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Needs Assessment for Standardized Medical Student Imaging Education:

Review of the Literature and a Survey of Deans and Chairs

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Rationale and Objectives: Medical imaging education often has limited representation in formal medical student curricula. Although the need for *greater* inclusion of radiology material is generally agreed on, the exact skillset that should be taught is less clear. The purpose of our study was to perform a needs assessment for a national radiology curriculum for medical students.

Materials and Methods: We analyzed data from previous unpublished portions of the American College of Radiology/Alliance of Medical Student Educators in Radiology survey of Deans and Radiology Chairs regarding prevalence of radiology curricular revisions, assessment tools, use of the American College of Radiology Appropriateness Criteria, and resources used in curriculum revision. We also performed a literature search through both PubMed and a general search engine (Google) to identify available resources for designing and implementing imaging curricula and curricular revisions.

Results: Medical school deans and chairs reported a need for more overall radiology content; one of every six programs (15%) reported they had no recognized imaging curriculum. Of schools currently *with* imaging curricula, 82% have undergone revision in the last 10 years using a variety of different resources, but there is no universally agreed on guide or standard curriculum. The PubMed and Google searches identified only 23 and eight resources, respectively, suggesting a sizable deficit in available guidance; however, a single published medical student radiology curriculum is available through the Alliance of Medical Student Educators in Radiology.

Conclusions: There is a need, but few available resources, to guide educators in adding imaging content to medical school curricula. We postulate that a standardized national curriculum directed by a focused skillset may be useful to educators and could result in greater uniformity of imaging skills among graduating US medical students. A proposed skillset to guide a national curriculum in radiology is described.

Key Words: Medical student; radiology curriculum; medical student education; national curriculum; curricular resources.

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Medical imaging has become a critical component of modern medical practice and diagnosis; however, imaging curricula in medical school education have not evolved at an equivalent pace. Medical imaging education, especially that emphasizing appropriate use of examinations has barely penetrated student training, raising the question as to whether US medical schools are adequately preparing students to be safe and efficient practitioners of evidence-based imaging (1). The recent American College of Radiology (ACR)/Alliance of Medical School Educators in Radiology (AMSER) white paper on the status of medical imaging education in the US (1) and numerous prior studies

(2–4) have shown the relatively poor penetration and incorporation of imaging instruction into medical school curricula across the country. These studies have suggested that more, and better integrated, imaging education is desired by US medical school leadership.

Although there is some consensus that *more* imaging content is needed, the exact skillset that should be taught is less clear. The *type* of content currently being taught has only been described in a limited fashion in both the radiology and education literature. Of the information available, much of it has been just recently published; the ACR/AMSER survey (1) showed large variability across 4-year medical school curricula in terms of subjects addressed. For example, 20% of Department Chairs stated that radiation safety was not taught in their medical school at any point in the curriculum. Eleven percent stated that diagnostic imaging algorithms (or “what should be ordered when”) were not covered. A surprising number of programs taught only about radiographs (21% did not cover computed tomography, 25% taught no ultrasound, 32% did not cover fluoroscopy, and 36% taught no magnetic resonance imaging) (1). Some authors have suggested that teaching medical students how to *interpret*

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advanced imaging modalities is unnecessary; however, students do need to understand when and why these modalities should be ordered to provide appropriate care for their patients as future practitioners (5), and for adequate United States Medical Licensing Examination (USMLE) preparation in the near term.

There are few studies that have directly addressed whether “utilization-oriented” content is taught to students (6). One way to measure if such information is being introduced is to assess if the ACR Appropriateness Criteria (7) are specifically taught. To our knowledge, there are no previous publications assessing whether the ACR Appropriateness Criteria are formally included in medical school curricula. Several recent studies have assessed student awareness of this resource. One found that 96% of senior medical students at one institution were not aware of the ACR Appropriateness Criteria as a resource (8), and another, which surveyed students at multiple US medical schools, found that 77% had never heard of the Appropriateness Criteria (4).

Despite this review of the existing literature, little has been gleaned about what is included in medical student radiology curricula across the US, and whether radiology educators receive sufficient curricular guidance and/or supporting resources to facilitate teaching and curriculum design. To our knowledge no data have been published as to (1) extent of curricular revisions to medical imaging content at programs across the US, (2) the resources schools use when designing or revising their imaging curricula, (3) whether the ACR Appropriateness Criteria are being taught, and (4) whether schools have adequate assessment methods to measure student mastery of pertinent imaging content.

The purpose of our study was to perform a needs assessment for a national radiology curriculum for medical students. We hypothesize that the need is great, and that it is currently largely unmet.

MATERIALS AND METHODS

There were three methods used to collect data: a survey of Deans of US allopathic medical schools and Chairpersons of Academic Radiology Departments, a search of the medical literature, and a general internet search.

Survey

Deans of US allopathic medical schools and Chairpersons of Academic Radiology Departments were both surveyed as part of a national ACR/AMSER survey aimed to establish the current status of medical student education in radiology in the US.

Some of the findings of this national ACR/AMSER survey of Deans and Radiology Chairs have been previously published, and the survey methods are outlined in Ref. (1). In brief, members of the ACR and AMSER conducted a detailed survey that was sent electronically to all

US members of the Society of Chairs of Academic Radiology Departments ($n = 124$) and US allopathic medical school deans ($n = 138$) with data collected from November 1 to December 18, 2012. Response rates reflected a balanced representation of US allopathic medical schools (see Appendix A). The responses of Deans and Chairs were reported separately.

The questions from this survey regarding the extent or penetration of curricular revisions, course assessment, use of the ACR Appropriateness Criteria, and resources used in curriculum revision have not been previously published. Results are tabulated with the absolute number reporting and as percentages.

Literature Search and Internet Search

A literature search was performed through PubMed using the search term “medical student radiology curriculum” for articles published since 2004. The PubMed search yielded 516 results. Results were reviewed by two authors (E.M.W., D.M.N.) to determine which had applicability to general radiology curricula; specifically articles addressing issues of (1) standardized curriculum, (2) recommended content, (3) curricular guidelines, (4) learning objectives, (5) radiology course structure, (6) radiology educational materials, or (7) radiology course assessment tools were included. As our goal was to identify currently available resources for revising or designing a comprehensive radiology curriculum and minimize results with only tangential applicability to this purpose, articles with a single content focus in which imaging was a method to teach nonradiologic content (such as the use of radiology in teaching anatomy) were excluded. Articles describing a singular teaching method (eg, problem-based learning or e-learning) or single educational activity (eg, a module to teach chest x-ray basics) were also excluded for the same reason.

A Google search was also performed to identify resources outside the literature from PubMed. The search term used was medical student radiology curriculum. Given Google’s ability to parse key terms from search strings, thereby resulting in few differences when multiple search strings are used, we limited the search and analysis to this one term, which yielded 269,000 results. Search results are ranked by “relevancy” through Google’s “PageRank” algorithm (9). The first 100 search results, presumably the most relevant, were evaluated by two authors (E.M.W., D.M.N.) to determine which links contained information and resources in the same seven categories listed previously. Google links to PubMed articles were excluded. News articles about publications already identified in our literature search were excluded. Multiple links pointing to a single website were assessed as a group as one resource; links pointing to two different resources hosted by the same umbrella website were counted as two different resources. Links to individual university web pages were excluded.

TABLE 1. Deans and Chairs Responses to “In Your Most Recent Revision of the Medical Imaging Curriculum, What Resources Were Employed?”

The AMSER* curriculum was consulted	24% (17/70)
The AMSER* curriculum was modified	11% (8/70)
Other curricular resources were used	9% (6/70)
Another standardized curriculum was used	3% (2/70)
The AMSER* curriculum was used verbatim	0% (0/70)
Has never been revised	1% (1/70)
Do not know	19% (13/70)
No answer	41% (29/70)

*AMSER, Alliance of Medical Student Educators in Radiology.

TABLE 2. Chairs Responses to “What Resources for Teaching Medical Imaging to Medical Students are Developed/Maintained within Your Radiology Department (if any)?”

Lectures	86% (49/57)
Textbooks	79% (45/57)
Tests	67% (38/57)
Curricula	65% (37/57)
Case databases	56% (32/57)
Website(s)	51% (29/57)
Interactive digital resources	51% (29/57)
Quizzes	39% (22/57)
Other	11% (6/57)
None	2% (1/57)
No answer	9% (5/57)

RESULTS

Survey Results

Formal Imaging Curriculum. Radiology department chairs and deans were surveyed as to whether medical imaging was a recognized component of the curriculum at their medical school. Seventy-eight percent responded yes (70/90) and 17% responded no (15/90). The remainder did not respond.

Most respondents who reported a recognized imaging curriculum ($n = 70$) stated that it had been revised since 2000 (answer choices included 5 years date ranges dating back to “before 1980”). Sixty-one percent (43/70) had undergone revision since 2010, 21% (15/70) between 2005 and 2009, and 3% (2/70) between 2000 and 2004.

Resources Used in Curriculum Development. Respondents were asked, “In your most recent revision of the medical imaging curriculum, what resources were employed?” Only 39% (27/70) of programs reported that they used at least one or more resource. Although a minority of respondents did report consulting or modifying the AMSER national curriculum, none used it verbatim. Detailed responses are presented in [Table 1](#).

When asked, “Are you familiar with the ACR Appropriateness Criteria for medical imaging?” Ninety-three percent (53/57) of radiology department chairs reported that they were familiar with the criteria. Only 60% (34/57), however, reported that these criteria were taught to students at their school.

Department chairs were asked, “What resources for teaching medical imaging to medical students are developed/maintained within your radiology department (if any)?” Eighty-nine percent (51/57) of programs reported that they have created at least one type of homegrown curricular resource for students at their institution. Detailed responses are presented in [Table 2](#).

Assessment of Imaging Skills. Department chairs were asked how imaging skills were assessed in both preclinical and clinical courses. Fifty-eight percent (33/57) reported that one or more assessment method was used in preclinical courses and 68% (39/57) reported the same of clinical courses. Detailed responses are presented in [Table 3](#).

Deans and department chairs were both surveyed as to whether assessment of student’s imaging interpretation skills was adequate. Most reported that more or much more assessment was needed (53%, 48/90), whereas fewer (39%, 35/90) reported that the current assessments were on target. No one reported that less assessment was needed.

PubMed Search

The PubMed search yielded 23 articles ([1,3,4,8,10–28](#)) that addressed the aforementioned topics. Of all the articles found, one referenced a national curriculum (AMSER), seven referred to suggested content, six discussed the structure of radiology courses, and four provided guidelines for curricular development. The results for the full search including the article references are listed in [Table 4](#).

Google Search

Many of the top 100 items on the Google search were excluded. Most were excluded as links to individual institutions, links to PubMed results, or for being links to news stories about PubMed results. A total of eight additional new resources were identified ([29–36](#)) beyond the aforementioned PubMed search. One link, to the AMSER *Standard National Radiology Curriculum*, was the only result describing an attempt at comprehensive programming in the form of a topic list. An additional three links pointed to curriculum materials, and two discussed assessment in radiology courses. The results for the full search and categorization of the results are listed in [Table 4](#).

DISCUSSION

Herein we performed a needs assessment for the development of national resources for designing, revising, and supporting a medical school radiology curriculum. The PubMed search and Google search for medical student radiology curricula identified very few existing resources beyond the single

TABLE 3. Chairs Responses to “How are Imaging Skills Assessed in Preclinical Courses?”

Assessment Method	Preclinical Curriculum	Clinical Curriculum
Imaging questions on examination(s) in radiology courses (elective or required)	26% (15/57)	60% (34/57)
Imaging questions on examination(s) in nonradiology courses	51% (29/57)	35% (20/57)
OSCE	4% (2/57)	5% (3/57)
Other	4% (2/57)	9% (5/57)
Imaging not formally assessed	9% (5/57)	5% (3/57)
Do not know	26% (15/57)	19% (11/57)
No answer	7% (4/57)	7% (4/57)

OSCE, Objective Structured Clinical Examination.

TABLE 4. Number of Curricular Resources Identified by PubMed and Google Searches

Content Subject	PubMed Search Results	Google Search Results
Standardized medical school radiology curriculum	1 [Ref. (27)]	1 [Ref. (28)]
Structure of curriculum	6 [Refs. (12,14,15,19,23,25)]	0
Suggested content	7 [Refs. (3,4,7,9–11,24)]	0
Curricular materials	1 [Ref. (17)]	3 [Refs. (30,32,33)]
Guidelines for curriculum development	4 [Refs. (1,13,18,21)]	1 [Ref. (35)]
Learning objectives	2 [Refs. (16,26)]	1 [Ref. (29)]
Current practices	2 [Refs. (20,22)]	0
Assessment	0	2 [Refs. (31,34)]

published medical student radiology resource promoted nationally through AMSER (29).

The second portion of our needs assessment was based on previously unpublished data from a nationwide ACR/AMSER survey of medical school deans and radiology department chairs. This rare resource captures information from the very people who decide what medical imaging content is taught to physicians in training. The information analyzed pertained to curricular revisions, resources, and direction in this periodic process required by accredited US medical schools. Deans and chairs both reported a need for more overall radiology content, which is consistent with previously published data (1); one of every six programs (15%) reported that they have no recognized imaging curriculum. Of schools with imaging curricula, most have undergone revision in the last 10 years using a variety of different resources, but there is no universally agreed on standard. Although the AMSER curriculum was the only national curriculum identified in our PubMed search and Google search, it was not used in its entirety by any school included in the survey.

As per the survey, radiology departments relied on differing self-generated teaching resources, likely in part because of the relative absence of shared educational resources. This clearly contributes to the heterogeneity of curricula demonstrated across the country, both between programs and to some extent within individual schools given that imaging education is increasingly delivered by numerous *nonradiology* faculty who may be using different self-generated resources (1). Self-

generated resources can certainly be outstanding, and in many cases specifically tailored to a school's needs. However, many schools do not have the resources (faculty time, salary support) to develop teaching materials to support an entire comprehensive imaging curriculum (1), and students at these programs may miss important content as a result.

A desired skillset for medical school graduates entering residency has been loosely established in the literature. Surveys of primary care residency program directors (11) and postgraduate year 1 residents in multiple specialties (3,12) highlighted basic chest and abdomen radiograph interpretation skills using a systematic approach. There is minimal information on what proportion of medical school radiology curricula is dedicated to teaching students image interpretation skills. The limited data that do exist demonstrates that image interpretation is heavily emphasized and that most interpretation is focused on radiographs (1,5). However, the recent ACR/AMSER survey (1) and several other studies performed by radiology educators (4,10) brought to light a separate set of noninterpretative skills that both radiologists and medical school Deans feel are important for medical school graduates to master: an appreciation for resource allocation including skills pertaining to rational examination selection, incorporation of patient safety considerations, and effective communication skills. This survey found that ACR Appropriateness Criteria, fundamental to appropriate and safe ordering of imaging examinations, were only

introduced to students at 60% of schools, despite it being a well-known resource to most radiologists. Its use is not directly suggested by the AMSER website, although many national learning objectives (33) address material that is well covered by this resource.

Only sporadic online teaching materials intended specifically for medical students (ie, not residents) were identified in the Google search. Ideal teaching resources would be (1) readily accessible, (2) comprehensive, and (3) shared freely between institutions. Shared teaching materials are available on the AMSER website and readily accessible to members (30); however, they are not at present comprehensive enough to address a well-rounded curriculum. Another resource, Case-based Online Radiology Education (CORE), although not entirely comprehensive, included utilization oriented content that is level-appropriate material for medical students (31). The downside of this resource is accessibility; it requires a paid subscription that likely impacts overall usage. The only other medical student teaching material identified was very limited in content and was focused entirely on image interpretation (32).

Textbooks are another obvious curricular resource, which were not directly analyzed in this study. Although some programs may use textbooks to inform, supplement, or even comprise their curriculum, previous authors (5) found that most current radiology textbooks intended for medical students are also focused primarily on image interpretation, and have inadequate emphasis on imaging utilization and appropriateness and other noninterpretive topics.

Survey results indicate that medical student knowledge of imaging was formally assessed in some way, however, some schools did not have examinations specific to their radiology courses. Very few resources for assessment tools were identified in our literature and Google searches. The few results ranged from a single website offering short quizzes pertinent to their collection of cases focusing entirely on image interpretation to the much more comprehensive and applicable "Radiology ExamWeb" (34). Radiology ExamWeb is a web-based resource for medical student assessment that provides a large multiple choice question bank, an examination development tool for instructors to create their own examinations, and standardized examinations identical in format to the "shelf examinations" (37) used throughout the country for student clerkships in the MS III year. ExamWeb penetrance has been increasing since its introduction in 2012, although currently it is only used in 45 programs (33%). Evaluating imaging knowledge in students is not yet a codified national expectation, and more widespread use of Radiology ExamWeb is likely diminished by the heterogeneous content being presented across institutions and institutional traditions.

The lack of codified expectations in medical student imaging education is a broad problem, with ramifications far beyond assessment techniques. Regarding diagnostic radiology, the Liaison Committee on Medical Education only requires that "(e)ducational opportunities must be available...in the disciplines that support general medical practice"

(38). This limited expectation is in contrast to findings presented in the ACR/AMSER white paper, where respondents were asked, "What can ACR or AMSER do at a national level to improve medical imaging education?" One of the most common responses was "...a consensus of what ALL medical students should know including findings, utilization, and safety" (1).

The current system and available resources do not appear to meet the needs of all radiology educators and no resources or guidelines stand out as being an industry lead. We postulate that a simplified curriculum focused primarily on core basic information "...a consensus of what ALL medical students should know..." may help align and round out individual programming efforts currently in practice across the country, and facilitate the development of shared curricular resources. Using the survey results, literature search results, and Google search results to help inform the process, we propose a more targeted national medical student curriculum in radiology, focused primarily on skills needed by *all* students entering all disciplines of medicine. Secondly, more targeted materials appropriate for students going into differing specialties could provide a practical supplementary curriculum for success in the postgraduate year 2 and beyond. In keeping with trends in graduate medical training promoting entrustable professional activities (39) and other measurable skills, we propose a "student skillset" as opposed to an "instructor topic list."

PROPOSED STUDENT SKILLSET TO GUIDE A NATIONAL CURRICULUM

Communication and Test Selection

- Request a consult (order examinations effectively) (5) and explain why requests are an MD to MD consult (12).
- Develop professionalism in MD to MD communication.
- Explain how radiologists are subspecialized.
- Demonstrate ability to use the ACR Appropriateness Criteria (1,4-6) and appropriate imaging examination ordering skills based on patient signs and symptoms.
- Describe the impact of clinical history on study protocoling and accurate interpretation (40).

Role of Imaging in the Health Care System

- Differentiate between cost, charge, and reimbursement.
- Describe the billing process.
- Explain how incidental findings contribute to health care costs.

Risks and Benefits of Imaging Studies

- Explain basic radiation risks and risk reduction techniques (1,4).
- Explain the uses and contraindications of intravenous contrast (41).

- Demonstrate knowledge of magnetic resonance imaging safety and ability to explain basics to both patients and employees (4).

Interpretation Basics

- Identify *basic* and emergent findings from a “must see” list on core modalities, such as the radiograph (9).
- Interpret a structured radiology report (9,42).
- Define commonly used imaging vocabulary.

Patient-Centered Imaging

- Explain the basics of how examinations are performed and what a patient should expect (13).
- Participate in a multidisciplinary conference where Radiology is present and affects patient care (9).

Demonstrate Proficiency in Core Basic Imaging Content

- Take the AMSER ExamWeb examination on core basic imaging before graduation and achieve a passing score.
- Describe an imaging workup for a disease that might require several sequential examinations or imaging follow-up over time.

Supplementary Concepts Targeted to Specialty of Choice

- Complete an educational module, targeting specialized vocabulary and concepts that correlate to the student’s area of specialty postgraduate training (43).

Adoption of these objectives could promote greater imaging skills equivalency among graduating medical school seniors and ensure that they are taught critical noninterpretive skills emphasizing appropriate and rational imaging examination selection. This approach also allows flexibility to individual programs as these goals may be achieved using homegrown materials and can be expanded on to include local perspectives and expertise. If such a curriculum is established, it will also allow systematic development of corresponding standardized curricular materials that programs with well-developed imaging curricula could implement piecemeal as needed, whereas programs with limited resources could use them collectively to create an entire curriculum.

CONCLUSIONS

There is a need, but few currently available resources, to guide educators in adding imaging content to medical school curricula. We postulate that a standardized national curriculum directed by a focused skillset may be useful to educators, and could result in greater uniformity of imaging skills among graduating US medical students.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.acra.2015.03.020>.

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