Artificial Intelligence in Aortic Surgery: The Rise of the Machine

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The first concept of Artificial Intelligence (AI) came into attention during 1920s and currently it is rapidly being integrated in our daily clinical practice. The use of AI has evolved from basic image-based analysis into complex decisions related to different surgical procedure. AI has been very widely used in the cardiology field, however the use of such machine-led decisions has been limited and explored at slower pace in surgical practice. The use of AI in cardiac surgery is still at its infancy but growing dramatically to reflect the changes in the clinical decision making process for better patient outcomes. The machine-led but human controlled algorithms will soon be taking over most of the decision making processes in cardiac surgery. This review article focuses on the practice of AI in aortic surgery and the future of such technology-led decision making pathways on patient outcomes, surgeon's learning skills and adaptability.

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Central Message

Artificial intelligence is a very new concept in aortic surgery, future development in the form of genetics and machine-led decision-making can overcome many of the current unsolved or difficult tasks aiming to provide substantive optimal outcomes.

Perspective Statement

Artificial intelligence (AI) is a growing service in many aspects of medicine. The practice of AI outside medicine proved its usefulness in supporting faster and more reliable decision-making. Aortic surgery is complex and the decision of choosing different treatment method can be variable and often difficult among different clinical practitioners. AI will help not only in following a proper algorithm but also a standardization in care provision.

INTRODUCTION

Artificial Intelligence (AI) combines the ability of computation mixed up with input and experiences learned. The combination results in machines that are capable of self-learning and able to adapt to change. It can predict a pattern of behavior, assimilate resemblance to human thought process or "selective thinking" and can take the forms of selecting and arranging dataset, creating an appropriate predictive model and evaluating and refining that model. We have encountered this through digital technologies such as robotic implants that can respond to programmed coordinates hence, performing intrinsic tasks and modeling human thoughts reducing significant errors and providing optimal clinical outcomes. The transformation of healthcare over the past decade has emerged from accruing big data, which need to be interpreted and operationalized by physicians and surgeons. This big data process is crucial and demand more personalized care in an era dominated with personalized healthcare and molecular understanding of disease process. This represents an aid to unravel novel genotypes and phenotypes of existing diseases, improve the quality of patient service and care, enable cost effectiveness models, and reduce readmission and mortality rates.[1] This perspective aims to illustrate the challenges of AI in cardioaortic settings, discuss and elaborate on what have been achieved thus far and what the future perspectives hold.

THE CHALLENGES

According to a white paper by Stanford Medicine[2] "the sheer volume of healthcare data is growing at an astronomical rate: 153 exabytes (one exabyte = one billion gigabytes) were produced in 2013 and an estimated 2,314 exabytes will be produced in 2020, translating to an overall rate of increase at least 48 percent annually." The bottom line to a machine that can eliminate errors and operate in virtually zero risk field is an AI, which can house and store an enormous amount or quantifiable data built in personalized patient model yielding better

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outcomes. However, to achieve this, acquisition of data streamed from patients in different clinical settings represents a challenge. The lack of data protocols, standardization, and data privacy are major contributors to these challenges within any given healthcare field. To the modern aortic surgeon and researcher, the consumer side of captured data remains a far fetch and reach. Regardless of where data are stored and what content it relays, data contribute heavily to outcome reporting which can transform aortic surgery into digital and intelligent system.

Since storing and retrieving can be computational and time expensive, it is key to have a storage infrastructure that facilitates rapid data-analytic demand. Overcoming those restraints can allow us to understand how precision medicine and in particular AI can help delineate genes and environmental effect, pathophysiological traits, personalize the most suitable treatment to each individual, better predict cardioaortic surgical population health to improve policy-making and decision-making.

WHY MACHINE LEARNING IS NECESSARY FOR THE AORTIC SURGEON?

The ability of AI to automate and help in the clerical functions which are consuming in this day and age can be very much done by machine that are specifically built to automatically chart using speech recognition during a patient visit. This could free surgeons to return to talking to the patient rather than spending almost twice as much time on the laborious computerized notes keeping. This will enhance a better formulation of a diagnosis, and development of evidence-based algorithms providing more accurate differential diagnoses which is imperative in multidisciplinary approach that lacks coherence and evidence in current era.

Jeganathan et al demonstrated in a forward-thinking study that it is feasible to perform automated analyses of mitral valve with good reproducibility.[3] They used geometric parameters of mitral valve analysis without significant user's input. Ability to readily perform such clinically relevant measurements is likely to introduce more uniformity and accuracy into quantitative analyses avoiding individual biases which could cloud judgment and deter outcomes.

Artificial neural network and machines can learn specific tasks through repetition and iteration. This process is over seen by an observer to solidify the training process of the machine. In order to provide this training process, data and algorithms need to mirror real-world tasks and performance. Hence, rapid identification of patients at high risk of death may trigger additional therapeutic interventions, which in turn may change the course of the disease and improve prognosis. This concept can be liberally applied in aortic surgery. The coordinates to developing such mechanistic intelligence is known as "Deep learning"; currently, the most popular machine-learning paradigm, which resembles our profound learning abilities embedded in our brains. It can delve into our psychology and behavioral pattern and help guide in clinical decision-making to minimize error. The decision aid can be supplemented by mathematical principles including Bayes's theorem. This would assign initial probabilities to hypotheses based on our acquired knowledge and let this form of hypotheses be consistent with data collated rendering the most applicable depiction to support the original hypothesis and skimming those that are not.

The learning algorithms based on Bayesian inference and mathematical optimization with learning algorithms based on support vector machine[4] can apply their learning algorithms for different problems. Although the superintelligence form has yet to be unraveled, this concept would surely be helpful in complex decision-making and coupled with clinical expertise, it will improve the process for modern aortic surgeon optimizing the surgical outcome for patients involved.

THE SCEPTICS

There is always a chance that adversity between 2 cultures—computer vs the surgeon will lead to a middle man known as the sceptic. We are trained by apprenticeship; our years of training in the old system marginally had any exposure to the extravaganza of the high-tech showbiz we encounter today. The era of minimal approach, endovascular technology, and computer-generated AI in imaging modality have all vital role to play and are here to stay. Hence, we have to evolve and revolve around what technology brings us so we can lead and stay in the game. Better cosmetic to our patients and with less invasiveness, hospital length of stay yielding a cost-effective approach are the main features on commissioners' menus main dishes.

Human intelligence coupled with AI will promote centralized patient care and promote precision healthcare. Some have a disparate flavor to machine learning believing that AI presents no human interface and cannot be interrogated, even if its predictions are extraordinarily accurate. Well, AI can support, rather than replace our roles as good and caring clinicians, amplifying time to care and cost equally especially in an era where aging population is on the rise and care becomes more of an empathy rather than just provision. This may impact positively the relationship between patients and clinicians. A recent study investigated the predictive value of a machine-learning algorithm that "incorporates speckle-tracking echocardiographic data for automated discrimination of hypertrophic cardiomyopathy (HCM) from physiological hypertrophy seen in athletes."[5] The study's results showed a positive impact of machine-learning algorithms in assisting in "the discrimination of physiological versus pathological patterns of hypertrophic remodelling for automated interpretation of echocardiographic images, which may help novice readers with limited experience."[5]

AI IS HERE TO STAY

In an era where predictions and models were constructed to elicit far reach structures such as the blackhole, and with gene editing technology in business, with the predictive tool to outline risks and predict clinical outcomes and death, AI is manifesting itself in different shapes and forms. It is our sole responsibility to embrace this and educate our senses and instincts. John Elefteriades' group presenting to us the decision-making algorithm for

ascending aortic aneurysm,[6] which very much match an AI concept enhancing our thinking process and predictions of this dire and silent disease yielding to correctly identify both at-risk and safe patients and optimizing patient and surgeon clinical outcomes and expectations, respectively. AI and its forms of implementation via either supervised learning, unsupervised learning, machine learning, or cognitive computing have already seen the dawn of light and are here to stay.

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