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Short Communication

The integration of radiology curriculum in undergraduate medical education

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ABSTRACT

Knowledge of basic radiology is an essential component of the undergraduate medical curriculum. Pre-clinical education introduces medical students to essential knowledge and skills. However, the current curriculum and radiology teaching are not without inherent limitations. This article explores the essential role of radiology education for medical students and discusses the current state of affairs. It also highlights the limitations and associated challenges and proposes solutions.

1. Introduction

The single most transformative event in medical education in North America arguably was the Flexner Report of 1910 [1]. Flexnerian curriculum advocates for learning basic and biomedical sciences prior to the clinical sciences [2]. Unfortunately, that is not how patients seek care.

Following the Flexnerian curriculum, radiology has not been a part of the pre-clinical medical curriculum. Medical students are exposed to informal radiology education during their clinical rotations. The importance of early academic radiology teaching to medical students in their pre-clinical years has received more attention in recent years [3]. Focused radiology training can be a clinical tool for medical students during their clinical rotations and the follow-up clinical practice. Furthermore, radiologic imaging can teach anatomy to medical students [4].

Imaging is an essential part of the diagnostic process, including evaluation for complications, prognosis, and disease staging. Exposure to radiology education at the undergraduate level gives the medical students a perspective about the specialty as a future career. It also allows the students to develop valuable relationships and professional networks. Artificial intelligence (AI (radiology is essential to radiology education development. Improving the radiology practice by AI tools improves radiology education by making students faster and better learners when paired with high-quality AI.

The necessity of medical imaging in patient management has increased enormously. However, more strategies to strengthen radiology practice should be implemented [5]. This article comprehensively views the current radiology teaching strategies, highlighting the limitations and drawbacks and introducing potential solutions.

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Abbreviations

CXR	Chest X-ray
CT	Computerised tomography
US	Ultrasound
MRI	Magnetic resonance imaging
PET	Positron emission tomography
AI	Artificial intelligence
PD	Program director
IR	Interventional radiology

Table 1
Imaging modalities in COVID-19.

Clinical Scenario	CXR	CT	CXR + CT	CXR + US	CXR + CT + US
Asymptomatic patients	50%	35.75%	14.19%	–	–
Suspected symptomatic patients	36.59%	34.15%	29.27%	–	–
Confirmed patients	21.74%	28.26%	43.48%	–	4.35%
Patients with severe symptoms	10.20%	30.61%	48.98%	4.08%	6.12%
Critically ill patients	33.33%	18.75%	22.92%	12.50%	12.50%
At the end of confinement	44.83%	37.93%	17.45%	–	–

2. Importance of radiology education in medical school curriculum

Radiology is an integral part of the diagnostic and therapeutic process. The basic knowledge of radiology should be an integral part of the pre-clinical medical students' education. Imaging like X-ray, ultrasound, MRI, CT, and positron emission tomography (PET) facilitate the understanding of the anatomical, pathological and physiological aspects of the disease process. The use of these different imaging tools in clinical practice and the process of disease identification is considered a basic radiological knowledge that the students should acquire.

3. Role of radiology in the COVID-19 pandemic

A recent example of the utility of radiology is imaging in coronavirus disease – 2019 [COVID-19], which emphasises the importance of acknowledging medical students about how to use radiology in emergency situations that face the world like the COVID-19 pandemic. A global survey by the International Society of Radiology showed widespread use of chest imaging in suspected cases and confirmed severe COVID-19 [6]. The use of different imaging in COVID-19 is reviewed in Table 1.

4. Role of ultrasound in medical procedures

Another example of radiology utilities is ultrasound guidance in bedside procedures; ultrasound can guide multiple procedures performed at the patient's bed, like paracentesis, thoracocentesis, pericardiocentesis, abscess drainage, and central venous or arterial insertion line. Interventional radiology-based invasive procedures like embolization, angiography, thrombolysis, inferior vena cava filter, and radiofrequency ablation are becoming the new norm. Students should be educated about the clinical value of each, risk, benefits, and uses, which can give them a robust basic understanding in the preclinical stage that enables them to use them in the clinical practice effectively.

5. Artificial intelligence role in radiology education

Diagnostic imaging is considered one of the clinical applications of AI. AI is an excellent tool to improve the teaching and learning of radiology.

The sensitivity, specificity, and accuracy of AI-based applications in detecting minor radiographic and tissue-based abnormalities is a significant advantage over the current radiology teaching practices [7]. AI can identify imaging pattern changes that are not easily identified by human eyes, thus potentially negating the inter-reviewer variability while interpreting images. An example is the tissue changes related to early ischemic stroke, which can be effectively identified by brain MRI using machine learning within 4.5 h from the beginning of symptoms with greater sensitivity than human observations [8]. AI can also identify image pattern changes related to disease mechanisms that are poorly understood, e.g., immunotherapy-associated autoimmune myocarditis [9]. AI can recognize the inflammation of myocardial tissues early, leading to an earlier treatment and lower morbidity and mortality rates [9]. Using AI techniques, subtle heart abnormalities can be recognized at the functional or structural level [10]. These otherwise challenging abnormalities can quickly be deconstructed by AI, which can be a fantastic strategy to improve medical students' performance and reasoning in case of difficult scenario interpretation [11,12].

Radiology practice is improving using AI, and radiology learning will be positively affected. Radiologists can improve their practice by using AI. Radiology training programs should develop curricula that include carrying out this new responsibility of AI training by radiologists. AI can dramatically improve radiology education and offer many opportunities to bring learning into radiology [13].

6. Medical trainees' competency in image interpretations

At least 95% of program directors (PDs) in paediatrics, internal medicine, obstetrics and gynaecology, and general surgery believe that the least acceptable image analysis skill for medical trainees is the "ability to recognize normal from abnormal." 91% of PDs want their future trainees, at minimum, to have the ability to decide when to order images and accordingly refer to appropriate imaging guidelines [14]. However, many medical trainees lack these crucial skills [15].

Issues surrounding high-value care and unnecessary imaging orders during training have emerged due to the lack of a trainee's ability to determine which tests are essential, which imaging modality is preferred, and the risks associated with each [16]. Poor education is the root cause of many of these problems [17]. Radiology in most medical schools is not introduced until the 4th year, which is still insufficient [18].

7. Recommendations on radiology education

The UK Royal College of Radiologists (RCR) recommends teaching radiology as a separate subject and integrated subject throughout the pre-clinical and clinical medical curriculum [19]. This necessitates the integration of radiology with the basic sciences like anatomy. The integration of radiology into the undergraduate medical curriculum across Europe is advancing, but it is still limited in most medical schools worldwide [20,21].

8. Radiologists' contribution in radiology education

The shortage of professional radiologists, who teach medical students the principles of image analysis in their clerkship, has contributed to the gap in radiology education.

Even though radiology is essential in clinical practice, 30% of clinicians prefer to teach radiological images to students without a radiologist [22,23]. Also, even though AI has a promising role in medical education. However, it is not the substitute for medical knowledge and

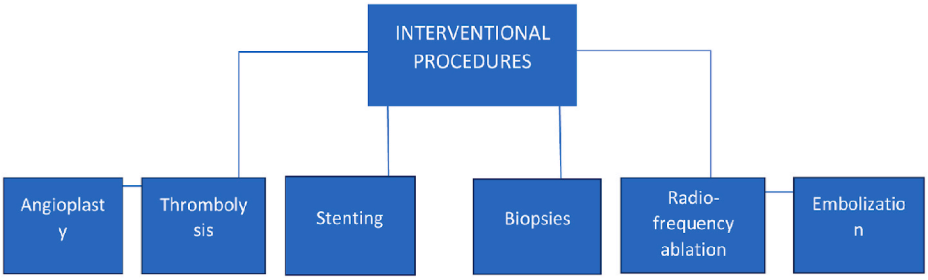

Fig. 1. Example of interventional radiology procedures.

skills needed for imaging and trade secrets learned with years of experience in image interpretation. That is why radiology will never be taught better than radiologists by themselves.

Deans of allopathic medical schools in the United States and chairpersons of academic radiology departments were polled as part of a national American College of Radiology (ACR) and the Alliance of Medical Student Educators in Radiology (AMSER) survey to determine the present state of medical student radiology education in the United States [24]. Cost and a lack of radiology faculty members were noted as barriers by deans; however, they were less frequently mentioned than logistics or the "lack of cooperation between clerkship directors and radiologists [2].

9. Suggested improved strategy in radiology education

Root-cause analysis of radiology education strategies is needed to bring about improvement. The strategy of integrating radiology education should focus on image interpretation, essential learning, and analysis of principles in the pre-clinical medical students' curriculum [25]. That is how students can have the image interpretation needed in the clinical stage. Also, radiologists should seek out opportunities to make a significant contribution to the medical education curriculum. Radiology clerkships can play an important role in image analysis learning. Additional structured online independent learning sessions can also be beneficial [26,27].

Substantial barrier radiologists face in radiology education is the lack of time due to competing clinical demands [28]. An institutional level strategy developed to provide radiologists with dedicated teaching time may work. Also, technological resource availability like handheld ultrasound probes would help with radiological education.

75% of clinical radiology directors in the UK report insufficient personnel to deliver safe and effective patient care [29]. Residency training programs should be increased to increase radiologists' number to meet the constantly increasing demands in the specialty. Students should be well-informed about the prospects of considering radiology as a career option. If radiology were recognized as a significant contributor to medical education and clinical practice, more students would choose to join this field, providing more future radiologists who are passionate about teaching [30,31]. Furthermore, interventional radiology (IR) should be spotlighted as an excellent choice for a future career. IR, a specialised radiology field, enables clinicians to perform procedures to diagnose and treat many conditions like tumours by radio ablation or cryoablation. Examples of these conditions are shown in Fig. 1. It is an exciting specialty to consider as time, effort, pain, and complications can be reduced by the minimally invasive IR, unlike the traditional open surgery.

10. Conclusions

Radiology is an essential part of disease recognition, follow-up, and treatment by using various imaging tools that are considered a mainstay in the medical field. Added to this, AI transforms this part into a higher state. The knowledge of these multiple imaging tools and the importance of AI implementation should be introduced and strengthened in the preclinical medical curricula. However, students' weakness in this field is still a recognizable issue that should be solved. More strategies to improve and expand the standard of radiology education should be implemented to have skillful students, specialists, and radiologists who can deliver a higher quality and cost-effective medical care.

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The main concept was determined by I.U, M.J.T, and L.A.S. L.A.S, S.I, H.A.S, O.A, Z.Y, and M.J.T performed a literature review and wrote the initial manuscript. O.A, Z.Y, M.J.T, and I.U reviewed the manuscript and critically revised it to the final form. Manuscript editing is done by HM.

Declaration of competing interest

There is No conflict of interest.

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