Medical imaging is a critical and growing component of modern medical diagnosis and practice. Over the past 4 decades, advances in diagnostic imaging have contributed greatly to patient care, improving our ability to detect disease, guide procedures, and deliver treatments (1). Most medical specialties now regularly use medical imaging, which has led to a substantial increase in the number of diagnostic imaging examinations performed in recent years (2,3). It is estimated that imaging services have grown at about twice the rate of other health care technologies over the past decade (4).

The increased use of medical imaging comprised examinations that are beneficial to patients’ welfare and examinations that could be considered inappropriate to use (4). Several publications have documented that as many as 25%–50% of advanced imaging studies fail to improve patient welfare and may be unnecessary (4–7). This not only contributes to escalating health care costs in the United States (4,8,9) but also exposes patients to unnecessary risks including radiation, contrast-related complications (7,10–14), and unnecessary interventions for incidentalomas (15).

Among a number of factors that contribute to imaging overutilization, physician knowledge gaps regarding imaging safety and appropriateness play an important role (4,16). Studies have shown that referring physicians sometimes lack expertise in determining which tests are most appropriate. For example, Lehnert and Bree (17) found that 26% of computed tomography or magnetic resonance imaging scans performed by primary care physicians were for inappropriate indications. A separate survey of medical house staff found that less than 50% of respondents were able to correctly answer half
the questions regarding appropriate imaging test choice for specific clinical situations (18). In addition, a number of studies have demonstrated that referring physicians and physician trainees, regardless of specialty, lack knowledge of radiation doses and safety (19–24).

Thus, educating physicians on appropriate imaging utilization and imaging safety has been increasingly recognized as important for patient care and health care cost containment (25–29). Targeted education campaigns have been promoted by a number of medical organizations, including the “Choosing Wisely” and “Image Gently” campaigns (30,31). Efforts have also included the development of electronic order entry systems with integrated clinical decision support systems (16,32). Others have developed free access resources that aim to help physicians select imaging modalities that are safer and more appropriate for their patients. The American College of Radiology (ACR) has developed one of these comprehensive imaging decision support resources called the ACR Appropriateness Criteria (ACR-AC). This free, online, evidence-based, peer-reviewed resource is designed to help referring physicians choose the best imaging examination for more than 200 commonly encountered clinical scenarios (33). It provides an appropriateness rating of each imaging option and most importantly attempts to introduce radiologist knowledge into the decision algorithm before the examination being ordered. Specifically, each potential test is described with a discussion of both its pros and cons including any associated radiation risk and a pertinent literature review regarding each option.

Despite the availability of versions of the ACR-AC since 1993, awareness and utilization of this resource by nonradiologists remains low (1,26,34). For instance, a survey by Bautista et al. (27) found that 1.7% of residents and 3.0% of attending referring physicians reported using the ACR-AC as one of their top three resources for selecting the best imaging technique. Another survey found that 81% of interns across a wide representation of referring specialties had never heard of or used the ACR-AC (35). Unsurprisingly, awareness of this resource is also low among medical students. As most current medical students will become future referring physicians, it is of particular importance that education efforts are directed toward this group. A study by Dillon et al. (29) found that 96% of senior medical students at one institution were not aware of the ACR-AC. A survey of students at multiple US medical schools by Prezzia et al. (28) found that 77% had never heard of the ACR-AC.

The purpose of this study was to assess whether medical students at our institution order imaging studies independently, what resources they use to help in decision making, and whether those familiar with the ACR-AC use the resource in clinical practice. A secondary aim was to determine whether increasing familiarity with the ACR-AC could impact student usage. To our understanding, this is the first study to evaluate medical student use of the ACR-AC within a clinical setting.

MATERIALS AND METHODS

This study was confirmed as exempt-status by our institutional review board.

Survey Design and Administration

A survey was created to assess awareness and use of the ACR-AC as well as imaging practices and preferences among third year medical students. The 11-question survey was created by a team of three authors and then reviewed and edited by two faculty members with extensive experience in educational survey design. The survey comprised questions using a 5-point Likert Scale, yes or no, multiple choice, and free response formats; the survey questions are presented in Tables 1-3.

The survey was distributed on paper, in person to 109 third year medical students (of a class of 150) who were in attendance for a radiology lecture in October 2014, during which the ACR-AC were not discussed. The lecture was part of a weeklong course that occurred midway in third year, between core rotations. The survey was distributed by a member of the third year medical student class who was among the study authors. Surveys were collected anonymously, and students did not indicate their name or identifying information. Participation was optional.

Increasing Student Familiarity with the ACR-AC

At our institution, radiology is taught in an integrated longitudinal fashion over the first 2 years (30 hours). During the third year, students have four radiology lectures that occur in between clinical clerkships that focus on skills for wards. However, the ACR-AC is not currently incorporated into the radiology curriculum until the fourth year, when most medical school class take a 4–week elective focused on appropriate imaging examination selection (100 hours). To introduce third year medical students to the ACR-AC, a lecture describing the purpose, utility, and benefits of the resource was given immediately after the collection of the preintervention survey. The lecture material was presented by two third year medical students (who were study authors) and a radiology faculty member using a PowerPoint presentation. The tutorial also included a live demonstration on how to access and navigate this resource using “right lower quadrant pain” as a clinical vignette. To remind students about this resource, and for those not in attendance, a follow-up e-mail was sent 1 week later to all third year medical students that included the lecture slides and instructions on how to use the ACR-AC. Students were also provided an electronic PowerPoint module on their online course platform as reference material.

Follow-up Survey Design and Administration

A 13-question postintervention survey was designed to evaluate whether this brief intervention had any impact on student use of the ACR-AC and on various imaging
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer Choices</th>
<th>Preintervention Responses, n (%)</th>
<th>Postintervention Responses</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever placed an order for an imaging exam (including orders which needed to be co-signed) before?</td>
<td>Yes 70 (68)</td>
<td>74 (74.8)</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 33 (32)</td>
<td>25 (25.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you initiate ordering an imaging study on your own (as opposed to being told that ordering an imaging study is needed)?</td>
<td>5 Always 0 (0)</td>
<td>0 (0)</td>
<td>.025</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Often 4 (5.6)</td>
<td>7 (9.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Sometimes 18 (25.4)</td>
<td>31 (41.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Rarely 34 (47.9)</td>
<td>31 (41.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Never 15 (21.15)</td>
<td>5 (6.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you typically consult any resource in deciding what study to order?</td>
<td>Yes 46 (64.8)</td>
<td>50 (67.6)</td>
<td>.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 25 (35.2)</td>
<td>24 (32.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If so, which resource do you primarily use?</td>
<td>UpToDate 42 (*)</td>
<td>55 (*)</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medscape 4 (*)</td>
<td>3 (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ACR-AC 6 (*)</td>
<td>6 (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Google 11 (*)</td>
<td>7 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Access Medicine 1 (’)</td>
<td>0 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 15 (’)</td>
<td>2 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever heard of the ACR Appropriateness Criteria?</td>
<td>Yes 8 (11.3)</td>
<td>61 (82.4)</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 63 (88.7)</td>
<td>13 (17.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you have heard of it have you ever used the ACR Appropriateness Criteria in deciding what to order?</td>
<td>Yes 3 (37.5)</td>
<td>13 (21.3)</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 5 (62.5)</td>
<td>48 (78.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did learning about the ACR Appropriateness Criteria change how you approach ordering imaging studies?</td>
<td>Yes N/A</td>
<td>12 (20.1)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No 46 (79.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you have heard of the ACR Appropriateness Criteria, how likely are you to use it in your future practice?</td>
<td>5 Very likely N/A</td>
<td>18 (23.1)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Likely 28 (35.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Possibly 29 (37.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Unlikely 2 (2.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Not at all 1 (1.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you have input on what imaging study is ordered in collaboration with the team?</td>
<td>5 Always 5 (4.9)</td>
<td>9 (9.1)</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Often 14 (13.7)</td>
<td>19 (19.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Sometimes 37 (36.3)</td>
<td>41 (41.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Rarely 40 (39.2)</td>
<td>27 (27.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 Never 6 (5.9)</td>
<td>3 (3.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When orders are placed for an imaging study, how strong is your understanding of the rationale for the choice of imaging (ie, CT vs. MRI vs. US)?</td>
<td>5 Very strong 2 (1.9)</td>
<td>4 (4.0)</td>
<td>.38</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Strong 27 (26.2)</td>
<td>32 (32.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 Moderate 65 (63.1)</td>
<td>59 (59.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Low 9 (8.7)</td>
<td>4 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 None 0 (0)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If a resource were designed to help you learn about and select appropriate radiology studies, what format would you prefer?</td>
<td>Mobile application 66 (‘)</td>
<td>69 (‘)</td>
<td>.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Book 4 (’)</td>
<td>8 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internet site 43 (’)</td>
<td>36 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electronic medical record based 19 (’)</td>
<td>19 (’)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other 2 (’)</td>
<td>1 (’)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACR-AC, American College of Radiology Appropriateness Criteria; CT, computed tomography; MRI, magnetic resonance imaging; N/A, not applicable; US, ultrasound.

*Percentage could not be calculated as some respondents chose more than one answer option.

1Questions included only on postintervention survey.
behaviors. The postsurvey was administered 6 months after the intervention and presurvey and at the end of the students’ third year. The preintervention and postintervention surveys were nearly identical. Two additional questions were added to the postintervention survey. These are marked with an dagger in Table 1.

The postintervention survey was administered using the same methodology to 110 of 150 students in attendance at a radiology lecture. Given slight variations in attendance to specific lectures, the groups of 109 and 110 surveyed students (which comprised approximately 73% of the medical school class each) had substantial overlap, although were not exactly the same cohort. To maintain anonymity and survey feasibility, responses were not collected in a paired fashion.

Data Coding

The survey included two free text questions. A single radiologist analyzed all free text responses for common themes and coded each individual comment by theme.

Statistical Analyses

Data were summarized with the absolute number and percentage selecting each answer choice. To statistically compare answers to questions asked on both the preintervention and postintervention surveys, the Fisher’s exact test was used. Differences were considered statistically significant with a P value < .05.

RESULTS

The response rate for the initial survey was 103 of 109 (94%), and the response rate for the second survey was 99 of 110 (90%). The survey responses for yes or no, multiple choice, and Likert Scale questions are reported in Table 1.

<table>
<thead>
<tr>
<th>Coded Responses for Students Choosing UptoDate as Preferred Resource</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>17</td>
</tr>
<tr>
<td>Habit/familiarity</td>
<td>10</td>
</tr>
<tr>
<td>Trust/reliability</td>
<td>7</td>
</tr>
<tr>
<td>Availability of other information (medical management, and so forth)</td>
<td>7</td>
</tr>
<tr>
<td>Used by other members of the team</td>
<td>4</td>
</tr>
<tr>
<td>Links to literature</td>
<td>4</td>
</tr>
<tr>
<td>Organization/format</td>
<td>3</td>
</tr>
<tr>
<td>Fast/efficient</td>
<td>2</td>
</tr>
<tr>
<td>Comprehensive</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Total responses</td>
<td>57*</td>
</tr>
</tbody>
</table>

*Percentages of total not calculated as some students chose multiple options.

Most students reported initiating imaging examination orders independently (74 of 100, 74.8%) and consulting resources (50 of 74, 67.6%), but they expressed a strong preference for non–ACR–AC resources, most notably UptoDate (http://www.uptodate.com) via its online mobile application interface. In a free text question, students were asked, “Why do you prefer this resource?” Responses (UptoDate, n = 42 for survey 1 and n = 55 for survey 2) were coded into 10 different categories and are presented in Table 2. Most respondents cited ease of use and familiarity as the leading reasons. Students expressed a strong preference for an imaging examination selection resource to be formatted as a mobile application.

Perceived awareness of the ACR–AC resource increased from 8 of 71 (11.3%) to 61 of 74 (82.4%) 6 months after the lecture and tutorial. Although more students used the resource, given that more were familiar with it (13 after the intervention compared to 3 on the preintervention survey), the proportion of students choosing to use it remained low, only 13 of 61 (21.3%) versus 3 of 8 (37.5%) preintervention.

Students were asked, “If you have heard of the ACR–AC but have not used it in practice, why not”? Free text responses were coded into eight different categories and are presented in Table 3. Most respondents simply said they “forgot” about it during relevant moments, deferred to the opinions of the resident or attending, or used more familiar resources.

DISCUSSION

Similar to previous authors (28,29), we found that most third year medical students at our institution had not heard of the ACR–AC. Most students who consulted a reference when choosing an imaging study used UptoDate. After performing a simple introduction to increase familiarity with the ACR–AC, awareness of the resource markedly improved (from 11.3% to 82.4%, P < .001). However, use of the resource among those who were aware of it did not increase, 21.3% after the intervention compared with 37.5% initially.

The students’ preference for UptoDate was true both before and after the intervention, and in fact, use of UptoDate...
significantly increased \((P = .001)\) later in their clerkship year despite increased familiarity with the ARC-AC. This may be due to the students simply becoming more seasoned during their additional 6 months experience on wards, and thus becoming more familiar with the common practices and resources of their supervising residents and student colleagues. The most common reason students provided for their reliance on Uptodate was its ease of use \((n = 17)\), including its online application-based format. Habit and familiarity \((n = 10)\) was also a commonly cited reason for use of the resource, as was trust \((n = 7)\), and the fact that it was used by other team members \((n = 4)\).

Given that more attention has been placed on proper utilization and reducing risks from imaging, there has been a renewed focus among medical educators on improving the radiology education trainees receive in medical school \((1)\). There is a growing trend toward abandoning curricula that focus almost entirely on imaging interpretation skills in favor of those that emphasize imaging appropriateness and safety \((1,3,28,29,36,37)\). This concept was underscored by a recent national survey of Radiology Department Chairs and Medical School Deans, who called for the development and incorporation of resources that emphasize imaging safety, appropriateness, and utilization into medical school curricula, including the ACR-AC \((1)\). Another argument for including this type of content within medical training is the idea that instilling good imaging practices early in training is more effective than correcting already formed habits \((1,28)\).

Ideally, if medical students can be taught to use appropriate imaging practices (such as use of the ACR-AC), they will be more likely to use these practices throughout their careers \((7)\). Ultimately, this may help improve patient care and reduce costs by reducing unnecessary imaging.

Although such education efforts focusing on appropriate examination selection are increasingly targeting medical students in an attempt to effect their future practice patterns, many assume that medical students do not actually order imaging studies themselves. We found that most third year medical students at our institution do place orders for imaging studies \((75\%)\), and of those that do, most \((93.2\%)\) have initiated requesting studies on their own without consulting other members of their team. Therefore, targeting education efforts toward these students is not just for the benefit of their future imaging habits, but for their current practices as well.

Our study suggests that increasing awareness of the ACR-AC is not enough to increase use of the resource among medical students. Should increasing utilization of the ACR-AC be a goal, as suggested by some authors and radiology organizations \((1)\), greater efforts beyond simply publicizing the resource will likely be required. Based on our institutional experience, it seems unlikely that the resource will be used preferentially in the future practice of these students unless it is presented in an easy to use, easy to access, searchable, online mobile application–based format \((the\ most\ desired\ feature\ reported\ by\ students,\ n = 69)\). Or secondarily, unless its use is guaranteed by incorporation into an Electronic Health Record–based decision support program such as “ACR Select” \((38)\), an idea that also held appeal to the students \((n = 19)\). Other authors have also suggested that the format could be more “user friendly” and suggested that numeric rankings for many possible imaging tests could be replaced by more concise recommendations or flow charts \((39)\).

In addition, expansion of traditional education efforts would also likely be useful. More comprehensive integration of ACR-AC–based materials into medical school curricula, could certainly have a more substantial effect on use of the resource than the single lecture–based introduction in our study. Efforts are currently underway by the Alliance of Medical Student Educators in Radiology to create sharable, discrete resources (educational blocks) that will include an expanded focus on appropriate imaging examination utilization and patient safety.

There are additional factors that may contribute to underuse of the ACR-AC beyond those which were elucidated in our study. Some authors have suggested that the ACR-AC are not adequately “evidence-based,” relying heavily on expert opinion in some cases \((39)\). It is possible that such opinions affect use among referring clinicians, but this was not specifically addressed by the medical students in our study population.

Although our students did not report increased use of the ACR-AC over this study period, most \((59\%)\) said they would likely or very likely use the resource in their future practice. It is likely that to some extent, the medical student’s subordinate role on the clinical team may have impaired introduction of the ACR-AC as a new tool, when most more complex imaging decisions were likely made by supervising physicians. Even when imaging appropriateness resources were consulted, the students would likely defer to their residents or attendings preferred sources, an occurrence that was reported by some students. If any attempts at increasing familiarity with the ACR-AC are to have substantial effect on medical students’ imaging habits, supervising residents and faculty would likely need to be targeted, as well.

Our study has several additional limitations. First, it represents the experience at a single institution only. Second, the student surveys were collected anonymously and as such responses on the initial and follow-up surveys were not linked, thereby mildly hindering sensitivity for detecting differences. In addition, our introduction to the ACR-AC was short, comprised a single lecture and a reminder e-mail to the entire class. It is possible that a more sustained intervention would yield more pronounced findings. We also relied on self-reporting to estimate usage of the ACR-AC resource, as we had no mechanism to track direct accessing of the ACR-AC content. The second survey was also administered 6 months after the lecture introduction to the ACR-AC. Given our reliance on self-reporting, it is possible that perceived usage might have been higher if the second survey occurred earlier. However, we hoped to give the students adequate occasion to use the resource during their core clerkships. Finally, we did not directly assess whether imaging appropriateness improved among students who used the resource or whether there
was any difference in imaging appropriateness between stu-
dents who used the ACR-AC compared to other resources.

In summary, we found that use of the ACR-AC was low
among third year medical students, despite the fact that they
did order imaging studies independently and often used a
resource to assist in appropriate examination selection. Fur-
thermore, use remained low even after increasing familiarity
with the resource. This underutilization is concerning for the imme-
diate impact on their patients but also is significant for the lost
opportunity for radiologists to influence imaging practices
shown to be inefficient currently. The largest barrier to
improved utilization amongst this medical student population
appears to be the lack of a quick, easy-to-use online mobile
application–based interface. Packaging of the ACR-AC in
such a format might substantially increase its appeal and practi-
cality to the next generation of digitally savvy physicians. Incor-
poration of the imaging AC into electronic order entry decision
support software was less desired, but was also thought to repre-
sent an improvement over the current format. In addition,
more comprehensive integration of ACR-AC-based learning
materials into medical school curricula, might have a more
pronounced effect on student usage of the resource. These
improvements could have a large effect on future physician
ordering practices and improvement of rational, safe, and
cost-effective use of medical imaging.

REFERENCES

1. Straus CM, Webb EM, Kondo KL, et al. Medical student radiology educa-
tion: summary and recommendations from a national survey of medical
2. Gunderman RB, Siddiqui AR, Heitkamp DE, et al. The vital role of radiology
in the medical school curriculum. AJR Am J Roentgenol 2003; 180(5):
1239–1242.
3. Kondo KL, Swedlow M. Medical student radiology curriculum: what skills
do residency program directors believe are essential for medical students
578–580.
6. America’s Health Insurance Plans. Ensuring quality through appropriate
use of diagnostic imaging. Washington, DC: America’s Health Insurance
7. Brenner DJ, Hall EJ. Computed tomography–an increasing source of radi-
9. Rao VM, Levin DC. The overuse of diagnostic imaging and the choosing
medicine studies in the United States and worldwide: frequency, radiation
dose, and comparison with other radiation sources–1950-2007. Radiology
from computed tomographic scans performed in the United States in
12. NCRP report no.160: ionizing radiation exposure of the population of the
13. Spring DB, Bettmann MA, Barkan HE. Deaths related to iodinated contrast
media reported spontaneously to the U.S. food and drug administration,
Radiology 1997; 204(2):335–337.
14. Spring DB, Bettmann MA, Barkan HE. Nonfatal adverse reactions to iodin-
ated contrast media: Spontaneous reporting to the U.S. food and drug
16. Ip IK, Schneider LJ, Hanson R, et al. Adoption and meaningful use of
computerized physician order entry with an integrated clinical decision
support system for radiology: ten-year analysis in an urban teaching hos-
17. Lehert BE, Bree RL. Analysis of appropriateness of outpatient CT and
MRI referred from primary care clinics at an academic medical center: how critical is the need for improved decision support? J Am Coll Radiol 2010;
7(3):192–197.
18. Taragin BH, Feng L, Ruzal-Shapiro C. Online radiology appropriateness
survey: results and conclusions from an academic internal medicine resi-
assessment of pediatric surgeons for potential risks of radiation exposure
knowledge about radiation doses and radiation risks of computed tomog-
ferrals of children to computed tomography in Germany–a cross-sectional
survey of medical practice and awareness of radiation related health risks
among physicians. BMC Health Serv Res 2012; 12:47. 4963-12-47.
clinicians, radiologists and interns’ knowledge and practice pertaining to
radiation exposure related to radiological imaging. Eur J Radiol 2012;
81(3):e264–e268.
23. Zhou GZ, Wong DD, Nguyen LK, et al. Student and intern awareness of
ionising radiation exposure from common diagnostic imaging procedures.
24. Sadigh G, Khan R, Kassin MT, et al. Radiation safety knowledge and per-
ceptions among residents: a potential improvement opportunity for gradu-
ate medical education in the United States. Acad Radiol 2014; 21(7):
869–878.
proves second-year medical students’ perceived confidence and knowledge
26. Chiuanda AB, Mohammed TL. Knowledge of ACR thoracic imaging appro-
priateness criteria(R) among trainees: one institution’s experience. Acad
27. Bautista AB, Burgos A, Nickel BJ, et al. Do clinicians use the American Col-
lege of Radiology appropriateness criteria in the management of their pa-
28. Bocca C, Vorona G, Greenspan R. Fourth-year medical student opinions and
basic knowledge regarding the field of radiology. Acad Radiol 2013;
29. Dillon JE, Slaten PJ. Teaching evidence-based imaging in the radiology
clerkship using the ACR appropriateness criteria. Acad Radiol 2010;
17(7):912–916.
32. Sistrom CL, Dang PA, Weilburg JB, et al. Effect of computerized order en-
try with integrated decision support on the growth of outpatient procedure
volumes: seven-year time series analysis. Radiology 2009; 251(1):
147–155.
Appropriateness-Criteria/ Accessed May 9, 2015.
34. Logie CI, Smith SE, Nagy P. Evaluation of resident familiarity and utiliza-
tion of the ACR musculoskeletal study appropriateness criteria in the context of
35. Saha A, Roland RA, Hartman MS, et al. Radiology medical student educa-
tion: an outcome-based survey of PGY-1 residents. Acad Radiol 2013;
content in top-selling radiology textbooksw: what are we teaching medical
39. Blackmore GC, Medina LS. Evidence-based radiology and the ACR