

BÖLÜM 17



MİTRAL KAPAK CERRAHİ HASTALIKLARI

Zülfiye KUZU¹

MITRAL KAPAK ANATOMİSİ

Mitral kapak (MV), mitral halka, subvalvüler aparat, ön ve arka yaprakçıklar, korda tendinea ve papiller kaslardan oluşmaktadır. Bu yapılar, kalp döngüsü boyunca kapanmayı ve açılmayı sağlamak için eş zamanlı olarak çalışır

Mitral Halka

Mitral halka, kapak ağzının çevresini ve kapağın tabanını çevreleyen ve onu sol kalp içinde sabitleyen bir fibröz doku halkasıdır (1). Aort kapağına bitişik olup, sol koroner ve aort anulusunun koroner olmayan çıkıntılarının yarısı ile fibröz bir sürekliliği paylaşır (2, 3). Şekli ve çapı, kalp döngüsü sırasında değişir (4), onu dinamik bir yapı haline getirir: diyastolde, anulus daha dairesel bir şekle sahipken, sistolde, sistol ile eşzamanlı olarak düzlemsel olmayan bir eyer şekline dönüşür

Mitral Kapak

Mitral kapak, geometrik biçimlerine ve halkayla olan anatomik bağlantılarına göre, ön mitral kapakçık (AML) ve posterior mitral yaprakçık (PML), komissural kısımlara ayrılır (1,5). Her

kapakçıkta üç bölge bulunur: önde A1-A3 ve arkada P1-P3. Arka yaprakçık yarım ay şeklindedir ve ön yaprakçığa kıyasla nispeten kısa bir radyal uzunluğa sahiptir. Ön yaprakçık ise kubbe şeklinde, daha uzun ve daha kalındır (1,2). Sistolde, her iki yaprağın serbest kenarı birleşerek valfi kapatır, diyastolde ise serbest kenarlar ayrılır ve valf açılır (2,5). Her iki yaprakçığın doku özellikleri de bölgeye göre değişir: orta kısım daha ince ve pürüzsüzken, serbest kenarlara doğru doku daha kalın ve pürüzlü hale gelir (1,5,6). Posterior yaprakçık ayrıca, bazal bölge olarak adlandırılan, halkanın yakınında bir korda bağlanma alanına sahiptir (7). Her iki yaprakçıkta da dört histolojik katmandan oluşur. Sol atriyuma bitişik olan en üstteki, esas olarak hizalanmış elastik/kollajen liflerden oluşan esas tabakadır. Atriyalin altında, serbest kenarın çoğunluğunu oluşturan elastik liflerle birlikte proteoglikanlar ve glikozinglikanlardan oluşan hücre dışı bir matristen oluşan spongioza bulunur. Spongiozanın altında, hizalanmış kollajen lifleri ile her bir yaprağın merkezi yapısal kollajenöz çekirdeğini oluşturan ana yük taşıyan bir tabaka olan fibroza bulunur. Son olarak, ventriküler tabaka, elastik ve kollajen liflerle katlanmış sürekli bir endotelial hücre tabakası ile kaplanır (5).

¹ Uzm. Dr., Kayseri Şehir Hastanesi, Kardiyoloji Kliniği, zulfiyekuzu07@hotmail.com



KAYNAKLAR

1. Dal-Bianco, J.P. and Levine, R.A. (2013) Anatomy of the mitral valve apparatus: role of 2D and 3D echocardiography. *Cardiology Clinics*, 31, 151–164.
2. Ranganathan, N., Lam, J.H., Wigle, E.D. and Silver, M.D. (1970) Morphology of the human mitral valve. II. The valve leaflets. *Circulation*, 41, 459–467.
3. Veronesi, F., Corsi, C., Sugeng, L., Mor-Avi, V., Caiani, E.G., Weinert, L., et al. (2009) A study of functional anatomy of aortic-mitral valve coupling using 3D matrix transesophageal echocardiography. *Circulation: Cardiovascular Imaging*, 2, 24–31
4. Jiang, L., Owais, K., Matyal, R., Khabbaz, K.R., Liu, D.C., Montealegre-Gallegos, M., et al. (2014) Dynamism of the mitral annulus: a spatial and temporal analysis. *Journal of Cardiothoracic and Vascular Anesthesia*, 28, 1191–1197.
5. McCarthy, K.P., Ring, L. and Rana, B.S. (2010) Anatomy of the mitral valve: understanding the mitral valve complex in mitral regurgitation. *European Journal of Echocardiography*, 11, i3–9.
6. Al-Atabi, M., Espino, D.M., Hukins, D.W. and Buchan, K.G. (2012) Biomechanical assessment of surgical repair of the mitral valve. *Proceedings of the Institution of Mechanical Engineers. Part H. Journal of Engineering in Medicine*, 226, 275–287
7. Lam, J.H., Ranganathan, N., Wigle, E.D. and Silver, M.D. (1970) Morphology of the human mitral valve. I. Chordae tendineae: a new classification. *Circulation*, 41, 449–458.
8. Rusted IE, Scheffley CH, Edwards JE. Studies of the mitral valve. I. Anatomic features of the normal mitral valve and associated structures. *Circulation*. 1952 Dec;6(6):825-31.
9. Victor S, Nayak VM. Variations in the papillary muscles of the normal mitral valve and their surgical relevance. *J Card Surg*. 1995 Sep;10(5):597-607.
10. Komeda M, Glasson JR, Bolger AF, Daughters GT, Ingels NB, Miller DC. Papillary muscle-left ventricular wall “complex”. *J Thorac Cardiovasc Surg*. 1997 Feb;113(2):292-300; discussion 300-1.
11. Chiechi MA, Lees WM, Thompson R. Functional anatomy of the normal mitral valve. *J Thorac Surg*. 1956 Sep;32(3):378-98.
12. Burch GE, Giles TD. Angle of traction of the papillary muscles in normal and dilated hearts: a theoretical analysis of its importance in mitral valve dynamics. *Am Heart J*1972;84:141–4)
13. Iung B, Vahanian A. Epidemiology of acquired valvular heart disease. *Can J Cardiol* 2014;30:962_970
14. Carabello BA. Modern management of mitral stenosis. *Circulation* 2005;112:432–7.
15. Ranjan Rupesh, Pressman Gregg S. Aetiology and epidemiology of mitral stenosis [Internet]. Vol. 16. [cited 2020 Apr 29]. Available from: <https://www.escardio.org/Journals/E-Journal-of-Cardiology-Practice/Volume-16/Aetiology-and-epidemiology-of-mitral-stenosis>, <https://www.escardio.org/Journals/E-Journal-of-Cardiology-Practice/Volume-16/Aetiology-and-epidemiology-of-mitral-stenosis>
16. Yadgir S, Johnson CO, Aboyans V, Adebayo OM, Adedoyin RA, Afarideh M, et al Burden of Disease Study Nonrheumatic Valve Disease Collaborators. Global, regional, and national burden of calcific aortic valve and degenerative mitral valve diseases, 1990-2017. *Circulation* 2020;141:1670_1680.
17. Abramowitz Y, Jilaihawi H, Chakravarty T, Mack MJ, Makkar RR. Mitral annulus calcification. *J Am Coll Cardiol* 2015;66:1934_1941.
18. Desnos C, Iung B, Himbert D, Ducrocq G, Urena M, Cormier B, Brochet E, OuP, Vahanian A, Bouleti C. Temporal trends on percutaneous mitral commissurotomy: 30 years of experience. *J Am Heart Assoc* 2019;8:e012031.
19. Bertrand PB, Mihos CG, Yucel E. Mitral annular calcification and calcific mitral stenosis: therapeutic challenges and considerations. *Curr Treat Options Cardiovasc Med* 2019;21:19.
20. Lancellotti P, Nkomo VT, Badano LP, et al. Expert consensus for multi-modality imaging evaluation of cardiovascular complications of radiotherapy in adults: a report from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *J Am Soc Echocardiogr* 2013;26:1013–32.
21. Morris MF, Maleszewski JJ, Suri RM, et al. CT and MR imaging of the mitral valve: radiologic-pathologic correlation. *RadioGraphics* 2010;30:1603–20.
22. Baumgartner H, Hung J, Bermejo J, et al. Echocardiographic assessment of valvular stenosis: EAE/ASE recommendations for clinical practice. *J Am Soc Echocardiogr* 2009;22:1–23.
23. Lin SJ, Brown PA, Watkins MP, et al. Quantification of stenotic mitral valve area with magnetic resonance imaging and comparison with Doppler ultrasound. *J Am Coll Cardiol* 2004;44:133–7.

24. Salerno M, Sharif B, Arheden H, et al. Recent advances in cardiovascular magnetic resonance: techniques and applications. *Circ Cardiovasc Imaging* [Internet 2017;10. Jun [cited 2020 Apr 29] Available from <https://www.ahajournals.org/doi/10.1161/CIRCIMAGING.116.003951>.
25. Dill T. Contraindications to magnetic resonance imaging. *Heart* 2008;94:943–8.
26. Kim JY, Kim SH, Myong JP, Kim YR, Kim TS, Kim JH, Jang SW, Oh YS, Lee MY, Rho TH. Outcomes of direct oral anticoagulants in patients with mitral stenosis. *J Am Coll Cardiol* 2019;73:1123_1131.
27. Bouleti C, Iung B, Laouenan C, Himbert D, Brochet E, Messika-Zeitoun D, Detaint D, Garbarz E, Cormier B, Michel PL, Mentre F, Vahanian A. Late results of percutaneous mitral commissurotomy up to 20 years: development and validation of a risk score predicting late functional results from a series of 912 patients. *Circulation* 2012;125:2119_2127.
28. Wilkins GT, Weyman AE, Abascal VM, Block PC, Palacios IF. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. *Br Heart J* 1988;60:299_308.
29. Desnos C, Iung B, Himbert D, Ducrocq G, Urena M, Cormier B, Brochet E, Ou P, Vahanian A, Bouleti C. Temporal trends on percutaneous mitral commissurotomy: 30 years of experience. *J Am Heart Assoc* 2019;8:e012031.
30. Song H, Kang DH, Kim JH, Park KM, Song JM, Choi KJ, Hong MK, Chung CH, Song JK, Lee JW, Park SW, Park SJ. Percutaneous mitral valvuloplasty versus surgical treatment in mitral stenosis with severe tricuspid regurgitation. *Circulation* 2007;116:1246_250.
31. Nunes MC, Tan TC, Elmariah S, do Lago R, Margey R, Cruz-Gonzalez I, Zheng H, Handschumacher MD, Inglessis I, Palacios IF, Weyman AE, Hung J. The echo score revisited: impact of incorporating commissural morphology and leaflet displacement to the prediction of outcome for patients undergoing percutaneous mitral valvuloplasty. *Circulation* 2014;129:886_895.
32. Tomai F, Gaspardone A, Versaci F, Ghini AS, Altamura L, De Luca L, Gioffre G, Gioffre PA. Twenty year follow-up after successful percutaneous balloon mitral valvuloplasty in a large contemporary series of patients with mitral stenosis. *Int J Cardiol* 2014;177:881_885.
33. Bouleti C, Iung B, Himbert D, Messika-Zeitoun D, Brochet E, Garbarz E, Cormier B, Vahanian A. Relationship between valve calcification and long-term results of percutaneous mitral commissurotomy for rheumatic mitral stenosis. *Circ Cardiovasc Interv* 2014;7:381_389.
34. Abramowitz Y, Kazuno Y, Chakravarty T, Kawamori H, Maeno Y, Anderson D, Allison Z, Mangat G, Cheng W, Gopal A, Jilaihawi H, Mack MJ, Makkar RR. Concomitant mitral annular calcification and severe aortic stenosis: prevalence, characteristics and outcome following transcatheter aortic valve replacement. *Eur Heart J* 2017;38:1194_1203.
35. Nishimura RA, Vahanian A, Eleid MF, Mack MJ. Mitral valve disease: current management and future challenges. *Lancet* 2016;387:1324_1334.
36. Alexis SL, Malik AH, El-Eshawi A, George I, Sengupta A, Kodali SK, Hahn RT, Khalique OK, Zaid S, Guerrero M, Bapat VN, Leon MB, Adams DH, Tang GHL. Surgical and transcatheter mitral valve replacement in mitral annular calcification: a systematic review. *J Am Heart Assoc* 2021;10:e018514.
37. Okuno T, Brugger N, Asami M, Heg D, Siontis GCM, Winkel MG, Lanz J, Grani C, Huber A, Stortecky S, George I, Kodali S, Pilgrim T, Windecker S, Khalique OK, Praz F. Clinical impact of mitral calcium volume in patients undergoing transcatheter aortic valve implantation. *J Cardiovasc Comput Tomogr* 2021;15:356_365.
38. Urena M, Himbert D, Brochet E, Carrasco JL, Iung B, Nataf P, Vahanian A. Transseptal transcatheter mitral valve replacement using balloon-expandable transcatheter heart valves: a step-by-step approach. *JACC Cardiovasc Interv* 2017;10:1905_1919.
39. Sud K, Agarwal S, Parashar A, Raza MQ, Patel K, Min D, Rodriguez LL, Krishnaswamy A, Mick SL, Gillinov AM, Tuzcu EM, Kapadia SR. Degenerative mitral stenosis: unmet need for percutaneous interventions. *Circulation* 2016;133:1594_1604.
40. Guerrero M, Urena M, Himbert D, Wang DD, Eleid M, Kodali S, George I, Chakravarty T, et al. O'Neill W, Feldman T. 1-Year outcomes of transcatheter mitral valve replacement in patients with severe mitral annular calcification. *J Am Coll Cardiol* 2018;71:1841_1853.
41. Yoon SH, Whisenant BK, Bleiziffer S, Delgado V, Dhoble A, Schofer N, et al. Outcomes of tran-

- scatheter mitral valve replacement for degenerated bioprostheses, failed annuloplasty rings, and mitral annular calcification. *Eur Heart J* 2019;40:441_451.
42. Guerrero M, Vemulapalli S, Xiang Q, Wang DD, Eleid M, Cabalka AK, Sandhu et. Al. Thirty-day outcomes of transcatheter mitral valve replacement for degenerated mitral bioprostheses (valve-in-valve), failed surgical rings (valve-in-ring), and native valve with severe mitral annular calcification (valve-in-mitral annular calcification) in the United States: data from the Society of Thoracic Surgeons/American College of Cardiology/Transcatheter Valve Therapy Registry. *Circ Cardiovasc Interv* 2020;13:e008425.
 43. Wang DD, Guerrero M, Eng MH, Eleid MF, Meduri CU, Rajagopal V, Yadav PK, et al. Alcohol septal ablation to prevent left ventricular outflow tract obstruction during transcatheter mitral valve replacement: first-in-man study. *JACC Cardiovasc Interv* 2019;12:1268_1279.
 44. Khan JM, Babaliaros VC, Greenbaum AB, Foerster JR, Yazdani S, McCabe JM, et al. Anterior leaflet laceration to prevent ventricular outflow tract obstruction during transcatheter mitral valve replacement. *J Am Coll Cardiol* 2019;73:2521_2534.
 45. Praz F, Khalique OK, Lee R, Veeragandham R, Russell H, Guerrero M, Islam et al. George I. Transcatheter implantation of a transcatheter heart valve for severe mitral annular calcification. *J Thorac Cardiovasc Surg* 2018;156:132_142.
 46. Lung B, Delgado V, Rosenhek R, Price S, Prendergast B, Wendler O, De Bonis M, et al. Contemporary presentation and management of valvular heart disease: The EURObservational Research Programme Valvular Heart Disease II Survey. *Circulation* 2019;140:1156_1169.
 47. Cahill TJ, Prothero A, Wilson J, Kennedy A, Brubert J, Masters M, Newton JD, Dawkins S, Enriquez-Sarano M, Prendergast BD, Myerson SG. Community prevalence, mechanisms and outcome of mitral or tricuspid regurgitation. *Heart* 2021;doi: 10.1136/heartjnl-2020-318482.
 48. De Bonis M, Al-Attar N, Antunes M, Borger M, Casselman F, Falk V, et al. Surgical and interventional management of mitral valve regurgitation: a position statement from the European Society of Cardiology Working Groups on Cardiovascular Surgery and Valvular Heart Disease. *Eur Heart J* 2016;37:133–139.
 49. Dziadzko V, Dziadzko M, Medina-Inojosa JR, Benfari G, Michelena HI, Crestanello JA, Maalouf J, Thapa P, Enriquez-Sarano M. Causes and mechanisms of isolated mitral regurgitation in the community: clinical context and outcome. *Eur Heart J* 2019;40:2194_2202.
 50. Kingue S, Ba SA, Balde D, Diarra MB, Anzouan-Kacou JB, Anisubia B, Damorou JM, Ndobu P, Menanga A, Kane A, Kakou-Guikahue M, Kenfack M, Metogo B, Chelo D, Yangnigni E, Tantchou C, Bertrand E, Monsuez JJ, Working Group on Tropical Cardiology of the Société française de cardiologie. The VALVAFRIC study: a registry of rheumatic heart disease in Western and Central Africa. *Arch Cardiovasc Dis* 2016;109:321_329.
 51. Habib G, Lancellotti P, Antunes MJ, Bongiorni MG, Casalta JP, Del Zotti F, et al. ESC Scientific Document Group. 2015 ESC Guidelines for the management of infective endocarditis: The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC). Endorsed by: European Association for Cardio-Thoracic Surgery (EACTS), the European Association of Nuclear Medicine (EANM). *Eur Heart J* 2015;36:3075_3128.
 52. Lancellotti P, Tribouilloy C, Hagendorff A, Popescu BA, Edvardsen T, Pierard LA, Badano L, Zamorano JL, Scientific Document Committee of the European Association of Cardiovascular Imaging. Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2013;14:611_644.
 53. Zoghbi WA, Adams D, Bonow RO, Enriquez-Sarano M, Foster E, Grayburn PA, Hahn RT, Han Y, Hung J, Lang RM, Little SH, Shah DJ, Shernan S, Thavendiranathan P, Thomas JD, Weissman NJ. Recommendations for noninvasive evaluation of native valvular regurgitation: a report from the American Society of Echocardiography developed in collaboration with the Society for Cardiovascular Magnetic Resonance. *J Am Soc Echocardiogr* 2017;30:303_371.
 54. Antoine C, Benfari G, Michelena HI, Maalouf JF, Nkomo VT, Thapa P, Enriquez-Sarano M. Clinical outcome of degenerative mitral regurgitation. *Circulation* 2018;138:1317_1326.
 55. Carpentier A. Cardiac valve surgery—the “French correction”. *J Thorac Cardiovasc Surg* 1983;86:323_337.

56. Gavazzoni M, Taramasso M, Zuber M, Russo G, Pozzoli A, Miura M, Maisano F. Conceiving Mitra-Clip as a tool: percutaneous edge-to-edge repair in complex mitral valve anatomies. *Eur Heart J Cardiovasc Imaging* 2020;21:1059_1067.
57. Cawley PJ, Hamilton-Craig C, Owens DS, Krieger EV, Strugnelli WE, Mitsumori L, D'Jang CL, Schwaegler RG, Nguyen KQ, Nguyen B, Maki JH, Otto CM. Prospective comparison of valve regurgitation quantitation by cardiac magnetic resonance imaging and transthoracic echocardiography. *Circ Cardiovasc Imaging* 2013;6:48_57.
58. Penicka M, Vecera J, Mirica DC, Kotrc M, Kockova R, Van Camp G. Prognostic implications of magnetic resonance-derived quantification in asymptomatic patients with organic mitral regurgitation: comparison with Doppler echocardiography-derived integrative approach. *Circulation* 2018;137:1349_1360.
59. Garg P, Swift AJ, Zhong L, Carlhall CJ, Ebberts T, Westenberg J, Hope MD, Bucciarelli-Ducci C, Bax JJ, Myerson SG. Assessment of mitral valve regurgitation by cardiovascular magnetic resonance imaging. *Nat Rev Cardiol* 2020;17:298_312.
60. Kitkungvan D, Nabi F, Kim RJ, Bonow RO, Khan MA, Xu J, Little SH, Quinones MA, Lawrie GM, Zoghbi WA, Shah DJ. Myocardial fibrosis in patients with primary mitral regurgitation with and without prolapse. *J Am Coll Cardiol* 2018;72:823_834.
61. Bakkestrom R, Banke A, Christensen NL, Pecini R, Irmukhamedov A, Andersen M, Borlaug BA, Moller JE. Hemodynamic characteristics in significant symptomatic and asymptomatic primary mitral valve regurgitation at rest and during exercise. *Circ Cardiovasc Imaging* 2018;11:e007171.
62. Utsunomiya H, Hidaka T, Susawa H, Izumi K, Harada Y, Kinoshita M, Itakura K, Masada K, Kihara Y. Exercise-stress echocardiography and effort intolerance in asymptomatic/minimally symptomatic patients with degenerative mitral regurgitation combined invasive-noninvasive hemodynamic monitoring. *Circ Cardiovasc Imaging* 2018;11:e007282.
63. Pizarro R, Bazzino OO, Oberti PF, Falconi M, Achilli F, Arias A, Krauss JG, Cagide AM. Prospective validation of the prognostic usefulness of brain natriuretic peptide in asymptomatic patients with chronic severe mitral regurgitation. *J Am Coll Cardiol* 2009;54:1099_1106.
64. Clavel MA, Tribouilloy C, Vanoverschelde JL, Pizarro R, Suri RM, Szymanski C, Lazam S, Oberti P, Michelena HI, Jaffe A, Enriquez-Sarano M. Association of B-type natriuretic peptide with survival in patients with degenerative mitral regurgitation. *J Am Coll Cardiol* 2016;68:1297_1307.
65. Grigioni F, Clavel MA, Vanoverschelde JL, Tribouilloy C, Pizarro R, Huebner M, Avierinos JF, et al. MIDA Investigators. The MIDA Mortality Risk Score: development and external validation of a prognostic model for early and late death in degenerative mitral regurgitation. *Eur Heart J* 2018;39:1281_1291.
66. Essayagh B, Antoine C, Benfari G, Messika-Zeitoun D, Michelena H, Le Tourneau T, Mankad S, Tribouilloy CM, Thapa P, Enriquez-Sarano M. Prognostic implications of left atrial enlargement in degenerative mitral regurgitation. *J Am Coll Cardiol* 2019;74:858_870.
67. Rusinaru D, Tribouilloy C, Grigioni F, Avierinos JF, Suri RM, Barbieri A, Szymanski C, Ferlito M, Michelena H, Tafaneli L, Bursi F, Mezghani S, Branzi A, Habib G, Modena MG, Enriquez-Sarano M, Mitral Regurgitation International DAtabase (MIDA) Investigators. Left atrial size is a potent predictor of mortality in mitral regurgitation due to flail leaflets: results from a large international multicenter study. *Circ Cardiovasc Imaging* 2011;4:473_481.
68. Barbieri A, Bursi F, Grigioni F, Tribouilloy C, Avierinos JF, Michelena HI, Rusinaru D, Szymanski C, Russo A, Suri R, Bacchi Reggiani ML, Branzi A, Modena MG, Enriquez-Sarano M, Mitral Regurgitation International Database (MIDA) Investigators. Prognostic and therapeutic implications of pulmonary hypertension complicating degenerative mitral regurgitation due to flail leaflet: a multicenter long-term international study. *Eur Heart J* 2011;32:751_759.
69. Grigioni F, Benfari G, Vanoverschelde JL, Tribouilloy C, Avierinos JF, Bursi F, Suri RM, Guerra F, Pasquet A, Rusinaru D, Marcelli E, Theron A, Barbieri A, Michelena H, Lazam S, Szymanski C, Nkomo VT, Capucci A, Thapa P, Enriquez-Sarano M, MIDA Investigators. Long-term implications of atrial fibrillation in patients with degenerative mitral regurgitation. *J Am Coll Cardiol* 2019;73:264_274.
70. Szymanski C, Magne J, Fournier A, Rusinaru D, Touati G, Tribouilloy C. Usefulness of preoperative



- atrial fibrillation to predict outcome and left ventricular dysfunction after valve repair for mitral valve prolapse. *Am J Cardiol* 2015;115:1448_1453.
71. Jung JC, Jang MJ, Hwang HY. Meta-analysis comparing mitral valve repair versus replacement for degenerative mitral regurgitation across all ages. *Am J Cardiol* 2019;123:446_453.
 72. Lazam S, Vanoverschelde JL, Tribouilloy C, Grigioni F, Suri RM, Avierinos JF, de Meester C, Barbieri A, Rusinaru D, Russo A, Pasquet A, Michelena HI, Huebner M, Maalouf J, Clavel MA, Szymanski C, Enriquez-Sarano M, MIDA Investigators. Twenty-year outcome after mitral repair versus replacement for severe degenerative mitral regurgitation: analysis of a large, prospective, multicenter, international registry. *Circulation* 2017;135:410_422.
 73. Feldman T, Foster E, Glower DD, Kar S, Rinaldi MJ, Fail PS, Smalling RW, Siegel R, Rose GA, Engeron E, Loghini C, Trento A, Skipper ER, Fudge T, Letsou GV, Massaro JM, Mauri L, EVEREST II Investigators. Percutaneous repair or surgery for mitral regurgitation. *N Engl J Med* 2011;364:1395_1406
 74. Sorajja P, Vemulapalli S, Feldman T, Mack M, Holmes DR, Jr., Stebbins A, Kar S, Thourani V, Ailawadi G. Outcomes with transcatheter mitral valve repair in the United States: an STS/ACC TVT Registry Report. *J Am Coll Cardiol* 2017;70:2315_2327.
 75. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JGF, Coats AJS, Falk V, Gonzalez-Juanatey JR, Harjola VP, Jankowska EA, Jessup M, Linde C, Nihoyannopoulos P, Parissis JT, Pieske B, Riley JP, Rosano GMC, Ruilope LM, Ruschitzka F, Rutten FH, van der Meer P, ESC Scientific Document Group. 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;37:2129_2200.
 76. Zilberszac R, Heinze G, Binder T, Laufer G, Gabriel H, Rosenhek R. Long-term outcome of active surveillance in severe but asymptomatic primary mitral regurgitation. *JACC Cardiovasc Imaging* 2018;11:1213_1221.
 77. Lancellotti P, Pibarot P, Chambers J, Edvardsen T, Delgado V, Dulgheru R, Pepi M, Cosyns B, Dweck MR, Garbi M, Magne J, Nieman K, Rosenhek R, Bernard A, Lowenstein J, Vieira ML, Rabischoffsky A, Vyhmeister RH, Zhou X, Zhang Y, Zamorano JL, Habib G. Recommendations for the imaging assessment of prosthetic heart valves: a report from the European Association of Cardiovascular Imaging endorsed by the Chinese Society of Echocardiography, the Inter-American Society of Echocardiography, and the Brazilian Department of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging* 2016;17:589_590.
 78. Asgar AW, Mack MJ, Stone GW. Secondary mitral regurgitation in heart failure: pathophysiology, prognosis, and therapeutic considerations. *J Am Coll Cardiol* 2015;65:1231_1248.
 79. Bertrand PB, Schwammenthal E, Levine RA, Vandervoort PM. Exercise Dynamics in secondary mitral regurgitation: pathophysiology and therapeutic implications. *Circulation* 2017;135:297_314.
 80. Deferm S, Bertrand PB, Verbrugge FH, Verhaert D, Rega F, Thomas JD, Vandervoort PM. Atrial functional mitral regurgitation: JACC Review Topic of the Week. *J Am Coll Cardiol* 2019;73:2465_2476.
 81. Goliash G, Bartko PE, Pavo N, Neuhold S, Wurm R, Mascherbauer J, Lang IM, Strunk G, Hulsmann M. Refining the prognostic impact of functional mitral regurgitation in chronic heart failure. *Eur Heart J* 2018;39:39_46.
 82. Cavalcante JL, Kusunose K, Obuchowski NA, Jellis C, Griffin BP, Flamm SD, Kwon DH. Prognostic impact of ischemic mitral regurgitation severity and myocardial infarct quantification by cardiovascular magnetic resonance. *JACC Cardiovasc Imaging* 2020;13:1489_1501.
 83. Grigioni F, Enriquez-Sarano M, Zehr KJ, Bailey KR, Tajik AJ. Ischemic mitral regurgitation: long-term outcome and prognostic implications with quantitative Doppler assessment. *Circulation* 2001;103:1759_1764.
 84. Acker MA, Jessup M, Bolling SF, Oh J, Starling RC, Mann DL, Sabbah HN, Shemin R, Kirklin J, Kubo SH. Mitral valve repair in heart failure: five-year follow-up from the mitral valve replacement stratum of the Acorn randomized trial. *J Thorac Cardiovasc Surg* 2011;142:569_574, 574 e561.
 85. Deja MA, Grayburn PA, Sun B, Rao V, She L, Krejca M, Jain AR, Leng Chua Y, Daly R, Senni M, Mokrzycki K, Menicanti L, Oh JK, Michler R, Wrobel K, Lamy A, Velazquez EJ, Lee KL, Jones RH. Influence of mitral regurgitation repair on survival in the surgical treatment for ischemic heart failure trial. *Circulation* 2012;125:2639_2648.



86. Petrus AHJ, Dekkers OM, Tops LF, Timmer E, Klautz RJM, Braun J. Impact of recurrent mitral regurgitation after mitral valve repair for functional mitral regurgitation: long-term analysis of competing outcomes. *Eur Heart J* 2019;40:2206_2214.
87. Acker MA, Parides MK, Perrault LP, Moskowitz AJ, Gelijns AC, Voisine P, Smith PK, Hung JW, Blackstone EH, Puskas JD, Argenziano M, Gammie JS, Mack M, Ascheim DD, Bagiella E, Moquete EG, Ferguson TB, Horvath KA, Geller NL, Miller MA, Woo YJ, D'Alessandro DA, Ailawadi G, Dagenais F, Gardner TJ, O'Gara PT, Michler RE, Kron IL, CTSN. Mitral-valve repair versus replacement for severe ischemic mitral regurgitation. *N Engl J Med* 2014;370:23_32.
88. Wu AH, Aaronson KD, Bolling SF, Pagani FD, Welch K, Koelling TM. Impact of mitral valve annuloplasty on mortality risk in patients with mitral regurgitation and left ventricular systolic dysfunction. *J Am Coll Cardiol* 2005;45:381_387
89. Jung B, Armoiry X, Vahanian A, Boutitie F, Newton N, Trochu JN, Lefevre T, et al. MITRA-FR Investigators. Percutaneous repair or medical treatment for secondary mitral regurgitation: outcomes at 2 years. *Eur J Heart Fail* 2019;21:1619_1627.
90. Stone GW, Lindenfeld J, Abraham WT, Kar S, Lim DS, Mishell JM, Whisenant B, Grayburn PA, Rinaldi M, Kapadia SR, Rajagopal V, Sarembock IJ, Brieke A, Marx SO, Cohen DJ, Weissman NJ, Mack MJ, COAPT Investigators. Transcatheter mitral-valve repair in patients with heart failure. *N Engl J Med* 2018;379:2307_2318.
91. Harmel EK, Reichenspurner H, Girdauskas E. Subannular reconstruction in secondary mitral regurgitation: a meta-analysis. *Heart* 2018;104:1783_1790.
92. Kassop D, Donovan MS, Cheezum MK, et al. Cardiac masses on cardiac CT: a review. *Curr Cardiovasc Imaging Rep* [Internet] 2014;7. [cited 2020 May 10] Available from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4090749/>.
93. Colin GC, Gerber BL, Amzulescu M, Bogaert J. Cardiac myxoma: a contemporary multimodality imaging review. *Int J Cardiovasc Imaging* 2018;34:1789–808.
94. Gray IR. Recurring cardiac myxoma. *Br Heart J* 1985;53:645–9.
95. Burke A, Tavora F. The 2015 WHO classification of tumors of the heart and pericardium. *J Thorac Oncol* 2016;11:441–52.
96. Gomadam PS, Stacey RB, Johnsen AE, Kitzman DW, Kon ND, Upadhya B. Papillary fibroelastoma of the mitral valve chordae with systemic embolization. *J Cardiol Cases* 2014;10:125–8.