

20 Interventionelle Therapie struktureller Herzerkrankungen

20.1 Aortenklappenstenose

- [1] Roberts WC, Ko JM. Frequency by decades of unicuspid, bicuspid, and tricuspid aortic valves in adults having isolated aortic valve replacement for aortic stenosis, with or without associated aortic regurgitation. *Circulation* 111:920–925, 2005
- [2] Baumgartner H, Hung J, Bermejo J et al. Recommendations on the echocardiographic assessment of aortic valve stenosis: a focused update from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *J Am Soc Echocardiogr* 30:372–392, 2017
- [3] Baumgartner H, Falk V, Bax JJ et al. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J* 38:2739–2791, 2017
- [3a] Vahanian A, Beyersdorf F, Praz F et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease: developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 43(7):561–632, 2021
- [3b] Deutsche Gesellschaft für Kardiologie – Herz- und Kreislaufforschung e.V. ESC Pocket Guidelines. Herzklappenerkrankungen, Version 2021. Börm Bruckmeier, Grünwald, 2022
- [4] Schwarz F, Baumann P, Manthey J et al. The effect of aortic valve replacement on survival. *Circulation* 66:1105–1110, 1982
- [5] Cribier A, Eltchaninoff H, Bash A et al. Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description. *Circulation* 106:3006–3008, 2002
- [6] Omran H, Schmidt H, Hackenbroch M et al. Silent and apparent cerebral embolism after retrograde catheterisation of the aortic valve in valvular stenosis: a prospective, randomised study. *Lancet* 361:1241–1246, 2003
- [7] Cribier A, Savin T, Saoudi N et al. Percutaneous transluminal valvuloplasty of acquired aortic stenosis in elderly patients: an alternative to valve replacement. *Lancet* 1:63–67, 1986
- [8] Cribier A, Remadi F, Koning R et al. Emergency balloon valvuloplasty as initial treatment of patients with aortic stenosis and cardiogenic shock. *N Engl J Med* 326:646, 1992
- [9] Otto CM, Mickel MC, Kennedy JW et al. Three-year outcome after balloon aortic valvuloplasty. Insights into prognosis of valvular aortic stenosis. *Circulation* 89:642–650, 1994
- [10] Serruys PW, Luijten HE, Beatt KJ et al. Percutaneous balloon valvuloplasty for calcific aortic stenosis. A treatment „sine cure“? *Eur Heart J* 9:782–794, 1988
- [11] Lieberman EB, Bashore TM, Hermiller JB et al. Balloon aortic valvuloplasty in adults: failure of procedure to improve long-term survival. *J Am Coll Cardiol* 26:1522–1528, 1995
- [12] Litvack F, Jakubowski AT, Buchbinder NA et al. Lack of sustained clinical improvement in an elderly population after percutaneous aortic valvuloplasty. *Am J Cardiol* 62:270–275, 1988
- [13] Sack S, Kahlert P, Khandanpour S et al. Revival of an old method with new techniques: balloon aortic valvuloplasty of the calcified aortic stenosis in the elderly. *Clin Res Cardiol* 97:288–297, 2008
- [14] Agatiello C, Eltchaninoff H, Tron C et al. Balloon aortic valvuloplasty in the adult. Immediate results and in-hospital complications in the latest series of 141 consecutive patients at the University Hospital of Rouen (2002–2005). *Arch Mal Coeur Vaiss* 99:195–200, 2006
- [15] Sack S, Henrichs KJ, Erbel R et al. Echocardiographic and angiographic evaluation

- of left ventricular function during percutaneous transluminal aortic valvuloplasty. *Cathet Cardiovasc Diagn* 26:82–91, 1992
- [16] Ben-Dor I, Maluenda G, Dvir D et al. Outcomes of concomitant percutaneous coronary intervention and balloon aortic valvuloplasty. *Catheter Cardiovasc Interv* 82:E835–E841, 2013
 - [17] Vahanian A, Baumgartner H, Bax J et al. Guidelines on the management of valvular heart disease: The Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology. *Eur Heart J* 28:230–268, 2007
 - [18] Charlson E, Legedza AT, Hamel MB. Decision-making and outcomes in severe symptomatic aortic stenosis. *J Heart Valve Dis* 15:312–321, 2006
 - [19] Iung B, Baron G, Butchart EG et al. A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. *Eur Heart J* 24:1231–1243, 2003
 - [20] Roques F, Nashef SA, Michel P et al. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. *Eur J Cardiothorac Surg* 15:816–822, 1999; discussion 822–833, 1999
 - [21] Vaquette B, Corbineau H, Laurent M et al. Valve replacement in patients with critical aortic stenosis and depressed left ventricular function: predictors of operative risk, left ventricular function recovery, and long term outcome. *Heart* 91:1324–1329, 2005
 - [22] Nashef SA, Roques F, Michel P et al. European system for cardiac operative risk evaluation (EuroSCORE). *Eur J Cardiothorac Surg* 16:9–13, 1999
 - [23] O'Brien SM, Shahian DM, Filardo G et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 2 – isolated valve surgery. *Ann Thorac Surg* 88:S23–S42, 2009
 - [24] Iung B, Cachier A, Baron G et al. Decision-making in elderly patients with severe aortic stenosis: why are so many denied surgery. *Eur Heart J* 26:2714–2720, 2005
 - [25] Hanzel GS, Harrity PJ, Schreiber TL et al. Retrograde percutaneous aortic valve implantation for critical aortic stenosis. *Catheter Cardiovasc Interv* 64:322–326, 2005
 - [26] Webb JG, Chandavimol M, Thompson CR et al. Percutaneous aortic valve implantation retrograde from the femoral artery. *Circulation* 113:842–850, 2006
 - [27] Lichtenstein SV, Cheung A, Ye J et al. Transapical transcatheter aortic valve implantation in humans: initial clinical experience. *Circulation* 114:591–596, 2006
 - [28] Cribier A, Eltchaninoff H, Tron C et al. Early experience with percutaneous transcatheter implantation of heart valve prosthesis for the treatment of end-stage inoperable patients with calcific aortic stenosis. *J Am Coll Cardiol* 43:698–703, 2004
 - [29] Cribier A, Eltchaninoff H, Tron C et al. Treatment of calcific aortic stenosis with the percutaneous heart valve: mid-term follow-up from the initial feasibility studies: the French experience. *J Am Coll Cardiol* 47:1214–1223, 2006
 - [30] Ye J, Cheung A, Lichtenstein SV et al. Transapical aortic valve implantation in humans. *J Thorac Cardiovasc Surg* 131:1194–1196, 2006
 - [31] Webb JG, Pasupati S, Humphries K et al. Percutaneous transarterial aortic valve replacement in selected high-risk patients with aortic stenosis. *Circulation* 116:755–763, 2007
 - [32] Walther T, Simon P, Dewey T et al. Transapical minimally invasive aortic valve implantation: multicenter experience. *Circulation* 116: 1240–1245, 2007
 - [33] Grube E, Laborde JC, Zickmann B et al. First report on a human percutaneous transluminal implantation of a self-expanding valve prosthesis for interventional treatment of aortic valve stenosis. *Catheter Cardiovasc Interv* 66:465–469, 2005
 - [34] Grube E, Laborde JC, Gerckens U et al. Percutaneous implantation of the CoreValve self-expanding valve prosthesis in high-risk patients with aortic valve disease: the Siegburg first-in-man study. *Circulation* 114:1616–1624, 2006
 - [35] Grube E, Schuler G, Buellesfeld L et al. Percutaneous aortic valve replacement for severe aortic stenosis in high-risk patients using the second- and current third-generation self-expanding CoreValve prosthesis: device success and 30-day clinical outcome. *J Am Coll Cardiol* 50:69–76, 2007
 - [36] Grube E, Buellesfeld L, Mueller R et al. Progress and current status of percutaneous aortic valve replacement: results of three device generations of the CoreValve

- Revalving system. *Circ Cardiovasc Interv* 1:167–175, 2008
- [37] Piazza N, Grube E, Gerckens U et al. Procedural and 30-day outcomes following transcatheter aortic valve implantation using the third generation (18 Fr) core-valve revalving system: results from the multicentre, expanded evaluation registry 1-year following CE mark approval. *Euro-Intervention* 4:242–249, 2008
- [38] Leon MB, Smith CR, Mack M et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *N Engl J Med* 363:1597–1607, 2010
- [39] Smith CR, Leon MB, Mack MJ et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *N Engl J Med* 364:2187–2198, 2011
- [40] Adams DH, Popma JJ, Reardon MJ et al. Transcatheter aortic-valve replacement with a self-expanding prosthesis. *N Engl J Med* 370:1790–1798, 2014
- [41] Leon MB, Smith CR, Mack MJ et al. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 374:1609–1620, 2016
- [42] Reardon MJ, Van Mieghem NM, Popma JJ et al. Surgical or transcatheter aortic-valve replacement in intermediate-risk patients. *N Engl J Med* 376:1321–1331, 2017
- [43] Popma JJ, Deeb GM, Yakubov SJ et al. Transcatheter aortic-valve replacement with a self-expanding valve in low-risk patients. *N Engl J Med* 380:1706–1715, 2019
- [44] Mack MJ, Leon MB, Thourani VH et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. *N Engl J Med* 380:1695–1705, 2019
- [45] Abdel-Wahab M, Mehilli J, Frerker C et al. Comparison of balloon-expandable vs self-expandable valves in patients undergoing transcatheter aortic valve replacement: the CHOICE randomized clinical trial. *JAMA* 311:1503–1514, 2014
- [46] Feldman TE, Reardon MJ, Rajagopal V et al. Effect of mechanically expanded vs self-expanding transcatheter aortic valve replacement on mortality and major adverse clinical events in high-risk patients with aortic stenosis: The REPRISE III randomized clinical trial. *JAMA* 319:27–37, 2018
- [47] Lanz J, Kim WK, Walther T et al. Safety and efficacy of a self-expanding versus a balloon-expandable bioprosthesis for transcatheter aortic valve replacement in patients with symptomatic severe aortic stenosis: a randomised non-inferiority trial. *Lancet* 394:1619–1628, 2019
- [48] Figulla HR, Cremer J, Walther T et al. Positionspapier zur kathetergeführten Aortenklappenintervention. *Kardiologie* 3:199–206, 2009
- [49] Kuck KH, Eggebrecht H, Figulla HR et al. Positionspapier zu Qualitätskriterien zur Durchführung der transkathetären Aortenklappenimplantation (TAVI). *Kardiologie* 9:11–26, 2015
- [50] Kuck KH, Eggebrecht H, Elsässer A et al. Qualitätskriterien zur Durchführung der kathetergestützten Aortenklappenimplantation (TAVI). Aktualisierung des Positionspapiers der Deutschen Gesellschaft für Kardiologie. *Kardiologie* 10:282–300, 2016
- [51] Vahanian A, Alfieri O, Al-Attar N et al. Transcatheter valve implantation for patients with aortic stenosis: a position statement from the European Association of Cardio-Thoracic Surgery (EACTS) and the European Society of Cardiology (ESC), in collaboration with the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur Heart J* 29:1463–1470, 2008
- [52] Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) et al. Guidelines on the management of valvular heart disease (version 2012). *Eur Heart J* 33:2451–2496, 2012
- [53] Baumgartner H, Cremer J, Eggebrecht H et al. Kommentar zu den Leitlinien (2017) der ESC/EACTS zum Management von Herzklappenerkrankungen. *Kardiologie* 12:184–193:2018
- [54] Hildebrandt HA, Mahabadi AA, Totzeck M et al. Imaging for planning of transcatheter aortic valve implantation. *Herz* 42:554–563, 2017; Erratum: *Herz* 42:564, 2017
- [55] Gerckens U, Pizzulli L, Raisakis K. Alcohol septal ablation as a bail-out procedure for suicide left ventricle after transcatheter aortic valve implantation. *J Invasive Cardiol* 25:E114–E117, 2013

- [56] Binder RK, Webb JG, Willson AB et al. The impact of integration of a multidetector computed tomography annulus area sizing algorithm on outcomes of transcatheter aortic valve replacement: a prospective, multicenter, controlled trial. *J Am Coll Cardiol* 62:431–438, 2013
- [57] Blanke P, Reinöhl J, Schlensak C et al. Prosthesis oversizing in balloon-expandable transcatheter aortic valve implantation is associated with contained rupture of the aortic root. *Circ Cardiovasc Interv* 5:540–548, 2012
- [58] Nietlispach F, Leipsic J, Al-Bugami S et al. CT of the ilio-femoral arteries using direct aortic contrast injection: proof of feasibility in patients screened towards percutaneous aortic valve replacement. *Swiss Med Wkly* 139:458–462, 2009
- [59] Otto CM, Kumbhani DJ, Alexander KP et al. 2017 ACC Expert consensus decision pathway for transcatheter aortic valve replacement in the management of adults with aortic stenosis: a report of the American College of Cardiology Task Force on Clinical Expert Consensus Documents. *J Am Coll Cardiol* 69:1313–1346, 2017
- [60] Bundesministerium für Gesundheit. Richtlinie über Maßnahmen zur Qualitätssicherung bei der Durchführung von minimal-invasiven Herzklappeninterventionen gemäß § 137 Absatz 1 Satz 1 Nummer 2 für nach § 108 SGB V zugelassene Krankenhäuser (Richtlinie zu minimalinvasiven Herzklappeninterventionen/MHI-RK). *BAnz AT* 24.07.2015 B6, 2015
- [61] Schymik G, Wendler O, Hengstenberg C et al. Outcomes of transfemoral balloon expandable transcatheter aortic valve implantation: comparison of two subsequent valve generations. *Catheter Cardiovasc Interv* 96:930–939, 2020
- [62] Thomas M, Schymik G, Walther T et al. Thirty-day results of the Sapien aortic Bioprosthesis European Outcome (SOURCE) Registry: a European registry of transcatheter aortic valve implantation using the Edwards Sapien valve. *Circulation* 122:62–69, 2010
- [63] Schymik G, Lefèvre T, Bartorelli AL et al. European experience with the second-generation Edwards Sapien XT transcatheter heart valve in patients with severe aortic stenosis: 1-year outcomes from the SOURCE XT Registry. *JACC Cardiovasc Interv* 8:657–669, 2015
- [64] Wendler O, Schymik G, Treede H et al. SOURCE 3 Registry: design and 30-day results of the European postapproval registry of the latest generation of the Sapien 3 transcatheter heart valve. *Circulation* 135:1123–1132, 2017
- [65] Wendler O, Schymik G, Treede H et al. SOURCE 3: 1-year outcomes post-transcatheter aortic valve implantation using the latest generation of the balloon-expandable transcatheter heart valve. *Eur Heart J* 38:2717–272, 2017
- [66] Saia F, Gandolfo C, Palmerini T et al. In-hospital and thirty-day outcomes of the SAPIEN 3 Ultra balloon-expandable transcatheter aortic valve: the S3U registry. *EuroIntervention* 15:1240–1247, 2020
- [67] Buellesfeld L, Gerckens U, Schuler G et al. 2-year follow-up of patients undergoing transcatheter aortic valve implantation using a self-expanding valve prosthesis. *J Am Coll Cardiol* 57:1650–1657, 2011
- [68] Ussia GP, Barbanti M, Petronio AS et al. Transcatheter aortic valve implantation: 3-year outcomes of self-expanding CoreValve prosthesis. *Eur Heart J* 33:969–976, 2012
- [69] Grube E, Van Mieghem NM, Bleiziffer S et al. Clinical outcomes with a repositionable self-expanding transcatheter aortic valve prosthesis: the international FORWARD study. *J Am Coll Cardiol* 70:845–853, 2017
- [70] Manoharan G, Van Mieghem NM, Windecker S et al. 1-year outcomes with the Evolut R self-expanding transcatheter aortic valve: from the international FORWARD study. *JACC Cardiovasc Interv* 11:2326–2334, 2018
- [71] Popma JJ, Reardon MJ, Khabbaz K et al. Early clinical outcomes after transcatheter aortic valve replacement using a novel self-expanding bioprosthesis in patients with severe aortic stenosis who are suboptimal for surgery: results of the Evolut R U.S. study. *JACC Cardiovasc Interv* 10:268–275, 2017
- [72] Forrest JK, Mangi AA, Popma JJ et al. Early outcomes with the Evolut PRO repositionable self-expanding transcatheter aortic valve with pericardial wrap. *JACC Cardiovasc Interv* 11:160–168, 2018

- [73] Möllmann H, Hengstenberg C, Hilker M et al. Real-world experience using the ACURATE neo prosthesis: 30-day outcomes of 1000 patients enrolled in the SAVI TF registry. *EuroIntervention* 13:e1764-e1770, 2018
- [74] Kim WK, Hengstenberg C, Hilker M et al. The SAVI-TF Registry: 1-year outcomes of the European post-market registry using the ACURATE neo transcatheter heart valve under real-world conditions in 1000 patients. *JACC Cardiovasc Interv* 11:1368–1374, 2018
- [75] Wenaweser P, Stortecky S, Schütz T et al. Transcatheter aortic valve implantation with the NVT Allegra transcatheter heart valve system: first-in-human experience with a novel self-expanding transcatheter heart valve. *EuroIntervention* 12:71–77, 2016
- [76] Manoharan G, Linke A, Moellmann H et al. Multicentre clinical study evaluating a novel resheathable annular functioning self-expanding transcatheter aortic valve system: safety and performance results at 30 days with the Portico system. *EuroIntervention* 12:768–774, 2016
- [77] Linke A, Holzhey D, Möllmann H et al. Treatment of aortic stenosis with a self-expanding, resheathable transcatheter valve: one-year results of the international multicenter Portico transcatheter aortic valve implantation system study. *Circ Cardiovasc Interv* 11:e005206, 2018
- [78] Hyman MC, Vemulapalli S, Szeto WY et al. Conscious sedation versus general anesthesia for transcatheter aortic valve replacement: insights from the National Cardiovascular Data Registry Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy Registry. *Circulation* 136:2132–2140, 2017
- [79] Walther T, Simon P, Dewey T et al. Transapical minimally invasive aortic valve implantation: multicenter experience. *Circulation* 116:I240–I245, 2007
- [80] Ruge H, Lange R, Bleiziffer S et al. First successful aortic valve implantation with the CoreValve ReValving system via right subclavian artery access: a case report. *Heart Surg Forum* 11:E323–E324, 2008
- [81] Fraccaro C, Napodano M, Tarantini G et al. Expanding the eligibility for transcatheter aortic valve implantation the transsubclavian retrograde approach using: the III generation CoreValve revalving system. *JACC Cardiovasc Interv* 2:828–833, 2009
- [82] Petronio AS, De Carlo M, Bedogni F et al. Safety and efficacy of the subclavian approach for transcatheter aortic valve implantation with the CoreValve revalving system. *Circ Cardiovasc Interv* 3:359–366, 2010
- [83] Testa L, Brambilla N, Laudisa ML et al. Right subclavian approach as a feasible alternative for transcatheter aortic valve implantation with the CoreValve ReValving system. *EuroIntervention* 8:685–690, 2012
- [84] Schäfer U, Ho Y, Frerker C et al. Direct percutaneous access technique for transaxillary transcatheter aortic valve implantation: „the Hamburg Sankt Georg approach“. *JACC Cardiovasc Interv* 5:477–486, 2012
- [85] Bauernschmitt R, Schreiber C, Bleiziffer S et al. Transcatheter aortic valve implantation through the ascending aorta: an alternative option for no-access patients. *Heart Surg Forum* 12:E63–E64, 2009
- [86] Bapat V, Attia R. Transaortic transcatheter aortic valve implantation: step-by-step guide. *Semin Thorac Cardiovasc Surg* 24:206–211, 2012
- [87] Cocchieri R, Petzina R, Romano M et al. Outcomes after transaortic transcatheter aortic valve implantation: long-term findings from the European ROUTE†. *Eur J Cardiothorac Surg* 55:737–743, 2019
- [88] Philipsen TE, Rodrigus IE, Claeys MJ et al. Alternative access in transcatheter aortic valve implantation: brachiocephalic artery access. *Innovations (Phila)* 7:372–375, 2012
- [89] Kiser AC, Caranasos TG, Peterson MD et al. Suprasternal transcatheter aortic valve replacement in patients with marginal femoral access. *Innovations (Phila)* 13:1–4, 2018
- [90] Modine T, Lemesle G, Azzaoui R et al. Aortic valve implantation with the CoreValve ReValving System via left carotid artery access: first case report. *J Thorac Cardiovasc Surg* 140:928–929, 2010
- [91] Mylotte D, Sudre A, Teiger E et al. Transcarotid transcatheter aortic valve replacement: feasibility and safety. *JACC Cardiovasc Interv* 9:472–480, 2016
- [92] Debry N, Delhay C, Azmoun A et al. Transcarotid transcatheter aortic valve replacement: general or local anesthesia.

- JACC Cardiovasc Interv 9:2113–2120, 2016
- [93] Lederman RJ, Babaliaros VC, Greenbaum AB. How to perform transcaval access and closure for transcatheter aortic valve implantation. *Catheter Cardiovasc Interv* 86:1242–1254, 2015
- [94] Greenbaum AB, O'Neill WW, Paone G et al. Caval-aortic access to allow transcatheter aortic valve replacement in otherwise ineligible patients: initial human experience. *J Am Coll Cardiol* 63:2795–2804, 2014
- [95] Greenbaum AB, Babaliaros VC, Chen MY, Stine AM, Rogers T, O'Neill WW, Paone G, Thourani VH, Muhammad KI, Leonard RA, Ramee S, Froendle JF, Lederman RJ. Transcaval access and closure for transcatheter aortic valve replacement: a prospective investigation. *J Am Coll Cardiol* 69:511–521, 2017
- [96] Costa G, De Backer O, Pilgrim T et al. Feasibility and safety of transcatheter aortic valve implantation: a multicentre European registry. *EuroIntervention* 15:e1319–e1324, 2020
- [97] Fröhlich GM, Baxter PD, Malkin CJ et al. Comparative survival after transapical, direct aortic, and subclavian transcatheter aortic valve implantation (data from the UK TAVI registry). *Am J Cardiol* 116:1555–1559, 2015
- [98] Rodés-Cabau J, Puri R, Chamandi C. The caval-aortic access for performing TAVR: pushing the limits of alternative access for nontransfemoral candidates. *J Am Coll Cardiol* 69:522–525, 2017
- [99] Lanz J, Greenbaum A, Pilgrim T et al. Current state of alternative access for transcatheter aortic valve implantation. *EuroIntervention* 14:AB40–AB52, 2018
- [100] Toutouzas K, Benetos G, Voudris V et al. Pre-dilatation versus no pre-dilatation for implantation of a self-expanding valve in all comers undergoing TAVR: the DIRECT trial. *JACC Cardiovasc Interv* 12:767–777, 2019
- [101] Dumonteil N, Terkelsen C, Frerker C et al. Outcomes of transcatheter aortic valve replacement without predilation of the aortic valve: insights from 1544 patients included in the SOURCE 3 registry. *Int J Cardiol* 296:32–37, 2019
- [102] Auffret V, Regueiro A, Campelo-Parada F et al. Feasibility, safety, and efficacy of transcatheter aortic valve replacement without balloon predilation: a systematic review and meta-analysis. *Catheter Cardiovasc Interv* 90:839–850, 2017
- [103] Butter C, Okamoto M, Schymik G et al. Degree of valve calcification in patients undergoing transfemoral transcatheter aortic valve implantation with and without balloon aortic valvuloplasty: findings from the multicenter EASE-IT TF registry. *Catheter Cardiovasc Interv* 94:469–478, 2019
- [104] Cilingiroglu M, Margmakiolis K. Predilatation for transcatheter aortic valve replacement: still have a role. *Catheter Cardiovasc Interv* 94:479–480, 2019
- [105] Patsalis PC, Al-Rashid F, Neumann T et al. Preparatory balloon aortic valvuloplasty during transcatheter aortic valve implantation for improved valve sizing. *JACC Cardiovasc Interv* 6:965–971, 2013
- [106] Sinning JM, Hammerstingl C, Vasa-Nicotera M et al. Aortic regurgitation index defines severity of peri-prosthetic regurgitation and predicts outcome in patients after transcatheter aortic valve implantation. *J Am Coll Cardiol* 59:1134–1141, 2012
- [107] Patsalis PC, Konorza TF, Al-Rashid F et al. Incidence, outcome and correlates of residual paravalvular aortic regurgitation after transcatheter aortic valve implantation and importance of haemodynamic assessment. *EuroIntervention* 8:1398–1406, 2013
- [108] Patsalis PC, Konorza TF, Al-Rashid F et al. Hemodynamic assessment of paravalvular aortic regurgitation after TAVI: estimated myocardial supply-demand ratio and cardiovascular mortality. *Am J Physiol Heart Circ Physiol* 304:H1023–H1028, 2013
- [109] Kahlert P, Al-Rashid F, Plicht B et al. Incidence, predictors, origin and prevention of early and late neurological events after transcatheter aortic valve implantation (TAVI): a comprehensive review of current data. *J Thromb Thrombolysis* 35:436–449, 2013
- [110] Kahlert P, Knipp SC, Schlamann M et al. Silent and apparent cerebral ischemia after percutaneous transfemoral aortic valve implantation: a diffusion-weighted magnetic resonance imaging study. *Circulation* 121:870–878, 2010

- [111] Ghanem A, Müller A, Nähle CP et al. Risk and fate of cerebral embolism after transfemoral aortic valve implantation: a prospective pilot study with diffusion-weighted magnetic resonance imaging. *J Am Coll Cardiol* 55:1427–1432, 2010
- [112] Arnold M, Schulz-Heise S, Achenbach S et al. Embolic cerebral insults after transapical aortic valve implantation detected by magnetic resonance imaging. *JACC Cardiovasc Interv* 3:1126–1132, 2010
- [113] Rodés-Cabau J, Dumont E, Boone RH et al. Cerebral embolism following transcatheter aortic valve implantation: comparison of transfemoral and transapical approaches. *J Am Coll Cardiol* 57:18–28, 2011
- [114] Astarci P, Glineur D, Kefer J et al. Magnetic resonance imaging evaluation of cerebral embolization during percutaneous aortic valve implantation: comparison of transfemoral and trans-apical approaches using Edwards Sapiens valve. *Eur J Cardiothorac Surg* 40:475–479, 2011
- [115] Fairbairn TA, Mather AN, Bijsterveld P et al. Diffusion-weighted MRI determined cerebral embolic infarction following transcatheter aortic valve implantation: assessment of predictive risk factors and the relationship to subsequent health status. *Heart* 98:18–23, 2012
- [116] Lansky AJ, Schofer J, Tchetché D et al. A prospective randomized evaluation of the TriGuard™ HDH embolic DEFLECTION device during transcatheter aortic valve implantation: results from the DEFLECT III trial. *Eur Heart J* 36:2070–2078, 2015
- [117] Haussig S, Mangner N, Dwyer MG et al. Effect of a cerebral protection device on brain lesions following transcatheter aortic valve implantation in patients with severe aortic stenosis: the CLEAN-TAVI randomized clinical trial. *JAMA* 316:592–601, 2016
- [118] Van Mieghem NM, van Gils L, Ahmad H et al. Filter-based cerebral embolic protection with transcatheter aortic valve implantation: the randomised MISTRAL-C trial. *EuroIntervention* 12:499–507, 2016
- [119] Kapadia SR, Kodali S, Makkar R et al. Protection against cerebral embolism during transcatheter aortic valve replacement. *J Am Coll Cardiol* 69:367–377, 2017
- [120] Dvir D, Webb JG, Bleiziffer S et al. Transcatheter aortic valve implantation in failed bioprosthetic surgical valves. *JAMA* 312:162–170, 2014
- [121] Bernardi FLM, Dvir D, Rodes-Cabau J et al. Valve-in-valve challenges: how to avoid coronary obstruction. *Front Cardiovasc Med* 6:120, 2019
- [122] Makkar RR, Fontana G, Jilaihwai H et al. Possible subclinical leaflet thrombosis in bioprosthetic aortic valves. *N Engl J Med* 373:2015–2024, 2015
- [123] Chakravarty T, Søndergaard L, Friedman J et al. Subclinical leaflet thrombosis in surgical and transcatheter bioprosthetic aortic valves: an observational study. *Lancet* 389:2383–2392, 2017
- [124] Rodés-Cabau J, Masson JB, Welsh RC et al. Aspirin versus aspirin plus clopidogrel as antithrombotic treatment following transcatheter aortic valve replacement with a balloon-expandable valve: the ARTE (Aspirin versus Aspirin + Clopidogrel following transcatheter aortic valve implantation) randomized clinical trial. *JACC Cardiovasc Interv* 10:1357–1365, 2017
- [125] Dangas GD, Tijssen JGP, Wöhrle J et al. A controlled trial of rivaroxaban after transcatheter aortic-valve replacement. *N Engl J Med* 382:120–129, 2019
- [126] De Backer O, Dangas GD, Jilaihwai H et al. Reduced leaflet motion after transcatheter aortic-valve replacement. *N Engl J Med* 382:130–139, 2019
- [127] Collet JP, Berti S, Cequier A et al. Oral anti-Xa anticoagulation after trans-aortic valve implantation for aortic stenosis: the randomized ATLANTIS trial. *Am Heart J* 200:44–50, 2018
- [128] Nijenhuis VJ, Bennaghmouch N, Hassell M et al. Rationale and design of POPULAR-TAVI: antiPlatelet therapy fOr Patients undergoing Transcatheter Aortic Valve Implantation. *Am Heart J* 173:77–85, 2016
- [129] Van Mieghem NM, Unverdorben M, Valgimigli M et al. Edoxaban Versus standard of care and their effects on clinical outcomes in patients having undergone Transcatheter Aortic Valve Implantation in Atrial Fibrillation: Rationale and design of the ENVISAGE-TAVI AF trial. *Am Heart J* 205:63–69, 2018
- [130] Spitzer E, Van Mieghem NM, Pibarot P et al. Rationale and design of The Transca-

- theter Aortic Valve Replacement to UNload the Left ventricle in patients with ADvanced heart failure (TAVR UNLOAD) trial. *Am Heart J* 182:80–88, 2016
- [131] Thielmann M, Eggebrecht H, Wendt D et al. New techniques for the treatment of valvular aortic stenosis – transcatheter aortic valve implantation with the Sapien heart valve. *Minim Invasive Ther Allied Technol* 18:131–141, 2009
- [132] Yoon SH, Lefèvre T, Ahn JM et al. Transcatheter aortic valve replacement with early- and new-generation devices in bicuspid aortic valve stenosis. *J Am Coll Cardiol* 68:1195–1205, 2016
- [133] Yoon SH, Makkar, R. Transcatheter aortic valve replacement for bicuspid aortic valve: challenges and pitfalls. *Interv Cardiol Clin* 7:477–488, 2018
- [134] Yoon SH, Sharma R, Chakravarty T et al. Transcatheter aortic valve replacement in bicuspid aortic valve stenosis: where do we stand. *J Cardiovasc Surg (Torino)* 59:381–391, 2018
- [135] Kahlert P, Al-Rashid F, Weber M et al. Vascular access site complications after percutaneous transfemoral aortic valve implantation. *Herz* 34:398–408, 2009
- [136] Marquis-Gravel G, Redfors B, Leon MB et al. Medical treatment of aortic stenosis. *Circulation* 134:1766–1784, 2016
- [137] Brandenburg VM, Schurgers LJ, Kaesler N et al. Prevention of vasculopathy by vitamin K supplementation: can we turn fiction into fact? *Atherosclerosis* 240:10–16, 2015
- [138] Willems BA, Vermeer C, Reutelingsperger CP et al. The realm of vitamin K dependent proteins: shifting from coagulation toward calcification. *Mol Nutr Food Res* 58:1620–1635, 2014
- [139] Cranenburg EC, Vermeer C, Koos R et al. The circulating inactive form of matrix Gla Protein (ucMGP) as a biomarker for cardiovascular calcification. *J Vasc Res* 45:427–436, 2008
- [140] Lees JS, Chapman FA, Witham MD et al. Vitamin K status, supplementation and vascular disease: a systematic review and meta-analysis. *Heart* 105:938–945, 2019
- [141] Brandenburg VM, Reinartz S, Kaesler N et al. Slower progress of aortic valve calcification with vitamin K supplementation: results from a prospective interventional proof-of-concept study. *Circulation* 135:2081–2083, 2017; correction in *Circulation* 141:e54, 2020
- [142] Koos R, Mahnken AH, Sinha AM et al. Aortic valve calcification as a marker for aortic stenosis severity: assessment on 16-MDCT. *Am J Roentgenol* 183(6):1813–1818, 2004
- [143] Westenfeld R, Krüger T, Schlieper G et al. Effect of vitamin K2 supplementation on functional vitamin K deficiency in hemodialysis patients: a randomized trial. *Am J Kidney Dis* 2012;59: 186–95.
- [144] Oikonomaki T, Papasotiriou M, Ntrinas T et al. The effect of vitamin K2 supplementation on vascular calcification in haemodialysis patients: a 1-year follow-up randomized trial. *Int Urol Nephrol*. 2019 Nov;51(11):2037-2044..

20.2 Aortenklappeninsuffizienz

- [1] Iung B, Baron G, Butchart EB et al. A prospective survey of patients with valvular heart disease in Europe: the Euro Heart Survey on Valvular Heart Disease. *Eur Heart J* 24:1231–1243, 2003
- [2] Baumgartner H, Falk V, Baxx J et al. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J* 38:2739–2791, 2017
- [2a] Vahanian A, Beyersdorf F, Praz F et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease: Developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 43(7):561–632, 2021
- [3] Habib G, Lancellotti P, Altunes MJ et al. 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* 36:3075–3128, 2015
- [4] Erbel R, Aboyans V, Boileau C et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the

- adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). *Eur Heart J* 35:2873–2926, 2014
- [5] Hildebrandt HA, Erbel R, Kahlert P. Compassionate use of the self-expandable Medtronic CoreValve prosthesis for the treatment of pure aortic regurgitation in a patient at prohibitive risk for surgical valve replacement. *Catheter Cardiovasc Interv* 82:E939–E942, 2013
 - [6] Roy DA, Schaefer U, Guetta V et al. Transcatheter aortic valve implantation for pure severe native aortic valve regurgitation. *J Am Coll Cardiol* 61:1577–1584, 2013
 - [7] Takagi H, Hari Y, Kawai N et al. Meta-analysis and meta-regression of transcatheter aortic valve implantation for pure native aortic regurgitation. *Heart Lung Circ* 29:729–741, 2019
 - [8] Wernly B, Eder S, Navarese EP et al. Transcatheter aortic valve replacement for pure aortic valve regurgitation: „on-label“ versus „off-label“ use of TAVR devices. *Clin Res Cardiol* 108:921–930, 2019
 - [9] Vahanian A, Alfieri O, Al-Attar N et al. Transcatheter valve implantation for patients with aortic stenosis: a position statement from the European Association of Cardio-Thoracic Surgery (EACTS) and the European Society of Cardiology (ESC), in collaboration with the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur Heart J* 29:1463–1470, 2008
 - [10] Hensey M, Murdoch DJ, Sathananthan J et al. First-in-human experience of a new-generation transfemoral transcatheter aortic valve for the treatment of severe aortic regurgitation: the J-Valve transfemoral system. *EuroIntervention* 14:e1553–e1555, 2019
- Developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 43(7):561–632, 2021
- [3] Wilkins GT, Weyman AE, Abascal VM et al. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and mechanism of dilatation. *Br Heart J* 60:299–308, 1988
 - [4] Lung B, Cormier B, Ducimetiere P et al. Immediate results of percutaneous mitral commissurotomy: a predictive model on a series of 1514 patients. *Circulation* 94:2124–2130, 1996
 - [5] Nobuyoshi M, Arita T, Shirai S et al. Percutaneous balloon mitral valvuloplasty: a review. *Circulation* 119:e211–e219, 2009
 - [6] Meneguz-Moreno RA, Costa JR Jr, Gomes NL et al. Very long term follow-up after percutaneous balloon mitral valvuloplasty. *JACC Cardiovasc Interv* 11:1945–1952, 2018
 - [7] Maisano F, Taramasso M. Mitral valve-in-valve, valve-in-ring, and valve-in-MAC: the good, the bad, and the ugly. *European Heart J* 40:452–455, 2019
 - [8] Yoon SH, Whisenant BK, Bleiziffer S et al. Outcomes of transcatheter mitral valve replacement for degenerated bioprostheses, failed annuloplasty rings, and mitral annular calcification. *Eur Heart J* 40:441–451, 2019

20.3 Mitralklappenstenose

- [1] Inoue K, Owaki T, Nakamura T et al. Clinical application of transvenous mitral commissurotomy by a new balloon catheter. *J Thorac Cardiovasc Surg* 87:394–402, 1984
- [2] Vahanian A, Beyersdorf F, Praz F et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease:

20.4 Mitralklappeninsuffizienz

- [1] Nkomo VT, Gardin JM, Skelton TN et al. Burden of valvular heart diseases: a population-based study. *Lancet* 368:1005–1011, 2006
- [2] Nishimura RA, Otto CM, Bonow RO et al. 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. *Circulation* 129:2440–2492, 2014
- [3] Enriquez-Sarano M, Avierinos JF, Messika-Zeitoun D et al. Quantitative determinants of the outcome of asymptomatic

- mitral regurgitation. *N Engl J Med* 352:875–883, 2005
- [4] Rossi A, Dini FL, Faggiano P et al. Independent prognostic value of functional mitral regurgitation in patients with heart failure: a quantitative analysis of 1256 patients with ischaemic and non-ischaemic dilated cardiomyopathy. *Heart* 97:1675–1680, 2011
 - [5] Ellis SG, Whitlow PL, Raymond RE et al. Impact of mitral regurgitation on long-term survival after percutaneous coronary intervention. *Am J Cardiol* 89:315–318, 2002
 - [6] Vahanian A, Beyersdorf F, Praz F et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease: developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 43(7):561–632, 2021
 - [7] Attizzani GF, Ohno Y, Capodanno D et al. Extended use of percutaneous edge-to-edge mitral valve repair beyond EVEREST (Endovascular Valve Edge-to-Edge Repair) criteria: 30-day and 12-month clinical and echocardiographic outcomes from the GRASP (Getting Reduction of Mitral Insufficiency by Percutaneous Clip Implantation) registry. *JACC Cardiovasc Interv* 8:74–82, 2015
 - [8] Lesevic H, Karl M, Braun D et al. Long-term outcomes after MitraClip implantation according to the presence or absence of EVEREST inclusion criteria. *Am J Cardiol* 119:1255–1261, 2017
 - [9] Feldman T, Foster E, Glower DD et al. Percutaneous repair or surgery for mitral regurgitation. *N Engl J Med* 364:1395–406, 2011
 - [10] Stone GW, Lindenfeld J, Abraham WT et al. Transcatheter mitral-valve repair in patients with heart failure. *N Engl J Med* 379:2307–2318, 2018
 - [11] Obadia JF, Messika-Zeitoun D, Leurent G et al. Percutaneous repair or medical treatment for secondary mitral regurgitation. *N Engl J Med* 379:2297–2306, 2018
 - [12] Praz F, Spargias K, Chrissosheris M et al. Compassionate use of the Pascal transcatheter mitral valve repair system for patients with severe mitral regurgitation: a multicentre, prospective, observational, first-in-man study. *Lancet* 390:773–780, 2017
 - [13] Rottländer D, Degen H, Haude M. The Carillon: strategies for optimal patient selection and optimised results. *EuroIntervention* 12:Y64–Y66, 2016
 - [14] Rottländer D, Schneider T, Degen H et al. Coronary sinus to mitral valve annulus topography and response to the percutaneous coronary sinus-based mitral valve contour system. *EuroIntervention* 15:923–926, 2019
 - [15] Schofer J, Siminiak T, Haude M et al. Percutaneous mitral annuloplasty for functional mitral regurgitation: results of the Carillon Mitral Annuloplasty Device European Union Study. *Circulation* 120:326–333, 2009
 - [16] Siminiak T, Wu JC, Haude M et al. Treatment of functional mitral regurgitation by percutaneous annuloplasty: results of the TITAN Trial. *Eur J Heart Fail* 14:931–938, 2012
 - [17] Lipiecki J, Siminiak T, Sievert H et al. Coronary sinus-based percutaneous annuloplasty as treatment for functional mitral regurgitation: the TITAN II trial. *Open Heart* 3:e000411, 2016
 - [18] Witte KK, Lipiecki J, Siminiak T et al. The REDUCE FMR trial: a randomized sham-controlled study of percutaneous mitral annuloplasty in functional mitral regurgitation. *JACC Heart Fail* 7:945–955, 2019
 - [19] Maisano F, Taramasso M, Nickenig G et al. Cardioband, a transcatheter surgical-like direct mitral valve annuloplasty system: early results of the feasibility trial. *Eur Heart J* 37:817–825, 2016
 - [20] Nickenig G, Hammerstingl C, Schueler R et al. Transcatheter mitral annuloplasty in chronic functional mitral regurgitation: 6-month results with the cardioband percutaneous mitral repair system. *JACC Cardiovasc Interv* 9:2039–2047, 2016
 - [21] Messika-Zeitoun D, Nickenig G, Latib A et al. Transcatheter mitral valve repair for functional mitral regurgitation using the Cardioband system: 1 year outcomes. *Eur Heart J* 40:466–472, 2019
 - [22] Nickenig G, Schueler R, Dager A et al. Treatment of chronic functional mitral valve regurgitation with a percutaneous annuloplasty system. *J Am Coll Cardiol* 67:2927–36, 2018

- [23] Colli A, Manzan E, Aidietis A et al. An early European experience with transapical off-pump mitral valve repair with NeoChord implantation. *Eur J Cardiothorac Surg* 54:460–466, 2018
- [24] von Bardeleben RS, Colli A, Schulz E et al. First in human transcatheter COMBO mitral valve repair with direct ring annuloplasty and neochord leaflet implantation to treat degenerative mitral regurgitation: feasibility of the simultaneous toolbox concept guided by 3D echo and computed tomography fusion imaging. *Eur Heart J* 39:1314–1315, 2018
- [25] Colli A, Manzan E, Rucinskas K et al. Acute safety and efficacy of the NeoChord procedure. *Interact Cardiovasc Thorac Surg* 20:575–80, 2015
- [26] Bapat V, Rajagopal V, Meduri C et al. Early experience with new transcatheter mitral valve replacement. *J Am Coll Cardiol* 71:12–21, 2018
- [27] Webb JG, Murdoch DJ, Boone RH et al. Percutaneous transcatheter mitral valve replacement: first-in-human experience with a new transseptal system. *J Am Coll Cardiol* 73:1239–1246, 2019
- [28] Cullen MW, Cabalka AK, Alli OO et al. Transvenous, antegrade melody valve-in-valve implantation for bioprosthetic mitral and tricuspid valve dysfunction: a case series in children and adults. *JACC Cardiovasc Interv* 6:598–605, 2013
- [29] Descoutures F, Himbert D, Maisano F et al. Transcatheter valve-in-ring implantation after failure of surgical mitral repair. *Eur J Cardiothorac Surg* 44:e8–e15, 2013
- [30] Søndergaard L, De Backer O, Franzen OW et al. First-in-human case of transfemoral CardiAQ mitral valve implantation. *Circ Cardiovasc Interv* 8:e002135, 2015
- [31] Shah M, Jorde UP. Percutaneous mitral valve interventions (repair): current indications and future perspectives. *Front Cardiovasc Med* 6:88, 2019
- [32] Muller DWM, Farivar RS, Jansz P et al. Transcatheter mitral valve replacement for patients with symptomatic mitral regurgitation: a global feasibility trial. *J Am Coll Cardiol* 69:381–391, 2017.
- [33] Testa L, Latib A, Montone RA et al. Transcatheter mitral valve regurgitation treatment: state of the art and a glimpse to the future. *J Thorac Cardiovasc Surg* 152:319–327, 2016

20.5 Trikuspidalklappeninterventionen

- [1] Taramasso M, Vanermen H, Maisano F et al. The growing importance of secondary tricuspid regurgitation. *J Am Coll Cardiol* 59:703–710, 2012
- [2] Stuge O, Liddicoat J. Emerging opportunities for cardiac surgeons within structural heart disease. *J Thorac Cardiovasc Surg* 132:1258–1261, 2006
- [3] Cohen SR, Sell JE, McIntosh CL et al. Tricuspid regurgitation in patients with acquired, chronic, pure mitral regurgitation. *J Thorac Cardiovasc Surg* 94:488–497, 1987
- [4] Matsunaga A, Duran CM. Progression of tricuspid regurgitation after repaired functional ischemic mitral regurgitation. *Circulation* 112:1453–1457, 2005
- [5] Fukuda S, Song JM, Gillinov AM et al. Tricuspid valve tethering predicts residual tricuspid regurgitation after tricuspid annuloplasty. *Circulation* 111:975–979, 2005
- [6] Di Mauro M, Bivona A, Iaco AL et al. Mitral valve surgery for functional mitral regurgitation: prognostic role of tricuspid regurgitation. *Eur J Cardiothorac Surg* 35:635–640, 2009
- [7] Nath J, Foster E, Heidenreich PA. Impact of tricuspid regurgitation on long-term survival. *J Am Coll Cardiol* 43:405–409, 2004
- [8] Taramasso M, Maisano F, De Bonis M et al. Prognostic impact and late evolution of untreated moderate functional tricuspid regurgitation in patients undergoing aortic valve replacement. *J Card Surg* 31:9–14, 2016
- [8a] Vahanian A, Beyersdorf F, Praz F et al. 2021 ESC/EACTS Guidelines for the management of valvular heart disease: developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 43(7):561–632, 2021
- [9] Hammerstingl C, Schueler R, Malasa M et al. Transcatheter treatment of severe tricuspid regurgitation with the MitraClip system. *Eur Heart J* 37:849–853, 2016
- [10] Braun D, Orban M, Orban M et al. Transcatheter edge-to-edge repair for severe tri-

- cuspid regurgitation using the triple-orifice technique versus the bicuspidalization technique. *JACC Cardiovasc Interv* 11:1790–1792, 2018
- [11] Taramasso M, Alessandrini H, Latib A et al. Outcomes after current transcatheter tricuspid valve intervention: mid-term results from the international TriValve registry. *JACC Cardiovasc Interv* 12:155–165, 2019
- [12] Nickenig G, Kowalski M, Hausleiter J et al. Transcatheter treatment of severe tricuspid regurgitation with the edge-to-edge MitraClip technique. *Circulation* 135:1802–1814, 2017
- [13] Orban M, Besler C, Braun D et al. Six-month outcome after transcatheter edge-to-edge repair of severe tricuspid regurgitation in patients with heart failure. *Eur J Heart Fail* 20:1055–1062, 2018
- [14] Braun D, Nabauer M, Orban M et al. One-year results of transcatheter treatment of severe tricuspid regurgitation using edge-to-edge repair technique. *EuroIntervention* 14:e413–e415, 2018
- [15] Nickenig G, Weber M, Lurz P et al. Transcatheter edge-to-edge repair for reduction of tricuspid regurgitation: 6-month outcomes of the TRILUMINATE single-arm study. *Lancet* 394:2002–2011, 2019
- [16] Fam NP, Ho EC, Zahrani M et al. Transcatheter tricuspid valve repair with the Pascal system. *JACC Cardiovasc Interv* 11:407–408, 2018
- [17] Anderson A, Hausleiter J, von Bardeleben RS et al. One year outcomes of the TRI-REPAIR study assessing Cardioband tricuspid valve reconstruction system for patients with functional tricuspid regurgitation. *J Card Failure* 25:11, 2019
- [18] Nickenig G, Weber M, Schueler R et al. 6-month outcomes of tricuspid valve reconstruction for patients with severe tricuspid regurgitation. *J Am Coll Cardiol* 73:1905–1915, 2019
- [19] Hahn RT, Meduri CU, Davidson CJ et al. Early feasibility study of a transcatheter tricuspid valve annuloplasty: SCOUT trial 30-day results. *J Am Coll Cardiol* 69:1795–1806, 2017
- [20] Giannini F, Colombo A. Percutaneous treatment of tricuspid valve in refractory right heart failure. *Eur Heart J Suppl* 21:B43–B47, 2019
- [21] Figulla HR, Kiss K, Lauten A. Transcatheter interventions for tricuspid regurgitation – heterotopic technology: TricValve. *EuroIntervention*, 12:116–118, 2016
- [22] Lauten A, Figulla HR, Unbehaun A et al. Interventional treatment of severe tricuspid regurgitation: early clinical experience in a multicenter, observational, first-in-man study. *Circ Cardiovasc Interv* 11:e006061, 2018
- [23] Toggweiler S, De Boeck B, Brinkert M et al. First-in-man implantation of the Tricento transcatheter heart valve for the treatment of severe tricuspid regurgitation. *EuroIntervention* 14:758–761, 2018
- [24] Werner P, Russo M, Scherzer S et al. Transcatheter caval valve implantation of the Tricento valve for tricuspid regurgitation using advanced intraprocedural imaging. *JACC Case Reports* 1:720–721, 2019
- [25] Dreger H, Mattig I, Hewing B et al. Treatment of severe TRicuspid regurgitation in patients with advanced heart failure with CAval vein implantation of the edwards Sapien XT VALve (TRICAVAL): a randomized controlled trial. *EuroIntervention* 15:1506–1513, 2020
- [26] Kenny D, Hijazi ZM, Walsh KP. Transcatheter tricuspid valve replacement with the Edwards Sapien valve. *Catheter Cardiovasc Interv* 78:267–270, 2011
- [27] Calvert PA, Himbert D, Brochet E et al. Transfemoral implantation of an Edwards Sapien valve in a tricuspid bio-prosthesis without fluoroscopic landmarks. *EuroIntervention* 7:1336–1339, 2012
- [28] Hoendermis ES, Douglas YL, van den Heuvel AF. Percutaneous Edwards Sapien valve implantation in the tricuspid position: case report and review of the literature. *EuroIntervention* 8:628–633, 2012
- [29] Perlman GY, Dvir D. Treatment of tricuspid regurgitation with the Forma repair system. *Front Cardiovasc Med* 5:140–146, 2018

20.6 Defekte im interatrialen Septum

- [1] Baumgartner H, De Backer J, Babu-Narayan SV et al., ESC Scientific Document Group. 2020 ESC Guidelines for the management of adult congenital heart

- disease. *Eur Heart J* 42:563–645, 2020
- [2] Parsons FG, Keith A. Seventh report of the Committee of Collective Investigation of the Anatomical Society of Great Britain and Ireland, 1896–97. *J Anat Physiol* 32:164–186, 1897
 - [3] Hagen PT, Scholz DG, Edwards WD. Incidence and size of patent foramen ovale during the first 10 decades of life: an autopsy study of 965 normal hearts. *Mayo Clin Proc* 59:17–20, 1984
 - [4] Lechat P, Mas JL, Lascault G et al. Prevalence of patent foramen ovale in patients with stroke. *N Engl J Med* 318:1148–1152, 1988
 - [5] Webster MW, Chancellor AM, Smith HJ et al. Patent foramen ovale in young stroke patients. *Lancet* 2(8601):11–12, 1988
 - [6] Hausmann D, Mügge A, Becht I et al. Diagnosis of patent foramen ovale by transesophageal echocardiography and association with cerebral and peripheral embolic events. *Am J Cardiol* 70:668–672, 1992
 - [7] Van Camp G, Schulze D, Cosyns B et al. Relation between patent foramen ovale and unexplained stroke. *Am J Cardiol* 71:596–598, 1993
 - [8] Meier B. Catheter-based closure of the patent foramen ovale. *Circulation* 120:1837–1841, 2009
 - [9] Konstantinides S, Geibel A, Kasper W et al. Patent foramen ovale is an important predictor of adverse outcome in patients with major pulmonary embolism. *Circulation* 97:1946–1951, 1998
 - [9a] Desai AJ, Fuller CJ, Jesurum JT et al. Patent foramen ovale and cerebrovascular diseases. *Nat Clin Pract Cardiovasc Med* 3:446–455, 2006
 - [10] Nellessen U, Daniel WG, Matheis G et al. Impending paradoxical embolism from atrial thrombus: correct diagnosis by transesophageal echocardiography and prevention by surgery. *J Am Coll Cardiol* 5:1002–1004, 1985
 - [11] Ghanem A, Liebetrau C, Diener H-C et al. Interventioneller PFO-Verschluss. Konsensuspapier der Arbeitsgruppe Interventionelle Kardiologie (AGIK) der Deutschen Gesellschaft für Kardiologie – Herz- und Kreislaufforschung (DGK) gemeinsam mit der Deutschen Gesellschaft für Neurologie (DGN) und der Deutschen Schlaganfallge-
sellschaft (DSG). *Der Kardiologe* 12(6):415–423, 2018
 - [12] Diener H-C, Grau A, Baldus S et al. Kryptogener Schlaganfall und offenes Foramen ovale, S2e-Leitlinie, 2018. In: Deutsche Gesellschaft für Neurologie (Hrsg) Leitlinien für Diagnostik und Therapie in der Neurologie. Online: www.dgn.org/leitlinien (abgerufen am 12.11.2018)
 - [13] Wahl A, Praz F, Findling O et al. Percutaneous closure of patent foramen ovale for migraine headaches refractory to medical treatment. *Catheter Cardiovasc Interv* 74:124–129, 2009
 - [14] Mattle HP, Evers S, Hildick-Smith D et al. Percutaneous closure of patent foramen ovale in migraine with aura, a randomized controlled trial. *Eur Heart J* 37:2029–2036, 2016
 - [15] Kent DM, Ruthazer R, Weimar C et al. An index to identify stroke-related vs incidental patent foramen ovale in cryptogenic stroke. *Neurology* 81:619–625, 2013
 - [16] Silver MD, Dorsey JS. Aneurysm of the septum primum in the adults. *Arch Path Lab Med* 102:62–65, 1978
 - [17] Topaz O, Edwards JE, Bojack-Mackey S et al. Aneurysm of fossa ovalis in adults: a pathologic study. *Cardiovasc Pathol* 12:219–225, 2003
 - [18] Olivares-Reyes A, Chan S, Lazar EJ et al. Atrial septal aneurysm: a new classification in two hundred five adults. *J Am Soc Echocardiogr* 10:644–656, 1997
 - [19] Topaz O. Aneurysm of the atrial septum with fenestrations – the crossroads of pathophysiology and intervention. *Catheter Cardiovasc Interv* 79:1178–1179, 2012
 - [20] Schreiner G, Erbel R, Mohr-Kahaly S et al. Detection of aneurysms of the atrial septum using transesophageal echocardiography. *Z Kardiol* 74:440–444, 1985
 - [21] Schnieder M, Siddiqui T, Karch A et al. Clinical relevance of patent foramen ovale and atrial septum aneurysm in stroke: findings of a single-center cross-sectional study. *Eur Neurol* 78:264–269, 2017
 - [22] Hanley PC, Tajik AJ, Hynes JK et al. Diagnosis and classification of atrial septal aneurysm by two-dimensional echocardiography: report of 80 consecutive cases. *J Am Coll Cardiol* 6:1370–1382, 1985
 - [23] Mügge A, Daniel WG, Angermann C et al. Atrial septal aneurysm in adult patients: a multicenter study using transthoracic and

- transesophageal echocardiography. *Circulation* 91:2785–2792, 1995
- [24] Lethen H, Flachskampf FA, Hanrath P. Aneurysm des Vorhofseptums. Diagnostik und therapeutische Konsequenzen. *Dtsch Med Wschr* 119:229–234, 1994
- [25] Yetkin E, Atalay H, Ileri M. Atrial septal aneurysm: prevalence and covariates in adults. *Int J Cardiol* 223:656–659, 2016
- [26] Rana BS, Thomas MR, Calvert PA et al. Echocardiographic evaluation of patent foramen ovale prior to device closure. *JACC Cardiovasc Imaging* 3:749–760, 2010
- [27] Kutty S, Sengupta PP, Khandheria BK. Patent foramen ovale: the known and the to be known. *J Am Coll Cardiol* 59:1665–1671, 2012
- [28] Maggioro P, Bellingue J, Chieng D et al. Ischaemic stroke and the echocardiographic „Bubble Study“: are we screening the right patients? *Heart Lung Circ* 28:1183–1189, 2019
- [29] Shanks M, Manawadu D, Vonder Muhll I et al. Detection of patent foramen ovale by 3D echocardiography. *JACC Cardiovasc Imaging* 5:329–331, 2012
- [30] Hildick-Smith D, Williams T, MacCarthy P et al. Occlutech Percutaneous Patent foramen Ovale closure: Safety and Efficacy registry (OPPOSE). *Int J Cardiol* 245:99–104, 2017
- [31] Pizzino F, Khandheria, Carerj S et al. PFO: Button me up, but wait ... Comprehensive evaluation of the patient. *J Cardiol* 67:485–492, 2016
- [32] Bartel T, Müller S. Contemporary echocardiographic guiding tools for device closure of interatrial communications. *Cardiovasc Diagn Ther* 3:38–46, 2013
- [33] Lambertz H, Schweizer P, Erbel R et al. Value of contrast echocardiography in the diagnosis of tricuspid insufficiency. *Z Kardiol* 71:771–778, 1982
- [34] Mohr-Kahaly S, Erbel R, Zotz R et al. Left ventricular contrast echocardiography using Gelifundol – assessment of hemodynamics, contractility and ECG. *Z Kardiol* 76:699–705, 1987
- [35] Becher H. Kontrastechokardiographie: klinische Anwendung und Zukunftsperspektiven. *Herz* 27:201–216, 2002
- [35a] https://www.ema.europa.eu/en/documents/overview/sonovue-epar-summary-public_de.pdf (abgerufen 21.11.2022)
- [35b] <https://www.ema.europa.eu/en/medicines/human/EPAR/liminity> (Update 29.06.2022) (abgerufen 21.11.2022)
- [35c] Senior R, Lindner JR, Edvardsen T et al. Ultrasound contrast agent hypersensitivity in patients allergic to polyethylene glycol: position statement by the European Association of Cardiovascular Imaging. *Eur Heart J – Cardiovasc Imag* 22:959–960, 2021
- [35d] <http://www.ema.europa.eu/medicines/human/EPAR/optison> (Update 27.06.2022) (abgerufen 21.11.2022)
- [36] Wally D, Knotzer H, Kilo J et al. The Eustachian valve as a pitfall in persistent foramen ovale and atrial septum defect closure. *J Cardiothorac Vasc Anesth* 25:680–682, 2011
- [37] Rana BS, Shapiro LM, McCarthy KP et al. Three-dimensional imaging of the atrial septum and patent foramen ovale anatomy: defining the morphological phenotypes of patent foramen ovale. *Eur J Echocardiogr* 11:i19–i25, 2010
- [38] Porter TR, Mulvagh SL, Abdelmoneim SS et al. Clinical applications of ultrasonic enhancing agents in echocardiography: 2018 American Society of Echocardiography guidelines update. *J Am Soc Echocardiogr* 31:241–274, 2018
- [38a] Pristipino C, Sievert H, Ascenzo FD et al. European position paper on the management of patients with patent foramen ovale. General approach and left circulation thromboembolism. *EuroIntervention* 20;14:1389–1402, 2019
- [39] Bradley EA, Chakinala M, Billadello JJ. Usefulness of medical therapy for pulmonary hypertension and delayed atrial septal defect closure. *Am J Cardiol* 112:1471–1476, 2013
- [40] Kijima Y, Akagi T, Takaya Y et al. Treat and repair strategy in patients with atrial septal defect and significant pulmonary arterial hypertension. *Circ J* 80:227–234, 2016
- [41] Oka S, Nakamura J, Tokumasu Y et al. „Treat and repair“ strategy for atrial septal defect with significant pulmonary arterial hypertension in an elderly Case. *Austin Cardio & Cardiovasc Case Rep* 4:1030, 2019
- [42] Liang F, Yang S, Yao L et al. Ambrisentan and tadalafil synergistically relax endothe-

- lin-induced contraction of rat pulmonary arteries. *Hypertension* 59:705–711, 2012
- [43] Sitbon O, Channick R, Chin KM et al. Selexipag for the treatment of pulmonary arterial hypertension. *N Engl J Med* 373:2522–2533, 2015
- [44] Yao A. „Treat-and-repair“ strategy for atrial septal defect and associated pulmonary arterial hypertension. *Circ J* 80:69–71, 2016
- [45] Patel K, Doshi R, Goyal H et al. Transcatheter patent foramen ovale closure versus standard medical therapy for prevention of recurrent stroke: updated meta-analysis with an importance on shunt size. *Eur J Intern* 57:e31–e33, 2018
- [46] Garg L, Haleem A, Varade S et al. Patent foramen ovale closure in the setting of cryptogenic stroke: a meta-analysis of five randomized trials. *J Stroke Cerebrovasc Dis* 27:2484–2493, 2018
- [47] Pristipino C, Sievert H, D’Ascenzo F et al. European position paper on the management of patients with patent foramen ovale: general approach and left circulation thromboembolism. *EuroIntervention* 40:3182–3195, 2019
- [48] Meier B. PFO closure, when the going gets tough ... *Catheter Cardiovasc Interv* 64:345–347, 2007
- [49] Wahl A, Tai T, Praz F et al. Late results after percutaneous closure of patent foramen ovale for secondary prevention of paradoxical embolism using the Amplatzer PFO occluder without intraprocedural echocardiography: effect of device size. *JACC Cardiovasc Interv* 2:116–123, 2009
- [50] Bartel T, Konorza T, Neudorf U et al. Intracardiac echocardiography: an ideal guiding tool for device closure of interatrial communications. *Eur J Echocardiogr* 6:92–96, 2005
- [51] Pavlovic M, Buellesfeld L, Meier B. Tools & techniques: PFO/ASD closure. *Euro-Intervention* 7:408–410, 2011
- [52] Carroll JD, Saver J, Thaler DE et al. Closure of patent foramen ovale versus medical therapy after cryptogenic stroke. *New Engl J Med* 368:1092–1100, 2013
- [52a] Saver JL, Carroll JD, Thaler DE et al., RESPECT Investigators. Long-term outcomes of patent foramen ovale closure or medical therapy after stroke. *N Engl J Med* 377:1022–1032, 2017
- [53] Hornung M, Bertog SC, Franke J et al. Long-term results of a randomized trial comparing three different devices for percutaneous closure of a patent foramen ovale. *Eur Heart J* 34:3362–3369, 2013
- [54] Stortecky S, da Costa BR, Mattle HP et al. Percutaneous closure of patent foramen ovale in patients with cryptogenic embolism: a network meta-analysis. *Eur Heart J* 36:120–128, 2015
- [55] Hildick-Smith D, Williams T, MacCarthy P et al. Occlutech Percutaneous Patent foramen Ovale closure: Safety and Efficacy registry (OPPOSE). *Int J Cardiol* 245:99–104, 2017
- [56] Krizanec F, Sievert H, Pfeiffer D et al. The Occlutech Figulla PFO and ASD occluder: a new nitinol wire mesh device for closure of atrial septal defects. *J Invasive Cardiol* 22:182–187, 2010
- [57] Saguner AM, Wahl A, Praz F et al. Figulla PFO occluder versus Amplatzer PFO occluder for percutaneous closure of patent foramen ovale. *Catheter Cardiovasc Interv* 77:709–714, 2011
- [58] Trabatttoni D, Gaspardone A, Sgueglia GA et al. Amplatzer versus Figulla occluder for transcatheter patent foramen ovale closure. *EuroIntervention* 12:2092–2099, 2017
- [59] Neuser J, Akin M, Bavendiek U et al. Mid-term results of interventional closure of patent foramen ovale with the Occlutech Figulla® Flex II occlude. *BMC Cardiovasc Disord* 16:217, 2016
- [60] Astarcioglu MA, Kalcik M, Sen T et al. Ceraflex versus Amplatzer occluder for secundum atrial septal defect closure. Multi-center clinical experience. *Herz* 40(Suppl 2):146–150, 2015
- [61] Peirone A, Contreras A, Ferrero A et al. Immediate and short-term outcomes after percutaneous atrial septal defect closure using the new Nit-Occlud ASD-R device. *Catheter Cardiovasc Interv* 84:464–470, 2014
- [62] Araszkievicz A, Slawek S, Trojnaraska O et al. Interventional closure of patent foramen ovale with Nit-Occlud® device in prevention of recurrent neurologic events: long-term results. *Catheter Cardiovasc Interv* 92:159–164, 2018
- [63] Sigler M, Söderberg B, Schmitt B et al. Carag bioresorbable septal occluder (CBSO):

- histopathology of experimental implants. *EuroIntervention* 13:1655–1661, 2018
- [64] Gaspardone A, De Marco F, Sgueglia GA et al. Novel percutaneous suture-mediated patent foramen ovale closure technique: early results of the NobleStitch EL Italian Registry. *EuroIntervention* 14:e272–e279, 2018
- [65] Meier B. Closure of the patent foramen ovale, if only a stitch in time saved nine. *EuroIntervention* 14:e250–251, 2018
- [66] Li Y, Zhou K, Hua Y et al. Amplatzer occluder versus CardioSeal/StarFlex occluder: a meta-analysis of the efficacy and safety of transcatheter occlusion for patent foramen ovale and atrial septal defect. *Cardiol Young* 23:582–596, 2013
- [67] Trabattoni D, Gaspardone A, Sgueglia GA et al. Amplatzer versus Figulla occluder for transcatheter patent foramen ovale closure. *EuroIntervention* 12:2092–2099, 2017
- [68] Bock M, Mohrs OK, Voigtlaender T et al. MRT-Sicherheitsaspekte und -Artefakte von Vorhofseptum-Okkludersystemen bei 1,5 Tesla: eine Phantomstudie. *Fortschr Röntgenstr* 178:272–277, 2006
- [69] Windecker S, Wahl A, Chatterjee T et al. Percutaneous closure of patent foramen ovale in patients with paradoxical embolism. Long-term risk of recurrent thromboembolic events. *Circulation* 101:893–898, 2000
- [70] Meier B. Pacman sign during device closure of the patent foramen ovale. *Catheter Cardiovasc Interv* 60:221–223, 2003
- [71] Meier B. Closure of patent foramen ovale: technique, pitfalls, complications, and follow up. *Heart* 91:444–448, 2005
- [72] Wahl A, Kunz M, Moschovitis A et al. Long-term results after fluoroscopy-guided closure of patent foramen ovale for secondary prevention of paradoxical embolism. *Heart* 94:336–341, 2008
- [2] Leute A, Kirchhof P, Breithardt G et al. German Competence Network on Atrial Fibrillation (AFNET): a nationwide cooperation for better research and patient care. *Med Klin* 101:662–666, 2006
- [3] Lloyd-Jones DM, Wang TJ, Leip EP et al. Lifetime risk for development of atrial fibrillation: the Framingham Heart Study. *Circulation* 110:1042–1026, 2004
- [4] Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke* 22:983–988, 1991
- [5] Lin HJ, Wolf PA, Kelly-Hayes M et al. Stroke severity in atrial fibrillation: the Framingham Study. *Stroke* 27:1760–1764, 1996
- [6] Garcia DA, Hylek E. Reducing the risk for stroke in patients who have atrial fibrillation. *Cardiol Clin* 26:267–275, 2008
- [7] Block PC, Burstein S, Casale PN et al. Percutaneous left atrial appendage occlusion for patients in atrial fibrillation suboptimal for warfarin therapy: 5-year results of the PLAATO (Percutaneous Left Atrial Appendage Transcatheter Occlusion) study. *JACC Cardiovasc Interv* 2:594–600, 2009
- [8] The European Atrial Fibrillation Trial Study Group. Optimal oral anticoagulant therapy in patients with nonrheumatic atrial fibrillation and recent cerebral ischemia. *N Engl J Med* 333:5–10, 1995
- [9] The Boston Area Anticoagulation Trial for Atrial Fibrillation Investigators. The effect of low-dose warfarin on the risk of stroke in patients with nonrheumatic atrial fibrillation. *N Engl J Med* 323:1505–1511, 1990
- [10] Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. *Ann Intern Med* 146:857–867, 2007
- [11] Walker AM, Bennett D. Epidemiology and outcomes in patients with atrial fibrillation in the United States. *Heart Rhythm* 5:1365–1372, 2008
- [12] Go AS, Hylek EM, Borowsky LH et al. Warfarin use among ambulatory patients with nonvalvular atrial fibrillation: the anticoagulation and risk factors in atrial fibrillation (ATRIA) study. *Ann Intern Med* 131:927–934, 1999
- [13] Holmes DR, Reddy VY, Turi ZG et al. PROTECT AF Investigators. Percutaneous clo-

20.7 Interventioneller Vorhofohrverschluss

- [1] Erbel R, Möhlenkamp S, Jöckel KH et al. Cardiovascular risk factors and signs of subclinical atherosclerosis in the Heinz Nixdorf Recall Study. *Dtsch Arztebl Int* 105:1–8, 2008

- sure of the left atrial appendage versus warfarin therapy for prevention of stroke in patients with atrial fibrillation: a randomised non-inferiority trial. *Lancet* 374:534–542, 2009
- [14] Alberg H. Atrial fibrillation: a study of atrial thrombus and systemic embolism in a necropsy material. *Acta Med Scand* 185:373–379, 1969
- [15] Stoddard MF, Dawkins PR, Prince CR et al. Left atrial appendage thrombus is not uncommon in patients with acute atrial fibrillation and a recent embolic event: a transesophageal echocardiographic study. *J Am Coll Cardiol* 25:452–459, 1995
- [16] Klein AL, Grimm RA, Murray RD et al. Assessment of cardioversion using transesophageal echocardiography investigators: use of transesophageal echocardiography to guide cardioversion in patients with atrial fibrillation. *N Engl J Med* 344:1411–1420, 2001
- [17] Blackshear JL, Odell JA. Appendage obliteration to reduce stroke in cardiac surgical patients with atrial fibrillation. *Ann Thorac Surg* 61:755–759, 1996
- [18] Sievert H, Lesh MD, Trepels T et al. Percutaneous left atrial appendage transcatheter occlusion to prevent stroke in high-risk patients with atrial fibrillation: early clinical experience. *Circulation* 105:1887–1889, 2002
- [19] Hanna IR, Kolm P, Martin R et al. Left atrial structure and function after percutaneous left atrial appendage transcatheter occlusion (PLAATO): six-month echocardiographic follow-up. *J Am Coll Cardiol* 43:1868–1872, 2004
- [20] Ostermayer SH, Reisman M, Kramer PH et al. Percutaneous left atrial appendage transcatheter occlusion (PLAATO system) to prevent stroke in high-risk patients with non-rheumatic atrial fibrillation: results from the international multi-center feasibility trials. *J Am Coll Cardiol* 46:9–14, 2005
- [21] Sievert H, Bayard YL. Percutaneous closure of the left atrial appendage: a major step forward. *JACC Cardiovasc Interv* 2:601–602, 2009
- [22] Fountain RB, Holmes DR, Chandrasekaran K et al. The Protect AF (Watchman) left atrial appendage system for embolic (Protection in patients with atrial fibrillation) trial. *Am Heart J* 151:956–961, 2006
- [23] Sick PB, Schuler G, Hauptmann KE et al. Initial worldwide experience with the Watchman left atrial appendage system for stroke prevention in atrial fibrillation. *J Am Coll Cardiol* 49:1490–1495, 2007
- [23a] Grygier M, Olasińska-Wisniewska A, Araszkievicz A et al. The Watchman FLX – a new device for left atrial appendage occlusion – design, potential benefits and first clinical experience. *Adv Interv Cardiol* 13: 62–66, 2017
- [24] Reddy VY, Sievert H, Halperin J. Percutaneous left atrial appendage closure vs warfarin for atrial fibrillation- a randomized clinical trial. *JAMA* 312(19):1988–1998, 2014
- [25] Reddy VY, Doshi SK, Kar S et al. 5-year outcomes after left atrial appendage closure: from the PREVAIL and PROTECT AF trials. *J Am Coll Cardiol* 70:2976–2978, 2017
- [26] Reddy VY, Möbius-Winkler S, Miller MA et al. Left atrial appendage closure with the Watchman device in patients with a contraindication for oral anticoagulation: the ASAP Study (ASA Plavix feasibility study with Watchman left atrial appendage closure technology). *J Am Coll Cardiol* 61:2551–2556, 2013
- [27] Singh SM, Micieli A, Wijeyesundera HC. Economic evaluation of percutaneous left atrial appendage occlusion, dabigatran, and warfarin for stroke prevention in patients with nonvalvular atrial fibrillation. *Circulation* 127:2414–2423, 2013
- [28] Toumanidis S, Sideris EB, Agricola T et al. Transcatheter patch occlusion of the left atrial appendage using surgical adhesives in high-risk patients with atrial fibrillation. *J Am Coll Cardiol* 58:2236–2240, 2011
- [29] Meier B, Blaauw Y, Khattab AA et al. EHRA/EAPCI expert consensus statement on catheter-based left atrial appendage occlusion. *Europace* 16:1397–1416, 2014
- [30] Plicht B, Konorza TFM, Kahlert P et al. Risk factors for thrombus formation on the Amplatzer cardiac plug after left atrial appendage occlusion. *J Am Coll Cardiol Interv* 6:606–613, 2013
- [31] Freixa X, Chan JLK, Tzikas A et al. The Amplatzer™ cardiac plug 2 for left atrial appendage occlusion: novel features and first-in-man experience. *EuroIntervention* 8:1094–1098, 2013

- [31a] Lakkireddy D, Thaler D, Ellis CR et al. Amplatzer Amulet Left Atrial Appendage Occluder versus Watchman Device for Stroke Prophylaxis (Amulet IDE): a randomized, controlled trial. *Circulation* 144:1543–1552, 2021
- [31b] Osmancik P, Herman D, Neuzil P et al. Left atrial appendage closure versus direct oral anticoagulants in high-risk patients with atrial fibrillation. *J Am Coll Cardiol* 75:3122–3135, 2020
- [32] Hindricks G, Potpara T, Dagres N et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association of Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 42:373–498, 2021
- [33] Crystal E, Lamy A, Connolly SJ et al. Left Atrial Appendage Occlusion Study (LAAOS): a randomized clinical trial of left atrial appendage occlusion during routine coronary artery bypass graft surgery for long-term stroke prevention. *Am Heart J* 145:174–178, 2003
- [34] Healey JS, Crystal E, Lamy A et al. Left Atrial Appendage Occlusion Study (LAAOS): results of a randomized controlled pilot study of left atrial appendage occlusion during coronary bypass surgery in patients at risk for stroke. *Am Heart J* 150:288–293, 2005
- [35] Heist EK, Refaat M, Danik SB et al. Analysis of the left atrial appendage by magnetic resonance angiography in patients with atrial fibrillation. *Heart Rhythm* 3:1313–1318, 2006
- [36] Kanderian AS, Gillinov AM, Pettersson GB et al. Success of surgical left atrial appendage closure: assessment by transesophageal echocardiography. *J Am Coll Cardiol* 52:924–929, 2008
- [37] Salzberg SP, Gillinov AM, Anyanwu A et al. Surgical left atrial appendage occlusion: evaluation of a novel device with magnetic resonance imaging. *Eur J Cardiothorac Surg* 34:766–770, 2008
- [38] Salzberg SP, Plass A, Emmert MY et al. Left atrial appendage clip occlusion: Early clinical results. *J Thorac Cardiovasc Surg* 139:1269–1274, 2009
- [39] Pisters R, Lane DA, Nieuwlaar R et al. A novel user-friendly score (HAS-BLED) to assess 1-year risk of major bleeding in patients with atrial fibrillation: the Euro Heart Survey. *Chest* 138:1093–1100, 2010

20.8 Hypertroph-obstruktive Kardiomyopathie (HOCM)

- [1] Morrow AG, Braunwald E. Functional aortic stenosis; a malformation characterized by resistance to left ventricular outflow without anatomic obstruction. *Circulation* 20:181–189, 1959
- [2] Elliott P, Andersson B, Arbustini E et al. Classification of the cardiomyopathies: a position statement from the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J* 29:270–276, 2008
- [3] Elliott PM, Anastakis A, Borger MA et al. 2014 ESC Guidelines on diagnosis and management of hypertrophic cardiomyopathy: the Task Force for the Diagnosis and Management of Hypertrophic Cardiomyopathy of the European Society of Cardiology (ESC). *Eur Heart J* 35:2733–2779, 2014
- [3a] Arbelo E, Protonotarios A, Gimeno JR et al. ESC Scientific Document Group. 2023 ESC Guidelines for the management of cardiomyopathies. *Eur Heart J* 44:3503–3626, 2023
- [4] Messmer BJ. Surgery for hypertrophic obstructive cardiomyopathy (HOCM): what to do with concomitant mitral insufficiency? *J Thorac Dis* 9:E381–E383, 2017
- [5] Teo EP, Teoh JG, Hung J. Mitral valve and papillary muscle abnormalities in hypertrophic obstructive cardiomyopathy. *Curr Opin Cardiol* 30:475–482, 2015
- [6] Gersh BJ, Maron BJ, Bonow RO et al. 2011 ACCF/AHA guideline for the diagnosis and treatment of hypertrophic cardiomyopathy: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation* 124:2761–2796, 2011
- [6a] Ommen SR, Mital S, Burke MA et al. AHA/ACC Guideline for the diagnosis and treatment of patients with hypertrophic cardiomyopathy: executive summary: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *J Am Coll Cardiol* 76:3022–3055, 2020
- [7] Morrow AG, Reitz BA, Epstein SE et al. Operative treatment in hypertrophic subaortic stenosis: techniques, and the results

- of pre and postoperative assessments in 83 patients. *Circulation* 52:88–102, 1975
- [8] Sigwart U. Non-surgical myocardial reduction for hypertrophic obstructive cardiomyopathy. *Lancet* 346:211–214, 1995
 - [9] Kuhn H. Transcatheter ablation of septal hypertrophy (TASH): a 5-year experience. *Z Kardiol* 89:559–564, 2000
 - [10] Gleichmann U, Seggewiss H, Faber L et al. Kathetertherapie der hypertrophen obstruktiven Kardiomyopathie. *Dtsch Med Wochenschr* 121:679–685, 1996
 - [11] Holmes DR, Valeti US, Nishimura RA. Alcohol septal ablation for hypertrophic cardiomyopathy: indications and technique. *Catheter Cardiovasc Interv* 66:375–389, 2005
 - [12] Nishimura RA, Seggewiss H, Schaff HV. Hypertrophic obstructive cardiomyopathy: surgical myectomy and septal ablation. *Circ Res* 121:771–783, 2017
 - [13] Batzner A, Pfeiffer B, Neugebauer A et al. Survival after alcohol septal ablation in patients with hypertrophic obstructive cardiomyopathy. *J Amer Coll Cardiol* 72:3095–4097, 2018
 - [14] Kashtanov M, Rzhannikova A, Chernyshev S et al. Results of ten-year follow-up of alcohol septal ablation in patients with obstructive hypertrophic cardiomyopathy. *Int J Angiol* 27:202–207, 2018
 - [15] Mateo JJS, Gimeno JR. Alcohol septal ablation in hypertrophic cardiomyopathy. *Glob Cardiol Sci Pract* 2018:30, 2018
 - [16] Faber L, Seggewiss H, Gleichmann U. Percutaneous transluminal septal myocardial ablation in hypertrophic obstructive cardiomyopathy: results with respect to intraprocedural myocardial contrast echocardiography. *Circulation* 98:2415–2421, 1998
 - [17] Koljaja-Batzner A, Pfeiffer B, Seggewiss H. Septal collateralization to right coronary artery in alcohol septal ablation: solution to a dangerous pitfall. *JACC Cardiovasc Interv* 11:2009–2011, 2018
 - [18] Gimeno JR, Tomé MT, McKenna WJ. Alcohol septal ablation in hypertrophic cardiomyopathy: an opportunity to be taken. *Rev Esp Cardiol (Engl Ed)* 65:314–318, 2012
 - [19] Veselka J, Jensen MK, Liebrechts M et al. Low procedure-related mortality achieved with alcohol septal ablation in European patients. *Int J Cardiol* 209:194–195, 2016
 - [20] Veselka J, Faber L, Jensen MK et al. Effect of institutional experience on outcomes of alcohol septal ablation for hypertrophic obstructive cardiomyopathy. *Can J Cardiol* 34:16–22, 2018
 - [21] Oto A, Aytemir K, Okutucu S et al. Cyanoacrylate for septal ablation in hypertrophic cardiomyopathy. *J Interv Cardiol* 24:77–84, 2011
 - [22] Asil S, Kaya B, Canpolat U et al. Septal reduction therapy using nonalcohol agent in hypertrophic obstructive cardiomyopathy: single center experience. *Catheter Cardiovasc Interv* 92:557–565, 2017
 - [23] Erbel R, Heusch G. Coronary microembolization – its role in acute coronary syndromes and interventions. *Herz* 24:558–575, 1999
 - [24] Erbel R, Heusch G. Coronary microembolization. *J Am Coll Cardiol* 39:22–24, 2000
 - [25] Skyschally A, Haude M, Dörge H et al. Glucocorticoid treatment prevents progressive myocardial dysfunction resulting from experimental coronary microembolization. *Circulation* 109:2337–2342, 2004
 - [26] Dickmann B, Baars T, Heusch G et al. Transcatheter septal ablation in hypertrophic obstructive cardiomyopathy by embolizing microspheres. *Eur Heart J* 34:2489, 2013
 - [27] Gross CM, Schulz-Menger J, Kramer J et al. Percutaneous transluminal septal artery ablation using polyvinyl alcohol foam particles for septal hypertrophy in patients with hypertrophic obstructive cardiomyopathy: acute and 3-year outcomes. *J Endovasc Ther* 11:705–711, 2004
 - [28] Vriesendorp PA, Van Mieghem NM, Vletter WB et al. Microsphere embolisation as an alternative for alcohol in percutaneous transluminal septal myocardial ablation. *Neth Heart J* 21:245–248, 2013
 - [29] O'Mahony C, Jichi F, Pavlou M et al. A novel clinical risk prediction model for sudden cardiac death in hypertrophic cardiomyopathy (HCM risk-SCD). *Eur Heart J* 35:2010–2020, 2014
 - [30] Cherif E, Ghazal S. Alcohol septal ablation after suboptimal surgical septal myectomy. *CASE (Phila)* 2:210–217, 2018
 - [31] Nguyen A, Schaff HV, Hang D et al. Surgical myectomy versus alcohol septal ablation for obstructive hypertrophic cardiomyopathy: a propensity score-matched

- cohort. *J Thorac Cardiovasc Surg* 157:306–315, 2019
- [32] Osman M, Kheiri B, Osman K et al. Alcohol septal ablation vs myectomy for symptomatic hypertrophic obstructive cardiomyopathy: systematic review and meta-analysis. *Clin Cardiol* 42:190–197, 2019
- [33] Veselka J, Zemánek D, Jahnlová D et al. Risk and causes of death in patients after alcohol septal ablation for hypertrophic obstructive cardiomyopathy. *Can J Cardiol* 31:1245–1251, 2015
- [34] Sari M, Izgi C, Kahveci G et al. Infarction of the septomarginal band and tricuspid papillary muscle rupture related to alcohol septal ablation for hypertrophic cardiomyopathy. *Echocardiography* 35:880–884, 2018
- [35] Chowdhary S, Galiwango P, Woo A et al. Inferior infarction following alcohol septal ablation: a consequence of „collateral damage“? *Catheter Cardiovasc Interv* 69:236–242, 2007
- [36] Kashtanov M, Rzhannikova A, Chernyshev S et al. Results of ten-year follow-up of alcohol septal ablation in patients with obstructive hypertrophic cardiomyopathy. *Int J Angiol* 27:202–207, 2018
- [37] Batzner A, Pfeiffer B, Neugebauer A et al. Survival after alcohol septal ablation in patients with hypertrophic obstructive cardiomyopathy. *J Amer Coll Cardiol* 72:3095–4097, 2018
- [38] Charron P, Elliott PM, Gimeno JR et al. The Cardiomyopathy Registry of the EURObservational Research Programs of the European Society of Cardiology: baseline data and contemporary management of adult patients with cardiomyopathies. *Eur Heart J* 39:1784–1793, 2018
- [39] Iacob M, Pinte F, Tintoiu I et al. Microcoil embolisation for ablation of septal hypertrophy in hypertrophic obstructive cardiomyopathy. *Kardiol Pol* 61:350–355, 2004
- [40] Durand E, Mousseaux E, Coste P et al. Non-surgical septal myocardial reduction by coil embolisation for hypertrophic obstructive cardiomyopathy: early and 6 months follow-up. *Eur Heart J* 29:348–355, 2008
- [40a] Okutucu S, Aytemir K, Oto A. Glue septal ablation: a promising alternative to alcohol septal ablation. *JRSM Cardiovasc Dis* 5:2048004016636313, 2016
- [41] Lawrenz T, Borchert B, Leuner C et al. Endocardial radiofrequency ablation for hypertrophic obstructive cardiomyopathy: acute results and 6 months' follow-up in 19 patients. *J Am Coll Cardiol* 57:572–576, 2011
- [42] Szumowski Ł, Dąbrowski M, Tyczynski P et al. Endocardial radiofrequency ablation for septal hypertrophy. *Kardiol Pol* 74:700, 2016
- [43] Liu L, Liu B, Li J et al. Percutaneous intramyocardial septal radiofrequency ablation of hypertrophic obstructive cardiomyopathy: a novel minimally invasive treatment for reduction of outflow tract obstruction. *EuroIntervention* 13:e2112–e2113, 2018
- [44] Liu L, Li J, Zuo L et al. Percutaneous intramyocardial septal radiofrequency ablation for hypertrophic obstructive cardiomyopathy. *J Am Coll Cardiol* 72:1898–1909, 2018
- [45] Keane D, Hynes B, King G et al. Feasibility study of percutaneous transvalvular endomyocardial cryoablation for the treatment of hypertrophic obstructive cardiomyopathy. *J Invasive Cardiol* 19:247–251, 2007
- [46] Oto A, Aytemir K, Okutucu S et al. Cyanoacrylate for septal ablation in hypertrophic cardiomyopathy. *J Interv Cardiol* 24:77–84, 2011
- [47] Arnold AD, Howard JP, Chiew K et al. Right ventricular pacing for hypertrophic obstructive cardiomyopathy: meta-analysis and meta-regression of clinical trials. *Eur Heart J Qualit Care Clin Outcomes* 5:321–335, 2019
- [48] Olivetto I, Oreziak A, Barriales-Villa R et al.; EXPLORER-HCM study investigators. Mavacamten for treatment of symptomatic obstructive hypertrophic cardiomyopathy (EXPLORER-HCM): a randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet* 396(10253):759–769, 2020. Erratum in: *Lancet* 396(10253):758, 2020

20.9 Interventionelle Pulmonal-klappenimplantation

- [1] Bonhoeffer P, Boudjemline Y, Saliba Z et al. Transcatheter implantation of a bovine valve in pulmonary position: a lamb study. *Circulation* 102:813–816, 2000
- [2] Bonhoeffer P, Boudjemline Y, Saliba Z et al. Percutaneous replacement of pulmonary valve in a right-ventricle to pulmonary-artery prosthetic conduit with valve dysfunction. *Lancet* 356:1403–1405, 2000
- [3] Bonhoeffer P, Boudjemline Y, Qureshi SA et al. Percutaneous insertion of the pulmonary valve. *J Am Coll Cardiol* 39:1664–1669, 2002
- [4] Sridharan S, Coats L, Khambadkone S et al. Images in cardiovascular medicine. Transcatheter right ventricular outflow tract intervention: the risk to the coronary circulation. *Circulation* 113:e934–e935, 2006
- [5] Nordmeyer J, Ewert P, Gewillig M et al. Acute and midterm outcomes of the post-approval MELODY Registry: a multicentre registry of transcatheter pulmonary valve implantation. *Eur Heart J* 40:2255–2264, 2019
- [6] Cribier A, Eltchaninoff H, Bash A et al. Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description. *Circulation* 106:3006–3008, 2002
- [7] Cribier A, Remadi F, Koning R et al. Emergency balloon valvuloplasty as initial treatment of patients with aortic stenosis and cardiogenic shock. *N Engl J Med* 326:646, 1992
- [8] Zahn EM. Self-expanding pulmonary valves for large diameter right ventricular outflow tracts. *Int Cardiol Clin* 8:73–80, 2019
- [9] Metzner A, Stock UA, Iino K et al. Percutaneous pulmonary valve replacement: autologous tissue-engineered valved stents. *Cardiovasc Res* 88:453–461, 2010
- [10] Spriestersbach H, Prudlo A, Bartosch M et al. First percutaneous implantation of a completely tissue-engineered self-expanding pulmonary heart valve prosthesis using a newly developed delivery system: a feasibility study in sheep. *Cardiovasc Interv Ther* 32:36–47, 2017
- [11] Schmitt B, Spriestersbach H, H-Ici DO et al. Percutaneous pulmonary valve replacement using completely tissue-engineered off-the-shelf heart valves: six-month in vitro functionality and matrix remodeling in sheep. *EuroIntervention* 12:62–70, 2016
- [12] Ewert P. Pulmonalklappeninsuffizienz bei EmaH – interventionelle Therapie. *Kardiologie up2date* 16:43–54, 2020
- [13] Zhang X, Puehler T, Seiler J et al. Tissue engineered transcatheter pulmonary valved stent implantation: current state and future prospect. *Int J Mol Sci* 23:723, 2022
- [14] Baumgartner H, De Backer J, Babu-Narayan SV et al. 2020 ESC Guidelines for the management of adult congenital heart disease. *Eur Heart J* 42:563–645, 2021