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Multimodality imaging in assessment of intestinal complications pre-stomal reversal

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Abstract

Background Several imaging modalities are available to assess complications post intestinal stoma creation. The aim of this study was the radiological assessment of intestinal complications pre-stomal closure using routine fluoroscopic water-soluble contrast enema (WSCE), combined CT-WSCE, and MRI-enema with rectal gel administration. Additionally, we aimed to investigate the potential alterations in the surgical management plan based on imaging findings.

Results This prospective cross-sectional study recruited 130 patients with stomas referred for the assessment of stoma integrity. Thirty-six patients with stoma-related intestinal complications were included. Patients with complications were subdivided into 3 groups. Group A 15 patients with intestinal stomas referred for WSCE pre-stomal closure and complementary CT-WSCE evaluation was performed. Comparison between the detection of the complications by WSCE alone and combined CT-WSCE among group A was statistically significant ($p=0.008$) yet the alteration of the surgical plan based on both modalities was not statistically significant ($p=0.063$). Group B 11 patients with poor general conditions were referred directly for combined CT-WSCE assessment, complications diagnosed in this group: 6 (54.5%) intestinal obstruction, 2 (18.2%) pericolic collections, 2 (18.2%) abnormal fistula and 1 (9.1%) anastomotic leak. Group C 10 patients with intestinal stomas with malignant or inflammatory conditions referred directly for MRI-enema assessment, showed complications as follows: 3 (30%) colon/rectal tumoral recurrence, 2 (20%) strictures, 2 (20%) pericolic collections and 3 (30%) abnormal intestinal fistulous communications. Comparison between complicated colorectal cancer patients (20 patients) versus other complicated patients secondary to other surgical indications (16 patients) enrolled in the study from the 3 different groups was not statistically significant ($p=0.125$).

Conclusions Combined CT and WSCE is superior in the detection of intestinal fistulas, peri-colic collections, tumor recurrence, and para-stomal hernias than WSCE alone and might lead to a change of management. MRI after rectal gel administration can serve as reliable substitute in some patients for the detection of intestinal complications namely fistulas and tumor recurrence.

Keywords Surgical stomas, Colostomy, Ileostomy, Colorectal neoplasms

Background

Intestinal stomas are important in the management of several gastrointestinal diseases. Hartman's colostomy, ileostomy, and loop colostomy are the most used stomas in surgical practice. Intestinal stoma can be temporary or permanent with indications in children such as intestinal malformations, including Hirschsprung's disease and anorectal malformation. In adults, indications include colorectal cancer (commonest), inflammatory bowel diseases, diverticular disease of the colon complicated by

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obstruction, penetrating intestinal injuries, and intestinal anastomotic leak [1].

Intestinal ostomies are classified according to the segment of the intestine that is brought out to the surface of the body. Ileostomies are typically created in the right side of the abdomen, while colostomies are mostly done in the left aspect of the abdomen [2]. Complications after surgical stomas may either occur early or late after surgery. Within 30 days from stoma creation, the early common complications are ischemia/necrosis, parastomal abscess, and stoma retraction. The late complications include stomal prolapse, parastomal hernia (PH), and varices. Strangulation and intestinal obstruction can be either early or late complications [3]. Colorectal cancer patients also require in several cases adjuvant radiotherapy after stoma creations, with intestinal complications such as bowel obstruction, fistula formations and strictures [4].

Several imaging modalities are used to assess stomal integrity whether in early postoperative stages or late prereversal of stoma. Water soluble contrast enema (WSCE) under fluoroscopy is usually performed before the closure of intestinal stoma to assess anastomotic integrity and detect leak, fistula formation or blockage. It has been showed that the WSCE use in the immediate postoperative phase has a low predictive value to detect subclinical contrast leaks [5]. While contrast-enhanced CT is used mostly to rule out postoperative complications or during follow-up of neoplastic conditions. In some cases, performing a CT with WSCE may be used to provide combined functional and anatomic information [3].

MRI-enema is a novel imaging technique providing detailed assessment of the pelvic region with accurate imaging of the pelvic organs with no ionizing radiation, which is particularly important to young patients with chronic diseases. It also assists in identifying location of leaks, providing valuable information for early revision surgery with early protection from pelvic sepsis [6].

The radiological assessment of intestinal stomas prestomal closure is considered clinically relevant to rule out related complications that might potentially lead to alterations in the surgical management. We aimed to assess the detection of post-operative intestinal complications pre-stomal reversal via different radiological modalities including WSCE, combined CT with WSCE and MRI-enema using rectal gel.

Materials and methods

This prospective cross-sectional observational study was approved by the research ethics committee and informed consent was obtained from all the recruited patients. The study was performed at the diagnostic and interventional radiology depatment of a tertiary health care univesity hospital from June 2022 to Feburary 2023.

Patients

The inclusion criteria included compliant patients, from age 14 or older, of both genders and patients with intestinal stomas created for any reason with radiologically detected intensitnal complication. The exclusion criteria included children less than 14 years old, non-compliant patients e.g., mentally challenged, patients with contraindications to radiation e.g., pregnant ladies and patients with contraindications to MRI e.g., cochlear implants, cardiac pacemakers, and severe claustrophobia. Patients with no radiologically detected complications were also excluded.

Patients recruited for this study were 130 participants referred by the general surgery department and surgical team at the emergency department to assess the stomal integrity and to exclude the intestinal complications before the stomal closure. According to clincal assessment and patient's general conditions, patients were divided into 3 groups (Fig. 1).

Group A this group included 109 patients referred for fluorscopic WSCE as part of their work-up pre elective stomal reversal. Eighty-six patients were found uncomplicated and hence excluded from the study. The remaining 23 patients were suspected to have complications by WSCE and then underwent complementary CT-WSCE study to confirm these complications. Eight cases were found to be uncomplicated by both WSCE and CT-WSCE and exluded. Accordingly, 15 patients were found to have complications, 8 of them were detected by WSCE and confirmed by the complimentary CT-WSCE, while 7 cases were inconspicous on WSCE and detected by CT-WSCE only.

Group B included 11 patients with poor general conditions and high clinical suspicion to have intestinal complications seen in an emergency setting and were referred from the emergency surgical team for urgent assessment of those complications by CT with contrast delination of the distal bowel loop with WSCE. All patients referred showed evidence of intestinal complications and were included.

Group C 10 patients with intestinal stomas with known malignant conditions (distal colonic/rectal cancers), patients with history of suspected pelvic irradiation complications and patients post pelvic surgery were referred by the general surgery department pre-stomal closure. They underwent MRI with rectal gel administration to rule out tumor recurrence, stricture, or presence of

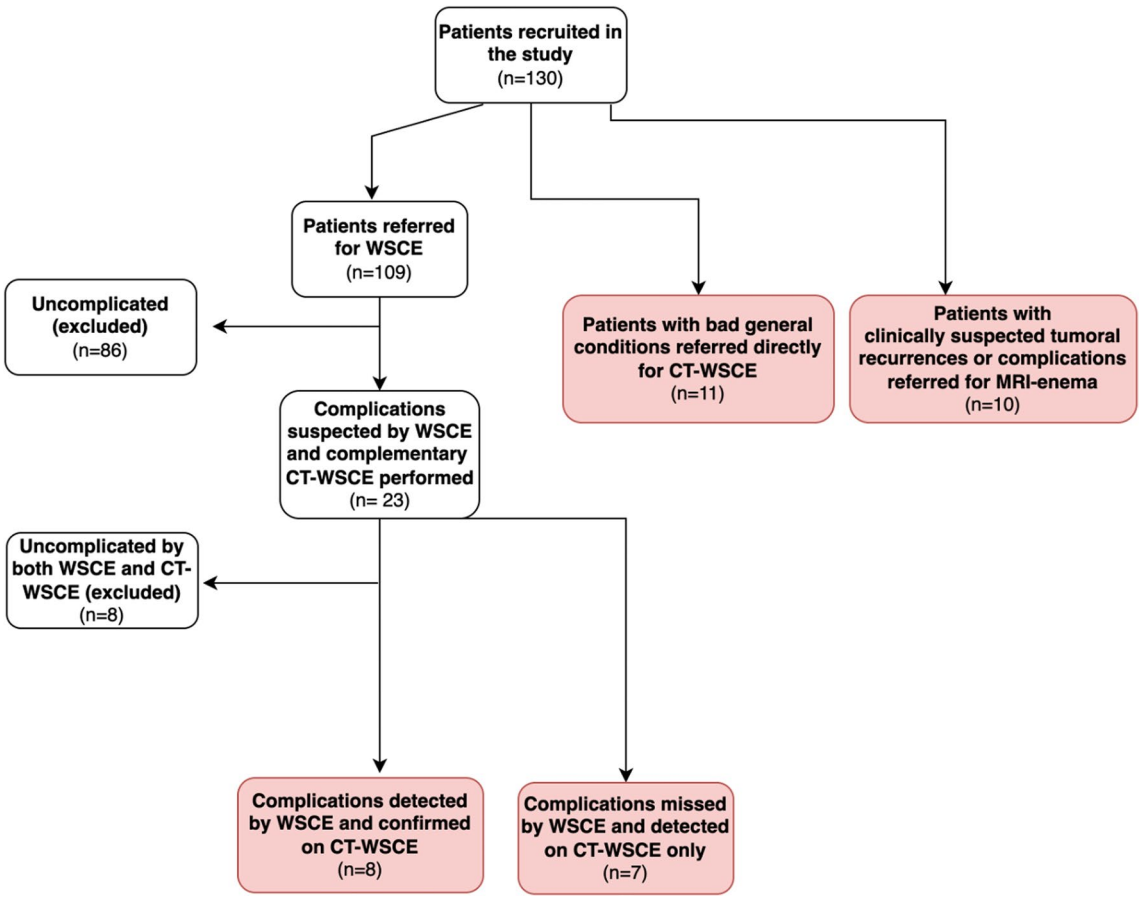

Fig. 1 Flowchart summarizing the patients included in the study

intestinal fistulas. Patients all patients referred showed evidence of intestinal complications and were included.

Imaging techniques

Fluoroscopic water-soluble contrast enema (WSCE) fluoroscopy imaging was performed in the supine position (Luminos dRF Max fluoroscopy, Siemens). A plain film was obtained in antero-posterior (AP) view. A lubricated urinary-type Foley catheter was introduced into the stoma. The catheter was connected to the nozzle of the enema bag and filled with a water-soluble contrast medium Omnipaque 350 ml (GE healthcare) then progressive filling of the bowel lumen connected to the stoma on fluoroscopy was observed, AP, lateral and oblique views were acquired [7]. Complimentary CT acquisition was done on 16 CT scanner (SOMATOM Emotion, Siemens) in some patients of group A, with no additional oral or IV contrast administered.

Combined CT with WSCE after water-soluble contrast enema administration through the rectum (done similarly to routine WSCE), CT acquisition was done on 16 CT scanner (SOMATOM Emotion, Siemens) and multiplanar reformatted images were created. Oral and IV contrast were administered Ultravist/iopromide (Bayer AG) in patients referred from the emergency department (group B).

MRI-enema evaluation after injection of warm ultrasound gel per rectum. Patients were imaged on 1.5-T MRI machine (Achieva, Philips Medical System) in the supine position using abdominal phased-array coil. No oral or intravenous contrast agent was administered. T2–weighted images turbo spin-echo sequences were acquired in three planes; axial, coronal, and sagittal [repetition time ms/echo time ms (TR/TE) 4000/100, field of view (FOV) 240–260 mm, slice thickness 2–4 mm, gap 0–0.5 mm, number of signals acquired 2, flip angle

Table 1 Demographics, surgical indications, detected complications and surgical management alterations among patients studied in the 3 studied groups

Patient	Age	Indication of surgery	Type of surgery	Complication	Detection of complication by WSCSE	Detection of complication by CT	Intended surgical management	Change of management based on WSCE	Change of management based on CT
Group A (WSCE & CT)									
1	16	Hirschsprung disease	Ileostomy	Stricture	Yes	Yes	Resection anastomosis	Yes	Yes
2	66	Iatrogenic colonic injury	Resection & colostomy	Fistula (recto-vesical)	Yes	Yes	Fistulectomy	Yes	Yes
3	57	Colorectal cancer	Resection & colostomy	Intestinal obstruction	No	Yes	Emergency laparotomy	No	Yes
4	24	Traumatic colonic injury	Ileostomy	Fistula (entero-cutaneous)	No	Yes	Fistulectomy	No	Yes
5	30	Pelvic sepsis post rectal surgery	Colostomy	Pericolic collection	No	Yes	Drainage	No	Yes
6	43	Complicated diverticular disease	Resection & colostomy	Fistula (colo-colic)	Yes	Yes	Fistulectomy	Yes	Yes
7	60	Colorectal cancer	Resection & colostomy	Stomal prolapse	No	Yes	Stoma reversal	No	No
8	40	Iatrogenic colonic injury	Ileostomy	Stricture	Yes	Yes	Resection anastomosis	Yes	Yes
9	34	Colorectal cancer	Resection & ileostomy	Leak	Yes	Yes	Exploration and repair	Yes	Yes
10	39	Colorectal cancer	Resection & ileostomy	Leak	Yes	Yes	Exploration and repair	Yes	Yes
11	45	Colorectal cancer	Resection & colostomy	Para-stomal hernia	No	Yes	Stoma reversal + repair hernia on same session	No	Yes
12	43	Colorectal cancer	Resection & colostomy	Tumor recurrence	No	Yes	Management of recurrence	No	Yes
13	34	Colorectal cancer	Resection & colostomy	Fistula (entero-cutaneous)	No	Yes	Fistulectomy	No	Yes
14	38	Colorectal cancer	Resection & ileostomy	Para-stomal hernia	No	Yes	Stoma reversal + repair hernia on same session	No	Yes
15	31	Hirschsprung disease	Resection & ileostomy	Stricture	Yes	Yes	Resection anastomosis	Yes	Yes
Group B (combined CT-WSCE only)									
16	27	Mesentric vascular occlusion	Resection & ileostomy	Pericolic collection			Drainage		
17	35	Colorectal cancer	Resection & ileostomy	Intestinal obstruction			Emergency laparotomy		
18	39	Iatrogenic colonic injury	Colostomy	Fistula (recto-vaginal)			Fistulectomy		
19	30	Iatrogenic colonic injury	Resection & colostomy	Leak			Exploration and repair		
20	14	Pelvic sepsis post rectal surgery	Resection & ileostomy	Intestinal obstruction			Emergency laparotomy		
21	40	Traumatic colonic injury	Resection & colostomy	Intestinal obstruction			Emergency laparotomy		
22	75	Colorectal cancer	Resection & colostomy	Intestinal obstruction			Emergency laparotomy		

Table 1 (continued)

Patient	Age	Indication of surgery	Type of surgery	Complication	Detection of complication by WSCSE	Detection of complication by CT	Intended surgical management	Change of management based on WSCE	Change of management based on CT
23	50	Colorectal cancer	Resection & colostomy	Intestinal obstruction			Emergency laparotomy		
24	52	Colorectal cancer	Resection & ileostomy	Intestinal obstruction			Emergency laparotomy		
25	55	Complicated diverticular disease	Resection & colostomy	Fistula (colo-colic)			Fistulectomy		
26	54	Mesentric vascular occlusion	Resection & jejunostomy	Pericolic collection			Drainage		
Group C (MRI-enema only)									
27	61	Colorectal cancer	Resection & ileostomy	Fistula (recto-vaginal)			Fistulectomy		
28	43	Complicated diverticular disease	Resection & colostomy	Fistula (colo-colic)			Fistulectomy		
29	31	Hirschsprung disease	Resection & ileostomy	Stricure			Resection anastomosis		
30	50	Colorectal cancer	Resection & ileostomy	Tumor recurrence			Management of recurrence		
31	74	Colorectal cancer	Resection & colostomy	Pericolic collection			Drainage		
32	42	Colorectal cancer	Resection & colostomy	Fistula (recto-ileal)			Fistulectomy		
33	40	Colorectal cancer	Resection & colostomy	Tumor recurrence			Management of recurrence		
34	39	Colorectal cancer	Resection & colostomy	Pericolic collection			Drainage		
35	28	Colorectal cancer	Resection & colostomy	Stricture			Resection anastomosis		
36	52	Colorectal cancer	Resection & ileostomy	Tumor recurrence			Management of recurrence		

90, matrix 512×512]. STIR (short tau inversion recovery) weighted images were acquired in three planes; axial, coronal and sagittal [repetition time ms/echo time ms (TR/TE) [repetition time ms/echo time ms (TR/TE) 2600/60, field of view (FOV) 240–260 mm, slice thickness 2–4 mm, gap 0–0.5 mm, number of signals acquired 2, flip angle 90, matrix 512×512]. Diffusion weighted images WI were obtained (*b*-values 0, 500 and 800 s/mm^2).

Image analysis

Early and long-term stoma related complications were assessed by a junior radiologist (N.A.) with 2 years of radiological experience. Findings were verified by two radiologists (M.A. and S.M.) each with 9 years' experience and validated by a senior GI radiologist (M.F.O.) with over 19 years of radiological experience. Evaluations included stomal site and position assessment (normal, retracted or prolapsed), bowel wall thickness, presence of leakage, stricture, fistula, collection or para-stomal hernias, assessment of the rest of bowel loops (bowel loops dilatation or obstruction) and MRI assessment of tumoral recurrence (colonic wall thickening, presence of diffusion restriction, ±presence of malignant-looking perirectal lymph nodes). Intended surgical management and surgical plan alterations based on imaging were discussed with a general surgeon (M.T.) with 10 years of surgical experience.

Statistical analysis

Data were coded and entered using the statistical package for the Social Sciences version 28 (IBM Corporation). Data were summarized using mean, standard deviation, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. For comparing categorical

data, Chi-square test was performed. Exact test was used instead when the expected frequency is less than 5. Comparison between the change decision by CT-WSCE and by WSCE was done using the non-parametric McNemar test [8]. *P*-values less than 0.05 were considered statistically significant.

Results

Demographics, surgical indications, detected complications and surgical management alterations among all the studied groups are summarized in Table 1.

Group A (fluoroscopic WSCE and complimentary CT-WSCE)

Fifteen patients were found to have complications by either WSCE or CT-WSCE 40 ± 13 years old (age range 16–66 years). Seven patients (46.7%) showed intestinal complications detected on WSCE and confirmed by CT-WSCE. While 8 patients (53.3%) were only detected by the complimentary CT-WSCE and were inconspicuous on the WSCE alone.

Intestinal complications detected in group A were as follows: 4 (26.7%) intestinal fistulas, 3 (20%) strictures, 2 (13.3%) anastomotic leaks, 2 (13.3%) para-stomal hernias as well as 1 (6.7%) intestinal obstruction, 1 (6.7%) pericolic collection, 1 (6.7%) stomal prolapse, and (6.7%) tumoral recurrence. The 7 complicated patients missed by WSCE and only detected by the complimentary CT-WSCE were 2 (13.3%) intestinal fistulas, 2 (13.3%) parastomal hernias, 1 (6.7%) intestinal obstruction, 1 (6.7%) peri-colic collection and 1 (6.7%) tumor recurrence. Comparison between both modalities regarding the detection of complications yielded a statistically significant difference ($p = 0.08$).

Regarding the 4 intestinal fistulas detected in group A, conventional WSCE was able to detect the recto-vesical as well as one of the cases with enterocutaneous fistula, while the other 2 cases of fistulas (1 small entero-cutaneous fistulous tract near the colostomy opening and 1 small colo-colic fistula) were missed on the routine WSCE and diagnosed by the complimentary CT only.

The complicated cases were discussed with surgical team with the intended surgical management were changed based to the complications detected on the imaging in 14 out of the 15 patients (93.3%) as follows: fistulectomy 4 (26.7%), resection anastomosis 3 (20%), hernia repair in same session 2 (13.3%), exploration and repair 2 (13.3%), management of recurrence 1 (6.7%), emergency laparotomy 1 (6.7%) and drainage 1 (6.7%).

Table 2 Radiotherapy-related changes abnormalities detected among the 8 patients from group C with colorectal cancer

Radiotherapy-related changes detected by MRI	Number of patients
Presacral fibrotic sheets	8 (100%)
Mottled osseous marrow signal of the pelvic bones (fatty marrow conversion)	6 (75%)
Pelvic floor muscles abnormal signal intensity	5 (62.5%)
Mural thickening of the urinary bladder	4 (50%)
Sacral plexus nerve roots edema signal	2 (25%)
Distal ureteric stricture with upstream hydroureter and hydronephrosis	2 (25%)
Recto-vaginal fistula	1 (12.5%)
Ileo-rectal fistula	1 (12.5%)

Based on the CT-WSCE findings in group A, change in the surgical management plan was reached in 12 out of the 15 cases (80%) with postponed reversal of stoma and altered surgical management. While decision of the surgical management was stomal reversal with parastomal hernia repair in the same session was 2 (13.3%) and no change in the surgical management in 1 patient (6.7%) with stoma prolapse. Comparison between change of management based on WSCE versus CT in group A patients was statistically not significant ($p = 0.063$).

Group B (combined CT-WSCE only)

All 11 patients with poor general conditions mean age 43 ± 16 years old (age range 14–75 years) referred directly for combined CT-WSCE were all found to have intestinal complications as follows: 6 (54.5%) patients with intestinal obstruction (IO), 2 (18.2%) showed pericolic collections, while 2 (18.2%) had fistula and 1 (9.1%) case had an anastomotic leak.

Based on the CT findings, surgical management plan was to delay stomal reversal in all cases and surgical interventions as follows: emergency laparotomy in the 6 (54.5%) patients diagnosed with IO, drainage in 2 (18.2%) cases with peri-colic collection, exploration and repair the case diagnosed with an anastomotic leak (10%), and finally fistulectomy in the 2 (18.2%) patients diagnosed with abnormal fistulous formation.

Group C (MRI-enema only)

All 10 patients referred for MRI-enema with intestinal stomas mean age 46 ± 13 years old (age range 28–74 years) due to malignant or inflammatory conditions showed complications as follows; 3 (30%) showed

Table 3 Comparison between complicated colorectal cancer patients versus other complicated surgical indication patients enrolled in the study from the 3 different groups

	Indication of surgery		
	Colorectal cancer ($n=20$)	Other indications ($n=16$)	*p*-value
Type of complications count (%)			
Tumor recurrence	4 (20.0%)	–	0.125
Stricture	1 (5.0%)	4 (25.0%)	
Stomal prolapse	1 (5.0%)	0 (0.0%)	
Pericolic collection	2 (10.0%)	3 (18.8%)	
Para-stomal hernia	2 (10.0%)	0 (0.0%)	
Anastomotic leak	2 (10.0%)	1 (6.3%)	
Intestinal obstruction	5(25.0%)	2 (12.5%)	
Abnormal fistula formation	3 (15.0%)	6 (37.5%)	

P-value less than 0.05 was considered as statistically significant

evidence of colon/rectal tumoral recurrence, 2 (20%) showed strictures, 2 (20%) patients with pericolic collections while 3 (30%) showed abnormal fistulous communications. MRI findings suggested changes in the management plan in all patients; fistulectomy in 3 cases (30%), management of the tumoral recurrence in 3 cases (30%), drainage in 2 cases (20%) with the peri-colic collection, and finally resection anastomosis in 2 cases (20%) with a stricture. Additional radiotherapy-related changes were noted on the MRI scans of the 8 colorectal patients are summarized in Table 2.

Comparison between complicated colorectal cancer patients (20 patients) versus other complicated patients secondary to other surgical indications (16 patients) enrolled in the study from the 3 different groups was not statistically significant ($p=0.125$) (Table 3).

Discussion

The most prevalent complication among all the studied patients from the 3 groups was abnormal fistulous communications in 9 (25%) patients followed by intestinal obstruction in 7 (19%) patients.

Among group A, from the 4 patients diagnosed with abnormal fistulous communications, only 2 of them were primarily visible on the WSCE while the other 2 were only diagnosed on the complimentary CT-WSCE (Fig. 2), suggesting that CT-WSCE is likely to be superior to routine WSCE in the detection of small intestinal-fistulas with the added value of precise delineation of the location and size of the fistulous tract needed prior to surgical management. Our findings disagreed with a prior study that compared routine WSCE under fluoroscopic guidance, CT following WSCE, and scintigraphy in the detection of postoperative complications following ileoanal anastomoses and stated that fistulas are commonly missed by these modalities [9].

Additionally, parastomal hernias and parastomal prolapse were only diagnosed on the complimentary CT studies among group A patients (Fig. 3), which agrees with a systematic review that compared between different modalities for the diagnosis of parastomal hernia and stated that the use of CT increases the parastomal hernia detection rate, indicating that this is a more accurate modality compared with clinical examination [10]. Although the presence of parastomal hernia diagnosis does not necessitate postponing the stoma reversal, but it requires hernia repair in the same surgical setting.

In discordance with a recent study that explored the optimal examination to detect occult anastomotic leakage after rectal resection in patients with stomas that compared digital rectal examination, routine WSCE, and CT-WSCE, concluded that WSCE alone may have high false-negative radiological results and suggested that CT following WSCE should be the standard method to assess anastomosis integrity before early stomal closure [11]. Yet among our cohort, anastomotic leaks were equally diagnosed by both routine WSCE and CT-WSCE among our studied cohort, possibly due to the sample size.

Comparison between the detection of the complications by WSCE alone and combined CT-WSCE among group A was statistically significant ($p=0.008$) yet the alteration of the surgical plan based on both modalities was not statistically significant ($p=0.063$) although CT-WSCE suggested alteration in the management plan in 12 (80%) patients of group A patients, in contrast to routine WSCE that suggested changes in only 7 (46.7%) of patients.

Among the patients with poor general conditions examined in group B, IO was the most prevalent diagnosis in 6 (54.5%) (Fig. 4) patients which is concordant with a systematic review and meta-analysis that evaluated the diagnostic utility of CT for bowel obstruction and concluded that CT has considerable accuracy in the diagnosis of bowel obstruction, predicting surgical intervention, etiology, and transition point [12].

Moving to group C, where 10 patients with intestinal stomas due to malignant or inflammatory conditions were referred directly for MRI assessment with rectal gel administration. It was previously proposed in

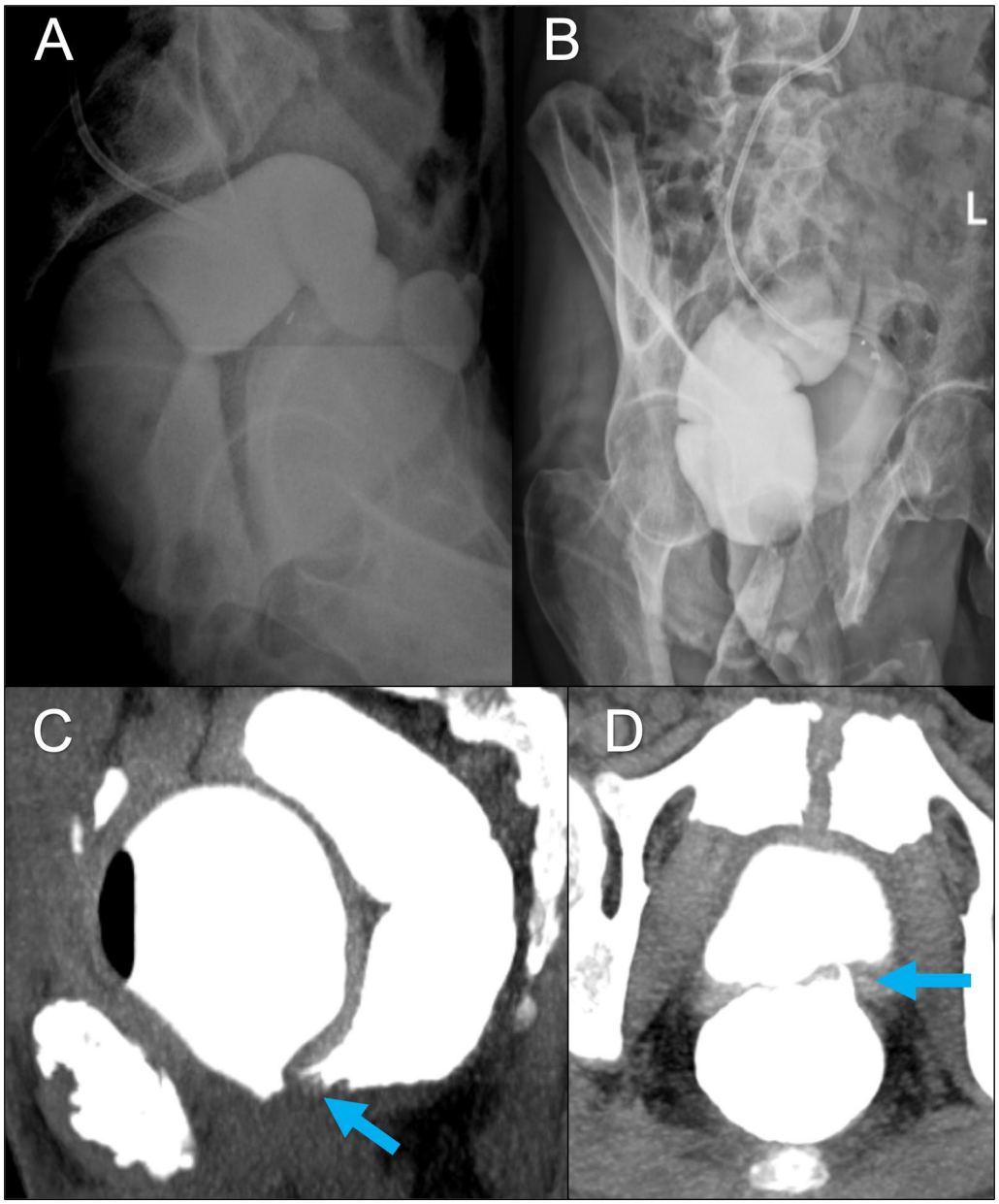

Fig. 2 66-year-old male patient with history of colon cancer, underwent surgical resection and colostomy and received radiotherapy, presented with recurrent attacks of UTI, referred for assessment of the distal loop pre-stomal reversal, WSCE was performed followed by complimentary CT study. **A** and **B** Lateral and left oblique views of water-soluble contrast enema under fluoroscopic guidance showed opacification of the urinary bladder during administration of the rectal contrast. **C** and **D** Axial and sagittal CT study of the pelvis with MIP reconstruction after administration of water-soluble contrast enema revealed the presence of small fistulous communication (blue arrows) between the left aspect of bladder base and the lower rectum. Based on the imaging findings, the surgical management plan was fistulectomy and postponing the stoma reversal

a recent study to administer 400 ml of 1% gadolinium contrast solution per rectum to diagnose early complications post stoma creation [6], yet we altered the technique and used ultrasound rectal gel instead since gel is more readily available especially that we were primarily investigating late postoperative complications among this group of patients.

MRI after administration of rectal gel allowed soft tissue characterization of the recurrence (Fig. 5) as well as

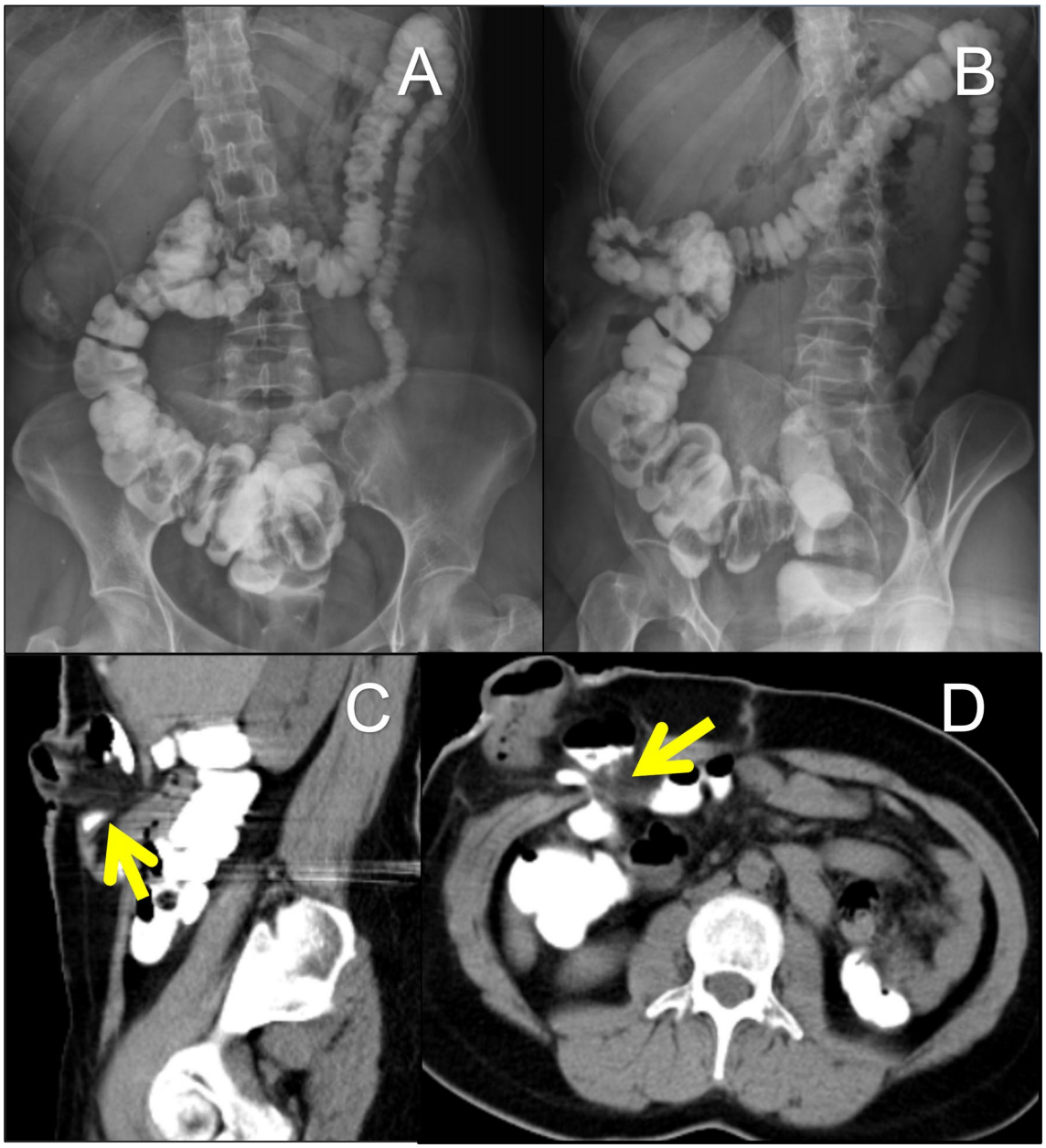

Fig. 3 38-year-old female patient with history of colon cancer underwent surgical resection and ileostomy, referred for assessment of the distal loop pre-stomal closure, WSCE was performed followed by complimentary CT study. **A** and **B** AP and left oblique view of water-soluble contrast enema under fluoroscopic guidance shows free flow of the administrated contrast material down to the anal canal with no stricture, leakage, or filling defects. **C** and **D** Sagittal and axial CT study of the abdomen after administration of water-soluble enema revealed the presence of parastomal hernia containing ileal and colonic loops, with mild diffuse mural thickening (yellow arrows). Accordingly, the surgical management was to repair the hernia and reverse the stoma on the same session

the presence of lymph nodes in 2 patients. In addition, DWI exhibited a restricted diffusion pattern within the bowel wall indicated the neoplastic nature of the bowel wall thickness rather than radiotherapy-induced colitis/stricture, our findings were in concordance with previous studies [13, 14] that suggested that standard MRI has a high accuracy for the diagnosis of locally recurrent rectal cancer, with the addition of DWI might help radiologists to suggest the presence of a recurrence more confidently.

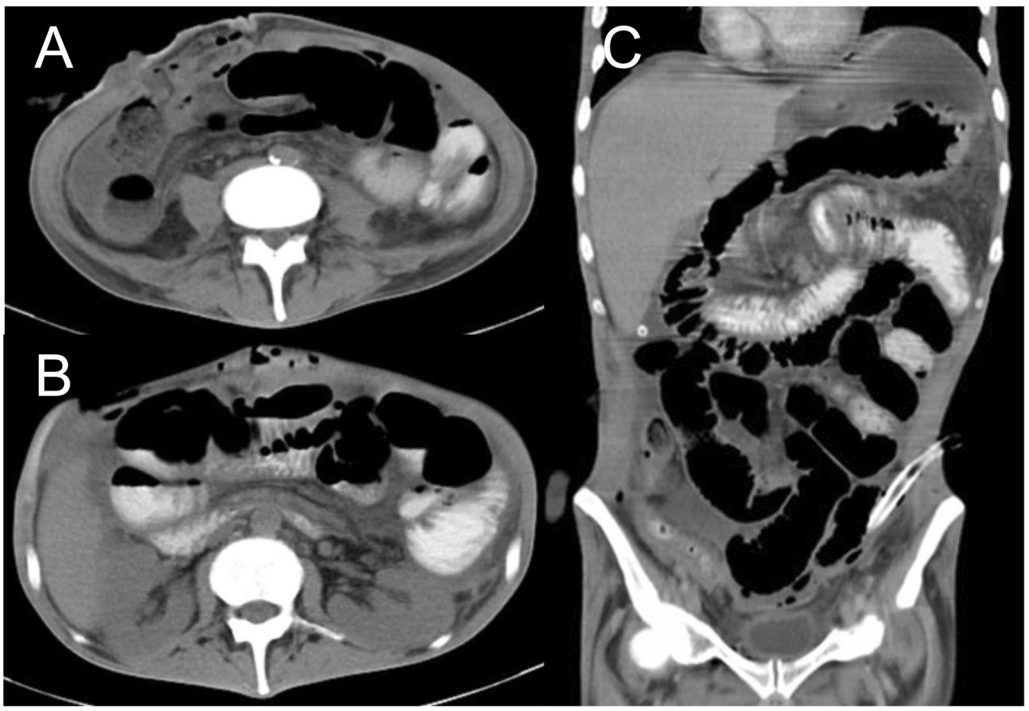

Fig. 4 37-year-old female patient with history of iatrogenic colonic injury during cesarian section and ileostomy was performed, few days later the patient presented to the emergency department with abdominal pain, absolute constipation and vomiting, she was referred directly for CT combined with water soluble contrast enema. **A** and **B** Axial CT images showed dilated small bowel loops showing multiple air-contrast levels suggestive of small bowel obstruction (IO) with no gross abnormalities at the stoma. **C** Coronal CT images confirmed the same findings. Accordingly, the surgical management plan was laparotomy to relieve the obstruction

Additionally, MRI allowed the detection of radiotherapy-related changes in 8 patients with a history of colorectal cancer who received radiotherapy (Fig. 6) such as fatty marrow conversion of pelvic bones and vertebrae, pelvic floor muscle changes, sacral plexus nerve root edema, abnormal fistulous communications, urological complications, e.g. ureteric stricture, in agreement with studies that suggested imaging post–radiation changes in pelvic neoplastic conditions [15, 16].

The initial surgical indication for more than half of the cases, 20 out of 36 (56%) patients with intestinal complications included in our cohort, was colorectal neoplasms suggesting a slight increase in prevalence of intestinal complications among colorectal cancer patients, yet comparison between both groups was not statistically significant, possibly due to the sample size.

Our study does have its limitations, there might have been some selection bias as we focused primarily on complicated cases, especially among patients in group B and C. A bigger sample size would likely reflect better on the evaluation of each independent type of complication by each modality. Only 10 patients with high clinical suspicion of complications, particularly colorectal cancers, were scheduled for MRI-enema. In addition to the fact, that temporal separation between stoma creation and investigation of complications prior reversal was not unified.

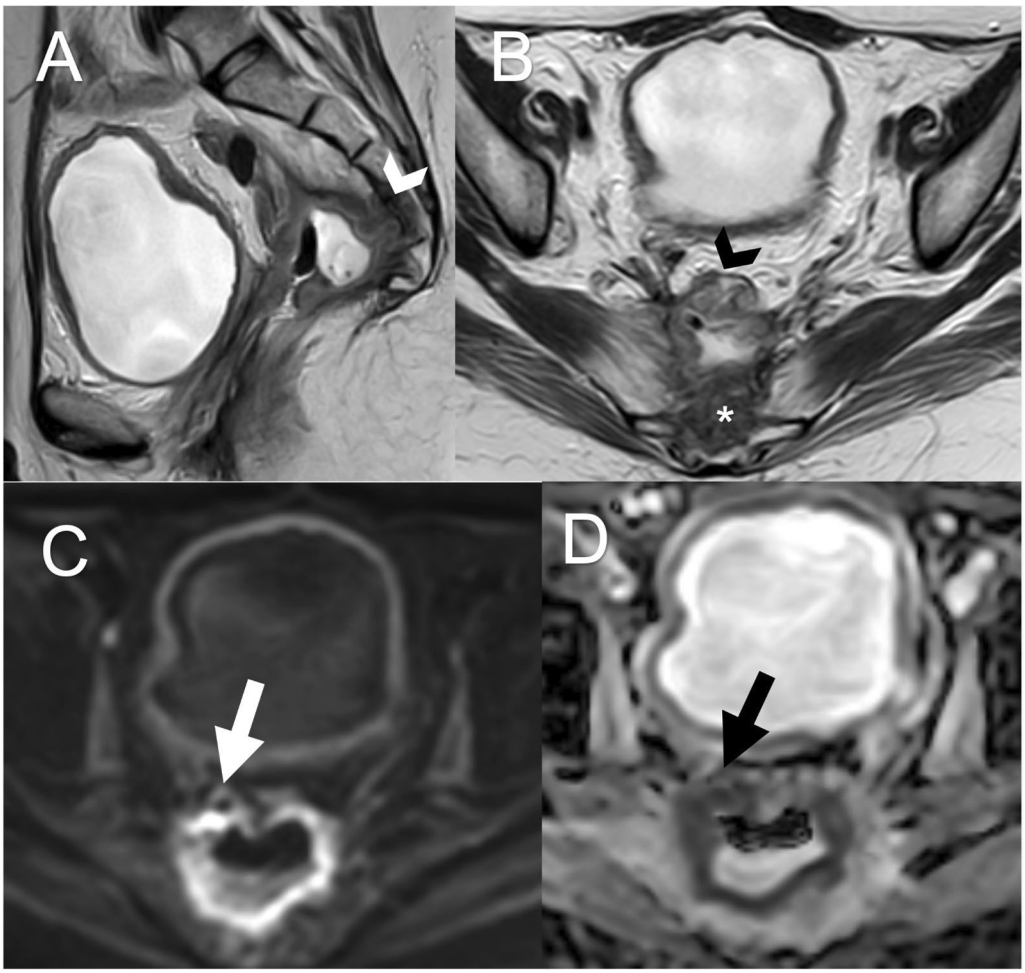

Fig. 5 47-year-old female patient with history of rectal cancer, underwent surgical resection and ileostomy, received chemo and radiotherapy, complained of bleeding per rectum and coccydynia, and was referred for assessment by MRI with administration of rectal gel. **A** Sagittal T2 weighted image revealed tumoral recurrence (white arrow head) mainly along the posterior wall of the rectum infiltrating the tip of the coccyx. **B** Axial T2 weighted images showed the recurrent tumour (black arrow head) infiltrating the coccyx (asterisk). **C** and **D** Axial DWIs and ADC map images show the same recurrent tumour as evidenced by marked diffusion restriction (white arrow) with corresponding low ADC value (black arrow)

Conclusions

In conclusion, CT-WSCE was found superior that WSCE alone in the detection of abnormal intestinal fistulous communications, intestinal obstruction, peri-colic collections, colorectal tumoral recurrences, and parastomal hernias, although some of these complications can be detected on routine WSCE, yet CT allows their detection and precise localization and might impact the surgical management plan. MRI-enema using rectal gel administration is a substitute technique without ionizing radiation that can serve as a reliable alternative in the detection of intestinal complications and can aid surgical decisions.

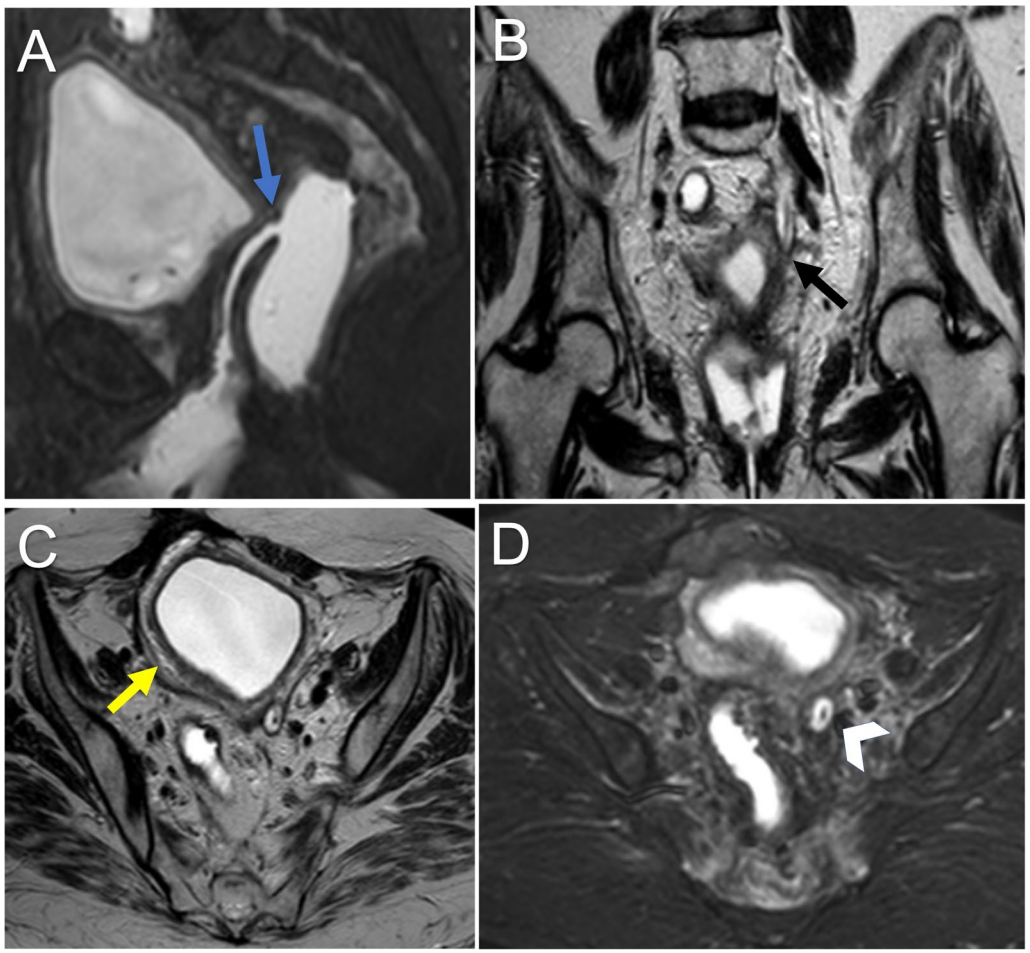

Fig. 6 61-year-old female patient with history of colon cancer, underwent surgical resection and ileostomy, received chemo and radiotherapy, complained of vaginal discharge, and was referred for assessment by MRI with administration of rectal gel. **A** Sagittal STIR weighted image revealed passage of the injected rectal gel to the hysterectomy stump with evidence of fistulous communication (white arrow) seen anteriorly at the mid rectum communicating with the posterior surface of the upper aspect of the hysterectomy stump. **B**, **C** and **D** Coronal T2, axial T2 and STIR weighted images show mild mural thickening and stricture of the left distal ureter (black arrow) and subsequent moderate hydroureter showing in situ double-J stent (arrowhead), mild vesical mural thickening (yellow arrow) and stranding of the peri-vesical fat planes also noted as well as pre-sacral soft tissue sheets (post radiation changes). Accordingly, the surgical management plan was fistulectomy and postponing the stoma reversal

Abbreviations

CT	Computed tomography
DWI	Diffusion weighted imaging
IO	Intestinal obstruction
IV	Intravenous
MRI	Magnetic resonance imaging
PH	Para-stomal hernia
WSCE	Water soluble contrast enema

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All authors have read and approved the manuscript. MFO, MA & MTM designed research. MA & NA performed research. MA & NA analyzed data. SM & MA wrote the paper.

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Availability of data and materials
All the datasets used and analysed during this study are available with the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study way approved by the research ethics committee of the Radiology department of the Faculty of medicine Cairo University on 20/6/2022, reference number (MS-154-2022). All patients included in this study gave a written informed consent to participate in the research. If the patient was less than 16 years old, or unconscious at the time of study, written informed consent was given by their parent or legal guardian.

Consent for publication
All patients included in this study gave a written informed consent to publish the data contained in this study. If the patient was less than 16 years old, or unconscious at the time of study, written informed consent was given by their parent or legal guardian.

Competing interests
The authors declare that they have no competing interests.

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