

Imaging for Colorectal Cancer



Yosef Nasseri, MD^{a,*}, Sean J. Langenfeld, MD^b

KEYWORDS

• Imaging • Colorectal cancer • MRI • Endorectal ultrasonography • CT

KEY POINTS

- Plain films and abdominal ultrasonography have limited roles in modern staging of colorectal cancer.
- Patients are often referred for surgery with inadequate imaging, and it is the surgeon's responsibility to ensure proper preoperative staging.
- Rectal cancer requires additional local staging with endorectal ultrasonography or pelvic MRI to determine whether neoadjuvant chemoradiation will be beneficial.
- After curative resection, yearly computed tomography scans of the chest, abdomen, and pelvis are recommended for most patients.

INTRODUCTION

A comprehensive approach to colorectal cancer includes thorough radiologic imaging, which allows appropriate initial staging of the disease, as well as subsequent surveillance for disease recurrence. Several imaging modalities are used with different associated advantages and disadvantages. This article provides an overview of appropriate modern imaging in the evaluation of colon and rectal cancer. Recommendations mirror those of the American Society of Colon and Rectal Surgeons (ASCRS)^{1–3} as well as the National Comprehensive Cancer Network (NCCN).^{4,5}

DIFFERENT IMAGING MODALITIES

Plain Films

Before the widespread adoption of more capable imaging modalities, plain films were the mainstay of diagnosis and staging for colorectal cancer. However, its role in

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^a Surgery Group of Los Angeles, 8635 West 3rd Street, Suite 880W, Los Angeles, CA 90048, USA;

^b General Surgery Residency, Department of Surgery, University of Nebraska Medical Center, 983280 Nebraska Medical Center, Omaha, NE 68198-3280, USA

* Corresponding author.

E-mail address: yosefnasseri@gmail.com

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modern medicine has diminished. In general, plain films do not possess adequate sensitivity for the identification of primary and metastatic lesions, so they are only useful when the findings are advanced and dramatic.

Chest radiographs (CXR) can be used to detect pulmonary lesions, which may represent primary or malignant tumors. However, the sensitivity for detection of colorectal metastases is poor.² One retrospective review found that CXR detected only 36.7% of pulmonary metastases.⁶ Abdominal radiographs may be useful for identification of the large bowel obstructions that can occur from a locally advanced primary tumor (**Fig. 1**). Abdominal films can be aided by the administration of Gastrografin to better identify the offending tumor (**Fig. 2**).

Ultrasonography

Ultrasonography of the abdomen has a low sensitivity for primary tumors. Its main historical significance was for the detection of liver metastases. Several important studies on staging and surveillance of colorectal cancer, including the GILDA (Gruppo Italiano di Lavarò per la Diagnosi Anticipata) trial,⁷ used ultrasonography as the primary method for detecting liver lesions. However, current guidelines have abandoned abdominal ultrasonography in favor of computed tomography (CT) because of its increased sensitivity and reproducibility. Endorectal ultrasonography remains an important element in the local staging of rectal cancer, and it is discussed in greater detail later in this article.

Computed Tomography

CT has become a mainstay in the diagnosis and staging of colorectal cancer. It can be used to assess the location and extent of the primary tumor (**Fig. 3**), involvement of adjacent organs, enlargement of regional and distant lymph nodes, and the presence or absence of metastatic disease. CT is the most common modality used to stage colorectal hepatic metastases.⁸ With the advent of helical CT (also called spiral CT),

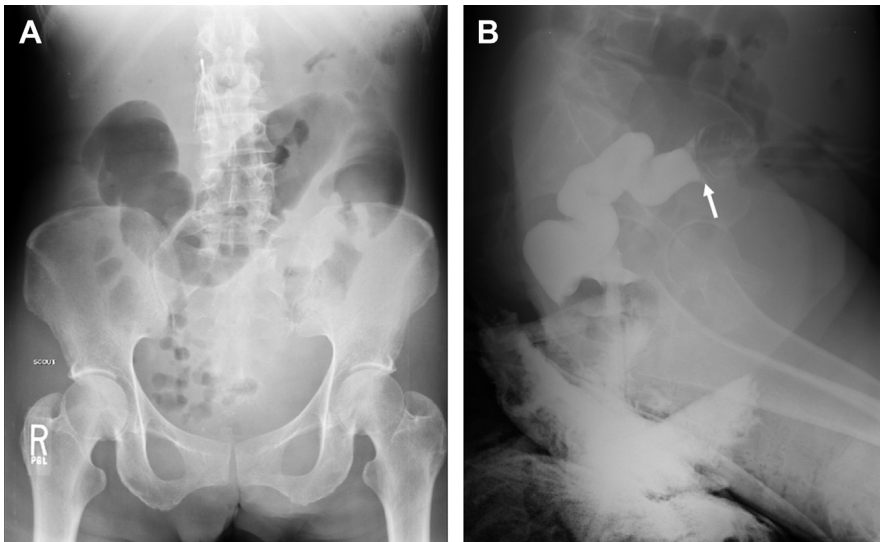


Fig. 1. Large bowel obstruction on plain film. (A) Proximal colon dilatation caused by sigmoid mass. (B) Gastrografin enema revealing obstructing sigmoid colon cancer (arrow).

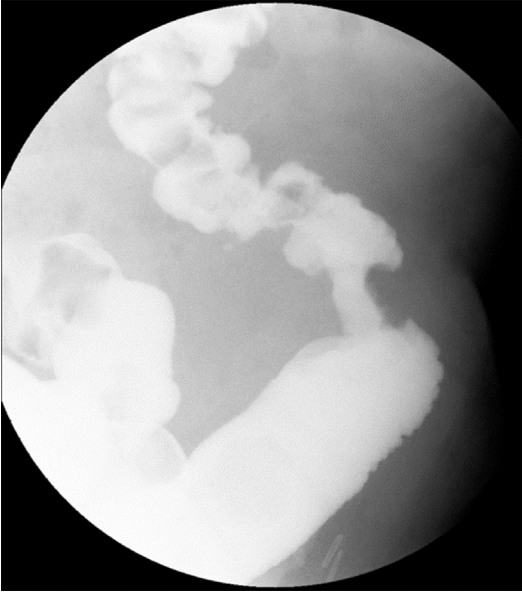


Fig. 2. Radiograph of apple core lesion. Gastrografin enema showing a rectal apple core sign caused by partially obstructing mass.

which images many slices at once (as opposed to original CT scans, which captured images slice by slice), CT's reliability in correctly detecting hepatic metastases preoperatively has improved, with an estimated sensitivity of 85%, positive predictive value of 96%, and false-positive rate of 4%.⁹ At present, most tertiary and quaternary

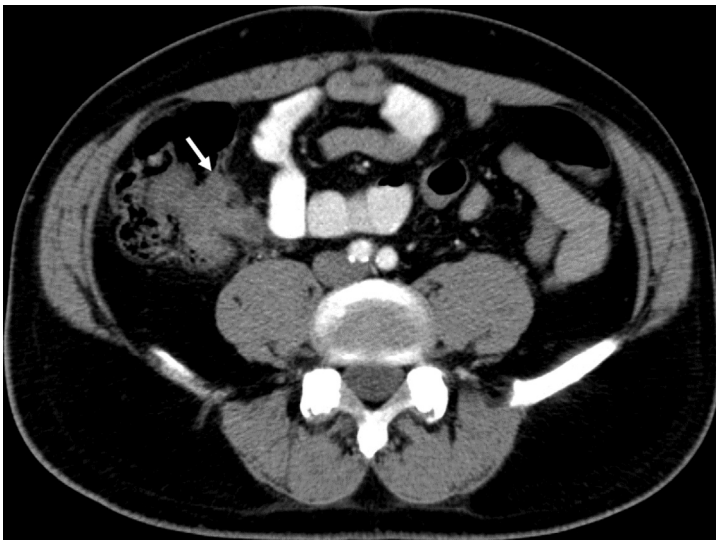


Fig. 3. CT scan of the abdomen, revealing a large cecal mass (arrow).

centers have 32-slice and 64-slice CT scanners with remarkable resolution and speed compared with prior generations.

Chest CT plays an important role in the pulmonary metastatic work-up of a primary colorectal cancer (Fig. 4). Its overall accuracy in detecting lung metastases preoperatively is 83.9%, with a sensitivity and specificity of up to 73% and 74%, respectively.^{10,11} However, CT detects many indeterminate lesions, most of which are benign, which in turn necessitates further evaluation. Great disagreement therefore exists about the need for preoperative CT scans of the chest.

MRI

MRI is used extensively to evaluate hepatic metastases, because it provides increased detail that may affect resectability (Fig. 5). It is also used to evaluate primary tumors that encroach on or invade adjacent structures, once again to determine resectability and/or the need for neoadjuvant therapy. The role of pelvic MRI in the local staging of rectal cancer is discussed later in this article.

Like CT, MRI technology has also improved dramatically in recent years, improving both the speed and resolution of images. There have been increases in the strength of the magnetic field, with current machines using 3-T and even 7-T technology.¹² For pelvic MRI, high-resolution MRI scans via endorectal or phased-array coil methods provide a clear view of rectal wall anatomy, thereby allowing the accurate assessment of the depth of rectal tumor invasion (Fig. 6).

PET and PET/Computed Tomography

PET scans, by themselves or in conjunction with a CT scan (PET/CT) (Fig. 7), have a less-defined role in the evaluation of colorectal cancer. Although it does not have a role in the routine staging of colorectal cancer, it does have utility in the detection of occult disease as well as further evaluation of indeterminate lesions, and may be helpful in identifying metastatic disease when uncertainty exists regarding the benefit of surgical resection. It can also be used to assess changes in tumor metabolism, because cancers often show a decrease in glucose avidity after systemic treatment.

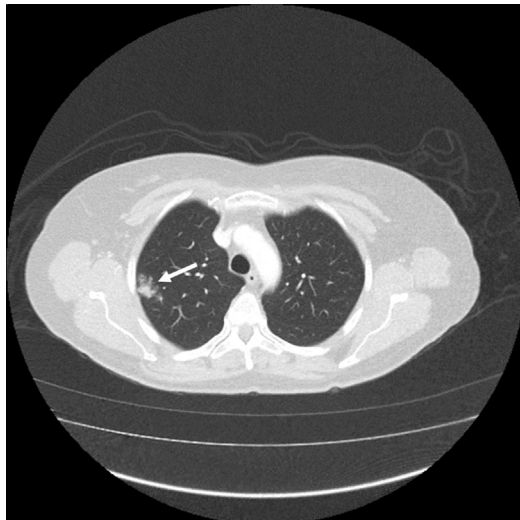


Fig. 4. CT of lung showing metastatic adenocarcinoma in the right upper lobe (arrow).

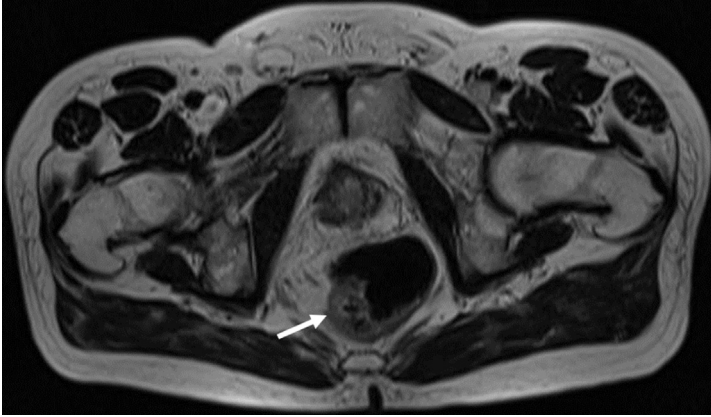


Fig. 5. Sagittal and axial MRI of the abdomen revealing colorectal liver metastases (*arrow*).

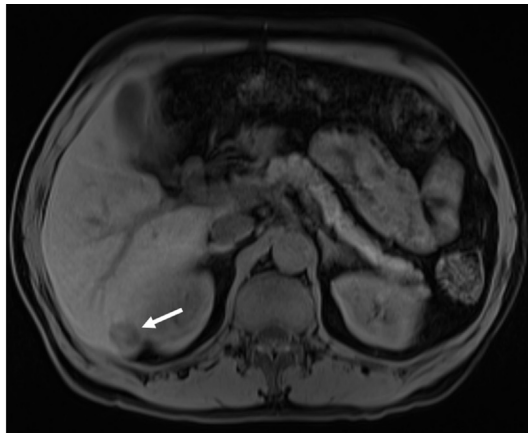
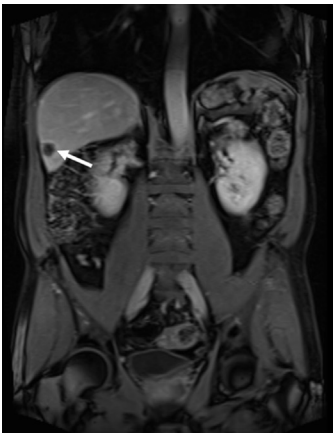


Fig. 6. MRI of abdomen and pelvis revealing colorectal liver metastases (*arrows*).

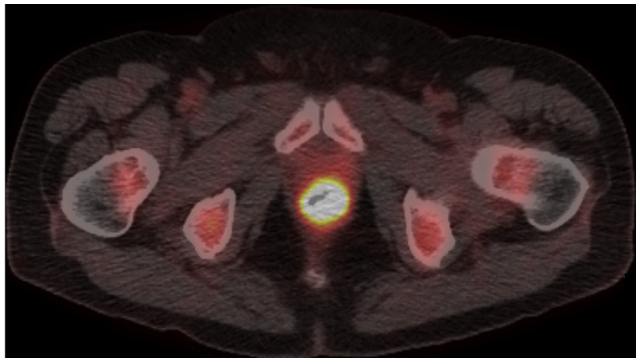


Fig. 7. PET/CT images reveal a rectal tumor both in the sagittal and axial views (*arrow*).

INITIAL STAGING OF COLORECTAL CANCER

When a patient has a new diagnosis of colon or rectal cancer, the next step is to determine the cancer's stage, because this has a large impact on prognosis and treatment options. Therefore, one of the first bifurcations in the decision tree is based on the presence or absence of metastatic disease.

For colon and rectal cancer, both the ASCRS practice parameters and the NCCN guidelines recommend routine preoperative radiographic staging with a CT scan of the chest, abdomen, and pelvis.²⁻⁵ Based on these recommendations, chest radiograph is no longer adequate for preoperative pulmonary evaluation. The CT scan should be done with both oral and intravenous (IV) contrast, and rectal contrast is generally unnecessary.

Patients often arrive to the surgeon's clinic with preexisting laboratory tests and imaging of varying extent and quality. It is the surgeon's responsibility to ensure proper preoperative imaging. A noncontrasted CT scan should be considered inadequate for staging purposes, and should be repeated with contrast when necessary. When patients have allergy to IV contrast, an acceptable alternative is to obtain a gadolinium-enhanced MRI scan of the abdomen along with a noncontrasted CT of the chest. Note that although gadolinium is hyperosmolar, it is much less nephrotoxic than the iodine-based contrasts used for CT scans,¹³ and it is also associated with a lower risk of allergic reaction. If neither of these imaging modalities are possible, then a PET/CT scan may be ordered knowing that it may not detect smaller lesions.

Approach to Positive Radiologic Findings

When abnormalities are detected on staging CT scan, more information is often necessary. CT scans cannot always accurately categorize liver lesions, and so cysts, hemangiomas, and metastatic tumors may appear radiologically similar. When available, a gadolinium-enhanced MRI scan of the abdomen may better characterize liver lesions. If found to be cysts or hemangiomas, then no further work-up is necessary. If found to be indeterminate or worrisome for malignancy, core-needle biopsy should be performed by the interventional radiology (IR) team, either using CT or ultrasonography to assist with the biopsy.

Another common finding on CT scan that may be worrisome for systemic disease is retroperitoneal lymphadenopathy. This consideration is extremely important, because retroperitoneal spread of colorectal cancer is associated with a very poor prognosis,¹⁴ and resection of the primary tumor may be unnecessary and even counterproductive. When these nodules are large enough, they can often be safely biopsied by IR as well. When the lesions are too small, or they are not accessible because of proximity to other retroperitoneal structures such as the aorta and inferior vena cava, then the surgeon may want to proceed with surgery with curative intent, with plans to monitor the nodules with serial imaging. However, if adequate suspicion exists for metastatic disease, then it is often appropriate to initiate a trial of primary systemic chemotherapy to see whether (1) the nodules shrink with therapy, and/or (2) the patient manifests more conventional evidence of systemic disease.

When there are abnormal findings on CT of the chest, the surgeon must balance the risk of pulmonary metastasis with the likelihood of nonpathologic pulmonary nodules. Once again, IR-guided biopsy is often feasible. The surgeon may also want to use the assistance of a thoracic surgeon for further work-up, and possibly therapeutic intervention.

Another important consideration is for locally advanced colon cancers that are found to encroach or invade adjacent structures. This situation may be as simple as

a cecal cancer abutting the anterior abdominal wall, or it may include more distal cancers that invade the liver, duodenum, pancreas, and major vessels. However, this occurrence is uncommon, but it can typically be detected through preoperative imaging, allowing the surgeon to plan accordingly to ensure a safe R0 resection.

LOCAL STAGING FOR RECTAL CANCER

Colon cancer is generally more straightforward than rectal cancer to diagnose and treat. Once it has been established that there is no metastatic disease, the next step is to surgically remove the offending colonic segment. In contrast, rectal cancer involves a more complex decision tree, in which the next step is to locally stage the tumor to determine whether it is early (stage I [T1–2N0]) or locally advanced (stage II [T3–4N0]) or stage III (TxN1–2). Early tumors are treated with immediate surgery. Locally advanced tumors require neoadjuvant chemotherapy and radiation before surgical intervention.

When the surgeon receives a referral for sigmoid, rectosigmoid, or rectal cancer, an important component of the initial office examination is rigid proctosigmoidoscopy to determine the distance from the anal verge. Often, tumors that seem colonic on flexible endoscopy actually lie within the extraperitoneal rectum. Therefore, surgeons should never rely on endoscopic pictures or the endoscopist's estimation, and a digital examination is not adequate to exclude extraperitoneal disease. There is no hard cutoff for labeling rectal cancers based on distance from the anal verge, and gender and body habitus affect this determination. However, most experts agree that tumors less than or equal to 12 cm from the anal verge should be considered for neoadjuvant therapy when locally advanced.

The ASCRS practice parameters and the NCCN guidelines both recommend routine preoperative staging with either endorectal ultrasonography (ERUS) or high-resolution pelvic MRI. If the lesion is determined to be locally advanced (stage II or III), patients should undergo neoadjuvant chemotherapy and radiation. For the NCCN, MRI is preferred to ERUS,⁵ but neither technique has proved to be universally superior. Both are described later, along with their relative strengths and weaknesses.

Endorectal Ultrasonography

ERUS is a reliable approach to the local staging of rectal cancer, and is typically performed by a specialty-trained surgeon rather than a radiologist. ERUS involves a transducer covered with a water-filled balloon that is passed through a proctoscope, which is inserted into the patient's rectum,¹⁵ allowing a 360° view of the rectal lumen. There are normally 5 rings seen in the images (**Fig. 8**). Radially outward, these layers correspond with (1) the area between the balloon and rectal mucosa, (2) mucosa and muscularis mucosa, (3) submucosa, (4) muscularis propria, and (5) the area between the muscularis propria and perirectal fat. Occasionally, 7 layers are observed, when the muscularis propria appears as 2 darker rings surrounding a lighter, white ring.¹⁵

T stage is determined by invasion of the layers of the rectal wall that were mentioned earlier, prefixed by a *u*; for example, uT1 and uT2. ERUS is better than MRI and CT for determining T stage, with an overall accuracy of 84%, sensitivity of 81% to 96%, and specificity of 91% to 98%, depending on stage.^{16,17} Mesorectal lymph nodes (LNs) can also be assessed (**Fig. 9**), with a sensitivity of 67% and specificity of 78%.² Nodes are deemed to be positive when larger than 5 to 10 mm. However, reliance on LN size may understage a significant number of patients, because nodal metastasis occurs in up to 50% of nodes smaller than 5 mm.^{17,18}

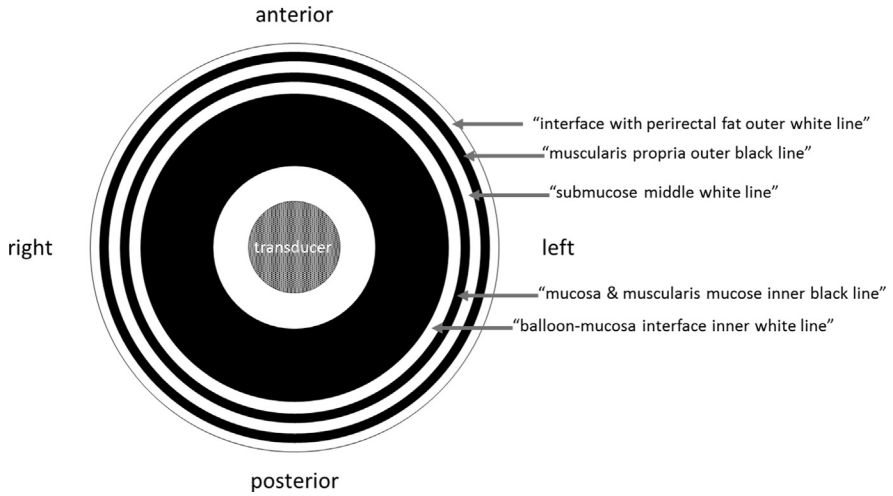


Fig. 8. Cartoon rendering of an ERUS image. The various dark and light rings correlate with anatomic structures.

ERUS is a more dynamic and less expensive study than MRI, but it is operator dependent and requires special training to perform. ERUS is also sometimes hindered by stenotic lesions, bulky lesions, and patient discomfort.

Pelvic MRI

Pelvic MRI is an acceptable alternative to ERUS for the local staging of rectal cancer. Although earlier studies showed sensitivity and specificity to be similar to ERUS, advances in technology and image resolution have led many experts to switch to routine staging with MRI. Specifically, high-resolution imaging with phased-array coils have

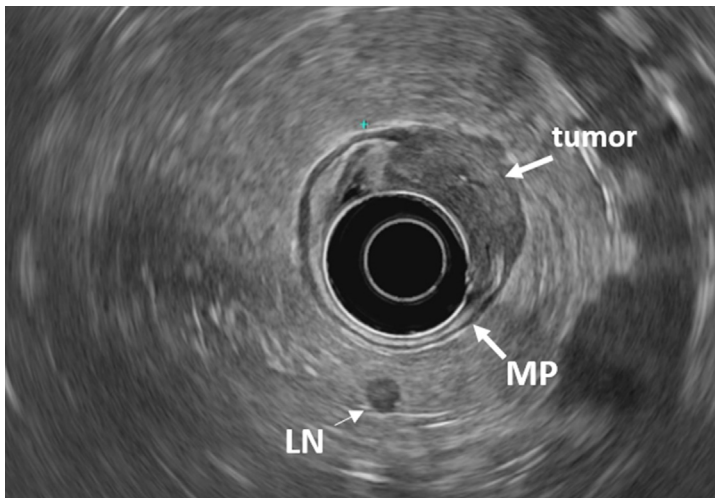


Fig. 9. ERUS image with clinically positive mesorectal lymph node. Midrectal tumor invading the muscularis propria (MP) and an involved LN (T3N1 lesion).

improved accuracy and eliminated the need for an endorectal coil, which is often found by patients to be uncomfortable.¹⁷

A 2012 meta-analysis of T and N staging with MRI showed significant heterogeneity among studies, many of which used older technology.^{18,19} The investigators reported a pooled sensitivity and specificity of 87% and 75%, respectively, for T stage, and 77% and 71% for N stage. In general, MRI is better than ERUS for detecting morphologic abnormalities among LNs smaller than 10 mm, including mixed signal intensity and/or irregular borders, perhaps allowing the detection of subcentimeter metastatic nodes.² Importantly, MRI has a 94% specificity for involvement of the circumferential radial margin, which is an important factor that cannot be accurately assessed with ERUS. MRI can also assess other threatened margins, along with involvement of adjacent pelvic organs such as the prostate or vagina, which may also assist in preoperative planning.

Compared with ERUS, MRI is more expensive and more time consuming. It is more likely to overstage T2 tumors than ERUS, and it has difficulty differentiating active tumor from treatment-related scarring and fibrosis.²⁰ However, MRI does have the advantage of improved patient comfort; improved reproducibility; better understanding of related pelvic anatomy, including the levators and the mesorectal envelope; and better characterization of subcentimeter mesorectal LNs. At present, experts still disagree on which test is the most appropriate for tumor staging, and unbiased clinicians are likely to find uses for both techniques in their practices depending on patient and tumor characteristics.

SURVEILLANCE AFTER CURATIVE RESECTION OF COLORECTAL CANCER

After patients have received surgery with curative intent, serial imaging plays an important role in the subsequent cancer surveillance. There is great disagreement among major organizations regarding the intensity of surveillance, as well as the need for surveillance in patients with stage 1 cancer. Discussions regarding these topics are outside the scope of this article.

When an intense surveillance program has been chosen for patients with colon and rectal cancer, serial laboratory tests, office examinations, and endoscopic evaluations are warranted. In addition, both the ASCRS and the NCCN recommend annual CT scans of the chest, abdomen, and pelvis for the first 5 years after resection.^{1,4,5} At present, there is no role for routine PET/CT, MRI, or ultrasonography for patients after curative resection. However, these tests are used selectively when necessary, as previously outlined.

When abnormalities are found on surveillance imaging, it is important to reference the initial preoperative scans. Indeterminate nodules that are unchanged in size can be closely monitored, typically with reduced imaging intervals. However, new nodules or enlarging nodules require biopsy to exclude metastatic disease. In addition, restaging CT scans should be obtained whenever a patient has shown other signs or symptoms concerning for recurrent malignancy, including weight loss and failure to thrive, new-onset abdominal complaints, shortness of breath, and increases in serum carcinoembryonic antigen level.

SUMMARY

Radiologic imaging plays a crucial role in the diagnosis and treatment of colon and rectal cancer. It is often the responsibility of the surgeon to ensure that proper staging has been completed. A strong understanding of the different available tests, their strengths and weaknesses, and their relative indications can allow for outstanding

patient care, and avoid costly and time-consuming tests that are not ultimately beneficial.

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