



BÖLÜM 68

Mitral Kapak Cerrahisi Sonrası Komplikasyonlar

Ünsal VURAL ¹

1. GİRİŞ

Edmunds ve ark'ları¹ protez kapak replasmanı sonrası sonuçlarını raporladıkları kılavuzlarında replasman sonrası erken komplikasyonların;

- Yara yeri enfeksiyonları
- Operasyonel kanamalar
- Disritmi
- Kapağa ait yapısal ve yapısal olmayan komplikasyonlar
- Kapak endokraditi
- Sağ veya sol ventrikül yetmezliği
- Sol ventrikül rüptürü

Geç komplikasyonların ise;

- Tromboemboli (serebral, periferik ya da intestinal siteme olabileceği gibi kapak lifletlerinin trombüs nedeniyle fonksiyonunu yitirmesi şeklinde de olabilir)
- Yüksek doz antikoagulan kullanımına bağlı; eklem, cilt altı, gastrointestinal sistem, idrar yolları ve mukozalarda oluşan kanama komplikasyonları
- Protez kapak endokarditi
- Yapısal ve yapısal olmayan işlev bozuklukları

- Ani ölüm ve ileti bozuklukları olduğunu belirtmişlerdir.

Yayımlanan 2000'den sonraki çalışmalarda ise, hasta-yılı başına %0,7-3,5 kapak ile ilgili komplikasyon olduğu bildirilmiştir²⁻⁴.

1.1 Yara Yeri Enfeksiyonları

Kalp damar cerrahisinde, mediastinit ve sternal yara enfeksiyonları sık enfeksiyonlar olup en sık gözlenen enfeksiyon etkenleri ise, stafiokokus aureus ve koagülaz negatif stafilokoklardır. Bu sebeple operasyonlarda genellikle, anestezi indüksiyonu esnasında profilaksi önerilmektedir. Profilaksi süresi 72 saate kadar uzatılabilmekle birlikte, bu sürenin 24 saati geçmemesi tavsiye edilmektedir. Profilaktik antibiyotik uygulamasının, göğüs ve mediasten tüplerin alınmasına kadar uzatılmasını destekleyecek bilimsel kanıt yoktur. Ayrıca, kapak disfonksiyonu, regürjitasyonlu mitral kapak prolapsusu, hipertrofik kardiyomiyopati, daha önce endokardit saptanması gibi durumunlarda da endokardit gelişme riski yüksektir. Bu tür riskli girişimlerde mutlaka profilaksi uygulanması gerekir. Enfeksiyon gelişimini etkileyen risk faktörleri;

¹ Doç. Dr. Ünsal VURAL, S.B. S.B.Ü. Dr. Siyami Ersek Göğüs Kalp ve Damar Cerrahisi Eğitim ve Araştırma Hastanesi, Kalp ve Damar Cerrahisi unsalvural@gmail.com



lantasyonu ile tedavi edilemeyen şiddetli mitral yetmezliği ve mitral kapak yaralanması gibi yukarıda belirtilen komplikasyonlarla ilgilidir.

4.2.6 Başarısız Prosedür: İşlemsel başarısızlık oranı %0-26 arasındadır. Bununla birlikte, prosedürel başarının olmamasının tanımı konusunda büyük bir değişkenlik vardır ve buna karar vermek operatöre bırakılmıştır. Teknik başarı, mitral anatomiye, operatör deneyimine ve kullanılan cihaza bağlıdır. Yeni nesil cihazlar ile çalışmak daha kolaydır ve klibe bağlı hareketler daha iyi tolere edilir. İlk deneyimlerden sonra, daha karmaşık vakalarda bile, erken dönem prosedür başarısı %90'ın üzerinde olmuştur.

4.2.7 Ekstrinsik Koroner Arter Kompresyonu: Koroner arterlerle, özellikle sol sirkumfleks arterle yakınlığı göz önüne alındığında, cihazın açılması ve gerilmesinden sonra bu arterlerin sıkıştığı izlenebilir. Hastaların %16'sında bir ramus dalı veya diagonal arterin⁷⁶ %65-80'inde ise bir circumflex arterin koroner sinüs ve mitral kapak alanı arasından seyrettiği izlenebilir⁷⁷. Cihazın yerleştirilmesinden hemen önce koroner anjiyogram, eş zamanlı bir koroner sinüs venogramı, olası koroner arter ekstrinsik kompresyonunu değerlendirmek için yeterlidir. Dolaylı kompresyon nedeniyle önemli koroner daralma olması durumunda, implante edilen cihazın etkisi azaltılmalıdır.

4.2.9 Sol Ventrikül Sistolik Fonksiyonunun Akut Bozulması: Bu fenomen genellikle geçicidir. Cerrahi mitral kapak onarımına kıyasla daha az sıklıkta olmasına rağmen, dolaşımı desteklemek için inotropik ilaçlar gerekebilir. Ancak β -adrenerjik agonistlerin miyokard iskemisine, aritmilere iyi geldiği ve şiddetli sol ventrikül disfonksiyonu olan hastalarda orta dönem mortaliteyi azalttığı gösterilmiştir⁷⁸. Bu durumda işlem öncesi, sırası ve sonrasında 0.01 $\mu\text{g/kg/dk}$ levosimendan uygulanması, perkütan fonksiyonel mitral yetmezliğinin düzeltilmesini takiben akut hemodinamik kötüleşme riskini azaltmaya yardımcı olabilir⁷⁹.

4.2.10 Diğer Ciddi komplikasyonlar: İmpantasyonu sırasında (veya sonrasında) bildiri-

len diğer olaylar şunlardır; perikardiyal efüzyon (muhtemelen prosedürle ilgili), sol femoral psödoanevrizma (işlemle ilgili), üst ekstremitte hemiparezisi, gastrointestinal kanama, geç mitral kapak endokarditi sayılabilir⁸⁰.

KAYNAKLAR

1. Edmunds LH Jr, Clark RE, Cohn LH, Grunkemeier GL, Miller DC, Weisel RD. Guidelines for reporting morbidity and mortality after cardiac valvular operations. The American Association for Thoracic Surgery, Ad Hoc Liaison Committee for Standardizing Definitions of Prosthetic Heart Valve Morbidity. *Ann Thorac Surg.* 1996 Sep;62(3):932-5. doi: 10.1016/s0003-4975(96)00531-0. PMID: 8784045.2.
2. Misawa Y. Heart valve replacement for patients with end-stage renal disease in Japan. *Ann Thorac Cardiovasc Surg.* 2010 Aug;16(1):4-8. PMID: 20190702.
3. Azarnoush K, Laborde F, de Riberolles C. The Sorin Bicarbon over 15 years clinical outcomes: multicentre experience in 1704 patients. *Eur J Cardiothorac Surg.* 2010 Dec;38(6):759-66. doi: 10.1016/j.ejcts.2010.03.060. Epub 2010 May 14. PMID: 20471851
4. Van Nooten GJ, Bové T, Van Belleghem Y, François K, Caes F, Vandenplas G, De Pauw M, Taeymans Y. Twenty-year single-center experience with the medtronic open pivot mechanical heart valve. *Ann Thorac Surg.* 2014 Apr;97(4):1306-13. doi: 10.1016/j.athoracsur.2013.11.035. Epub 2014 Feb 6. PMID: 24507942.
5. Ateş S, Nazik S, Şahin A, Kardaş F, Erdoğan A. Cerrahi Alan Enfeksiyonlarının Değerlendirilmesi. *KSÜ Tıp Fak Der.* 2019; 14(1): 16-19. <https://doi.org/10.17517/ksut-fd.467381>
6. Malone DL, Genuit T, Tracy JK, Gannon C, Napolitano LM. Surgical site infections: reanalysis of risk factors. *J Surg Res.* 2002 Mar;103(1):89-95. doi: 10.1006/jsre.2001.6343. PMID: 11855922.
7. Zerr KJ, Furnary AP, Grunkemeier GL, Bookin S, Kanhere V, Starr A. Glucose control lowers the risk of wound infection in diabetics after open heart operations. *Ann Thorac Surg.* 1997 Feb;63(2):356-61. doi: 10.1016/s0003-4975(96)01044-2. PMID: 9033300.
8. Cappabianca G, Rotunno C, de Luca Tupputi Schinosa L, Ranieri VM, Paparella D. Protective effects of steroids in cardiac surgery: a meta-analysis of randomized double-blind trials. *J Cardiothorac Vasc Anesth.* 2011 Feb;25(1):156-65. doi: 10.1053/j.jvca.2010.03.015. Epub 2010 May 26. PMID: 20537923
9. Cannegieter SC, Rosendaal FR, Wintzen AR, van der Meer FJ, Vandenbroucke JP, Briët E. Optimal oral anticoagulant therapy in patients with mechanical heart valves. *N Engl J Med.* 1995 Jul 6;333(1):11-7. doi: 10.1056/NEJM199507063330103. PMID: 7776988.
10. Ryder SJ, Bradley H, Brannan JJ, Turner MA, Bain WH. Thrombotic obstruction of the Björk-Shiley valve: the



- Glasgow experience. *Thorax*. 1984 Jul;39(7):487-92. doi: 10.1136/thx.39.7.487. PMID: 6463927; PMCID: PMC459846.
11. Labaf A, Grzymala-Lubanski B, Stagmo M, Lövdahl S, Wieloch M, Sjölander A, Svensson PJ. Thromboembolism, major bleeding and mortality in patients with mechanical heart valves- a population-based cohort study. *Thromb Res*. 2014 Aug;134(2):354-9. doi: 10.1016/j.thromres.2014.06.007. Epub 2014 Jun 12. PMID: 24985036.
 12. Bourguignon T, Bergöend E, Mirza A, Ayegnon G, Neville P, Aupart MR, Marchand M. Risk factors for valve-related complications after mechanical heart valve replacement in 505 patients with long-term follow up. *J Heart Valve Dis*. 2011 Nov;20(6):673-80. PMID: 22655498.
 13. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP 3rd, et al; American College of Cardiology/ American Heart Association Task Force on Practice Guidelines. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: executive summary: a report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2014 Jun 10;63(22):2438-88. doi: 10.1016/j.jacc.2014.02.537. Epub 2014 Mar 3. Erratum in: *J Am Coll Cardiol*. 2014 Jun 10;63(22):2489. PMID: 24603192.
 14. Ookita Y, Okada Y, Otsuji Y, Komeda M, Nakatani S, Matsuzaki M, Yoshida K (2012) Guidelines for surgical and interventional treatment of vascular heart disease (JCS). http://www.j-circ.or.jp/guideline/pdf/JCS2012_ookita_d.pdf. Accessed 20 Oct 2014.
 15. Gohlke-Bärwolf C. Anticoagulation in valvar heart disease: new aspects and management during non-cardiac surgery. *Heart*. 2000 Nov;84(5):567-72. doi: 10.1136/heart.84.5.567. PMID: 11040023; PMCID: PMC1729481.
 16. Huang G, Schaff HV, Sundt TM, Rahimtoola SH. Treatment of obstructive thrombosed prosthetic heart valve. *J Am Coll Cardiol*. 2013 Nov 5;62(19):1731-6. doi: 10.1016/j.jacc.2013.07.075. Epub 2013 Aug 28. PMID: 23994405
 17. Groves P. Valve disease: Surgery of valve disease: late results and late complications. *Heart*. 2001 Dec;86(6):715-21. doi: 10.1136/heart.86.6.715. PMID: 11711480; PMCID: PMC1730041.
 18. Karlson KJ, Ashraf MM, Berger RL. Rupture of left ventricle following mitral valve replacement. *Ann Thorac Surg*. 1988 Nov;46(5):590-7. doi: 10.1016/s0003-4975(10)64712-1. PMID: 3190341.
 19. Villari B, Vassalli G, Monrad ES, Chiariello M, Turina M, Hess OM. Normalization of diastolic dysfunction in aortic stenosis late after valve replacement. *Circulation*. 1995 May 1;91(9):2353-8. doi: 10.1161/01.cir.91.9.2353. PMID: 7729021
 20. Lund O, Erlandsen M. Changes in left ventricular function and mass during serial investigations after valve replacement for aortic stenosis. *J Heart Valve Dis*. 2000 Jul;9(4):583-93. PMID: 10947054.
 21. Bonow RO. Radionuclide angiography in the management of asymptomatic aortic regurgitation. *Circulation*. 1991 Sep;84(3 Suppl):I296-302. PMID: 1884499.
 22. Nakano S, Sakai K, Taniguchi K, Miyamoto Y, Shintani H, Shimazaki Y, Matsuda H, Kawashima Y. Relation of impaired left ventricular function in mitral regurgitation to left ventricular contractile state after mitral valve replacement. *Am J Cardiol*. 1994 Jan 1;73(1):70-4. doi: 10.1016/0002-9149(94)90729-3. PMID: 8279381.
 23. Enriquez-Sarano M, Schaff HV, Orszulak TA, Tajik AJ, Bailey KR, Frye RL. Valve repair improves the outcome of surgery for mitral regurgitation. A multivariate analysis. *Circulation*. 1995 Feb 15;91(4):1022-8. doi: 10.1161/01.cir.91.4.1022. PMID: 7850937.
 24. Pagani FD, Benedict MB, Marshall BL, Bolling SF. The economics of uncomplicated mitral valve surgery. *J Heart Valve Dis*. 1997 Sep;6(5):466-9. PMID: 9330165.
 25. Zieliński T, Pogorzelska H, Rajecka A, Biedermavn A, Sliwiński M, Korewicki J. Pulmonary hemodynamics at rest and effort, 6 and 12 months after mitral valve replacement: a slow regression of effort pulmonary hypertension. *Int J Cardiol*. 1993 Nov;42(1):57-62. doi: 10.1016/0167-5273(93)90102-m. PMID: 8112906.
 26. Porter A, Shapira Y, Wurzel M, Sulkes J, Vaturi M, Adler Y, Sahar G, Sagie A. Tricuspid regurgitation late after mitral valve replacement: clinical and echocardiographic evaluation. *J Heart Valve Dis*. 1999 Jan;8(1):57-62. PMID: 10096483
 27. King RM, Schaff HV, Danielson GK, Gersh BJ, Orszulak TA, Piehler JM, Puga FJ, Pluth JR. Surgery for tricuspid regurgitation late after mitral valve replacement. *Circulation*. 1984 Sep;70(3 Pt 2):I193-7. PMID: 6744564.
 28. Calderwood SB, Swinski LA, Waternaux CM, Karchmer AW, Buckley MJ. Risk factors for the development of prosthetic valve endocarditis. *Circulation*. 1985 Jul;72(1):31-7. doi: 10.1161/01.cir.72.1.31. PMID: 4006134.
 29. Davenport J, Hart RG. Prosthetic valve endocarditis 1976-1987. Antibiotics, anticoagulation, and stroke. *Stroke*. 1990 Jul;21(7):993-9. doi: 10.1161/01.str.21.7.993. PMID: 2368115.
 30. Eykyn SJ. Endocarditis: basics. *Heart*. 2001 Oct;86(4):476-80. doi: 10.1136/heart.86.4.476. PMID: 11559695; PMCID: PMC1729945.
 31. Lytle BW, Priest BP, Taylor PC, Loop FD, Sapp SK, Stewart RW, McCarthy PM, Muehrcke D, Cosgrove DM 3rd. Surgical treatment of prosthetic valve endocarditis. *J Thorac Cardiovasc Surg*. 1996 Jan;111(1):198-207; discussion 207-10. doi: 10.1016/S0022-5223(96)70417-8. PMID: 8551767.
 32. Grubitzsch H, Schaefer A, Melzer C, Wernecke KD, Gabbieri D, Konertz W. Outcome after surgery for prosthetic valve endocarditis and the impact of preoperative treatment. *J Thorac Cardiovasc Surg*. 2014 Nov;148(5):2052-9. doi: 10.1016/j.jtcvs.2014.05.025. Epub 2014 May 16. PMID: 24951022.
 33. Ramlawi B, White LE, Santora RJ, Reardon MJ. Recurrent prosthetic valve endocarditis with aortic-ventricu-



- lar disruption: a surgical challenge. *J Heart Valve Dis.* 2013 Jan;22(1):126-32. PMID: 23611000.
34. Harrison DC, Ibrahim MA, Weyman AE, Kuller LH, Blot WJ, Miller DE. The Björk-Shiley convexo-concave heart valve experience from the perspective of the supervisory panel. *Am J Cardiol.* 2013 Dec 15;112(12):1921-31. doi: 10.1016/j.amjcard.2013.08.020. Epub 2013 Sep 21. PMID: 24063829.
35. Komi M, Sugaya A, Akutsu H, Sato H, Kaminishi Y, Misawa Y. A worn Björk-Shiley prosthetic valve without valve dysfunction observed during ascending aortic replacement. *Clin Case Rep.* 2014 Oct;2(5):180-2. doi: 10.1002/ccr3.86. Epub 2014 Jun 30. PMID: 25614806; PMCID: PMC4302620.
36. Gunn JM, Malmberg M, Vähäsilta T, Lahti AI, Kuttala KT. Thirty-year results after implantation of the Björk-Shiley Convexo-Concave Heart valve prosthesis. *Ann Thorac Surg.* 2014 Feb;97(2):552-6. doi: 10.1016/j.athoracsur.2013.09.032. Epub 2013 Nov 6. PMID: 24206963.
37. Misawa Y, Saito T, Konishi H, Oki S, Kaminishi Y, Sakano Y, Morita H, Aizawa K. Clinical experience with the Bicarbon heart valve prosthesis. *J Cardiothorac Surg.* 2007 Jan 25;2:8. doi: 10.1186/1749-8090-2-8. PMID: 17254363; PMCID: PMC1794238
38. Shanmugam G, MacArthur K, Pollock J. Mechanical aortic valve replacement: long-term outcomes in children. *J Heart Valve Dis.* 2005 Mar;14(2):166-71. PMID: 15792175.
39. Borger MA, Ivanov J, Armstrong S, Christie-Hrybinsky D, Feindel CM, David TE. Twenty-year results of the Hancock II bioprosthesis. *J Heart Valve Dis.* 2006 Jan;15(1):49-55; discussion 55-6. PMID: 16480012.
40. Cohn LH, Peigh PS, Sell J, DiSesa VJ. Right thoracotomy, femorofemoral bypass, and deep hypothermia for re-replacement of the mitral valve. *Ann Thorac Surg.* 1989 Jul;48(1):69-71. doi: 10.1016/0003-4975(89)90180-x. PMID: 2764604.
41. Nishida T, Sonoda H, Oishi Y, Tanoue Y, Nakashima A, Shiokawa Y, Tominaga R. Single-institution, 22-year follow-up of 786 CarboMedics mechanical valves used for both primary surgery and reoperation. *J Thorac Cardiovasc Surg.* 2014 May;147(5):1493-8. doi: 10.1016/j.jtcvs.2013.05.017. Epub 2013 Jul 13. PMID: 23856208.
42. Hurler A, Abad C, Feijoo J, Ray V, Ponce G. Long-term clinical performance of Sorin tilting-disc mechanical prostheses in the mitral and aortic position. *J Cardiovasc Surg (Torino).* 1997 Oct;38(5):507-12. PMID: 9358810.
43. Oh SJ, Park S, Kim JS, Kim KH, Kim KB, Ahn H. Reoperation for non-structural valvular dysfunction caused by pannus ingrowth in aortic valve prosthesis. *J Heart Valve Dis.* 2013 Jul;22(4):591-8. PMID: 24224426.
44. Ellensen VS, Andersen KS, Vitale N, Davidsen ES, Segadal L, Haaverstad R. Acute obstruction by Pannus in patients with aortic medtronic-hall valves: 30 years of experience. *Ann Thorac Surg.* 2013 Dec;96(6):2123-8. doi: 10.1016/j.athoracsur.2013.07.019. Epub 2013 Sep 23. PMID: 24070701.
45. Gallo I, Nistal F, Artiñano E. Six- to ten-year follow-up of patients with the Hancock cardiac bioprosthesis. Incidence of primary tissue valve failure. *J Thorac Cardiovasc Surg.* 1986 Jul;92(1):14-20. PMID: 3724217.
46. Utley JR, Leyland SA, Nguyenduy T. Comparison of outcomes with three atrial incisions for mitral valve operations. Right lateral, superior septal, and transseptal. *J Thorac Cardiovasc Surg.* 1995 Mar;109(3):582-7. doi: 10.1016/S0022-5223(95)70292-X. PMID: 7877322.
47. Modi P, Hassan A, Chitwood WR Jr. Minimally invasive mitral valve surgery: a systematic review and meta-analysis. *Eur J Cardiothorac Surg.* 2008 Nov;34(5):943-52. doi: 10.1016/j.ejcts.2008.07.057. Epub 2008 Sep 30. PMID: 18829343.
48. Svensson LG, Atik FA, Cosgrove DM, Blackstone EH, Rajeswaran J, Krishnaswamy G, Jin U, Gillinov AM, Griffin B, Navia JL, Mihaljevic T, Lytle BW. Minimally invasive versus conventional mitral valve surgery: a propensity-matched comparison. *J Thorac Cardiovasc Surg.* 2010 Apr;139(4):926-32.e1-2. doi: 10.1016/j.jtcvs.2009.09.038. Epub 2009 Nov 27. PMID: 19945121.
49. Ritwick B, Chaudhuri K, Crouch G, Edwards JR, Worthington M, Stuklis RG. Minimally invasive mitral valve procedures: the current state. *Minim Invasive Surg.* 2013;2013:679276. doi: 10.1155/2013/679276. Epub 2013 Dec 5. PMID: 24382998; PMCID: PMC3870135.
50. Falk V, Cheng DC, Martin J, Diegeler A, Folliquet TA, Nifong LW, Perier P, Raanani E, Smith JM, Seeburger J. Minimally invasive versus open mitral valve surgery: a consensus statement of the international society of minimally invasive coronary surgery (ISMICS) 2010. *Innovations (Phila).* 2011 Mar;6(2):66-76. doi: 10.1097/IMI.0b013e318216be5c. PMID: 22437890.
51. Mihaljevic T, Cohn LH, Unic D, Aranki SF, Couper GS, Byrne JG. One thousand minimally invasive valve operations: early and late results. *Ann Surg.* 2004 Sep;240(3):529-34; discussion 534. doi: 10.1097/01.sla.0000137141.55267.47. PMID: 15319724; PMCID: PMC1356443.
52. Iribarne A, Easterwood R, Russo MJ, Wang YC, Yang J, Hong KN, Smith CR, Argenziano M. A minimally invasive approach is more cost-effective than a traditional sternotomy approach for mitral valve surgery. *J Thorac Cardiovasc Surg.* 2011 Dec;142(6):1507-14. doi: 10.1016/j.jtcvs.2011.04.038. Epub 2011 Jun 14. PMID: 21665228; PMCID: PMC3182301.
53. Mkalaluh S, Szczechowicz M, Dib B, Sabashnikov A, Szabo G, Karck M, Weymann A. Early and long-term results of minimally invasive mitral valve surgery through a right mini-thoracotomy approach: a retrospective propensity-score matched analysis. *PeerJ.* 2018 May 28;6:e4810. doi: 10.7717/peerj.4810. PMID: 29868261; PMCID: PMC5978402.
54. Stähle E, Tammelin A, Bergström R, Hambreus A, Nyström SO, Hansson HE. Sternal wound complications--incidence, microbiology and risk factors. *Eur J Cardiothorac Surg.* 1997 Jun;11(6):1146-53. doi: 10.1016/s1010-7940(97)01210-4. PMID: 9237601.
55. Lamelas J, Williams RF, Mawad M, LaPietra A. Comp-



- lications Associated With Femoral Cannulation During Minimally Invasive Cardiac Surgery. *Ann Thorac Surg.* 2017 Jun;103(6):1927-1932. doi: 10.1016/j.athoracsur.2016.09.098. Epub 2016 Dec 22. PMID: 28017338.
56. Sagbas E, Caynak B, Duran C, Sen O, Kabakci B, Sanioglu I, Akpinar B. Mid-term results of peripheric cannulation after port-access surgery. *Interact Cardiovasc Thorac Surg.* 2007 Dec;6(6):744-7. doi: 10.1510/icvts.2007.162669. Epub 2007 Sep 10. PMID: 17846077.
 57. Davierwala PM, Seeburger J, Pfannmueller B, Garbade J, Misfeld M, Borger MA, Mohr FW. Minimally invasive mitral valve surgery: "The Leipzig experience". *Ann Cardiothorac Surg.* 2013 Nov;2(6):744-50. doi: 10.3978/j.issn.2225-319X.2013.10.14. Erratum in: *Ann Cardiothorac Surg.* 2014 Jul;3(4):436. PMID: 24349976; PMCID: PMC3856988.
 58. Moss E, Halkos ME. Cost effectiveness of robotic mitral valve surgery. *Ann Cardiothorac Surg.* 2017 Jan;6(1):33-37. doi: 10.21037/acs.2017.01.03. PMID: 28203539; PMCID: PMC5293631.
 59. el Asmar B, Perier P, Couetil JP, Carpentier A. Failures in reconstructive mitral valve surgery. *J Med Liban.* 1991;39(1):7-11. PMID: 1941982.
 60. Steppich B, Stegmüller F, Rumpf PM, Pache J, Sonne C, Lesevic H, Braun D, Hausleiter J, Kasel AM, Ott I. Vascular complications after percutaneous mitral valve repair and venous access closure using suture or closure device. *J Interv Cardiol.* 2018 Apr;31(2):223-229. doi: 10.1111/joic.12459. Epub 2017 Nov 16. PMID: 29148095.
 61. Eggebrecht H, Schelle S, Puls M, Plicht B, von Bardeleben RS, Butter C, May AE, Lubos E, Boekstegers P, Ouarrak T, Senges J, Schmermund A. Risk and outcomes of complications during and after MitraClip implantation: Experience in 828 patients from the German TRANScatheter mitral valve interventions (TRAMI) registry. *Catheter Cardiovasc Interv.* 2015 Oct;86(4):728-35. doi: 10.1002/ccd.25838. Epub 2015 Feb 12. PMID: 25601532.
 62. Körber MI, Silwedel J, Friedrichs K, Mauri V, Huntgeburth M, Pfister R, Baldus S, Rudolph V. Bleeding Complications After Percutaneous Mitral Valve Repair With the MitraClip. *Am J Cardiol.* 2018 Jan 1;121(1):94-99. doi: 10.1016/j.amjcard.2017.09.027. Epub 2017 Oct 12. PMID: 29122275.
 63. Obadia JF, Messika-Zeitoun D, Leurent G, Iung B, Bonnet G, Piriou N et al. Percutaneous Repair or Medical Treatment for Secondary Mitral Regurgitation. *N Engl J Med.* 2018 Dec 13;379(24):2297-2306. doi: 10.1056/NEJMoa1805374. Epub 2018 Aug 27. PMID: 30145927.
 64. Bilge M, Saatci Yaşar A, Ali S, Alemdar R. Left atrial spontaneous echo contrast and thrombus formation at septal puncture during percutaneous mitral valve repair with the MitraClip system of severe mitral regurgitation: a report of two cases. *Anadolu Kardiyol Derg.* 2014 Sep;14(6):549-50. doi: 10.5152/akd.2014.5355. Epub 2014 Jun 25. PMID: 24889775.
 65. Maisano F, Franzen O, Baldus S, Schäfer U, Hausleiter J, Butter C, Ussia GP, Sievert H, Richardt G, Widder JD, Moccetti T, Schillinger W. Percutaneous mitral valve interventions in the real world: early and 1-year results from the ACCESS-EU, a prospective, multicenter, nonrandomized post-approval study of the MitraClip therapy in Europe. *J Am Coll Cardiol.* 2013 Sep 17;62(12):1052-1061. doi: 10.1016/j.jacc.2013.02.094. Epub 2013 Jun 7. PMID: 23747789.
 66. Feldman T, Kar S, Rinaldi M, Fail P, Hermiller J, Smalting R, Whitlow PL, Gray W, Low R, Herrmann HC, Lim S, Foster E, Glower D; EVEREST Investigators. Percutaneous mitral repair with the MitraClip system: safety and midterm durability in the initial EVEREST (Endovascular Valve Edge-to-Edge REpair Study) cohort. *J Am Coll Cardiol.* 2009 Aug 18;54(8):686-94. doi: 10.1016/j.jacc.2009.03.077. PMID: 19679246.
 67. Praz F, Braun D, Unterhuber M, Spirito A, Orban M, Brugger N, Brinkmann I, Spring K, Moschovitis A, Nabauer M, Blazek S, Pilgrim T, Thiele H, Lurz P, Hausleiter J, Windecker S. Edge-to-Edge Mitral Valve Repair With Extended Clip Arms: Early Experience From a Multicenter Observational Study. *JACC Cardiovasc Interv.* 2019 Jul 22;12(14):1356-1365. doi: 10.1016/j.jcin.2019.03.023. Epub 2019 May 22. PMID: 31129091.
 68. Nickenig G, Estevez-Loureiro R, Franzen O, Tamburino C, Vanderheyden M, Lüscher TF et al; Transcatheter Valve Treatment Sentinel Registry Investigators of the EURObservational Research Programme of the European Society of Cardiology. Percutaneous mitral valve edge-to-edge repair: in-hospital results and 1-year follow-up of 628 patients of the 2011-2012 Pilot European Sentinel Registry. *J Am Coll Cardiol.* 2014 Sep 2;64(9):875-84. doi: 10.1016/j.jacc.2014.06.1166. PMID: 25169171.
 69. 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 Nov 7;70(19):2315-2327. doi: 10.1016/j.jacc.2017.09.015. PMID: 29096801.
 70. Nusca A, Bressi E, Colaioni I, Miglionico M, Di Sciascio G. Antiplatelet therapy in valvular and structural heart disease interventions. *Cardiovasc Diagn Ther.* 2018 Oct;8(5):678-693. doi: 10.21037/cdt.2018.06.08. PMID: 30498690; PMCID: PMC6232349.
 71. Rahhab Z, Ren B, Oei F, de Jaegere PP, Van Mieghem NM. Mitral Valve Injury After MitraClip Implantation. *JACC Cardiovasc Interv.* 2016 Sep 26;9(18):e185-6. doi: 10.1016/j.jcin.2016.07.007. Epub 2016 Aug 31. PMID: 27592013.
 72. Danduch L, Millan X, Li CH, Arzamendi D. Residual "inter-clip" regurgitation due to a partial detachment, treated with AMPLATZER Vascular Plug II implantation. *EuroIntervention.* 2018 Feb 2;13(15):e1774-e1775. doi: 10.4244/EIJ-D-17-00789. PMID: 28891470.
 73. Mesana TG, Lam BK, Chan V, Chen K, Ruel M, Chan K. Clinical evaluation of functional mitral stenosis after mitral valve repair for degenerative disease: potential affect on surgical strategy. *J Thorac Cardiovasc Surg.* 2013 Dec;146(6):1418-23; discussion 1423-5. doi: 10.1016/j.



- jtcvs.2013.08.011. Epub 2013 Sep 26. PMID: 24075470.
74. Neuss M, Schau T, Isotani A, Pilz M, Schöpp M, Butter C. Elevated Mitral Valve Pressure Gradient After MitraClip Implantation Deteriorates Long-Term Outcome in Patients With Severe Mitral Regurgitation and Severe Heart Failure. *JACC Cardiovasc Interv.* 2017 May 8;10(9):931-939. doi: 10.1016/j.jcin.2016.12.280. PMID: 28473116.
 75. Kuwata S, Taramasso M, Czopak A, Luciani M, Pozzoli A, Ho E, Ferrero Guadagnoli A, Saccocci M, Gaemperli O, Nietlispach F, Zuber M, Feldman T, Maisano F. Continuous Direct Left Atrial Pressure: Intraprocedural Measurement Predicts Clinical Response Following MitraClip Therapy. *JACC Cardiovasc Interv.* 2019 Jan 28;12(2):127-136. doi: 10.1016/j.jcin.2018.07.051. Epub 2018 Dec 26. PMID: 30594511.
 76. Lansac E, Di Cerna I, Al Attar N, Messika-Zeitoun D, Raffoul R, Vahanian A, Nataf P. Percutaneous mitral annuloplasty through the coronary sinus: an anatomic point of view. *J Thorac Cardiovasc Surg.* 2008 Feb;135(2):376-81. doi: 10.1016/j.jtcvs.2007.05.071. PMID: 18242272.
 77. Choure AJ, Garcia MJ, Hesse B, Sevensma M, Maly G, Greenberg NL, Borzi L, Ellis S, Tuzcu EM, Kapadia SR. In vivo analysis of the anatomical relationship of coronary sinus to mitral annulus and left circumflex coronary artery using cardiac multidetector computed tomography: implications for percutaneous coronary sinus mitral annuloplasty. *J Am Coll Cardiol.* 2006 Nov 21;48(10):1938-45. doi: 10.1016/j.jacc.2006.07.043. Epub 2006 Nov 1. PMID: 17112981.
 78. Tamargo J, López-Sendón J. Bases y evidencias clínicas de los efectos de los nuevos tratamientos farmacológicos en la insuficiencia cardíaca [Rationale and clinical evidence for the effects of new pharmacological treatments for heart failure]. *Rev Esp Cardiol.* 2004 May;57(5):447-64. Spanish. PMID: 15151778.
 79. Freixa X, Hernández M, Farrero M, Sitges M, Jiménez G, Regueiro A et al. Levosimendan as an adjunctive therapy to MitraClip implantation in patients with severe mitral regurgitation and left ventricular dysfunction. *Int J Cardiol.* 2016 Jan 1;202:517-8. doi: 10.1016/j.ijcard.2015.09.056. Epub 2015 Sep 25. PMID: 26440466.
 80. Messika-Zeitoun D, Nickenig G, Latib A, Kuck KH, Baldus S, Schueler R, La Canna G, Agricola E, Kreidel F, Huntgeburth M, Zuber M, Verta P, Grayburn P, Vahanian A, Maisano F. Transcatheter mitral valve repair for functional mitral regurgitation using the Cardio-band system: 1 year outcomes. *Eur Heart J.* 2019 Feb 1;40(5):466-472. doi: 10.1093/eurheartj/ehy424. PMID: 30124798.