



HELICAL COMPUTED TOMOGRAPHY PNEUMOCOLON TO ASSESS COLONIC TUMORS

KEYWORDS

Helical computed Tomography, Pneumocolon, colonic tumors

Dr Ramesh R. Chaple

Dr. Akash Mahalle

Associate Professor Indira Gandhi Govt. Medical College Nagpur.

Senior Resident, Indira Gandhi Govt. Medical College Nagpur.

ABSTRACT

Background: colonic carcinoma has traditionally been diagnosed by barium or colonoscopy provides staging information accurately. With development of high resolution scanner the accurate staging, expected prognosis and also assistance in effective management has become easy. The distension of colon by air reduces the misinterpretation of feces and collapsed bowel as tumour. The purpose of this study was detection and characterization of colonic masses by CT Pneumocolon examination and to differentiate them from benign pathologies and to determine the accuracy of spiral CT Pneumocolon in staging colonic carcinoma.

Methodology: all patients of all ages with suspicious colonic malignancy on clinical ground and barium study or colonoscopy or ultrasound were included in study. With proper written informed consent these patients underwent contrast enhanced CT scan with colon being insufflated with room air at maximal tolerable level. Colonic distension monitoring was done by scout CT radiograph.

Results: total 61 cases were studied, out of which 37(61%) were male and 24(39%) were females. The peak incidence of colonic pathologies was between 41 to 70 years. It is observed that most of the burden of malignant colonic pathologies was on anorectal region (n=21, 47%) while that of benign pathologies is in caecum (n=6, 38%). CT Pneumocolon has sensitivity and specificity for differentiating benign from malignant lesions was 100% (45/45) and 82% (13/16). The overall accuracy rate was 95%. It has been found that majority (n=13, 81%) of benign lesions produces bowel thickening <2cm and majority (n=35, 78%) of malignancies shows wall thickness >2cm. The accuracy of CT Pneumocolon in staging parameters was- 1) In Local serosal invasion-97% (39/40)(sensitivity), 40%(2/5) (specificity), 2) in Lymph nodal involvement- 70%(19/27)(sensitivity), 83%(15/18)(specificity), 3) In Metastasis- 100%(7/7)(sensitivity), 100% (38/38)(specificity).

Conclusion: helical CT Pneumocolon is non-invasive, rapid and highly sensitive for the detection of colonic malignancy. The technique is helpful not only in differentiating between colonic benign and malignant lesions but also grouping them in different subtypes and origins.

Introduction:

Colonic carcinoma has traditionally been diagnosed by Barium or colonoscopy or combination of both leading to surgical resection. Neither barium nor colonoscopy provides staging information accurately. Accurate staging is utmost important at treatment planning via several new therapeutic options. With the development of high-resolution scanners it has become easy. For obtaining reliable results from CT scan, distension of bowel with air or water as contrast agent is important precondition; otherwise collapsed colon or feces within it mimic the tumour. Water enema can be difficult and distressing to the old patients and has risk of water incontinence. Air insufflation of colon can be achieved easily and rapidly with well toleration by patients. CT Pneumocolon demonstrates both the mural and extramural involvement of colon conditions. Various criteria that allow one to differentiate benign and malignant conditions include attenuation pattern of colonic wall thickening, degree of colonic wall thickening, circumferential symmetrical versus asymmetrical thickening; length of involvement and associated perientric abnormalities like abnormal fat or hypervascularity and surrounding and distant lymph nodes and metastasis to other organs. The purpose of this study was detection and characterization of colonic masses by CT Pneumocolon examination and to differentiate them from benign pathologies and to determine the accuracy of spiral CT Pneumocolon in staging colonic carcinoma.

MATERIALS AND METHODS: This prospective hospital based study included 61 patients who were referred to the department of Radiodiagnosis for CT Abdomen. The inclusion criteria was referred patients of all ages with complaints and/or

clinical and/or barium studies/ colonoscopies/ Sonographic abnormalities suspicious of colonic malignancy referred for CT evaluation. All included patients were evaluated for detailed clinical history, physical examination and relevant investigations. The study was carried out with Siemens Dual Slice CT scanner. Proper bowel preparation was given before the study. All patients received oral diluted sodium amidotrizoate and meglumine amidotrizoate mixture to opacify the small intestine to identify it separately from large intestine. Air was insufflated through the rectal tube to the maximum tolerable level and adequate colonic distension was monitored via CT scout film. Patients with no abnormality with plain scan were excluded from the study. Eligible candidates were undergone contrast study. The lesions were further categorized according to imaging features and as benign and malignant. All colonic carcinomas were staged as per the modified Duke's classification^{13, 14} and had further Histopathological proof of diagnosis.

Result: The present study included 37 (61 %) male patients and 24 (39 %) females. Age in years Females Males Total 0 – 10 00011 – 20 11221 – 30 34731 – 40 36941 – 50 571151 – 60 6101661 – 70 6713 > 70 123 Total 25 366 1 Age in years Females Males Total The age in which colonic pathologies occurred varied from 18 years to 81 years (mean age 57 years). The peak incidence was between 41 years to 70 years. Male outnumbered females in all age groups.

Most of the burden of malignant colonic pathologies is on the anorectal region (n=21, 47%) decreasing proximally, while benign pathologies are commoner proximally in caecum (n=6, 38%).

Tab. No 1 Age Distribution of Patients

Age in years	Females	Males	Total
0 – 10	0	0	0
11 – 20	1	1	2
21 – 30	3	4	7
31 – 40	3	6	9
41 – 50	5	7	11
51 – 60	6	10	16
61 – 70	6	7	13
> 70	1	2	3
Total	25	36	61
Age in years	Females	Males	Total

Tab. No 2 Prevalence of CT appearances in malignant and benign pathologies

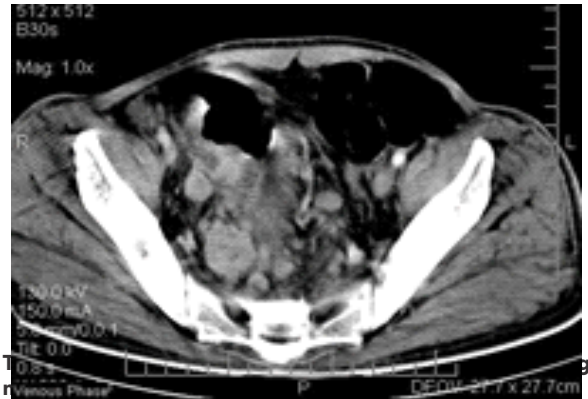
CT appearances	Colon malignancy (n=45)	Benign pathologies(n=16)
Colonic wall thickening		
Mild <2cm	10	13
Marked >2cm	35	3
Attenuation of wall thickening		
Homogenous	9	7
Stratified attenuation	0	5
Mixed	36	4
Length of colon involved		
<5cm	34	5
5-10cm	11	9
>10cm	0	2
Pericolonic fat stranding		
None	2	0
Mild	34	5
Moderate	8	7
Severe	1	4
Pericolonic lymph nodes	22	7
Deformed ileo-caecal Junction	1	4
Pattern of involvement		
Asymmetric	45	4
Symmetric	0	12

It has been found that majority (n=13,81%) benign conditions produce bowel thickening <2cm with mean wall thickness 1.2cm and majority (n=35,78%) of the malignancies show wall thickness >2cm with mean wall thickness 2.5cm. Most (n=7,44%) of the benign inflammatory pathologies show homogenous attenuation of the thickened bowel wall. Stratified type of bowel wall attenuation seen only in benign cases (n=5,31%) while n=4,25% benign cases show mixed attenuation. Most (n=36,80%) the malignant lesions show mixed attenuation of thickened bowel wall. Short segment involvement was seen in most (n=34,75%) of the malignant pathologies with mean length of involved bowel 4.7cm while most (n=11,69%) benign inflammatory pathologies show long segment involvement with mean length 7.9cm. Moderate to strong pericolonic fat stranding found to be mostly (n=11,69%) associated with benign inflammatory pathologies, while most (n=36, 80%) of the malignant pathologies show mild stranding. Pericolonic lymph nodes more than 1cm in short axis diameter were seen in stage C and D (n=22, 49%) of malignant lesions while also seen in most (n=7,44%) cases of tuberculosis. All of the cases of malignancy show asymmetric bowel wall thickening and few cases of tuberculosis also show asymmetric thickening. Most (n=12,75%) of the cases of benign

pathologies show symmetric involvement of bowel wall. Deformed ileo-caecal junction was seen in most (n=4,45%) of the cases of tuberculosis while it was seen in only one case of malignancy.

Most common site of metastasis from colonic carcinoma is liver (100%, n=7/7) followed by pulmonary (29%, n=2/7). Modality Studies done Malignancy detected Percentage CT Pneumocolon 45 100% Barium enema 25 100% Colonoscopy 31 24/78%

Some of the patient had undergone barium enema and colonoscopy prior to CT Pneumocolon. Barium enema was performed in 25 patients with cancer and 6 carcinomas were missed due to perceptual error, faecal residue and improper study. Colonoscopies were performed in 31 patients with cancer and 24 cases were diagnosed correctly. Undetected lesions were in proximal colon, which was not reached. Lymph Nodal Metastasis.



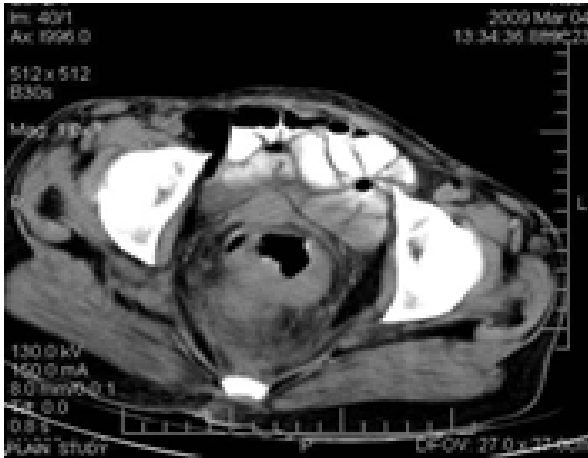
Modality	Studies done	Malignancy detected	Percentage
CT Pneumocolon	45	45	100%
Barium enema	25	25	100%
Colonoscopy	31	24	78%

Tab. No 4 CT Pneumocolon findings versus pathologic findings (Stage A-D refers to Modified Duke's classification)

Pathologic Findings	CT Pneumocolon Findings					
	Stage A	Stage B	Stage C	Stage D	Benign	Total
Stage A	2	3				5
Stage B	1	9	3			13
Stage C		8	12			20
Stage D				7		7
Benign			3		13	16
Total	3	20	18	7	13	61

Forty five patients were found to have colonic carcinomas. Of the 45 carcinomas 5 were found to be duke's stage A on histopathology out of which 2 were correctly staged and 3 were

over staged. 13 carcinomas were histologically classified as stage B, of which 9 were correctly staged and 3 were over staged because of significant regional lymphadenopathy which found to be reactive on histology and 1 was under staged. 20 dukes stage carcinomas were found of which 12 were correctly staged and 8 under staged due to false negative lymph nodes findings. All 7 dukes stage D carcinoma were correctly staged by CT.



43 of the 45 patients had adjacent peri-colonic fat invasion Stage B carcinoma of rectum through serosa on CT. In 40 patients findings were confirmed pathologically. In 2 patients carcinomas outer wall was smooth and these had duke's stage A on pathology. Lymph node status was incorrectly assessed in 8 of the 20 stage C. 13 benign pathologies were correctly detected however 3 were incorrectly diagnosed as stage C carcinoma due to eccentric wall thickening, irregular outer serosal wall with pericolonic fat stranding and significant enlarged pericolonic lymph nodes.

CT Pneumocolon correctly detected the malignancy in all 45 patients while 3 benign lesions were incorrectly labelled as malignant. Sensitivity and specificity for differentiating benign from malignant lesion was 100% (45/45) and 82% (13/16). The overall accuracy rate was 95%.

Tab. No 5 Accuracy of CT Pneumocolon in staging parameters

Modality	Sensitivity	Specificity
Local serosal invasion	97%(39/40)	40%(2/5)
Lymph node involvement	70%(19/27)	83%(15/18)
Metastasis	100%(7/7)	100%(38/38)

We correctly identified serosal invasion in 39 out of 40 patients and we incorrectly labelled 3 patients which did not have serosal invasion as positive. We correctly diagnosed lymph node involvement in 19 out of 27 patients while we incorrectly labelled three patients out of 18 as positive for lymph nodes. We correctly detected metastasis in 7 out of 7 patients while we have not incorrectly labelled any patient who did not have metastasis.

Discussion: Colonic carcinomas are one of the most common carcinomas in western world and the incidence of colonic carcinoma is also increasing in India due increase in life expectancy (Mohandas KM et al (2000)¹ and changing in food habits (Sinha R et al 2003)². Colonoscopy and barium enema are the main methods of diagnosis of colorectal carcinoma.

However both modalities do not permit a precise preoperative prediction as to whether a tumour is limited to colonic wall or has spread into surrounding tissues. The purpose of our study was to evaluate the accuracy of CT Pneumocolon in detection and in characterization and in differentiating it from benign pathologies and in staging colonic carcinomas.

Normal colonic wall thickness should not exceed 3mm in a well distended segment and thickness greater than 6mm is considered abnormal (Sun CH et al 2005). In our study bowel wall thickness more than 5mm considered as abnormal.

In present study 61 patients were evaluated with CT Pneumocolon who suspected to have colonic carcinoma or diagnosed as colonic carcinoma through other modalities.

Gender and age distribution of cases:

In our study we include 25 females and 36 males. Peak age for benign pathologies was from 21 to 50 years and for malignant pathology was from 51 to 70 years. The mean age for malignant group was 64 years while that for benign group was 41 years. The overall mean age was 57 years. Xiong L et al (2004)³ studied frequency and CT patterns of bowel wall thickening proximal to cancer of the colon in surgically proven adenocarcinoma with 111 male and 74 female with mean age of presentation was 59 years. Harisinghani MG et al (2003)⁴ studied the role of CT halo sign for differentiating benign from malignant colonic disease in 92 patients (70 males and 22 females; mean age 57 years) with pathologically proven colonic wall thickening.

Etiopathological distribution of lesions on CT:

Malignant neoplastic (n=45,74%) lesions were most common followed by infective contributed mainly by tuberculosis (9) followed by other benign lesions including polyps, crohn's disease and diverticulitis (2 each) and one lesion was of vascular origin.

Regional distribution of colonic lesions: Ileo-caecal junction was most common site of tuberculosis (n=9; 56%) in this present study, similar (n=10; 52%) to study by Sinan T et al (2002)⁵ In present study rectum was most common site of malignancy (n=21; 47%) as in study by Xiong L. et al (2004)³ (n=66; 36%). In present study 2 cases of diverticulitis were found in sigmoid colon extending to descending colon which is the most common site in western population, however in a study done by Yoke sun lee (1987)⁶ it was found that in Indians diverticular disease more predominantly involve right colon. Both the polyps were found in rectum which is commonest site as also seen in the study done by Don chin jung et al (2004)⁹.

Clinical symptoms of patients:

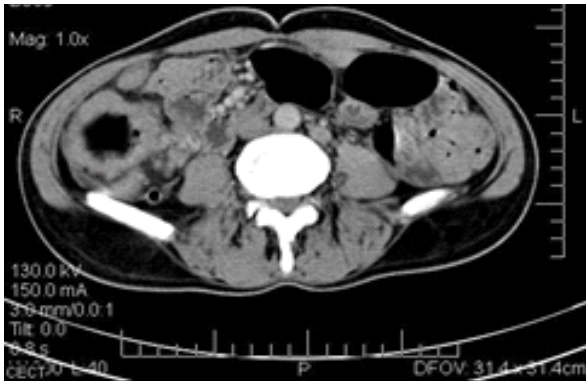
According to Bafandeh Y et al (2006) rectal bleeding (52.4%) and bloody diarrhea (16.2%) were the most common presenting symptoms in patients with colorectal cancer. In present study also bleeding per rectum (43%) was the most common presenting complaint followed by change in bowel habit (36%) in malignant group. In benign group pain in abdomen (68%) was the most common symptom followed by fever.

Benign colonic pathologies:

Tuberculosis: Ileo-caecal junction was most common site of tuberculosis (n=9; 56%) in this present study, similar (n=10; 52%) to study by Sinan T et al (2002)⁵.

Range of bowel wall thickness in tubercular pathology was 0.5 to 3 cm in Balthazar EJ et al (1990)⁷ similar to this study 0.5 to 2.2 cm. Intraabdominal lymphadenopathy and central necrosis

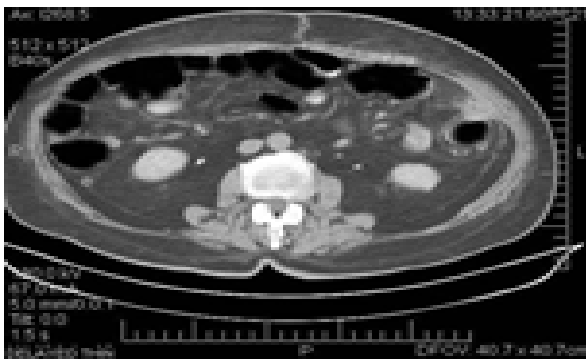
was seen in 81% and 36% respectively in study by Balthazar EJ et al (1990)⁷, whereas 100% and 67% respectively in present study. Thickened bowel segment had homogenous Caecal Tuberculosis



enhancement (64%) and equal incidence (45%) of involvement of symmetry versus asymmetric in study by Balthazar EJ et al (1990)⁷. Equal cases of homogenous and heterogeneous enhancement with predominant symmetric involvement (78%) of bowel wall thickening were noted in this present study. Deformed ileocaecal junction with cicatrized caecum was seen in 45% in Balthazar EJ et al (1990)⁷ study, whereas 45% in this study. Other findings were ascites, peritoneal involvement and splenomegaly as also noted by **Sinan T et al (2002)**⁵. **Alvian Lesnik et al (2006)**⁸ reported that tuberculosis can be confused with colonic carcinoma and radiologists should be aware that infectious granulomatous diseases and tuberculosis should be considered.

Polyps: In our study two cases of polyp were found and both were located in rectum which is commonest site as also seen in the study done by **Don chin jung et al (2004)**⁹.

Diverticulitis: According to **Suwalee P et al (2008)** CT features of includes bowel wall thickness less than 12mm, preserved wall enhancement, the involved segment being more than 10 cm, presence of severe colonic standing and associated diverticula. In Present study both cases of diverticulitis were seen as long segment (10.4cm) of smooth, concentrically thickened, enhancing bowel wall associated with diverticula. Both cases were located in sigmoid colon, which is the **fig. Diverticulitis**



most common site in western population, however in a study done by Yoke sun lee (1987)⁵ was found that in Indians diverticular disease more predominantly involve right colon.

Crohn's disease: One case of crohn's disease was found in ileocaecal region and other case was found in rectum. Both were seen as concentric area of bowel wall thickening showing halo sign with surrounding area of inflammation as described by **Frager et al (1983)**.

Differentiation between Malignant and Benign colonic pathologies:

CT Pneumocolon has been frequently used to differentiate colon malignancy from benign pathologies using following parameters:

1) Degree of colonic wall thickening: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ mild (<2cm) of bowel wall thickening was present mostly in benign pathologies while most of the marked (>2cm) thickening was mostly present in malignant cases. According to **Suwalee P et al (2008)**⁵¹ mild (<1.2cm) thickening indicates benign pathology (diverticulitis) and marked thickening (>1.2cm) indicates colon cancer. In present study it has been found that majority (n=13, 81%) benign inflammatory pathologies produce bowel thickening <2cm with mean wall thickness 1.2cm and majority (n=35, 78%) of the malignancies show wall thickness >2cm with mean wall thickness 2.5cm.

2) Attenuation of thickened colonic wall: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ the stratified type of attenuation more commonly seen in Benign pathologies rather than carcinoma. In present study we found (n=5, 31%) of benign pathologies showing stratified attenuation. No case of malignancy shows such attenuation. Mixed attenuation seen more commonly in carcinoma and indicate high grade malignancy. In present study we found n=36, 80% of carcinoma showing mixed attenuation. Some benign cases n=4, 25% show mixed type of attenuation.

3) Length of colon involved: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ gastrointestinal neoplasm show mostly focal short segment (a few centimetres) involvement while diffuse long segment thickening of bowel wall mostly seen in benign conditions as compared to malignant neoplasms. In present study short segment involvement was seen in most (n=34, 76%) of the malignant pathologies with mean length of involved bowel 4.7cm while most of the (n=11, 69%) benign inflammatory pathologies show long segment involvement with mean length 7.9cm.

4) Pericolonic fat stranding: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ when stranding of the perienteric fat is presented adjacent to a thickened segment of bowel, an inflammatory process should be suspected. In the study done by **Suwalee P et al (2008)**¹¹ pericolonic severe fat stranding was more common in patients with diverticulitis (89.5%) than colonic carcinoma, in most of the cases show mild fat stranding (73.9%). In present study, we found moderate to severe fat standing more commonly in benign patients (n=11, 69%), and in malignant patients we found mild stranding more commonly (n=34, 76%).

5) Pattern of involvement: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ Symmetric thickening is present when the involved segment shows the same degree of thickening throughout the circumference of the abnormal segment. Asymmetric thickening relates to different degrees of eccentric thickening around the circumference of the involved segment. Symmetric thickening is seen in intestinal inflammatory conditions, infections, bowel oedema, and ischemia. Asymmetric or eccentric bowel thickening is mainly seen with malignant conditions. In present study all (100%) Caecal Carcinoma of the malignant tumours were asymmetric whereas benign disease shows symmetric involvement more commonly (75%).

6) Pericolic lymph nodes: In present study enlarged (more than 1cm in short axis diameter) lymph nodes were seen in n=22, 49% cases of malignancy and n=7, 44% cases of benign disease. Both the values are comparable, so involvement of lymph nodes was not found to be better criteria for differentiation. Also in study done by Suwalee P et al (2008)¹¹ all the parameters except presence of lymph nodes were statistically significant in differentiating diverticulitis from colon cancer.

7) Deformed ileocaecal junction: According to **Michael Macarti and Emil J. Balthazar (2001)**¹⁰ deformed ileocaecal junction, cicatrized pulled up caecum are more commonly seen in tuberculosis. In present study deformed ileocaecal junction seen in 25% cases of benign disease and 45% cases of tuberculosis. While it was seen in only one patient of carcinoma.



Colon carcinoma:

Detection and differentiation from benign pathologies: In present study we detected all the 45 colonic carcinomas using CT Pneumocolon. Some of the patient had undergone barium enema and colonoscopy prior to CT Pneumocolon. Barium enema was performed in 25 patients with cancer and 6 carcinomas were missed due to perceptual error, faecal residue and improper study. Colonoscopies were performed in 31 patients with cancer and 24 cases were diagnosed correctly. In the study done by **Harvey CJ et al (1998)**¹² all the 37 carcinomas were detected correctly. Not a single case of carcinoma was missed. Out of 24 barium enemas done in cancer patients 4 cases were missed and out of 29 colonoscopies done in cancer patients, four proximal lesions were undetected as they were present proximally.

In **present study**, we detected all 45 colonic carcinomas correctly and misdiagnosed 3 benign lesions as stage C malignancy due to irregular outer colon wall with opacification and significant lymphadenopathy. So the sensitivity and specificity for differentiating benign from malignant lesion was 100 % (45/45) and 82 % (13/16). The overall accuracy rate was 95 %. In the study done by Harvey CJ et al (1998)¹² all the 37 carcinomas were detected correctly and 2 benign lesions were misdiagnosed as Stage B colonic carcinoma. So the sensitivity and specificity for differentiating benign from malignant lesion was 100 % (38/38) and 86 % (13/16). The overall accuracy rate was 96 %.

In **present study**, 4 cases of mucinous adenocarcinoma were seen as heterogeneously enhancing large eccentric masses with some showing intra-tumoral calcification Mucinous Adenocarcinoma.

Distribution of metastasis and morphological types:

Most common site for metastasis other than lymph nodes were found to be liver (n=7/7, 100%) followed by lung (n=2/7, 29%), peritoneum and abdominal wall. In morphology, annular type (n=29, 65%) was most common followed by polypoidal and plaque like.



Staging:

Sensitivity and specificity for local serosal invasion were found to be 97 % (39/40) and 40 % (2/5) and for lymph nodal involvement were found to be 70 % (19/27) and 83 % (15/18). Overall staging accuracy was 66% (34/45).

In the study done by **Harvey CJ et al (1998)**¹² sensitivity and specificity for local serosal invasion were found to be 100%(35/35) and 33%(1/3) and for lymph node involvement were found to be 56%(9/16) and 95%(21/22). The overall staging accuracy was 79 % (30/38).

Disadvantages of the technique includes lack of histology, poor polyp detection (<5mm) rate and lack of mucosal detail.

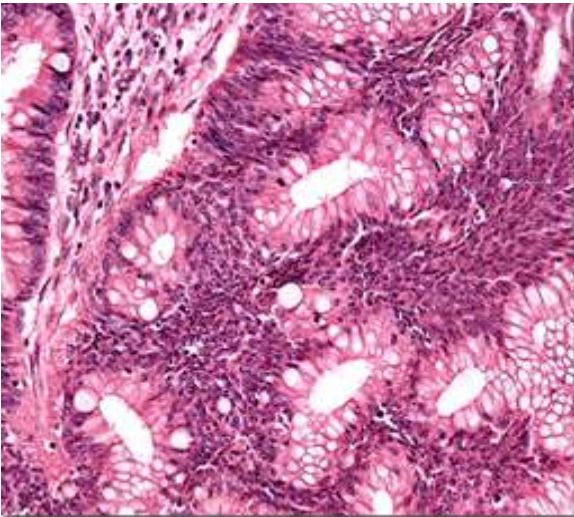
A case of Sigmoid Adenocarcinoma:



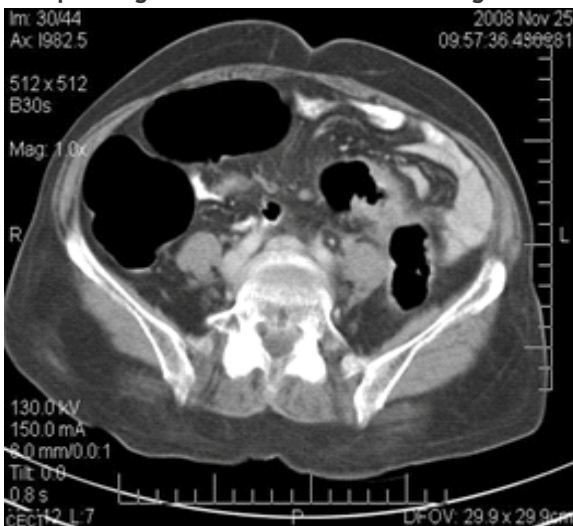
Irregular stricture in sigmoid colon seen on barium enema



Colonoscopy Sigmoid showing growth



Histopathological slide of Adenocarcinoma of sigmoid



Stricturous annular growth of sigmoid with pericolic fat involvement

Conclusions:

1) Helical CT Pneumocolon is highly sensitive for the detection of colonic malignancy.

2) It seems to be helpful in differentiating malignant from benign colonic lesions with the help of appropriate analysis of degree, length and pattern of bowel wall involvement, pattern of wall enhancement, pericolic fat stranding and deformed ileo-caecal junction and other miscellaneous findings. It gives overall accuracy of 95% in differentiating benign from malignant.

3) It can also characterise malignant lesions and help to differentiate adenocarcinoma into mucinous and non-mucinous subtypes. It helps to characterise the benign lesions and also helps to differentiate them into infective (tuberculosis), inflammatory, diverticular, polypoidal and vascular origins.

4) It is helpful in staging of colonic cancer. Staging accuracy was found to be 66% in this study.

Helical CT Pneumocolon appears to be a non-invasive and a rapid investigation that shows clearly the lumen of the colon, wall of the colon, surrounding structures, extra luminal component of colonic lesions and metastasis and provides valuable information preoperatively. In addition it is less operator dependent and well tolerated by patients and technically easy.

References:

- Mohandas KM, Desai DC. Epidemiology of digestive tract cancers in India. V. Large and small bowel. *Indian J Gastroenterol*. 1999 Jul-Sep;18(3):118-21.
- Sinha R, Anderson DE. Cancer risk and diet in India. *J postgrad Med*. 2003 Jul-Sep;49(3):222-8.
- Xiong L, Chintapalli KN, Dodd GD et al. Frequency and CT patterns of bowel wall thickening proximal to cancer of the colon. *AJR Am J Roentgenol*. 2004 Apr;182(4):905-9.
- Harisinghani MG, Wittenberg J, Blake MA et al. Halo sign: useful CT sign for differentiating benign from malignant colonic disease. *Clin Radiol*. 2003 Apr;58(4):306-10.
- Sinan T, Sheikh M, Ramadan S et al. CT features in abdominal tuberculosis: 20 years experience. *BMC Med Imaging*. 2002 Nov 12;2(1):3.
- Yoke Sun Lee. Diverticular disease of large bowel in Singapore. Volume 29, Number 5/may, 1986:330-335.
- Balthazar EJ, Gordon R, Hulnick D. Ileocecal tuberculosis: CT and radiologic evaluation. *AJR Am J Roentgenol*. 1990 Mar;154(3):499-503.
- Alvin Silva, Amy K Hara et al. CT Colonography with Intravenous Contrast Material: Varied Appearances of Colorectal Carcinoma. September 2005 *RadioGraphics*, 25, 1321-1334
- Don Jin Chung, Kyu Chan Huh et al. CT Colonography using 16 MDCT in the evaluation of colorectal cancer. *AJR* 2004; 184:98-103
- Michael Macari and Emil J. Balthazar CT of bowel wall thickening Significance and Pitfalls of Interpretation. *AJR* 2001; 176:1105-1116.
- Suwalee P, Yutthaphun Wannasopha. Differentiation of CT appearance between diverticulitis and colon cancer. Using thin sectional 16 slice MDCT. *Chiang Mai Medical Journal* 2008; 47(3):105-113.
- Harvey CJ, Amin Z et al Helical CT pneumocolon to assess colonic tumors: Radiologic Pathologic correlation *AJR* 1998; 170:1439-1443.
- Kirklın JW, Dockerty MB, Waugh JM. The role of the peritoneal reflection in the prognosis of carcinoma of the rectum and sigmoid colon. *Surg Gynecol Obstet* 1949;88: 326-331.
- Dukes CE. The classification of cancer of the rectum. *J Pathol Bacteriol* 1932;35:323-332