2. BÖLÜM

KARDİYOVASKÜLER GÖRÜNTÜLEME VE YAPAY ZEKA

İbrahim UYAR [1]

GİRİŞ

Kardiyovasküler hastalıklar dünya genelinde ölüm nedenleri arasında ilk sırada yer alır. Bu hastalıkların tanı, tedavi ve prognoz öngörüsünde daha az maliyet ve zaman kaybına yol açan yüksek doğruluk oranına sahip radyolojik incelemelere gereksinim vardır. Kardiyolojik problemleri olan hastaların değerlendirmesinde yapay zeka ile işlenmiş radyolojik görüntüler ve klinik verilerin kullanılması kardiyovasküler hastalıkların yönetiminde klinisyenlere yardımcı olabilir. Radyoloji, yapay zeka kullanımının en yoğun kullanıldığı disiplindir. Bu bölümde, yapay zekanın kardiyovasküler görüntüleme yöntemlerindeki (ekokardiyografi, bilgisayarlı tomografi, manyetik rezonans görüntüleme ve nükleer görüntüleme) kullanımı ve önemi vurgulamaktadır.

YAPAY ZEKA

Yapay zeka (YZ-*'artificial intelligence')*, bir bilgisayarın veya bilgisayar kontrolündeki bir robotun çeşitli işlevleri zeki canlılara benzer şekilde yerine getirme becerisi olarak tanımlanmıştır. Başka bir ifadeyle modelleşmiş makinelerin öğrenme, problem çözme ve toplanan verilere dayalı otonom karar verme gibi insan zihniyle ilişkilendirilen bilişsel işlevleri taklit etmesidir. YZ uygulamaları, geleneksel kural tabanlı *('rule-based')* bilgisayar algoritmalarından farklılık gösteren yeni algoritmalar ile makine öğreniminin (MÖ-*'machine learning')* sağlanması koşuluyla gerçekleştirilir (1). YZ; klinisyenler için pratik uygulamada pek mümkün olmayan sınırsız sayıdaki veriyi aynı anda gözlemleme,

[1] Op. Dr., İzmir Tepecik Eğitim ve Araştırma Hastanesi Kalp ve Damar Cerrahisi, druyar@yahoo.com

KAYNAKÇA

1. Russell SJ, Norvig P. Artificial intelligence: a modern approach. 2nd ed. Upper Saddle River, N.J.: Prentice Hall/Pearson Education; 2003.
2. Darcy AM, Louie AK, Roberts LW. Machine Learning and the Profession of Medicine. JAMA. 2016 Feb 9;315(6):551-2.
3. Shameer K, Johnson KW, Glicksberg BS, Dudley JT, Sengupta PP. Machine learning in cardiovascular medicine: are we there yet? Heart. 2018 Jul; 104(14):1156-64.
4. Johnson KW, Torres Soto J, Glicksberg BS, et al. Artificial Intelligence in Cardiology. J Am Coll Cardiol. 2018 Jun 12;71(23):2668-79.
5. Papanicolas I, Woskie LR, Jha AK. Health Care Spending in the United States and Other High-Income Countries. JAMA. 2018 Mar 13;319(10):1024-39.
6. Isla MC, Campello MV, Izquierdo C, et al.Image-Based Cardiac Diagnosis With Machine Learning: A ReviewFront. Cardiovasc. Med.24 January 2020, doi:10.3389/fcvm.2020.00001.
7. Dey D, Slomka PJ, Leeson P, et al. Artificial Intelligence in Cardiovascular Imaging: JACC State-of-the-Art Review. J Am Coll Cardiol. 2019 Mar 26;73(11):1317-35.
8. Lee JG, Jun S, Cho YW, et al. Deep Learning in Medical Imaging: General Overview. Korean J Radiol. 2017 Jul-Aug;18(4):570-84.
9. Madani A, Arnaout R, Mofrad M, Arnaout R. Fast and accurate view classification of echocardiograms using deep learning. NPJ Digit Med. 2018;1:6.
10. Zhang J, Gajjala S, Agrawal P, et al. Fully Automated Echocardiogram Interpretation in Clinical Practice. Circulation. 2018 Oct 16;138(16):1623-35.
11. Tabassian M, Alessandrini M, Herbots L, et al. Machine learning of the spatio-temporal characteristics of echocardiographic deformation curves for infarct classification. Int J Cardiovasc Imaging. 2017 Aug;33(8):1159-67.
12. Narula S, Shameer K, Salem Omar AM, Dudley JT, Sengupta PP. Machine-Learning Algorithms to Automate Morphological and Functional Assessments in 2D Echocardiography. J Am Coll Cardiol. 2016 Nov 29;68(21):2287-95.
13. Sengupta PP, Huang YM, Bansal M, et al. Cognitive Machine-Learning Algorithm for Cardiac Imaging: A Pilot Study for Differentiating Constrictive Pericarditis From Restrictive Cardiomyopathy. Circ Cardiovasc Imaging. 2016 Jun;9(6):e004330.
14. Kusunose K, Abe T, Haga A, et al. A Deep Learning Approach for Assessment of Regional Wall Motion Abnormality From Echocardiographic Images. JACC Cardiovasc Imaging. 2020 Feb;13(2 Pt 1):374-381.
15. Samad MD, Ulloa A, Wehner GJ, et al. Predicting Survival From Large Echocardiography and Electronic Health Record Datasets: Optimization With Machine Learning. JACC Cardiovasc Imaging. 2019 Apr;12(4):681-89.
16. Kang D, Dey D, Slomka PJ, et al. Structured learning algorithm for detection of nonobstructive and obstructive coronary plaque lesions from computed tomography angiography. J Med Imaging (Bellingham). 2015 Jan;2(1):014003.
17. Motwani M, Dey D, Berman DS, et al. Machine learning for prediction of all-cause mortality in patients with suspected coronary artery disease: a 5-year multicentre prospective registry analysis. Eur Heart J. 2017 Feb 14;38(7):500-7.
18. Haro Alonso D, Wernick MN, Yang Y, Germano G, Berman DS, Slomka P. Prediction of cardiac death after adenosine myocardial perfusion SPECT based on machine learning. J Nucl Cardiol. 2019 Oct;26(5):1746-54.
19. Shah SJ, Katz DH, Selvaraj S, et al. Phenomapping for novel classification of heart failure with preserved ejection fraction. Circulation. 2015 Jan 20;131(3):269-79.
20. Lancaster MC, Salem Omar AM, Narula S, Kulkarni H, Narula J, Sengupta PP. Phenotypic Clustering of Left Ventricular Diastolic Function Parameters: Patterns and Prognostic Relevance. JACC Cardiovasc Imaging. 2019 Jul;12(7 Pt 1):1149-61.

21. Krittanawong C, Tunhasiriwet A, Zhang H, Wang Z, Aydar M, Kitai T. Deep Learning With Unsupervised Feature in Echocardiographic Imaging. J Am Coll Cardiol. 2017 Apr 25;69(16):2100-1.
22. Feigenbaum H. Evolution of echocardiography. Circulation. 1996 Apr 1;93(7):1321-7.
23. Moghaddasi H, Nourian S. Automatic assessment of mitral regurgitation severity based on extensive textural features on 2D echocardiography videos. Comput Biol Med. 2016 Jun 1;73:47-55.
24. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur Heart J. 2016 Jul 14;37(27):2129-200.
25. Tabassian M, Sunderji I, Erdei T, et al. Diagnosis of Heart Failure With Preserved Ejection Fraction: Machine Learning of Spatiotemporal Variations in Left Ventricular Deformation. J Am Soc Echocardiogr. 2018 Dec;31(12):1272-84.e9.
26. Wolterink JM, Leiner T, Viergever MA, Isgum I. Generative Adversarial Networks for Noise Reduction in Low-Dose CT. IEEE Trans Med Imaging. 2017 Dec;36(12):2536-45.
27. Wolterink JM, Leiner T, de Vos BD, van Hamersvelt RW, Viergever MA, Isgum I. Automatic coronary artery calcium scoring in cardiac CT angiography using paired convolutional neural networks. Med Image Anal. 2016 Dec;34:123-36.
28. Zreik M, Leiner T, de Vos BD, van Hamersvelt RW, Viergever MA, Isgum I. Automatic Segmentation of the Left Ventricle in Cardiac Ct Angiography Using Convolutional Neural Networks. I S Biomed Imaging. 2016: 40-43.
29. Itu L, Rapaka S, Passerini T, et al. A machine-learning approach for computation of fractional flow reserve from coronary computed tomography. J Appl Physiol (1985). 2016 Jul 1;121(1):42-52.
30. Dey D, Gaur S, Ovrehus KA, et al. Integrated prediction of lesion-specific ischaemia from quantitative coronary CT angiography using machine learning: a multicentre study. Eur Radiol. 2018 Jun;28(6):2655-64.
31. Zreik M, Lessmann N, van Hamersvelt RW, et al. Deep learning analysis of the myocardium in coronary CT angiography for identification of patients with functionally significant coronary artery stenosis. Med Image Anal. 2018 Feb;44:72-85.
32. Coenen A, Kim YH, Kruk M, et al. Diagnostic Accuracy of a Machine-Learning Approach to Coronary Computed Tomographic Angiography-Based Fractional Flow Reserve: Result From the MACHINE Consortium. Circ Cardiovasc Imaging. 2018 Jun;11(6):e007217.
33. Tesche C, Vliegenthart R, Duguay TM, et al. Coronary Computed Tomographic Angiography-Derived Fractional Flow Reserve for Therapeutic Decision Making. Am J Cardiol. 2017 Dec 15;120(12):2121-7.
34. Siegersma KR, Leiner T, Chew DP, Appelman Y, Hofstra L, Verjans JW. Artificial intelligence in cardiovascular imaging: state of the art and implications for the imaging cardiologist. Neth Heart J. 2019 Sep;27(9):403-13.
35. van Rosendael AR, Maliakal G, Kolli KK, et al. Maximization of the usage of coronary CTA derived plaque information using a machine learning based algorithm to improve risk stratification; insights from the CONFIRM registry. J Cardiovasc Comput Tomogr. 2018 May - Jun;12(3):204-9.
36. Mannil M, Eberhard M, von Spiczak J et al. Artificial Intelligence and Texture Analysis in Cardiac Imaging. Current Cardiology Reports (2020) 22:131.
37. Winther HB, Hundt C, Schmidt B, et al. v-net: Deep Learning for Generalized Biventricular Mass and Function Parameters Using Multicenter Cardiac MRI Data. JACC Cardiovasc Imaging. 2018 Jul;11(7):1036-8.
38. Tan LK, Liew YM, Lim E, McLaughlin RA. Convolutional neural network regression for short-axis left ventricle segmentation in cardiac cine MR sequences. Med Image Anal. 2017 Jul;39:78-86.

39. Baessler B, Mannil M, Oebel S, Maintz D, Alkadhi H, Manka R. Subacute and Chronic Left Ventricular Myocardial Scar: Accuracy of Texture Analysis on Nonenhanced Cine MR Images. Radiology. 2018 Jan;286(1):103-112.
40. Dawes TJW, de Marvao A, Shi W, et al. Machine Learning of Three-dimensional Right Ventricular Motion Enables Outcome Prediction in Pulmonary Hypertension: A Cardiac MR Imaging Study. Radiology. 2017 May;283(2):381-90.
41. Samad MD, Wehner GJ, Arbabshirani MR, et al. Predicting deterioration of ventricular function in patients with repaired tetralogy of Fallot using machine learning. Eur Heart J Cardiovasc Imaging. 2018 Jul 1;19(7): 730-8.
42. Driessen RS, Raijmakers PG, Danad I, et al. Automated SPECT analysis compared with expert visual scoring for the detection of FFR-defined coronary artery disease. Eur J Nucl Med Mol Imaging. 2018 Jul;45(7):1091-1100.
43. Nakajima K, Kudo T, Nakata T, et al. Diagnostic accuracy of an artificial neural network compared with statistical quantitation of myocardial perfusion images: a Japanese multicenter study. Eur J Nucl Med Mol Imaging. 2017 Dec;44(13):2280-9.
44. Arsanjani R, Xu Y, Dey D, et al. Improved accuracy of myocardial perfusion SPECT for detection of coronary artery disease by machine learning in a large population. J Nucl Cardiol. 2013 Aug;20(4):553-62.
45. Betancur J, Commandeur F, Motlagh M, et al. Deep Learning for Prediction of Obstructive Disease From Fast Myocardial Perfusion SPECT: A Multicenter Study. JACC Cardiovasc Imaging. 2018 Nov;11(11):1654-63.
46. Arsanjani R, Dey D, Khachatryan T, et al. Prediction of revascularization after myocardial perfusion SPECT by machine learning in a large population. J Nucl Cardiol. 2015 Oct;22(5):877-84.
47. Betancur J, Otaki Y, Motwani M, et al. Prognostic Value of Combined Clinical and Myocardial Perfusion Imaging Data Using Machine Learning. JACC Cardiovasc Imaging. 2018 Jul;11(7):1000-9.