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Comparative Study between Low dose Virtual Colonoscopy (CT Colonoscopy) and Conventional Colonoscopy in Colorectal Tumors and Tumor like lesions

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ABSTRACT:

Purpose: to assess the role of low dose CT colonography (virtual colonoscopy) as a non-invasive imaging technique in detection and diagnosis of colonic lesions using optical colonoscopy and / or operative findings as a reference standard, as well as highlighting its advantages and possible pitfalls.

Methods: sixty-one patients were examined by low dose CT after standard bowel preparation, rectal insufflation and IV contrast injection. Imaging was performed in both supine and prone positions. Evaluation consisted of review of the transverse CT images, sagittal and coronal reformations and 3D endoluminal images. CT colonographic findings were correlated with standard conventional colonoscopic and/or operative findings.

Results: Low dose virtual colonoscopy identified over all 12 malignant colonic masses with sensitivity about 100 %, 4 polyps out of 5 polyps measured ≥10 (80 %), 2 polyps out of 3 polyps measured 6-9 mm (66.6 %), 2 polyps out of 4 polyps measured 1-5 mm (50%). The overall sensitivity of polyp detection was 66.7 % with 5 false positive and 4 false negative polyps. The overall sensitivity and specificity of low dose virtual colonoscopy were 88.6 % and 70.5 % respectively. The positive predictive value was 88.6 %, negative predictive value was 70.5 % and accuracy was 83.6 %.

Conclusion: Low dose CT colonography has high sensitivity for the detection of clinically important polyps and cancer as well as multiple advantages over conventional colonoscopy in imaging of colorectal neoplasms.

Introduction and aim of work.

Colorectal carcinoma is among the leading causes of malignancy related deaths in the world. Because of the natural history of the progression from colorectal polyp to carcinoma, with most frank colo-rectal cancers arising from pre-existing polyps, early and prompt diagnosis can have a significant effect on patient mortality ***(1)***. Not only will detection and removal of precursor adenomas result in a decrease in the incidence of colorectal cancer, frank colo-rectal neoplasia has a great potential for cure when detected at an early stage.

There is a continued search for method of early detection of colorectal neoplasms that is cost- effective, safe, and acceptable to patients. Current methods used to detect colorectal polyps and colonic cancer include sigmoidoscopy, colonoscopy, The effectiveness of each modality remains controversial, and each method has inherent limitations ***(2)***.

Though colonoscopy is currently considered the reference standard for the detection of colorectal neoplasia it has various potential limitations. First, up to 10% of colonoscopic examinations are technically difficult even for experienced colonoscopists. including poor bowel preparation, redundant colon, colonic spasm, marked diverticulosis, obstructing masses or strictures, and angulation or fixation of colonic loops, most commonly due to previous pelvic surgery. Second, it does not allow evaluation of the liver and other organs outside the colon. In addition, it has a blind area, as a colonoscope passes in only one direction. For example, the opposite side of a colonic fold cannot be evaluated exactly. Finally, it is invasive and uncomfortable ***(3)***.

Mahmoud Farag *et al*Therefore, computed tomographic (CT) colonography, or "virtual colonoscopy," has rapidly emerged as a fast, less invasive, accurate, and well-tolerated approach that can photograph the whole colon and accurately identify colonic neoplasms. A CT examination of the completely prepared and air-dilated colon is referred to as a CT colonography. Within a few seconds to minutes of scanning and a maximum of 15 minutes of examination time, volumetric CT data throughout the colon are obtained. These data are used

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with sophisticated imaging software to study the colon at an offline workstation utilizing a combination of 2D and 3D pictures. (4).
The main disadvantage of CTC remains the use of ionizing radiation. This topic becomes of particular interest when CTC is proposed as a screening tool. Therefore, new strategies to keep the dose as low as reasonably achievable, without significantly sacrificing image quality, are strongly advisable. (4).

Actually, the CTC dose is about one-half of that from a conventional CT examination and in 2016 American College of Radiology recommended a radiation dose not exceeding 10 mSv, the high natural contrast between the luminal gas, the soft tissue of the colonic wall or lesions, and residual tagged feces and fluids allow to use lower dose settings without compromising the core task of CTC, which is the detection of cancer and polyps (5).

In this context, dose can be further reduced in CTC examinations by using automatic tube current modulation (ATCM), that automatically adjusts the x-ray tube current (mAs) according to the size and attenuation characteristics of the body parts being examined and the scan plane (5).

The aim of this study is to assess the role of CT colonography (virtual colonoscopy) as a non- invasive imaging technique in detection and diagnosis of colorectal neoplasia using conventional colonoscopy and/or operative findings as a reference standard, as well as highlighting its advantages and possible pitfalls.

Patients and methods

This study included 61 patients thought to have colorectal lesions .

Inclusion criteria:

Patients of either sex with findings or symptoms suggestive of colonic or rectal lesions such as hematochezia, stools with a positive hemoccult test, iron deficiency anemia, alteration of bowel habits.
Personal or family history of colonic neoplasms

Exclusion criteria:

Pregnant or lactating females
Patients known to have elevated serum creatinine levels more than 1.5mg/dl and not on regular dialysis.

All CT colonography examinations were followed by conventional colonoscopy and / or surgery depending upon clinician's recommendations and accordingly findings at the colonoscopy and / or the surgery were considered as a reference standard.

Image acquisition

All CT examinations were performed on a 64 MDCT at a private radiology clinic. Prior to the examination all the patients were subjected to
consent writing and history taking. The day before the CT examination was scheduled to be performed all patients underwent standard bowel preparation that typically consisted of a clear liquid diet, an orally administered laxative, a cathartic colon preparation, and an enema. Patients were asked to fast 6 hours before the examination.

All patients underwent rectal room air insufflation on the CT table using a standard enema tube. After confirming a scout image that showed appropriate distention of all colonic segments, 50–75 ml of iodinated contrast agent (iopromide; Ultravist 300) was injected intravenously. The patient was then placed in a supine posture, and CT scanning was initiated in the cranio-caudal direction. Following completion, the patient was flipped to the prone position, and the scanning process was resumed. While the data was being collected, patients were urged to hold their breath. Or undergo superficial respiration to avoid motion artifacts.

Technical parameters

Scanning was performed 64 channel MSCT scanner. The scanning parameters were as follows beam collimation 0.75 mm, a pitch of 1–
1.5. CT scanning was performed at 120 kVp,
40-60 mAs (according to patient size, and by using tube current modulation), 600 msec gantry rotation time. Image reconstructions were performed with 1 mm reconstruction thickness with 0.7 mm reconstruction intervals. Effective Dose 5.5-6.7 mSv(sum of supine and prone)

Image processing and data interpretation

The axial images of the patients were then transferred to a workstation for computer post- processing using commercially available software that provides surface and volume renderings. The processed images included sagittal and coronal two-dimensional (2D) reformatted as well as three-dimensional endoluminal images which were viewed continuously providing an endoscopic like examination.

The evaluation consists of initial review of the magnified 2D transverse CT images followed by review of the endoluminal images in the interactive (fly-through) mode, as well as the reformatted coronal

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and sagittal 2D CT images.

The transverse and reformatted coronal and sagittal 2D CT images were displayed alongside the endoluminal images in a four-quadrant display format to allow easy verification of any identified lesion on all images . Endoluminal viewing was performed in both antegrade and retrograde directions and with the patient in both supine and prone positions to avoid blind areas.

The results of CT virtual colonoscopy of the patients were compared with the findings of conventional colonoscopy and/or surgical findings regarding:

- Site of the lesion
- Size of the lesion
- Appearance (morphology) of the lesion
- Extra-luminal extension if any
- Other incidental colonic findings, if any such as colonic diverticular disease, etc.
- Extra-colonic manifestations .

Results

This study involved 61 patients thought to have colorectal lesions. 35 patients were women and 26 were men with a mean age of 55.

Virtual colonoscopy and conventional colonoscopy were performed on all of the 61 patients. Only six out of the sixty patients underwent surgery. The entire colon was seen by the virtual colonoscopy in the 61 patients while complete visualization of the colon by conventional colonoscopy was possible in 59 patients as two patients had an obstructing mass lesion hindering the passage of the colonoscope to the more proximal colonic segments.

Conventional colonoscopy

Of the 61 patients, 12 patients had normal findings, on the other hand 2 patients have more than one lesion We reported 51 colonic lesions in other 49 patients as follow: 12 polyps, 15 malignant masses, 15 inflammatory changes,7 diverticulae, 1 volvulus and 1 elongated colon.

A total of 12 polyps, 4 polyps measured 1-5 mm in diameter, 3 measured 6-9 mm in diameter and 5 polyps measured 10mm or larger.as shown in (Table 1).

Table 1: Number of Polyps by size at colonoscopy

Polyp Size (mm)	Number of Polyps
1-5 mm	4
6-9 mm	3
≥10 mm	5

15 carcinomas were pathologically proven as adenocarcinomas and are located as shown in **Table (2).**

Colonoscopy was complete in 59 patients. The two cases where the colonoscopy was incomplete were due to the presence of an obstructing carcinoma.

Table 2: Segment Location and Number of cancers

Rectum	2
Sigmoid colon	6
Descending Colon	1
Splenic flexure	-
Transverse Colon	1
Hepatic flexure	1
Ascending Colon	2
Caecum	2

Virtual colonoscopy

The findings at virtual colonoscopy were compared to conventional colonoscopy findings which were considered as the reference standard by using two different methods: the direct by- polyp comparison and by- patient comparison.

By using direct by- polyp matching, which took into account polyp size and location for identification and matching of polyps when comparing the results with findings of conventional colonoscopy, that is a polyp noted at virtual colonoscopy was considered to have matched with a polyp seen at conventional colonoscopy when it was located in the same or adjacent segment and was of similar size, 8 polyps of the 12 polyps detected by fiberoptic colonoscopy were correctly identified by low dose virtual colonoscopy giving an overall sensitivity rate of 66.7% for polyp detection by low dose virtual colonoscopy.

The sensitivity of polyp detection by low dose virtual colonoscopy according to size of the polyp was as follows:

2 of 4 polyps measuring between 1-5 mm were detected by low dose virtual colonoscopy with a sensitivity of 50%.

Out of the 3 polyps measuring 6-9 mm in diameter 2 polyps were correctly identified by low dose virtual

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colonoscopy with a sensitivity of 66.6%.
The highest sensitivity for low dose virtual colonoscopy at detection of polyps was for polyps measuring 10 mm or larger where 4 out of 5 polyps were accurately identified by low dose virtual colonoscopy with a sensitivity of about 80% . as shown in **Table (3).**

Table 3: Polyp Detection Rate at CT Colonography

Polyp Size (mm)	Number of	Sensitivity
1-5 mm	2/4	50 %
6-9 mm	2/3	66.6 %
≥10 mm	4/5	80 %

Virtual colonoscopy had a 100% (6 of 6) sensitivity for the detection of carcinomas.

Low dose virtual colonoscopy demonstrated 5 false positive polyps. These false positive

findings were in colonic segments containing residual fecal matter and in regions of thickened and complex haustral folds which were misinterpreted as polyps. As shown in **(Table 4).**

Table 4: False positive Polyps related to Poor preparation and Complex haustral folds at CT Colonography

Polyp Diameter (mm)	Poor Preparation	Complex Folds
1- 5 mm (n=4)	2	-
6-9 mm (n=6)	1	1
≥10 mm (n=1)	-	1

Low dose virtual colonoscopy did not reveal 4 polyps out of the 12 polyps identified by fiberoptic colonoscopy (false negatives). 2of these missed polyps measured between 1-5 mm in diameter, 1of these polyps measured between 6-9 mm and 1 measured more than 10 mm.
These false negative findings were in fluid filled colonic segments, and in regions of collapsed bowel segments.as shown in **(Table 5).**

Table 5: False Negative Polyps related to Poor Preparation and Poor Colonic Distention

Polyp Diameter (mm)	Poor Preparation	Poor Distention
1- 5 mm (n=20)	1	1
6-9 mm (n=4)	-	1
≥10 mm (n=1)	1	-

Results of low dose virtual colonoscopy were also analyzed on a per-patient basis. In this assessment, the findings at low dose virtual colonoscopy and at fiberoptic colonoscopy were considered to coincide if both studies showed at least one colonic lesion or if didn't show any colonic lesions.
Only the presence of at least one colonic lesion (neoplastic, inflammatory …etc.) was considered. The size, number and location of lesions was not used in determining study concordance.
When results of low dose virtual colonoscopy were analyzed according to this method of by- patient comparison, the performance of low dose virtual colonoscopy improved that :
12 patients were free of colonic lesions by low dose virtual colonoscopy; that is true negatives, with 5 false positive cases.
39 patients had a colonic lesions by low dose virtual colonoscopy; that is true positives, with 5 false negative cases.
The overall sensitivity and specificity were 88.6% and 70.5% respectively. The positive predictive value was 88.6%, the negative predictive value was 70.5% and accuracy was 83.6 %.
Virtual colonoscopy detected 35 incidental extracolonic findings in 25 patients distributed as seen in the following table **(table 6)**

Table 6: showing diagnoses and number of extracolonic findings detected by CT colonography.

Incidental extracolonic	Number
Liver Cirrhosis	2
Splenomegaly	2
Gall Stones	5
Intussusception	1
Hepatic Deposits	2
Lung Deposits	1

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Para-aortic	1
Bowel containing	2
Fat containing inguinal	4
Retroperitoneal	1
Renal Cysts	6
Uterine fibroid	3
Aortic atherosclerosis	5

Discussion

In this study which involved 61 patients low dose CT colonography accurately detected all the 15 invasive carcinomas detected by the conventional colonoscopy giving a sensitivity rate for detection of carcinomas of 100%. Results showed that a greater number of left sided colonic lesions detected, matching with the commonly upheld opinion that colorectal malignancy is invariably more common at the left sided colonic segments. These results coincided similarly with those of a study performed by Bai W. et al ***(1)*** .

Histologically, most colon carcinomas arise from the mucosal lining and are adenocarcinomas ***(1).*** This was also consistent with the findings of our study where all of the 15 invasive carcinomas detected were proven histologically to be adenocarcinomas. Their appearance and clinical behavior depend on where they originate. In their study of the varied appearances of colorectal carcinoma Chang et al.***(2)*** reported that left-sided lesions form annular masses, which tend to be diagnosed earlier because they cause obstruction. Right-sided lesions are generally diagnosed later because of the relatively larger caliber of the right colon, and they tend to grow into polypoid fungating masses with a propensity for necrosis. Likewise, lesions in our study behaved similarly where almost all right sided lesions assumed the form of polypoidal outgrowths of variable size, whereas those arising on the left side were invariably represented by either focal or more extensive circumferential wall thickening compromising the colonic lumen to variable degrees.

Contrast material enhanced CT colonography has the potential advantage of providing images of the bowel wall, extracolonic tissues and the liver in one setting, therefore it can be used to stage colorectal cancers which cannot be performed by conventional colonoscopy.

Colorectal carcinomas are clinically staged by using the modified Astler-Coller-Dukes staging system or the TNM system established by the American Joint Committee of cancer. While CT colonography does not allow differentiation of a carcinoma confined to the mucosa from that invading the submucosa and thus cannot be used to differentiate stages T1 and T2 (coinciding to stages A and B1 of the modified Astler-Coller- Dukes staging system), it can reliably stage higher grades of colorectal cancer ***(1).***

This was true in our study where out of a total of 15 patients with colorectal carcinoma, using the modified Astler-Coller-Dukes staging system, 14 patients were accurately staged by CT colonography, with only one patient being incorrectly staged. Findings were as follows:

- 7 patients were accurately diagnosed as stage B2 (coinciding to T3N0M0), where the CT colonography images showed a poorly defined peripheral wall with a rounded or nodular margin and pericolic fat infiltration or a pericolic mass.

- 4 patients were accurately diagnosed as stage C (coinciding to any T N1or2 M0), where the CT colonography images showed enlarged or clustered small pericolic lymph nodes.

- 3 patient was accurately diagnosed as stage D (coinciding to any T, any N, M1), where the CT colonography images showed distant metastasis or direct local invasion.

Only 1 patient was incorrectly staged by CT colonography. This patient was under-staged where the CT images showed a well-defined peripheral wall with clear adjacent fat suggesting stage A whereas the histopathological examination following surgery accurately put them at stage B1 (coinciding to T2N0M0), thus underlining the inability of CT colonography to accurately differentiate a tumor confined to the mucosa from one actually invading the submucosa as previously mentioned.

With synchronous colon cancers or precancerous colonic polyps occurring in approximately 5% of cases with diagnosed colorectal cancer as cited by **O'Shea** ***(5),*** it becomes of utmost importance to evaluate the entire colon. This is especially important in cases with an obstructing carcinoma, beyond which the conventional colonoscope fails to pass. **Ricci** et al ***(6),*** reported that their study findings indicated that CT colonography is an accepted technique for evaluation of the non- visualized part of the colon after incomplete colonoscopy and that it can increase the diagnostic yield of masses and clinically important polyps in this part of the colon. The same situation was encountered in our study where 1 of the patients with colorectal carcinoma had an obstructing

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mass at the level of the transverse colon with failure of passage of the colonoscope beyond this level. In this patient complete evaluation of the proximal colon was possible with CT colonography where the presence of any clinically significant synchronous lesions was ruled out as none were detected.

Results of several studies evaluating CT colonography showed promise in the ability of virtual colonoscopy to detect colorectal polyps. Our study revealed a sensitivity of 50%, 66.6% and 80% in detection of polyps in measuring 10mm or more, 6-9 mm and 1-5mm respectively. This coincided similarly with results of several large studies whose sensitivity values for polyp detection lie within close range. In a study involving 300 patients Chang et al ***(2)*** showed that the sensitivity was 90% (74 of 82) for the detection of polyps 10 mm or larger, 80.1% (113 of 141) for polyps 5.0–9.9 mm, and 59.1% (178 of 301) for polyps smaller than 5 mm. In the largest study performed to date, recruiting a total of 1233 adults Pickhardt et al.

(7) reported sensitivity values 93.9% ,93.8% and 88.7% for polyps at least 10mm , 8mm, and at least 5 mm in diameter respectively . Fenlon et al ***(8),*** in a study involving 100 patients, demonstrated CT colonography to have a sensitivity of 91% for polyps that were 10mm or larger and 82% for polyps that were 6-9mm in size.

As can be expected, the performance of virtual colonoscopy is highly dependent on the size of the lesion, with rate of detection of polyps decreasing as size of the lesion decreases. However, the clinical importance of these small lesions and the importance of their detection is questionable. Macari et al ***(9)*** cited that up to as many as 90% of all colorectal carcinomas develop from benign adenomas through a series of genetic alterations. Unfortunately, however, most imaging studies cannot predict the histology of colorectal lesions. The imaging criterion that has primarily been used to determine clinical significance is size. Size has been shown to be the most simple and practical indicator of polyp abnormalities and is closely related to the degree of dysplasia in the lesion. Cianci et al ***(3)*** and Macari et al ***(9)*** both reported that the majority of diminutive polyps, those measuring 5mm or smaller, are not adenomas, but more often these small lesions represent hyperplastic polyps or normal mucosal tags at histological assessment that have no clinical potential to become cancer, hence negating the importance of their detection. However, some controversy exists. Macari et al ***(9)*** reported that in a study of 1,048 colorectal polyps measuring up to 6 mm, researchers found that 61% were neoplastic (adenomas); the remainder were divided equally between hyperplastic polyps and normal colonic mucosa

.Nevertheless, the authors also reported that most diminutive adenomas never progress through the complete adenoma carcinoma sequence. In fact, in that cohort of polyps, the incidence of carcinoma was extremely low, 0.1%.. According to Macari et al ***(9)*** analysis of data from the National Polyp Study shows that an average of 5.5 years is required for the transformation of a large adenomatous polyp into cancer. An average of 10 years is needed for the smallest polyps to develop into cancer. Thus, in light of the above, the importance of detection of small polyps by CT colonography is not paramount as the vast majority of these lesions are benign with no malignant potential. As for those diminutive lesions unfortunate enough to have malignant potential, if an appropriate screening and surveillance interval were established for CT colonography, small

adenomas that could be missed by colonography and should subsequently increase in size would be detected on follow up studies before they reach the stage of invasive carcinoma. Macari et al ***(9)*** suggested that in patients with normal findings on CT colonography examinations, follow-up imaging is recommended in 5 years.

Other than the size of the lesion, two other commonly encountered causes of false negative results in this study were residual fluid and collapsed bowel segments.

In our study 4 of the false negative polyps, i.e., those detected by conventional colonoscopy and not by virtual colonoscopy were in fluid filled segments of the bowel. They could not be detected on either prone or supine images, owing to the large amount of fluid present that could not shift enough to allow for adequate mucosal visualization. In presence of smaller amount of fluid, however, adequate mucosal visualization is achieved via careful evaluation of both prone and supine image sets. These findings were in concordance with those reported by Mang et al ***(10)*** in their assessment of the pitfalls encountered in CT colonography. They cited that residual fluid obscures colonic lesions and leads to perceptual errors. Because of gravity, residual fluid is always found more commonly in the descending colon and rectum with the patient in the supine position, whereas they reported that the fluid moves to the transverse colon with the patient in the prone position. Consequently, they stressed the importance of performing CT colonography with the patient in both prone and supine positions, which will shift any retained fluid into other colonic segments, rendering hidden

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lesions visible. However, if large amounts of fluid are present, visualization of the entire mucosa may not be guaranteed at prone and supine imaging, as was also depicted in this study.

A further cause of false negative results met with in this study was colonic under-distention. As reported by Mang et al ***(10)***, optimal colonic distention is a necessary pre-requisite to accurate CT colonographic data interpretation, as under-distention leads to luminal narrowing or colonic segment collapse which results in lesions going undetected. They stated that the diagnostic performance of virtual colonoscopy.

can be improved by evaluating both prone and supine image sets, as gas tends to move to the highest part of the colon. Commonly, the left colon, rectum and sigmoid colon are collapsed when the patient is supine, whereas the transverse colon is often collapsed when the patient is prone. In this study 2 of the polyps detected by conventional colonoscopy and missed by virtual colonoscopy were in collapsed bowel segments that failed to adequately distend even after patient repositioning, highlighting the importance of ensuring adequate bowel distention of all colonic segments on the initial scout view and re-distention of any collapsed segment with rectal insufflation of additional gas.

There was a total of 5 false positive results, representing those lesions detected by virtual colonoscopy and not on conventional colonoscopy in this study.

Analysis of results and retrospective evaluation of CT images revealed that 3 of these lesions were in poorly cleansed bowel segments containing residual fecal matter which was mistakenly diagnosed as polypi in these cases. The remaining 2 false positive lesions were in areas of complex haustral folds which were inaccurately diagnosed as polyps.

As can be inferred from the above, the commonest cause of false positive findings in this study was residual fecal matter. Similarly, in the study performed by Macari et al ***(11),*** they reported that residual fecal material accounts for the vast majority of false positive findings at CT colonography. They cited that through careful evaluation of several characteristics, it is possible to differentiate residual stool from true polyps. Retained stool often contains incorporated air that can be recognized at CT as a heterogeneous filling defect on 2D images. A lack of wall attachment and movement of the suspected lesion on supine and prone images also indicate the fecal nature of the suspected abnormality. Colorectal polyps have homogenous soft tissue attenuation without intra-tumoral air. Despite these differentiating points cited by Macari et al ***(11),*** which allowed us to properly differentiate polypi from residual stool in many cases in this study, however some lesions displayed overlapping features giving

rise to misdiagnoses and false positive results. Residual fecal material occasionally, appeared homogenous internally and was adherent to the colonic wall thereby simulating polyps and was falsely diagnosed as such.

2 of the false positive lesions encountered in this study were in areas of bulbous and irregular inter-haustral folds, namely along the short limb of hepatic and splenic flexures, and in poorly or inadequately distended colonic segments. Though in many instances scrolling through contiguous axial images at the workstation, revealed the linear nature of the fold, further confirmed by viewing the endoluminal images which provided an en face view of the mucosa that was helpful in distinguishing between the round shape of polyps and the longitudinal structure of folds, this was not possible in all cases. In poorly distended colonic segments especially where colonic folds were originally of a more complex nature, such as those mentioned above, continuous navigation through the colon was difficult leading to false positive diagnosis of complex and thickened folds which appear as rounded or polypoid lesions on 2D images as polyps. Likewise, complex inter-haustral folds were mentioned as a common cause of false positive results by a lot of studies including those performed by Mang et al ***(10)*** and Macari et al ***(11).***

As cited by **Mang *et al.* *(4)***, the ability to evaluate the extracolonic organs of the entire abdomen and pelvis, in addition to assessing the colon, is an important benefit inherent in CT colonography. No other colorectal screening examination has this use. Since the vast majority of the patients likely to be referred to virtual colonoscopy are likely to belong to the older age group, other abdominal diseases are likely to be encountered incidentally. The potential for saving many lives by detecting life-threatening lesions in organs outside the colon in the course of colon screening is real and is an exciting potential benefit.

In our study a total of 35 incidental extracolonic findings were detected. While some of these findings were of significant clinical importance such as intussusception, hepatic and lung metastatic deposits, most were of moderate or low clinical importance such as splenomegaly, and gall stones. Whether the findings were of high clinical importance necessitating surgical interference or radio and chemotherapy or simply requiring medical treatment and follow up, the ability to evaluate the entire abdomen and the pelvis in the course

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of a colonic examination holds the promise for earlier detection at a more curable stages.

Low Dose CT colonography techniques

The Health Physics Society in 2016 stated that below an exposure of 100 mSv, the observed radiation effects in people are not statistically different from zero. If one assumes a CTC dose of 5 mSv, the theoretic risk of cancer induction at the initial screening age of 50 is 0.04%, dropping to 0.02% by age 70.These numbers are pretty small Compared with a 5% lifetime risk of developing colon cancer (3).
Many ways to decrease the exam dose were modulated including:

Reduce Tube Current (mAs)

The easiest and most straightforward way to reduce radiation dose is by reducing the tube current (mAs), as the dose decreases linearly with a reduction in mAs. However, the limitation of tube current reduction is the concomitant increase in image noise. Multiple studies have shown aggressive reductions in mAs, to as low as 10 mAs, are possible without an effect on the accuracy of polyp detection***(3)***..

Automatic Dose Modulation

Automatic dose modulation (also known as automatic exposure control), which varies radiation output on the basis of the size, shape, and composition of the patient. More specifically, this technique varies the radiation output by the position of the CT tube in relation to the patient, with the largest reductions in same output made in the lateral versus AP projections. A variation of automatic dose modulation is organ-based tube current modulation, where radiographs incident upon more radiosensitive portions of the body (such as in the anterior projection for breast tissue or testes) are reduced and compensated by increases in the opposite projection (i.e. posterior) ***(3)***.

Reduce Tube Voltage (kVp)

Although radiation dose decreases linearly with tube current, it decreases to a near exponential extent (by a power of 2.6) with reductions in peak tube voltage (kVp).In addition to dose reduction, reducing tube voltage also increases the measured attenuation of fecal/fluid tagging agents as the kVp more closely approaches the K-edge of iodine and barium (33.2 and 37.4 keV, respectively). This increases the contrast between and conspicuity of submerged polyps and tagged fluid. However, decreasing kVp also leads to a proportionately greater increase in image noise compared with reducing mAs. However, contrast to noise ratio (CNR) between tagged fluid and polyps is largely maintained ***(3)***.

Iterative Reconstruction

Iterative reconstruction techniques have now become available on most current generation CT scanners and results in significantly lower image noise in CT image reconstruction over traditional filtered back-projection techniques, This technique goes by various trade names including ASiR, ASiR-V, Veo, iDose4, IMR, IRIS, SAFIRE, ADMIRE, AIDR.
As the image is iteratively reconstructed using sophisticated statistical and algebraic reconstruction algorithms, significant computational power and time are required depending on the algorithm employed, usually ranging between 5 and 45 minutes for an abdomen/pelvis CT. When used for CTC, a 50% to 75% reduction in radiation dose is possible without an effect on image quality. For example, when reducing kVp from 120 to 100 for CTC on a GE scanner, an adaptive statistical iterative reconstruction (ASiR) setting of approximately 50% can mitigate the resultant increase in image noise to a level comparable to filtered back-projection. Reductions in beam hardening and streak artifacts related to tagged fluid and bone are also possible, as is a future potential to increase spatial resolution ***(3)***.
In our study we decreased the effective dose about (30-40% of usual CTC dose) to 5.5-6.5 mSv by decreasing the effective mAs to 40-80mAs (in comparison to 90-110mAs in usual dose) ,and justifying the length of examined to include only the colon to decrease the exposure dose also by using the tube current modulation.

Conclusion

The results of our study show that low dose CT colonography is a sensitive test for detection of clinically important polyps measuring 10mm or larger and can reliably depict colorectal carcinoma. Its main limitation is it's lower sensitivity for smaller polyps, yet if patients undergo routine interval screening at suitable time intervals, missing small lesions is likely to be clinically insignificant. Among other disadvantages of CT colonography at this point includes the need for bowel preparation similar to that for standard

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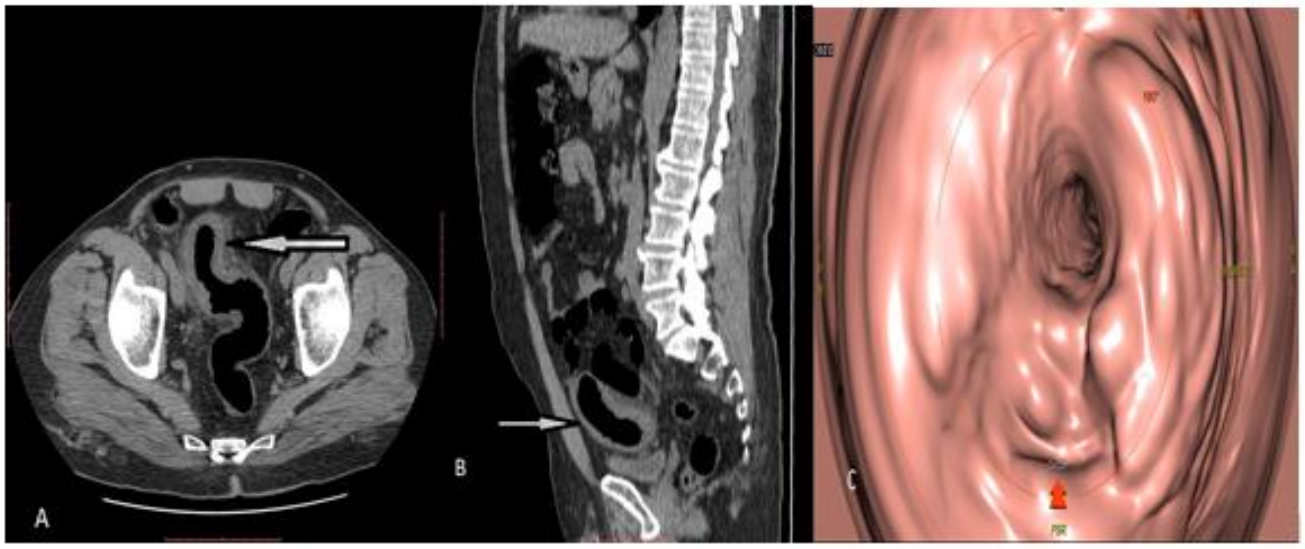
colonoscopy. Poor colonic distention or preparation limits the accuracy of CT colonography, however it is encouraging that technical problems related to retained fluid, residual stool, and incompletely distended segments of the colon can often be corrected by careful evaluation of both prone and supine sets of images. Prone imaging in combination with supine imaging will readily move colonic fluid and often will move retained stool into opposite parts of the colon. Nevertheless, measures undertaken to ensure proper colonic distention and preparation remains necessary to improve the diagnostic performance of CT colonography. Advantages of CT colonography compared with conventional colonoscopy include a shorter procedural time, less risk to the patient, and no need for intravenous sedation. Furthermore, CT colonography may be more accurate in precise localization of lesions, can evaluate the colon proximal to an obstructing lesion, reliably stage advanced invasive colorectal malignancy and can detect incidental extracolonic findings of clinical importance. Finally , it is important to note that by having a non-invasive tool available for colorectal examination, more patients will ultimately undergo colorectal examination, thereby leading to increased detection and ultimately removal of clinically important pre-cancerous lesions.

Cases

Case 1: Male patient 63 years old, complaining from lower abdominal pain . Axial and sagittal CT images **(A & B)** show circumferential mural thickening at the sigmoid colon (arrows), endoluminal low dose CT virtual colonoscopy **(C)** shows intra-luminal cauliflower mass, 3D colon map **(D)** shows luminal stricture (arrows), optical colonoscopic image **(E)** shows the same cauliflower mass.



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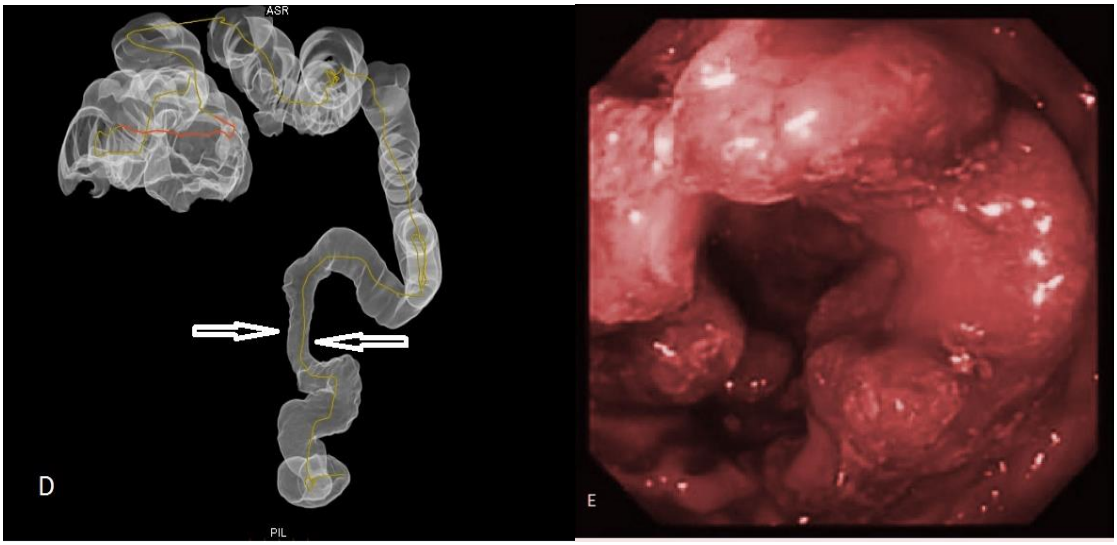

Case 2:

Male patient 68 years old, complaining from chronic constipation Axial CT images **(A, B)** show two pedunculated polyps, endo-luminal low dose CT virtual colonoscopy (**C**) images shows pedunculated polyp measuring about 9 mm arising from its haustral folds of the caecum (virtual image). Fiberoptic colonoscopy image (**D**) shows the same polyp.

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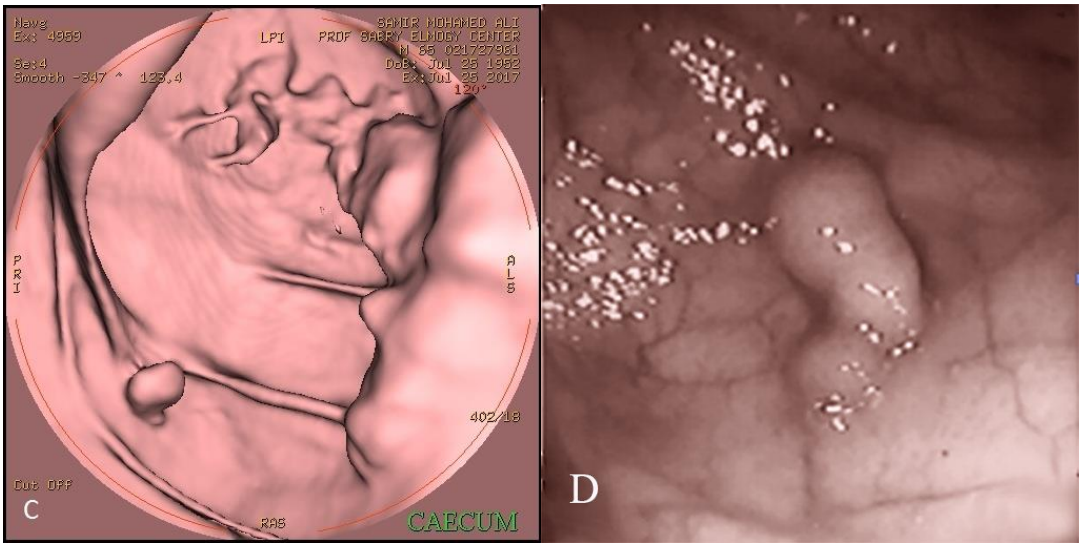
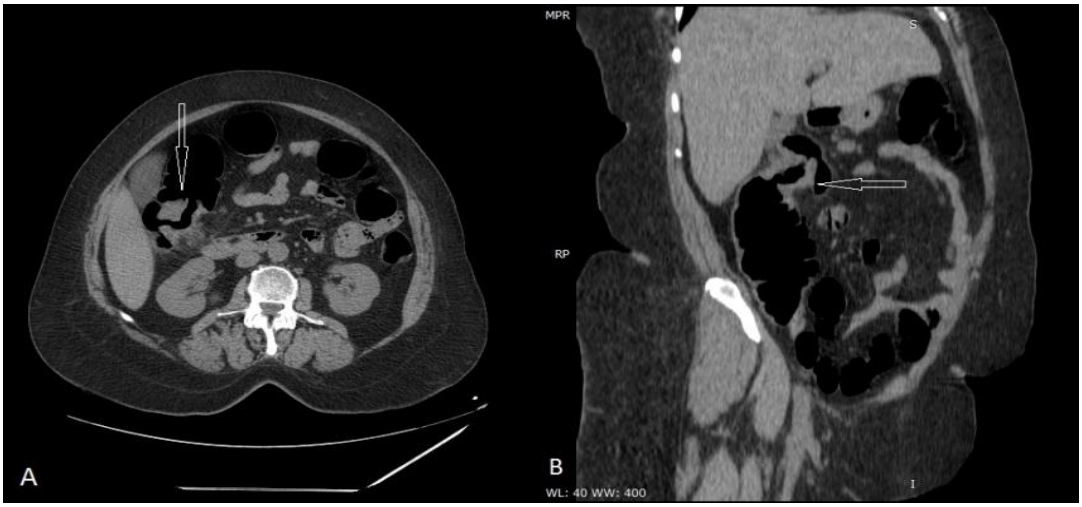


Case 3:

Female patient 61 years old, complaining from constipation . Axial and coronal oblique CT images (A & B) show circumferential annular stricture of the hepatic flexure (arrows), endoluminal low dose CT virtual colonoscopy images (C,D) show intra-luminal cauliflower mass, 3D colon map images (E) show luminal stricture (apple core appearance).optical colonoscopic image (F) shows the same cauliflower mass.



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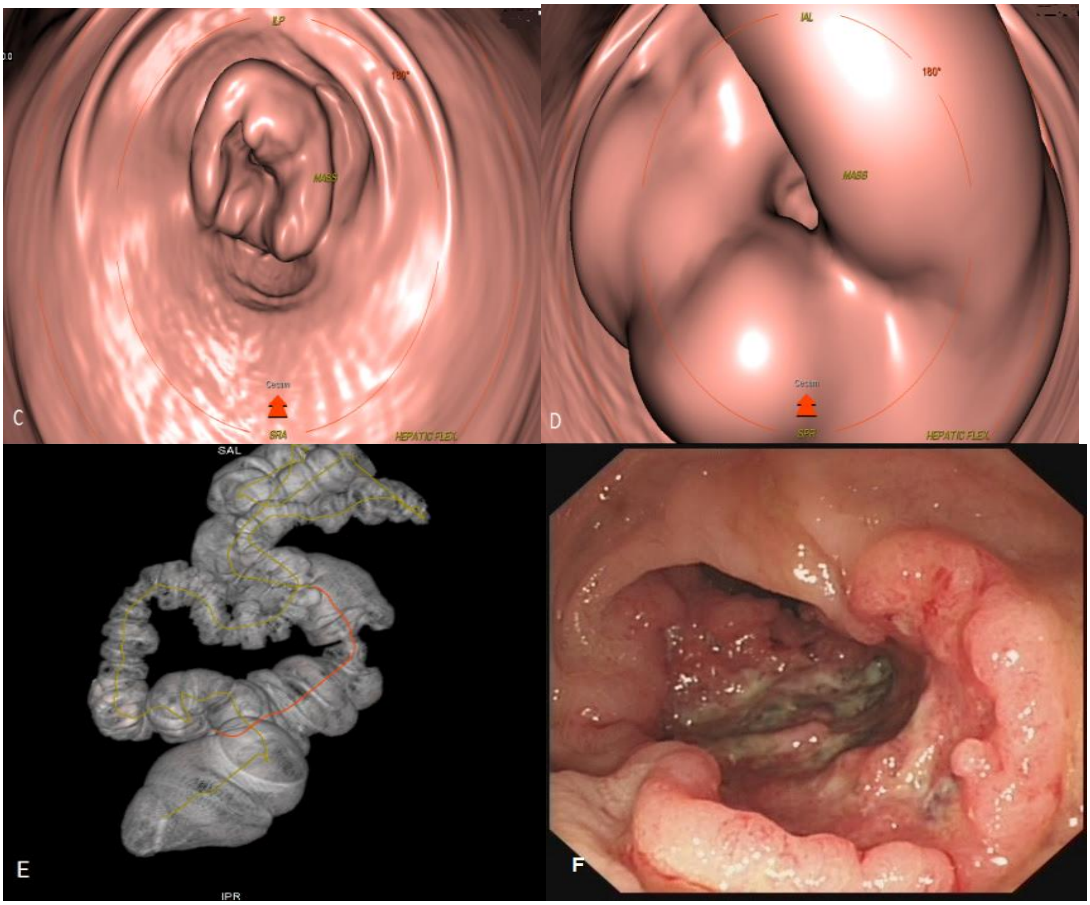
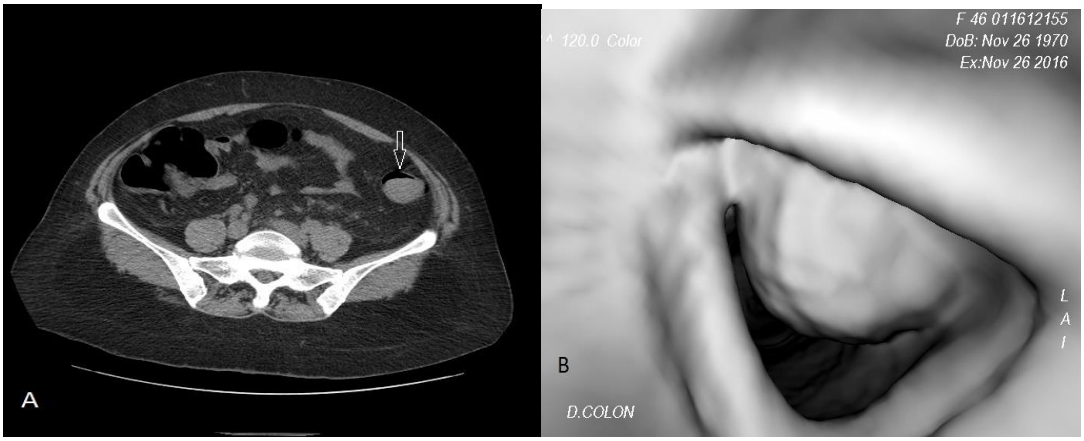


Case 4: Female patient 46 years old, complaining from abdominal pain & bleeding. Axial CT image (A) shows sessile polypoidal soft tissue mass, Endo-luminal low dose CT virtual colonoscopy images (B,C) show the polyp arising from haustral fold of the descending colon (virtual image), fiberoptic colonoscopy image (D) shows the same polyp.



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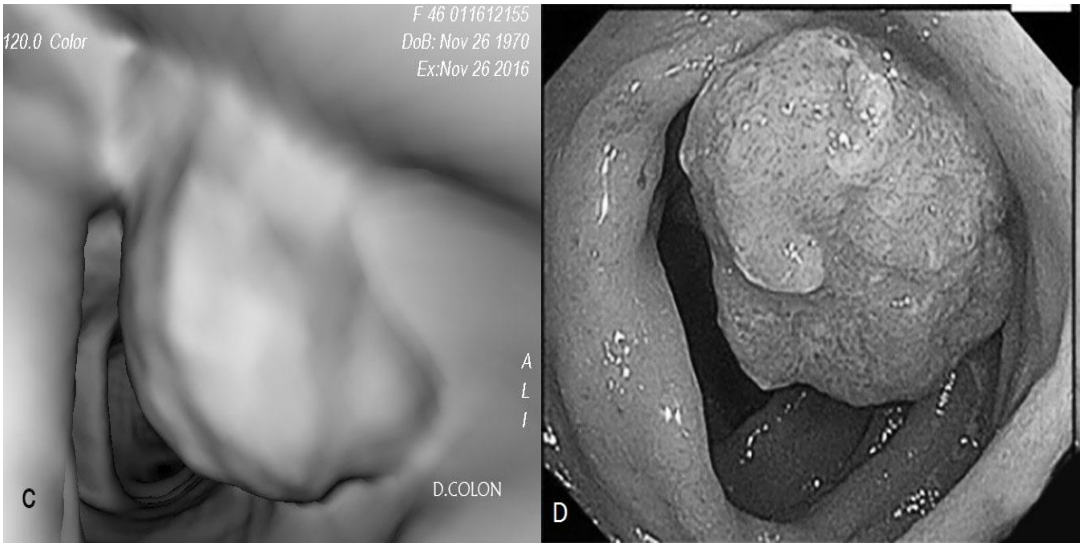

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