

Online Resources to Boost Radiological Skills Among Trainees

Nara Miriam Michaelson, MD

Andrew D. Schweitzer, MD

J. Levi Chazen, MD

Matthew S. Robbins, MD

Increased availability of imaging has transformed clinical practice in new and exciting ways. Residents and fellows now must be both competent and confident in radiological skills in order to interpret images and make many critical decisions. Emergency and internal medicine residents, for example, often need to distinguish between various causes of acute shortness of breath in order to guide time-sensitive and life-saving treatment. For neurology residents, the ability to evaluate MRIs independently can be pivotal when seeing patients with multiple sclerosis, where up to 20% of patients have later been found to be misdiagnosed.¹ Indeed, trainees from nearly all branches of medicine must acquire radiological skills as part of their practice. Due to the digital and visual nature of radiological didactics, we believe that online resources have the potential to enhance, and even comprise the backbone of, how trainees learn these vital skills in collaboration with trained radiologists. Furthermore, with the accelerated global shift to online education, there is currently a need for available online graduate medical education resources.

Free and Easily Accessible Web-Based Imaging Resources

We believe trainees and curriculum developers would benefit from an assessment of a contemporary list of resources to help strengthen imaging skills. Imaging lends itself to active self-directed learning, requiring repeated exposure, familiarization, and incorporation of feedback for successful development. In this perspective, we review a collection of easily accessible and educational online resources based on an informal survey among our peers. We discuss platforms geared toward general practice (TABLE 1), in addition to resources for trainees in subspecialties such as cardiology, pulmonology, orthopedics, rheumatology, and neurology (TABLE 2). We provide an overview of their unique characteristics as well as

prevailing commonalities. We specifically highlight free online resources, since these provide residents with key information with the fewest barriers to access.

Learningradiology.com

Learningradiology.com² was developed by William Herring, MD, who was the former Vice Chair of the Department of Radiology and the Radiology Residency Program Director at Einstein Medical Center in Philadelphia, Pennsylvania. He started the website in 2002 and included many educational features, including a “case of the day” series, lecture videos, online flashcards, quizzes, as well as an index of radiological signs. One section of the site focuses specifically on abnormalities of pulmonary, gastrointestinal, and musculoskeletal organs and can serve as a quick reference guide. There is also a set of condensed notes that highlights major clinical syndromes with their related organ systems. This format provides useful descriptions of common conditions and examples of their imaging.

The multitude of resources may require some time for orientation, and web advertisements may be a source of distraction. However, a basic search bar is provided to help navigate through the site.

RadiologyAssistant.nl

RadiologyAssistant.nl³ is an educational site of the Radiological Society of the Netherlands. This site includes a user-friendly interface and has various sections related to imaging of the abdomen, breast, cardiovascular system, musculoskeletal system, brain, spine, as well as imaging in pediatrics. It skillfully places imaging within a useful clinical context, for example by providing illustrative cases of acute causes of abdominal pain, helping learners distinguish between appendicitis, mesenteric adenitis, nephrolithiasis, ovarian cyst rupture, Crohn’s disease, and diverticulitis.

The site also includes instruction on how to systematically review imaging, such as with marker

DOI: <http://dx.doi.org/10.4300/JGME-D-20-00641.1>

TABLE 1

Characteristics of 4 Web-Based Radiological Educational Resources for Generalists

	LearningRadiology.com	RadiologyAssistant.nl	Radiopaedia.org	University of Virginia, Intro to Radiology
Additional materials for fee	X		X	
Advertisements	X		X	
Case-based modules	X		X	
Case of the day/week	X		X	
Concise clinical overviews	X	X		X
Curated bibliography	X	X		X
Flashcards	X			X
Quizzes	X		X	X
Search by radiographic finding	X		X	
Social media content	X		X	

placement on an abnormality for correlation in other series. Limitations include the lack of quizzes and cases to test diagnostic skills. Each section concludes with a list of key references from the literature.

Radiopaedia.org

Radiopaedia.org⁴ is a free web-based platform described as an open-edit radiology resource, compiled by radiologists and other health professionals. A group of volunteer editors oversee its accuracy and continued development, similar to Wikipedia.org. The user interface is divided into articles, cases, courses, and quizzes. The articles provide detailed information on a variety of clinical findings and diagnoses. They describe epidemiology, clinical presentation, complications, pathology, and imaging modalities to most likely diagnose the condition. Hyperlinks throughout the article take you directly to

a related section. The “Case of the Day” is a notable and useful feature, as well as more how-to articles, such as “MRI sequences overview” with annotated images that allow scrolling through the various sections. Articles vary in length, and the longer articles may not be well-suited to more spontaneous reading by residents during moments of downtime. With a large volume of articles, it may take time to find a topic of interest, although a search bar is available to aide in accessibility. There are also many advertisements. The process of clinical reasoning is not as heavily emphasized, and diagnoses are often already stated in the title. This site provides online courses that are priced at \$60 to \$120 for 3 months of access and are taught by expert radiologists. Quiz mode is useful for strengthening diagnostic skills, and the educational summaries from cases are succinct. Overall, the site is robust, with 38 555 cases and 14 424 articles as of September 2020.

TABLE 2

Characteristics of 4 Web-Based Radiological Educational Resources for Specialists

Characteristic	ASNR Neurocurriculum Live ⁵	HeadNeckBrainSpine.com ⁶	Thoracicrad.org ⁷	Radiology Core Lectures ⁸
Specialty focus	Neurology/Neurosurgery	Neurology/Neurosurgery	Cardiothoracic	Orthopedic/Rheumatology
Case-based modules	X	X	X	
Case of the day/week	X		X	
Concise clinical overviews	X	X	X	X
Flashcards		X		
Quizzes	X	X		
Search by radiographic finding		X	X	X
Social media content	X			

Abbreviation: ASNR, American Society of Neuroradiology.

Introduction to Radiology, University of Virginia Health (online)

This interactive online tutorial website was created by the University of Virginia Health System's Department of Radiology (www.med-ed.virginia.edu/courses/rad/).⁹ It includes thoracic, abdominal, and musculoskeletal radiology, as well as neuroradiology, pediatric radiology, and nuclear medicine. The platform focuses on high-yield topics such as common chest imaging examples as seen in an intensive care unit and emergency room settings.

Within each major subheading, there are specific examples of the most important conditions not to miss, from fractures of the skull to fractures of the foot. It also includes quizzes to test understanding after review. One unique feature is the high-resolution chest computed tomography (CT) interpretation section, which explicitly demonstrates differences between various radiographic terms such as honeycombing, ground glass opacity, tree-in-bud, bronchiectasis, and air trapping.

The main limitations are the lack of a search bar and its simple hypertext page layout, which may not be conducive to some learning styles. It provides a curated selection of topics, most often focusing on conditions found in emergency medicine and critical care settings.

Discussion

Given the virtual educational climate of the COVID-19 era, this perspective seeks to direct learners to high-quality resources for self-guided instruction. A precedent exists in curriculum transformation with the incorporation of point-of-care ultrasound (POCUS) image acquisition and interpretation skills in standard trainee education. Many POCUS skills are taught in-person at the bedside, but now there are also online resources to guide and supplement training.¹⁰ This principle is in line with the “flipped classroom” model,¹¹ which has already been widely implemented in undergraduate medical education and could also play a role in graduate medical education by promoting independent study with real-world feedback. Preliminary reports exist in the literature of training programs adapting to online resources by transitioning didactic lectures to digital platforms and providing virtual courses.¹² Examples include journal clubs, case-based morning reports, and professors' rounds, as well as grand rounds.¹³ Structured tutorials as provided on the CREATE (Clinical Radiologist Educator Alliance for Teaching Excellence) website can also serve as guides.¹⁴ Learners can benefit from the flexibility of an online curriculum as well as from transformative in-person feedback from

faculty, which may boost confidence and competence in these critical skills.¹⁵

References

1. Kaisey M, Solomon AJ, Luu M, Giesser BS, Sicotte NL. Incidence of multiple sclerosis misdiagnosis in referrals to two academic centers. *Mult Scler Relat Disord*. 2019;30:51–56. doi:10.1016/j.msard.2019.01.048.
2. Herring W. Learning Radiology. www.learningradiology.com. Accessed October 8, 2020.
3. Radiological Society of the Netherlands. Radiology Assistant. <https://radiologyassistant.nl>. Accessed October 8, 2020.
4. Radiopaedia Organization. Radiopaedia. <http://radiopaedia.org>. Accessed October 8, 2020.
5. Schweitzer AD. The importance of appropriate matching of confidence and competence in radiology training and beyond. *Clin Imaging*. 2020;66:64–66. doi:10.1016/j.clinimag.2020.04.031.
6. Young B. HeadNeckBrainSpine. <http://headneckbrainspine.com>. Accessed October 8, 2020.
7. Society of Thoracic Radiology. Thoracicrad.org. <https://thoracicrad.org>. Accessed October 8, 2020.
8. International Skeletal Society and Society of Skeletal Radiology. Radiology Core lectures. <https://radiologycorelectures.org/msk/>. Accessed October 8, 2020.
9. University of Virginia Health. Introduction to Radiology: an online interactive tutorial. <https://www.med-ed.virginia.edu/courses/rad>. Accessed October 8, 2020.
10. UCLA Hospitalist Medicine. Proceduralist.org: building bedside skills. <https://proceduralist.org>. Accessed October 8, 2020.
11. Sandrone S, Berthaud JV, Carlson C, Cios J, Dixit N, Farheen A, et al. Education research: flipped classroom in neurology: principles, practices, and perspectives. *Neurology*. 2019;93(1):e106–e111. doi:10.1212/WNL.0000000000007730.
12. Kwon YS, Tabakin AL, Patel HV, Backstrand JR, Jang TL, Kim IY, et al. Adapting urology residency training in the COVID-19 Era. *Urology*. 2020;141:15–19. doi:10.1016/j.urology.2020.04.065.
13. Agarwal S, Sabadia S, Abou-Fayssal N, Kurzweil A, Balcer LJ, Galetta SL. Training in neurology: flexibility and adaptability of a neurology training program at the epicenter of COVID-19. *Neurology*. 2020;94(24):e2608–e2614. doi:10.1212/WNL.0000000000009675.
14. American Society of Neuroradiology. ASNR Neurocurriculum Live. <https://www.asnr.org/education/neurocurriculum-live>. Accessed October 8, 2020.

15. Clinical Radiologist Educator Alliance for Teaching Excellence. CREATE. <http://www.create-rad.com>. Accessed October 8, 2020.



All authors are with NewYork–Presbyterian Hospital/Weill Cornell Medical Center. **Nara Miriam Michaelson, MD**, is Second-Year Neurology Resident, Department of Neurology; **Andrew D.**

Schweitzer, MD, is Assistant Professor and Radiology Program Director, Department of Radiology; **J. Levi Chazen, MD**, is Associate Professor and Neuroradiology Fellowship Director, Department of Radiology; and **Matthew S. Robbins, MD**, is Associate Professor and Neurology Program Director, Department of Neurology.

Corresponding author: Nara Miriam Michaelson, MD, NewYork–Presbyterian Hospital/Weill Cornell Medical Center, michaelson.nara@gmail.com