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A Discussion of Colon Cancer and Screening Using Virtual Colonoscopy

Introduction
Colon [colorectal] caner is the second most common cause of cancer-related death (behind lung cancer) in the United States. It is the number one cause of cancer-related death in non-smokers. But survival can be improved if the disease is detected early. Precursor (early) lesions (such as adenomas and colon polyps), which are most commonly silent, almost always precede the development of this neoplasm (cancer) by several years. Most people that have early colon cancer have no symptoms and feel fine. Symptoms, which include rectal bleeding, abdominal pain, constipation, diarrhea and weight loss, are most commonly apparent only with advanced disease.

The total cost of colorectal cancer annually in the US is estimated to be $10 billion, of which $2.5 billion represents direct physician costs and the remaining 75% of the cost related to hospital and nursing home care and lost productivity. The toll is not only on the individual with the cancer, but to their family, to their occupation, and to their financial well-being.

Screening is performed to detect disease at a stage when cure or control is potentially possible. It presumes that a test or series of tests will identify asymptomatic persons at risk for the disease. Persons with a positive result on screening can be further evaluated to determine whether they actually have the disease. Ideally, once a diagnosis is determined, early intervention should change the course of the disease, resulting in decreased morbidity and mortality. These basic principles of screening for any disease are very germane to colon cancer. Success however, is based upon several basic assumptions. There must be effective treatment at the preclinical, asymptomatic stage that can reduce mortality in the screened group as compared with the unscreened group. In addition, the sensitivity, specificity, accessibility, cost and associated risks of the screening test itself must be reasonable.

Data have shown that early detection of colon cancer saves lives and that the most likely person to develop colon cancer is one at "average" risk. This suggests those so called "risk factors" are somewhat helpful, but have a poor ability to predict who actually has or does not have colon cancer or an early cancerous lesion. There is an age related incidence of colon cancer and the risk increases significantly between the ages of 45 and 50 in men and women. Thus, most clinicians recommend that their patients, by at least age 50, undergo some form of colon cancer screening. Standard colonoscopy is considered by most to be the current reference standard for colon screening. However, due to a variety of factors, only about 21% of patients recommended to have screening colonoscopy actually have the test done.

Recent advances in imaging have suggested that low radiation dose computed tomography [CT] has a role in fast, convenient, very safe colon scanning and can diagnose tumors on the order of 8-10 mm (or less) in size and find nearly 100% of true cancers.

The following information discusses the concepts of colon cancer, colon cancer detection, screening methods and results, and discusses the potential role of virtual colonoscopy.

Colon [Colorectal] Cancer

Excluding skin cancer, colorectal cancer is the third most common cancer found in men and women. Between 1990 and 1995 the incidence and morality rates for colorectal cancer per 100,000 individuals was 54.5 and 21.9 for men and 38.2 and 14.9 for women, respectively. These rates are no different between whites and blacks and are similar for Asians, but may be less for Hispanics. The American Cancer Society {ACS} says that about 98,200 new cases of colon cancer [46,200 in men and 52,000 in women] and 37,200 new cases of rectal cancer [21,100 in men and 16,100 in women] were diagnosed in 2001. The ACS estimates that this year there will be 48,100 deaths from colon cancer and 8,600 deaths from rectal cancer. The good news is that the death rate has, however, been reducing if you look at the past 20 years as a whole. This is felt to be because of earlier diagnosis and more effective therapy.

At least 95% of colon and rectal cancers are adenocardinomas. These are cancers of the cells that line the inside of the colon and rectum. There are some other, more rare tumors such as cacinoid, gastrointestinal stromal tumors, and lymphomas. For adenocarcinoma of the colon or rectum, the 5-year survival rate is 90% for people whose colorectal cancer is found and treated in an early stage, in the absence of local or distant metastases. However, only about 37% of colorectal cancers are found at this early stage. Once the cancer has spread to other organs or to regional lymph nodes, the 5-year survival rate goes down to 65%. For individuals in whom the colorectal cancer has spread to distant sites such as the liver or lungs, the 5-year survival rate is dismal at about 8%.

Survival rates from colorectal cancers are dictated by the pathologic stage of the disease when found. Survival is greater than 90% when cancers are limited to the bowel wall at the time of diagnosis. Seventy-five percent of cancers found by screening asymptomatic patients are confined to the bowel wall (Duke's classification A and B), however, >50% of patients who undergo screening after developing symptoms have a more advanced stage (Duke's C and D).

The risks of any bowel lesion (most commonly polyps) developing into true cancer is directly related to size: nearly 0% if the polyp is <5 mm, 1% if it is between 5 and 10 mm, 10% risk with size 10-20 mm, and >30% risk with polyps larger than 20 mm.

There are a number of "risk factors" for colorectal carcinoma and they are listed in detail below:

- A family history of colorectal cancer – In about 5-10% of patients with colorectal cancer there is a known inherited genetic abnormality associated with development of cancer; these have specific names such as familial adenomatous polyposis [FAP] and hereditary nonpolyposis colorectal cancer [HNPCC]. The ACS recommend screening test schedules or people with a family history of colon cancer that is more aggressive than that recommended to the general public for colorectal cancer screening as it may develop at a much earlier age – generally between 30 and 50.
- A personal history of prior colorectal cancer – just like for heart disease where the most powerful risk for a heart attack is having had one previously, individuals with a prior

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history of colon cancer are more likely to develop it again and more aggressive surveillance is necessary

- A personal history of intestinal polyps – some types of polyps such as hyperplastic and inflammatory polyps do not increase the risk of can while others such as adenomatous polyps do increase the risk; this risk increases in direct proportion to the actual number of adenomatous polyps present.
- A personal history of inflammatory bowel disease – Diseases such as ulcerative colitis or Crohn's colitis, where the colon is inflamed over a long period of time, increase the risk of cancer significantly. Screening is recommended to begin early in life and to be repeated frequently.
- Age – The chances of developing colorectal cancer increase markedly after age 50. About 90%-93% of people found to have colorectal cancer are older than 50. Fifty percent of men and women who are 50 years of age or older have asymptomatic, pre-cancerous polyps. At least 75% of colorectal cancers occur in those with no family or personal history and not risk actors that would place them at high risk. Age is considered by most to be the MOST important "risk factor" and a leading indication for colorectal "screening".
- Diet – A diet that consists mostly of foods that are high in fat, especially from animal sources, is associated with an increased risk for colorectal cancer. Interestingly, the diet that is considered to be appropriate for reducing the risk of heart disease is the same diet that is considered to be beneficial in reducing a personal risk for colon cancer. This includes eating a least 5 servings of fruits and vegetables every day and several servings of other foods from sources such as breads, cereals, grain products, rice, pasta, or beans.
- Physical inactivity
- Obesity – This is particularly true if there is excess fat in the waist over the thighs or hips [increased waist/hip ratio]. Although a clear understanding of why this association exists has not been shown, research suggests that the excess fat changes overall metabolism in a way that increases growth of cells in the colon and rectum. This may, in fact, be an example of weight contributing to gene expression, as is seen in some lipid metabolism disorders that have an adverse affect on the development of heart disease. An elevated BMI above 30 is consistent with obesity.
- Smoking – Smokers are 30%-40% more likely to die of colorectal cancer. Smoking may be responsible for causing as much as 12% of fatal colorectal cancers. It is unclear if this affect is via the systemic effects of smoke on cell and endothelial growth or a direct affect due to swallowed cancer-causing material during the act of smoking.

Conventional Methods of Colon Cancer Detection

Current conventional methods used or suggested to be of value in detection of colon and/or rectal cancer includes:

- Digital rectal examination – This test often done by a doctor, as part of a routine physical examination can be useful in prostate cancer evaluation; although it is true that some very large tumors may be found, this test is too insensitive to be considered an adequate screening test for colorectal cancer.
- Fecal occult blood test – The digital rectal examination however, can produce a small specimen of stool that can be subjected to occult blood testing; however, the patient also can do this at home from a stool sample. A large number of colon cancers or invasive polyps cause bleeding of the intestinal mucosa and even in small amount, can result in a

positive fecal occult blood test; thus this test is relatively simple and sensitive to colonic abnormalities, but has a very poor specificity. A recent VA hospital study showed that occult blood was found in only about 24% of those with advanced cancer. There are a number of other situations, including common hemorrhoids, which can result in blood in the stool. Additionally, the specificity is further damaged if the patient is also taking aspirin or aspirin containing medications, as this commonly causes some mild and mostly benign gastrointestinal bleeding. If the fecal occult blood test is positive on several occasions and the patient is not taking aspirin, then further work-up is generally recommended. The cost for a fecal occult blood test is about $25, but it is abnormal in only 30-40% of colorectal cancers and just 10% of adenomas. If the test is positive, colonoscopy is recommended.

- Sigmoidoscopy – this test involves the use of either a fixed or flexible scope that can be used to exam about the last 50 cm of the colon; as many as 70% of all colon cancers have at least one site within this distance from the rectum (although a normal exam does NOT rule out cancer at another site and even with a positive test, there could be more sites in the proximal colon that were not found); however, this has been a useful test and most medical residents learn how to use a rigid sigmoidoscope and many are able to use the flexible variety [which actually is a short version of the colonoscope; it is not uncommon to screen for colon cancer using a combination of the digital examination, fecal occult blood testing, and a sigmoidoscopy – all of which can be done in the doctor's office; however, a recent VA hospital study has suggested that such screening fails to identify about one quarter of subjects with advanced cancer, and one half of subjects with advanced proximal neoplasia. The cost of a sigmoidoscopy is about $300. If the test is positive for polyps or a suspicious lesion, then colonoscopy is recommended.
- Ultrasound – endorectal ultrasound uses a special transducer that can be inserted directly into the rectum and can be used to determine how far a cancer has invaded into the bowel wall; however, this is a quite specialized procedure and not offered at all medical centers and is not considered useful for screening, but only as a second test after finding rectal cancer; an ultrasound transducer can be used from the abdomen and may be of help in looking at the larger organs as a survey for metastatic disease, but cannot look at the bowel itself and is thus not a screening test.
- Barium enema – for many years, this was the reference standard for evaluating the colon, but has been improved by doing "double contrast" plus/minus "air contrast"; this requires a very thorough bowel cleansing prior to the test and is moderately uncomfortable. The exam however is not adequate to visualize the sigmoid colon and thus a complete screening would require both a barium enema as well as a sigmoidoscopy. Double-contrast barium enema is considered to be superior to conventional barium enema, but is more time consuming and requires a good deal of patient positions and cooperation. The test is uncomfortable for most individuals. The cost is about $500, and added to the sigmoidoscopy for a complete exam, is about $800. If the barium enema suggests a polyp or a suspicious mass, colonoscopy is required for follow up.
- Colonoscopy – this test allows visualization of the colon directly as opposed to indirectly, as with barium enema. Thus, it has replaced barium enema/sigmoidoscopy in many medical centers. Additionally, Gastroenterologists now currently perform this test in general while radiologists do barium enema. The exam can be quite uncomfortable and thus the patient is sedated by means of an intravenous medication ("conscious sedation" although general anesthesia may be used in some instances). The colonoscope is about 1

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cm in diameter and is inserted into the rectum and advanced to the most proximal portion of the colon or distal small bowel. Along the way during the pull out, the physician is able to take "snapshots" and also potentially able to perform biopsies or even removal of small polyps. The procedure take only about 10 minutes, but could take longer depending on the quality of the bowel prep, the time for biopsies if necessary and to account for any complications such as mild bleeding; there is an additional time spent in the recovery room lasting 20-60 minutes, followed by a feeling of grogginess for several hours. Bleeding, perforation of the bowel, cardiac, respiratory and blood pressure problems, and even death can occur but in a very small number of individuals (colonic perforation in one in 500-1000 cases and death in one in 2000-5000 cases). Full recovery generally is found by the next day following the procedure. The cost of this procedure is about $1,600-$2,000 and fails to demonstrate the entire colon in about 10% of patients; furthermore it is ineffective in examining areas of the colon blocked by masses or in areas of severe narrowing.. Insurance coverage is variable and depends on the perception of "risk". Medicare covers about 80% of approved amount and is considered an acceptable test following a positive fecal occult blood test or an abnormal sigmoidoscopy/barium enema.

Of the available tests, direct colonoscopy is the one currently considered to be the best for colon and rectal cancer diagnosis and screening (although recent data have challenged this conclusion). Insurance reimbursement is becoming better for the test, especially if there are supporting diagnosis codes.

Alternative Screening Methods for Colorectal Cancer Detection

Magnetic resonance imaging (MRI) and x-ray CT are two potentially alternative methods for colon screening. Currently, CT methods ("virtual colonoscopy") are the best validated:

- MR Imaging has made great strides in the past several years. MRI has excellent soft tissue resolution, but without use of specialized external coils, has relatively poor spatial resolution compared to CT and especially compared to conventional x-ray. MRI abdominal imaging has improved recently and there have been limited efforts to develop direct colon imaging. Luboldt at University Hospital Zurich reported in 1999 on MR Colonography in 132 patients. In order to visualize the lumen they used gadopentetate dimeglumine contrast mixed with water. T-1 weighted 3-D gradient-echo MR studies with multiple projections were viewed by two radiologists. Diagnostic quality was considered adequate in 127 (96%) of patients. Lesions smaller than 5 mm were not visualized, but 19/31 (61%) of 6-10 mm lesions and 26/27 (96%) of >10 mm lesions were visualized. They concluded that MR Colonography had a sensitivity of 93%, a specificity of 99%, a positive predictive value of 92%, and a negative predictive value of 98%. The problems are that other laboratories have not reconfirmed these data and they did not comment on the time required for the study. Smatterings of papers have appeared in the literature regarding MR, but this method still remains highly experimental.
- CT Virtual Colonography – This technique has been rapidly developing over the past several years and will be discussed in detail in a later section.

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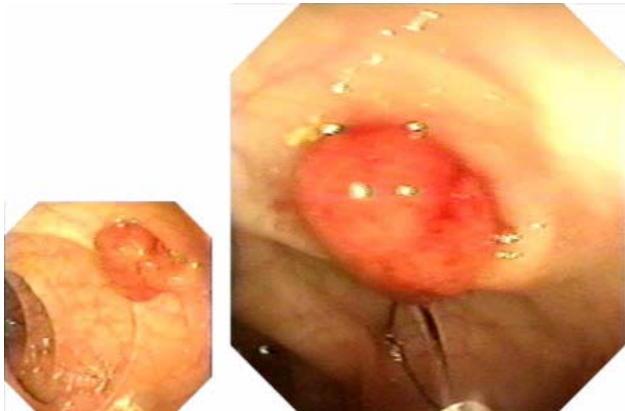
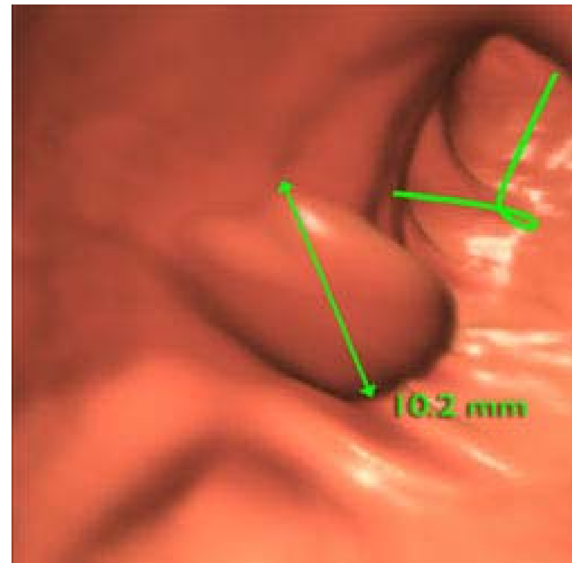
What about lesion size and risk of cancer?
The direct imaging methods used to screen for colon cancer (barium enema, optical colonoscopy, and virtual colonoscopy using MRI or CT) are looking for specific anatomic findings that either indicate that cancer has occurred or "precursors" for colon cancer. The most common "precursor" lesion is the colonic polyp. The accompanying figure shows a polyp in the same patient as seen using optical colonoscopy as well as CT virtual colonoscopy.

There is a "natural history" of colon polyps with regard to the risk of developing into cancer and is given in the table below.



Standard optical colonoscopy study in a patient with a 10 mm colon polyp.



Three dimensional virtual colonoscopy study demonstrating a 10 mm colon polyp.

These data point out that not all polyps are "pre-cancerous" and that size is the most important predictor of the overall risk. Unlike lung cancer, colorectal cancer is very slow growing. A 5 mm lung nodule found on a screening CT of the chest has a risk, if cancerous, of growing by 50-100% in volume in the next 3-9 months. A 5 mm colon polyp has a risk of growing by 50-100% in size measured in a time period of 5-10 years. The most important polyps are those on the order of 8-10 mm size, due to the risk of adenoma development and the increased risk of colon cancer as a whole. Screening methods then need to concentrate on two things: 1. being able to view the entire colon, and 2. being accurate in finding polyps of 8-10 mm (or larger) in size.

Polyp Size	Chance of Cancer Now	Chance of Being an Adenoma	If Adenoma, Risk of Cancer in Next 10 Years	Overall Chance of Colon Cancer in Next 10 Years
<5 mm	<0.01%	30%	<5%	1%
5-9 mm	<1%	50%	5-10%	2-5%
10-15 mm	1-5%	80%	10-15%	5-10%

Colonography [Virtual Colonoscopy] Using CT
CT and computer technology have made great strides in the past few years that have revolved around faster scan speeds, increased numbers of images per scan, thinner slice width, significantly shortened overall scan times, increased spatial resolution, and ability to handle hugh image datasets.

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Virtual imaging is display of a virtual "reality" that represents basically a "fantastic voyage" through a particular section of the body. Virtual bronchoscopy was first described years ago, but remains in its infancy. Virtual vascular imaging has been shown feasible using the newer spiral CT scanners and especially using electron beam tomography [EBT].

Virtual Colonoscopy [more properly then called "Colonography"] is a new procedure that fuses computed tomography of the large bowel with advanced techniques for rendering two- and three-dimensional images to produce views of the colonic mucosa similar to those obtained during direct colonoscopy. In general, results suggest that it is more accurate that barium enema and approaches and may exceed the sensitivity of conventional colonoscopy.

The advantage of CT [both EBT and more conventional spiral/helical CT] is that two-dimensional reconstructed images are actually part of a true volumetric (three-dimensional) dataset.

The process of colonic pneumotography was introduced in 1994. The basic methods involved in the initial studies included a full bowel preparation, intravenous administration of the smooth muscle relaxant, and colon insufflation with air to sufficiently dilate the colonic lumen. The "contrast" is air and the density differences between air and soft tissue make definition of the colonic mucosa straightforward. Of note, more recently introduced use of CO_2 has shown considerable benefits to patients by reducing cramping.

One of the first investigations was done at the Mayo Clinic [published in 1997] and included 70 consecutive patients known to have polyps or undergoing follow-up one to five years after polypectomy. The sensitivity and specificity of virtual colonoscopy (VC) was 75% and 90% respectively for adenomatous polyps ≥10 mm in diameter, 66% and 63% for adenomas ≥5 mm, and 45% and 80% for polyps <5 mm. When compared with single contrast barium enema, VC had a higher detection rate and fewer false positive results.

Fenlon and colleagues from Boston University published the first comparison of VC vs. colonoscopy in the NEJM in 1999. One hundred patients at high risk for colorectal neoplasia were studies. The entire colon was visualized in 87 patients using VC compared to 89 with colonoscopy [p=NS]. VC identified all cancers, 20/22 (91%) of polyps ≥10 mm in diameter, 33/40 (82%) that were 6 mm or larger, and 29/53 (45%) that were <5 mm. There were 19 false positive VC findings for polyps and no false positive findings of cancer. They concluded that in patients at high risk for colon cancer VC had similar efficacy to colonoscopy for detection of polyps 6 mm or larger in size.

Another recent study appeared from a New York group who has compared studies VC and colonoscopy in 300 patients. The table below lists the particulars of the Fenlon and New York results. The most striking finding is that VC was 100% sensitive for pre-existing cancers.

The summary data shown below are from the earlier studies using VC. They confirmed that VC is a very powerful test for colon cancer and that the vast majority of polyps, which account for 90% of the pre-cancerous lesions, can be found. However, the largest criticism put forward by many groups was that these data were from "high risk" patients. That is, maybe VC is great in those individuals who are at high likelihood of actually having colon disease, but it does not

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prove that it would be of value in the “average risk” individual. This criticism is commonly expressed when any new screening test is put forward and is called “referral bias”. This can falsely increase the sensitivity (the number of truly positive tests) of the test since a majority of the patients tested have the disease that is under investigation. But, as the sensitivity increases, the specificity (the number of truly negative tests) can go down. However, the same criticism could be raised for the “reference standard” of invasive colonoscopy since studies using this method have concentrated on validation in those who are at “high risk”.

Study	Cancers	Polyps >10 mm	Adenomas >10 mm	Polyps 6-9 mm	Adenomas 6-9 mm	Polyps < 5mm	Adenomas <5 mm
NEJM 1999	3/3 100%	20/22 91%	-----	62/93 67%	46/51 90%	29/53 55%	12/18 67%
Radiology 2001	8/8 100%	74/82 90%	64/68 94%	113/141 80%	72/88 82%	178/301 59%	95/142 67%
Composite n=400	11/11 100%	90%	----	175/23 75%	118/129 91%	207/354 58%	107/160 67%

What was needed was a study that carefully looked at standard colonoscopy and current state of the art VC methods in the “average” risk patient. A landmark study looking at precisely this group of patients was recently published in the New England Journal of Medicine.

In December 2003 a large study (1233 patients) was reported by the combined efforts of the National Naval Medical Center, the National Cancer Institute, and Walter Reed Army Medical Center (Pickhardt PJ, et al. Computed tomography virtual colonoscopy to screen for colorectal neoplasia in asymptomatic adults. New Engl J of Med 2003;349:2191-2200). Unlike all prior studies (including those looking at the validity of standard colonoscopy) these were “average risk” subjects. What makes this so important is that, as stated earlier, the average risk individual actually represents the largest group who are known to develop colon cancer (that is, “risk factors” for colon cancer, except for age and family history, are not particularly predictive of who will or will not get the disease). In this study individuals underwent same day colonoscopy and VC. State of the art 3-dimensional CT rendering was used in this study. The sensitivity of VC for 8 mm and 10 mm polyps were virtually identical at 94%. Smaller polyps of 6 mm were less evaluable by VC, but with a sensitivity of nearly 88%. The specificity for 10 mm polyps was 96% and dropped to 92% and 80% if the polyp was 8 mm and 6 mm, respectively. Only two polyps were found to be cancerous in the entire study, but both were properly identified by VC. Interestingly, one of these polyps was initially missed by conventional colonoscopy and was shown to be a cancer only on repeat optical colonoscopy, after reviewing the VC results. Their conclusions were “CT virtual colonoscopy with the use of three-dimensional approach is an accurate screening method for the detection of colorectal neoplasia in asymptomatic average-risk adults and compares favorably with optical colonoscopy in terms of the detection of clinically relevant lesions.”

The disadvantage of VC is that it does not provide the detail that can be obtained using video-colonoscopy. Mucosal detail and color is not visible which limits characterization of lesions. Clearly for very small polyps, VC is inferior to colonoscopy. However, the likelihood of cancer

in small lesions is <1%. Just the same, the time between serial tests using VC may need to be shorter than that for colonoscopy for precisely this reason. It must be borne in mind that 10%-20% of all polyps and up to 5% of colon cancers are missed, even using conventional colonoscopy. VC, like barium enema, is a diagnostic and not a therapeutic technique. All patients in whom VC identifies polyps may then have to undergo colonoscopy for biopsy and/or removal.

An advantage of VC is that it is less operator-dependent than barium enema. VC is minimally invasive and does not carry the low but real (1 in 1500) risk of perforation associated with conventional colonoscopy. VC is well tolerated by patients and does not require sedation. The entire procedure can be done in 5-10 minutes while colonoscopy takes about 30 minutes. The patient is ready to go back to work within an hour after VC, but will need to take the day off with conventional colonoscopy and will not be allowed to drive home. VC is also less expensive than conventional colonoscopy [roughly $900 vs. $1600]. The examination done using EBT as compared with spiral CT takes overall less time, each individual image is acquired in 100 msec compared to up to 500 msec so that bowel motion is eliminated as a cause for artifact, and involves about 1/10 the total radiation exposure.

VC image analysis can be time consuming, but the learning curve is steep. Diagnosis can usually be made from the two dimensional images and generating a three dimensional image, the most demanding in terms of computer power, appeared to be necessary only for problem solving such as differentiating between a polyp and a haustral fold. However, this field is rapidly changing with development of workstations designed with virtual luminography in mind. Using 3-dimensional imaging allows for an infinite number of viewing angles to be explored; something that simply cannot be done during colonoscopy and is impossible from later review of the videotape. An additional advantage of VC is that localization of lesions is likely more accurate. In one study 38 cancers were correctly localized by means of VC compared with 32 by conventional colonoscopy.

Currently only colonoscopy is able to perform a true "biopsy" of suspicious areas; however, issues of improved tissue characterization using VC are underway. Under development at the Mayo Clinic is a "virtual biopsy" method. An area representing a polyp or tumor can be digitally segmented and processed as a separate object and facilitates both geometric and densitometric measures for the segmented object as distinct from the surrounding colonic mucosa.

Who Should be Considered for Colon Cancer Screening?

The most important thing to remember is that the incidence of colon cancer increases considerably in all individuals after age 45-50. Those individuals with a family history of colon cancer should consider screening at an earlier age of 35-40. Colon cancer is common and yet it can be cured with proper screening. Virtually all doctors agree that some form of colon cancer screening makes sense for most of their middle-aged or older patients. The best way to determine if colon cancer is developing or if there are polyps or adenomas present is to perform a direct visualization of the colon. At the present time, optical colonoscopy is the reference standard. However, eventhough colonoscopy is effective in the average risk individual, about 90% of these screening exams are in fact normal. Only about 21% of those who have been suggested by their doctor to undergo screening colonoscopy have the test done in a timely manner. The reasons relate to issues of the needed bowel preparation, the loss of time from work or school, and the use of sedation or anesthesia in order to perform the test.

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Virtual colonoscopy offers an alternative in the average risk individual. However, a colon preparation is necessary for VC as well. The preparation is a bit gentler than that needed for standard colonoscopy. No medications or anesthesia are needed and the VC examination can actually be done in about 15 minutes. If CO_2 is used rather than room air to fill the colon during the examination, there is little cramping during and after the procedure. Just the same, VC is not for everyone. The individual who is considered to be high risk for colon cancer should undergo direct colonoscopy as often some of the lesions can be removed or treated in the same session. Additionally, since VC can miss some smaller lesions, the traditional follow up for a normal optical colonoscopy of about 10 years probably needs to be reduced to about 5 years for VC.

Below are some potential situations in which VC could be considered:

- Men and women over the age of 50 that have no prior history of colon cancer – some form of cancer screening is recommended by the ACS in all such individuals
- Individuals who are scheduled for a "screening" colonoscopy who, for personal or health reasons, would prefer to not have anesthesia or undergo formal colonoscopy
- Individuals scheduled for "screening" barium enema or sigmoidoscopy and who may prefer to have the entire colon examined by VC
- Individuals of any age who have been considered to be "high risk" for colon cancer and have NOT had a screening colonoscopy within the past 5 years [history of chronic inflammatory bowel disease, prior history of colon cancer, history of polyps]
- Men and women >40 years of age with at least one additional colorectal cancer risk factor including:
  - A family history of colorectal cancer under age 50
  - A diet consisting of high fat, especially animal products
  - Physical inactivity (less than three hours of activity per week – this includes walking, biking, formal exercise, or housework)
  - Obesity – a BMI > 30
  - Current smokers or smokers with a greater than 10 pack year history of cigarette use

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