

Neuroimaging Wisely

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ABSTRACT

SUMMARY: Diagnostic imaging is the most rapidly growing physician service in the Medicare and privately insured population. The growing share of medical costs devoted to imaging procedures has led to increasing concerns among the key federal agencies and private payers. In an attempt to educate health care providers, patients, and families on the importance of making optimal clinical decisions, the American Board of Internal Medicine Foundation organized the Choosing Wisely initiative with strong collaboration from specialty societies representing nearly all medical disciplines. Among 45 tests and treatments listed on the Choosing Wisely Web site, 24 are directly related to imaging. Eleven of the 24 are associated with neuroimaging. The listing of imaging tests in the Choosing Wisely program by multiple medical societies other than the radiology societies acknowledges that appropriate use of medical imaging is a shared responsibility between radiologists and referring physicians. In this article, we highlight why radiologists are uniquely positioned to support the appropriate use of imaging. We review some of the strategies that radiologists can use to help their referring physicians with appropriate ordering of neuroimaging in real-world practice and address some of the challenges and pitfalls in implementing patient-centered imaging decision-making and shifting to a value-based focus in radiology.

ABBREVIATIONS: AAFP = American Academy of Family Physicians; AAO-HNS = Academy of Otolaryngology–Head and Neck Surgery; ACR = American College of Radiology; R-SCAN = Radiology Support, Communication, and Alignment Network

Starting in the late 1990s, rates of use of diagnostic imaging studies within all modalities have seen a dramatic rise, with average growth rates in the use of CT, MR imaging, and nuclear medicine studies of >10% each year in ambulatory settings between 1995 and 2001.¹ Additionally, from 2000 to 2007, the use of imaging studies grew faster than any other physician service among Medicare patients,² raising concerns about overuse of imaging.³ Diagnostic imaging undoubtedly plays an essential role in the diagnosis and treatment planning of many patients. The increasing use of advanced imaging techniques, however, has substantial financial implications, with approximately \$100 billion spent on outpatient imaging alone in 2006, and is a major driving

force for increasing governmental health care expenditures and rising insurance premiums faced by employers and individuals.⁴

The purpose of this article was to highlight the unique role radiologists play in ensuring the appropriate use of imaging studies, particularly neuroimaging. We will review how clinical guidelines can help frame decisions about the appropriate use of neuroimaging studies. We will then review ways in which radiologists can collaborate with clinicians in ensuring appropriate ordering and discuss potential challenges in making the transition to a value-centered practice approach.

Appropriate Neuroimaging Guidelines

Choosing Wisely Campaign. To heighten awareness of overused diagnostic tests and treatments, the American Board of Internal Medicine launched the Choosing Wisely initiative⁵ in 2012. As a part of this campaign, 9 leading medical organizations, including the American College of Radiology (ACR) and leadership bodies from various medicine subspecialties, were asked to choose 5 common tests or treatments whose use should be re-evaluated by the ordering physicians. Among 45 tests and procedures listed, half were directly related to imaging.⁶ Since 2012, other medical societies have joined the original 9 and offered their own lists of overused tests or procedures. According to a recent compilation from Rao and Levin,⁷ nearly half of this expanded list of overused

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tests and treatments relates to either diagnostic radiology or cardiac imaging. Furthermore, in an expanded survey of 26 major medical societies, 38 of the 130 (29%) listed overused services targeted imaging, more than any other category.⁸ Nearly a quarter of the most overused imaging tests related to neuroimaging, which placed second among all subspecialties behind cardiac testing. This finding reflects neurologic symptoms and disorders, both acute and chronic, having such a high prevalence and accounting for a significant proportion of chief symptoms in both emergency and outpatient settings.^{9,10} Although the Choosing Wisely campaign was inspired primarily from the overuse of diagnostic testing and therapies, it should not be viewed exclusively as an initiative to ration or restrict care to patients. Rather, the primary goal of the campaign is to encourage a more patient-centered care model and “to promote physician and patient conversations about making choices about treatments.”⁵

Imaging 3.0. In response to pressure placed on the field as a result of the Choosing Wisely initiative, several radiology societies, including the American Board of Radiology, ACR, and Radiological Society of North America, have made the concept of value and quality-based care, rather than volume-driven care, a pillar of their Imaging 3.0 initiative.¹¹ One of the key components of the value-based Imaging 3.0 campaign is development and refinement of clear, evidenced-based guidelines regarding the appropriateness of different imaging modalities in wide varieties of clinical settings and scenarios among all subspecialties. These encompass a number of tools, including appropriateness criteria, practice guidelines or parameters, and different software solutions to support clinical decision-making and the selection of the most appropriate imaging test in any particular clinical setting.

Imaging Appropriateness: Illustration of Selected Adult and Pediatric Neurologic Conditions

Practice parameters describe recommended conduct of specific imaging tests or image-guided interventions. They are derived from the current literature and the consensus opinion of experts. Practice parameters are not intended to be legal standards of care or conduct and may be modified as determined by individual circumstances and available resources. The ACR, in collaboration with the American Society of Neuroradiology, the Society of NeuroInterventional Surgery, and the Society of Pediatric Radiology, has developed 20 practice parameters and technology standards that pertain to neuroimaging and neurointervention (<http://www.acr.org/Quality-Safety/Standards-Guidelines/Practice-Guidelines-by-Technique/Neuroradiology>).

Appropriateness criteria are guidelines to assist the referring physicians and other providers in making the most appropriate imaging or treatment decisions for specific clinical conditions. Examples of appropriateness criteria include the ACR Appropriateness Criteria and the Canadian Association of Radiology guidelines. The ACR Appropriateness Criteria include more than 20 separate topics discussing the appropriateness of imaging in adult and pediatric neurologic conditions (<http://www.acr.org/Quality-Safety/Standards-Guidelines/Practice-Guidelines-by-Modality/Neuroradiology>).

Reviewing all the neuroimaging-related practice parameters and appropriateness criteria and the underlying evidence goes

beyond the scope of this article and has been addressed elsewhere.¹² Following are examples illustrating selected adult and pediatric neurologic conditions in which the selection of appropriate imaging is often challenging for referring physicians, and in which different rules, guidelines, and practice parameters have been developed by different professional societies and entities to help the referring physician's decision process.

Traumatic Brain Injury. Traumatic brain injury is a common reason for presentation in emergency settings, with most injuries classified as “mild.”¹³ Mild traumatic brain injury is typically defined according to clinical criteria such as the Glasgow Coma Scale and other clinical signs and symptoms at the time of presentation.^{14,15} Several sets of basic clinical criteria, such as the New Orleans Criteria and the Canadian Head CT Rule and clinical guidelines from the American College of Emergency Physicians/Centers for Disease Control and Prevention¹⁶ and the ACR Appropriateness Criteria¹⁷ detail “high-risk” criteria that warrant evaluation of patients with mild traumatic brain injury with CT of the head, which is the preferred method of evaluation of head trauma (On-line Table 1). Further details on neuroimaging guidelines for patients with traumatic brain injury are provided in a white paper written jointly by the ACR, American Society of Neuroradiology, and American Society of Functional Neuroradiology.^{18,19}

Headache. Headache is among the most common medical symptoms, both in emergency and outpatient settings.²⁰ Most primary headaches can be evaluated via history and physical examination alone. Neuroimaging is warranted to distinguish primary headaches from secondary causes (On-line Table 1). While guidelines such as the Headache Consortium guidelines in migraine work-up,²¹ multispecialty consensus on diagnosis and treatment of headache,²² and the ACR Appropriateness Criteria²³ offer precise, evidence-based guidelines for headache types such as migraines, vascular origin, and post traumatic, recommendations for some headache types such as tension are still not well-defined. Indications for neuroimaging are strongly based on clinical history and a detailed physical examination. MR imaging is generally the preferred technique for a change in headache character or chronic headache with new neurologic examination findings (On-line Table 1). Conversely, stable headaches or headaches with stable examination findings or classic migraine patterns should not be evaluated via neuroimaging.

Low Back Pain. Low back pain is one of the most common reasons for seeking outpatient medical care.²⁴ Given the chronicity of most back pain relative to other presenting neurologic symptoms, duration of symptoms and response to conservative treatment play an important role in imaging strategies, as detailed in a meta-analysis²⁵ and in multiple published guidelines (On-line Table 1).²⁶⁻²⁸ Specifically, in the absence of “red flag” features,²⁶ imaging should be reserved for pain lasting >4–6 weeks and not responding to an appropriate trial of conservative therapy. Imaging work-up should be pursued with MR imaging with little-to-no role for plain radiographs in the absence of acute trauma (On-line Table 1).

Syncope. Although syncope and syncope mimics are common reasons for emergency department visits, the etiology of a synco-

pal episode can usually be determined from a detailed history and physical examination.²⁹ Imaging is not recommended unless underlying neurologic etiology is suspected in the initial work-up as advocated by the San Francisco Syncope Rule,³⁰ European Society of Cardiology Guidelines,²⁹ and the American Academy of Family Physicians (AAFP) guidelines (On-line Table 1).³¹

Hearing and Vision Loss. Hearing and vision loss are common neurologic symptoms, especially in an aging population.^{32,33} While most of these conditions require further work-up with a proper clinical history and examination, there are settings in which diagnostic imaging may help identify life-threatening or reversible causes from more benign, age-related etiologies. With vision loss, imaging should only be considered for acute vision loss or new concerning vision examination findings as described by the guidelines from the American Academy of Ophthalmology,³⁴ AAFP,³⁵ and ACR (On-line Table 1).³⁶ In the absence of trauma, evaluation is generally performed with MR imaging. According to the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS),³⁷ there is a role for imaging in conductive hearing loss, generally evaluated with CT of the temporal bones, and sensorineural hearing loss, generally evaluated with MR imaging. Cases of explained progressive, symmetric conductive or sensorineural hearing loss, which account for most hearing loss referrals, do not warrant imaging evaluation (On-line Table 1).

Other Head and Neck Disorders. Uncomplicated acute rhinosinusitis and hoarseness are encountered routinely in the ambulatory setting.³⁸ While most of these cases are benign and self-limited, more extensive evaluation with focused diagnostic imaging may be necessary in selected cases. The proper imaging evaluation algorithm for rhinosinusitis follows published guidelines from the Infectious Diseases Society of America,³⁹ AAO-HNS,⁴⁰ AAFP,⁴¹ and ACR (On-line Table 1).⁴² For cases meeting the clinical criteria of acute or subacute uncomplicated rhinosinusitis, imaging is not to be pursued. CT is recommended only in cases of complicated sinusitis, immunocompromised hosts, or recurrence. In contrast, there is generally a lesser role of imaging in the initial evaluation of hoarseness. In fact, according to guidelines from the AAO-HNS,⁴³ imaging should only be considered after a clinical examination with direct laryngoscopy.

Pediatric Neurologic Conditions. Although there is some overlap between the frequently encountered neurologic conditions of children and adults, several neurologic symptoms are unique to children. Additionally, work-up and imaging of the common symptoms may differ between children and adults. Because children are also likely to present in the emergency setting, it is imperative that emergency department physicians, in addition to pediatricians, be aware of the appropriateness of imaging pediatric patients. Furthermore, because children are more sensitive to ionizing radiation effects, these patients should be imaged judiciously.

As with adults, mild traumatic brain injury is a common emergency department presentation with potentially devastating sequelae.⁴⁴ Several sets of criteria such as the Pediatric Emergency Care Applied Research Network rule,⁴⁵ the Children's Head Injury Algorithm for the Prediction of Important Clinical Events

rule,⁴⁶ the Canadian Assessment of Tomography for Childhood Head Injury rule,⁴⁷ and the ACR Appropriateness Criteria⁴⁸ outline high-risk criteria specific to the pediatric population that warrant evaluation with CT (On-line Table 2). Alternatively, pediatric patients with mild traumatic brain injury in the emergency department may have CT substituted if no neurologic symptoms are observed.

Acute rhinosinusitis is another head and neck pathology common to both adults and pediatric patients.⁴⁹ Indications for imaging pediatric patients have been specifically evaluated in guidelines by the Infectious Diseases Society of America,³⁹ the American Academy of Pediatrics,⁵⁰ and the ACR⁵¹ and are similar to recommendations for adult patients. These indications include any high-risk signs and symptoms as detailed in On-line Table 2.

Last, febrile seizure is a unique entity to pediatric patients.⁵² According to the guidelines from American Academy of Pediatrics⁵³ and the ACR,⁵⁴ patients meeting the criteria for simple febrile seizure (lasting <15 minutes and not recurring within 24 hours) should not undergo imaging (On-line Table 2). Complex febrile seizures (prolonged, recurring more than once in 24 hours, or focal) are rarely associated with underlying pathology such as meningitis, encephalitis, or child abuse. Imaging, preferably with MR imaging or CT, may be performed in selected patients with complex febrile seizures when meningitis/encephalitis or underlying trauma is suspected.^{54–56}

Barriers to Implementation

Application of the imaging appropriateness principles discussed above can prove challenging. The most important factors contributing to the referring physicians' inappropriate use of imaging include time constraints and demanding patients.^{57,58} Many physicians face greater pressure because the fee-for-service payment model, which still dominates US health care, rewards physicians who see patients in bulk. The propensity for shorter patient visits is now ubiquitous in medicine because the primary care physician generates revenue per visit.⁵⁷ This results in a shorter time for the referring physicians to research appropriate tests, consult a radiologist, or convince a patient that an imaging test is not necessary. Furthermore, there is increased scrutiny of the medical decision-making and displacement of financial risk to the practitioner. Defensive medicine, a term describing alterations in clinical behavior due to the threat of malpractice liability,⁵⁹ has a disputed impact on ordering practices in the emergency setting.⁶⁰ Last, a potential barrier to the implementation of clinical decision-support tools, discussed in greater detail in the following section, is the potential for circumventing their use with out-of-network referrals, though this was shown not to be the case in a recent study by Prabhakar et al.⁶¹

One of the important obstacles to promoting adoption of resource-conscious neuroimaging ordering habits relates to the difficulty of disseminating the relevant guidelines among the referring physicians. Despite the inclusion of "systems-based practice" as one of the 6 core competencies of the Accreditation Council for Graduate Medical Education, awareness of imaging appropriateness is not being emphasized in residency training. As an illustration, Taragin et al⁶² administered a survey in which internal medicine residents were asked to choose the appropriate examination for specific clinical situations. Less than 50% of the respondents

answered more than half of the 12 questions correctly. A similar study conducted with emergency medicine residents demonstrated no significant improvement in the ability to choose appropriate studies over the course of a 4-year residency.⁶³ Given the lack of emphasis placed on this topic in residency training, physicians are more likely to turn to Google searches than the appropriateness criteria when determining the most appropriate imaging technique for patients.^{63,64} Although ahead of their peers in other specialties, radiology residents' knowledge of appropriateness guidelines is still incomplete, with residents answering a median of 15 of 20 appropriateness questions correctly in study by Chiunda and Mohammed.⁶⁵ In a survey by Powell et al,⁶⁶ while most radiology trainees were familiar with the ACR Appropriateness Criteria, only 14% of residents reported regular inclusion of the Criteria in formal faculty didactics.

Importance of Ordering Wisely and Clinical Decision Support

Beginning in January 2017, the Centers for Medicare and Medicaid Services will require all referring physicians to use some form of Clinical Decision Support technology before ordering advanced imaging examinations for Medicare patients (https://www.cms.gov/Medicare/Demonstration-Projects/DemoProjects/EvalRpts/downloads/RAND_EMID_Report_to_Congress.pdf). This law specifies that the Clinical Decision Support system must use appropriate-use criteria "developed or endorsed by national professional medical specialty societies or other provider-led entities." Additionally, the criteria used must be scientifically valid and evidence-based.⁶⁴ Physicians ordering advanced imaging services will be reimbursed only if claims for reimbursement confirm that the appropriate-use criteria were consulted, whether the examination ordered adhered or did not adhere to an acceptable clinical decision-support rating.

Several decision-support tools have been developed to meet this need; examples include Medicalis (<https://consult.medicalis.com/>) and ACR Select (<http://www.acr.org/Quality-Safety/Appropriateness-Criteria/ACR-Select>) in the United States. ACR Select is a commercially available tool developed by National Decision Support Company (<https://www.linkedin.com/company/national-decision-support-company>), which licensed the ACR Appropriateness Criteria and incorporated them into a digitally consumable version that can be integrated into electronic medical records and computerized order systems. Other international radiology organizations such as the Royal College of Radiologists in the United Kingdom (referral guidelines) and the Canadian Association of Radiologists (Diagnostic Imaging Referral Guidelines) have created similar tools and documents to facilitate the appropriate use of imaging. Insurers contract radiology benefit managers to provide authorization for advanced imaging services. These radiology benefit managers are private companies that use their own proprietary algorithms to determine appropriateness. These software solutions can be incorporated into the electronic medical records. Since its adoption, various implemented decision-support tools have led to improvement in appropriateness adherence in numerous settings. For example, Ip et al⁶⁷ showed a 12% sustained reduction in cross-sectional imaging for the outpatient, while Dunne et al⁶⁸ showed a 12% sustained reduction in

CT pulmonary angiography use in the emergency department after implementation of clinical decision-support systems. Although early data on imaging use with support tools are promising, their effect on clinical outcomes has yet to be fully evaluated.

In what may be the most critical element of the implementation of this mandate, the Centers for Medicare and Medicaid Services released its determination of what constitutes acceptable appropriate-use criteria at the end of 2015.^{69,70} The Centers for Medicare and Medicaid Services selection of these criteria will have to meet the following measures: 1) Criteria must be developed or endorsed by national professional medical specialty societies or provider-led entities, 2) Criteria must be scientifically valid and evidence-based, and 3) Criteria must be based on published studies that are reviewable by stakeholders.

What Can Radiologists Practically Do to Address the Situation?

This change in culture provides an opportunity for radiologists to guide and support our clinician colleagues during the transition to value-based care. Effectively guiding referring providers toward appropriate imaging use will rely on improving clinicians' knowledge and effective communication among all members involved in the care of patients, which includes radiologists. These goals can be achieved on a clinician-to-radiologist level or as a part of larger clinician-support projects and initiatives.

To effectively influence clinicians' ordering behavior, improving knowledge about imaging appropriateness must be made a top priority. Furthermore, optimal communication between radiologists and referrers is critical because the effective exchange of information can both prevent unnecessary or inappropriate testing and help ensure that patients experience fewer delays in care.^{71,72} Continued strong bonds between radiologists and clinicians will also allow development of educational and quality-improvement programs in imaging appropriateness. A recent article reported the initiatives undertaken by a progressive group of radiologists, which included Continuing Medical Education programs for referring physicians and midlevel practitioners.³⁰ This group developed a mobile ordering guidelines app for the referrers to use as a reference when ordering imaging examinations. They even provide a communication center that allows the ordering physicians to connect directly with radiologists at any time of day. Interventions like these will be invaluable in changing the ordering patterns that have become ingrained in clinical practice and residency training programs. In some cases, referring clinicians have initiated educational programs within their own departments in an effort to optimize their imaging examination-ordering behavior.⁷³ Similarly, the Kaiser Permanente Colorado branch has tried to use the recommendations of the Choosing Wisely campaign for affordable health care at the management level.⁷⁴

Any radiologist can engage in a similar effort by participating in the Radiology Support, Communication, and Alignment Network (R-SCAN) project, for which the ACR received one of the 39 health care collaborative network grants of the CMS Transforming Clinical Practice Initiative to support new levels of care coordination and integration as health care payment systems transition from volume-driven to value-based (www.acr.org/rscan).

R-SCAN is a Practice Quality Improvement project that focuses on improving imaging use for 11 topics defined in the Choosing Wisely campaign, including the neuroimaging topics discussed individually in the first part of this article. In R-SCAN, radiologists collaborate with their referring clinicians, assess the baseline use of a certain imaging test, implement a series of interventions to improve the use of such test, and finally measure the effect of the interventions on the use rate of this test. R-SCAN program participants are guided by a step-by-step “recipe” and can earn Continuing Medical Education credits and American Board of Radiology approved Maintenance of Certification Part 4 credit and position themselves for success under new payment structures of the Medicare Access and CHIP Reauthorization Act of 2015, which will govern how radiologists are paid in the near future (<https://www.congress.gov/bill/114th-congress/house-bill/2>).

In addition to improving referring clinicians’ knowledge of imaging recommendations, continuing knowledge of imaging appropriateness among radiologists should not be overlooked. To ensure that the next generation of radiologists is ready to guide referring clinicians, this skill should be mastered in residency. Thus, the ACR Appropriateness Criteria have been an increasingly incorporated feature in radiology resident curricula.⁷⁵ Emerging evidence suggests that the clinicians are changing how they practice in response to the Choosing Wisely campaign. Alterations in radiation therapy practices in patients with breast cancer in response to the Choosing Wisely campaign have been reported recently. Clinical decision-support systems have thus far shown substantial promise in reining in unnecessary imaging examination orders. A 2013 study demonstrated a reduction of >75% in the number of inappropriately ordered imaging studies for evaluation of coronary artery disease when a point-of-order decision support tool was used, with a simultaneous significant increase in the percentage of appropriate studies ordered.⁷⁶ Siström et al⁷⁷ demonstrated significant reductions in the outpatient volume of CT, sonography, and MR imaging examinations after implementation of a computerized electronic medical record order-entry system with integrated Clinical Decision Support. Finally, a study showed that targeted use of an imaging decision-support system could reduce inappropriate neuroimaging orders, with resultant substantial decreases in use rates of lumbar MR imaging for low back pain, head MR imaging for headache, and sinus CT for sinusitis.⁷⁸

CONCLUSIONS

There is a shift toward more appropriate use of health care resources in medicine, particularly imaging. Despite imaging being a crucial tool for better diagnosis and effective patient management, we have not optimized its use. One of the important reasons for inappropriate imaging referral is increasing financial pressure of the fee-for-service payment model, resulting in insufficient, short patient visits, leaving the referring physicians insufficient time to evaluate patients, research the appropriate imaging study, consult a radiologist, or talk to the patient about the appropriateness of imaging. Additional barriers include demanding patients and fear of poor physician evaluations and medical malpractice. Deficiency of knowledge on when and how to use imaging may also cause inappropriate imaging referrals.

Current campaigns such as Choosing Wisely and Imaging 3.0 raise awareness and encourage a culture of appropriate use of imaging. This coupled with greater physician knowledge and use of the criteria for appropriate imaging can help ensure that each patient gets exactly the imaging he or she needs, to the benefit of both our patients and our health care system. Implementing a practical medical imaging decision-making process is a complex undertaking requiring resource organization at every level of process-referral, scheduling, point-of-care, and follow-up.

Collaborative partnership among radiologists, referring physicians, and payers is critical for this transition, and radiologists can play a very important role. The R-SCAN project provides an opportunity for radiologists to positively influence the appropriate use of imaging and to emphasize their value as integral members of the health care team.

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