Original Article

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Radiology Section

Role of CT Colonography in Colonic Lesions and Its Correlation with Conventional Colonoscopic Findings

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ABSTRACT

Background: Preoperative evaluation in patients with colorectal carcinoma is essential for a correct therapeutic plan. Conventional colonoscopy has certain limitations including its inability to detect synchronous lesions in case of distal obstructive mass and inaccurate tumour localization. CT colonography combines cross sectional imaging with virtual colonoscopic images and offers a comprehensive preoperative evaluation in patients with colorectal carcinoma including detection of synchronous lesions with accurate segmental localization and loco regional staging.

Aim: The objective was to determine the role of CT colonography in various colonic lesions and to correlate the findings with conventional colonoscopy and histopathological findings.

Settings and Design: This prospective study included 50 patients with clinical symptoms suspicious of colonic pathology.

Materials and Methods: All the patients underwent both CT colonography and conventional colonoscopy on the same day. CT colonography was performed in supine and prone position. Considering histopathological and/or surgical findings as gold standard, sensitivity and specificity of both the modalities were calculated.

Results: Conventional colonoscopy missed two synchronous lesions proximal to occlusive mass and one lesion proximal to the anastomotic site; all were detected with CT colonography. One carpet lesion in rectum and one case of mild ulcerative colitis were missed by CT colonography. Sensitivity and specificity for detection of colorectal cancer were 97.56% and 100%, resp. with PPV and NPV of 100% and 93.75%, for CT colonography and 92.68% and 100%, respectively with PPV and NPV of 100% and 83.3% for conventional colonoscopy. Sensitivity for correct detection of acute and chronic ulcerative colitis of CT colonography was 66.6 % and 100 %, resp.

Conclusion: CT colonography has higher sensitivity than conventional colonoscopy for detection of colorectal carcinoma, including its ability to detect abnormalities proximal to obstructing lesion, accurate segmental localization of lesions and staging. However, some limitations of CT colonography were difficulty in detection of flat lesions and lack of information about hyperemia and superficial mucosal erosion, where conventional colonoscopy scored over CT colonography.

Keywords: Colorectal Carcinoma, Ulcerative colitis, Virtual colonoscopy

INTRODUCTION

Colonic pathology encompasses a wide range of lesions from inflammatory changes to frank malignancy, with colon cancer being a leading cause of death worldwide. For many years, conventional colonoscopy has constituted the sole available diagnostic examination for the colon. The information gained by this modality is restricted to the lumen only. It does not allow the evaluation of the liver and other organs outside the colon. Although standard colonoscopy is a total colonoscopic examination, it fails to demonstrate the entire colon in 5-15% of cases [1]. Furthermore there is risk of perforation in a few but finite number of cases. The introduction of computed tomography (CT) made it possible to assess not only colonic wall but also extra colonic pathology. However, conventional CT with cross sectional images is insufficient to detect small mucosal polyps and small cancers.

In search of a rapid, non-invasive, accurate and well-tolerated tool for complete evaluation of colorectal pathology, computed tomography (CT) colonography or "virtual colonoscopy" [2] has evolved quickly. This technique was first introduced by Vining et al., [3] as a single investigation combining the advantages of endoscopy with cross sectional, thus allowing intraluminal and transmural evaluation of the colon, along with detection of any extra colonic pathology. CT colonography uses volumetric CT data combined with advanced imaging software to create two-dimensional and three-dimensional images of colon. Thin section axial images are acquired, from which MPRs and 3-D display modes including endoluminal viewing images are obtained. 3-D endoluminal images simulate the endoluminal perspective of colonoscope, and thus CT colonography is also termed as virtual colonoscopy. The two dimensional images are complementary, and in combination give excellent detail about colon [3].

Over the years CT colonography has emerged not only as a potential screening technique for detection of small polyps and early cancer but also as total colonic examination technique in symptomatic patients suspected of harboring colonic pathology. It has important role in detection and staging of colorectal malignancy.

AIM

This prospective study aimed to detect and characterize colonic lesions using CT colonography in patients suspicious of colonic lesions and to correlate these findings with conventional colonoscopy and histopathology.

MATERIALS AND METHODS

The ethical committee of our institute approved this prospective study. Informed consent was taken from all patients undergoing this study. We prospectively studied 50 patients over a period starting from October 2012 to November 2014 at SGRD Medical College, Amritsar, India. All the patients underwent CT colonography and conventional colonoscopy on the same day. The findings of CT colonography and conventional colonoscopy were blinded to prevent bias. The histopathological and/or surgical finding of these patients was also recorded. Considering these findings as gold standard, CT colonography and conventional colonoscopic findings were correlated with them.

Patient preparation

Patient preparation was the same for CT colonography and conventional colonoscopy. All patients were instructed to have liquid diet and drink more liquids one day prior to the examination. Commercially available cathartic solution, PEG (poly ethylene glycol), 236 grams with 4L of water was consumed orally over 4 h, starting 12 h prior to examination. After the oral lavage was consumed, 10 mg of Bisacodyl was consumed to reduce residual faecal material and retained fluid.

Procedure of CT colonography

One ml (20 mg) of buscopan was administered intravenously, just before CT colonography to reduce bowel peristalsis and colonic spasm. A small rubber catheter was inserted in left lateral position after lubricating with 2% lignocaine gel. Air was insufflated using a pneumatic bulb with an average of 30-40 bulb compressions. CT examination was performed by using Siemens Somatom Emotion 6. The scanning parameters were 120 mAs, 130 kVp, 6x2.0 mm collimation, 0.6 sec gantry rotation time, 6mm slice thickness and 2.5 mm reconstruction interval. A standard CT scout image was obtained in supine position, which will allow rapid assessment of colonic distension. When colonic distension was found to be inadequate, further air insufflations were given to maximum patient tolerance. Plain CT images were obtained from diaphragm to pubic symphysis in supine position. After scanning in the supine position, patients were repositioned in prone position and post contrast images after 80 mL of iv contrast were obtained.

Image analysis

The 2-D axial images were interpreted first with a point to point comparison between supine and prone images. This was followed by review of the coronal and sagittal MPRs with linking of source supine and prone images. Finally, the 3-D endoluminal images were reviewed in the interactive (fly through) mode. Endoscopic viewing was obtained in both antegrade and retrograde direction using both supine and prone source images. Areas of interest were recorded and compared with 2-D axial and MPR images. The presence, number, location, size and morphologic features of lesions were assessed. The size of the lesions was measured on both axial images and MPRs. Colonic distension was assessed in all the six colonic segments in both supine and prone positions. Extracolonic findings if any were also recorded.

RESULTS

A total of 50 patients with clinical suspicion of colonic pathology were included in the study. CT colonography and conventional colonoscopy was performed in all the patients. Visualization of the entire colon was possible in all the patients with CT colonography and only in 31 patients (62%) with entire colon visualization with conventional colonoscopy.Hence, it was seen that CT colonography is a better modality than conventional colonoscopy to visualize entire colon, even in presence of occlusive lesions.($p<0.001$, chi-square value = 23.457, DF=1). A total of 56 lesions were detected in 50 patients. Distribution of the lesions on the basis of histopathological findings is shown in [Table/Fig-1].

Lesion	Total number of lesion detected= 56 (in 50 patients)	Percentage
Adenocarcinoma	41	73.2
Ulcerative colitis	7	12.5
Tubercular colitis	3	5.3
Colonic polyposis	4	7.1
Lipoma	1	1.7

[Table/Fig-1]: Distribution of lesions on the basis of histopathological findings

A total of 37 patients were detected for adenocarcinoma. In two patients, apart from the 'index' lesion, two more neoplastic lesions (synchronous carcinomas) were found, i.e., three lesions each in two patients. Hence, making a total of 41 lesions in 37 patients diagnosed for adenocarcinoma. Two cases had both adenocarcinoma as well as colonic polyposis; hence it has been counted in both the categories.

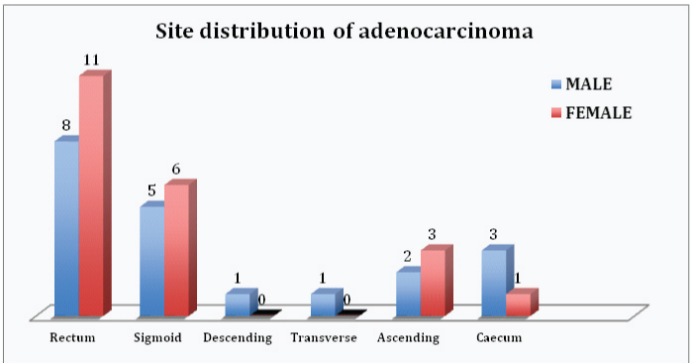
Incidentally, the study group consisted of 25 males and 25 females. The youngest patient was 10 y and oldest was 75 y.The largest number of patients was in the age group of 61-70 y (20%). P-value between age and sex distribution was 0.132 (not significant).

Most common presentation of the patients was altered bowel habits (66%) followed by bleeding per rectum/ stool mixed with blood (46%), pain abdomen (38%) and weight loss (22%). Most common site of involvement of adenocarcinoma was rectum (n=19) followed by sigmoid colon (n=11) as shown in [Table/Fig-2].

All the lesions were correctly localized with CT colonography. However, on conventional colonoscopy, all eight rectosigmoid adenocarcinomas were reported as rectal lesions because colonoscope could not be passed beyond the distal extent of the occlusive mass. Also, on conventional colonoscopy, one transverse colon lesion was reported to be in splenic flexure; and one ascending colon lesion was localized in transverse colon. Out of 41 adenocarcinomas, Conventional colonoscopy detected 38 lesions; two proximal synchronous lesions were missed because colonoscope could not be passed beyond distal occlusive mass and one lesion proximal to the anastomotic site was also missed, as colonoscope could not reach up to the lesion due to tortuous and abnormal anatomy of the colon. All these lesions were detected with CT colonography [Table/Fig-3a-g].

Forty lesions including four proximal synchronous lesions were detected by CT colonography. One carpet/flat lesion in the rectum was missed by CT colonography, which was detected later on conventional colonoscopy (confirmed on surgical correlation). When CT colonography was reviewed retrospectively, it was found that the carpet lesion was missed as the residual fluid in rectum masked it. Sensitivity and specificity of CT colonography in detecting lesion was 97.56% and 100%, respectively. PPV and NPV was 100% and 93.75%. Sensitivity and specificity of conventional colonoscopy in detecting lesion was 92.68% and 100%, respectively. PPV and NPV was 100% and 83.3%. P-value of difference between sensitivity and specificity of CT colonography and conventional colonoscopy was 0.305 (not significant). CT colonographic findings in patients with colonic adenocarcinoma are shown in [Table/Fig-4].

Sensitivity and specificity of CT colonography for correct 'T' staging was 100% and 86.66% with PPV and NPV of 77.77% and 100%, resp. Diagnostic accuracy was 91%.Surgical correlation was available for 22 lesions. Of 15 lesions that were assigned as T2 histopathological stage, 14 were correctly staged at CTC and one was overstaged as T3 due to pericolonic stranding, which on histopathological analysis turned out to be due to fibrosis.Of 7 lesions assigned as T3, 6 were correctly staged at CTC, and one



[Table/Fig-2]: Site distribution of adenocarcinoma(total number of adenocarcinoma patients= 41)

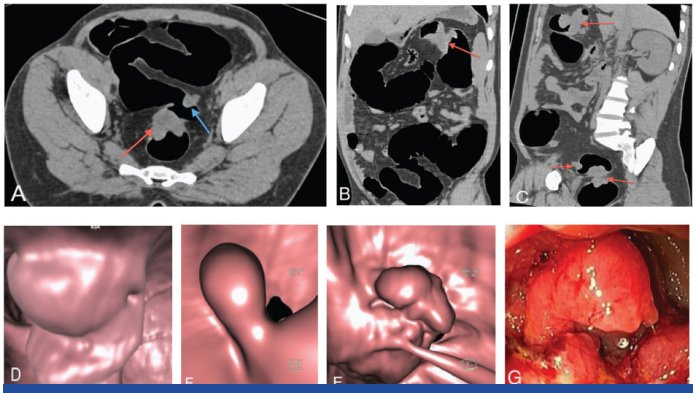
was overstaged as T4 due to loss of fat plane but per-operative there was no invasion of adjacent organ. Sensitivity and specificity for correct 'N' staging was 100% and 66.67%. PPV and NPV were 88.89% and 100%, resp. Diagnostic accuracy was 90.9%. On CT colonography, malignant lymph nodes were reported with 18 lesions. However, histopathology revealed only 16 lesions to be associated with malignant lymph nodes. Malignant lymph nodes reported with two lesions were found to be reactive.

There were 7 cases of ulcerative colitis – 3 acute and 4 chronic. CT colonographic findings in ulcerative colitis are described in table. Most common segment involved in both acute and chronic UC was rectum. Most common CT colonographic abnormality detected was diffuse mural thickening with mean wall thickness of 8 mm. In chronic ulcerative colitis, findings in addition to mural thickening were loss of haustrations and granular mucosa. Granularity of mucosa was best appreciated on endoluminal images [Table/Fig-5a-f].

One patient of acute UC was missed on CT colonography. Sensitivity for detecting acute and chronic ulcerative colitis of CT colonography is 66.6% and 100%, respectively. CT colonographic findings and characterization of various lesions in colonic polyposis is described in [Table/Fig-6,7a-g].

There were 3 cases of tubercular colitis. All the patients were found to have involvement of caecum (100%). Terminal ileum and ascending colon were involved in 2 patients (66.6%). Mean mural thickness was 9 mm. Pericolonic stranding; mesenteric lymphadenopathy and luminal narrowing were seen in all the patients.

Colonic lipoma was seen in one female patient aged 50 years, who presented with the complaints of altered bowel habits. CT colonography revealed a well-defined smooth surfaced sessile polypoidal mass with broad base arising from the left lateral wall of sigmoid colon showing fat attenuation with maximum diameter of 3.7 cms. Conventional colonoscopy confirmed the findings. Surgical resection was done later and histopathology findings were consistent with the diagnosis of lipoma [Table/Fig-8a-e].



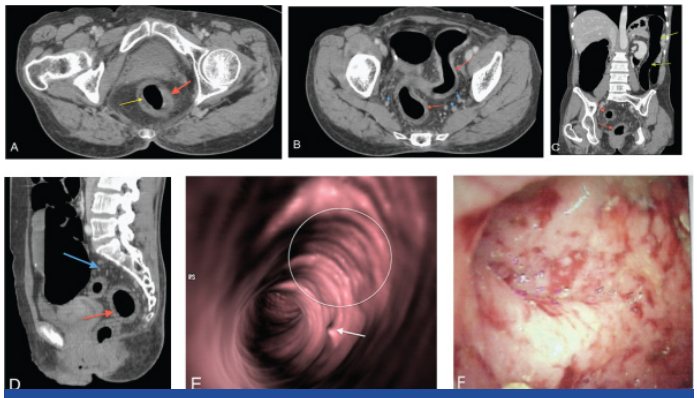
[Table/Fig-3a-g]: Synchronous carcinoma
(A) CT colonographic images (performed after incomplete conventional colonoscopy) shows two synchronous polypoidal lesions in recto-sigmoid region. The sessile polyp in the sigmoid colon shows pericolonic nodular stranding (blue arrow) (B) Another lobulated polypoidal lesion (third synchronous lesion) causing luminal narrowing was seen at the splenic flexure (C) Oblique saggital reconstructed CT image shows all the three polypoidal lesions; two in rectosigmoid region and one at splenic flexure. Endoluminal fly through images (D,E,F) shows the polypoidal lesion in rectum, sigmoid colon and splenic flexure, respectively. Conventional colonoscopic image (G) shows the constricting lobulated mass in the rectum

Findings	2-D Axial & MPRs	Endoluminal View (fly through mode)
Annular	22	
-Constricting mass		18
-Markedly thickened and nodular folds		4
Semiannular	4	
Mural thickening	26	
-Asymmetrical	22	
-Symmetrical	4	
Maximum mural thickness		
11-20 mm	19	
21-30 mm	5	
> 30 mm	2	
Abrupt transition/ shouldering	23	
Polypoidal mass	14	14
< 5 cms	6	
5 – 10 cms	8	
Enhancement	40	
-Homogenous	12	
-Heterogeneous	28	
Pericolonic/ rectal fat		
-Stranding	17	
-Lost	5	
-Normal	18	

[Table/Fig-4]: CT colonographic findings in patients with colonic adenocarcinoma

DISCUSSION

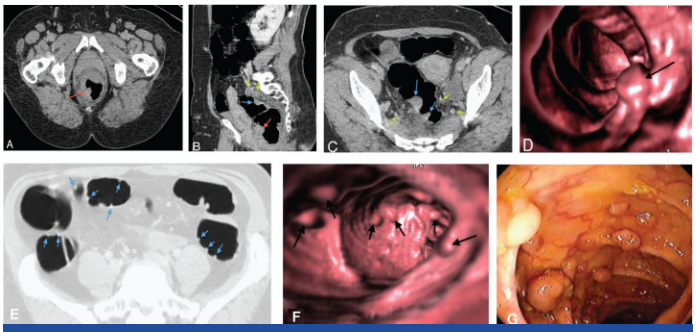
CT colonography was able to detect all the synchronous lesions proximal to distal occlusive mass. In case of incomplete colonoscopy due to some impassable obstructing mass, colonoscopic detection of synchronous lesions may be precluded.Therefore, evaluation of proximal colon and synchronous lesion, if any, is of paramount importance prior to surgical management of the patient. Total colonic examination even in patients with occlusive masses, is a major advantage of CT colonography [4-7]. In studies conducted by Rockey DC et al., [8] and Pickhardt PJ et al., [9], it was concluded that CTC represents a valuable tool to evaluate the proximal colon after incomplete colonoscopy. One flat lesion in rectum was missed on CT colonography in a patient who presented with bleeding per rectum as the residual fluid in rectum masked it. In a meta-analysis by Pickhardt et al., [9], most cancers missed at CT colonography were located in the rectosigmoid colon. The relative increase in missed rectosigmoid cancers at CT colonography may relate to challenges with luminal distention. Yucel C et al., [10] described some inherent limitations of CTC. Flat lesions may be more difficult to detect with CTC because the conspicuity of flat lesions on 3D endoluminal imaging is diminished; varying soft-tissue window settings and using fecal tagging may help to improve detection. The results for sensitivity and specificity of CT colonography and conventional colonoscopy in our study were in accordance with previous studies conducted by Pickhardt et al., [9] with sensitivity of CT colonography and conventional colonoscopy for colorectal cancer to be 96.1% and 94.7%, resp. Halligan S et al., [11] found sensitivity 95.9% of CT colonography in detection of colorectal



[Table/Fig-5a-f]: Chronic ulcerative colitis
Axial CT images (A,B) shows diffuse symmetrical circumferential wall thickening of rectum and sigmoid colon with loss of haustrations (red arrow). Hypodense rim was observed in the middle of the thickened wall giving "target sign" appearance indicating submucosal fat deposition (yellow arrow). Multiple subcentemetric regional lymph nodes were seen. (blue arrows).
Reconstructed coronal CT image (C) shows reduced distensibility with loss of haustral folds of the descending colon (green arrows)
Reconstructed saggital CT image (D) shows increased presacral space due to fat deposition (blue arrow). Circumferential mural thickening of rectum and sigmoid colon were also observed (red arrow). Endoluminal fly through images (E) show granular mucosa (circle) with a small pseudopolyp. (white arrow) Conventional colonoscopy images (F) show multiple mucosal erosions and superficial ulcerations

	Case 1	Case 2	Case 3	Case 4
Age of patient	10	40	21	25
Family history (first degree relative)	Negative	Present	Present	Negative
Number	10 polyps	Multiple polyps, 1 mass	22 polyps	2 polyps
Site	Rectum (8), sigmoid colon(2)	Whole colon (from rectum to caecum)	Rectum (10), sigmoid colon (6), descending colon (6)	Descending colon
Morphology	Smooth sessile polyps	Smooth sessile polyps	Sessile and pedunculated polyps with irregular surface; Broad based sessile mass with irregular frondlike appearance	Pedunculated polyps with long stalk
Average size	7 mm	< 5 mm	Polyps -15 mm, mass -55 mm	12 mm
CT colonography diagnosis	Benign polyps	Malignant mass with multiple polyps	Malignant mass and suspicious looking polyps	Benign polyps
Conventional colonoscopy findings	Multiple small sessile polyps	Ulceroproliferative growth rectum with multiple polyps in whole colon	Polypoidal mass rectum with multiple sessile and pedunculated irregular polyps	Pedunculated polyps with long stalk
Histopathological diagnosis	Hamartomatous polyps	Polyps-tubular adenomas, Mass-adenocarcinoma	Mass – villous adenoma, Polyps- Tubulovillous adenomas	Hamartomatous polyps
Final diagnosis	Juvenile polyposis	Familial adenomatous polyposis	Vilous adenoma with multiple tubulovillous adenomatous polyps	Hamartomatous polyps

[Table/Fig-6]: CT colonographic findings and characterization of various lesions in colonic polyposis



[Table/Fig-7a-g]: Familial adenomatous polyposis
Axial and reconstructed sagittal CT images (A, B) shows irregular thickening of the anterior and right lateral walls of the rectum (red arrows) with multiple enlarged regional lymph nodes (green arrows). On HPR, this turned out to be moderately differentiated adenocarcinoma.
(B,C) shows multiple broad based sessile polyps with smooth surface in rectosigmoid region (shown by blue arrow). Endoluminal fly through view (D) depicts a smooth surfaced sessile polyp (black arrow) of sigmoid colon.
Numerous small sessile polyps (blue arrows) were seen in the entire large bowel (E). On endoluminal fly through views (F) these small sessile polyps (black arrows) were better demonstrated. Conventional colonoscopy image (G) showed similar findings

carcinoma. A comparative study by Neri et al., [12] has shown that CT colonography is superior to conventional colonoscopy in the identification of colonic masses, the completeness of colonic evaluation, and the precise definition of the segmental location of the carcinoma.

Though both supine and prone CT axial scans could detect all the lesions, morphology of 8 lesions was better demonstrated on prone scans which was mainly be due to redistribution of residual fluid and better distensibility. Chen et al., [13] in their study emphasized that as fluid and retained feces could be expected be change their position, non dependent surface could be assessed without interference by retained material and concluded that use of both the supine and prone positions for patients undergoing CT colonography improves evaluation of the colon and increases sensitivity.

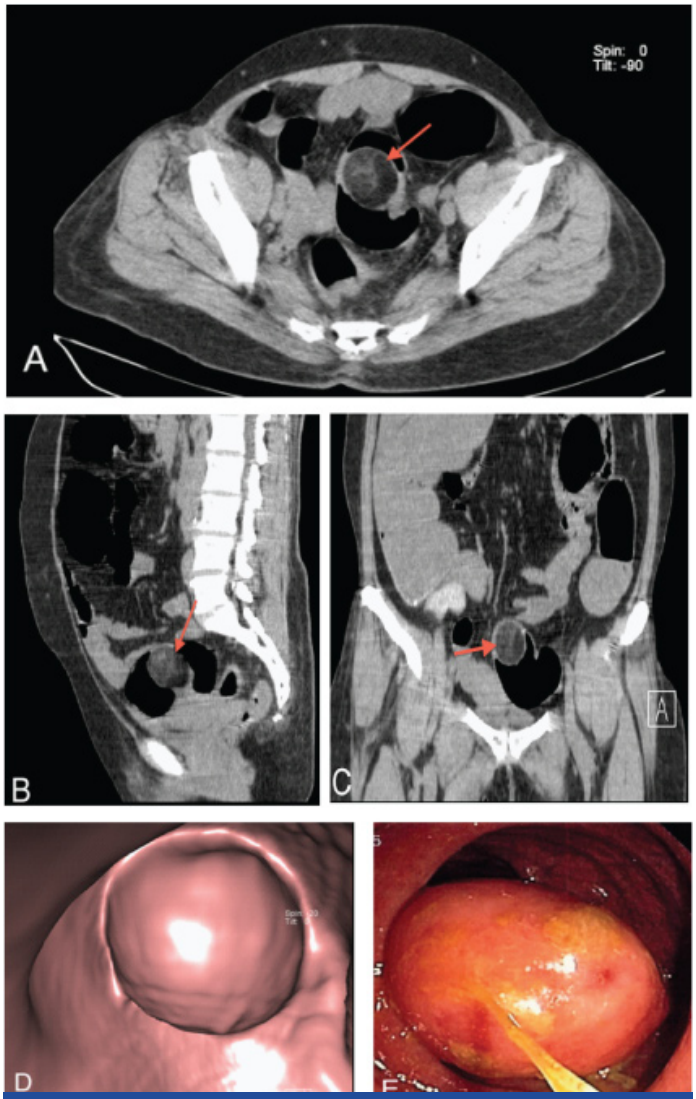
Site distribution of adenocarcinoma lesions was in accordance with the studies conducted by Chung et al., [14] and Filippone et al., [15] with maximum number of lesions in rectum followed by sigmoid colon. All these lesions were correctly localized by CT colonography. However, precise localization of the tumour with conventional colonoscopy can be challenging as anatomical landmarks may not be readily apparent at conventional colonoscopy and often only the distance from the anal verge is recorded. Previous studies showed that colonoscopy has a suboptimal accuracy in locating the tumour [16].

Yucel C et al., [10] stated that even when conventional colonoscopy is performed by experienced endoscopists, approximately 6–26% of colonoscopic examinations are incomplete and fail to reach the level of the cecum. In elderly patients, the rate of incomplete colonoscopies has been reported to be as high as 22–33%. Higher percentage of incomplete conventional colonoscopy in our study may be due to the patient presenting at an advanced stage of disease.

The potential of CT colonography in patients with colorectal cancer is appealing since it combines local and distant staging of disease with detection of synchronous colonic lesions. It may replace conventional colonoscopy, particularly where histological proof of malignancy has been obtained by previous incomplete endoscopic examinations. In a recent study by Sali L et al., [17], it was concluded that CT colonography is a reliable technique to delineate the precise segmental location of colorectal carcinoma, to establish the presence of synchronous cancers and polyps greater than 10 mm, and to perform a fairly accurate tumour staging.

One case of ulcerative colitis having superficial mucosal erosions was missed on CT colonography in our study. Gore et al., [18] stated that the presence of active ulceration did not significantly alter the CT colonographic appearance of the colon wall. Changes of the bowel wall itself are difficult to observe unless inflammatory reactions lead to thickening of the intestinal wall or involve adjacent structures like the mesenteric fat or vessels [19].

The sensitivity for correct detection of acute and chronic ulcerative colitis by CT colonography in our study were in close approximation with the study conducted by Anderson et al., [20] who reported a sensitivity of 63.6%, and 100%, respectively. Conventional colonoscopy is more sensitive than CT colonography in detecting early mucosal erosions. One advantage of CT colonography is to delineate extracolonic findings associated with IBD. The potential indication to study with CT colonography in patients with IBD is the detection of polyps and masses, since it is well known that IBD carries an increased risk of colorectal cancer [20]. Laghi A et al., [21] stated in their study the current indications of CT colonography which included the evaluation of patients who had undergone a previous incomplete conventional colonoscopy or those who are unfit for conventional colonoscopy (elderly and frail individuals, severe comorbidity, or with contraindication to sedation).



[Table/Fig-8a-e]: LIPOMA
Axial (A), reconstructed Coronal and Saggital CT images (B,C) shows a well defined broad based smooth surfaced sessile polyp arising from left lateral wall of sigmoid colon; showing CT attenuation number of -30 to -50 HU(fat attenuation). Virtual and conventional colonoscopy images (D,E) shows a large smooth sessile polyp. Histopathological analysis showed the polyp to be lipoma

LIMITATIONS

Some limitations of CT colonography in our study conducted were difficulty in detection of flat lesions and lack of information about hyperemia and superficial mucosal erosion, where conventional colonoscopy scored over CT colonography.

CONCLUSION

CT colonography is a rapid and accurate noninvasive modality for total colonic examination. It does not require any prior sedation and is relatively better tolerated as compared to conventional colonoscopy.

From the study conducted, we conclude that CT colonography has higher sensitivity than conventional colonoscopy for detection of colorectal carcinoma, including the ability of CT colonography to detect abnormalities proximal to obstructing lesion, accurate segmental localization of abnormalities within the colon, and fairly accurate pre-operative tumour staging.

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