Artificial intelligence may cause a significant disruption to the radiology workforce

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Abstract

The increasingly realistic prospect of artificial intelligence (AI) playing an important role in radiology has been welcomed with a mixture of enthusiasm and anxiousness. A consensus has arisen that AI will support radiologists in the interpretation of less challenging cases, which will give the radiologists more time to focus on the challenging tasks as well as interactions with patients and other clinicians. The possibility of AI replacing a large number of radiologists is generally dismissed by the radiology community. The common arguments include the following: (1) AI will never be able match radiologists’ performance; (2) radiologists do more than interpret images; (3) even if AI takes over a large portion of the reading tasks, the radiologists’ effort will be shifted toward interactions with patients and other physicians; (4) the FDA would never agree to let machines do the work of radiologist; (5) the issues of legal liability would be insurmountable; and (6) patients would never put a complete trust in computer algorithms. In this paper, I analyze these arguments in detail. I find a certain level of validity to some of them. However, I conclude that none of the arguments provide sufficient support for the claim that AI will not create a significant disruption in the radiology workforce. Such disruption is a real possibility. Although the radiology specialty has shown an astonishing ability to adapt to the changing technology, the future is uncertain and an honest, in-depth discussion is needed to guide development of the field.
INTRODUCTION

Artificial intelligence (AI) has progressed immensely over the past 5-10 years with deep learning [1] leading the charge. Self-driving cars, a computer finally winning the ancient game Go against the best human player, and an increasing number of studies showing AI algorithms matching human performance in medicine illustrate the potential for dramatic changes. The radiology community has reacted to this new wave with a mixture of enthusiasm and anxiety. The question on the minds of many in the profession is, will computer algorithms replace radiologists, and, if so, when and to what extent.

The question is more than academic. An overly optimistic view of AI could result in fewer radiologists being trained, leading to a labor shortage in this extremely important aspect of medical care [2]. Similarly, if AI does come to dominate the radiology field, many young doctors will needlessly undergo highly demanding and costly training (5-6 years post M.D. in the United States), only to find there are no jobs available. They would face the prospect of having to retrain for a different sub-specialty.

A number of opinions have been expressed on this topic, often very strongly. Geoffrey Hinton, the “godfather of deep learning” has stated that “if you work as a radiologist you are like Wile E. Coyote [...] you’re already over the edge of the cliff, but you haven’t yet looked down. There’s no ground underneath” [3]. Eliot Siegel, a radiologist, refers to speculation about AI replacing radiologists as “unfounded hype” [4]. Another radiologist, Robert Schier, has referred
to the “assertion that computers will always merely assist—and never replace—radiologists” as “delusional” [5].

The current consensus appears to be that computer algorithms will not replace radiologists, only make them more efficient by relieving humans of repetitive tasks. This would leave radiologists more time to, for example, review more difficult cases or interact with patients and referring physicians.

This view could be described as the AI-skeptical view. In my discussions with radiologists and radiology researchers and in the various opinion pieces on the topic, a number of arguments have been brought up to support this currently prevailing view. The aim of this paper is to thoroughly analyze these arguments and assess their validity. Before analyzing the arguments of AI-skeptics, for the sake of completeness, let us briefly look at the basic argument of the AI-optimists.

THE PROMISE OF AI REPLACING RADIOLOGISTS

The argument of the AI optimists is simple: AI will perform radiologists’ work at least as well as humans— and do it much faster and cheaper—so there will be no reason to pay radiologists.

I consider a moderate (and I assume more common) interpretation: AI may replace radiologists for image interpretation but not for procedures, teaching, etc. This means that AI would create a dramatic disruption to the radiology workforce by eliminating the need for medical image interpretation by humans rather than taking away a job of every single radiologist.
The prospect of AI accurately interpreting medical imagery certainly has very appealing aspects. For one, it could yield significant gains for healthcare in the United States and around the world. Lower costs would make radiological tests available to more people, especially those in poor areas. This best case outcome is of course not guaranteed. Market and advocacy-driven introduction of AI in radiology could lead to less than optimal value delivered to the society. In the worst case scenario, introduction of AI in radiology could even increase the costs to the patient.

Regardless of what the consequences of AI overtaking medical interpretation would be, a number of arguments have been presented against the possibility of such replacement. These arguments are discussed below.

THE ARGUMENTS AGAINST AI REPLACING RADIOLOGISTS

Argument 1: Algorithms will never be able to interpret images as well as humans can.

Other versions of this argument include “as radiologists we know how difficult some of the tasks are and there is no way that a computer algorithm could do the same”, or “the clumsy algorithms I saw could not even recognize X from Y in natural images and I do not see a way they could perform more sophisticated tasks such as interpretation of medical images”, or “computer algorithms can only find obvious and common signs of disease in medical images and the radiologist will still be needed to interpret the subtler findings”. 
It is only natural to appreciate the brilliance of the human perceptual and deductive apparatus especially when one has spent a good portion of one’s life doing what almost no one around them could do (e.g., finding very subtle signs of cancer in images and subsequently saving patients’ lives). It is also very easy to dismiss the possibility that machines could ever match this ability when one is surrounded by clumsy algorithms that could not match the intellect of a 3-year-old.

However, this feeling appears to be common for professions where computer algorithms already have shown superiority vs. human experts. Even as recently as one or two years before the DeepMind’s algorithm beat the world’s best player at the game Go (ref: https://www.npr.org/sections/thetwo-way/2017/05/23/529673475/like-a-god-google-a-i-beats-human-champ-of-notoriously-complex-go-game), one could see predictions that this would not happen for 10 or 20 years and the chatter of the human trait of “creativity” being essential to the game. Likewise, composing music was long considered an essentially human activity. But algorithms now exist that can compose music indistinguishable, to many human ears, from the compositions of Johann Sebastian Bach [6].

These examples do not prove that algorithms will excel at radiology. But they demonstrate that a human conviction alone about the complexity of a task does not mean a computer cannot do the task as well as or better than a human.

Second, the clumsy computer algorithms in practice a decade ago, or even five years ago, are not so clumsy anymore. The rapid development of deep learning algorithms, combined with easy access to computing power, has resulted in dramatic gains. Deep learning algorithms can:
classify natural images with a performance similar to a human [7]; drive cars [8]; read lips better than a human expert [9]; generate paintings; and perform many other previously unthinkable tasks. Visual tasks are no longer “safe” from the reign of AI.

In fact, evidence is emerging that computer algorithms might perform medical image interpretation as well as or better than radiologists. A deep learning program, CheXnet[10], performed better than a radiologist in detecting pneumonia. On June 30, 2018, a computer program called BioMind won (2-0) a competition with a team of 15 neuroimaging experts in which different brain diseases were diagnosed in 225 cases [11]. In a study released in September 2018, a deep learning algorithm outperformed radiologists at staging liver fibrosis with a notable margin [12]. Among specialties closely related to radiology, an algorithm developed by Google performed on par with dermatologists in classifying skin lesions [13], and an algorithm developed by DeepMind performed comparably or better than human experts in recommending referral for some retinal diseases [14]. All of these studies have their limitations, and some of the specific conclusions can be questioned. But the picture that emerges is that, if not now, someday an AI algorithm will be able to interpret complex medical images as well as or better than humans.

Finally, some AI skeptics bring up the specific limitations of the currently available algorithms (and there are plenty). In this argumentation, since we know how the current deep learning algorithms process data, we can be confident that those algorithms will not match radiologists. I do not find this reasoning convincing. First, we do not fully understand all aspects of the processing that is done by neither convolutional neural networks nor human brain. Second, the fact that AI might approach some task in a much more basic way that we do (or we believe that
we do) does not mean that the simpler way is not sufficient. Deep Blue, for example, when beating Garry Kasparov at chess was implementing a very simple algorithm. In this context, an AI-skeptic could also make a more general argument that humans process information in a way that is impossible to be implemented in a computer but that is a very difficult argument to defend (although some attempts are available: [15]). Finally, even if we were able to demonstrate that a particular AI-based solution is intrinsically incapable of solving a given problem, the recent progress of AI suggests that if the problem is important, a solution will be found.

**Argument 2: Radiologist do a lot more than just read images.**

Other activities performed by radiologists include image-guided surgical procedures and consulting with referring clinicians to explain findings. Highly sophisticated autonomous robots do not yet exist to perform image-guided surgery, nor can computer algorithms converse with humans, explain their findings in detail, or answer additional questions.

At the first look this argument is valid. But let us dive little deeper. In a prospective study [16], researchers observed 14 Canadian radiologists in 3 hospitals to establish how they spend their time at work. A surprising result was that only 36.4% of the radiologists’ time was spent on interpretation of images. That might suggest that roughly two-thirds of their time is spent on activities a computer couldn’t do. This is not necessarily an accurate conclusion. According to the analyzed study, 10.9% of the radiologists’ time was devoted to procedures, which is essential work and not likely to be taken over by machines any time soon. Among other activities, consultations with physicians (phone and office) were found to constitute only 3.2%
in total. Although the prospect of this task being taken over by machines is low (though not unthinkable), it constitutes a very small time commitment.

A large item on the list was teaching, 14.6% of the radiologists’ time. But teaching is rare in private practices raising the share of time devoted to reading images. Also, in a world where medical image interpretation is performed by computer algorithms, the demand for teaching humans will be highly reduced.

According to the study, 12.3% of radiologists’ time was personal time and meals. Other items included: consults with radiologists, technologists or nurses (9.1%); protocolling studies (3.5%); out-of-office meetings (5.5%); and other tasks, including research (4.4%). These items are more difficult to assess in terms of their essential nature, but it would not be unreasonable to believe that these activities would be less common in a world where the image interpretation (and some related tasks, such as scheduling or protocolling) is performed by computer algorithms.

Finally, it is important to note that the estimate of 36.4% for image interpretation was measured in a hospital setting and is likely not representative of a private radiology practice where one could expect 50-75% of the time to be devoted to image interpretation and reporting.

In conclusion, in the world where computer algorithms interpret images, the demand for the work of a radiologist would drop to at most 50% of the current demand. A more pessimistic view is that AI could swallow up all but the procedures and consults work (15% in the above study), leaving demand for only 15% of the current radiology positions. The argument that radiologists perform tasks other than image interpretation is valid against the radical thesis that
AI will replace every single radiologist since there will still be a demand for other tasks that radiologists perform. However, the argument does not appear valid against the more moderate AI-optimist thesis that AI will replace many (maybe most) radiologists to the point that it will create a dramatic disruption in the radiology workforce.

Please note that to maintain the focus of this discussion, my analysis considers only the current status of the profession, because this what we can understand and measure. The discipline is constantly changing and some of the factors that might contribute to this change are constantly changing imaging technologies, aging patient population, and high burnout rate among radiologists. If AI overtakes image interpretation, the consequences would be more complex than radiologist jobs simply disappearing. Some new jobs for radiologists (and other fields) could be created in the process, and many radiologists could adapt to the new reality by taking such positions. This scenario still leaves room for a significant disruption in the radiology workforce. I comment on these possibilities at the end of this article.

**Argument 3: Even if a computer algorithm takes over some responsibilities of radiologists, including image interpretation, radiologists will spend more time and focus on other tasks, such as seeing patients, discussing cases with primary care physicians and oncologists, or reading particularly difficult cases.**

This argument relies on the thesis that other doctors and patients and, in turn, society in general would benefit from highly trained clinicians devoting more attention to tasks that are currently not well attended or are not attended at all. The question is whether the benefits to
society would merit the additional time. In the current healthcare system in the United States, they might not.

The correct question in this context appears to be whether the additional time spent with patients and referring clinicians or on particularly difficult cases would provide value to radiology practices, academic or private, which at the end decide on whether to hire radiologists. Although one could argue this either way, the elephant in the room is: Why are radiology practices not hiring radiologists to spend more time on these tasks now? The fact that they are not suggests that in the current healthcare system there is no demand for these extended activities. So if AI were to take over a large portion of the image-interpretation work, radiology practices would likely just reduce staffing.

Please note that one can analyze this argument only in the context of a particular healthcare system (U.S. in this case), which is determined by the interaction of interests of patients, doctors, clinical practices, insurance companies, medical device and drug companies, medical societies, regulatory guidelines, and legislation. This analysis addresses the current state of the system in question and could be different if the system changed.

**Argument 4: Computer algorithms could not make decisions without the supervision of a radiologist because regulatory agencies such as the FDA would never allow it.**

No FDA regulation states that an activity currently performed by a specialist physician cannot be performed without the supervision of such a specialist. However, to be generous toward this argument, I will assume that it should be interpreted as follows: although no specific
regulations exist that prohibit unsupervised AI in medicine, it is very unlikely that the FDA would approve such a device given the high risk and other reasons.

Recent experience, however, points in the opposite direction. The FDA recently approved an algorithm [17, 18] that interprets an eye image acquired by a primary care physician or a nurse and provides the results without oversight by an ophthalmologist, who would otherwise interpret the image. This situation is analogous to a primary care physician ordering a radiology exam, such as a chest X-ray or a mammogram, and receiving results generated by an AI algorithm without a consultation with a radiologist. The example above suggests that if an algorithm is sufficiently tested, the FDA is open to allowing this type of unsupervised automated analysis.

The FDA-based argument against AI replacing radiologists assumes that allowing machines to make decisions is too dangerous because it would place patients’ lives at risk. However, a large number of devices have been approved that hold a similar level of responsibility. Examples include common laboratory blood tests. Although results of these tests are eventually interpreted by a physician, the values put in the report are generated by a machine, and mistakes in generating these values could have grave consequences. Despite this risk, we trust in these tests as long as they are well validated. No reason exists from the risk point of view for why we would not extend this trust to AI-interpreted radiology exams.

The general attitude of the FDA toward AI appears to be very positive, and the agency has shown interest in facilitating bringing AI devices to market by updating their regulatory pathways [19].
Argument 5: A human reader will ultimately need to look at images and approve the diagnosis because of legal liability.

Radiologists and radiology practices are responsible for image interpretation and occasionally get sued. Who will be responsible for mistakes made by computer algorithms? This is not a trivial question, but I believe it can be answered.

The world is full of activities posing risk that used to be or could be performed by humans but are performed by machines. An example from the world outside of medicine is riding in an elevator. Even though most elevators do not have operators anymore, the issue of legal responsibility for failure is settled. Responsibility may for example fall on the property owner or the equipment manufacturer.

An important example from the world of medicine is laboratory tests. Lab tests have much in common with radiology tests: They are commonly ordered by a primary care physician and provide him/her with important information about the patient. Even though these tests might provide inaccurate information, and inaccurate information might pose a risk to the patient’s health, generation of the test results (i.e. the actual analysis of the sample) does not require “double checking” by a physician or another health care provider. Despite this lack of oversight, legal responsibility is not an insurmountable obstacle. The new AI devices, already approved for clinical use, will lead the path for resolution of necessary additional legal issues.
Argument 6: Patients would never agree to image interpretation by a computer without a radiologist to confirm the analysis.

Most discussion of this argument is speculative. I am not aware of any systematic studies on the topic. I can understand the uncertainty or even fear associated with not having a human doctor looking over an image that purports to tell whether I have cancer. On the other hand, I can also imagine a rational consumer of healthcare preferring whatever method of image interpretation is proven to be the most accurate. If that is a machine, the machine would be the choice.

An important point here is that, for better or worse, adoption of particular technology in a radiology practice is rarely guided by the wishes of untrained patients. Nor should they be. As patients, if AI replaces radiologists, we will just have to accept it, just as we accept the use of an MRI scanner, a blood test, or a genomic test for a tumor (e.g. Oncotype DX).

**DISCUSSION**

The important role for radiologists in the development of machine-learning algorithms and their implementation in the clinical practice

One of the main challenges in the development of useful AI algorithms in radiology is the chasm that exists between scientists who study machine learning and radiology-domain experts. As it stands now, brilliant machine-learning scientists frequently devote their efforts to developing sophisticated solutions to unimportant problems. This is often because these scientists fail to appreciate the complexity of medical problems. They often do not know how different pieces of
information are used in patient care, how and when decisions are made based on which pieces of information, and how (in this case) a radiologist interacts with other healthcare providers such as primary care physicians, pathologists, oncologists, surgeons, and technologists.

Given this significant challenge, the role of a domain expert is crucial. This radiology expert is primarily a radiologist, but depending on a specific problem, it could also be other physicians, technologists, and machine learning scientists highly experienced and familiar with the clinical reality of the approached problems. Development of useful AI systems will rely on incorporating the vast knowledge and ability of radiologists into the AI systems in both indirect ways (e.g., through providing labels) and direct ways (e.g., through guiding feature development and selection). Although there has always been a group of radiologists devoted to the development of AI, it is my pleasure to see a significant raise of the number of radiologists excited about contributing to this cause and often leading the effort.

**The new roles for radiologists in the AI-based radiology of the future**

If AI overtakes medical-image interpretation or a large part of it, the process will likely result in a complex restructuring of healthcare around medical imaging. This process is likely to create a new demand for skilled human work. New tasks could include overseeing the functioning of the machines, interfacing between the AI and the information recipients (patients, other physicians), and developing new uses of the AI-interpreted imaging modalities. Other tasks will likely need to be performed that are currently not even considered.

In such situation, the community of radiologists will need to adapt to the new reality. However, this cannot be taken for granted as a saving grace for the profession. The exact nature of the
new demand for expertise and work that would arise if AI overtook medical image interpretation is difficult to predict. The often highly specialized expertise possessed by radiologists might or might not be suited to the new demands.

CONCLUSIONS

The intent of this article was to analyze the common arguments against the possibility of AI algorithms replacing radiologists. I conclude that the arguments do not withstand close examination. While some have a degree of merit, none provides sufficient evidence that there will be no significant disruption in the radiology workforce due to AI.

Does this mean that the profession is doomed obsolescence? By no means. The radiology specialty was born of technology and has grown around technology. It has shown the ability to evolve. It is possible that AI will transform radiology into a substantially altered specialty in which a human specialist will still play an important role.

While the future is unknown, what is certain is that an honest discussion about what we know and how the future might look is important to shaping the future of the profession. This discussion should include multiple perspectives in addition to medical and technical ones, including health economics, policy, legal, informatics, and business. The intention of this paper is to contribute to this discussion.

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TAKE-HOME POINTS

- The question of whether artificial intelligence (AI) algorithms will create a significant disruption in the radiology workforce is of practical significance.
- A common opinion is that AI algorithm will assist rather than replace radiologists and multiple arguments have been brought up to support it.
- Upon closer examination, the arguments do not support the thesis that there will be no significant disruption in the radiology workforce and such disruption is a real possibility.
- While the future is unknown an honest and detailed discussion is needed to shape the future of the profession.

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