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Computed Tomography colonography in suspected colorectal lesions and its correlation with Optical Colonoscopy.

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Abstract
Introduction: *Colorectal cancers is a common malignancy and early detection and treatment of polyps before they become malignant, as well as early detection of malignant tumors has significantly made the prognosis better. Optical Colonoscopy has been the standard test for evaluation of the colon, but the information is restricted to the lumen only. However Computed Tomography Colonography with Virtual colonoscopy acts as a single investigation combining the advantages of endoscopy with cross sectional imaging, thus allowing intraluminal, transmural and also extra colonic abdominal and pelvic organs. We prospectively compared Computed Tomography Colonography with Optical Colonoscopy for the detection of colorectal lesions*
Aim and Objectives: *To determine the sensitivity of Computed Tomography Colonography with that of Optical Colonoscopy in the detection of Colorectal lesions (polyps and cancers). 2. To compare and correlate the imaging findings of Computed Tomography Colonography with that of Optical Colonoscopy in detection of colorectal malignant mass lesion taking histopathological report as the gold standard.*
Materials and methods: *This study is a Cross sectional study conducted after obtaining approval from the ethics board committee of the institute and informed written consent from the patients. 58 adult Patients with suspected colorectal lesion underwent CT colonography and Optical colonoscopy during a period of 2 years. CT colonography, Optical colonoscopy and HPE findings were interpreted keeping each investigator blinded from each other of their findings. Data analysis was done with SPSS version 21.*
Results *The sensitivity and specificity to detect polyp by CT Colongraphy are 96% and 87.9%. and by Optical Colonoscopy are of 100% (for all completed examination). Correlation for polyp detection by CT Colonography and Optical Colonoscopy was found to be significant at p<0.5. The sensitivity and specificity for detection of colorectal adenocarcinoma by CT Colonography are 100% and 97.6% and by Optical colonoscopy were of 93.8% and 97.6%. Extracolonic findings were seen in 22 patients (37.9%). Optical Colonoscopic examination was incomplete in 4 patients and CT Colonography had all complete examination in all the patients.*
Conclusion *CT Colonography is a promising imaging modality in the detection of colorectal lesions with high sensitivity and specificity for polyps and cancer detection along with the added advantage of complete colonic examination and ability to see extraluminal or extracolonic findings compared to the Optical colonoscopy. Sensitivity and specificity for lesion detection can be further increased if CT Colonography is combined with Optical Colonoscopy and will be helpful in better, early and accurate detection of lesion and also better management by reducing false positive and false negative cases .*

Keywords: *Computed tomography colonography, Multiplanar imaging, Optical colonoscopy, Virtual colonoscopy, Polyps, HPE (Histopathological examination)*

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I. Introduction

Colonic pathology encompasses a wide range of lesions from inflammatory changes to frank malignancy, with colon cancer being the leading cause of death worldwide. Colorectal cancers is a common malignancy associated with significant morbidity and mortality. Colorectal cancer (CRC) is a formidable health problem worldwide. It is the third most common cancer in men (663000 cases, 10.0% of all cancer cases) and the second most common in women (571000 cases, 9.4% of all cancer cases) [1]. The 5-year survival rate for patients with colorectal cancer is presently reported to be 83–90% if the disease is confined to the bowel wall and less than 10% if there are distant metastases; thus, early detection and treatment are critical. . Bowel cancers

are not rare as previously believed and that routine screening for bowel cancer in all the risk patients should be carried out regularly so as to detect cancer early.[2]

Apart from major advances in treatment, the two key reasons contributing to this decline in death rates from colorectal cancer are early detection and treatment of polyps before they have become malignant, as well as detection of malignant tumors at earlier stages, which has a significantly better prognosis compared to later stages. Most clinically significant polyps are adenomas. By definition, adenomas contain dysplasia i.e. intra-epithelial neoplasia. Colorectal cancer (CRC) represents extension of this neoplasia beyond the muscularis mucosa into the submucosa. Perhaps two-thirds of CRC originates via an adenomatous precursor (the adenoma carcinoma sequence). Detection of polyps is therefore clinically important, particularly as their removal substantially reduces subsequent risk of malignancy.

The principle of colorectal cancer screening is based on the fact that most colorectal adenocarcinomas develop from pre-existing adenomas *via* numerous molecular and genetic steps, the adenoma-to-carcinoma sequence theory. Fortunately, it is estimated that there is a long time interval of 10 to 15 years for the development of colorectal carcinoma from normal colon and almost 5 years for the development of adenoma from normal colon. Hence, by diagnosing and removing the polyps before they become malignant, it may be possible to potentially prevent invasive colorectal cancers.

Numerous methods such as fecal occult blood testing (FOBT), double contrast barium enema (DCBE), flexible sigmoidoscopy (FS) and Optical Colonoscopy (OC) have been used with varying efficacy for the screening and evaluation of colorectal lesions so as to facilitate treatment at the earliest. Apart from Optical Colonoscopy (OC) other investigations have relatively low sensitivity and specificity in detecting colorectal pathology. So, Optical Colonoscopy has been the standard test for evaluation of the colon, with an excellent sensitivity and specificity for diagnosis of colorectal cancer and polyps. However, it is an invasive test and carries the risk of significant complications, such as perforation. Apart from its invasive nature, other issues such as cost, availability and also skill dependency and patients' experience led to the introduction and development of diagnostic imaging methods for evaluating the colon and rectum. 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. Furthermore there is risk of perforation in a few but finite number of cases.[3] Improving CRC screening compliance and the limited use and declining volume of Barium enema necessitated a more robust imaging technique for colorectal cancer evaluation.[4]

Computed Tomographic Colonography (CTC) was first introduced by Vining in 1994 as an alternative imaging method for evaluation of the colon. In this technique, helical computed tomography (CT) data is used to produce three dimensional images and hence simulates a virtual endoluminal view; hence, also called virtual colonoscopy. 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. The two dimensional images are complementary, and in combination give excellent detail about colon. High sensitivity rates for colorectal cancer can be obtained by this method.

Virtual colonoscopy acts as a single investigation combining the advantages of endoscopy with cross sectional imaging, thus allowing intraluminal and transmural evaluation of the colon, permits evaluation of the colon proximal to the obstructive lesions, and also of extra colonic abdominal and pelvic organs minimal invasiveness, no sedation and with a low risk of procedure related complications. Preliminary studies also show that patients prefer Virtual Colonoscopy (VC) to both double-contrast barium enema and Optical Colonoscopy (OC). This underlines the excellent potential of CT colonoscopy as a screening tool for colorectal cancer on a universal basis.[5] With this background knowledge, we prospectively compared Computed Tomography Colonography (CTC) with Optical Colonoscopy (OC) for the detection of colorectal lesions mainly polyps, cancer and others.

II. Aims And Objects:

1. To determine the sensitivity of Computed Tomography Colonography with that of Optical Colonoscopy in the detection of Colorectal lesions (polyps and cancers).
2. To compare and correlate the imaging findings of Computed Tomography Colonography with that of Optical Colonoscopy in detection of colorectal malignant mass lesion taking histopathological report as the gold standard.

III. Materials And Methods

This Cross sectional study was carried out in the Department of Radiodiagnosis, Regional Institute of Medical Sciences, Imphal in collaboration with the Department of Surgery, RIMS, Imphal.

The study commenced from October 2015 to September 2017, for a period of two years. A total of fifty-eight (58**)** adult patients referred from Department of Surgery with suspected colorectal lesions and fulfilling the inclusion criterias were enrolled in the study.

1. Inclusion criteria

1) Patients of 18 year or above referred from Department of Surgery with the history of familial adenomatous polyposis or hereditary nonpolyposis cancer syndromes, family history of colorectal carcinoma, past history of colorectal polyps, follow-up of an abnormal screening test result (i.e. positive guaiac-based stool test, barium enema examination, or sigmoidoscopy result) performed, evaluation for hematochezia, change in bowel habits, mass in right iliac fossa, abnormal weight loss, abdominal pain, and iron deficiency anemia.
2) Patients of 18 year or above presenting with suspected colorectal lesion and who have had an incomplete Optical Colonoscopy earlier either due to obstructive mass or due to non compliance.

2. Exclusion criteria:

1) Patients below 18 years of age.
2) Known severe allergy to IV contrast agent.
3) High grade GI obstruction.
4) Intestinal perforation.
5) Pregnant women.
6) Patient who had prior colorectal surgery, suspected inflammatory bowel disease, acute diverticulitis or bowel obstruction, rejection for Optical Colonoscopy or CT Colonography for any reason, medical condition that precluded the use of bowel preparation, inability to give informed consent.

3. Study variables

The colon was divided into eight segments for examination: caecum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid and rectum. Findings for each segments are noted using the following parameters

- lesion size
- number
- morphology
- location
- attenuation
- mural thickening
- abrupt transition/shouldering
- pre-colonic fat stranding
- enhancement (if applicable) of polyps, mass
- diverticula and any other relevant findings will be noted
- Presence of any extra colonic findings or alternate diagnosis will also be recorded if identified.

4. Working definition

Computed Tomographic Colonography (CTC) was first introduced by Vining in 1994 as an alternative imaging method for evaluation of the colon, in which helical computed tomography (CT) data is used to produce three dimensional images and simulates a virtual endoluminal view; hence, also called virtual colonoscopy. CT Colonography uses volumetric CT data combined with advanced imaging software to create two-dimensional and three-dimensional images of colon. Multiplanar imaging (MPR) and 3-Dimensional display modes including endoluminal viewing images reconstructed from thin axial sections. 3-D endoluminal images simulate the endoluminal perspective of colonoscope. The two dimensional images are complementary, and in combination give excellent detail about colon.

5. Study tools

Study was carried out using **64 sclice Multidetector CT scanner** manufactured by Philips, Netherland on 9/2007 with model serial number 10311 in the Department of Radiodiagnosis, RIMS, Imphal in collaboration with Department of Surgery, RIMS, Imphal.

And **Optical Colonoscopy** with Fujinon Colonoscope, High definition, system 2200 processor, Fujinon Corporation, 1-324 UETAKE-CHO,KITA-KU, SAITAMA-SHI, SAITAMA JAPAN, made in Japan,2010.

6. Outcome variables

Sensitivity, specificity, positive predictive value (ppv), negative predictive value (npv), accuracy of Computed Tomographic Colonography.

7. Method of recruitment:

Patients referred from the department of Surgery, RIMS, who are suspected of having colorectal lesions and who fulfill the inclusion criteria.

8. Procedures

Informed consents were obtained from all the cases. Clinical history of each case including age, sex, marital status, occupation, religion, address, personal history, family history and past history were collected from the patients. The chief presenting complaint with duration were also noted. All the cases were subjected to general and systemic examination. Routine laboratory tests including kidney function test were done in all cases and patients were subjected to CT Colonoscopy with 2D plans using multiplanar reconstructions (MPR) in axial, coronal and sagittal planes in different window levels and width (soft tissue window; lung window), along with 3D endoluminal images (fly through mode), volume rendered images (3D transparency mode).

Study was carried out using same 64 sclice Multidetector CT scanner in the Department of Radiodiagnosis, RIMS, Imphal in collaboration with Department of Surgery, RIMS, Imphal.

Optical Colonoscopy was done in Department of surgery with Fujinon colonoscope, in the gastrointestinal surgery unit.

All the patients underwent bowel preparation and 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 given orally over 4 h, starting 12 h prior to examination, 10 mg of Bisacodyl were also given to reduce residual fecal material and retained fluid. An enema was performed prior to the test if necessary. 20mg Buscopan was administered intravenously immediately prior to scanning (20mg/mL of hyoscine butylbromide)

During the examination, patient was placed in the left lateral decubitus position and the colon was insufflated with 40 puffs (approximately 50 ml/puff) of room air or up to the tolerance of patient, gently through a rectal tube via a partially inflated and fixed Foley's catheter after applying 2% lignocaine jelly.

A standard CT scout image was obtained in supine position and colonic distension was assessed. Plain CT images were then obtained from diaphragm to pubic symphysis in supine position using the following parameters:

1. Surview test with preset parameter (view angle - 180^{o} /AP view)
2. Standard dose/routine helical CT parameters : Tube voltage 120kVp, Tube current-time 250mAs/slice, Collimation 64x0.625, Pitch 0.797, Rotation time 0.75sec, FOV 350mm and acquisition Slice thickness of 5mm without oral, rectal contrast ; intravenous contrast was used when deemed necessary
3. Contrast enhanced helical CT (only when necessary) using IV iodinated contrast with the same parameters as above. About 80ml of iodinated contrast agent (Inj. Omnipaque 350) was injected in the cubital vein at the rate of 3-4ml/sec, at a dose of 1 to 1.5 ml/kg body weight with an auto injector. Scanning was started about 70 seconds after injection to acquire portal phase. Oral or rectal contrast was not used.

Thin section images from the standard-dose helical MDCT scans with reconstructed Maximum Intensity Projection (MIP) and Multi Planar Reconstruction (MPR) images were interpreted from the Extended Brilliance Workstation, along with the help of preinstalled Colonography endoluminal view computer software. The images of standard-dose MDCT Colonography were analyzed and findings recorded were stored in Digital Versatile Disks (DVD). The same patient underwent Optical Colonoscopy (blinded of the results of CT colonographic findings) on the same day or within one week in the surgery gastroenterology unit and their findings and datas were also noted and recorded and was also kept stored in Digital Versatile Disks (DVD). Both the findings were compared for the same features and these findings were compared at the end of case collection with the help of Consultant Radiologist and results were interpreted. For those patients undergoing Optical Colonoscopy assisted biopsy or polypectomy and or surgery, those findings and their subsequent histopathological reports was considered as the final diagnosis and thereby the data available was used for determining the sensitivity and specificity of the CT Colonography (Virtual colonoscopy). Visualization of any extracolonic pathologies were also recorded and studied.

9. Data collection

Patient data collection was done using a pro forma containing particulars of the patient, chief complaints, history of present illness, personal history, history of past illness, socio-economic history, family history, patient examination, investigation profile, CT Colonography findings, Optical Colonoscopic findings, surgical findings and histopathological report.

10. Statistical Analysis

- Data was entered and analysed using SPSS version 21.
- Summarization and analysis was carried out using descriptive statistics, like age, lesion size, number, location which were presented as mean SD, while percentage was used to present sex, attenuation, mural thickening, abrupt transition/shouldering, pre colonic fat stranding, enhancement.
- Chi-square test was used to find the association nominal outcomes.
- P value less than 0.05 was taken as significant.
- Kappa statistic was used to find out the level of agreement between Computed Tomographic Colonography and Optical Colonoscopy.

11. Ethical Approval

- Informed consents from all the patients included in the study.
- Ethical approval to carry out the study was obtained from the Institutional Medical Ethics Board, RIMS, Imphal.

IV. Results And Observation

A total of 58 patients suspected of having colorectal lesions underwent CT colonography (CTC) and Optical Colonoscopy (OC) and findings were recorded for comparision and correlation. Patients age ranges from 26-87 years,(mean age of 54.84) and standard deviation of 12.4. 45 Colorectal lesions were detected in 44 patients. CTC detected polyps in 16 males (57.1%) and 12 females(42.9%). Also CTC detected 17(29.3%) masses in 9 males (52.9%) and 8 females (47.1%) patients. Histopathological report confirmed 16 cancers among the masses; 9 (56.2%) in males and 7 (43.8%) in females with a male to female ratio of 1.3:1. Total number of polyps detected by CTC were 28 and by OC were 25; 4 polyps detected by CTC were not seen on OC; and 1 polyp was missed on CTC whereas picked up by OC (giving rise to 1 false negative result). 16 colorectal masses were detected by OC including one false negative and one false positive case and 17 masses were detected on CTC including 1 false positive case which turns out to be inflammatory mass in caecum. Complete colonic examination were not achieved by OC in 5 patients, (3 non-compliant patients; 1 elderly frail patient and 1 occlusive lesion in which scope cannot be passed beyond the lesion) whereas CTC was able to undergo complete colonic examination of proximal colon up to the caecum; also in cases of occlusive lesion.

Patients mostly presented with symptom of bleeding per rectum (26.8%), followed by altered bowel habit(24.4%), anaemia (21.9%), Right iliac fossa mass (12.2%), weight loss (9.8%), abdominal pain (4.8%)respectively. (Figure 1)

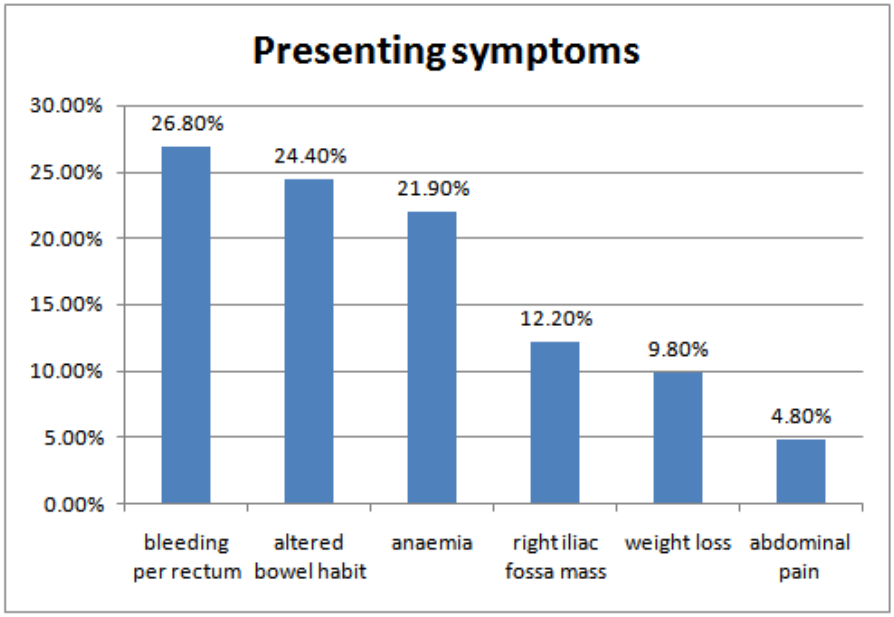


Figure1: Symptoms of patients having colorectal lesions.

Maximum lesions were detected in distal colon, sigmoid(40%), rectum(24%), descending colon(12%) ,transverse colon (8%), and ascending colon (16%). (Figure 2)

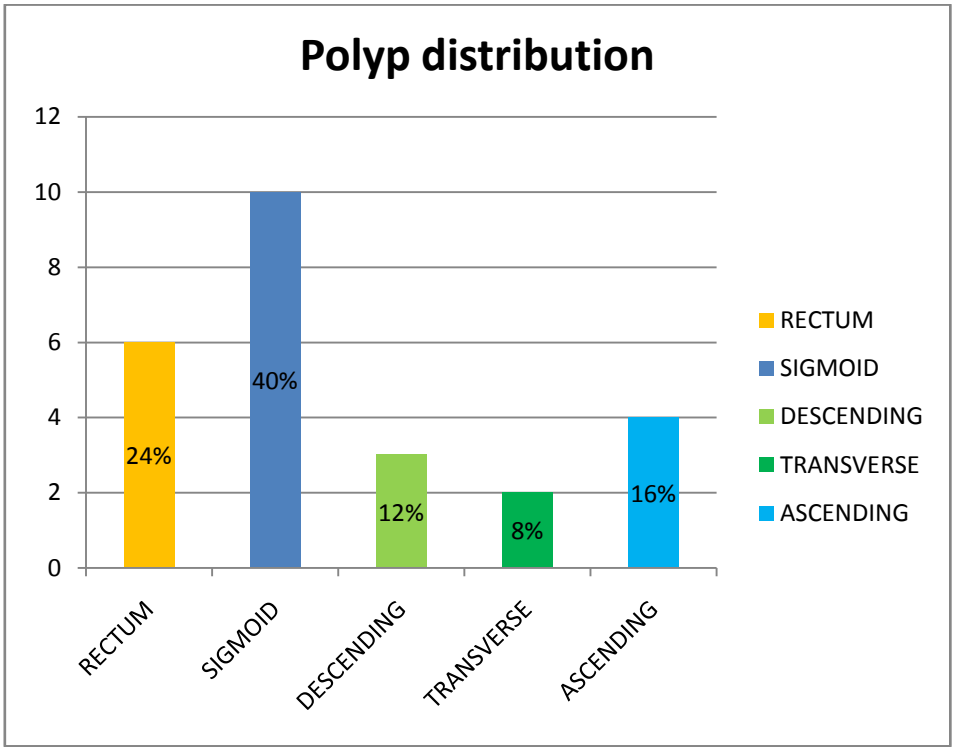


Figure 2: Polyp distribution in the colon

The sensitivity of CTC to detect polyp was 96% and specificity was 87.9%. OC being Gold standard has a sensitivity and specificity of 100% (for all completed examination). And that CTC has a positive predictive value and negative predictive value of 85.71% and 96.66% respectively with an accuracy of 91.38%.

Table1: Sensitivity and specificity of CTC with that of OC

CTC POLYP * OC POLYP Cross tabulation					
			OC POLYP		Total
			(-)	(+)	
CTC POLYP	(-)	Count % within OC POLYP	29 (87.9%)	1 (4.0%)	30 (51.7%)
	(+)	Count % within OC POLYP	4 (12.1%)	24 (96.0%)	28 (48.3%)
Total		Count % within OC POLYP	33 (100.0%)	25 (100.0%)	58 (100.0%)

CTC: Computed Tomography Colonography; OC: Optical Colonoscopy

Polyps detected on Optical Colonoscopy of size larger than or equal to 10 mm were biopsied and sent for histopathological examination. Out of the 25 polyps detected 22(88% were benign inflammatory, hyperplastic polyps); 1(4%) was dysplastic, and 2(8%) were malignant (adenocarcinoma) which were larger than 10mm. (Figure 3). Correlation for polyp detection by CTC and OC was found to be significant at $p<0.5$.

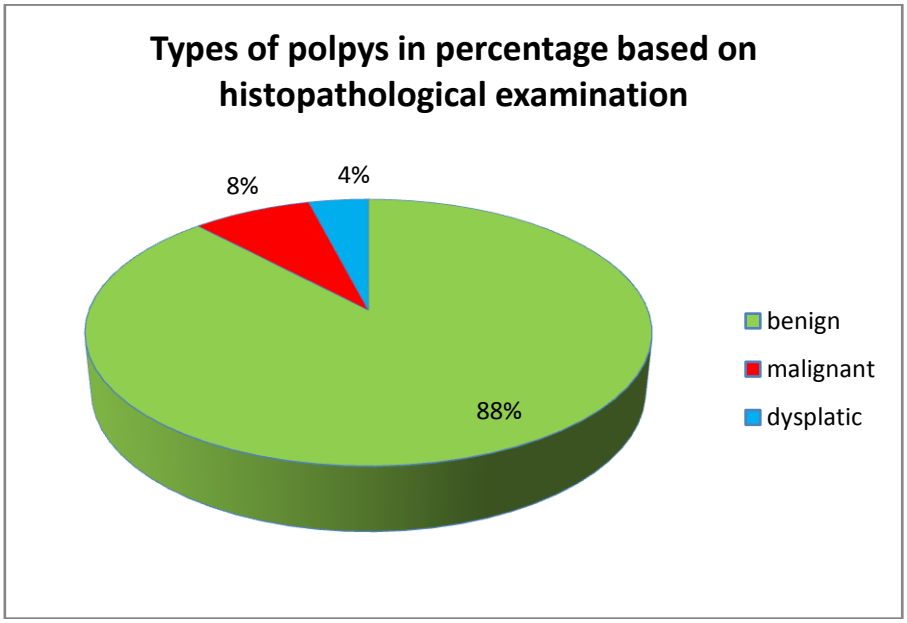


Figure 3: Histopathological correlation of polyps

Table2: Sensitivity and specificity of OC for colorectal cancer detection taking Histopapthology as gold standard.

OC MASS * HPE MASS Cross tabulation					
			HPE MASS		Total
			MALIGNANT	NEGATIVE	
OC MASS	(-)	Count % within HPE MASS	1 (6.2%)	41 (97.6%)	42 (72.4%)
	(+)	Count % within HPE MASS	15 (93.8%)	1 (2.4%)	16 (27.6%)
Total		Count % within HPE MASS	16 (100.0%)	42 (100.0%)	58 (100.0%)

OC: Optical Colonoscopy; HPE: Histopathological Examination following Optical Colonoscopy and biopsy or surgery and biopsy.

Table 3: Sensitivity and specificity of CT Colonography for colorectal cancer detection taking Histopapthology as gold standard.

CTC MASS * HPE MASS Cross tabulation					
			HPE MASS		Total
			MALIGNANT	NEGATIVE	
CTC MASS	(-)	Count % within HPEMASS	0 (0.0%)	41 (97.6%)	41 (70.7%)
	(+)	Count % within HPE MASS	16 (100.0%)	1 (2.4%)	17 (29.3%)
Total		Count % within HPE MASS	16 (100.0%)	42 (100.0%)	58 (100.0%)

OC: Optical Colonoscopy; HPE: Histopathological Examination

16 (27.6%) masses were detected by OC including 1false positive and 1 false negative cases giving a sensitivity and specificity of 93.8% and 97.6% for detection of colorectal adenocarcinoma which were histologically proven by biopsy following colonoscopy and or surgery, and the positive and negative predictive value were 93.8% and 97.6% respectively.

Similarly, 17(29.3%) masses were detected by CT Colonoscopy out of which 1was a false positive case. The sensitivity and specificity for the detection of colorectal adenocarcinoma by CTC was 100% and 97.6% respectively, with positive and negative predictive value being 94.11% and 100% respectively. Lesion reporting in CTC was done using C-RADS (CT Colonography Reporting and Data System).These 17 lesions were categorized as C4, out of which 1turned out to be an inflammatory mass. Other findings of suspected malignant masses on CT were asymmetric wall thickening, polypoidal/ lobulated mass, pericolonic fat

stranding, shouldering/abrupt transition, and enhancement on contrast administration, enlarged or necrotic regional lymph nodes, or suspicious metastatic lesion.

Site of distribution of adenocarcinoma were rectum (37.50%), sigmoid (25%), ascending colon & caecum (25%), transverse (6.20%) and descending colon (6.20%). (Figure. 4)

Diverticula were equally picked up on CT Colonography and Optical Colonoscopy and were located mostly in ascending colon.

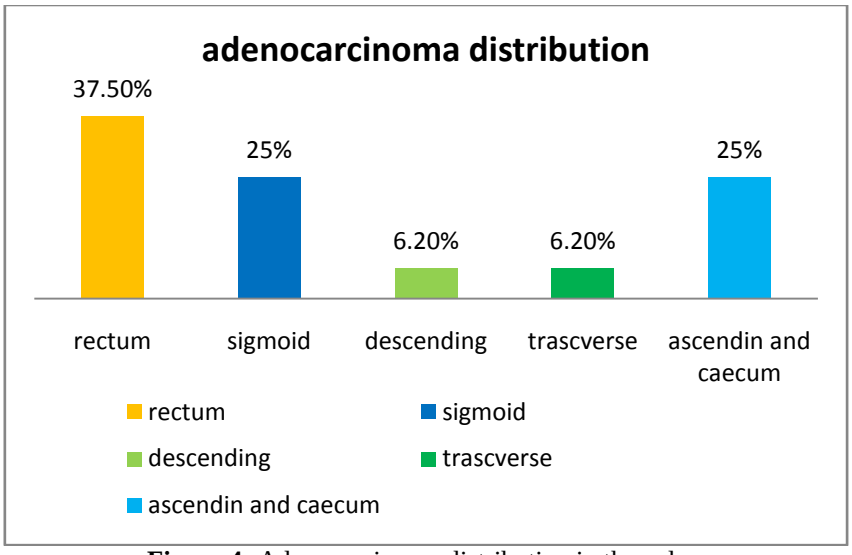
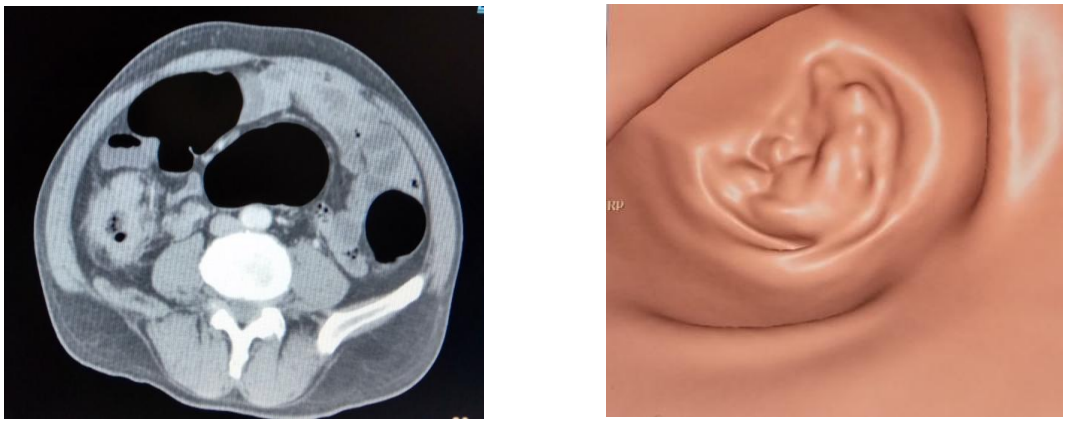


Figure 4: Adenocarcinoma distribution in the colon

Extracolonic findings were seen in 22(37.9%) patients, 16 (72.7%) males and 6 (27.3% females) and were renal calculi, cystitis, cholelithiasis, chronic pancreatitis, hepatic cysts, fatty liver disease, ovarian cyst and ascites, pleural effusions, aortic aneurysm and degenerative disease of the spine. Lesions were reported according to C-RADS. Most extracolonic lesions were E2 in 17(77.3%) patients and E3 in 4(18%) patients with 1(4.5%) patient having E4 lesion as abdominal aortic aneurysm.

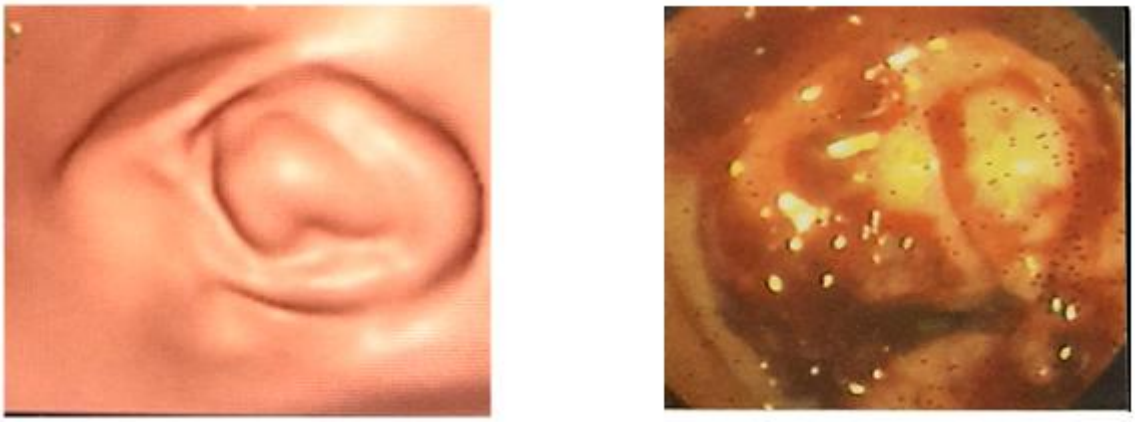
Optical Colonoscopic examination was incomplete in 4 patients, of which 3 due to non-compliance and in one patient scope was not able to pass due to obstructive lesion. Whereas CT Colonography had all complete examination in all the patients.

Patient's preference was for CT Colonography over Optical Colonoscopy due to minimal invasiveness, lesser discomfort and duration of the examination. No complications were seen in both modalities during and after the procedures.



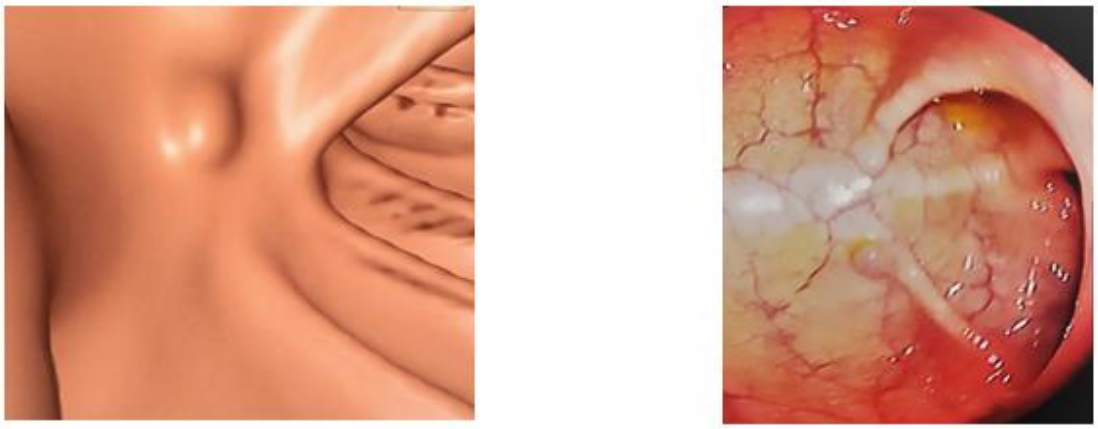
a. **b.**

Figure 5: (a) Axial CT view of the ascending colon mass causing luminal obstruction, (b)CT Colonographic view of the luminal polypoidal mass causing luminal obstruction.



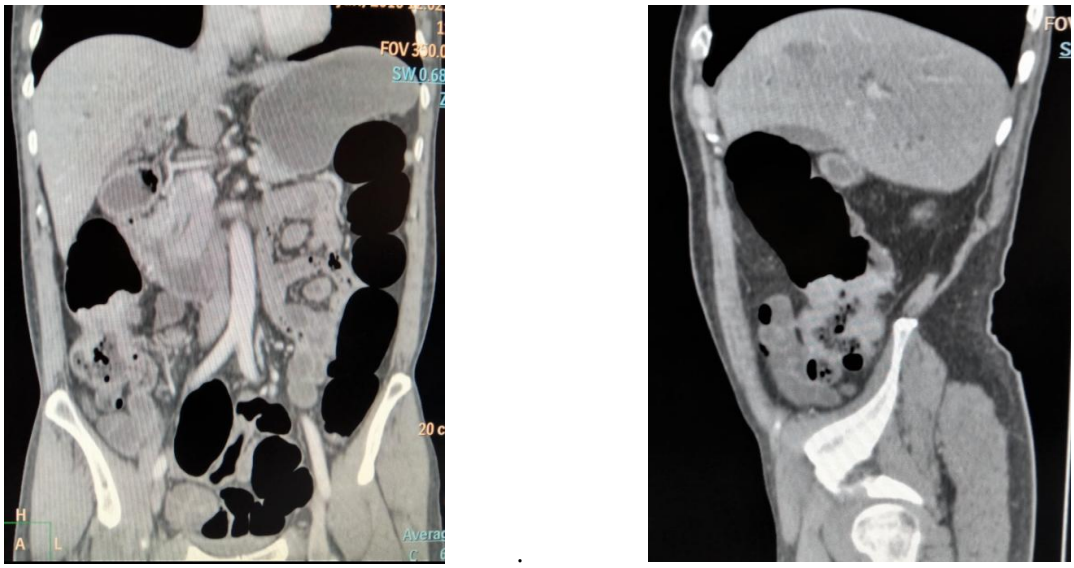
a. **b.**

Figure 6:(a) CT Colonograhic image of an obstructive growth in sigmoid colon. (b) Optical Colonoscopy photograph of the same growth.



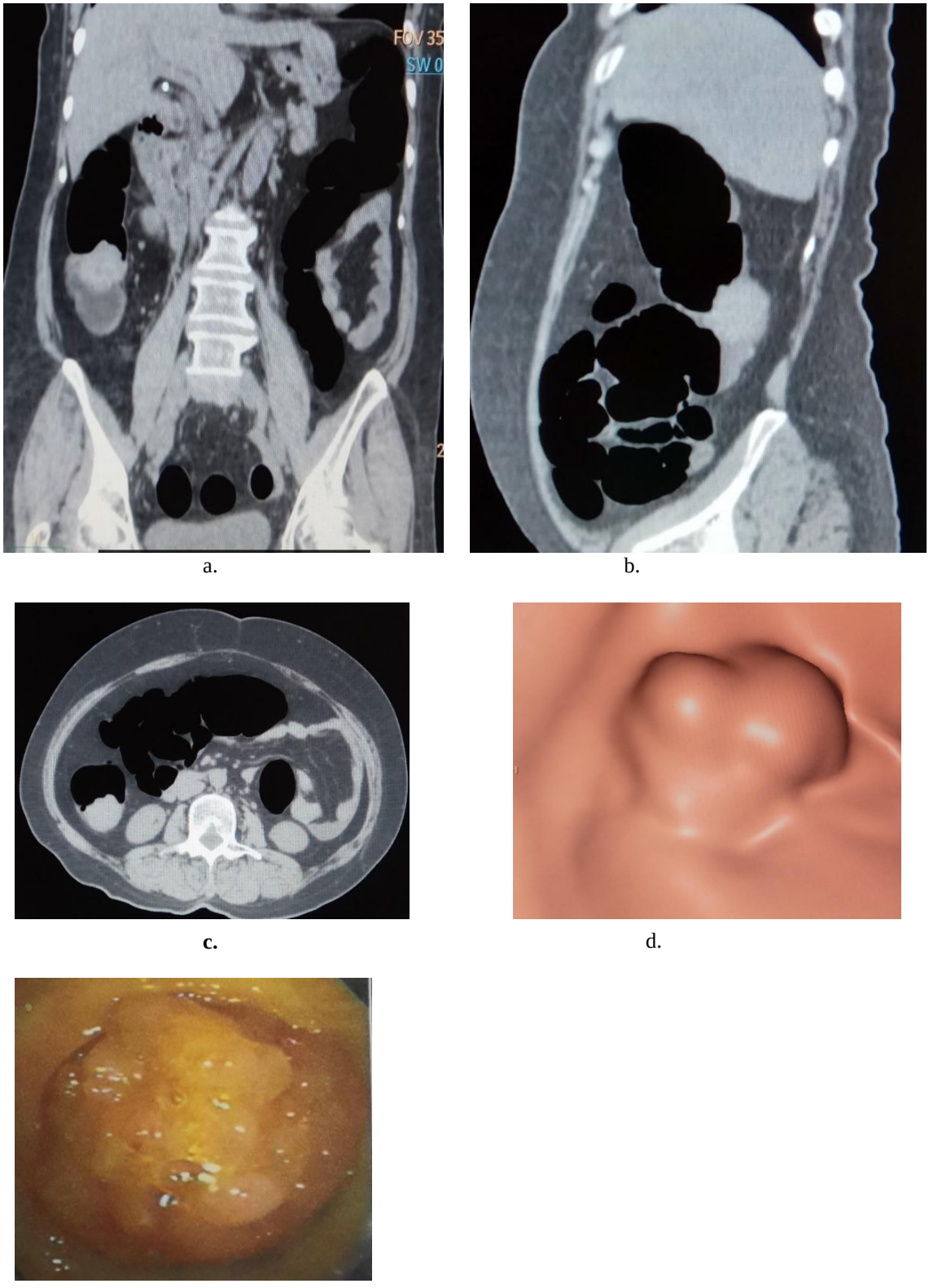
a. b.

Figure 7:(a) CT Colonographic endoluminal view of transverse colon polyp. (b) photograph of the polyp on Optical Colonoscopy.



a b

Figure 8: CT coronal (a) and sagittal (b) MPR images showing irregular mass like asymmetric wall thickening involving the ascending colon showing enhancement on post intravenous contrast administration. Hisotopathology reported adenocarcinoma



a. b.

c. d.

e.

Figure 9:(a) coronal (b) sagittal (c)axial MPR CT image of ascending colon polyp**,(**d) CT Colonographic image and (e) Optical Colonocopy photograph of the same polyp

V. Discussion

CT Colonography is a rapidly evolving diagnostic imaging modality which is gaining favour over the recent years for the evaluation of colorectal lesions, with its minimal invasiveness, rapidity of examination, completeness, ability to give extracolonic findings and visualize intramural growth from muscular wall of colon

(with relatively normal mucosa) and better patient acceptance, without any need for sedation. This study determines the sensitivity of Computed Tomography Colonography with that of Optical Colonoscopy in the detection of colorectal lesions (polyps and cancers), compares and correlates the imaging findings of Computed Tomography Colonography with that of Optical Colonoscopy in detection of malignant masses taking histopathological report as the gold standard.
Reporting were done in CT Colonoscopy using CRADS. [6]

Categorization of colonic findings:

Table 4: C-RADS (CT Colonography Reporting And Data System).

Category	Description
C0	**Inadequate study or awaiting prior study for comparison** ● inadequate preparation, where lesions ≥10mm can not be excluded due to abundant fluid or feces ● inadequate insufflation with one or more colonic segments collapsed on both views ● awaiting prior study for comparison
C1	**Normal colon or benign lesion - continue routine screening** ● no abnormality of the colon found ● no polyp ≥6mm ● non-neoplastic findings - diverticula, inverted diverticulum, lipoma, etc.
C2	**Intermediate polyp or indeterminate finding - surveillance or colonoscopy recommended** ● <3 polyps 6 - 9mm ● indeterminate finding where polyp ≥6mm cannot be excluded despite technically adequate exam
C3	**Polyp, possibly advanced adenoma - follow-up colonoscopy recommended** ● polyp >=10mm ● ≥3 polyps 6 - 9mm
C4	**Colonic mass, likely malignant - surgical consultation recommended** ● lesion compromises colonic lumen ● extracolonic invasion

Categorization of extracolonic findings:

Category	Description
E0	**Limited exam** - compromised by artifacts, severly limited evaluation of extracolonic soft tissues
E1	**Normal exam or anatomic variant** - no extracolonic pathology found ● ureter fissus, retroaortic renal vein as anatomic variants, etc.
E2	**Clinically unimportant finding** - no workup indicated ● simple cysts in liver or kidney ● uncomplicated cholecystolithiasis (gallstones) ● vertebral hemangioma, etc.
E3	**Likely unimportant finding, incompletely characterized** - workup may be indicated based on local practice and patient preference ● minimally complex or homogeneously hyperattenuating kidney cysts, etc.
E4	**Potentially important finding** - further workup according to accepted practice guidelines ● solid renal mass ● lympadenopathy ● aortic aneurysm ● parenchymal nodule in lung ≥1cm, etc.

Optical Colonoscopy is considered gold standard for the detection of colorectal lesions including polyps and cancers, with its added advantage of diagnostic and therapeutic capabilities in form of biopsy and polypectomy. It has the added advantage of mucosal patterns and superficial ulcers visualisation. However, because of invasive nature, patient's discomfort, need for sedation and minimal but significant risk of perforation a better modality is required, and so, CT Colonography has come up as a new technique for detection of polyp and cancers.

It was observed that sensitivity of CT Colonography to detect polyp was 96% and specificity was 87.9%. Out of the 25 polyps detected, 22(88%) were benign inflammatory hyperplastic polyps; 1(4%) was dysplastic, and 2(8%) were malignant (adenocarcinoma) which were larger than 10mm. Majority of the cancers were seen in age group of 60-65years. Correlation for polyp detection by CT Colonography and Optical Colonoscopy was found to be significant at $p<0.5$. And kappa value of 0.827 was found which suggest almost perfect agreement between the test.

This sensitivity was similar to the findings of the study in systematic meta-analysis by Pickard PJ et al [2] in which the sensitivity of CT Colonography for colorectal cancer was 96.1% (398 of 414; 95% confidence

interval [CI]: 93.8%, 97.7%) without heterogeneity (I^2 = 0%). The sensitivity of OC for colorectal cancer, derived from a subset of 25 studies including 9223 patients, was 94.7% (178 of 188; 95% CI: 90.4%, 97.2%) with a moderate degree of heterogeneity (I (2) = 50%) and concluded that CT Colonography was highly sensitive for colorectal cancer, especially when both cathartic and tagging agents are combined in the bowel preparation. 4 false positive lesions (12.1%) picked up on CT Colonography but visualized on Optical Colonoscopy were found to be either thickened mucosal fold or mild intraluminal irregularity. 1 (4%) small <6mm polyp located in the sigmoid colon was missed by CT colonogrpahy due to inadequate distension and residual fluid. It was detected on Optical Colonoscopy. Using the "colon-dissection" reconstruction software which provides a high resolution in the z-axis for detecting colonic masses and polyps down to a diameter of less than 2 mm can improve the sensitivity to about 90 % as reported by Rottgen R et al.[1]

Heuschmid M et al[5] observed that, CT Colonography has similar high accuracy (sensitivity/patient: 83-100% and specificity/patient: 93-100%) in detecting pathological colonic changes. They opined that CT Colonography is an excellent diagnostic technique for the evaluation of patients with incomplete conventional colonoscopy allowing the assessment of extracolonic abdominal and pelvic organs.

Hope et al[7] compared the abilities of routine clinical CT Colonography and conventional colonoscopy to detect colorectal neoplasms using second-look colonoscopy to clarify discrepant results also showed similar sensitivitiy for polyps 10 mm or larger was 95% and its specificity was 98% and suggesting CT Colonography as a potential and valuable clinical screening method for colorectal neoplasms. Comparative study in Indian population by Kalra N et al[8], Multidetector Computed Tomographic Colonography and conventional colonoscopy for detection of colorectal polyps and cancer the sensitivity and specificity of CT colonography were 65% and 77%, respectively, for lesions 1-5 mm; 97% and 83% for 6-9 mm-sized lesions; and 100% and 100% for lesions 10 mm or larger. Extra colonic findings were also seen in 24 of 42 patients (57%) and concluded that CT Colonography was reliable for detecting lesions of 6 mm or larger in size. It permits evaluation of the region proximal to an occlusive growth, which is often not possible with optical colonoscopy. Their findings are in concordance with that of our study, with a good sensitivity and specificity for the detection polyps, more for > 10mm in size. As risk of malignancy increases with polyp size, detection of polyps larger than 10 mm may be used as a cut off level for screening purposes. In our study, two polyps larger than 10 mm were found to be adenocarcinomas.

Meta-analytical study by Haan MC et al [9] observed that sensitivities for CT colonography in patients with polyps or adenomas ≥ 10 mm were 83.3% and 87.9%, with corresponding specificities of 98.7% and 97.6%. Little lower sensitivity in their study may be due to the differences in patient selection through risk stratification into average and high risk patients and difference in the technique of bowel preparation in their study.

16 masses detected by Optical Colonoscopy in our study including 1 false positive and 1 false negative cases giving a sensitivity and specificity of 93.8% and 97.6% for detection of colorectal adenocarcinoma were histologically proven by biopsy following colonoscopy and or surgery, and with a positive and negative predictive value of 93.8% and 97.6% respectively. Similarly, 17 masses were detected by CT colonoscopy including 1 false positive case giving a sensitivity and specificity of 100% and 97.6% respectively for detection of colorectal adenocarcinoma and a positive and negative predictive value of 94.11% and 100% respectively. Both false positive cases seen in both Optical Colonoscopy and CT Colonography were located in the caecum which appeared as elevated polypoidal mass and turns out to be inflammatory mass. 1 false negative case was missed on Optical Colonoscopy which was due to improper visualization of lesion located in the ascending colon as well as patient's non-compliance during negotiation of the colonoscope. However, no false negative case was seen in with CT Colonography, with virtual 3D endoluminal view reinforced by 2D - MPR reconstructed images and with contrast enhanced images enabling detection of morphology and location of the lesion correctly.

Kunwarpal S et al[10] found that sensitivity and specificity for detection of colorectal cancer were 97.56% and 100%, respectively 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. Also Laghi A et al[11] opined that CT Colonography is a robust and reliable imaging test of the colon and accuracy for the detection of colorectal cancer is as high as conventional colonoscopy.

Recent studies show good sensitivity for the identification of non polypoid (flat) lesions as well. Current CT Colonography indications include evaluation of patients who had undergone a previous incomplete Conventional Colonoscopy or those who are unfit for Conventional Colonoscopy (elderly and frail individuals, patients with underlying severe clinical conditions, or with contraindication to sedation). CT Colonography can also be efficiently used in the assessment of diverticular disease (excluding patients with acute diverticulitis, where the exam should be postponed), before laparoscopic surgery for Colorectal cancer for accurate localization of the lesion[13], in the evaluation of colonic involvement of deep pelvic endometriosis replacing barium enema. CT Colonography is also a safe procedure in patients with colostomy. For Colorectal cancer screening, CT Colonography should be considered an opportunistic screening test (not available for population,

or mass screening) to be offered to asymptomatic average-risk individuals, of both genders, starting at age of 50 years.[9]

CT Colonography is also preferred in patients where patient are non-compliant to opt for Optical Colonoscopy, or where Optical Colonoscopy is contraindicated, as in elderly frail patients, patients with severe co-morbidities such as cardiopulmonary disease, patients with coagulopathy.

Limitations of this study are: small sample size, inadequate bowel preparation and inadequate bowel distension, lesions < 10mm not undergoing biopsy/ surgery and difficulty in detecting flat lesion. CT Colonography also cannot provide information about mucosal hyperaemia, and superficial mucosal erosions. Adequate bowel preparation and distension however can be improved by giving proper instruction to patients, checking adequacy of distension by scout tomogram and re-insufflation of air if necessary. Patient's preference for CT Colonography over Optical Colonoscopy were most likely due to lesser discomfort, lesser duration of the examination and minimal invasive nature.

The accuracy and reliability of the results that we achieved in our study still requires larger prospective studies on larger sample size.

VI. Conclusion

CT Colonography appears to be a promising imaging modality in the detection of colorectal lesions mainly polyps and cancers and so also diverticula. With a high sensitivity and specificity for polyp detection 96% and 87.9% with an accuracy of 91.38% and also with high sensitivity and specificity for cancer detection of 100% and 97.6% respectively (for detection of colorectal adenocarcinoma). Better results could be obtained with the use of 2nd read CAD (computer- aided detection), endoluminal fly through to and fro from rectum to cecum and vice versa, and correlating finding with 2D and MPR, adequate bowel preparation and by achieving adequate distention by checking scout tomogram, and also giving hands- on- training of radiologist before optimal results can be obtained. Many of the similar studies also show good correlation with the achieved sensitivity and specificity of colorectal polyps and cancer. Thus, CT Colonography shows promising results for detection of colorectal lesions specially polyps and cancer and with its minimal invasive nature, better patient acceptance, ability to visualize entire colon, and ability to give extracolonic findings, can be a potential screening tool with reliable results.

Along with the added advantage of complete colonic examination and ability to see extraluminal or extracolonic findings and give alternative diagnosis if any.

And also, sensitivity and specificity for lesion detection can further be increased if CT Colonography is combined with Optical Colonoscopy, which will be helpful in better, early and accurate detection of lesion and by reducing false positive and false negative cases and help in better management..

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