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INVITED COMMENTARY

Emergency Department Neuroimaging: Are We Using our Heads?

Patterns of neuroimaging use in emergency settings vary widely. A study of Canadian EDs found that neuroimaging rates for patients with minor head trauma with similar characteristics ranged from 16% to 70% between hospitals and 6% to 80% among individual physicians.¹ Understanding these variations is a key step to determine appropriate use.

See also page 260

In this issue of the *Archives*, Raja and colleagues report head CT and MRI rates in US EDs from 2007. The national average rate for neuroimaging in the ED was 6.7%. Rates were higher in elderly patients, in urban settings, and in nonprofit hospitals. The 3 leading complaints associated with neuroimaging were trauma, headache, and dizziness, and the 3 leading discharge diagnoses were trauma, headache, and seizure. While previous studies have reported local imaging rates^{2,3} and rates of imaging

in subpopulations with specific complaints,^{4,5} this report provides neuroimaging rates from a national sampling of undifferentiated patients.

There are some challenges with extrapolating data from this study. Because the data are at the visit level rather than patient level, it is possible that a single patient generated multiple visits (and multiple CT scans). Also, because individual EDs were sampled over 4-week periods, it is possible that frequent visitors could have attended surrounding EDs. Finally, the usual limitations of using an administrative data set are present, including potentially lower accuracy of *International Classification of Diseases, Ninth Revision, Clinical Modification* coding and procedure codes (from which these imaging rates are obtained) and self-reported data fields (eg, race/ethnicity, where there is approximately a 15% nonresponse rate and therefore includes imputed values).

Even with such limitations, this study provides a valuable benchmark for national neuroimaging rates. What this report cannot answer, however, is whether our current imaging rates are too low (resulting in significant amounts of inappropriately missed disease), just right, or too high (resulting in excessive risks from imaging without significant improvements in outcomes). One reason for concern that rates might be too high is that the use of medical imaging over the past 2 and a half decades has increased anywhere from 6-fold⁶ to 20-fold.⁷ Reasons for increased imaging, especially CT scanning, include increased availability, improved acquisition times, improved image accuracy and detail, and the desire for increased diagnostic certainty.⁸

Besides the increase in the sheer numbers of scans, there is also reason to worry about the doses of radiation delivered with any one scan. A recent report in the *New York Times* described a group of patients who presented with complaints and findings consistent with radiation poisoning, including hair loss in a circumferential band. It was discovered that these patients had received toxic doses of radiation during CT scanning of the head to evaluate for suspected stroke.⁹ Research suggests that such experiences may present a more systematic problem than previously recognized. In an evaluation of medical imaging at 4 hospitals, Smith-Bindman and colleagues¹⁰ reported that effective doses varied significantly (13-fold mean variation). For routine head CT scans, the minimum and maximum effective doses recorded ranged from 0.3 to 6 mSv, and for stroke studies, the doses ranged from 4 to 56 mSv.

Our ultimate goal in ordering medical imaging is to gain knowledge that will lead to an effective intervention. Said another way: no one's condition ever improves solely by having an imaging test. We would like to avoid unnecessary exposure to radiation, its consequent risks, and also detection of incidental findings that can lead to patient concern, further medical evaluation (often including further imaging and radiation), and interventions of undetermined value.

The development of decision rules represents an important step toward this goal. Neurotrauma is the leading indication for neuroimaging in the ED with 1.42 million head CT scans ordered annually for this indication based on this report by Raja and colleagues. There has been a significant investment in research to assist clini-

cians in selection or exclusion of neuroimaging for these patients. However, as with many decisions rules, the question remains: what is the desired outcome? Should our goal be the detection of *any* “radiologically significant” injury, of which most (approximately 90%-99%¹¹⁻¹⁷) are nonsurgical and do not lead to additional intervention? Or should it be detection of only those injuries requiring neurosurgical intervention (ie, a clinical outcome)? How much specificity is it worth sacrificing to increase our sensitivity for radiologically significant injury?

A recent study compared the sensitivity and specificity of 6 guidelines for minor head injury.¹⁸ For detection of neurosurgical lesions, all of the decision rules were exquisitely sensitive, showing narrow confidence intervals that reached 100%. For positive predictive value, however, there were significant variations. The best performing rule, the Canadian High Risk Rule, would have required 39 CT scans to detect 1 neurosurgical lesion. The worst performing rules, the New Orleans and the National Institute for Health and Clinical Excellence, would have required 52 and 54 CT scans, respectively, to achieve the same. Given the 1.4 million head CT scans ordered for trauma in the United States, use of the New Orleans rule for mild head trauma could result in 450 000 *more* CT scans per year compared with use of the Canadian Rule without a corresponding increase in detection of injuries requiring neurosurgical intervention.¹⁹

Despite this information, current medical society (and Centers for Disease Control and Prevention) recommendations for imaging of minor head trauma in the United States use New Orleans criteria, which is most sensitive for radiologically significant disease.^{20,21} One widely cited validation study of this rule, however, reported a specificity of only 3%. Clearly, casting a net widely exposes many more patients to the expense and exposure of imaging. While the goal of these consensus guidelines is to reduce unnecessary imaging, we have learned from experience the fine balance between high sensitivity and lower specificity when developing and applying decision rules. More than a decade ago, guidelines for the use of lumbar spine radiographs were promulgated to improve the accuracy of imaging in low-back pain, based on identification of “red flags” for infection fractures and tumors. When these guidelines were retrospectively evaluated in a large family practice population, their use would have resulted in a 238% increase in use.²² This experience provides an important lesson in the unintended consequences of well-intended decision rules.

One approach to address the debate over how to identify and approach radiologic vs clinical outcomes is the development of a “2-tiered” decision rule. The first tier mandates neuroimaging to identify patients at highest risk for neurosurgical disease. The second tier allows for either imaging or an observation period in the group at risk for radiologically significant findings but without significant risk for neurosurgical intervention.^{23,24} The desired management of second-tier patients will vary by setting, patient preference, and clinician preference. This approach has been successfully used in the Canadian imaging rule for adults and, more recently, a decision rule for children.^{23,24}

The desire to improve “diagnostic certainty” through increased use of medical imaging, however, may remain

unrequited. As noted in a now famous editorial by Jerome Kassirer,^{25(p1273)}

diagnostic certainty usually is unattainable; it is frequently not required for optimal care; and because all tests are imperfect and some impose risk, the attempt to reach certainty with more and more tests sometimes produces substantial harm. . . . The errors and risks inherent in diagnostic tests demand that we think about their use in terms of the probabilities and values of outcomes we are trying to achieve.

As a society and as a profession, we cannot allow the temptation for diagnostic certainty to undermine the intent of our profession: the patient’s best interest. It has been estimated that approximately one-third of all CT scans in the United States are not medically necessary.⁷ To achieve the best interests of our patients, we must be led by our heads, not by our technology.

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COMMENTS AND OPINIONS

Cardiac Function in 5-Year Survivors of Childhood Cancer

The article by van der Pal et al¹ on cardiac function in survivors of childhood cancer is very concerning, reporting a 27% incidence of abnormal cardiac function. However, the authors define abnormal cardiac function as a left ventricular shortening fraction (LVSF) below 30%. This level appears to have been chosen based on extrapolation to an ejection fraction of 50%. This is considerably higher than many standard references that quote a lower limit for LVSF of 27% to 28%.^{2,3} Although difficult to extrapolate from the limited data provided, even a 20% decrease in the threshold for shortening fraction would dramatically decrease the incidence of abnormal left ventricular function. While the article by van der Pal et al¹ provides valuable data on risk factors for late cardiac complications of cancer therapy, the inappropriately high threshold for cardiac function chosen by the authors yields a distortion in what may be the true incidence and is needlessly alarming.

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In reply

Rosenberg suggests that our definition of an LVSF of less than 30% as an abnormal cardiac function in a series of asymptomatic adult childhood cancer survivors is inappropriate.¹ We respectfully disagree. Our choice was based on the Common Terminology Criteria for Adverse Events (CTC-AE), an established scoring system for both acute and chronic conditions in patients with cancer,² and using the lower thresholds for children,³ as Rosenberg suggests, is not adequate in our adult population. We acknowledge, however, that any dichotomization of a continuous measurement for the identification of a pathological condition may be overly simplistic. Indeed, the choice of an LVSF threshold for the definition of abnormal cardiac function matters for the prevalence estimate in our study: 27% of the survivors have an LVSF less than 30%, while 20.2% have an LVSF less than 29% and 15% have an LVSF less than 28%. It does, however, not matter for our conclusions on the determinants of decreased LVSF because those were based on linear regression analyses of continuous LVSF.

An important question is if a decreased LVSF due to childhood cancer treatment is associated with a higher risk of symptomatic clinical heart failure (CHF) in the long term. Although the risk of developing CHF in childhood cancer survivors is high,⁴ studies in survivors focusing on the predictive value of abnormal LVSF for later CHF are still lacking. Current data, in other patient populations, suggest that an abnormal LVSF is associated with an increased risk of CHF.^{5,6} Moreover, early treatment of asymptomatic left ventricular dysfunction can improve cardiac outcome.⁵ Therefore, we believe our data support the need for lifelong risk-stratified medical surveillance of childhood cancer survivors for the early detection of adverse events that are amenable to intervention.

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