

Kardiyovasküler Cerrahide Anestezi Yönetimi

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Giriş

Yaşlı nüfus olarak kabul edilen 65 ve daha yukarı yaşındaki nüfus, 2014 yılına göre %16 artarak 2018 yılında 7 milyon 186 bin 204 kişi oldu. Yaşlı nüfusun toplam nüfus içindeki oranı ise 2014 yılında %8 iken, 2018 yılında %8,8'e yükseldi. Nüfus projeksiyonlarına göre, yaşlı nüfus oranının 2023 yılında %10,2, 2030 yılında %12,9, 2040 yılında %16,3, 2060 yılında %22,6 ve 2080 yılında %25,6 olacağı tahmin ediliyor. Ölüm nedeni istatistiklerine göre, 2017 yılında ölen yaşlıların %45,1'i dolaşım sistemi hastalıkları nedeniyle hayatını kaybetmiştir. Yaşlı hasta grubunun genç hastalara göre 4 kat fazla invaziv işlemlere maruz kaldığı göz önüne alındığında, sağlık sistemimize ciddi etkilerinin olacağı göz ardı edilemeyecek bir gerçektir. Çünkü kardiyovasküler cerrahi geçirecek yaşlı hasta sayısı her geçen gün artmaktadır. Sonuçta hastalar ileri yaşta ve hastalıklarının ileri safhalarında doktora başvurmaktadırlar. Bu bölümde, tüm bu yeni durumlar göz önünde tutularak yaşlı hasta popülasyonunda, kardiyovasküler cerrahide anestezi yönetimi ele alınacaktır.

I. Genel Bakış

Kardiyovasküler sistem (KVS) hastalıkları esasen ileri yaş hastalıklarıdır. ABD'de 60 yaş üzeri yaklaşık 43,7 milyon kardiyovasküler hastalığı olan kişi olduğu tahmin edilmektedir. 2010 senesinde yapılan kardiyovasküler girişimlerin %51'i 65 yaş üstü hastalara uygulanmıştır. Koroner arter hastalığı (KAH), kalp kapak hastalıkları, kalp yetmezliği (KKY) ve atrial fibrilasyon (AF) prevalansı hep yaşla artmaktadır. 80 yaş üzeri erkeklerin %84,7'si ve kadınların %85,9'u kardiyovasküler hastalıkların değişik formlarına sahiptir. Bütün KVS hasta ölümlerinin 2/3'ü 75 yaş üzeri hastalarda meydana gelmektedir (1). Amerika Birleşik Devletleri'nde 1983 yılında, 65 yaş üstü hastalar, Koroner Arter Bypass Greft Operasyonlarının (KABGO) %12'sini oluşturmaktakta iken; bundan 10 sene sonra ise yarısını

- KABG esnasında uygun antikoagülasyon, ACT gibi hızlı testlerle 30 dakika arayla kontrol edilmeli ve 400-480 saniye arasında tutulmaya çalışılmalıdır.
- Hb <7,5 g/dL olduğunda öncelikle ultrafiltrasyon tedavi seçeneği olmalı, ultrafiltrasyon yapılamıyorsa ve yetersiz ise transfüzyon yapılmalıdır.
- Kan glukoz düzeyleri <180 mg/dL olacak şekilde ayarlanmalıdır.
- Kan elektrolit düzeyleri 30 dakikada bir ölçülmeli, gerekli ise elektrolit replasman yapılmalıdır.

Kaynaklar

1. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. *Circulation*. 2015;131(4):e29-322.
2. Gersh BJ, Kronmal RA, Schaff HV, Frye RL, Ryan TJ, Myers WO, et al. Long-term (5 year) results of coronary bypass surgery in patients 65 years old or older: a report from the Coronary Artery Surgery Study. *Circulation*. 1983;68(3 Pt 2)
3. Acinapura AJ, Jacobowitz IJ, Kramer MD, Adkins MS, Zisbrod Z, Cunningham JN, Jr. Demographic changes in coronary artery bypass surgery and its effect on mortality and morbidity. *European journal of cardio-thoracic surgery: official journal of the European Association for Cardio-thoracic Surgery*. 1990;4(4):175-81.
4. Khuri SF, Daley J, Henderson W, Hur K, Gibbs JO, Barbour G, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *Journal of the American College of Surgeons*. 1997;185(4):315-27.
5. Gehlot A, Mullany CJ, Ilstrup D, Schaff HV, Orzulak TA, Morris JJ, et al. Aortic valve replacement in patients aged eighty years and older: early and long-term results. *The Journal of thoracic and cardiovascular surgery*. 1996;111(5):1026-36.
6. Investigators oboR, Pacini D, Di Eusanio M, Fortuna D, Cristell D, Pugliese P, et al. Contemporary outcomes of conventional aortic valve replacement in 638 octogenarians: insights from an Italian Regional Cardiac Surgery Registry (RERIC). *European Journal of Cardio-Thoracic Surgery*. 2012;41(6):1247-53.
7. Brown JM, O'Brien SM, Wu C, Sikora JAH, Griffith BP, Gammie JS. Isolated aortic valve replacement in North America comprising 108,687 patients in 10 years: Changes in risks, valve types, and outcomes in the Society of Thoracic Surgeons National Database. *The Journal of thoracic and cardiovascular surgery*. 2009;137(1):82-90.
8. Lee R, Li S, Rankin JS, O'Brien SM, Gammie JS, Peterson ED, et al. Fifteen-Year Outcome Trends for Valve Surgery in North America. *The Annals of thoracic surgery*. 2011;91(3):677-84.
9. Cribier A, Eltchaninoff H, Bash A, Borenstein N, Tron C, Bauer F, et al. Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description. *Circulation*. 2002;106(24):3006-8.
10. Holmes DR, Jr., Nishimura RA, Grover FL, Brindis RG, Carroll JD, Edwards FH, et al. Annual Outcomes With Transcatheter Valve Therapy: From the STS/ACC TVT Registry. *The Annals of thoracic surgery*. 2016;101(2):789-800.

11. Arsalan M, Szerlip M, Vemulapalli S, Holper EM, Arnold SV, Li Z, et al. Should Transcatheter Aortic Valve Replacement Be Performed in Nonagenarians?: Insights From the STS/ACC TAVT Registry. *Journal of the American College of Cardiology*. 2016;67(12):1387-95.
12. Mayr NP, Michel J, Bleiziffer S, Tassani P, Martin K. Sedation or general anesthesia for transcatheter aortic valve implantation (TAVI). *Journal of thoracic disease*. 2015;7(9):1518-26.
13. Brecker SJ, Bleiziffer S, Bosmans J, Gerckens U, Tamburino C, Wenaweser P, et al. Impact of Anesthesia Type on Outcomes of Transcatheter Aortic Valve Implantation (from the Multicenter ADVANCE Study). *The American journal of cardiology*. 2016;117(8):1332-8.
14. Wendler O, Thielmann M, Schroefel H, Rastan A, Treede H, Wahlers T, et al. Worldwide experience with the 29-mm Edwards SAPIEN XT transcatheter heart valve in patients with large aortic annulus. *European journal of cardio-thoracic surgery: official journal of the European Association for Cardio-thoracic Surgery*. 2013;43(2):371-7.
15. Smith CR, Leon MB, Mack MJ, Miller DC, Moses JW, Svensson LG, et al. Transcatheter versus surgical aortic-valve replacement in high-risk patients. *The New England journal of medicine*. 2011;364(23):2187-98.
16. Stortecky S, Windecker S, Pilgrim T, Heg D, Buellesfeld L, Khattab AA, et al. Cerebrovascular accidents complicating transcatheter aortic valve implantation: frequency, timing and impact on outcomes. *EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology*. 2012;8(1):62-70.
17. Naber CK, Ghanem A, Abizaid AA, Wolf A, Sinning JM, Werner N, et al. First-in-man use of a novel embolic protection device for patients undergoing transcatheter aortic valve implantation. *EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology*. 2012;8(1):43-50.
18. Khawaja MZ, Thomas M, Joshi A, Asrress KN, Wilson K, Bolter K, et al. The effects of VARC-defined acute kidney injury after transcatheter aortic valve implantation (TAVI) using the Edwards bioprosthesis. *EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology*. 2012;8(5):563-70.
19. Kong WY, Yong G, Irish A. Incidence, risk factors and prognosis of acute kidney injury after transcatheter aortic valve implantation. *Nephrology (Carlton, Vic)*. 2012;17(5):445-51.
20. Nuis RJ, Rodes-Cabau J, Sinning JM, van Garsse L, Kefer J, Bosmans J, et al. Blood transfusion and the risk of acute kidney injury after transcatheter aortic valve implantation. *Circulation Cardiovascular interventions*. 2012;5(5):680-8.
21. Mollmann H, Kempfert J, Hamm CW, Walther T. Transcatheter aortic valve implantation. *Herz* 2010;35(2):62-8.
22. Bleiziffer S, Ruge H, Horer J, Hutter A, Geisbusch S, Brockmann G, et al. Predictors for new-onset complete heart block after transcatheter aortic valve implantation. *JACC Cardiovascular interventions*. 2010;3(5):524-30.

23. Schroeter T, Linke A, Haensig M, Merk DR, Borger MA, Mohr FW, et al. Predictors of permanent pacemaker implantation after Medtronic CoreValve bioprostheses implantation. *Europace: European pacing, arrhythmias, and cardiac electrophysiology: journal of the working groups on cardiac pacing, arrhythmias, and cardiac cellular electrophysiology of the European Society of Cardiology.* 2012;14(12):1759-63.
24. Iung B, Baron G, Butchart EG, Delahaye F, Gohlke-Bärwolf C, Levang OW, et al. A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. *European Heart Journal.* 2003;24(13):1231-43.
25. ACC/AHA guidelines for the management of patients with valvular heart disease. A report of the American College of Cardiology/American Heart Association. Task Force on Practice Guidelines (Committee on Management of Patients with Valvular Heart Disease). *Journal of the American College of Cardiology.* 1998;32(5):1486-588.
26. Bonow RO, Carabello BA, Chatterjee K, de Leon AC, Jr., Faxon DP, Freed MD, et al. 2008 focused update incorporated into the ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to revise the 1998 guidelines for the management of patients with valvular heart disease). Endorsed by the Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Journal of the American College of Cardiology.* 2008;52(13):e1-142.
27. Bonow RO, Carabello BA, Chatterjee K, de Leon AC, Jr., Faxon DP, Freed MD, et al. ACC/AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (writing Committee to Revise the 1998 guidelines for the management of patients with valvular heart disease) developed in collaboration with the Society of Cardiovascular Anesthesiologists endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. *Journal of the American College of Cardiology.* 2006;48(3):e1-148.
28. Vahanian A, Iung B, Messika-Zeitoun D, Détaint D, Mirabel M, Baron G, et al. What are the characteristics of patients with severe, symptomatic, mitral regurgitation who are denied surgery? *European Heart Journal.* 2007;28(11):1358-65.
29. Feldman T, Foster E, Glower DD, Kar S, Rinaldi MJ, Fail PS, et al. Percutaneous repair or surgery for mitral regurgitation. *The New England journal of medicine.* 2011;364(15):1395-406.
30. Whitlow PL, Feldman T, Pedersen WR, Lim DS, Kipperman R, Smalling R, et al. Acute and 12-month results with catheter-based mitral valve leaflet repair: the EVEREST II (Endovascular Valve Edge-to-Edge Repair) High Risk Study. *Journal of the American College of Cardiology.* 2012;59(2):130-9.
31. Chugh SS, Havmoeller R, Narayanan K, Singh D, Rienstra M, Benjamin EJ, et al. Worldwide epidemiology of atrial fibrillation: a Global Burden of Disease 2010 Study. *Circulation.* 2014;129(8):837-47.
32. Feinberg WM, Blackshear JL, Laupacis A, Kronmal R, Hart RG. Prevalence, Age Distribution, and Gender of Patients With Atrial Fibrillation: Analysis and Implications. *Archives of Internal Medicine.* 1995;155(5):469-73.
33. Lamassa M, Di Carlo A, Pracucci G, Basile AM, Trefoloni G, Vanni P, et al. Characte-

- istics, outcome, and care of stroke associated with atrial fibrillation in Europe: data from a multicenter multinational hospital-based registry (The European Community Stroke Project). *Stroke.* 2001;32(2):392-8.
34. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC, Jr., et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation.* 2014;130(23):2071-104.
 35. Roldan V, Marin F, Fernandez H, Manzano-Fernandez S, Gallego P, Valdes M, et al. Predictive value of the HAS-BLED and ATRIA bleeding scores for the risk of serious bleeding in a “real-world” population with atrial fibrillation receiving anticoagulant therapy. *Chest.* 2013;143(1):179-84.
 36. Marzec LN, Wang J, Shah ND, Chan PS, Ting HH, Gosch KL, et al. Influence of Direct Oral Anticoagulants on Rates of Oral Anticoagulation for Atrial Fibrillation. *Journal of the American College of Cardiology.* 2017;69(20):2475-84.
 37. Blackshear JL, Odell JA. Appendage obliteration to reduce stroke in cardiac surgical patients with atrial fibrillation. *The Annals of thoracic surgery.* 1996;61(2):755-9.
 38. Iskandar S, Vacek J, Lavu M, Lakkireddy D. Left Atrial Appendage Closure for Stroke Prevention: Devices, Techniques, and Efficacy. *Cardiology clinics.* 2016;34(2):329-51.
 39. De Backer O, Arnous S, Ihlemann N, Vejlstrup N, Jørgensen E, Pehrson S, et al. Percutaneous left atrial appendage occlusion for stroke prevention in atrial fibrillation: an update. *Open Heart.* 2014;1(1)
 40. Chan N-Y, Choy C-C, Lau C-L, Tsui P-T, Lo Y-K, Chu P-S, et al. TCTAP A-087 Percutaneous Left Atrial Appendage Occlusion Can Be Performed Under Conscious Sedation Without General Anaesthesia. *Journal of the American College of Cardiology.* 2014;63(12):24.
 41. Bayard YL, Omran H, Neuzil P, Thuesen L, Pichler M, Rowland E, et al. PLAATO (Percutaneous Left Atrial Appendage Transcatheter Occlusion) for prevention of cardioembolic stroke in non-anticoagulation eligible atrial fibrillation patients: results from the European PLAATO study. *EuroIntervention: journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology.* 2010;6(2):220-6.
 42. Holmes DR, Reddy VY, Turi ZG, Doshi SK, Sievert H, Buchbinder M, et al. Percutaneous closure of the left atrial appendage versus warfarin therapy for prevention of stroke in patients with atrial fibrillation: a randomised non-inferiority trial. *Lancet (London, England).* 2009;374(9689):534-42.
 43. Möbius-Winkler S, Majunke N, Sandri M, Mangner N, Linke A, Stone GW, et al. Percutaneous left atrial appendage closure: Technical aspects and prevention of perioperative complications with the watchman device. *World journal of cardiology.* 2015;7(2):65-75.
 44. Franzen OW, Klemm H, Hamann F, Koschyk D, von Kodolitsch Y, Weil J, et al. Mechanisms underlying air aspiration in patients undergoing left atrial catheterization. *Catheterization and cardiovascular interventions: official journal of the Society for Cardiac Angiography & Interventions.* 2008;71(4):553-8.

45. Chang CK, Chuter TA, Niemann CU, Shlipak MG, Cohen MJ, Reilly LM, et al. Systemic inflammation, coagulopathy, and acute renal insufficiency following endovascular thoracoabdominal aortic aneurysm repair. *Journal of vascular surgery*. 2009;49(5):1140-6.
46. Lippmann M, Lingam K, Rubin S, Julka I, White R. Anesthesia for endovascular repair of abdominal and thoracic aortic aneurysms: a review article. *The Journal of cardiovascular surgery*. 2003;44(3):443-51.
47. Jankovic Z, Ahmad N, Ravishankar N, Archer F. Transversus abdominis plane block: how safe is it? *Anesthesia and analgesia*. 2008;107(5):1758-9.
48. Aadahl P, Lundbom J, Hatlinghus S, Myhre HO. Regional anesthesia for endovascular treatment of abdominal aortic aneurysms. *Journal of endovascular surgery: the official journal of the International Society for Endovascular Surgery*. 1997;4(1):56-61.
49. Gallego-Ligorit L, Vives M, Valles-Torres J, Sanjuan-Villarreal TA, Pajares A, Iglesias M. Use of Dexmedetomidine in Cardiothoracic and Vascular Anesthesia. *J Cardiothorac Vasc Anesth*. 2018;32(3):1426-38.
50. Fattori R, Caldarera I, Rapezzi C, Rocchi G, Napoli G, Parlapiano M, et al. Primary endoleakage in endovascular treatment of the thoracic aorta: importance of intraoperative transesophageal echocardiography. *The Journal of thoracic and cardiovascular surgery*. 2000;120(3):490-5.
51. Rocchi G, Lofiego C, Biagini E, Piva T, Bracchetti G, Lovato L, et al. Transesophageal echocardiography-guided algorithm for stent-graft implantation in aortic dissection. *Journal of vascular surgery*. 2004;40(5):880-5.
52. Swaminathan M, Lineberger CK, McCann RL, Mathew JP. The importance of intraoperative transesophageal echocardiography in endovascular repair of thoracic aortic aneurysms. *Anesthesia and analgesia*. 2003;97(6):1566-72.
53. Gonzalez-Fajardo JA, Gutierrez V, San Roman JA, Serrador A, Arreba E, Del Rio L, et al. Utility of intraoperative transesophageal echocardiography during endovascular stent-graft repair of acute thoracic aortic dissection. *Annals of vascular surgery*. 2002;16(3):297-303.
54. Gravereaux EC, Faries PL, Burks JA, Latessa V, Spielvogel D, Hollier LH, et al. Risk of spinal cord ischemia after endograft repair of thoracic aortic aneurysms. *Journal of vascular surgery*. 2001;34(6):997-1003.
55. Buth J, Harris PL, Hobo R, van Eps R, Cuypers P, Duijm L, et al. Neurologic complications associated with endovascular repair of thoracic aortic pathology: Incidence and risk factors. a study from the European Collaborators on Stent/Graft Techniques for Aortic Aneurysm Repair (EUROSTAR) registry. *Journal of vascular surgery*. 2007;46(6):1103-10.
56. Hanna JM, Andersen ND, Aziz H, Shah AA, McCann RL, Hughes GC. Results with selective preoperative lumbar drain placement for thoracic endovascular aortic repair. *The Annals of thoracic surgery*. 2013;95(6):1968-74.
57. Shahian DM, O'Brien SM, Filardo G, Ferraris VA, Haan CK, Rich JB, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 1--coronary artery bypass grafting surgery. *The Annals of thoracic surgery*. 2009;88(1):2-22.
58. O'Brien SM, Shahian DM, Filardo G, Ferraris VA, Haan CK, Rich JB, et al. The Society

- of Thoracic Surgeons 2008 cardiac surgery risk models: part 2--isolated valve surgery. *The Annals of thoracic surgery.* 2009;88(1):23-42.
59. Shahian DM, O'Brien SM, Filardo G, Ferraris VA, Haan CK, Rich JB, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 3--valve plus coronary artery bypass grafting surgery. *The Annals of thoracic surgery.* 2009;88(1):43-62.
 60. Fuster V, Ryden LE, Cannon DS, Crijns HJ, Curtis AB, Ellenbogen KA, et al. 2011 ACCF/AHA/HRS focused updates incorporated into the ACC/AHA/ESC 2006 guidelines for the management of patients with atrial fibrillation: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. *Circulation.* 2011;123(10):e269-367.
 61. Patti G, Chello M, Candura D, Pasceri V, D'Ambrosio A, Covino E, et al. Randomized trial of atorvastatin for reduction of postoperative atrial fibrillation in patients undergoing cardiac surgery: results of the ARMYDA-3 (Atorvastatin for Reduction of MYocardial Dysrhythmia After cardiac surgery) study. *Circulation.* 2006;114(14):1455-61.
 62. Ferguson TB, Jr., Coombs LP, Peterson ED. Internal thoracic artery grafting in the elderly patient undergoing coronary artery bypass grafting: room for process improvement? *The Journal of thoracic and cardiovascular surgery.* 2002;123(5):869-80.
 63. Martinez-Selles M, Garcia Robles JA, Prieto L, Dominguez Munoa M, Frades E. Heart failure in the elderly: age-related differences in clinical profile and mortality. *International journal of cardiology.* 2005;102(1):55-60.
 64. Van der Meer RW, Rijzewijk LJ, Diamant M, Hammer S, Schar M, Bax JJ, et al. The ageing male heart: myocardial triglyceride content as independent predictor of diastolic function. *Eur Heart J.* 2008;29(12):1516-22.
 65. Abozguia K, Phan TT, Shriv GN, Maher AR, Ahmed I, Wagenmakers A, et al. Reduced in vivo skeletal muscle oxygen consumption in patients with chronic heart failure--a study using Near Infrared Spectrophotometry (NIRS). *European journal of heart failure.* 2008;10(7):652-7.
 66. Deschenes MR, Connell AM, Jackson EM, Taylor JL, Glass EK. A comparison of physiological variables in aged and young women during and following submaximal exercise. *American journal of human biology : the official journal of the Human Biology Council.* 2009;21(6):836-43.
 67. Bharati S, Lev M. The pathologic changes in the conduction system beyond the age of ninety. *American heart journal.* 1992;124(2):486-96.
 68. Newman MF, Croughwell ND, Blumenthal JA, White WD, Lewis JB, Smith LR, et al. Effect of aging on cerebral autoregulation during cardiopulmonary bypass. Association with postoperative cognitive dysfunction. *Circulation.* 1994;90(5):243-9.
 69. Roach GW, Kanchuger M, Mangano CM, Newman M, Nussmeier N, Wolman R, et al. Adverse cerebral outcomes after coronary bypass surgery. Multicenter Study of Perioperative Ischemia Research Group and the Ischemia Research and Education Foundation Investigators. *The New England journal of medicine.* 1996;335(25):1857-63.
 70. Chaudhuri K, Storey E, Lee GA, Bailey M, Chan J, Rosenfeldt FL, et al. Carbon dioxide insufflation in open-chamber cardiac surgery: a double-blind, randomized clinical trial of neurocognitive effects. *The Journal of thoracic and cardiovascular surgery.* 2012;144(3):646-53.

71. Gold JP, Torres KE, Maldarelli W, Zhuravlev I, Condit D, Wasnick J. Improving outcomes in coronary surgery: the impact of echo-directed aortic cannulation and perioperative hemodynamic management in 500 patients. *The Annals of thoracic surgery*. 2004;78(5):1579-85.
72. Mirow N, Zittermann A, Korperich H, Borgermann J, Koertke H, Knobl H, et al. Diffusion-weighted magnetic resonance imaging for the detection of ischemic brain lesions in coronary artery bypass graft surgery: relation to extracorporeal circulation and heparinization. *The Journal of cardiovascular surgery*. 2011;52(1):117-26.
73. McDonagh DL, Berger M, Mathew JP, Graffagnino C, Milano CA, Newman MF. Neurological complications of cardiac surgery. *The Lancet Neurology*. 2014;13(5):490-502.
74. Bernick C, Kuller L, Dulberg C, Longstreth WT, Jr., Manolio T, Beauchamp N, et al. Silent MRI infarcts and the risk of future stroke: the cardiovascular health study. *Neurology*. 2001;57(7):1222-9.
75. Brady K, Joshi B, Zweifel C, Smielewski P, Czosnyka M, Easley RB, et al. Real-time continuous monitoring of cerebral blood flow autoregulation using near-infrared spectroscopy in patients undergoing cardiopulmonary bypass. *Stroke*. 2010;41(9):1951-6.
76. Murkin JM, Adams SJ, Novick RJ, Quantz M, Bainbridge D, Iglesias I, et al. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. *Anesthesia and analgesia*. 2007;104(1):51-8.
77. Schoen J, Meyerrose J, Paarmann H, Heringlake M, Hueppe M, Berger KU. Preoperative regional cerebral oxygen saturation is a predictor of postoperative delirium in on-pump cardiac surgery patients: a prospective observational trial. *Critical care (London, England)*. 2011;15(5):R218.
78. Slater JP, Guarino T, Stack J, Vinod K, Bustami RT, Brown JM, 3rd, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. *The Annals of thoracic surgery*. 2009;87(1):36-44.
79. de Tournay-Jette E, Dupuis G, Bherer L, Deschamps A, Cartier R, Denault A. The relationship between cerebral oxygen saturation changes and postoperative cognitive dysfunction in elderly patients after coronary artery bypass graft surgery. *J Cardiotorac Vasc Anesth*. 2011;25(1):95-104.
80. Deschamps A, Hall R, Grocott H, Mazer CD, Choi PT, Turgeon AF, et al. Cerebral Oximetry Monitoring to Maintain Normal Cerebral Oxygen Saturation during High-risk Cardiac Surgery: A Randomized Controlled Feasibility Trial. *Anesthesiology*. 2016;124(4):826-36.
81. Grossestreuer AV, Gaiesti DF, Donnino MW, Wiebe DJ, Abella BS. Magnitude of temperature elevation is associated with neurologic and survival outcomes in resuscitated cardiac arrest patients with postrewarming pyrexia. *Journal of critical care*. 2017;38:78-83.
82. Enomoto S, Hindman BJ, Dexter F, Smith T, Cutkomp J. Rapid rewarming causes an increase in the cerebral metabolic rate for oxygen that is temporarily unmatched by cerebral blood flow. A study during cardiopulmonary bypass in rabbits. *Anesthesiology*. 1996;84(6):1392-400.

83. Berger M, Browndyke J, Mathew JP. Intraoperative Glycemic Control to Prevent Delirium after Cardiac Surgery: Steering a Course between Scylla and Charybdis. *Anesthesiology*. 2015;122(6):1186-8.
84. Lindgren M, Eckert B, Stenberg G, Agardh CD. Restitution of neurophysiological functions, performance, and subjective symptoms after moderate insulin-induced hypoglycaemia in non-diabetic men. *Diabetic medicine: a journal of the British Diabetic Association*. 1996;13(3):218-25.
85. Puskas F, Grocott HP, White WD, Mathew JP, Newman MF, Bar-Yosef S. Intraoperative hyperglycemia and cognitive decline after CABG. *The Annals of thoracic surgery*. 2007;84(5):1467-73.
86. Butterworth J, Wagenknecht LE, Legault C, Zaccaro DJ, Kon ND, Hammon JW, Jr., et al. Attempted control of hyperglycemia during cardiopulmonary bypass fails to improve neurologic or neurobehavioral outcomes in patients without diabetes mellitus undergoing coronary artery bypass grafting. *The Journal of thoracic and cardiovascular surgery*. 2005;130(5):1319.
87. Hannan EL, Kilburn H, Jr, Racz M, Shields E, Chassin MR. Improving the Outcomes of Coronary Artery Bypass Surgery in New York State. *JAMA*. 1994;271(10):761-6.
88. Chow WB, Rosenthal RA, Merkow RP, Ko CY, Esnaola NF. Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. *Journal of the American College of Surgeons*. 2012;215(4):453-66.
89. Makary MA, Segev DL, Pronovost PJ, Syin D, Bandeen-Roche K, Patel P, et al. Frailty as a predictor of surgical outcomes in older patients. *Journal of the American College of Surgeons*. 2010;210(6):901-8.
90. Bagnall NM, Faiz O, Darzi A, Athanasiou T. What is the utility of preoperative frailty assessment for risk stratification in cardiac surgery? *Interactive cardiovascular and thoracic surgery*. 2013;17(2):398-402.
91. Kim SW, Han HS, Jung HW, Kim KI, Hwang DW, Kang SB, et al. Multidimensional frailty score for the prediction of postoperative mortality risk. *JAMA surgery*. 2014;149(7):633-40.
92. Milder DA, Pillinger NL, Kam PCA. The role of prehabilitation in frail surgical patients: A systematic review. *Acta anaesthesiologica Scandinavica*. 2018;62(10):1356-66.
93. Ng TP, Feng L, Nyunt MS, Feng L, Niti M, Tan BY, et al. Nutritional, Physical, Cognitive, and Combination Interventions and Frailty Reversal Among Older Adults: A Randomized Controlled Trial. *The American journal of medicine*. 2015;128(11):1225-36.
94. Berger M, Schenning KJ, Brown CHt, Deiner SG, Whittington RA, Eckenhoff RG, et al. Best Practices for Postoperative Brain Health: Recommendations From the Fifth International Perioperative Neurotoxicity Working Group. *Anesthesia and analgesia*. 2018;127(6):1406-13.
95. H OB, Mohan H, Hare CO, Reynolds JV, Kenny RA. Mind Over Matter? The Hidden Epidemic of Cognitive Dysfunction in the Older Surgical Patient. *Annals of surgery*. 2017;265(4):677-91.

96. Morandi A, Davis D, Bellelli G, Arora RC, Caplan GA, Kamholz B, et al. The Diagnosis of Delirium Superimposed on Dementia: An Emerging Challenge. *Journal of the American Medical Directors Association.* 2017;18(1):12-8.
97. Sprung J, Roberts RO, Weingarten TN, Nunes Cavalcante A, Knopman DS, Petersen RC, et al. Postoperative delirium in elderly patients is associated with subsequent cognitive impairment. *British journal of anaesthesia.* 2017;119(2):316-23.
98. Grigore AM, Matheu J, Grocott HP, Reves JG, Blumenthal JA, White WD, et al. Prospective randomized trial of normothermic versus hypothermic cardiopulmonary bypass on cognitive function after coronary artery bypass graft surgery. *Anesthesiology.* 2001;95(5):1110-9.
99. Timpa JG, O'Meara LC, Goldberg KG, Phillips JP, Crawford JH, Jackson KW, et al. Implementation of a Multidisciplinary Bleeding and Transfusion Protocol Significantly Decreases Perioperative Blood Product Utilization and Improves Some Bleeding Outcomes. *The journal of extra-corporeal technology.* 2016;48(1):11-8.
100. Mazer CD, Whitlock RP, Fergusson DA, Hall J, Belley-Cote E, Connolly K, et al. Restrictive or Liberal Red-Cell Transfusion for Cardiac Surgery. *The New England journal of medicine.* 2017;377(22):2133-44.
101. McPherson JA, Wagner CE, Boehm LM, Hall JD, Johnson DC, Miller LR, et al. Delirium in the cardiovascular ICU: exploring modifiable risk factors. *Critical care medicine.* 2013;41(2):405-13.
102. Cheng H, Li Z, Young N, Boyd D, Atkins Z, Ji F, et al. The Effect of Dexmedetomidine on Outcomes of Cardiac Surgery in Elderly Patients. *J Cardiothorac Vasc Anesth.* 2016;30(6):1502-8.
103. Djaiani G, Silverton N, Fedorko L, Carroll J, Styra R, Rao V, et al. Dexmedetomidine versus Propofol Sedation Reduces Delirium after Cardiac Surgery: A Randomized Controlled Trial. *Anesthesiology.* 2016;124(2):362-8.