

BÖLÜM 4

KARDİYOVASKÜLER GÖRÜNTÜLEMEDE GÜNCEL YAKLAŞIMLAR

Özden SEÇKİN ¹

KARDİYAK GÖRÜNTÜLEME YÖNTEMLERİNE GİRİŞ

Kardiyovasküler hastalıklar, günümüzde tüm dünyada morbidite ve mortalitenin en önemli nedenlerinden birini oluşturmaktadır. Erken tanı, doğru risk sınıflaması ve uygun tedavi stratejisinin belirlenmesi; hastaların yaşam süresini uzatmanın yanı sıra yaşam kalitesini de doğrudan etkilemektedir (1). Bu süreçte görüntüleme teknikleri, kardiyolojinin temel taşlarından biri olarak öne çıkmaktadır. Modern kardiyoloji pratiğinde doğru tanıya ulaşmanın ve tedavi sürecini yönlendirmenin neredeyse hiçbir alanı görüntüleme yöntemlerinden bağımsız düşünülemez.

Kardiyak görüntüleme yalnızca anatomik yapıları değerlendirmekle kalmaz, aynı zamanda fonksiyonel kapasite, doku karakterizasyonu, hemodinamik parametreler ve prognoz hakkında da değerli bilgiler sunar (2). Günümüzde görüntüleme yöntemleri; ekokardiyografi, bilgisayarlı tomografi, manyetik rezonans görüntüleme, nükleer kardiyoloji teknikleri ve invazif yöntemler olmak üzere farklı modaliteleri kapsamakta, her biri kendine özgü avantaj ve sınırlılıklarla klinik karar sürecine katkıda bulunmaktadır.

Teknolojik gelişmelerle birlikte görüntüleme alanı da büyük bir dönüşüm yaşamaktadır. Artık tek bir yöntemin sınırlı bilgileri yerine, multimodal görüntüleme yaklaşımı giderek daha fazla önem kazanmıştır (2). Aynı hastada farklı yöntemlerden elde edilen verilerin bütünleştirilmesi, hem tanısal doğruluğu artırmakta hem de bireyselleştirilmiş tedavi planlarının oluşturulmasına olanak sağlamaktadır. Özellikle kompleks kardiyomiyopatiler, yapısal kalp hastalıkları, kardiyonkoloji ve pulmoner hipertansiyon gibi multidisipliner değerlendirme gerektiren alanlarda bu yaklaşımın yeri tartışmasız hale gelmiştir.

¹ Dr. Öğr. Üyesi, Gazi Üniversitesi, Tıp Fakültesi, Kardiyoloji AD., ozden-seckin@hotmail.com, ORCID iD: 0000-0001-7385-4419

SONUÇ

Kardiyak görüntüleme, modern kardiyolojinin yalnızca tamamlayıcı bir unsuru değil, klinik kararların merkezinde yer alan vazgeçilmez bir bileşenidir. Günümüzde kullanılan farklı modaliteler, kalbin anatomisini, fonksiyonunu ve biyolojik süreçlerini benzersiz ayrıntılarla gözler önüne sermektedir. Bu yöntemler sayesinde hastalıkların tanısı daha erken konulabilmekte, tedavi stratejileri daha doğru planlanmakta ve prognoz öngörülerini daha güvenilir hale gelmektedir.

Multimodal yaklaşımın giderek güçlenmesi, tek bir görüntüleme yöntemine dayalı kararların ötesine geçilmesini sağlamış, klinisyene hasta özelinde en doğru yol haritasını çizme imkânı tanımıştır. Bu bütüncül bakış açısı, yalnızca bireysel hasta yönetimini değil, aynı zamanda kardiyolojinin gelecekteki gelişim yönünü de şekillendirmektedir.

Sonuç olarak kardiyak görüntüleme, yalnızca kalbin yapısını ve işlevini gösteren bir pencere değil, aynı zamanda klinisyenlere hastanın yaşam yolculuğuna dair öngörüler sunan güçlü bir rehberdir. Teknolojinin ilerlemesiyle birlikte bu rehber daha da keskinleşecek, kişiselleştirilmiş tıp anlayışını destekleyen vazgeçilmez bir dayanak olmaya devam edecektir.

KAYNAKLAR

1. Woodruff RC, Tong X, Khan SS, Shah NS, Jackson SL, Loustalot F, et al. Trends in cardiovascular disease mortality rates and excess deaths, 2010–2022. *American journal of preventive medicine*. 2024;66(4):582-9.
2. Bullock-Palmer RP, Flores Rosario K, Douglas PS, Hahn RT, Lang RM, Chareonthaitawee P, et al. Multimodality cardiac imaging and the imaging workforce in the United States: diversity, disparities, and future directions. *Circulation: Cardiovascular Imaging*. 2024;17(2):e016409.
3. Bunting KV, Steeds RP, Slater K, Rogers JK, Gkoutos GV, Kotecha D. A practical guide to assess the reproducibility of echocardiographic measurements. *Journal of the American Society of Echocardiography*. 2019;32(12):1505-15.
4. Savage D, Drayer J, Henry W, Mathews Jr E, Ware J, Gardin J, et al. Echocardiographic assessment of cardiac anatomy and function in hypertensive subjects. *Circulation*. 1979;59(4):623-32.
5. Savage DD, Henry WL, Eastman RC, Borer JS, Gorden P. Echocardiographic assessment of cardiac anatomy and function in acromegalic patients. *The American journal of medicine*. 1979;67(5):823-9.
6. Griffie MJ, Merkel MJ, Wei KS. The role of echocardiography in hemodynamic assessment of septic shock. *Critical care clinics*. 2010;26(2):365-82.
7. Keller M, Magunia H, Rosenberger P, Koeppen M. Echocardiography as a tool to assess cardiac function in critical care—a review. *Diagnostics*. 2023;13(5):839.
8. Mitchell C, Rahko PS, Blauwet LA, Canaday B, Finstuen JA, Foster MC, et al. Guidelines for performing a comprehensive transthoracic echocardiographic examination in adults: recommendations from the American Society of Echocardiography. *Journal of the American Society of Echocardiography*. 2019;32(1):1-64.
9. Wood PW, Choy JB, Nanda NC, Becher H. Left ventricular ejection fraction and volumes: it depends on the imaging method. *Echocardiography*. 2014;31(1):87-100.

10. Kaul S, Tei C, Hopkins JM, Shah PM. Assessment of right ventricular function using two-dimensional echocardiography. *American heart journal*. 1984;107(3):526-31.
11. Nagueh SF, Smiseth OA, Appleton CP, Byrd BF, Dokainish H, Edvardsen T, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *European Journal of Echocardiography*. 2016;17(12):1321-60.
12. Siegel RJ, Luo H, Makar M, Beigel R. Optimal use of echocardiography in valvular heart disease evaluation. *Heart*. 2015;101(12):977-86.
13. Pepi M, Muratori M. Echocardiography in the diagnosis and management of pericardial disease. *Journal of Cardiovascular Medicine*. 2006;7(7):533-44.
14. Parasuraman S, Walker S, Loudon BL, Gollop ND, Wilson AM, Lowery C, et al. Assessment of pulmonary artery pressure by echocardiography—a comprehensive review. *IJC Heart & Vasculture*. 2016;12:45-51.
15. Park J-H, Marwick TH. Use and limitations of E/e' to assess left ventricular filling pressure by echocardiography. *Journal of cardiovascular ultrasound*. 2011;19(4):169-73.
16. Sanders SP, Yeager S, Williams RG. Measurement of systemic and pulmonary blood flow and QP/QS ratio using Doppler and two-dimensional echocardiography. *The American journal of cardiology*. 1983;51(6):952-6.
17. Gottdiener JS, Bednarz J, Devereux R, Gardin J, Klein A, Manning WJ, et al. American Society of Echocardiography recommendations for use of echocardiography in clinical trials: a report from the american society of echocardiography's guidelines and standards committee and the task force on echocardiography in clinical trials. *Journal of the American Society of Echocardiography*. 2004;17(10):1086-119.
18. Malik SB, Chen N, Parker III RA, Hsu JY. Transthoracic echocardiography: pitfalls and limitations as delineated at cardiac CT and MR imaging. *Radiographics*. 2017;37(2):383-406.
19. Picano E, Pierard L, Peteiro J, Djordjevic-Dikic A, Sade LE, Cortigiani L, et al. The clinical use of stress echocardiography in chronic coronary syndromes and beyond coronary artery disease: a clinical consensus statement from the European Association of Cardiovascular Imaging of the ESC. *European Heart Journal-Cardiovascular Imaging*. 2024;25(2):e65-e90.
20. Graham F, Dobbin S, Sooriyakanthan M, Tsang W. Evolving standards in prosthetic heart valve assessment with cardiovascular imaging: Key changes in the 2024 American Society of Echocardiography Guidelines. *Structural Heart*. 2025;9(4):100372.
21. Ostrominski JW, DeFilippis EM, Bansal K, Riello III RJ, Bozkurt B, Heidenreich PA, et al. Contemporary American and European guidelines for heart failure management: JACC: heart failure guideline comparison. *Heart Failure*. 2024;12(5):810-25.
22. Praz F, Beyersdorf F, Haugaa K, Prendergast B. Valvular heart disease: from mechanisms to management. *The Lancet*. 2024;403(10436):1576-89.
23. Prager R, Bowdridge J, Pratte M, Cheng J, McInnes MD, Arntfield R. Indications, clinical impact, and complications of critical care transesophageal echocardiography: a scoping review. *Journal of Intensive Care Medicine*. 2023;38(3):245-72.
24. MacKay EJ, Zhang B, Augoustides JG, Groeneveld PW, Desai ND. Association of intraoperative transesophageal echocardiography and clinical outcomes after open cardiac valve or proximal aortic surgery. *JAMA Network Open*. 2022;5(2):e2147820-e.
25. Lancellotti P, Pellikka PA, Budts W, Chaudhry FA, Donal E, Dulgheru R, et al. The clinical use of stress echocardiography in non-ischaemic heart disease: recommendations from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *European Heart Journal-Cardiovascular Imaging*. 2016;17(11):1191-229.
26. Picano E, Sicari R. Stress echocardiography. *Clinical Echocardiography*. 2011:149-65.
27. Bhatia VK, Senior R. Contrast echocardiography: evidence for clinical use. *Journal of the American Society of Echocardiography*. 2008;21(5):409-16.
28. Niemann PS, Pinho L, Balbach T, Galuschky C, Blankenhagen M, Silberbach M, et al. Anatomically oriented right ventricular volume measurements with dynamic three-dimensional

- echocardiography validated by 3-Tesla magnetic resonance imaging. *Journal of the American College of Cardiology*. 2007;50(17):1668-76.
29. Hung J, Lang R, Flachskampf F, Shernan SK, McCulloch ML, Adams DB, et al. 3D echocardiography: a review of the current status and future directions. *Journal of the American Society of Echocardiography*. 2007;20(3):213-33.
 30. Mondillo S, Galderisi M, Mele D, Cameli M, Lomoriello VS, Zacà V, et al. Speckle-tracking echocardiography: a new technique for assessing myocardial function. *Journal of ultrasound in medicine*. 2011;30(1):71-83.
 31. Quintana RA, Bui LP, Moudgil R, Palaskas N, Hassan S, Abe J-i, et al. Speckle-tracking echocardiography in cardio-oncology and beyond. *Texas Heart Institute Journal*. 2020;47(2):96-107.
 32. Longobardo L, Suma V, Jain R, Carerj S, Zito C, Zwicke DL, et al. Role of two-dimensional speckle-tracking echocardiography strain in the assessment of right ventricular systolic function and comparison with conventional parameters. *Journal of the American Society of Echocardiography*. 2017;30(10):937-46. e6.
 33. Flohr TG, Raupach R, Bruder H. Cardiac CT: how much can temporal resolution, spatial resolution, and volume coverage be improved? *Journal of cardiovascular computed tomography*. 2009;3(3):143-52.
 34. Pontone G, Bertella E, Mushtaq S, Loguerchio M, Cortinovis S, Baggiano A, et al. Coronary artery disease: diagnostic accuracy of CT coronary angiography—a comparison of high and standard spatial resolution scanning. *Radiology*. 2014;271(3):688-94.
 35. Members WC, Gulati M, Levy PD, Mukherjee D, Amsterdam E, Bhatt DL, et al. 2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR guideline for the evaluation and diagnosis of chest pain: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Journal of the American College of Cardiology*. 2021;78(22):e187-e285.
 36. Knuuti J, Wijns W, Saraste A, Capodanno D, Barbato E, Funck-Brentano C, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes: The Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC). *European heart journal*. 2020;41(3):407-77.
 37. Maurovich-Horvat P, Ferencik M, Voros S, Merkely B, Hoffmann U. Comprehensive plaque assessment by coronary CT angiography. *Nature Reviews Cardiology*. 2014;11(7):390-402.
 38. Shaw LJ, Narula J. Risk assessment and predictive value of coronary artery disease testing. *Journal of Nuclear Medicine*. 2009;50(8):1296-306.
 39. Bild DE, Bluemke DA, Burke GL, Detrano R, Diez Roux AV, Folsom AR, et al. Multi-ethnic study of atherosclerosis: objectives and design. *American journal of epidemiology*. 2002;156(9):871-81.
 40. Pletcher MJ, Tice JA, Pignone M, Browner WS. Using the coronary artery calcium score to predict coronary heart disease events: a systematic review and meta-analysis. *Archives of internal medicine*. 2004;164(12):1285-92.
 41. George RT, Arbab-Zadeh A, Cerci RJ, Vavere AL, Kitagawa K, Dewey M, et al. Diagnostic performance of combined noninvasive coronary angiography and myocardial perfusion imaging using 320-MDCT: the CT angiography and perfusion methods of the CORE320 multicenter multinational diagnostic study. *American Journal of Roentgenology*. 2011;197(4):829-37.
 42. Ko BS, Cameron JD, Munnur RK, Wong DT, Fujisawa Y, Sakaguchi T, et al. Noninvasive CT-derived FFR based on structural and fluid analysis: a comparison with invasive FFR for detection of functionally significant stenosis. *JACC: Cardiovascular Imaging*. 2017;10(6):663-73.
 43. Achenbach S, Delgado V, Hausleiter J, Schoenhagen P, Min JK, Leipsic JA. SCCT expert consensus document on computed tomography imaging before transcatheter aortic valve implantation (TAVI)/transcatheter aortic valve replacement (TAVR). *Journal of cardiovascular computed tomography*. 2012;6(6):366-80.
 44. Benz DC, Ersözlü S, Mojon FL, Messerli M, Mitulla AK, Ciancone D, et al. Radiation dose reduction with deep-learning image reconstruction for coronary computed tomography angi-

- ography. *European Radiology*. 2022;32(4):2620-8.
45. Srinivas-Rao S, Cao J, Marin D, Kambadakone A. Dual-energy computed tomography to photon counting computed tomography: emerging technological innovations. *Radiologic Clinics*. 2023;61(6):933-44.
 46. Lima JA, Desai MY. Cardiovascular magnetic resonance imaging: current and emerging applications. *Journal of the American College of Cardiology*. 2004;44(6):1164-71.
 47. Shehata ML, Cheng S, Osman NF, Bluemke DA, Lima JA. Myocardial tissue tagging with cardiovascular magnetic resonance. *Journal of Cardiovascular Magnetic Resonance*. 2009;11(1):55.
 48. Al-Saadi N, Nagel E, Gross M, Bornstedt A, Schnackenburg B, Klein C, et al. Noninvasive detection of myocardial ischemia from perfusion reserve based on cardiovascular magnetic resonance. *Circulation*. 2000;101(12):1379-83.
 49. Hachamovitch R, Hayes S, Friedman JD, Cohen I, Shaw LJ, Germano G, et al. Determinants of risk and its temporal variation in patients with normal stress myocardial perfusion scans: what is the warranty period of a normal scan? *Journal of the American College of Cardiology*. 2003;41(8):1329-40.
 50. Mouden M, Timmer JR, Ottervanger JP, Reiffers S, Oostdijk AH, Knollemans S, et al. Impact of a new ultrafast CZT SPECT camera for myocardial perfusion imaging: fewer equivocal results and lower radiation dose. *European journal of nuclear medicine and molecular imaging*. 2012;39(6):1048-55.
 51. Di Carli MF, Dorbala S, Meserve J, El Fakhri G, Sitek A, Moore SC. Clinical myocardial perfusion PET/CT. *Journal of Nuclear Medicine*. 2007;48(5):783-93.
 52. Skali H, Schulman AR, Dorbala S. 18F-FDG PET/CT for the assessment of myocardial sarcoidosis. *Current cardiology reports*. 2013;15(4):370.
 53. Marchesseau S, Seneviratna A, Sjöholm AT, Qin DL, Ho JX, Hausenloy DJ, et al. Hybrid PET/CT and PET/MRI imaging of vulnerable coronary plaque and myocardial scar tissue in acute myocardial infarction. *Journal of Nuclear Cardiology*. 2018;25(6):2001-11.
 54. Kelly JM, Babich JW. PET tracers for imaging cardiac function in cardio-oncology. *Current cardiology reports*. 2022;24(3):247-60.
 55. Daubert MA, Tailor T, James O, Shaw LJ, Douglas PS, Kowalek L. Multimodality cardiac imaging in the 21st century: evolution, advances and future opportunities for innovation. *The British Journal of Radiology*. 2021;94(1117):20200780.
 56. Nahrendorf M, Sosnovik DE, French BA, Swirski FK, Bengel F, Sadeghi MM, et al. Multimodality cardiovascular molecular imaging, Part II. *Circulation: Cardiovascular Imaging*. 2009;2(1):56-70.
 57. Sermesant M, Delingette H, Cochet H, Jaïs P, Ayache N. Applications of artificial intelligence in cardiovascular imaging. *Nature Reviews Cardiology*. 2021;18(8):600-9.
 58. Lim KHA, Loo ZY, Goldie SJ, Adams JW, McMenamin PG. Use of 3D printed models in medical education: A randomized control trial comparing 3D prints versus cadaveric materials for learning external cardiac anatomy. *Anatomical sciences education*. 2016;9(3):213-21.