inflammation. Although CD more commonly affects the terminal ileum, colonic involvement is observed in approximately 50 % of patients, making colorectal surveillance relevant for a substantial subset [1]. These disorders exhibit substantial heterogeneity in both inflammatory burden and clinical manifestations, varying across patients and within individuals over time [1],[3].

Long-standing IBD is a well-established risk factor for the development of colorectal cancer (CRC), with most cases arising from dysplastic precursor lesions.

In UC, this risk increases significantly after eight years of disease duration, and evidence shows that nearly 20 % of CRC cases occur within the first eight years. Furthermore, patients diagnosed with UC at an older age exhibit an even higher incidence [1],[4]. In CD, the association with CRC is less clearly defined but remains significant in

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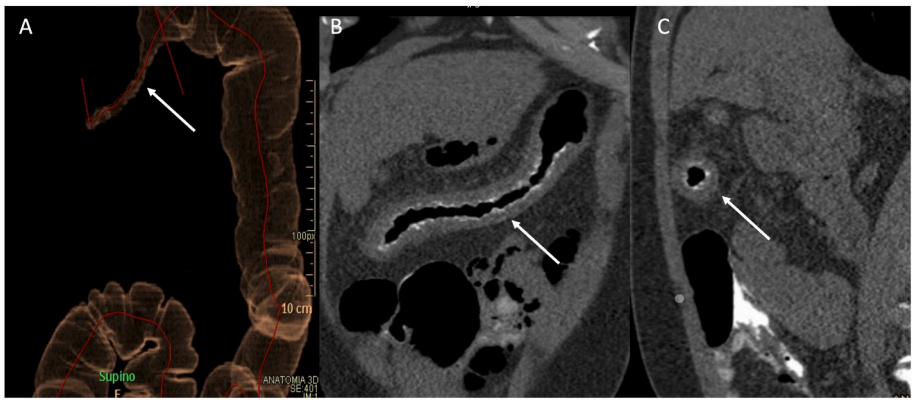

Fig. 1. A 60-year-old male smoker with a family history of IBD and a diagnosis of Crohn's disease, poorly controlled with medical therapy. The CTC shows a severe stenosis involving almost the entire transverse colon (white arrows in B and C), which is also well visualized on the 3D reconstruction (A).

patients with extensive and long-standing colonic disease [5],[6].

As a result, international guidelines recommend regular surveillance colonoscopies in patients with UC, typically beginning eight years after diagnosis and continuing at individualized intervals based on additional risk factors [5–8]. In contrast, standardized surveillance protocols for CD are lacking, partly due to the heterogeneity in disease distribution and behavior, and an unequivocal management algorithm is still absent [1],[7].

While colonoscopy remains the gold standard for dysplasia detection and disease monitoring, cross-sectional imaging plays an increasingly vital role in the management of IBD. Magnetic resonance imaging (MRI) and intestinal ultrasound (IUS) are widely employed due to their non-invasive nature, high diagnostic accuracy, and absence of ionizing radiation, an important consideration given the young age at diagnosis and the need for repeated evaluations [9].

These modalities are particularly effective for assessing disease activity and identifying extraluminal complications; however, they are limited in the evaluation of strictures, in the localization of previously detected endoluminal lesions, and in providing detailed vascular anatomy, which is often essential for surgical planning, especially in patients with prior surgeries or chronic inflammation altering normal anatomy [10–12].

CT Colonography (CTC), also known as virtual colonoscopy, offers several advantages versus other modalities, including rapid acquisition time and the ability to assess extra-intestinal complications through cross sectional imaging, and it is nowadays considered the best imaging technique to evaluate the colon [13–15]. The utility of CTC in IBD patients has been investigated in few papers [16–19], also considering its relative contraindication in active inflammation and its intrinsic exposure to ionizing radiation. The ability to significantly reduce radiation dose compared to the past and some advantages of CTC over other modalities suggest a potential role for this technique in selected IBD-related scenarios [20].

Therefore, this review aims to explore the selective role of CTC in patients with IBD and colonic involvement, with particular attention to clinical scenarios in which conventional colonoscopy or other imaging modalities are insufficient for comprehensive evaluation.

2. CTC technical aspects

This study reflects the experience of a single center, the radiology Department of the Luigi Sacco Hospital in Milan, between 2020 and 2024, during which approximately 1,000 CTC were performed. Examinations performed on patients with IBD were selected from the database.

The CTC technique comprises bowel preparation, colonic distension, CT scanning, and post-processing analysis, as outlined by the guidelines of various specialized societies [14],[21],[22].

Effective endoluminal evaluation of the colon requires bowel preparation. Standard protocols typically include a low-fiber diet in the 24–72 h preceding the examination, bowel cleansing with laxatives beginning 24 h prior, and oral administration of radiographic contrast agents for fecal tagging [14],[21].

We suggest using iodinated contrast material for fecal tagging, as it ensures homogeneous tagging of both fluid and solid stool residues, resulting in a consistent air-fluid interface. In our protocol, on the day of CTC, approximately 1 mL/Kg of iodinated contrast material diluted in 500 mL of water is administered orally at least three hours prior to the scan. This same-day technique is advantageous in IBD patients also allowing incidental visualization of the small bowel, as contrast-tagged fluid is typically present in the small bowel loops. The routine use of spasmolytic agents is advised prior to colonic distension, typically with either hyoscine butylbromide or glucagon [13],[23]. Spasmolytics may facilitate ileocecal valve incompetence, thus permitting retrograde distension of the terminal ileum, another advantageous feature in the context of IBD assessment.

As in conventional CTC, automated carbon dioxide insufflation is preferred over room air for colonic distension [14],[24]. Although rare cases of complications have been reported in the literature among patients with active IBD [16], in our experience, using an automated insufflation protocol, we have not had any complications (e.g. perforation). Therefore, to reduce this risk, a radiologist or a trained nurse must check the patient's feelings during colonic distension, searching for the right compromise between optimal distension and patient discomfort; this evaluation can be assisted by assessing the scout image appearance [13].When evaluating colonic strictures or wall thickening, a third scan in lateral decubitus position (in addition to the standard supine and prone acquisitions) is suggested to optimize assessment of the stenosis [25]. This additional scan should be performed in the decubitus opposite to the site of the stenosis (i.e. right lateral decubitus in case of sigmoid colon stenosis).

An alternative protocol that involves only supine and right lateral decubitus, omitting the prone decubitus [25], which is generally less well tolerated, may be considered. This alternative protocol has among others the advantage of being associated with a lower radiation dose.

Unlike the standard CTC protocol for average-risk patients, we advocate for the use of intravenous contrast medium in IBD cases, which is not designed to assess inflammatory activity, but rather to enhance the detection and characterization of disease-related complications [16]. Our protocol includes a baseline scan in the prone decubitus, followed by a supine portal venous phase scan obtained 75–80 s after intravenous injection of 100 mL of non-ionic iodinated contrast material, at a flow-rate of 3 mL/s.

While taking into account that the use of CTC is reserved for selected cases and not for surveillance disease purpose, it is essential that the

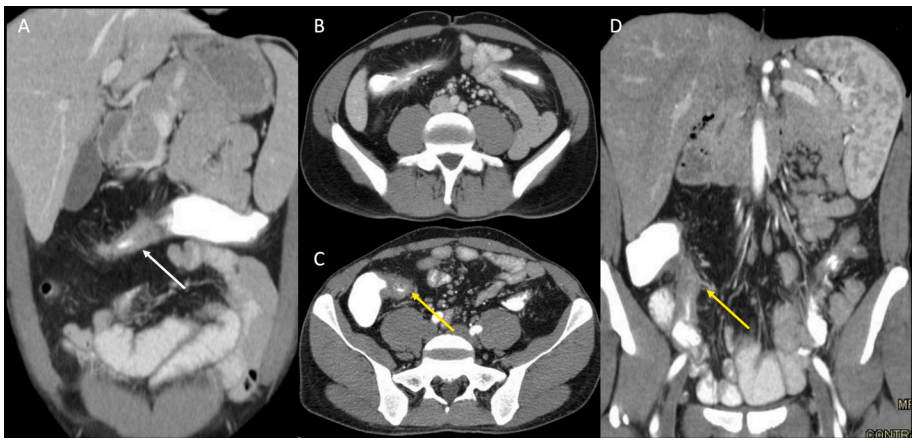

Fig. 2. A 37-year-old man smoker with a diagnosis of Crohn's disease and a history of segmental resection of the descending colon for severe stenosis and multiple jejuno-ileal stricturoplasties. He underwent CTC after a negative surveillance colonoscopy. The images show the presence of a stricture in the terminal ileum (yellow arrows in C and D) and another stricture in a more proximal ileal loop (white arrows in A and B). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

examination protocol include radiation dose reduction systems, especially in young subjects and women of childbearing age. In fact, patients with IBD are destined for lifelong disease surveillance imaging, and it is therefore critical that the choice of radiological examinations to undergo be based on no or reduced radiation. Recently, some authors have suggested the creation of an IBD patients radiation diary where the radiation doses of individual examinations would be progressively recorded, also with the intent to raise awareness among the medical establishment about the problem [26].

For image interpretation in IBD patients, we suggest primary review using 2D datasets at a standard workstation. Interpretation can be further enhanced with dedicated CTC workstations that support synchronized supine–prone comparisons, multiplanar reformations, and 3D navigation maps.

3. Typical IBD CTC findings

Similar to other imaging modalities, CTC can detect typical findings of CD and UC. The visualization of some of these features is enhanced by the colon distension achieved during the procedure. In both forms of IBD, CTC can also identify typical extracolonic findings. Notably, CTC allows for the assessment of visceral fat hypertrophy, which has been found to correlate well with fibrosis, muscular hypertrophy, transmural inflammation and stricture formation [17],[27],[28]. Additionally, CTC can visualize mesenteric lymph nodes.

3.1. Crohn's disease

In Crohn's disease, the most common finding is wall thickening, which is typically severe than in ulcerative colitis (Fig. 1) [28],[29]. Additionally, wall thickening in Crohn's disease is eccentric, often involving segmental areas with skip lesions During the acute phase of the disease, both the small bowel and colon exhibit mural stratification, with inflamed mucosa and serosa showing contrast enhancement following intravenous contrast medium injection [16],[30]. Edema within the wall may result in low attenuation density.

In patients with long-standing fibrotic disease, mural stratification is lost, and the pathological wall enhancement becomes more homogeneous. At this stage, patients may encounter lumen narrowing (Fig. 2), which can result in incomplete colonoscopy.

Among the extracolonic findings, CTC can reveal hypervascularity of the affected mesentery, along with dilatation, tortuosity, and prominence of the vasa recta (also known as the "comb sign") [31]. This sign indicates increased blood flow in the mesenteric vessels due to inflammation and dilation and therefore is a valuable indicator of active inflammation

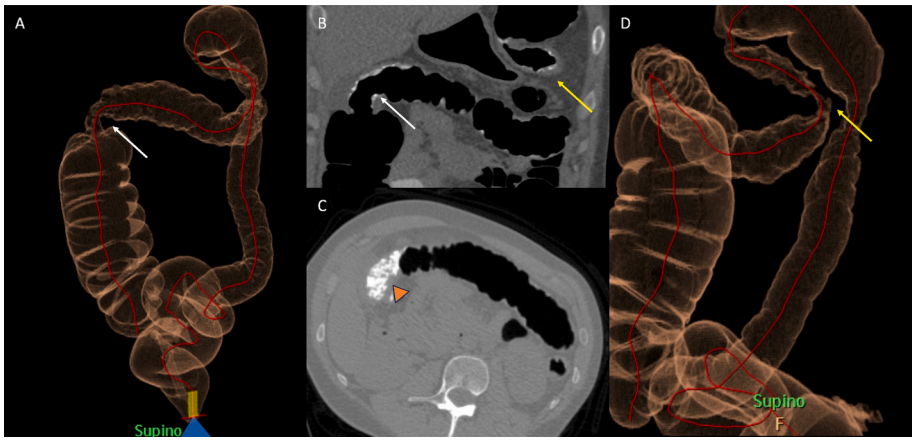

Fig. 3. A 32-year-old woman with a diagnosis of ulcerative colitis. Following the onset of bloody diarrhea and anemia, she underwent CTC after an incomplete conventional colonoscopy due to a substenosis at the splenic flexure. The CTC reveals two characteristic findings of IBD: substenosis at the splenic flexure (yellow arrows in B and D) and at the hepatic flexure (white arrows in A and B), where pseudopolyps are also observed (arrowhead in C). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
CTC indications in IBD patients.

Indications
Incomplete Colonoscopy
Contraindications for colonoscopy
Submucosal lesions
Complications IBD-related
Preoperative test

3.2. Ulcerative colitis

The course of UC is characterized by an acute followed by a subacute/chronic phase, each with distinctive radiologic findings. Imaging may appear normal in the early stages of the disease, whereas colonoscopy often reveals a granular mucosal pattern. As the disease progresses, severe mucosal ulceration occurs, which resulting in the formation of inflammatory pseudopolyps [30], visible on CTC as filling defects (Fig. 3). Diffuse and symmetric wall thickening is a hallmark of the subacute and chronic phases of disease [16],[30]. CTC, due to the distension of the entire colon, can highlight this finding, likely attributable to marked hypertrophy of the muscolaris mucosa, and can also identify lumen narrowing when present (Fig. 3). In this phase, the submucosa becomes thickened due to the deposition of fat (halo sign) [28]. Although this sign is frequently observed in patients with chronic ulcerative colitis, it can also be seen in other inflammatory conditions like Crohn's disease, graft-versus-host disease, and cytoreductive therapy, or even in case of obesity.

Chronic ulcerative colitis is typically associated with rectal narrowing and widening of the presacral space.

4. CTC indications

CTC indications for IBD patients are summarized in Table 1.

4.1. Patients with an incomplete colonoscopy

In patients with IBD who have had an incomplete colonoscopy due to luminal stenosis, CTC represents an alternative to further colonoscopy, given its accuracy in detecting colonic lesions [32] and its superiority versus other radiological techniques [14].

CTC scans are obtained after an optimal colon distension (insufflating preferably carbon dioxide) which facilitates the detection of colonic stenosis, a condition commonly encountered in IBD patients, particularly those with CD. CTC can suggest the true nature of the stenosis in the vast majority of cases, distinguishing IBD-related findings from those suggestive of CRC (Fig. 3). In case of marked wall thickening causing

Fig. 4. A 73-year-old woman with ulcerative colitis in remission. Recent conventional colonoscopy was interrupted at the sigmoid colon due to a stricture. CTC shows a sigmoid colon mass-like (arrows in A and B) with endoluminal pseudopolyp.

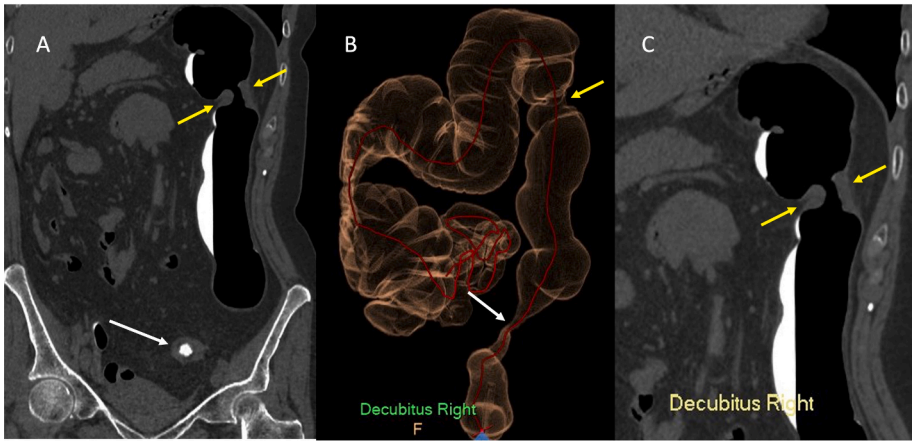

Fig. 5. A 55-year-old woman with active ulcerative colitis. A recent conventional colonoscopy was interrupted at the sigmoid colon due to a stricture. CTC shows diffuse and symmetric wall thickening causing severe stenosis of a long segment of the sigmoid colon (white arrows in A and B). Moreover, CTC detected a circular stenotic cancer in the proximal portion of descending colon (yellow arrows in A, B and C). Patient underwent subtotal colectomy and pathology confirmed descending colon adenocarcinoma (pT3NO) and disease activity in the affected segment of the sigmoid colon. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

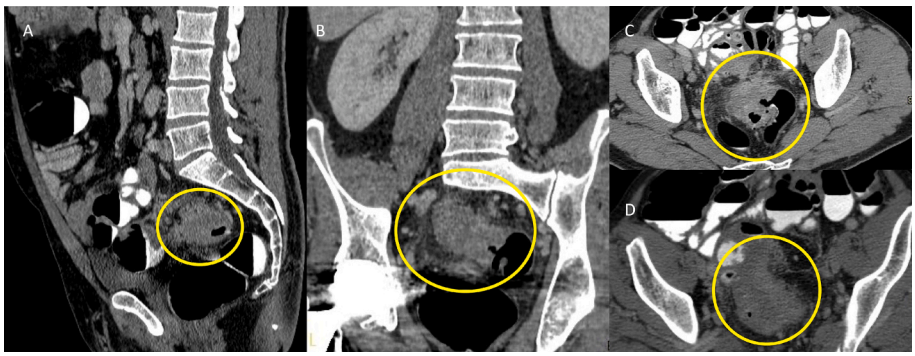

Fig. 6. A 57-year-old man with recurrent episodes of acute diverticulitis and a history of ileal Crohn's disease. After an onset of abdominal pain and episodes of hematochezia/proctorrhagia, he underwent a CTC following an incomplete conventional colonoscopy due to a severe stenosis at the sigmoid colon. The CTC revealed concentric thickening of the sigmoid colon, extending approximately 7 cm, with diverticula along the area of thickening (yellow circle in A, B, C and D). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

severe stenosis, the differential diagnosis between IBD and CRC can be more challenging (example in Fig. 4). In these rare cases, the diagnosis can only be definitively made by a pathologist based on the surgical specimen.

CTC may also reveal typical manifestations of IBD causing stenosis, while simultaneously identifying other colonic lesions, such as an unknown CRC located upstream of the stenosis (example in Fig. 5).

The ability to clarify the true nature of colonic stenosis and diagnose additional colonic lesions is a significant advantage of CTC over other imaging modalities, such as MRI and IUS.

The risk of developing colorectal cancer is higher in IBD patients compared to the general population [31]. Several guidelines recommend that all UC patients undergo screening colonoscopy due to their increased risk of CRC, particularly those with unifocal or multifocal dysplastic mucosa in areas of chronic inflammation identified on colonic biopsies [33]. Patients with chronic CD have an increased incidence of adenocarcinoma and lymphoma of the small bowel and colon, particularly in bypassed or excluded gut segments [30],[34].

In rare cases, wall thickening causing stenosis may be due to superimposed diverticular disease. CTC can also differentiate between CRC and chronic diverticular disease (Fig. 6) [35].

CTC can be safely performed on the same day following an incomplete colonoscopy, even in patients who have undergone biopsy or simple polypectomy.

4.2. Patients with contraindications for colonoscopy

CTC can be considered even in IBD patients where the colonoscopy is not clinically appropriate due to high comorbidity, inability to tolerate the procedure, or refusal.

Patients with a suspected submucosal lesion suggested by colonoscopy.

Submucosal lesions may appear during colonoscopy as broad-based, polypoid abnormalities characterized by elevation of the overlying colonic mucosa. These lesions may be intramural, originating from various layers of the intestinal wall, or extramural, arising from extrinsic processes. Imaging modalities such as MRI, IUS and conventional CT can be employed to identify and characterize submucosal lesions. In our opinion, even if CTC is not a substitute for conventional colonoscopy, interpretation is enhanced by CTC, which benefits from optimal colonic distension and the ability to simultaneously assess both endoluminal and extraluminal structures, features not fully achievable with other imaging modalities [36]. In selected cases, endoscopic ultrasound-guided fine-needle aspiration and/or biopsy may be necessary to obtain a preoperative definitive diagnosis [37].

Two illustrative cases highlighting the utility of contrast-enhanced CTC in patients with inconclusive endoscopic findings are described in Figs. 7 and 8.

4.3. Patients with IBD-related complications

Cross-sectional imaging has seen significant advancements in recent

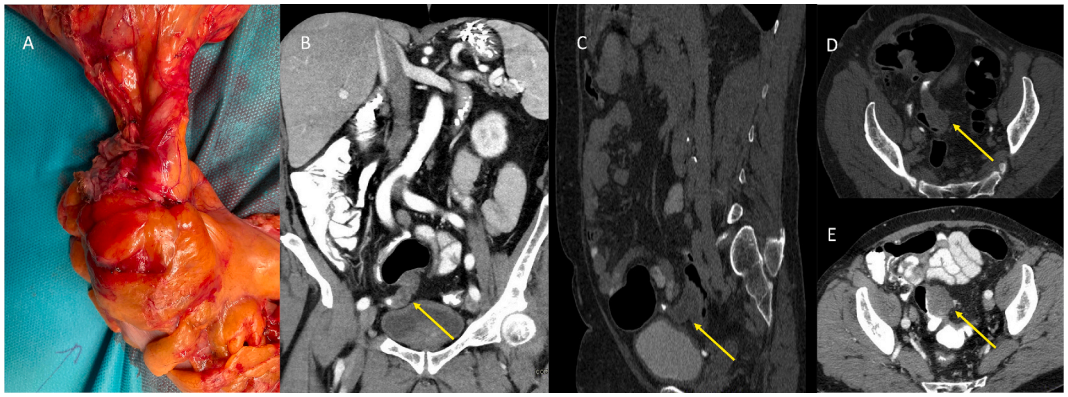

Fig. 7. A 69-year-old male with history of well-controlled UC, kept in remission with mesalazine therapy. A routine surveillance colonoscopy preformed six years ago first described a lesion at the level of the recto-sigmoid junction with inflammation of non-specific origin. One year ago, a contrast-enhanced CTC revealed a mass adjacent to the sigmoid colon with heterogenous content as an appendiceal mucocele involving the rectosigmoid junction, with irregular distal margins (yellow arrows in B, C, D and E). The diagnosis based on CTC findings was surgically confirmed and pathological analysis of the surgical specimen confirmed an appendiceal mucinous adenocarcinoma with sigmoid infiltration (T4 N0). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

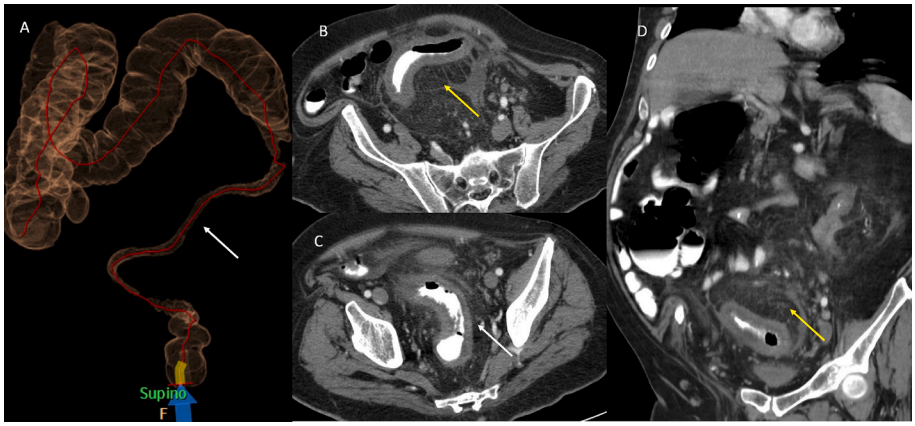

Fig. 8. A 68-year-old man who suffered from pathological obesity (BMI 34.8) with persistent mild abdominal pain and rapid weight loss underwent a conventional colonoscopy that revealed diffuse edema in the sigmoid colon with vascular congestion and focal ulcerative areas. A further contrast-enhanced CTC revealed significant wall thickening and lumen stenosis in the descending and sigmoid colon (white arrows in A and C) with increased thickness of the mesentery adjacent to the sigmoid colon and increased fat density (yellow arrows in B and D). Patient underwent an urgent exploratory laparotomy with left hemicolectomy and anterior rectum resection with terminal colostomy and pathology revealed colonic sclerosing mesenteritis. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

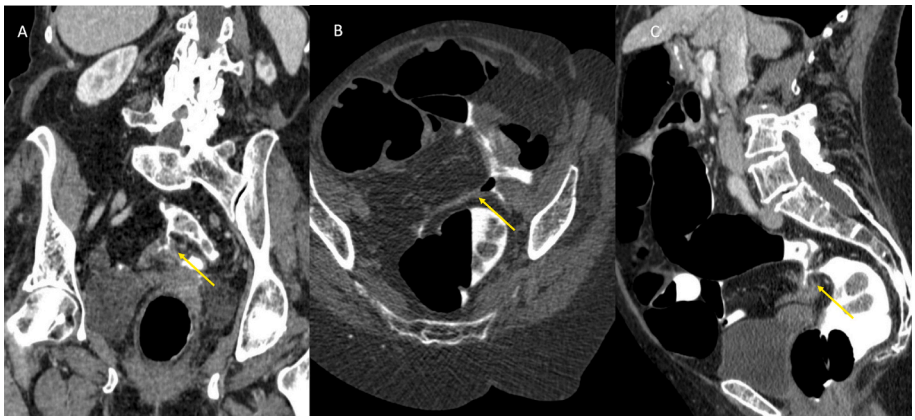

Fig. 9. An 83-year-old woman with a diagnosis of well-controlled ileal Crohn's disease, currently on treatment with Rifaximin. CTC revealed an additional entero-enteral fistula (yellow arrows in A, B and C) which was not detected on a pelvic MRI performed just one week prior. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

years and plays a crucial role in the follow-up of patients with IBD. It is widely employed to assess disease extent, mural and *peri*-enteric involvement, as well as to evaluate complications. CT, MRI, and US exhibit high and comparable diagnostic accuracy in the diagnosis of IBD and assessment of its associated complications.

Complications associated with IBD are common and often require surgical management. Intestinal and perianal fistulas are among the most frequent complications, primarily affecting patients with CD. These fistulas can significantly impair quality of life and carry substantial clinical and psychological consequences [38]. Fistulizing CD includes perianal fistulas and those that communicate with other viscera (urinary bladder, vagina), intestine (entero-enteric fistulae) or the abdominal wall (entero-cutaneous fistulae) [39].

According to recent ECCO-ESGAR guidelines, MR enterography is recommended as the imaging modality of choice for evaluating CD, as it allows for localization and assessment of disease activity and complications such as abscesses, fistulas, and strictures. However, its limitations include high cost, limited availability and the requirement of considerable patient compliance. These limitations underline the need for alternative imaging modalities in the assessment and particularly in the follow-up of the disease [6].

Although only a few studies have explored the role of CTC in detecting colonic fistulae [40],[41], a recent publication has demonstrated that CTC may be useful in selected cases for evaluating fistulizing IBD [42]. Specifically, in patients with IBD and fistulae, CTC may give crucial information for their management regarding the origin and anatomy of the fistula, the presence of local sepsis (abscess), and the involvement of adjacent organs.

Based on our clinical experience, CTC has proven particularly useful in identifying additional, previously undetected entero-enteral fistulas arising from the colon (most frequently from the sigmoid colon) in patients already diagnosed with perianal fistulae by pelvic MRI (Fig. 9). These findings, not visible on pelvic MRI, led to modifications in surgical planning.

Although intestinal ultrasound can also detect colonic fistulas, in our experience, the information provided by IUS has often been deemed insufficiently robust by surgeons, especially in cases where surgical intervention is under consideration. In contrast, CTC appears superior not only in confirming the presence of fistulae but also in accurately delineating their anatomical location.

Abscesses represent another common complication of IBD, predominantly in Crohn's disease.

These may be confined to the bowel wall and surrounding pericolic fat or may extend to adjacent structures such as bladder, psoas muscle, and pelvic sidewall. In case of abscess formation, CTC does not provide any additional diagnostic benefit compared to conventional CT.

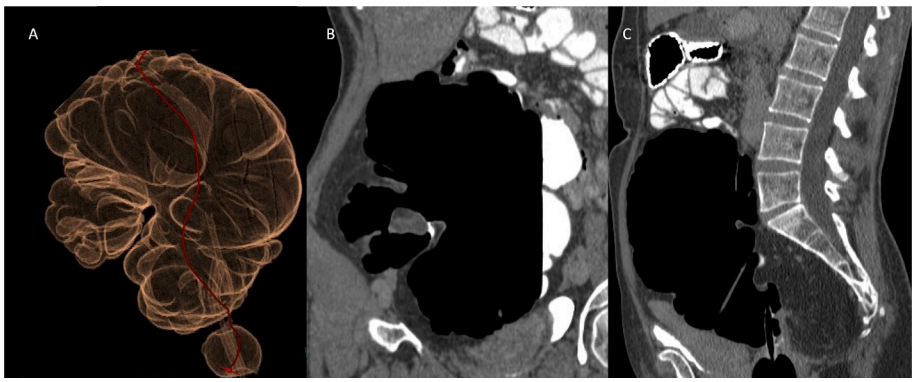

Fig. 10. A 63-year-old woman with Crohn disease in remission. Previous endoscopic and radiologic exams had incorrectly identified a large blind-ended loop as a post-surgical finding. However, CTC clarified the patient's anatomy, revealing a congenital colon malformation. In fact, the colon was replaced by a large pouch-like structure, approximately 30 cm in length, visible in both 3D colon map (A) and multiplanar views (B and C). This finding was confirmed by subsequent endoscopic examinations.

The utility of CTC in evaluating IBD-associated colonic luminal stenosis, a complication more frequently observed in CD patients, has already been discussed earlier in this manuscript.

4.4. Candidates for surgery

Patients with IBD have an increased risk of requiring surgical intervention. In particular, Crohn's disease, due to its relapsing and remitting course, frequently necessitates repeated surgeries. In patients who have undergone previous operations, the interpretation of postoperative imaging can be challenging, as prior surgical procedures may significantly alter normal anatomical landmarks .

CTC due to its digital nature, allows for accurate measurement of endoluminal lesions, offering superior compared to visual estimation during endoscopy [43]. CTC evaluates the colon after distension, thus allowing a better comprehension of the colon anatomy in comparison with other endoscopic and radiologic tests [19].

When combined with other preoperative imaging techniques such as MRI and IUS, CTC contributes essential anatomical information that aids in surgical planning in IBD patients [44].

Moreover, CTC can be specifically requested by surgeons for preoperative assessment and mesenteric vascular mapping. This information may influence the surgical approach and has the potential to reduce operative times. Several studies [45–48] have highlighted the utility of CTC in evaluating vascular branching patterns and the spatial relationships between colorectal lesions, vessels and adjacent organs. Notably, Haraikawa et al [49] demonstrated that CO2 insufflation during CTC improves visualization of peripheral vasculature.

In the context of altered anatomy due to chronic inflammation or previous surgeries, acquiring precise preoperative imaging is especially valuable.

A representative case of our series illustrates the utility of CTC in this setting. In a patient previously misdiagnosed with a post-surgical rectal configuration based on MRI and IUS, CTC accurately identified a congenital simil-pouch rectal malformation (Fig. 10). This finding led to a revision of the diagnosis and a change in clinical management.

5. Conclusions

CTC is a safe and reliable examination in patients with IBD with incomplete colonoscopy, given the possibility of obtaining crucial diagnostic information regarding the stenosis that prevents completion of the endoscopic examination and allowing for objective, reproducible assessment of colonic morphology of the entire colon.

This advantage explains its usefulness also in diagnosing colonic fistulae which complicate the disease course, and in patients who are candidates for surgery.

The utility of CTC in these selected scenarios is further supported by the limitations of MRI and IUS in providing comparable information.

CRediT authorship contribution statement

Mariani Leonardo: Conceptualization. **Colombo Francesco:** Conceptualization. **Meuli Sarah:** Conceptualization. **Zaffaroni Gloria:** Conceptualization. **Danelli Piergiorgio:** Conceptualization. **Maconi Giovanni:** Conceptualization. **Ianniello Andrea:** Conceptualization. **Flor Nicola:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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