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Evaluation of Cervical Cancer by Computed Tomography: Current Status

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In the evaluation of cervical cancer, computed tomography (CT) is used primarily to stage advanced tumors and evaluate for recurrence. Because of reports that CT imaging lacks sensitivity and specificity in the detection of primary tumors and metastatic lesions, its use in these applications has been limited, but recent improvements in CT technology may have increased its accuracy and may broaden its use. At the Second International Conference on Cervical Cancer, held April 11–14, 2002, the limitations of single-detector row CT scanners were compared with the capabilities of new CT technology. Improvements include the introduction of multidetector-row CT scanners, which can produce thinner tissue slices. This technology is needed for detection of parametrial extension, pelvic side-wall disease, extension into the pelvic viscera, lymphadenopathy, local tumor recurrence, and distant metastatic disease. New technology reduces the thickness of each slice to 1–3 mm, improving spatial resolution and making multiplanar imaging possible, which previously was feasible only with magnetic resonance imaging. Studies are needed to assess the use of the improved CT technology in evaluating cervical cancer. ***Cancer*** **2003;98(9 Suppl):2039–43.** © *2003 American Cancer Society.*

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The current role of computed tomography (CT) in cervical cancer is mainly staging advanced tumors and evaluating patients for recurrence. The use of CT in early disease has been limited because of prior reports of low sensitivity and specificity for local invasion in the pelvis; however, major advances in CT technology over the past few years may broaden the use of CT. Increases in the number of detector rows in scanners from 1 to 2, 4, 8, and recently to 16 have allowed the simultaneous acquisition of multiple slices, and the thickness of each slice has been reduced to improve spatial resolution. With thin slices, the flexibility of multiplanar imaging, previously realistic only with magnetic resonance imaging (MRI), is now feasible with CT. However, it must be remembered that a fundamental limitation of CT is that it depends strictly on X-ray attenuation.

Multidetector-Row CT

Slices as thin as 1–3 mm can be obtained easily with the newer multidetector-row scanners, which are much thinner than the 5–8 mm slices typically obtained with single-detector row CT scanners. Cervical cancer spreads laterally to the pelvic side wall and anteriorlor posterior to the bladder and rectum. However, the long axis of the uterus usually is oblique to the axial plane as the uterus is anteflexed or retroflexed. If thick slices are obtained, then the planes between the uterus, bladder, and bowel are not obvious because of partial volume

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averaging, making it difficult to detect local extension on axial slices. It also has been theorized that restriction to the axial plane in part limits assessment of the craniocaudal extent of tumor volume.[1] Three-dimensional (3-D) reconstruction of the CT data set removes this restriction and brings it to equal stature with MRI, inasmuch as it can be displayed in a 3-D format and reconstructed on any plane.

With thin slices, the data can be reconstructed for 3-D imaging with little artifact and pelvic anatomy displayed in sagittal and coronal planes, similar to MRI. The CT data are acquired as a volume and can be reconstructed in any plane defined by the user. This postprocessing is done after completion of the examination.

The relation of the primary tumor mass to the cul de sac, pelvic viscera, side wall, and blood vessels can be displayed on the 3-D images for surgical planning. The precise relation of lymph nodes relative to the aorta and pelvic vessels also can be demonstrated, and sagittal images can be used to show tumor extension into the uterus and vagina. The addition of 3-D images to the axial sections may increase the accuracy of the CT examination.

Studies are needed to determine whether the recent improvements in CT technology will increase the detection of primary cervical cancer tumors and local spread to the pelvis. Although the role of CT is being reevaluated by the American College of Radiology Imaging Network in a trial comparing CT and MRI with surgical staging, the trial has been closed because of poor accrual. The literature to date on the sensitivity and specificity of CT for detecting primary masses and metastatic lesions is based on the results of prior studies done on single-detector row scanners.

Single-Detector Row CT

Studies on the accuracy of CT have been performed on older scanners using thick slices measuring 8–10 mm^2. The scan times of 1–3 seconds also were longer than the currently available time of 0.5 seconds. Visualization of the primary tumor and parametrial spread, therefore, has been limited, and the role of CT has been mainly to stage advanced disease.[3] Up to 50% of Stage IB cancers have been described as undetectable because they are isodense to normal cervical parenchyma.[3] For parametrial disease, the accuracy is a low 30–58% because of false positive diagnoses.[2] Staging accuracy is greater with advanced disease and is 92% for Stage IIIB–IVB cancers.[4] Pelvic side-wall extension, ureteral obstruction, macroscopic bladder and rectal invasion, enlarged lymph nodes, and abdominal disease are detected.[3,5,6]

Pelvic lymph nodes may be enlarged because of metastases or secondary infection, and the two entities cannot be distinguished on CT.[7,8] There is overlap in the size and enhancement of malignant and hyperplastic lymph nodes.[9] However, if the lymph node is necrotic, then the positive predictive value for malignancy is 100%.[9] Having a lymph node of normal size does not exclude the possibility of the presence of microscopic tumor.[3] However, a meta-analysis of the literature on the utility of CT in identifying malignant lymph nodes showed that the presence of lymph nodes of normal size reduces the probability of metastases.[10] Conversely, the probability of tumor is increased only moderately if there are enlarged lymph nodes. There was no significant difference between CT, MRI, and lymphangiography in this study. Overall, CT is 65–80% accurate in detecting malignant lymph nodes, and biopsy is necessary for confirmation.[7,10] Detection of enlarged pelvic lymph nodes is equivalent to disease of International Federation of Gynecology and Obstetrics (FIGO) Stage IIIB with pelvic sidewall extension, and diagnosis of enlarged paraaortic or inguinal lymph nodes is equivalent to FIGO Stage IVB disease.[2] Patients with enlarged pelvic lymph nodes on CT have a lower 5-year disease free survival rate due to the development of distant metastases.[11]

In addition to staging, CT is used to guide lymph node biopsies, to plan radiation therapy, and to follow up.[7,8] CT has high sensitivity and specificity for detecting recurrent tumor.[2] Eighty-five percent of local recurrences were diagnosed correctly on CT in a study of 39 patients with recurrent disease.[12]

CT Protocol

Single-detector row spiral scanner

A spiral scan is performed from the symphysis pubis to the diaphragm. The scan may be performed in two parts—from the symphysis to the iliac crest and then from the iliac crest to the diaphragm—if 3-mm slices of the pelvis are desired. The scan is performed from caudal to cranial to image the cervix during maximal vascular enhancement. The patient is given 750–1000 mL of water-soluble contrast orally and is injected with 120 mL of nonionic contrast intravenously at 2 mL per second. The oral contrast is useful to opacify bowel loops so that they can be distinguished from extracervical tumor masses and local recurrences, which may appear cystic. The scan is started after a delay of 50 seconds after initiation of the contrast injection, and 5-mm slices are obtained at 5-mm intervals. Longer scan delays may be used if necessary to opacify the pelvic veins and ureters, which can be helpful when distinguishing unopacified vessels from lymph nodes and when delineating the ureters, which can be encased by tumor.

Multidetector-row spiral scanner

The scan direction, contrast amount, injection rate, and scan delay are the same for a multidetector-row spiral scanner and a single-detector row scanner. However, the slice thickness can be reduced. Our protocol is to use a slice collimation of 2.5 mm, to move or feed the table 12.5 mm per rotation, and to reconstruct 3–5 mm slices every 3–5 mm.

Primary Tumor Mass of Cervical Cancer

The normal cervix has a variable enhancement pattern on contrast-enhanced CT. Homogeneous enhancement is seen on delayed images after the injection of contrast medium.[13] The primary tumor is hypodense or isodense to normal cervical stroma. The hypodense areas are caused by necrosis, ulceration, or reduced vascularity.[7] Some masses may have gas within them due to necrosis or prior biopsy.[14] The cervix is enlarged to $>$ 3.5 cm anterior to posterior (AP), and a cervical AP size of $>$ 6 cm on CT correlates with a poorer outcome.[2,4] The margin of the cervix usually appears smooth and well defined if there is no extracervical extension of tumor.[14]

A secondary finding is distention of the endometrial cavity with blood, serous fluid, or pus due to obstruction of the endocervical canal.[2,15] The myometrium also may be invaded directly by cervical cancer, and the superior and inferior extent of tumor can be examined on sagittal and coronal images[16]: It is hypodense to normal myometrium on contrast-enhanced scans. Inferiorly, cervical cancer can be exophytic into the vagina or can invade the vaginal wall. The extent of invasion as proximal or distal vagina is defined on sagittal images.

Parametrial Extension of Disease

There are many normal structures in the parametrium, such as uterine vessels, nerves, fibrous tissues, lymphatics, and the distal ureter.[14] The distal ureter lies approximately 2 cm lateral to the margin of the cervix and can be encased by tumor.[3,14] Encasement of the ureter and parametrial soft tissue mass are specific signs of parametrial invasion on CT.[7,14] Ureteral narrowing can result in hydronephrosis, which is Stage IIIB disease. CT has an advantage over intravenous urography in that the hydronephrosis, hydroureter, and site of obstruction can be detected with a single examination.[17]

Other signs of parametrial disease are perivascular invasion and thickening of the uterosacral ligaments. Less specific findings are increased density and stranding of the parametrial fat and an ill-defined margin of the cervix.[7,14] These findings are not as specific as ureteral encasement, because parametrial inflammation without tumor extension can result in stranding of the parametrial fat in patients with cervical cancer.[4,14] This inflammation can be caused by instrumentation, ulceration and infection of the cervical tumor, and prior pelvic surgery.[14] In patients with endometriosis, nodularity of the soft tissues can mimic tumor.[18] Normal parauterine and paracervical ligaments and vessels also appear as soft tissue strands and can be misdiagnosed as parametrial tumor on CT. The strands are thinner than abnormal tumor or inflammatory strands, which are $>$ 3–4 mm thick.[7,14] CT with intravenous contrast and thin slices has been recommended to avoid these errors.[19]

Pelvic Side-Wall Disease

On CT, invasion of the pelvic side wall is diagnosed when the tumor is located $<$ 3 mm from the side wall.[3] With macroscopic invasion, the piriformis and obturator internus muscles are enlarged and heterogeneous. The muscles are infiltrated by enhancing tumor, and the iliac vessels are encased and narrowed.[7] The pelvic bones also may show lytic destructive changes due to direct extension of tumor.[3,20]

Extension Into the Pelvic Viscera

Signs of bladder and rectal invasion on CT are loss of the perivesical or perirectal fat plane, asymmetric nodular thickening of the bladder or rectal wall, an intraluminal mass, and development of a fistula between the cervix and the bladder.[2] Sagittal and axial images can be used to determine whether invasion exists. Bladder involvement is seen in patients with other evidence of disseminated disease, such as pelvic side-wall tumor or distant metastases.[5]

Lymphadenopathy

Lymph nodes that measure $>$ 1 cm in short-axis dimension on CT are considered abnormal.[3,10] The upper limits of normal for individual sites are 7 mm for the internal iliac lymph nodes, 9 mm for the common iliac lymph nodes, and 10 mm for the external iliac lymph nodes.[21] Cervical cancer can spread along the external iliac vessels, internal iliac vessels, and presacral tissues.[22] All three routes of spread lead to the common iliac lymph nodes and, eventually, to the paraaortic lymph nodes. In the external iliac route, the lymph nodes may lie medial and posterior to the external iliac vein, between the external iliac artery and vein, or lateral to the external iliac artery.[22] In the hypogastric route, the lymph nodes are adjacent to the branches of the internal iliac artery. The junctional lymph node between the internal and external iliac

vessels also may be enlarged.[22] Along the common iliac vessels, the lymph nodes may lie in the area between the common iliac arteries, between the common iliac vessels and psoas muscle and spine, or lateral to the common iliac artery.[22]

Local Tumor Recurrence

Local recurrence of cervical cancer occurs central in the pelvis or at the side wall and develops at least 6 months after the treated lesion has regressed.[23] Central recurrences involve the vaginal cuff and appear as soft tissue masses with variable degrees of necrosis.[2,23] They also can appear cystic with minimal soft tissue.[24] Like the primary tumor, recurrent disease can involve the bladder, rectum, and side wall.[12,23] In patients who have received radiation therapy, biopsy may be necessary to distinguish radiation fibrosis from recurrent tumor.[2]

Distant Metastatic Disease

Distant metastases occur to the liver, lung, bone and extrapelvic lymph nodes.[23] Liver metastases appear as solid masses with variable enhancement.[23] Adrenal metastases are present in approximately 15% of patients and usually derive from cervical adenocarcinomas.[23] Peritoneal metastases appear as soft tissue masses with ascites.[23]

Lung metastases occur most commonly as multiple pulmonary nodules and are seen in 33–38% of patients.[23,25] Diffuse interstitial lung disease caused by lymphangitic carcinomatosis is seen in less than 5% of patients.[25,26] Mediastinal adenopathy and pleural effusions are present in approximately one-third of patients with metastatic disease to the thorax.[25] Rarely, a pericardial effusion can develop.[27] Thoracic metastases are more common with adenocarcinoma of the cervix than with squamous cell carcinoma.[25]

Other manifestations of distant metastases are large necrotic psoas lesions that simulate abscesses and osseous lesions. Psoas disease typically has been reported in women infected with the human immunodeficiency virus in whom cervical cancer has a more aggressive course.[28] Osseous lesions are secondary to direct extension from adjacent lymph nodes and, thus, most commonly involve the lumbar spine.[23] The vertebral body is destroyed, and there is an accompanying soft tissue mass.[20]

Conclusions

CT can aid in the staging and follow-up of patients with advanced cervical cancer. Thin slices and multiplanar imaging of the pelvis are feasible with CT because of recent advances in technology. Sagittal and coronal images can be generated to evaluate the size and extent of tumor and to assess for local extension. Studies are needed to determine the value of these additional capabilities in the management of cervical cancer.

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