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Challenges of Radiology education in the era of artificial intelligence☆

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Abstract Artificial intelligence is a branch of computer science that is generating great expectations in medicine and particularly in radiology. Artificial intelligence will change not only the way we practice our profession, but also the way we teach it and learn it. Although the advent of artificial intelligence has led some to question whether it is necessary to continue training radiologists, there seems to be a consensus in the recent scientific literature that we should continue to train radiologists and that we should teach future radiologists about artificial intelligence and how to exploit it. The acquisition of competency in artificial intelligence should start in medical school, be consolidated in residency programs, and be maintained and updated during continuing medical education. This article aims to describe some of the challenges that artificial intelligencve can pose in the different stages of training in radiology, from medical school through continuing medical education.

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Retos de la formación en radiología en la era de la inteligencia artificial

Resumen La inteligencia artificial (IA) es una rama de las ciencias computacionales que está generando enormes expectativas en la medicina en general y en la radiología en particular. La IA no va a alterar solo la forma en que ejercemos la radiología, sino que también va a impactar en el modo en que la enseñamos y la aprendemos. Aunque se ha llegado a cuestionar la necesidad de seguir formando radiólogos como consecuencia de la llegada de la IA, la literatura científica reciente parece estar de acuerdo en que debemos seguir formándolos, incorporando a su capacitación nuevos conocimientos y competencias en IA. Esta nueva formación debería comenzar en la fase universitaria, consolidarse durante la residencia y mantenerse durante la etapa de formación continuada. Este artículo pretende describir algunos de los desafíos que la IA puede plantear en las diferentes fases formativas del radiólogo, desde la educación universitaria hasta la formación continuada.

Introduction

Artificial intelligence (AI), which was so termed more than 60 years ago and which could be defined (in a simplified way) as ''intelligence carried out by machines'', is a branch of computer science that has been generating enormous expectations in recent years in medicine in general, and in radiology in particular.[1–3] The interest generated is reflected in the rapidly growing number of publications on ''AI'' and ''radiology'', as well as the increase in communications and stands dedicated to AI in multiple international radiology forums and congresses.[4] Radiological scientific societies have realised the impact that AI can have in all areas (healthcare, technical, scientific, ethical, economic) of our profession, and various media have predicted a progressive disappearance of radiologists as consequence of the arrival of AI,[5–7] and there are even those who have wondered if it makes sense to continue training radiologists.[8,9] Fortunately, in the scientific literature there seems to be a generalised and growing consensus that we must continue to train radiologists, incorporating new knowledge and skills in AI, and that this training should begin in the university phase, be consolidated during the residency stage and maintained during the continuing education stage.[10–13] However, there are few studies that have analysed the challenges of radiological training in the era of AI. This study aims to describe some of the challenges that AI can pose in the different training phases of radiologists, from university education to continuing education.

What do radiologists think about artificial intelligence?

One of the most important elements to consider when trying to describe the challenges of radiology training in the age of AI is the perception of radiologists, residents and medical students about this technology and its impact on radiology. In recent years, several questionnaires have been published that address this issue from different perspectives.[14–21]

In general, a large majority of those surveyed consider that AI will have a great impact on the practice of radiology.[16,17] This impact will be positive for the majority of those consulted, highlighting, on the one hand, the possible reduction in errors and the time spent on each study and, on the other, an increase in the time dedicated to each patient.[15,16] However, and although the opinion that AI will replace radiologists is a minority,[19] at least a significant part of these groups think that AI could worsen their professional expectations.[14]

In this sense, several studies indicate that the foreseeable impact of AI acts as a disincentive for medical students when choosing radiology as a specialty,[18,20] causing anxiety even among those students who are thinking of opting for radiology. There is some evidence that this concern is greater among students than among existing radiologists.[20]

Currently, there is little or no AI training in either undergraduate or postgraduate study programmes. All the studies agree that students and professionals claim to have little knowledge about AI, wish to receive specific training and consider that it should be included in their study programmes.[14–21] In addition, students with knowledge of AI seem to be more likely to consider radiology as a specialty (to choose) than those without such knowledge,[21] and greater exposure to both AI and the specialty of radiology can reduce this anxiety.[19] These results indicate that AI training, in addition to being demanded and perceived as necessary, could be a protective factor against the potential disincentive effect of AI on future radiologists.

Training challenges in the age of artificial intelligence

The challenges of radiological training in the age of AI have been little explored in the scientific literature[6,7,12,13] and are generally not addressed in a comprehensive way. Below we describe some of the challenges that may appear in the different training stages of a radiologist (undergraduate training, specialised training and continuing training).

We recognise that some of the challenges can be applied to all three stages, but we find it interesting to highlight the main challenges based on the training stage of radiologists.

Challenges of undergraduate training

AI as a teaching tool. Teaching patient-centred clinical radiology means that some challenges of AI in undergraduate radiology training are common to those in teaching general medicine and other specialties. An expert system can provide immediate formative feedback to students. This makes the role of AI especially interesting in the formative assessment of medical students.[22] But comprehensive radiological training of medical students cannot be reduced to the teaching of interpretive skills (technical skills, acquisition of theoretical and practical knowledge, etc.) or to the application of AI algorithms.[11,12,22] AI lacks curiosity, empathy, imagination, common sense and ethics. It is unable to improvise and also does not *understand* nuances, body language or the value of a look or of holding the hand of a patient. Students need to understand that medicine is an art, not an exact science exercised solely by cold and inextricable algorithms.

Lack of scientific evidence that AI-based training is better than traditional training. We need to demonstrate that AI-based radiological training of students is better than traditional teaching or current teaching focused on problem-based learning, in which students have a more active role and where their competence is continuously assessed.[11,12] To do this, the new role of university professors as regards AI must be analysed, valid and reliable measures that analyse student performance must be developed, and ethical considerations for the use of this new technology in training should be included.[23]

Diversifying AI tools. Until now, AI tools have been used in the university environment mainly to predict student performance, predict their risk of dropping out of studies or to support the learning of theoretical knowledge.[11] It would be desirable to develop more AI tools that can be used for acquiring clinical skills. It is crucial to prepare current students for the role of AI in medical practice prior to their training as residents.[22]

Maintaining and increasing medical students' interest in radiology. According to several recent studies, radiology is a specialty whose interest and competitiveness among medical students has decreased in the United States in recent years. It seems that the decline in this interest is due, at least in part, to the emergence of AI[18,20] The perception of medical students in Spain regarding these issues is unknown.

Technological challenges. Are our universities ready to teach AI? The main challenges are to have greater digitisation of clinical content (especially radiological images), expert systems for its use in universities, better training of teachers in AI, and trying to ensure that this training is made available in an equitable way to all universities.[11] The digitisation of content and the provision of AI systems for teaching have economic costs that can pose a significant obstacle to their implementation.[12]

Curricular and administrative challenges. An additional challenge in our country is that the teaching of radiology in universities is heterogeneous, and in some it is still considered a ''minor'' subject.[24] In addition, there are time constraints on fitting AI into the medical curriculum, which sometimes has little space for basic radiology content.[12] Currently, there are 44 medical schools in Spain, and perhaps we should ask ourselves by whom, when and how AI should be taught. Should it be by radiologists or data scientists (engineers, computer scientists), or a combination of the two? Several studies suggest that AI could be introduced in medical schools as a multidisciplinary subject, including other computer tools, statistics, programming, technology management, etc., but always balanced with a human and holistic vision of the patient, in which AI complements and does not replace the doctor in the practice of medicine.[6,11,12] In Spain, only five faculties (to our knowledge) include a course on medical IT. An alternative position would be to link basic AI teaching to radiology training, as another technological development.[12]

Challenges of specialised training

End of ''resident duties''? Many of the AI tools perform tasks typically performed by residents (such as protocolising, monitoring or 'pre-reporting' radiological studies, segmenting and measuring lesions, etc.), so that the most tedious and repetitive tasks are performed quickly as if it was a ''virtual resident''.[6,13] Is it sensible for a resident to entrust these tasks to software without first understanding and performing them autonomously? Does it make sense for a first-year radiology resident to learn how to use an AI-based lung nodule detection tool (for example) before facing the challenge of reading multiple chest computed tomography (CT) studies and searching for those nodules (among many other things)? It may be desirable that only when a resident has internalised the chest CT reading process and has handled a sufficient number of CT studies can they then have access to AI tools and learn how their algorithms work, in which scenarios they can be used and when they do not work as expected. We believe that residents should keep reading and reporting the studies; only then will future radiologists be able to know how, when (at what stage of the process) and why AI tools may fail.

Artificial compartmentalisation. This consists of the loss of a global and holistic vision of the patient as a consequence of the application of different AI tools that solve (generally) very specific problems and issues, often dichotomously.[12] AI tools use narrow algorithms that try to solve specific questions, whereas we radiologists have multidisciplinary intelligence and we analyse and integrate many variables simultaneously.[3,25] We should not convey to residents the idea that the interpretation of a brain MRI or an abdominal CT scan can be ''nailed'' by sequentially applying different algorithms and waiting for the result of all of them to make a final diagnostic impression.

Delay in adapting the resident programme. If, thanks to AI, radiologists free themselves from the most tedious tasks, they will have more time to participate in multidisciplinary committees, interact with patients and other specialists, dedicate themselves to research and data management and analysis, etc.[6,9,13,18,22] Are we teaching residents these ''new duties'' of a radiologist? Are we adapting the residency pro-

gramme to this new augmented reality of the work of the radiologists of the future?

Automation bias (over-dependence on technology). If we introduce AI tools too early and indiscriminately in the residency, without human supervision and without analysing their advantages or limitations, less experienced radiology residents may come to think that AI is ''better'' than repetitive effort and human intellectual work, thereby incurring an automation bias.[26] In this way, we run the risk of turning residents into mere passive observers of ''opaque'' algorithms that make diagnoses, and of losing the mental expertise that radiologists have acquired through knowledge and repetitive experience in recent decades. Excessive and uncontrolled automation diminishes our capacity for learning, interpretation and critical analysis.

Challenges of continuing education

Lack of a structured curriculum. It makes it difficult to use AI in the continuing education of already specialised radiologists (what they need to learn is not so well defined). The level of knowledge, interest in learning and degree of commitment are highly variable among specialised radiologists.[13]

Legal implications of AI. We live in a culture that increasingly denounces medical negligence and holds it to account. There is no jurisprudence in the case of AI and its use in medicine, so specialist radiologists' willingness to adopt intelligent tools may be conditioned.[27] Who is responsible if something goes wrong as a result of an autonomous clinical decision made by an AI tool? The radiologist, its creators/developers, the hospital that decided to acquire said tool? Will radiologists have any legal responsibility if we cannot fully understand the complex algorithms (the ''black box'') hidden within a convolutional neural network?[6,9,25,27]

Deterrent effect of legislation. Legislation discourages radiologists from harnessing the potential of AI, as it tends to favour standard medical care (SMC), and, at present, AI is not considered to be SMC. In general, a radiologist only faces a possible legal liability if, having caused damage or harm to a patient, his/her performance does not conform to SMC. Therefore, the safest way to use AI from a liability perspective is not to use it. This could lead radiologists to tend to avoid AI or to under-use it as a mere confirmatory tool that consolidates the decision-making process (and not as a tool that helps improve the medical care of patients).[27,28]

Equity. AI can widen the differences between institutions that have many AI resources (large academic centres that collaborate with universities and technology companies) and hospitals with less technological capacity.[29] This would create large asymmetries between radiologists with training in AI and others with a lack of such training.

Inferring behaviour patterns. Radiologists will be converted into data that can be categorised and evaluated by AI tools, which will be able, in addition to quantifying the work they do, to infer patterns in performance and in personal, professional and institutional behaviour.[30] All this could generate a ''fear of control'' in radiologists.

Future perspectives and conclusions

Current data indicate that AI will be able to offer students and residents educational content based on their needs (personalised precision education), achieving greater standardisation and harmonisation in the acquisition of interpretive skills.[5,11–13] For older radiologists, AI will also allow them to improve their professional development, updating and refreshing their knowledge (also depending on their needs) to maintain professional competence throughout their work careers.[13] In addition, AI will reinforce the relationships between the teacher (professor, tutor) and the learner (student, resident), since delegating more routine tasks (acquisition of theoretical knowledge, exam evaluations and rotations, etc.) to AI tools will allow them to focus on tasks with greater added value (study habits, interviews, research, publications, communication skills, etc.)[7,9,22] Ideally, there will be more time for teaching and research, and that implies that radiologists will have to do research in AI and try to publish the results of AI tools in scientific journals.[6,12,23] The radiologist of the future, thanks to that multidisciplinary approach that characterises us and the liberation of the most tedious and repetitive tasks of our work, will have a central role in the integrated management of data (not only radiological, but also demographic, clinical and laboratory, etc.), so the need to create a subject at university (or even a specific training area) in medical imaging and data science, clinical IT or AI could be considered.[3,25] In this sense, AI will help radiologists to not interpret images in a de-contextualised way without discerning their clinical impact, and will allow us to integrate that information with a lot of other data, thus achieving greater prominence and greater visibility among patients.

Like it or not, AI is here to stay. Not only is it going to alter the way we work, but it is also going to impact the way we teach and learn. Radiologists have traditionally been early adopters of health technology and today we are the specialists with the best digital training and, probably, the ones best prepared for the development and implementation of AI applications in medicine. If radiologists embrace AI (as we have embraced other technological advances in the past) and balance its potential with a human and holistic vision of the patient, we will be able to improve the performance of our work and focus on tasks that add value and positively impact patient care and training for students and residents.

Authorship

1 Responsible for study integrity: LGS.
2 Study conception: LGS, JMMO, FSP, RdLG.
3 Study design: LGS.
4 Data collection: N/A.
5 Data analysis and interpretation:
6 Statistical processing: N/A.
7 Literature search: N/A.
8 Drafting of the article: LGS, JMMO, FSP, RdLG.

9 Critical review of the manuscript with intellectually relevant contributions: LGS, JMMO, FSP.
10 Approval of the final version: LGS, JMMO, FSP, RdLG.

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