



An Imaging Guide for the Busy Physician

Care to Care's Brief Reference to Efficient Medical Imaging

Michael Komarow MD, JD
Chief Medical Officer

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PREFACE

“The amount of information contained in an imaging study is enormous, especially with computed axial tomography and magnetic resonance imaging technologies. This increase in information may be essential for the care of patients, or it may be a distraction in the diagnostic process. Imaging techniques are rapidly evolving, so it is essential to work closely with your radiologist to select the appropriate imaging studies to answer your questions.¹”

The most common complaints arise most commonly, and cause the most over utilization of medical imaging. It is our purpose here to provide a quick guide to appropriate use of imaging examinations to foster prompt and accurate diagnosis.

Imaging examinations, from the simplest x-ray to the most complex fused PET-MRI can offer essential diagnostic information, but all have limits. No one benefits if an imaging exam does not reduce the degree of diagnostic uncertainty faced by the treating physician but radiation exposure, expenses, and the risks of false positive results all accumulate.

Despite considerable increases in imaging efficiency, radiation dosage from CT remains relatively high, and with it the risk of inducing malignancy. It is poor medicine to expose a patient to any risk without assessment of the potential benefit.

About 15% of the ionizing radiation exposure to the general public comes from artificial sources, and almost all of this exposure is due to medical radiation, largely from diagnostic procedures. Of the approximately 3 mSv annual global per caput effective dose estimated for the year 2000, 2.4 mSv is from natural background and 0.4 mSv from diagnostic medical exams. Diagnostic and therapeutic radiation was used in patients as early as 1896. Since then, continual improvements in diagnostic imaging and radiotherapy as well as the aging of our population have led to greater use of medical radiation. Temporal trends indicate that worldwide population exposure from medical radiation is increasing. In the United States, there has been a steady rise in the use of diagnostic radiologic procedures, especially x rays. Radiotherapy also has increased so that today about 40% of cancer patients receive some treatment with radiation. Epidemiologic data on medically irradiated populations are an important complement to the atomic-bomb survivors' studies. Significant improvement in cancer treatment over the last few decades has resulted in longer survival and a growing number of radiation-related second cancers. Following high-dose radiotherapy for malignant diseases, elevated risks of a variety of radiation-related second cancers have been

¹ LeBlond RF, Brown DD, DeGowin RL, "Chapter 17. Principles of Diagnostic Testing" (Chapter). LeBlond RF, Brown DD, DeGowin RL: DeGowin's Diagnostic Examination, 9th Edition: www.accessmedicine.com/content.aspx?aID=3658178.

observed. Risks have been particularly high following treatment for childhood cancer. Radiation treatment for benign disease was relatively common from the 1940's to the 1960's. While these treatments generally were effective, some resulted in enhanced cancer risks. As more was learned about radiation-associated cancer risks and new treatments became available, the use of radiotherapy for benign disease has declined. At moderate doses, such as those used to treat benign diseases, radiation-related cancers occur in or near the radiation field. Cancers of the thyroid, salivary gland, central nervous system, skin, and breast as well as leukemia have been associated with radiotherapy for tinea capitis, enlarged tonsils or thymus gland, other benign conditions of the head and neck, or benign breast diseases. Because doses from diagnostic examinations typically are low, they are difficult to study using epidemiologic methods, unless multiple examinations are performed. An excess risk of breast cancer has been reported among women with tuberculosis who had multiple chest fluoroscopies as well as among scoliosis patients who had frequent diagnostic x rays during late childhood and adolescence. Dental and medical diagnostic x rays performed many years ago, when doses were presumed to be high, also have been linked to increased cancer risks. The carcinogenic effects of diagnostic and therapeutic radionuclides are less well characterized. High risks of liver cancer and leukemia have been demonstrated following thorotrast injections, and patients treated with radium appear to have an elevated risk of bone sarcomas and possibly cancers of the breast, liver, kidney, thyroid, and bladder.²

Proper choice of which exam to use, and when to use it is therefore crucial. On the pages that follow we have attempted to give a guide to the proper use of imaging in a variety of non-emergent clinical circumstances. Readers' comments and suggestions are welcomed and should be sent to me at mkomarow@caretocare.com.

Abdominal Pain

Paying no heed to the sages who in creating CPT codes divided the abdomen into two parts (abdomen and pelvis) nature recognizes no such border. For our purposes we will consider the abdomen in five parts and just for the sake of being ornery also as the whole. The complex anatomy and multiplicity of structures within the abdomen make such divisions clinically useful, even if there is considerable overlap. In the charts below are listed common (and not so common) causes of abdominal pain and suggestions concerning whether CT or MR are useful in evaluating these particular diagnoses. This presupposes that the history, physical and prior exams have led to the consideration of one of the diagnoses as being the likely source of the patient's pain. Subjecting everyone with abdominal pain to a CT is not only cost ineffective it is a misapplication of a great deal of radiation. Judicious use of imaging can, however, swiftly lead to appropriate care. Please use what follows as a guide, to be combined with all the other clinical data you compile, and your best judgment.

² Health Phys. 2003 Jul;85(1):47-59.

Generalized Abdominal Pain

Differential	CT	MR	Comments
Abscess	Useful	Not a Primary Tool	
Aneurysm	Useful	As alternative to CT	MR may be used if there is contrast sensitivity.
Constipation	Not a Primary Tool	Not a Primary Tool	Colonoscopy or flexible sigmoidoscopy and barium enema
Ectopic Pregnancy	Not a Primary Tool	Not a Primary Tool	Ultrasound preferred
Gastritis	Not a Primary Tool	Not a Primary Tool	
Gastroenteritis	Not a Primary Tool	Not a Primary Tool	
Inflammatory Bowel Disease	Not a Primary Tool	Not a Primary Tool	Endoscopy generally preferred
Intestinal Obstruction	Not a Primary Tool	Not a Primary Tool	
Irritable bowel Syndrome	Not a Primary Tool	Not a Primary Tool	
Metabolic Disorders	Not a Primary Tool	Not a Primary Tool	
Pancreatitis	Useful	Useful	
Parasites	Not a Primary Tool	Not a Primary Tool	
Perforated Viscus	Useful	Not a Primary Tool	
Ruptured Spleen	Useful	Useful	
Urinary tract infection	Not a Primary Tool	Not a Primary Tool	
Vascular Disease	Useful	Useful	CTA or MRA

Epigastric or Upper Abdominal Pain

Suspected Diagnosis	CT	MRI	Comments
Aortic Aneurysm	Useful	May be Useful (MRA)	
Cholangitis	Useful	Useful	
Gall Stones	May be Useful	May be Useful	Ultrasound preferred
Gastric malignancy	Not a Primary Tool	Not a Primary Tool	
Gastritis	Not a Primary Tool	Not a Primary Tool	
Gastroparesis	Not a Primary Tool	Not a Primary Tool	
GE Reflux	Not a Primary Tool	Not a Primary Tool	
Hernia	Useful	Not a Primary Tool	Physical exam still best
Infections	Useful	May be Useful	
Ischemic bowel	Useful	Not a Primary Tool	
Lactase deficiency	Not a Primary Tool	Not a Primary Tool	
Malabsorption	Not a Primary Tool	Not a Primary Tool	
Myocardial pathology	Not a Primary Tool	Not a Primary Tool	
Pancreatitis	Useful	Not a Primary Tool	
Peptic Ulcer Disease	Not a Primary Tool	Not a Primary Tool	
Pneumonia	Not a Primary Tool	Not a Primary Tool	
Pregnancy	Not a Primary Tool	Not a Primary Tool	

Right Upper Quadrant Pain

Differential	CT	MRI	Comments
Cholelithiasis	Not a Primary Tool	Not a Primary Tool	Ultrasound
Cholecystitis	Not a Primary Tool	Not a Primary Tool	Ultrasound, HIDA
Cholangitis	Useful	Useful	
Hepatitis	Not a Primary Tool	Not a Primary Tool	Lab Studies
Appendicitis	Useful	Useful	
Peptic Ulcer	Useful	Not a Primary Tool	CT if complications are suspected
Pancreatitis	Useful	Useful	MRCP
Liver Abscess	Useful	Not a Primary Tool	US
Dyspepsia	Not a Primary Tool	Not a Primary Tool	
Liver, Pancreatic, or Biliary Cancer	Useful	Useful	
Budd Chiari	Useful	Useful	

Differential	CT	MRI	Comments
RLL Pneumonitis	Useful	Not a Primary Tool	
Pyelonephritis	Not a Primary Tool	Not a Primary Tool	
Urinary Calculi	Useful	Not a Primary Tool	
PID	Not a Primary Tool	Not a Primary Tool	US is preferred
Herpes Zoster	Not a Primary Tool	Not a Primary Tool	
Herniated Disc	Not a Primary Tool	Useful	
Abscess	Useful	Not a Primary Tool	
Intestinal Ischemia	Useful	Useful	

Abdominal Pain, Left Upper Quadrant

Differential	CT	MRI	Comment
Gastritis	Not a Primary Tool	Not a Primary Tool	Endoscopy
Pancreatitis	Useful	Useful	
Peptic Ulcer Disease	Not a Primary Tool	Not a Primary Tool	
Splenomegaly 2nd to neoplasm	Useful	Useful	
LLL Pneumonia	Not a Primary Tool	Not a Primary Tool	
Pyelonephritis	Not a Primary Tool	Not a Primary Tool	
Cardiac or Pericardiac disease	Useful	Useful	
Ruptured Spleen	Useful	Not a Primary Tool	
Urinary Calculi	Useful	Not a Primary Tool	
Gastric Cancer	Not a Primary Tool	Not a Primary Tool	Endoscopy
Diverticulitis	Useful	Not a Primary Tool	
Herpes Zoster	Not a Primary Tool	Not a Primary Tool	
Intestinal Ischemia	Useful	Useful	
Herniated Disc	Not a Primary Tool	Useful	
Abscess	Useful	Not a Primary Tool	
Trauma or Musculoskeletal	Useful	Not a Primary Tool	

Right Lower Quadrant Pain³

Differential	CT	MRI	Comment
Appendicitis	Useful	Not a Primary Tool	US also of value
Gastroenteritis	Not a Primary Tool	Not a Primary Tool	
Irritable Bowel Syndrome	Not a Primary Tool	Not a Primary Tool	
Cystitis	Not a Primary Tool	Not a Primary Tool	US or VCU if recurrent
Hernia	Useful	Not a Primary Tool	
Testicular	Not a Primary Tool	Not a Primary Tool	US
Prostatitis	Not a Primary Tool	Not a Primary Tool	
Diverticulitis	Useful	Not a Primary Tool	
Colon Cancer	Useful for staging	Useful for staging	Colonoscopy & BE
Urinary Calculi	Useful	Not a Primary Tool	
Intestinal Ischemia	Useful	Useful	
Intestinal Obstruction	Useful	Not a Primary Tool	
Abdominal Aortic Aneurysm	Useful	Useful	
Inflammatory Bowel Disease	Not a Primary Tool	Not a Primary Tool	Endoscopy Preferred
Typhlitis	Useful	Not a Primary Tool	
Herniated disc	Useful	Useful	MR preferred
Abdominal Abscess	Useful	Not a Primary Tool	

³ Doria, AS, Moineddin, R, Kellenberger, CJ, et al. US or CT for Diagnosis of Appendicitis in Children and Adults? A Meta-Analysis. *Radiology* 2006; 241:83.

Ege, G, Akman, H, Sahin, A, et al. Diagnostic value of unenhanced helical CT in adult patients with suspected acute appendicitis. *Br J Radiol* 2002; 75:721

Left Lower Quadrant Pain

Differential	CT	MRI	Comment
Diverticulitis	Useful	Not a Primary Tool	
Gastroenteritis	Not a Primary Tool	Not a Primary Tool	
Irritable Bowel Syndrome	Not a Primary Tool	Not a Primary Tool	
Gynecologic	Not a Primary Tool	Not a Primary Tool	US
Intestinal Ischemia	Useful	Useful	
Cystitis	Not a Primary Tool	Not a Primary Tool	
Hernia	Useful	Not a Primary Tool	
Prostatitis	Not a Primary Tool	Not a Primary Tool	
Urinary Calculi	Useful	Not a Primary Tool	
Colon Cancer	Useful for staging	Useful for staging	Colonoscopy & BE
Intestinal Obstruction	Useful	Not a Primary Tool	
Abdominal Aortic Aneurysm	Useful	Useful	
Herniated Disc	Useful	Useful	MRI preferred
Abdominal Abscess	Useful	Not a Primary Tool	

Chest Pain in Patients Not Seen in ER⁴

Acute carditis – MRI or nuclear studies may be of value
Aortic dissection – CT, MRI, MRA or CTA (consider Emergency Room)
Aortic stenosis – Echocardiography is the primary tool,
Bronchitis – CXR and lab studies are primary tools.
Cardiomyopathy – Echocardiography may be helpful
Costochondritis – Not generally diagnosed by imaging
Disc disease – MRI preferred, CT as an alternative
Esophageal rupture – CT useful
Esophageal spasm – Endoscopy or barium studies
GERD - Not generally diagnosed by imaging
Mitral Prolapse – Echocardiography preferred
Myocarditis - MRI or nuclear studies may be of value
Myocardial ischemia – Stress testing, myocardial perfusion scanning, Coronary CTA
Pancreatitis – CT and MRI are generally useful
Pericarditis – Not generally diagnosed by imaging
Peptic Ulcer Disease - UGI or endoscopy
Pleurisy – CT may be of value
Pneumonia – CXR, CT reserved for follow up or problem solving
Pneumothorax – CXR, CT reserved for follow up or problem solving
Pulmonary embolism – CT or CTA
Pulmonary hypertension - CXR, CT reserved for follow up or problem solving
Tension pneumothorax - CXR, CT reserved for follow up or problem solving
Tumor - CT

Abdel-Aty, H, Simonetti, O, Friedrich, MG. **T2-weighted cardiovascular magnetic resonance imaging.** J Magn Reson Imaging 2007; 26:452.

Cox, Gerald F., Sleeper, Lynn A., Lowe, April M., Towbin, Jeffrey A., Colan, Steven D., Orav, E. John, Lurie, Paul R., Messere, Jane E., Wilkinson, James D., Lipshultz, Steven E. **Factors Associated With Establishing a Causal Diagnosis for Children With Cardiomyopathy** Pediatrics 2006 118: 1519-1531

Headache

Imaging has a notoriously low yield in the work up of headache when there are no other neurologic complaints or findings. MRI or CT should be used judiciously when there are clinical findings that suggest a secondary, treatable cause. The differential diagnosis is virtually endless, including at least the following:

- Arterial dissection (carotid or vertebral)
- Arteriovenous malformation
- Brain abscess
- Brain tumor
- Caffeine, alcohol, or drug withdrawal
- Carbon monoxide poisoning
- Cerebral ischemia
- Cervical arthritis
- Cough headache (primary or secondary)
- Cluster headache
- Dental abscess
- Depression
- Glaucoma
- Head injury
- Hypertension
- Meningitis
- Migraine
- Neurocysticercosis
- Otitis media
- Post-lumbar puncture
- Preeclampsia
- Pseudotumor cerebri
- Refractive error
- Sinusitis
- Subarachnoid hemorrhage
- Subdural hemorrhage
- Temporal (giant cell) arteritis
- Temporomandibular joint syndrome
- Tension headache
- Venous sinus thrombosis (intracranial venous thrombosis)
- Somatoform disorder (eg, somatization)
- Trigeminal neuralgia
- Glossopharyngeal neuralgia
- Facial, tooth, or jaw pain

With so extensive a differential the temptation to search for a cause can be overwhelming, but the fact is that CT or

MRI are rarely of value in the absence of neurologic findings.⁵ Nonetheless there are situations that call for such studies. Any of the following clinical features should lead to careful consideration of an early imaging procedure: ⁶

- Altered level of consciousness, cognitive ability or personality
- Elevated WBC
- Exercise, sexual activity or exertion lead to headache
- Fever
- Focal Neurological Symptoms
- Immunosuppression
- Infection elsewhere in body
- Lyme disease
- Malignancy ⁷
- New headaches below age 5⁸ or over 50
- Pain in Neck or Shoulder
- Papilledema
- Pregnancy current or recent
- Sudden onset after recent trauma, straining or manipulation
- Sudden onset of "worst headache"
- Syncope
- Valsalva or straining worsens headache
- *Vertigo*
- *Vomiting*
- *Wakens from sleep*
- *Worsening of established headache pattern*

MRI is the examination of choice; contrast material may be administered if indicated. Consultation with the radiologist is recommended.

⁵ Yoshito Tsushima, and Keigo Endo **MR Imaging in the Evaluation of Chronic or Recurrent Headache** Radiology 2005 235: 575-579.

⁶ Forsyth, Peter A., Posner, Jerome B. **Headaches in patients with brain tumors: A study of 111 patients** Neurology 1993 43: 1678

Maytal, Joseph, Bienkowski, Robert S., Patel, Mahendra, Eviatar, Lydia **The Value of Brain Imaging in Children With Headaches** Pediatrics 1995 96: 413-416

Alehan, Fusun Korkmaz **Value of Neuroimaging in the Evaluation of Neurologically Normal Children With Recurrent Headache** J Child Neurol 2002 17: 807-809

Low Back Pain

Back pain is perhaps the most universal affliction this side of aging; and among the most common causes of medical office visits. Large numbers of CT and MRI exams are ordered to investigate LBP, and very few yield useful information or contribute to patient well-being.⁹ Worse, there is evidence that early imaging with CT or MRI may lead to unnecessary surgery, with resultant failure to improve and morbidity.¹⁰ Significant numbers of asymptomatic patients have findings on MRI that, in a symptomatic individual, may be taken to be indications for surgery, but which are in fact not contributing to the patient's discomfort.¹¹

A thorough history is the best tool to separate the wheat (cases that should be imaged) from the chaff (cases requiring medical management, but not immediate imaging.) The following signs and symptoms warrant early imaging:

- Abnormal CBC, Sed Rate, etc.
- Bladder or Bowel dysfunction
- Fever
- History of Cancer,
- Immunocompromised state
- IV drug use
- Major weakness of a limb
- Pain increased at rest
- Saddle anesthesia
- Severe pain, not responding to opiates after two days
- Recent Trauma
- Unexplained weight loss
- Urinary tract infections

Plain film imaging should not be dismissed. If a patient with only low back pain (i.e. without sciatica or other findings) fails to respond to six weeks of conservative therapy "normal findings on plain radiography and a normal Erythrocyte Sedimentation Rate can almost completely rule out systemic disease."¹² When further imaging is indicated as when there is no response to conservative measures, or pain worsens under treatment, MRI is the best choice, with CT reserved for cases in which MR is not available.¹³

The reader is encouraged to obtain an excellent review of Low Back pain published in the New England Journal in 2005 which contained the following:

⁹ Refshauge, K M, Maher, C G **Low back pain investigations and prognosis: a review** Br J Sports Med 2006 40: 494-498

¹⁰ Jeffrey G. Jarvik; et al; **Rapid Magnetic Resonance Imaging vs Radiographs for Patients With Low Back Pain: A Randomized Controlled Trial** JAMA. 2003;289(21):2810-2818.

¹¹ Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. **Magnetic resonance imaging of the lumbar spine in people without back pain.** N Engl J Med. 1994;331:69-73

¹² Jeffrey G. Jarvik; et al; **Rapid Magnetic Resonance Imaging vs Radiographs for Patients With Low Back Pain: A Randomized Controlled Trial** JAMA. 2003;289(21):2810-2818.

¹³ Ibid

MRI or radiography early in the course of an episode of low back pain do not improve clinical outcomes or reduce costs of care.¹⁴ MRI is best used to rule out the possibility of impending neurologic injury, infection, or tumors. Appropriate candidates for MRI include patients with low back pain who have associated neurologic symptoms or signs; associated systemic symptoms; risk factors for cancer, infection, or occult fractures; or persistent pain in the absence of neurologic signs or symptoms after four to eight weeks. Patients should understand that the reason for imaging is to rule out these serious conditions, and that common degenerative findings are expected. Ill-considered attempts to make a diagnosis on the basis of imaging studies may reinforce the suspicion of serious disease, magnify the importance of nonspecific findings, and label patients with spurious diagnoses.

Carragee, Eugene J **Persistent Low Back Pain** N Engl J Med 2005 352: 1891-1898

¹⁴ Gilbert FJ, Grant AM, Gillan MG, et al. **Low back pain: influence of early MR imaging or CT on treatment and outcome -- multicenter randomized trial.** Radiology 2004;231:343-351.

Joint Pain

Another common source of office visits to primary care physicians, joint pain may account for up to 5% of such visits.¹⁵ Not all joint pain is due to arthritis. Pain in and around joints can be caused by a dizzying variety of conditions, and a careful history and physical examination is, once again, the single best tool in directing the physician's course of investigation. Is the joint swollen, erythematous, or deformed? Is local musculature atrophied? Is the joint tender, is range of motion limited? These are all signs that joint pain, arthralgia, is likely due to joint inflammation, arthritis. The role of laboratory studies in determining the nature of an arthritic process, or of a systemic disease causing joint pain remains paramount.

Plain film radiography plays a critical role in evaluating joints, and should be used first whenever arthritis is suspected or is being evaluated. Ultrasound is inexpensive, readily available and free of ionizing radiation. It should not be overlooked when evaluating soft tissue sources of joint pain; in experienced hands is essentially equal to MRI in evaluating the rotator cuff.¹⁶

15 Palmer, Trish, Toombs, James D. Managing Joint Pain in Primary Care J Am Board Fam Pract 2004 17: S32-42

16 Al-Shawi, A., Badge, R., Bunker, T. The detection of full thickness rotator cuff tears using ultrasound J Bone Joint Surg Br 2008 90-B: 889-892

Seizures

From the clinician's point of view classification of the type of seizure disorder being evaluated is the first step. Generalized seizures always involve the loss of consciousness and may be subclassified as tonic (rigid,) clonic (characterized by repeated jerking movements without rigidity,) myoclonic (the most common,) atonic (flaccid,) and absence (petit mal.) Partial seizures may be simple (without loss of consciousness,) or complex (with some impairment of consciousness,) and may progress to a generalized seizure.¹⁷

As always a careful history and physical examination will be crucial in first determining that a seizure disorder is, in fact present, and in classifying the disorder. In children there may be stigmata of a number of diseases that lead to epilepsy, in adults physical findings of significance are less common. Lab studies and EEG are important data gathering tools, but imaging is of primary importance.¹⁸ Unless unavailable the study of choice in the initial evaluation of new or altered seizures is an MRI performed both without and with contrast. In a retrospective study of children less than two years of age Petrou cast some doubt on the necessity of contrast, indicated it to be essential to diagnosis in about 8% of cases.¹⁹ CT should be reserved for emergency situations in children and when MRI is unavailable or contraindicated.²⁰

When surgical planning is the reason for imaging a multimodality approach is recommended, PET imaging has come to be the first choice.^{21 22 23}

Vascular Disease

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- 17 Catlett Christina L, "Chapter 232. Seizures and Status Epilepticus in Adults" (Chapter). Tintinalli JE, Kelen GD, Stapczynski JS, Ma OJ, Cline DM: Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 6th Edition: <http://www.accessmedicine.com/content.aspx?aID=608041>.
 - 18 Krumholz, A., Wiebe, S., Gronseth, G., Shinnar, S., Levisohn, P., Ting, T., Hopp, J., Shafer, P., Morris, H., Seiden, L., Barkley, G., French, J. Practice Parameter: Evaluating an apparent unprovoked first seizure in adults (an evidence-based review): Report of the Quality Standards Subcommittee of the American Academy of Neurology and the American Epilepsy Society *Neurology* 2007 69: 1996-2007
 - 19 Petrou, Myria, Foerster, Bradley, Maly, Pavel V., Eldevik, Odd P., Leber, Steven, Sundgren, Pia C. Added Utility of Gadolinium in the Magnetic Resonance Imaging (MRI) Workup of Seizures in Children Younger Than 2 Years
 - 20 Ropper AH, Samuels MA, "Chapter 16. Epilepsy and Other Seizure Disorders" (Chapter). Ropper AH, Samuels MA: Adams and Victor's Principles of Neurology, 9th Edition: <http://www.accessmedicine.com/content.aspx?aID=3632229>.
 - 21 Elson L. So Role of Neuroimaging in the Management of Seizure Disorders *Mayo Clin Proc.* November 2002 77(11):1251-1264;
 - 22 Terence J. O'Brien, Ken Miles, Robert Ware, Mark J. Cook, David S. Binns, and Rodney J. Hicks *J Nucl Med* 49: 931-937; The Cost-Effective Use of 18F-FDG PET in the Presurgical Evaluation of Medically Refractory Focal Epilepsy First published on May 15, 2008; 10.2967/jnumed.107.048207
 - 23 Adrien Didelot , Philippe Ryvlin , Amélie Lothe , Isabelle Merlet , Alexander Hammers , and François Mauguière PET imaging of brain 5-HT1A receptors in the preoperative evaluation of temporal lobe epilepsy *Brain* 131: 2751-2764.

It is beyond the scope of these brief guidelines to delve deeply into the diagnosis of the various forms of vascular disease. For the sake of clarity, and brevity, we will cover cerebral, coronary, and peripheral vascular disease imaging.

Imaging of Cerebrovascular Disease²⁴

Stroke represents the major cause of neurologic hospitalization and disability. About 750,000 Americans suffer strokes annually, and 150,000 die. In recent years advances in imaging have led to a new and increased role in the diagnosis and treatment of cerebrovascular disease. No longer is imaging useful only to confirm and measure infarcts, or to determine if there is carotid stenosis. Imaging can now distinguish brain tissue that is hypoxic but salvageable, and thus guide therapy to reduce long term impairment.

Carotid Disease

Carotid Disease can be effectively treated by endarterectomy or angioplasty and stenting.²⁵ Screening asymptomatic individuals without known risk factors for carotid stenosis, however, is not recommended, indeed screening may cause more strokes than it prevents.²⁶ Screening individuals with a history of risk factors such as prior myocardial infarction, bruit, or peripheral vascular disease with Doppler US may be marginally effective.²⁷ When imaging is called for there are several choices available. Carotid Doppler US is reported to be about 90% sensitive and 85% specific for detecting significant stenosis.²⁸ But Doppler US is very operator sensitive, may over estimate stenoses, and is difficult in elderly patients with tortuous vessels. Magnetic Resonance and Computed Tomographic angiography are nearing gold standard acceptance. Compared to catheter angiography they have the advantages of being less invasive and permitting 3D viewing. The choice depends on local capabilities to a large extent.

Stroke

Stroke imaging serves several purposes. First it allows definition of whether one is dealing with a hemorrhagic (15%) or ischemic (85%) event. Second it confirms the diagnosis and describes the extent of damage. CT is the imaging modality of choice in the acute phase.²⁹ Follow up exams, especially after the administration of aggressive therapies, is appropriate.³⁰

24 Ropper AH, Samuels MA, "Chapter 34. Cerebrovascular Diseases" (Chapter). Ropper AH, Samuels MA: Adams and Victor's Principles of Neurology, 9th Edition:

25 North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med 1991; 325:445-453.

26 Whitty, C J M, Sudlow, C L M, Warlow, C P Investigating individual subjects and screening populations for asymptomatic carotid stenosis can be harmful J Neurol Neurosurg Psychiatry 1998 64: 619-623

27 Colin P. Derdeyn, and William J. Powers Cost-Effectiveness of Screening for Asymptomatic Carotid Atherosclerotic Disease Stroke 27: 1944-1950

28 Wardlaw JM; Chappell FM; Best JJ; Wartolowska K; Berry E Non-invasive imaging compared with intra-arterial angiography in the diagnosis of symptomatic carotid stenosis: a meta-analysis. Lancet. 2006 May 6;367(9521):1503-12.

29 Smith Wade S, English Joey D, Johnston S. C, "Chapter 364. Cerebrovascular Diseases" (Chapter). Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J: Harrison's Principles of Internal Medicine, 17th Edition: <http://www.accessmedicine.com/content.aspx?aID=2905494>.

- Ertl-Wagner, Birgit, Brandt, Tobias, Seifart, Christina, Forsting, Michael Diagnostic and Therapeutic Consequences of Repeat Brain Imaging and Follow-up Vascular Imaging in Stroke Patients AJNR Am J Neuroradiol 1999 20: 37-42

Cardiovascular Disease

Let's first look at the simplest of the modern cardiovascular screens, Calcium Scoring. Even after years of research and advocacy on both sides of the issue there remains doubt about the value of CT screening of asymptomatic individuals for calcification in the coronary arteries.³¹ It is not a recommended tool.

Myocardial Perfusion Imaging is among the most frequently ordered examinations in the United States and perhaps among the most over-ordered. There are a large number of appropriate indications for this sensitive test, but simply having a heart is not among them. In general MPI should be used when one of the following are met:³²

- Assessment prior to non-cardiac surgery
 - Any High Risk procedure*
 - Intermediate Risk AND ONE*
 - Arrhythmia*
 - Diabetes*
 - Framingham risk percentage is >10%*
 - History of CHF*
 - History of CVA*
 - Mitral or other valvular disease*
- Assessment within eight weeks after treatment of a cardiac condition
 - Atrial Fibrillation*
 - Congestive Heart Failure ONE*
 - New onset*
 - Recurrent*
 - Diabetes*
 - Framingham Risk >10%*
 - Ischemia at time of prior treatment (MI, unstable angina, chest pain syndrome)*
 - Condition not remedied*
 - Syncope or Near Syncope*
- Known Coronary Artery Disease
 - Changed chest pain*
 - CHF - annual exam*
 - Stable or asymptomatic - allowed every two years*
- No prior CAD diagnosis
 - Abnormal stress test*

"Leontiev, Oleg, Dubinsky, Theodore J. CT-Based Calcium Scoring to Screen for Coronary Artery Disease: Why Aren't We There Yet? *Am. J. Roentgenol.* 2007; 189: 1061-1063

"Brindis RG, Douglas PS, Hendel RC, et al, ACCF/ASNC appropriateness criteria for single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI): a report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group and the American Society of Nuclear Cardiology. *J Am Coll Cardiol* 2005; 46:1587- 1605

Fleisher LA, Beckman JA, Brown KA, et al, ACC/AHA 2007 guidelines on perioperative cardiovascular evaluation and care for non cardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines, *J Am Coll Cardiol*, 2007; 50:159-241.

Diabetes
Framingham risk percentage >10%
Patient on Digoxin or similar medication
Patient unable to perform stress test
Uninterpretable EKG
Ventricular tachycardia

In most other cases less expensive and radiation free examinations (e.g. EKG stress testing or echocardiography) should be sufficient. When in doubt consultation with a radiologist or cardiologist is advised.

Peripheral Arterial Disease

Peripheral arterial disease is another common complaint that leads to imaging procedures. Diminished or absent peripheral pulses, claudication, early fatigue of distal muscles are among the prominent symptoms. Doppler US studies represent an alternative to imaging in detecting and quantifying flow, and are readily available, noninvasive, and free of any risk of contrast reaction. A sensitive assessment can be had by measuring the systolic blood pressure at the ankle compared with the arm.³³ The ankle-brachial index (ABI) is calculated by dividing the ankle pressure by the arm pressure. (Under ideal circumstances BP should be measured using a Doppler device, but auscultation is generally sufficient.)³⁴ Patients with an ankle brachial index well below one require further investigation only if repair is contemplated, CTA or MRA are preferred.³⁵ If repair is not contemplated there is little reason to obtain any further imaging.³⁶

Cough, Subacute and Chronic ³⁷

The evaluation of cough in the adult is among the most frequently encountered reasons for visits to primary care physicians. Acute cough is, by definition, present less than three weeks and is most commonly due to an acute respiratory tract infection. Other considerations include an acute exacerbation of underlying chronic pulmonary disease, pneumonia, and pulmonary embolism.³⁸ Cough present for more than three weeks is either subacute (three

"Osamu Takahashi , Takuro Shimbo , Mahbubur Rahman , Rahman Musa , Wataru Kurokawa , Takeshi Yoshinaka , and Tsuguya Fukui **Validation of the auscultatory method for diagnosing peripheral arterial disease** Family Practice Advance Access published on February 1, 2006, DOI 10.1093/fampra/cm034. Fam. Pract. 23: 10-14.

"GAL Carmo , A Mandil , BR Nascimento , BD Arantes , JC Bittencourt , EB Falqueto , and AL Ribeiro **Can we measure the ankle-brachial index using only a stethoscope?** A pilot study Family Practice Advance Access published on February 1, 2009, DOI 10.1093/fampra/cm086. Fam. Pract. 26: 22-26.

Ouwendijk, Rody, et al **Multicenter Randomized Controlled Trial of the Costs and Effects of Noninvasive Diagnostic Imaging in Patients with Peripheral Arterial Disease: The DIPAD Trial** Am. J. Roentgenol. 2008 190: 1349-1357

"Rody Ouwendijk, Marianne de Vries, Peter M. T. Pattynama, Marc R. H. M. van Sambeek, Michiel W. de Haan, Theo Stijnen, Jos M. A. van Engelsehoven, and M. G. Myriam Hunink **Imaging Peripheral Arterial Disease: A Randomized Controlled Trial Comparing Contrast-enhanced MR Angiography and Multi-Detector Row CT Angiography** Radiology 2005 236: 1094-1103;

• Richard S. Irwin et al, **Diagnosis and Management of Cough: ACCP Evidence-Based Clinical Practice Guidelines** Chest January 2006 129:24S; doi:10.1378/chest.129.1_suppl.24S

• Irwin, Richard S., Madison, J. Mark **The Diagnosis and Treatment of Cough** N Engl J Med 2000 343: 1715-1721

to eight weeks) or chronic (more than eight weeks.)

The starting point in the evaluation of a patient with subacute or chronic cough is, as always, the history and physical. The goal here is to characterize the cough by duration and nature, to eliminate serious life-threatening disease, and to determine if there is a history of smoking or Angiotensin Converting Enzyme (ACE) inhibitor use. Cessation of smoking and ACE use should also be accomplished before any further evaluation is undertaken. It is appropriate to obtain a chest x-ray at initial evaluation, and comparison with prior films is advisable if possible. Should the CXR indicate a potential cause for the cough, a course of appropriate therapy should be administered. If that fails to provide relief, or if the CXR does not demonstrate a potential cause, the following stepwise approach is recommended by the American College of Chest Physicians.

The most common causes of chronic cough are Upper Airway Cough Syndrome (UACS), Asthma, Gastro-Esophageal Reflux Disorder (GERD), and ACE inhibitor use. None of these can be confidently diagnosed by means of medical imaging, and empirical treatment is therefore recommended to rule these out before advanced imaging techniques are employed.

UACS, which includes Post Nasal Drip (PND), is the preferred term as it is more inclusive than PND. It is a common cause of chronic cough. When no other cause for cough is apparent, it is worthwhile to attempt a therapeutic trial of decongestants and antihistamines prior to launching a more extensive work up.

Asthma is probably the next most common cause of chronic cough in adults, and the most common cause in children. It should be suspected in atopic patients, those with a personal or family history of asthma, or a cough characterized by wheezing, dyspnea, or occurrence after administration of a beta blocker. Again, a positive response to a therapeutic trial represents strong evidence that the cause of the cough has been found. If asthma is not found, testing for Non-Asthmatic Eosinophilic Bronchitis should follow.

Gastroesophageal reflux is the next most likely cause, and a treatment for it should be tried before any further imaging is contemplated.

If all of these trials fail to diagnose the cause of the cough, referral to a cough specialist may be indicated. It is at this point that further imaging may also be helpful. CT of the chest should be considered.

Obstetrical Ultrasound

CPT Code	Notes
76801	Refers solely to a first trimester examination.
76802	To be used for each additional gestation discovered with 76801. These codes are most often used to confirm a gestation, date it, and exclude ectopy. Suspected embryonic demise or molar pregnancy and pelvic pain are among other common indications. Repeat use of these codes is permissible when indicated. Note that these codes are the only ones limited to the first trimester.
76805	Used for exams performed after the first trimester, and codes for a complete anatomic evaluation of the fetus. As such it is best performed between 17 and 23 weeks.
76810	Codes for the same exam on each additional fetus. Both of these codes are appropriate only once (for each fetus) during the course of a pregnancy. There are specific follow up codes for any subsequent exams performed as a consequence of findings on these studies (see below 76815 and 76816.)
76811	Subject to some controversy. Defined as “Ultrasound, pregnant uterus, real time with image documentation, fetal and maternal evaluation plus detailed fetal anatomic examination, transabdominal approach; single or first gestation” it leaves one with the question of how it differs from 76805. The best we can say is that it is a matter of degree.
76811	Not a substitute for 76805, and should be limited to cases in which there is a higher than average risk of fetal problem. Among the indications are maternal exposure to teratogens, advanced maternal age, a number of maternal diseases and disorders, a prior history of fetal disorders, IVF, and abnormal findings on prior US exams. As with 76805 it is appropriate once during a pregnancy. Some flexibility exists in that it is proper for a second such exam to be billed if performed by a different physician as part of a second opinion work up, or if a new reason for suspicion arises during the pregnancy.
76812	Codes for each additional gestation.
76813 & 76814	Codes for the evaluation of nuchal translucency for a single or multiple gestation respectively. These exams are best preformed at 11 - 14 weeks, and are to be coded only once in a pregnancy.
76815	Codes for a limited obstetrical exam, and is used for routine exams to determine fetal position, confirm heart rate, evaluation of the placenta, cervix, and amniotic fluid. It may be repeated as needed, and applies to each fetus.
76816	Codes for anatomic exams that follow up abnormal findings on prior studies, monitor fetal growth, or evaluate the pregnancy after an intrauterine intervention of any kind. It is applied to each gestation, and may be repeated as needed.
76817	Transvaginal obstetrical ultrasound, is appropriately used to evaluate the risk of preterm labor, including cervical or uterine abnormalities, fetal anatomy not seen on transabdominal exams and suspected placenta previa. It may be repeated as needed, and is independent of the number of gestations.
76818	A biophysical profile that includes a Non Stress Test.

76819	A biophysical profile that does not. Indications for the study include previous fetal loss, multiple gestations, greater than 41 weeks gestational age, decreased fetal movements, and a host of maternal conditions. The tests can be repeated as needed, and are available for each fetus.
76820	Doppler Velocimetry Umbilical Arteries
76821	For the Middle Cerebral Artery are specialized exams that should be performed by those who deal with high risk pregnancies. Indications include IUGR, twin pregnancies with large differences in fetal size, and a number of maternal disorders.
76825 & 76826, 76827 & 76828	Initial and follow up fetal echocardiograms, the latter pair including Doppler technology. These are exams generally performed by pediatric and neonatal cardiologists.