Role of Artificial Intelligence in Cardiovascular Imaging

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Background

Advances in cardiovascular imaging is seeking to parallel to radiology which has been leading this field. The importance of artificial intelligence (AI) and machine learning (ML) in cardiovascular imaging lies in interpreting images rapidly, enabeling improved quality, preventing the interobserver and intraobserver interpretation variance, making quantification, reporting, diagnosis and risk prediction feasible (1).

Here we mention a plethora of studies having been published recently which examine its potential utility in various cardiac imaging techniques.

Ai in coronary Ct angiography

ML and especially Deep learning (DL) algorithms have shown to improve accuracy of diagnostic tests and prediction of cardiovascular diseases. As for idenification of coronary artery disease (CAD) Zreik et al. used DL in rest coronary CT angiograms of 166 patients to identify significant coronary artery stenosis and compared with invasive fractional flow reserve (FFR) measurements.The specificities and sensitivities reported were around 75% and 70% respectively, making it a possible alternative to invasive FFR (2).

As for prognostic evaluation the accuracy of classical AI to predict all-cause mortality at 5-year follow-up was evaluated in the CONFIRM registry together with all available clinical and visual CTA parameters. ML risk score demonstrated a significantly higher area under the curve (AUC 0.79) when compared with the Framingham Risk Score (AUC 0.61) and CTA severity scores (AUC 0.64) alone for predicting all cause mortality (3).

Also modeling and segmentation of all 4 heart valves and automatic quantitative evaluation of the complete valvular apparatus during minimally invasive valve implant procedures have been made feasible by AI embedded into cardiac CT (4).

AI in SPECT

As for the prediction of obstructive CAD on coronary angiography Arsanjani et al. used an AI model in automated single photon MPI analysis in 1181 patients and demonstrated an AUC as 0.94 for ML model which was higher than expert MPI reading (5).

In prognostic evaluation Betancur et al. found that the DL model using imaging with stress test data predicted MACE better than imaging data alone during 3.2±0.6 years follow-up in 2619 patients (area under the ROC curve:0.81 vs. 0.78) (6).

AI in MRI

For image segmentation and LV shape detection Avendi et al. used 45 MRI datasets together with AI and exhibited an %90 accuracy (7).

In individuals with pulmonary hypertension AI incorporated in cardiac MRI enabeling 3D cardiac motion was found to significantly improve the survival prediction when added to conventional imaging, clinical, haemodynamic and functional markers (AUC of 0.73 vs. 0.60, resp.) (8).

AI in echocardiography

AI is changing the landscape of echocardiography via instantenous assessment and fully automated measures, improving observer variation and generating accurate, consistent and automated interpretation (9). It recognises a wide range of patterns, allows the incorporation of currently unused data into the overall assessment of cardiac function and evaluates hidden relationships which at the end improve the accuracy of diagnosis (9, 10).

The current applications of echocardiography range from image acqusition to image analysis. Currently there are a number of widely-adopted commercial softwares developed for the functional analysis of 2DE data (e.g. EchoPAC by GE healthcare, QLAB by Philips etc.) (11). Furthermore automation with longitu-

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dinal strain and 3D echocardiography has already been incorporated into daily workflow (1). For image recognition Madani et al. used AI based on labeled still images and videos from 267 transthoracic echocardiograms with over 800.000 images. The model created accordingly was found to be able to classify 15 major echocardiography views with an overall accuracy of 97.8% and was able to diagnose structural disease from limited echocardiographic views (12).

As for classification of pathological patterns, Narula et al. used AI based model in 143 patients to differentiate between hypertrophic cardiomyopathy and physiologic hypertrophy and demonstrated the sensitivity and the specificity as 87% and 82% resp (13).

In 94 patients Sengupta et al.applied AI model for differentiating constrictive pericarditis from restrictive cardiomyopathy with multimodality imaging and pathology and showed an AUC of 0.962 and an accuracy of 93.7% (14).

Assessment of the left ventricular volume and function with automated quantification was one of the first applications of the AI to minimise error and variance. From 432 videoimages in 255 patients Knackstedt et al. used an AI model for the assessment of LV volumes and EF and found an 92.1% accuracy when compared with the reference manual tracking. Moreover they demonstrated that the left ventricular ejection fraction and longitudinal strain could be analysed in approximately 8 s reflecting the improved speed with AI (15).

For evaluating a heart failure with preserved EF, Sanchez-Martinez et al. showed that the AI using echocardiographic data may improve the diagnosis and clarification of heart failure with preserved EF (16).

Furthermore the AI models may aid in the assessment of valvular heart diseases. Such as for the quantification of MR, Moghaddasi H. et al used an AI model in 5004 frames and found an accuracy of 99.5%, 99.38%, 99.31% and 99.59% to detect none, mild, moderate,and severe mitral regurgitation resp (17).

Calleja et al demonstrated the ability of an AI model using 3DTEE and cardiac CT data with excellent reproducibility for quantifying and characterizing the distinctive anatomic changes of the aortic valve and the aortic root in patients with aortic regurgitation and severe aortic stenosis (18).

Regarding the wall motion abnormalities Raghavendra et al. used an AI model in 279 images and showed an accuracy of 0.75 (19).

One landmark echocardigraphy study was done by Zhang et al. where the authors successfully structured a fully automated echocardiogram interpretation program which included view identification, image segmentation, quantification of structure and function and detection of disease such as hypertrophic cardiomyopathy, cardiac amyloid, and pulmonary arterial hypertension via AI modeling and CNNs with great accuracy (20).

In spite of all these various data obtained from brilliant studies there are still some challenges remaining in terms of integration of the AI into the clinical routine cardiovascular imaging protocols.

The first difficulty arises from the the availability and secure dissemination of the data with high quality. This needs creating a bridge between cardiologists holding and using the data and IT community trying to analyze the data and create an effective model via AI. As the founding members of the Turkish Society of Cardiology Digital Cardiology Project Group our primary mission has focused on successfully overcoming this obstacle taking primarily the security of the data into account Secondly, there is the lack of standardization across the datasets and overcoming the sampling and observer selection bias seems cumbersome. Thus trustability of such a system may be questionable. Managing a conflict that may arise between AI and the physician will need great effort (11). Moreover there are legal issues such as who will be the regulator for this industry and who will be responsible for the mistakes arising in the delivery of care due to AI error in the AI based imaging? (11).

Following the clarification of these problems it is easy to assume that in the near future AI will be a routine application to aid the cardiologist in diagnosis and cardiologists having the capacity to manage AI will control and determine their capability (21).

Conflict of interest: None declared.

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