# Diagnostic Imaging in Emergency Medicine: How Much Is Too Much?

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## INTRODUCTION

Few topics are as pertinent to the current emergency medicine climate as the debate surrounding the overuse of diagnostic imaging. Use of advanced diagnostic imaging has increased in the United States exponentially since the advent of computed tomography (CT) and magnetic resonance imaging (MRI). CT use has increased from 3 million scans in 1980 to greater than 60 million in 2005, and is still increasing.[1] Although this growth stretches across the care continuum, it includes the emergency department (ED). Overall, CT use during ED visits increased 330%, from 3.2% of encounters in 1996 to 13.9% in 2007.[2]

This subject incorporates intertwined issues, including the reliability of history and physical examination findings, special or high-risk ED populations, fear of litigation, physician risk aversion, public opinion, patient satisfaction, reimbursement, timing pressures, and physician experience, to name just a few.

Given the topic's complexity, it is not surprising that a plethora of views has been circulating in both the medical literature and the popular press. One popular view is that young physicians use advanced diagnostic imaging as a crutch to account for their inability to perform physical examinations.[3-5] Physical examination skills sometimes falter. However, to state that this is the reason the overuse of advanced diagnostic imaging is occurring may be too simple and allows premature closure of a topic that is decidedly complex. There are no simple answers in this debate, but this article will attempt to paint the complexity of the picture, as well as some future directions from the perspective of a young physician.

The degree of contribution of junior physicians to the abundant ordering of CT scans is unknown. In one study, years since graduation and annual workload did not correlate with increased imaging use.[6] Limited evidence suggests that experience may not affect ordering of head CTs.[7] Providers with greater clinical experience are, however, more likely to consider previous imaging and discuss risks and benefits of imaging.[8] It has also been reported that physician assistants and advanced practice nurse practitioners, who often work under supervision of an attending physician, have ordering habits similar to that of attending physicians, and some studies show decreased ordering.[9]

To my knowledge, there have been no studies comparing ordering habits of resident versus attending physicians. Residents have various levels of autonomy, depending on year of training, hospital, attending supervisor, ED census, and acuity on shift. Patients presenting to academic medical centers were slightly more likely to undergo advanced imaging,[10] perhaps because academic centers serve more severely injured patients; have less-experienced clinicians (residents) ordering diagnostic tests; are environments in which there is more discussion in regard to differential diagnoses, prompting a more thorough evaluation of patients; or simply have more accessible CT or MRI facilities.[11] CT overuse seems to be a problem affecting the specialty as a whole, and the resident contribution to CT overuse has not yet been quantified. Residency training influences future independent practice patterns, and conversations about resource use are therefore important for residents.

CT is not the sole imaging modality with evidence of overuse. MRI use has also increased, sometimes inappropriately.[12,13] However, MRI machines are not always accessible from the ED.[14] Therefore, CT remains the main advanced diagnostic imaging modality in this context of care, and the main focus of this article.

## FIRST DO NO HARM

Advanced imaging is a double-edged sword. The increase in diagnostic imaging is not without untoward consequences for patients, including but not limited to higher costs,[15] increased exposure to radiation,[16] increase in incidental findings,[17] contrast-induced nephropathy, and contrast-induced allergic reactions.[18]

The cost of health care in the United States has been increasing for the past decade, without any significant increase in quality outcomes measures,[15,19] in part because of overimaging. Advanced medical imaging increases medical costs, driving up expenses for both patients and the medical system.[20-24]

Increased exposure to radiation is another well-documented consequence of increased imaging.[16] The typical CT radiation dose for a chest or abdomen and pelvis CT is 10 to 20 mSv. In adults, this is associated with a lifetime risk of fatal cancer of approximately one cancer per 2,000 CT scans, compared with a lifetime risk of dying from cancer in the US population of approximately 1 in 5.[25] Although individual risk is small, in a few decades up to 2% of all cancers may be due to radiation exposure from CT scans, an increase from the current estimated rate of 0.4%.[1] Some physicians do not believe radiation increases cancer risk.[8,26] Furthermore, awareness of the risk has not been found to influence the ordering of CT scans.[8]

Imaging also increases incidental findings, subclinical conditions not associated with the patient's presentation that may have gone undetected for the life of the individual. The concept of incidental findings has been discussed in the context of cancer screening.[17,27] Overdiagnosis increases testing and unnecessary treatments, which in turn bring adverse effects and psychological harm to patients while not decreasing and sometimes even increasing mortality.[27] Other harms include contrast-related allergies and contrast-induced nephropathy, as well as increased length of stay, potentially leading to ED crowding.[18,28]

Perhaps as a response to the trend of increasing radiation from diagnostic imaging and in the spirit of the "as low as reasonably achievable" principle,[29] physicists and radiologists are making efforts to reduce radiation amounts used with CT imaging, and in some cases have decreased effective radiation doses.[30,31]

## ARE WE REALLY ORDERING TOO MANY UNNECESSARY CT SCANS?

A study published by Kanzaria et al[32] examined emergency physician perceptions of medically unnecessary advanced diagnostic imaging and found that 97% of physicians think that sometimes they order unnecessary tests. *Unnecessary* was defined as a "study you would not order if you had no external pressures and were only concerned with providing optimal medical care." This article generated somewhat excessive and sometimes warped media coverage, and heated debate in the emergency medicine community, as evidenced in a pro/con column in *Emergency Physicians Monthly*.[33] The most thought-provoking part of the commentary was the need to define what is unnecessary from the point of view of an emergency physician and of the system itself, a rather complex task. This will ultimately point toward why CTs are ordered now more than ever before, and what proportion of it is excessive; specifically, do we order CTs to confirm a diagnosis we suspect when the history, physical examination, and evaluation are not sensitive enough? Do we order it because our consultants require it to evaluate the patient? Do we order it to help surgeons with intraoperative planning? Do we order it to 100% rule out a diagnosis that is life threatening despite being able to do so within a 2% uncertainty by using a clinical decision rule? Are we uncomfortable with the 2%, or is the patient uncomfortable with the 2%? Does fear of litigation make us uncomfortable? Do we overorder because our patients will not sleep soundly unless they receive that imaging test?

Knowing the causes of overordering is the first step in prioritizing interventions to decrease overuse of imaging. Research into establishing the factors influencing imaging decisions is needed. More conversations about these factors are needed at an educational level, an administrative level, and health care policy level. Lack of research, on the other hand, leaves room for speculation and unsuccessful strategies.

## WIDE VARIATION IN DIAGNOSTIC IMAGING EXISTS, AND MORE IMAGING DOES NOT DECREASE MORTALITY

Research shows that some of the advanced imaging ordered in the ED could be avoided. For instance, in one study, 10% to 35% of CTs obtained in the ED for mild traumatic brain injury were not recommended, according to the evidence-based guidelines.[34] Another retrospective study demonstrated a significant variation in CT use among emergency physicians for all chief complaints and CT types, with greater variation in the care of patients who were discharged, and with some providers' use being quite far from the mean. To the authors, this represented potential overuse.[35] Wide variations are also observed in other studies, including head CT use for minor head injury.[7,36]

The isolated contribution of physicians to this variation in use is also unknown. Wong et al[6] found that only 1% of the variability in ED imaging use was attributable to physicians. Other studies disagreed.[7,35,36]

Regardless of the variation in rates of imaging and its causes, there has been no significant improvement in morbidity or mortality. From 1998 to 2007, the prevalence of CT or MRI use during ED visits for injury-related conditions increased significantly, without an equal increase

in prevalence of life-threatening conditions.[11] Age-adjusted incidence of pulmonary embolism, which was stable in the 5 years before the introduction of multidetector CT pulmonary angiography, increased by 80% in the 8 years afterward,[37] but the diagnosed pulmonary emboli during this period were primarily subsegmental.[38-40] Simultaneously, overall CT pulmonary angiography use increased 14-fold.[41] Despite the increased incidence, age-adjusted mortality from pulmonary embolism changed little, from 12.3 to 11.9 per 100,000.[38] There is evidence that subsegmental emboli may not be life threatening or lead to significant morbidity, at least in a majority of the population.[38]

## INCREASED USE IS NOT NECESSARILY OVERUSE

Individuals advocating decreased imaging often suggest an emphasis on clinical examination as an alternative for making diagnoses, but ED patients are a special population that differ from outpatients. Important pathology can be missed if clinical examination is relied on to determine need for imaging.

Atrophy of physical examination skills and minimal time spent with patients are often quoted as reasons for increased imaging use.[3-5] It is clear that teaching and learning of clinical skills need improvement in the United States.[42] However, the physical examination has limitations that are well documented, and imaging can complement physical examination skills to expand on those diagnostic limitations. Immediately after discussing physical examination skills, one author commented that a CT scan is better at identifying an abdomen needing surgery than a senior surgeon's examination.[4]

Physical examination findings are less reliable in overweight patients,[43] who can represent up to 60% of the ED patient population, by some estimates.[44] Diagnosis may be difficult or delayed in obese surgical patients because of unreliability of physical examination results.[45]

Trauma patients represent another subset of those for whom clinical examination is unreliable. Often, they are intoxicated or have otherwise altered mental status, making them difficult to examine properly. They may not communicate pain proportional to their injuries, making diagnosis based solely on physical examination unreliable. Tissue injury signs such as ecchymosis may not be immediately apparent after injury. Vital signs in trauma patients are also not always indicative of clinical status and thus can be unreliable.[46]

For the elderly, another growing segment of the ED population, physical examination is also misleading. Elderly trauma patients have vital signs that do not always correspond to degree of illness.[47] Physical examination findings such as abdominal tenderness do not always correlate with presence of serious pathology.[48]

There is an increasing debate about the validity and reliability of "pathognomonic" physical examination findings, and not only for the special patient populations discussed above.[49-51] Several examination findings have been shown to actually lack sensitivity or specificity. For instance, in the ED, pneumonia cannot be confirmed or excluded by physical examination findings alone,[52] nor can cholecystitis,[53] thoracic aortic dissection,[54] acute mesenteric ischemia,[55] ectopic pregnancy,[56] or appendicitis.[57] Even among patients deemed by a surgeon to "definitely" have appendicitis, CT revealed that appendicitis was not present in 28% of cases in one study.[58] In these cases, it becomes necessary to perform diagnostic imaging to establish the correct diagnosis and treatment.

Although there is a negative connotation to "negative"-result imaging studies, use of advanced imaging can be useful for disposition planning, and help patients avoid invasive interventions or prevent delayed diagnoses. CT use changes potential management decisions by leading to timely surgery or decreasing admission rates by as much as 25%.[59,60] A systematic review in the surgical literature showed that preoperative abdominal CT is associated with lower negative-result appendectomy rates.[61] A prospective randomized trial of 152 patients showed that a selective approach to imaging reduced CT scanning by one third, but increased the negative appendectomy rate to 26% from 14%, and the rate of perforation from 10.3% to 18.4%.[62]

CT scans may also be underused in specific situations. Disparities based on race in head CT imaging during ED evaluation for headache, as well as disparities in neuroimaging for acute ischemic stroke based on insurance status, have been discussed in the literature.[63,64]

The acceptable diagnosis miss rate today is small; nontraditional presentations of common illnesses are in fact common, and traditional physical examination and history clues may be insufficient for making the diagnosis. Nowhere is this more pertinent than in the ED, where the new generation of physicians needs accurate, fast diagnoses for an often challenging and confounding patient population. So perhaps increased use of imaging is not necessarily overuse.

## WHAT FACTORS INFLUENCE PREVENTABLE IMAGING?

Even when guidelines and decision tools supporting limited imaging for low-risk patients exist, they are often not followed.[65,66] This choice seems to be influenced by

some nonclinical factors such as a lack of engaging the patient in the decision process, provider anxiety, patient anxiety, and time constraints.[66,67]

In the study by Kanzaria et al,[32] physician respondents indicated liability and risk of litigation as one of the principal reasons for overordering. Patient and family expectations, standard practice norms, and time saving were other prominent reasons. Reimbursement issues were not cited as a main reason driving overuse.

A recent systematic review of factors associated with imaging overuse in the ED suggested that lack of care integration and poor transfer of care may cause duplicate imaging for transferred trauma patients.[68] In the same review, reasons for imaging overuse in nontransferred patients included fear of litigation and lack of ultrasonographic services at night, which prompted abdominal CT orders.[68] Veterans Affairs clinicians overimaged uncomplicated back pain because of fears they could not refer the patient to a specialist for further evaluation without obtaining imaging first. Half of clinicians worried that the patient would be upset, and a quarter thought they would not have time to discuss the risks and benefits of imaging with the patient.[13]

Although the belief that medical liability risk could influence decisions is highly prevalent among physicians, findings are mixed in regard to the effect of liability risk on imaging orders at both the state and physician level, according to a systematic review examining 13 studies.[69] Legislation that substantially changed the malpractice standard for emergency physicians in 3 states had little effect on the intensity of practice, as measured by imaging rates, average hospital charges, or hospital admission rates.[70] Another study suggested that states with laws that limit monetary damages, mandate periodic award payments, or specify collateral source offset rules have lower odds of imaging compared with states without these laws, specifically for head CT ordered for head injury in women.[71]

Fear of missing even a low-probability diagnosis topped the list of reasons for overimaging in the study by

**Table.** Strategies to optimize use of appropriate advanced diagnostic imaging.

| Type of Strategies | Examples of Strategies |
|---|---|
| **Conferences** | Academy of Emergency Medicine Consensus Conference 2015<br>Preventing Overdiagnosis yearly conference, sponsored by the Dartmouth Institute, *British Medical Journal* |
| **National medical society initiatives aimed at education about optimal imaging** | Choosing Wisely initiative (internal medicine, other specialties including emergency medicine; American College of Emergency Physicians Choosing Wisely campaign)<br>Image Gently (pediatrics)<br>Image Wisely (radiology)<br>American College of Radiology appropriateness criteria<br>American Institute of Ultrasound in Medicine Ultrasound First |
| **Residency curriculum about advanced diagnostic imaging (lecture, small group, simulation)** | Recommended imaging test for specific indications<br>Risks of imaging: radiation exposure and cancer risk quantification, incidental findings and overdiagnosis, reactions to contrast<br>Training in shared decisionmaking<br>Alternative imaging options (ultrasonography) |
| **Research** | Imaging patterns of providers<br>What is the variation in imaging attributable to?<br>Shared decisionmaking in low- and high-risk situations, with large variability in physician behavior<br>Litigation<br>Patients' experiences and concerns about imaging<br>Increasing patient engagement<br>Mitigating provider and patient anxiety<br>Do imaging rates increase with time constraints (busy shift and decreased time available to spend evaluating patient)?<br>Comparative effectiveness research for different imaging options |
| **Government initiatives** | Centers for Medicare & Medicaid Services Appropriate Use Criteria rule (consult the criteria before ordering imaging for Medicare patients) |
| **Consensus discussions** | Degree of acceptable uncertainty in regard to specific diagnoses, given current diagnostic pathways and their risks |

Kanzaria et al.[32] Establishing trust and managing uncertainty may reduce imaging, as suggested by a qualitative study by Melnick et al.[66] Physicians may seek to avoid the small risk of failure by overordering rather than accepting the degree of uncertainty in every patient encounter. Current medical culture makes it hard to do otherwise. There is stigma associated with bad outcomes, even when inevitable. Mistakes are more emotionally charged and memorable. Moreover, communicating uncertainty is thought to diminish the perceived expertise of the physician, undermining the patient's trust.[72,73] This may be harder to navigate for a resident physician or a young attending physician, who might already possess some perceived lack of expertise. Probability neglect in a high-stress environment influences the belief that the chances of a bad outcome are greater[74] and perhaps falsely increases pretest probability, prompting overimaging. As medical professionals, we might benefit from accepting uncertainty and communicating that to the patient without losing trust, preferably in a shared decisionmaking model.[66]

## POSSIBLE SOLUTIONS FOR OVERIMAGING

To successfully tackle this problem, an integrated approach at the level of health policy, government mandate, hospital administration, physician associations, research, and education is needed. The Table summarizes some of the initiatives developed, educational initiatives needed, and possible research topics.

## CONCLUSION

The topic of advanced imaging is decidedly complex, and the notion that emergency physicians and trainees order too many advanced imaging studies is a flawed generalization based on incomplete consideration of the manifold issues surrounding advanced imaging use in medicine today. There is evidence pointing toward excessive ordering, but there are also circumstances in which advanced diagnostic imaging improves diagnosis when physical examination falters, improves outcomes, and can result in fewer admissions and surgical procedures. Physical examination skills and diagnostic imaging should not be a zero-sum situation. They are best used as counterparts to arrive at the correct diagnosis in a delicate balance, often determined by the specific clinical scenario. Multiple professional organizations supporting the diligent use of imaging have created resources and guidelines promoting conscientious use of advanced imaging. This debate will likely continue in clinical practice, and at the level of policymaking and research.

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