Improving the Application of Imaging Clinical Decision Support Tools: Making the Complex Simple

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With the promotion and incentivization of electronic health records and computerized order entry by CMS, there is a unique opportunity to catalyze the use of evidence-based guidelines with the inclusion of clinical decision support (CDS) tools. Imaging CDS tools have evolved from static paper algorithms, checklists, and scores to interactive systems that provide feedback and recommendations with the intent of directing health care providers to deliver best practices. Some of the major limitations of first generation imaging CDS tools include a lack of comprehensive evidence-based guidelines, limited ability to input detailed patient conditions and symptoms, and time-intensive user interfaces. Next-generation imaging CDS tools will attempt to close the information and interface gaps to provide more meaningful guidance to health care providers and improve the delivery of best practices to patients.

Key Words: Diagnostic imaging, clinical decision support, electronic health record, evidence-based medicine, quality of health care

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INTRODUCTION

Clinical decision support (CDS) systems can aid physicians in determining the need for diagnostic imaging and in the selection of the most appropriate imaging study when imaging is required. Appropriateness of any medical intervention can be defined by the RAND/UCLA health care utilization criteria:

> The indication to perform a medical procedure is appropriate when the expected health benefit (i.e., increased life expectancy, relief of pain, reduction in anxiety, improved functional capacity) exceeds the expected negative consequences (i.e., mortality, morbidity, anxiety of anticipating the procedure, pain produced by the procedure) by a sufficiently wide margin that the procedure is worth doing [1].

Inappropriate imaging conveys real harms, including radiation exposures, financial costs, risks associated with contrast media exposure, increased length of stay in a crowded health care system, and the performance of additional diagnostic procedures in pursuit of imaging findings. There are numerous initiatives aimed at reducing the use of inappropriate imaging and unnecessary radiation exposure, especially in the outpatient and emergency care settings. These initiatives use various tools, including radiology benefits managers, preauthorization processes instituted by payers and insurers, imaging CDS, and low-dose protocols and dose reduction technologies when imaging is performed [2]. Some published reports document a modest reduction in low-utility and inappropriate imaging examinations and an increase in the diagnostic yield of imaging after the implementation of CDS, whereas other studies have suggested negligible associated changes [3-7]. At the heart of all these initiatives is the question, "Can we prospectively perform the right imaging test, at the right time, for the right patient?"

The most refined clinical decision tools have been derived and validated using the scientific method. Early examples of these instruments began in the 1990s with the Ottawa ankle and foot rules (Table 1) [8]. The need for these guidelines was highlighted by the high frequency of imaging for common clinical complaints (such as ankle pain after minor trauma) and the low yield of diagnostic imaging. Subsequently, clinical decision instruments were developed for suspected cervical spine injury after trauma (the National Emergency X-Radiography Utilization Study, the Canadian cervical spine rule) [9], suspected traumatic brain injury (the New Orleans criteria, the Canadian CT head rule, the Pediatric Emergency Care Applied Research Network rule [10,11]), pulmonary embolism (the pulmonary embolism rule-out criteria, the Wells score, the Geneva score [12,13]), and appendicitis (the Alvarado score, the pediatric appendicitis score [14,15]).

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Table 1. Examples of clinical decision support instruments and their effects

Clinical Decision Instrument	Sensitivity	Specificity	Predicted Reduction in Imaging
NEXUS [16] (determines need for cervical spine imaging after trauma)	99%	12.9%	12.6%
Ottawa ankle rule [8]	98%	32%	30-40%
Canadian CT head rule [10] (determines need for head CT after trauma)	100%	51%	48%
Canadian cervical spine rule [9] (determines need for cervical spine imaging after trauma)	99%	45%	44%
Appendicitis (Alvarado score) [15]	99%*	43%*	approximately 30%
Pulmonary embolism rule-out criteria [12]	97%	23%	approximately 20%

Note: NEXUS = National Emergency X-Radiography Utilization Study.
*Varying thresholds on the scale can be used; these figures represent a threshold of 5.

Clinical decision rules must achieve a delicate and difficult balance: high sensitivity (avoiding missed injury or disease) and specificity sufficient to reduce imaging utilization. The development of an effective rule is time-consuming and costly; the National Emergency X-Radiography Utilization Study required National Institutes of Health funding and involved the enrollment of >34,000 patients at 21 medical centers [16]. The National Emergency X-Radiography Utilization Study II (a rule for traumatic brain injury) enrolled >13,000 patients and achieved 98.3% sensitivity but only 12.8% specificity, substantially limiting its clinical utility [17]. Even after successful derivation and validation of a rule, "success" may not be achieved if further validation demonstrates that the rule behaves differently in the hands of different practitioners (eg, nurses, paramedics) or has different sensitivity and specificity in different patient populations.

Some rules actually increase utilization when applied to new populations, particularly in health care settings in which baseline utilization of imaging is low [18]. Another barrier to success is physician willingness to adopt a rule and change from standard practice. Physicians may fail to adopt rules that are complex, are time-consuming to apply, or have sensitivity values that are unacceptable to individuals. As an example, the Canadian head CT rule has high sensitivity for clinically important head injuries and achieves moderate reductions in imaging utilization in study environments, but it has not been widely adopted in the United States. The rule is perceived as complex and difficult to remember, and its premise—that it is acceptable to miss some intracranial injuries not requiring treatment or affecting patient outcomes—is not accepted by many physicians in the litigious environment of the United States. Reluctance to adopt complex rules might be overcome by the use of electronic support, such as phone and tablet applications, websites with rules, or embedded decision support in electronic medical records and order entry systems.

These support systems fall into several categories, including validated clinical decision rules and expert consensus guidelines, and can be applied at several different points in the clinical process. Ideally, CDS would reduce unnecessary testing and increase appropriate testing by automatically alerting physicians to patients at low risk who do not require imaging and those at high risk for whom imaging has not yet been ordered (Table 2).

The ideal CDS system would reduce health care costs, patient radiation exposures, and patient evaluation times without compromising health care standards or patient quality of life. It should be evidence-based, easy and rapid to use, and flexible, allowing physician judgment

Table 2. Components of an ideal clinical decision support system

Feature	Example
Evidence-based	Rigorously derived and tested through internal and external validation phases
Sensitive and specific	Must capture nearly all cases, while avoiding imaging in a substantial fraction of patients
Cost effective	Specificity must be high enough that application of the rule does not increase costly imaging
Radiation effective	Suggests alternative imaging examinations that avoid ionizing radiation, or modifies imaging protocols when possible to reduce radiation exposure
Rapid	Includes information readily available at bedside, rather than detailed or nonroutine data (eg, laboratory testing, detailed neurologic examination)
Flexible/customizable	Allows physician to override on the basis of individual judgment and local practice rules (a log of such overrides can be used to provide feedback to physicians and administrators)
Integrated/automated	Automatically imports age, gender, medications, and medical history from electronic health record, rather than asking physician to input values