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CT Angiography for Late Complications of Coarctation Surgery

ABSTRACT & COMMENTARY

Synopsis: *Helical CT angiography can usually replace catheter angiography for the evaluation of late complications of surgery for aortic coarctation.*

Source: Schaffler GJ, et al. Helical CT angiography with maximum intensity projection in the assessment of aortic coarctation after surgery. *AJR Am J Roentgenol* 2000;175:1041-1045.

Late postoperative complications of coarctation of the aorta include re-stenosis and aneurysm. Traditionally, patients have undergone catheter-based angiography for diagnosis of re-stenosis or aneurysm formation.

This study evaluated 25 patients (mean age, 134 months) who had previously undergone coarctation repair (mean time after surgery, 109 months). All 25 patients had suspected re-stenosis on the basis of systolic blood pressure differential between the right upper and lower extremities or a flow jet in the postoperative segment of the aorta at echocardiography. Patients were examined with both catheter angiography and helical CT angiography. The CT data were displayed using maximum intensity projection (MIP) reconstructions. At the time of catheter angiography, Schaffler and colleagues measured systolic blood pressure gradients between the pre- and post-stenotic segments of the former coarctation.

On the basis of catheter angiography, 11 of 25 patients had a normal aortic contour (group A), 12 had a re-stenosis (group B), and two had an aneurysm at the surgical site (group C). In four patients a circumscribed pouch was demonstrated at the site of surgery, and an intimal flap was identified in four other patients. The mean time for performing MIP reconstructions was 15 minutes. The CT MIP reconstructions yielded identical results with respect to classification into the three groups (A,B, and C), circumscribed pouches, and intimal flaps. There was strong correlation between catheter angiography and CT angiography for measurement of the narrowest diameter

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in the area of former coarctation (r = 0.98) or in the descending aorta (r = 0.99). There was no correlation between the systolic pressure gradients found at catheter angiography and the ratio of the diameter of the former coarctation site to the diameter of the descending aorta (r = -0.04).

Schaffler et al concluded that CT angiography can replace catheter angiography for postoperative follow-up of aortic coarctation, and that catheter angiography should be reserved for patients who have abnormal findings on CT angiography that require endovascular intervention or surgery.

COMMENT BY GAUTHAM P. REDDY, MD

This study shows that a noninvasive technique can be as accurate as catheter angiography for postoperative evaluation of coarctation. The MIP reconstructions, which could be performed in a mean of only 15 minutes, provided diagnostic information nearly identical to that of catheter angiography.

Magnetic resonance imaging (MRI), which has been used for pre- and postoperative evaluation of coarctation for more than 10 years,[1] is an alternative to CT angiography. Some advantages of MRI over CT angiography include the absence of ionizing radiation and the lack of need for iodinated contrast agent. In addition, velocity-encoded cine MRI can be used to evaluate the functional significance of the stenosis.[2]

Given the wide availability of CT angiography and MRI, there is no reason to perform routine catheter angiography for the postoperative monitoring of patients with coarctation. Catheter angiography should be reserved for patients who need an endovascular intervention or whose noninvasive imaging examination is technically suboptimal. Patients who need repeat surgery usually do not need diagnostic catheter angiography if the CT angiography or MRI is performed. ❖

References

1. von Schulthess GK. Coarctation of the aorta: MR imaging. *Radiology* 1986;158:469-474.
2. Steffens JC, et al. Quantitation of collateral blood flow in coarctation of the aorta by velocity encoded cine MRI. *Circulation* 1994;90:937-943.

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The Role of Hysterosonography

ABSTRACT & COMMENTARY

Synopsis: *The results of this study suggest that in women with postmenopausal bleeding, transvaginal ultrasonography in conjunction with hysterosonography can improve diagnostic accuracy, clinical decision making, and the clinician's diagnostic certainty.*

Source: Bree RL, et al. US evaluation of the uterus in patients with postmenopausal bleeding: A positive effect on diagnostic decision making. *Radiology* 2000;21:260-264.

The purpose of this investigation was to examine women with postmenopausal bleeding (PMB), in an effort to determine not only the accuracy of hysterosonography (HSG), but also to evaluate its role with regard to diagnostic confidence and therapeutic decision making. To accomplish these goals, Bree collaborated with physicians from two academic and one community medical center. Initially, 123 patients were enrolled in the study, but due to either a technically unsuccessful HSG (10 patients) or incomplete follow-up (15 patients), 98 women ultimately formed the basis of the study. In these women, transvaginal ultrasound in conjunction with HSG revealed the following results: normal findings in 29 patients (30%); polyps in 46 (47%); fibroids in 11 (11%); hyperplasia in eight (8%); and cancer in four (4%). The results of the ultrasound examinations suggested, therefore, that 69 of these women had pathologic conditions that caused their PMB. This was confirmed by histopathology in 65 of these patients. Bree et al claimed that with regard to the four false-posi-

tive ultrasound diagnoses, two of these patients were bleeding at the time of hysteroscopy and dilatation and curettage, and this may have caused a significant lesion to be missed during the surgical procedure. In one patient who was bleeding during the HSG, a blood clot was misinterpreted as a polyp. Of the 29 negative HSG results, 28 were in agreement with histopathologic analysis. In one patient with a small focus of endometrial carcinoma, only a large leiomyoma was detected by HSG. Statistical analysis of these results revealed a sensitivity of 98%, specificity of 88%, positive predictive value of 94%, and negative predictive value of 97%.

Further data analysis suggested that in 86 patients (88% of the cases), the results of the ultrasound examinations substantially influenced the diagnostic certainty for the referring physicians, and that in 78 patients (80% of the cases), treatment decisions were influenced by the HSG results.

Another interesting aspect of this study related to measuring endometrial thickness on transvaginal ultrasound examinations. In women with PMB, multiple reports suggest 4 mm or 5 mm should be used as the cutoff value for determing an abnormally thick endometrium. Interestingly, when Bree et al determined endometrial thickness in 55 women with technically adequate transvaginal examinations, and in whom the HSG study revealed either a polyp or leiomyoma, the mean endometrial thickness was 7.2 mm ± 4.4 mm (range, 2-18 mm). Importantly, in 22 of these women, endometrial thickness was determined to be 5 mm or less.

COMMENT BY FAYE C. LAING, MD

Until recently, the traditional work-up for a woman with PMB consisted of doing either an initial endometrial biopsy or a more invasive dilatation and curettage. If the pathology results were negative, it was assumed the bleeding was not due to a significant problem, with atrophy being the likely cause. When hysteroscopy came on the scene, it became apparent that many cases of PMB did indeed have an anatomic basis, and that many polyps and fibroids were overlooked when the work-up consisted of biopsy, or dilatation and curettage.

Since the advent of transvaginal sonography and its superior resolution compared to transvaginal images, the question has been raised as to whether this noninvasive appproach can be used initially, in lieu of more invasive techniques to evaluate women with PMB. The addition of HSG to the ultrasound armamentarium, and results such as those reported by Bree et al further strengthen this thesis. There are several compelling reasons to advocate using his approach. First, as reported by Bree et al, sonohysterography has high sensitivity and accuracy, and it can alter patient treatment in 80% of cases. Second, given a choice, most women would likely prefer an initial HSG, as opposed to a more invasive procedure. Third, a cost analysis study has shown that when ultrasound is used initally, the total work-up of the patient is less costly.

One surprising result of this investigation is that 22 of 55 women (40%) with either a submucosal fibroid or polyp had an endometrial thickness that was 5 mm or less. Most authorities suggest that when a conventional transvaginal sonogram reveals a normal appearing endometrium with a diameter of less than 5 mm thick (some use < 4 mm), atrophy associated with superficial endometrial ulceration is likely, and that no further diagnostic procedures are required. Unfortunately, in this report, Bree et al only discussed endometrial thickness and did not address whether the endometrium had an abnormal appearance. I suspect close endometrial scrutiny in at least some of these cases would reveal focal pathology.

The question of when to do a HSG remains somewhat controversial. At one extreme are sonologists such as Bree who recommend HSG for all patients with PMB. At the opposite end of the spectrum are sonologists who claim that conventional transvaginal sonography can frequently identify focal edometrial pathology, in which case the HSG can be omitted. Many recommend HSG whenever conventional transvaginal sonography reveals an abnormal endometrium, or for cases that demonstrate either diffuse thickening or indeterminate findings. ❖

Helical CT Pulmonary Angiography in the Detection of Pulmonary Embolism

ABSTRACT & COMMENTARY

Synopsis: *The detection of deep venous thrombosis by indirect CT venography following CT pulmonary arteriography can have significant diagnostic benefit in the diagnosis of pulmonary thromboembolic disease.*

Source: Cham MD, et al. Deep venous thrombosis: Detection by using indirect CT venography. *Radiology* 2000; 216:744-751.

Since its initial description by remy-jardin and colleagues in 1992, there has been considerable interest in the use of helical CT pulmonary angiogra-

phy in the detection of pulmonary embolism. As the speed of helical scanners continually increases, the ability to obtain a greater number of more thinly collimated enhanced scans at a more optimal phase of intrarterial enhancement will progressively improve the ability of helical CT to detect emboli, particularly at the segmental and subsegmental level. However, it is clear from well- performed outcome studies that it is the status of the deep veins of the legs and pelvis that determines outcome in patients, with suspected pulmonary thromboembolic disease (PTD). In fact, most clinical algorithms for the evaluation of patients with suspected pulmonary embolism include some form of imaging of the deep venous system (usually duplex sonography) either because of symptoms of deep venous thrombosis (DVT) or those with inconclusive ventilation-perfusion lung scans or negative or inconclusive CT pulmonary angiograms. The rationale for evaluation of the deep venous system is that serial negative examinations for DVT portends a favorable clinical outcome and therefore, allows safe withholding of anticoagulant therapy. With the increased use of CT pulmonary angiography in the direct evaluation of the pulmonary arteries, the potential benefit of assessing the status of the deep venous system by performing indirect CT venography of the lower extremities and pelvis immediately following CT pulmonary angiography becomes obvious.[1] This study seeks to determine the feasibility of performing indirect CT venography following CT pulmonary angiography and its effect on the diagnosis of pulmonary thromboembolic disease by detecting DVT.

This prospective multi-institutional study enrolled 541 patients over a 10-month period who underwent combined CT pulmonary angiography followed by indirect CT venography for the evaluation of suspected pulmonary thromboembolism. The CT pulmonary angiograms were performed using helical scanners with a collimation of 3 mm at variable pitch and a bolus of 140 mL of 300 mg% nonionic contrast injected at a rate of 3 mL/sec through an arm vein. The chest scans started after a delay of 28 seconds. The CT venograms were obtained helically beginning 120 seconds after completion of the CT pulmonary angiogram using a helical acquisition with 10 mm collimation. The venographic scans were obtained from the iliac crests to the popliteal fossae. The examinations were evaluated for the quality of both the angiographic and venographic components and for presence or absence of pulmonary emboli or deep venous thrombi. One hundred sixteen patients also underwent lower extremity ultrasonography (US).

While the vast majority of CT angiograms were rated as good or excellent (95%), 23% of the venographic studies were rated as fair or poor. Indirect CT venography detected DVT in 45 patients, 16 of whom had no emboli on CT pulmonary angiography. The finding of DVT in these patients increased the diagnosis of thromboembolic disease by 18% over the 17% of patients with evidence of pulmonary emboli. All patients who had DVT on US had positive CT venograms, and an additional four patients who had negative ultrasound exams had DVT on CT venography.

COMMENT BY JEFFREY S. KLEIN, MD

This study, although hampered by certain design limitations, builds upon previous work that shows the feasibility of performing indirect CT venography following CT pulmonary angiography for the evaluation of pulmonary thromboembolic disease. The incremental increase in detection of thromboemboli provided by this technique will clearly prove useful as the study requires only an additional three minutes to perform following the CT angiographic study and relies only upon the contrast administered for the angiographic phase of the examination. The additional radiation exposure is cause for some concern, particularly in young and pregnant patients, and this will need to be addressed by reduction in exposure parameters and increases in helical pitch. The relatively high rate of fair or poor CT venographic studies is somewhat concerning given the nearly universal availability of high-quality duplex US of the deep veins. Some of the difficulties in obtaining reliably high quality CT venograms is likely due to variable left ventricular output and aortic and lower extremity arterial and venous circulation times. However, it is likely that with further advances in helical CT software that allows for assessment of time/density relationships after contrast administration, the technical difficulties of performing high quality indirect CT venography will be solved. The next several years will likely see this technique used in clinical trials that determine the safety of withholding anticoagulant therapy following a combined CT pulmonary angiogram and indirect pelvis and lower extremity venogram that is negative for thromboemboli. ❖

Reference

1. Loud PA, et al. Combined CT venography and pulmonary angiography in suspected thromboembolic disease: Diagnostic accuracy for deep venous evaluation. *AJR Am J Roentgenol* 2000;174:61-65.

Dynamic CT Perfusion in Acute Stroke

ABSTRACT & COMMENTARY

Synopsis: *The imaging of acute stroke is undergoing rapid evolution as advances are made in MR and CT technology. Because most patients with suspected acute stroke still are evalutated with CT scanning, CT-based methods of evaluating brain tissue perfusion could significantly improve the diagnosis and management of acute stroke. Mayer and colleagues present a method of dynamic CT perfusion imaging that is feasible for any clinic with a third-generation CT scanner and discuss the results of CT perfusion analysis in 70 patients.*

Source: Mayer TE, et al. Dynamic CT perfusion imaging of acute stroke. *AJNR Am J Neuroradiol* 2000;21:1441-1449.

The non-contrast head ct scan is the most widely used study in the setting of suspected acute stroke, and it is very useful for excluding other pathologies (such as brain hemorrhage or neoplasm) that may mimic cerebral infarction and for confirming the presence of cerebral infarction if characteristic CT findings are present. Both the diagnosis and treatment of acute stroke, however, might be improved if cerebral perfusion could be measured to identify tissue at risk and to confirm areas of infarcted tissue that might not be apparent on routine CT. Other technologies may be used to assess cerebral perfusion parameters (xenon CT, MR-based methods, positron emission tomography, etc.), but they are not necessarily available in a timely fashion or at all in many institutions. Mayer and colleagues had three aims in their study: to investigate whether the use of dynamic contrast-enhanced CT augmented by software that rapidly provides maps of perfusion parameters is feasible in cases of acute stroke, to determine which imaging parameters best detect tissue at risk, and to identify perfusion thresholds for predicting the development of infarction.

Mayer et al prospectively evaluated 70 adult patients with hemispheric symptoms of less than 12 hours' duration whose plain CT scans showed no signs of hematoma. The initial plain CT and the perfusion maps were compared with follow-up CT scans or MR scans obtained within a week. Patients with brain stem symptoms were excluded. After the routine non-contrast CT scan was performed, dynamic contrast-enhanced CT scans were acquired by injecting 50 mL of iodinated contrast medium via a 16-gauge catheter at 10 mL/sec. Because only a single section was obtained with each bolus, one to three levels were obtained per patient, with the initial section at the level of the basal ganglia and additional rostral or caudal scans obtained at the discretion of the monitoring physician. Commercially available software was used to estimate the following cerebral perfusion parameters: cerebral blood flow (CBF), cerebral blood volume (CBV), and time to peak (TTP). Technically, the method required only a personal computer with appropriate evaluation software and a DICOM connection to the CT scanner.

The results of perfusion CT for three patients with acute stroke symptoms showed no evidence of cerebral ischemia. Further assessment led to diagnoses of seizure in one, astrocytoma in one, and radiation injury in one. Fourteen patients had symptoms that resolved within 24 hours, with 13 diagnosed with transient ischemic attack and one diagnosed with migraine. Only two out of 13 had moderate TTP delay, and none developed an infarct. Of the 53 patients in whom cerebral infarction was confirmed by follow-up studies, six had lacunar infarcts. These small ischemic foci were difficult to distinguish from artifacts in the white matter by perfusion scanning, and the actual lesion was suspected in only two out of six cases. The remaining 47 patients included 44 territorial infarcts and three infarcts of hemodynamic origin (low flow due to carotid stenosis). Forty of these infarcts were detected on CBF maps, while seven of the smaller gyral infarcts were variably detected on TTP, CBV, and

Table

	Early CT signs of infarction	CBF < 60% of normal territories	CBV < 80% of normal territories	TTP > 3 sec behind TTP on normal side
Sensitivity	0.55	0.94	0.89	0.91
Specificity	0.96	0.87	0.91	0.61
PPV	0.96	0.94	0.95	0.83
NPV	0.51	0.87	0.81	0.78

Note: PPV = positive predictive value; NPV=negative predictive value

CBF maps. The Table presents an abbreviated summary of results of conventional and perfusion imaging in cases of subsequently confirmed nonlacunar infarcts.

Overall, the specificity of early CT signs of infarction (swelling or hypodensity of the gray matter) was very high, but sensitivity was relatively poor. CBF maps indicating moderate or severe deficits showed true-positive results for infarcts in more than 90% of the brain territories and patients. CBV maps showed fewer definite regions of low perfusion than did CBF maps, but gave fewer false-positives. TTP maps were nearly as sensitive indicators of cerebral infarction as were CBF maps but were less specific, probably due to carotid stenosis compensated via collaterals. CBF and TTP maps together were 100% sensitive for nonlacunar cerebral infarction.

COMMENT BY NANCY J. FISCHBEIN, MD

With the availability of an increasingly sophisticated therapeutic armamentarium for the patient with acute ischemic infarct comes the need to clearly diagnose the presence of infarction and to define territory at risk. Since CT scanning remains far more accessible than MR-based diffusion and perfusion techniques in most medical centers, the assessment of CT-based perfusion parameters may soon become an integral part of the management of these patients. Clarification as to which parameter or combination of parameters best defines regions of frank infarction, tissue at risk, and normal tissue will come as larger studies are done in more varied patient populations. For the moment, dynamic CT perfusion imaging is feasible in any clinic with a third-generation CT scanner and should probably be attempted in any patient thought to have acute ischemic symptoms who has a normal baseline CT scan. In this study, single-section CBF maps predicted all territorial infarcts with volumes larger than 10 mL. CBF images were superior to CBV images in sensitivity and superior to TTP images in specificity. Infarction occurred in all vascular territories where loss of perfusion was more than 70% and in more than half of the cases where perfusion losses were between 40% and 70%.

There are some drawbacks to dynamic CT perfusion that should be kept in mind as we all attempt to gain experience with this technique. First, at present, only a single section or a few sections can be acquired due to limits on the amount of contrast that can be injected, as well as time, radiation dose, and other considerations. Second, the CBF image can be used only as a relative CBF map, and this can be problematic when contralateral areas of brain have baseline abnormalities that would not be known at the time of the acute CT scan. Third, low spatial resolution can cause small lesions to be overlooked, though this generally will not compromise acute management as these patients would be unlikely to benefit from thrombolytic therapy. Image quality can also be impaired in patients with poor cardiac function. ❖

Evaluation of Pelvic Lymph Nodes With Dynamic Helical CT and Dynamic MR Imaging in Cervical Carcinoma

ABSTRACT & COMMENTARY

Synopsis: *Dynamic enhanced helical CT and MR imaging both have high accuracy but only moderate sensitivity in detecting pelvic lymph node metastases of cervical carcinoma using a size criterion of maximal axial nodal diameter larger than 10 mm. More optimal criteria for maximal axial nodal diameters may be 9 mm for helical CT and 12 mm for MR imaging.*

Source: Yang WT, et al. Comparison of dynamic helical CT and dynamic MR imaging in the evaluation of pelvic lymph nodes in cervical carcinoma. *Am J Radiology* 2000;175: 759-766.

In patients with cervical carcinoma, the presence of metastases in pelvic lymph nodes has important implications for prognosis and the choice of appropriate therapy. Unfortunately, the reported sensitivities and specificities of current radiologic techniques for distinguishing normal and metastatic pelvic lymph nodes have generally been less than optimal. In this study, Yang and associates in Hong Kong performed a prospective evaluation of two newer dynamic enhanced techniques, helical CT (with 7-mm section thickness) and MR imaging (with 4-, 5-, and 6-mm section thickness), for making this distinction in 43 women with biopsy-proven cervical carcinoma. They recorded the minimal and maximal axial diameters, CT attenuation, MR signal intensity, and areas of necrosis in visible pelvic lymph nodes. These findings were correlated with the results of pathologic examination of 949 lymph nodes surgically removed from 76 hemipelves in these women. Sixty-nine (7%) of the lymph nodes, from 17 hemipelves (22%), contained metastatic tumor at pathologic examination. Using a maximal axial diameter of more than 10 mm or the presence of central necrosis as criteria for nodal metastasis, Yang et al found the respective sensitivities of CT and MR imaging on a hemipelvis

basis to be 64.7% and 70.6%; specificities, 96.6 % and 89.8%; positive predictive values, 84.6% and 66.7%; negative predictive values, 90.5% and 91.4%; and accuracies, 89.5% and 85.5%. Then, using receiver operating characteristic curve analysis, they determined that optimal size criteria for distinguishing benign from metastatic nodes in their patient group were maximal axial nodal diameters of 9 mm for CT and 12 mm for MR imaging. Central necrosis within a node had a positive predictive value of 100% for metastasis; as would be expected, necrotic nodes tended to be large (with a mean maximal nodal diameter of 2.3 cm at CT and 1.9 cm at MR imaging). Nodal shape, MR signal intensity, and CT enhancement pattern could not reliably be used to distinguish benign and metastatic nodes.

COMMENT BY DAVID M. PANICEK, MD

Radiologists are well aware of the major limitations of lymph node assessment at CT and MR imaging: normal-sized nodes may contain microscopic deposits of metastatic tumor, whereas nodes free of tumor may be enlarged in reaction to some other process. Various approaches have been undertaken in an attempt to improve upon this situation, including analysis of parameters such as nodal shape, nodal enhancement, and site-specific and disease-specific size criteria for nodal enlargement; and use of node-specific contrast materials. To date, the only clinically useful sign of pelvic lymph node metastasis is nodal enlargement. The choice of a specific cutoff size beyond which a node is considered enlarged is controversial, however, and results in an unavoidable tradeoff between sensitivity and specificity; the smaller the size criterion used, the higher the sensitivity for nodal metastasis—but at the expense of lowered specificity. Comparison of various studies of lymph nodes is complicated by the use of short-axis diameter in many, long-axis diameter in others, and lack of any specification of how the node was measured in a few; also, use of different slice thicknesses and types of cross-sectional imaging techniques further confuses the issue.

As in all studies, there are some limitations of this one. Only patients who underwent surgery were enrolled, so some patients with very advanced disease were excluded; therefore, the study population was biased toward patients with less advanced disease. The section thickness was different for CT and MR imaging, which may at least partly account for the different optimal cutoff size criterion found for each technique. Most importantly, no node-by-node correlation between imaging and pathology was performed; thus, an imaging test would be considered "correct" if any node in a hemipelvis was scored as positive for metastasis on the images—even though that node may not have corresponded to any pathologically proven metastasis-bearing node surgically removed from elsewhere in the hemipelvis.

This study represents a good step in the right direction for refining the radiologic criteria for pelvic lymphadenopathy in patients with cervical carcinoma, but additional research is needed before new size criteria (or other parameters) can be adopted for routine clinical use. ❖

Is CT the Study of Choice for Pediatric Appendicitis?

ABSTRACT & COMMENTARY

Synopsis: *Helical CT with thin collimation is accurate in the diagnosis of appendicitis of children and young adults. CT also is useful in establishing alternative diagnoses in patients who do not have appendicitis.*

Source: Sivit CJ, et al. Evaluation of suspected appendicitis in children and young adults: Helical CT. *Radiology* 2000;216:430-433.

Possible appendicitis is the most common concern of emergency room physicians caring for children with abdominal pain. To avoid unneeded laparotomy and possible missed appendicitis, various imaging modalities have been used for evaluation of the appendix. In the study reported, retrospective review of children presenting with right lower quadrant pain who had a CT was performed. The subjects were 154 patients, 86 girls and 68 boys between the ages of 1-20 years. The patients presented over a three-year period and had a clinical manifestation that was thought equivocal for appendicitis. Patients with unequivocal appendicitis underwent laparotomy.

Helical scanning was performed from the diaphragm to the pubic symphysis and all patients received intravenous contrast medium administered at 3 mL/kg of body weight by using a power injector. Gastrointestinal tract opacification was achieved through oral or rectal administration of 3% diatrizoate meglumine solution. Appendicitis was diagnosed if the appendix did not fill completely with contrast material or air; if it exceeded 6 mm in cross-sectional diameter; or if an appendicolith, adjacent extraluminal air, or a complex fluid collection or mass was noted. Final

diagnoses were established by surgical and histopathologic evaluation in 69 patients and by clinical follow-up in 85 patients.

Of the 154 children in the study, 40% were proven to have appendicitis at appendectomy. Results were 58 true-positive diagnoses of appendicitis at CT and six patients with false-positive diagnosis of appendicitis at CT: the appendix diameter was 6.5-7.0 mm or pelvic fluid collections were present, thought to be periappendiceal abscesses. Of 87 patients with true-negative diagnoses at CT, 37% had an alternative diagnosis established on the basis of CT findings. There were three false-negative diagnoses at CT in patients with surgically proven appendicitis.

The high diagnostic accuracy of CT emphasizes the effectiveness of this examination. The use of thin collimation is recommended throughout the abdomen and the pelvis and rectal contrast may be more effective than oral contrast material.

COMMENT BY BEVERLY P. WOOD, MD

Of children presenting with acute abdomen and possible appendicitis, only about one-third have appendicitis. Laparotomy in the absence of appendicitis or delay in the case of appendicitis needs to be kept to a minimum. Cost of observation of equivocal cases is prohibitive; thus, establishing the diagnosis at the time of the emergency workup is ideal. To date, ultrasonography with graded pressure has been found to be accurate, although often inconclusive in very young children. CT is useful with few false-positive or false-negative examinations, and avoids unnecessary surgery or missed appendicitis. The accuracy of CT in children is the same as that in adults, and the studies are not more difficult to perform and interpret than in the adult age group. CT is effective in identifying other causes of abdominal pain in the presence of a negative appendix. Rectal contrast and thin collimation imaging of the lower abdomen and pelvis as well as evaluation of the entire abdomen increase the accuracy of the examination. Unfortunately, this study does not compare modalities, so it is not possible to determine how often CT alone accurately made the diagnosis as contrasted with ultrasound examination. ❖

CME Questions

40. The initial report of helical CT pulmonary angiography in the diagnosis pulmonary embolism was published in:
a. 1988.
b. 1990.
c. 1992 .
d. 1994.
e. 1996.

41. In this study, the use indirect CT venography increased the detection of thromboembolism by:
a. 0%.
b. 10%.
c. 18% .
d. 30%.
e. 50%.

42. In a case of acute ischemic infarction, dynamic CT perfusion assessment of the clinically involved territory would not be expected to potentially yield which of the following results?
a. CBF less than 60% of normal CBF
b. CBV less than 80% of normal CBV
c. TTP 3 seconds earlier than TTP on the contralateral side
d. TTP lagging 6 seconds behind TTP on the normal side

43. A pelvic lymph node in a patient with cervical carcinoma:
a. can be classified as metastatic with moderate sensitivity and high accuracy using dynamic CT or MR imaging.
b. often shows central necrosis at MR imaging regardless of whether the node is benign or contains metastasis.
c. exhibits more rapid enhancement at dynamic CT when the node contains metastasis.
d. can be classified as benign at MR imaging if it is oval-shaped.

44. What technique is recommended to evaluate the appendix?
a. CT of the pelvis 4-10 mm collimation
b. CT of the entire abdomen with thin collimation of the lower abdomen/pelvis
c. CT of the pelvis and ultrasound
d. CT of the entire abdomen without oral contrast material.

45. According to findings reported in this article, most cases of PMB are due to:
a. endometrial atophy.
b. submucosal fibroids or polyps.
c. endometrial hyperplasia.
d. endometrial carcinoma.

46. According to Bree et al, HSG should be done in women with PMB:
a. when the endometrium is diffusely thickened.
b. when the endometrium is focally thickened.
c. in all cases.
d. when the endometrial findings are indeterminate.

47. Which of the following statements is correct regarding post-operative imaging of patients with coarctation of the aorta?
a. CT angiography is less accurate than catheter angiography for diagnosis of aneurysm at the surgical site.
b. There is weak correlation between catheter angiography and CT angiography for diagnosis of re-stenosis.
c. There is strong correlation between anatomic stenosis at catheter angiography and the pressure gradient across the coarctation.
d. Catheter angiography should be reserved for patients who need endovascular intervention or surgery.
e. MRI can provide anatomical information but not functional information.

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Radiological Technologists: Vanishing Breed or Endangered Species?

Summit, Studies Conclude Major Work Changes Needed

By Julie Crawshaw

In south carolina's burgeoning upstate area, a woman may need to wait as long as six months for a mammogram. Tommy E. Cupples, MD, radiologist and assistant clinical professor of radiology at the University of South Carolina School of Medicine in Columbia, says the specialty of radiological technology is in real trouble if there aren't some significant changes made during the next few years.

Judy H. Speer, mammography coordinator at Greenville Technical College in Greenville, S.C., says the shortage is expected to hit critical proportions in the area next spring when Greenville Hospital System opens its Eastside Center for Women with nine mammography units on site. The hospital system hopes to reduce the wait from six months to one month by performing another 12,000-14,000 mammograms a year at its Eastside Center.

The hospital system is aggressively recruiting technologists, but the problem is there aren't many available. The American Society of Radiologic Technologists (ASRT) predicts 55,000 more technologists will be needed by the year 2008 to fill the projected need. Nationwide, more than 300 million radiologic procedures, including X-rays, CT scans and MRIs, are performed each year, and 8% of those are mammograms. That demand will only grow, since over the next three years a million women a year will celebrate their 40th birthday, a time when annual mammography screening typically begins. (*For a look at the declining numbers of technologists, see Tables on page 134.*)

Add to all that a financial crunch caused by low mammography reimbursement levels, and the results reach crisis proportions.

Leaders at a recent summit on Radiological Sciences and Sonography attempted to develop strategies to combat the shrinking numbers of radiological technologists, radiation therapists, and sonographers. The meeting, facilitated by the Society of Nuclear Medicine Technologist Section, focused on solutions for the personnel shortage.

"The outcome of this meeting is that we all agree that there must be major changes in the profession to ensure the personnel shortage does not threaten the delivery and quality of patient care," says Lynn May, chief executive officer of the ASRT. "We agreed on three basic tenets of work force development and workplace enhancement—increased recruitment, upgraded education, and advancement potential and improved working conditions to ensure a better rate of retention."

Participants at the Summit agreed to develop a recruitment video or videos that can target a wide audience of potential candidates, from kindergarten through high school, minority populations, and returning students seeking a second or third career. They also set the goal of adding a Research Center for Excellence in the Radiologic Sciences to the ASRT Website to encourage technologists to perform original research and provide them with updates on research projects.

However, just improving recruiting techniques won't solve the shortage problem, says ASRT Chairman Michael D. Ward, PhD, RT(R), FASRT, Director of Allied Health at the Jewish Hospital College of Nursing and Allied Health. He says the shortage has been exacerbated in part by the fact that nine-to-five jobs aren't the norm in radiology anymore.

"People have to take calls and work weekends. That's always been true to some extent, but it's gotten rougher because there are fewer people on the job."

Ward points out that even as the radiological technologist population has shrunk the variety of technological work in the job market at large has greatly increased, giving entry-level candidates more career choices.

"Many of those do have nine-to-five hours and are better paid," Ward says. He adds, "We should develop programs that meet the needs of today's students, including evening programs, weekend programs and distance-learning programs."

Table 1

Number of First-Time Candidates Taking Certification Examinations in Radiography and Radiation Therapy

Year	Radiography	Radiation Therapy
1994	10,629	1,046
1995	10,330	941
1996	9,427	708
1997	8,691	493
1998	8,146	437
1999	7,595	389

(*Certification exams administered by the American Registry of Radiological Technologists*)

Table 2

Number of Educational Programs in Radiography and Radiation Therapy

Year	Radiography	Radiation Therapy
1994	692	125
1995	677	120
1996	651	107
1997	624	95
1998	611	81
1999	601	80
2000	583	73

(*Educational programs accredited by the Joint Review Committee on Education in Radiological Technology*)

Salary Increases May Reduce Burnout Costs

Comparatively low pay is also a major issue in radiological sciences. Radiological technologists earn $12-$14 an hour, less than bartenders, wait staff, and others who often work on more flexible schedules and are in equally high demand. As more than two-thirds of U.S. hospitals are in the red and federal money does not appear to be forthcoming, finding the money to attract and keep a high-quality staff is a tough order.

An ASRT study mailed last December to 3,668 radiation oncology centers indicates that it takes an average of nearly four months to fill positions for radiation therapy and dosimetry. One center reported a position unfilled for two years.

The study drew 439 responses with one conclusion: Recent graduates can't begin to fill available radiology positions. Centers that responded reported 299 radiation therapist vacancies within the six months prior to receiving the survey, and 55 positions were reported as having been vacant for more than six months. There were 354 current vacancies—13 % of available positions—for radiation therapists. There were 533 full time equivalent positions for medical dosimetrists, with 84 current vacancies. Seventy-seven vacancies were

reported within six months of the survey date.

The survey asked centers to report measures used to recruit applicants to fill vacancies. More than 25% said they increased salaries or benefits; 21.6% offered sign-on bonuses that averaged $2,000- $3,000, but one center reported a $10,000 sign-on bonus. Only 3.9% reported adjusting salaries and benefits for all staff.

According to a study published in the fall issue of *Radiation Therapist*, radiation therapists experience significantly higher levels of emotional exhaustion and depersonalization than do nurses. The article pointed to recent studies of burnout in both jobs, and the nursing practice settings referred to included nursing homes and hospital AIDS units. The article points out that high levels of employee stress and associated burnout have been estimated to cost the United States in excess of $200 billion per year in absenteeism, reduced productivity, medical expenses, and compensation claims. The authors conclude, "real progress will be made when health care organizations realize the importance of providing a climate that promotes employee retention."[1]

Shortages and Smart Machines

While some may argue that proficiency standards for therapists can be lowered because the machines are getting smarter, Lynn May observes that technologists who are less capable than their predecessors isn't the answer. "There probably has been a dumbing-down in medical imaging because the system only allows paying people at marginal levels. But any industry that bases its future on recruiting the lowest level is doomed," he says.

May points out that information technology is quickly permeating medical imaging and radiation therapy. Typically, when this happens situations change quickly because quantitative and qualitative data are available for analyzing and improving outcomes. It also causes rejection of hierarchical structures in favor of knowledge cultures in which self-directed professionals share expertise to solve problems and improve productivity. "When that happens," he says, "the human resource solution is not to hire a lot of semi-skilled workers, but to hire fewer, more competent/better trained individuals who can meet many needs."

Legislation for Practice Standards in Works

Proposed legislation now before Congress, and supported by ASRT, would establish an inducement to states to establish mechanisms for licensing or registering all personnel performing medical imaging or radiation therapy, except for sonographers. Non-compliant states would lose Medicaid waivers

"The requirements of the bill are simple," May says. "If a technologist or other personnel is trained in an educational program, a competent authority must accredit that program. If a technologist or other personnel is practicing, a competent authority must credential them."

If the bill becomes law, the Secretary of Health and Human Services would develop regulations establishing minimum standards for both accreditation and credentialing. The regulations would provide time and opportunity for technologists and other personnel who do not meet minimum standards to achieve compliance.

The bill is actively promoted by the Alliance of Quality Medical Imaging and Radiation Therapy, a coalition of 14 organizations representing professional societies, accrediting agencies, and certifying bodies in the radiological sciences, other allied health professions and physicists.

Mammography Centers are Impacted

The shortage of technologists adds another troubling dimension to the difficulties many women already have getting a mammogram. According to a report by the Dow Jones news service, mammography centers are closing their doors because they can't afford to keep them open due to low reimbursement for the tests from managed-care insurers.

Radiologists complain that money they receive for mammograms is less than they need to keep their clinic doors open. They point the blame at managed care companies, which now have captured a large share of the health insurance market. Managed care companies, however, contend that reimbursement levels are appropriate and blame the problem on inefficient doctors and clinics.

Charles M. Cutler, MD, chief medical officer of the American Association of Health Plans, a Washington, DC-based HMO trade group, says that if women are having problems getting access to mammography centers, the problem lies in scheduling. As for radiologists who complain about reimbursement rates, Cutler adds, "presumably they negotiate fees that will be adequate for them to do their work."

That's easier said than done, says Richard J. Bagby, medical director at Boston Diagnostic Imaging in Orlando, FL, which performed 20,000 mammograms last year. Bagby says that many health plans negotiate a master radiology contract that requires clinics to take lower payments on high-volume tests such as mammograms in order to get favorable rates on more-lucrative procedures such as CT scans and magnetic resonance imaging. Sometimes, clinics just have to hope they can

make up the difference, he says. And, he adds, mammograms serve a community need that many doctors don't want to abandon.

Medicare's reimbursement rates are mandated by Congress and serve as a benchmark for many insurers. Last year, the agency paid for more than four million cancer-screening mammograms, reimbursing radiology offices, clinics, and other health centers an average of $46.11 for a cancer-screening mammogram, plus $21.70 to cover the radiologist's fee.

However, last summer Medicare began paying hospitals an average of $33.94 for so-called diagnostic mammograms, the more intensive examinations radiologists use to follow up any breast abnormality.

The new Medicare reimbursement rate for diagnostic mammograms performed at hospital outpatient clinics is 33% less than the amount the federal program pays a freestanding clinic for the same procedure. Physicians at both types of facilities receive an additional $33.68 for their professional services. That means hospitals' outpatient imaging centers now get 36% more for conducting a simple screening exam than they do for a more comprehensive and time-consuming diagnostic follow-up test. Although the disparity doesn't affect most mammography patients directly, hospitals say it creates a financial bind for many radiology facilities that offer mammograms.

Even high-volume mammography providers that can operate on lower profit margins are having problems. Radiologix Inc., a Dallas-based company that operates 124 radiology centers across the nation, says it earns a nominal profit on mammograms. The company pointed to its Baltimore facility as an example of a center that is significantly underpaid. The company reports that health plans in Baltimore pay an average of 83% of Medicare's fee and that one insurer there pays Radiologix just $23 for each test, 34% of the Medicare rate.

According to ASRT, about 1,800 student specialists took the national mammography exam in 1999, less than half the number who took the test in 1997. The American Cancer Society estimates that one million additional American women each year reach their 40th birthday, the age at which women are advised to begin having annual mammograms. This society says that this year about 182,800 new breast-cancer cases will be diagnosed and about 40,800 women will die from the disease. ❖

Reference

1. Akroyd D, Adams R. The cost of caring: A national study of burnout in radiation therapists. *Radiation Therapist*2000;9:123-130.