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Utility of artificial intelligence in cardiology

Dr. Rafael Vidal Perez, MD
******@***hotmail.com

Cardiac Imaging Consultant - Cardiology Department, Hospital Clinico Universitario de A Coruña
Spain

LinkedIn Twitter

A step forward for daily practice.

Artificial Intelligence (AI) tools are proving their utility in the evolving field of cardiology. However, it's necessary that cardiologists understand their full potential in order to use them efficiently in the near future.

Decision making in medicine

Nowadays, the decision-making process in medicine is a complex task that in an ideal world is based on the availability of reliable and objective evidences, fast access to knowledge, as well as proper interpretation of available facts with the incorporation of patient benefit-risk ratios into every step. However, the experience of the practice of medicine in the real world has taught us that these evidences are not always available, assimilation of knowledge takes time and decisions regarding each individual case may not always be objective (Bonderman, 2017).

It is known that the most errors in decision-making have been attributed mainly to two elements, one of them is bias such as categorising minorities (social bias) and the other one is the noise, which means that decisions are prejudiced by irrelevant factors such as current mood, time since the last drink or even the current weather, that was highlighted by Kahneman (2016). If you combine all of this information, there is indeed a clear room for improvement with respect to generating evidence, structuring knowledge and translating it into clinical decisions.

The incorporation of artificial intelligence (AI) tools in the field of cardiology into daily decision-making will most likely improve care. Of course however, it is necessary that cardiologists must retain the last step in the control of the system, keep an eye on the decisions and have the authority to change algorithms in the cases that may go wrong.

Artificial Intelligence

Many definitions for this topic exist, however there is no doubt that it depends on your focus in the field of healthcare.

In Wikipedia for example, (https://en.wikipedia. org/wiki/Artificial_intelligence) AI is referred to as the intelligence displayed by machines, in contrast with the natural intelligence displayed by humans and other animals. In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions that maximise its chance of success at some goal. Colloquially, the term is applied when a machine mimics "cognitive" functions that humans associate with other human minds, such as "learning" and "problem solving".

For other authors, AI is considered a branch of engineering that implements novel concepts to resolve complex challenges (Kahneman, 2016). Another definition for AI could be a field of computer science that aims to mimic human thought processes, learning capacity, and knowledge storage (Krittanawong, 2017), that probably fits best for medical approach.

Another element with a great relation to this topic is 'big data.' This term refers to extremely large datasets that cannot be analysed, searched, interpreted, or stored using traditional data-processing methods. Big data includes data from mobile phone applications, wearable technology, social media, environmental and lifestyle-related factors, sociodemographics, “omic” data (eg genomics, metabolomics, proteomics), and data from standardised electronic health records (EHRs) or precision medicine platforms (Krittanawong, 2017)

AI in cardiology

AI techniques such as machine learning, deep learning, and cognitive computing, may play a critical role in the evolution of cardiovascular medicine to facilitate precision cardiovascular medicine. In order to deal with cardiovascular big data, we will certainly need these techniques.

In cardiovascular biomedicine, there are four biomedical big data sources which are important:

1. Functional phenotypes such as demographics, echocardiograms, electrocardiography, haemodynamics, and imaging data
2. Molecular profiles derived from large-scale omics data that may be acquired in large trials or the clinical setting
3. Medical records, including patient electronic medical records containing laboratory test results, physician's notes and other information on disease, treatment, and epidemiology that may be mined for association studies and predictive modelling on prognosis and drug responses
4. Literature knowledge: it is estimated that in cardiovascular medicine there is a new publication released approximately every three minutes. This amount of data overwhelms human intelligence, but may be mined and structured by deep learning algorithms.

Despite its fast and wide penetration of medicine in general, as Kahneman (2016) points out, "Most cardiologists today are more likely to associate the term 'artificial intelligence' with a futuristic extraterrestrial phenomenon rather than with a tool that is just about to conquer medicine, including cardiovascular medicine."

Machine Learning
The term machine learning (ML) represents various techniques for solving complicated problems with big data by identifying interaction patterns among variables. In contrast to traditional statistics, machine learning is focussed on building automated clinical decision systems (such as readmission and mortality score systems) that help doctors make more accurate predictions, rather than simple estimated score systems.

Machine learning can be categorised into three learning types: supervised; unsupervised; and reinforcement. In supervised learning, algorithms use a dataset labelled by humans to predict the desired and known outcome; is great for classification and regression problems, but it requires a lot of data and is time-consuming because the data has to be labelled by humans.

Unsupervised learning seeks to identify novel disease mechanisms, genotypes, or phenotypes from hidden patterns present in the data; the objective is to find the hidden patterns in the data without feedback from humans. Reinforcement learning can be viewed as a hybrid of supervised and unsupervised learning; the objective of reinforcement learning is to maximise the accuracy of algorithms using trial and error (Krittanawong, 2017).

A good example of the use of machine learning in cardiology is the prediction of the survival of patients with heart failure and preserved ejection fraction by Shah (2015), which was the creation of an unsupervised learning model across 46 different variables to identify intrinsic structures within patients with this type of heart failure; they identified three distinct groups. Subsequently, they performed supervised learning to predict the difference in desired outcomes (mortality and hospitalisation) among the groups. However, the limitation of unsupervised learning is that the initial cluster pattern needs to be corrected without bias; therefore, the study needs to be validated with other cohorts.

Deep learning
It mimics the operation of the human brain using multiple layers of artificial neuronal networks that can generate automated predictions from input (training datasets).

Deep learning can be very powerful with relation to image recognition (eg facial recognition in Facebook, image search in Google), and can potentially be used in cardiovascular imaging (eg 2D-speckle-tracking echocardiography, 3D-speckle-tracking echocardiography, angiography, cardiac magnetic resonance). It can also be trained in an unsupervised manner for unsupervised learning tasks (eg novel drug-drug interaction), and, in addition, there is no limitation on working memory. It also works well with noisy data, such as 3D-speckle-tracking echocardiography and strain imaging data.

Deep learning algorithms will also facilitate the use of artificial real-time cardiovascular imaging with better spatial and temporal resolution, potentially improving the quality of care and reducing costs (Krittanawong, 2017).

One example found that using this technique (Kannathal, 2003) through a deep neural network classified the ECG signals of cardiac patients into normal, abnormal, and life-threatening states, and found the classification to be correct in approximately 99% of test cases.

Cognitive computing
Cognitive computing involves self-learning systems using machine learning, pattern recognition, and natural language processing to mimic the operation of human thought processes. In cognitive computing, a system or device is trained by machine learning or deep learning algorithms.

The goal of cognitive computing is to create automated computerised models that can solve problems without human assistance (Krittanawong, 2017).

IBM Watson, a well-known example of cognitive computing, continuously learns from datasets (eg EHR, social media, stock market) and can predict outcomes using multiple algorithms more accurately than humans.

One example of this use in cardiology is the research made by Dr. Partho Sengupta (2016) where he developed an associative memory classifier, a cognitive computing machine learning algorithmic approach, to classify constrictive pericarditis from restrictive cardiomyopathy, and demonstrated its feasibility for automated interpretation of speckle-tracking echocardiography data.

Artificial Intelligence in the field of cardiac imaging
AI will have a role to aid reproducibility in cardiac imaging, for example Siemens Healthcare was the first to introduce elements as algorithms into its cardiac echo systems several years ago to speed automation.

Philips Healthcare also has introduced elements of AI on its EPIQ ultrasound system some years ago. Here, they take a 3D echo dataset acquisition which automatically analyses the image to identify the heart's anatomy, labels it and then slices the optimal standard views for presentation. This tool eliminates issues with interoperated variability, because the software will always choose the best views based on machine learning, which uses thousands of prior studies representing the spectrum of patient anatomical variations. This would take years for a human operator to accumulate the same information.

Other vendors have also introduced elements of deep learning algorithms to help analyse echocardiograms or perform auto quantifications. Next generation echo systems will incorporate more AI features to further improve workflow by auto-completing time- consuming tasks so they can become more efficient and consistently be more accurate.

All of the major imaging system vendors are either developing their own AI or partnering with AI vendors with big announcements during 2017. Siemens Healthineers announced a partnership with IBM Watson, GE Healthcare announced it will be working with Partners HealthCare, which will be executed through the newly formed Massachusetts General hospital and Brigham and Women's Hospital Center for Clinical Data

Science. In addition to its EPIQ echo software, Philips also developed its own AI software to enhance its Intellispace Enterprise medical imaging informatics platform, which is smart enough to pull all of the patient's relevant prior exams for the same anatomy and open the images in the exact same format and view as the current exam.

Conclusion
AI tools such as machine learning, deep learning, and cognitive computing are promising and indeed they will change the way in which cardiology is practiced, especially in the cardiac imaging field. However, physicians need to be prepared for the upcoming AI era, and clear results of the utility of AI within daily practice is essential.

I believe that AI will not replace cardiologists, but it is important that cardiologists know how to use AI sufficiently to generate their hypotheses, perform big data analytics, and optimise AI applications in daily practice to bring on the era of precision cardiovascular medicine.

Key Points

- Decision-making process in medicine is a complex task
- Incorporation of artificial intelligence tools in the field of cardiology into daily decision-making will improve care
- Artificial intelligence tools like machine learning, deep learning or cognitive computing are proving their utility in cardiology
- In the field of cardiovascular imaging, artificial intelligence is showing a great potential

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