INCIDENCIA DE LESIÓN RENAL AGUDA Y EL REQUERIMIENTO DE TERAPIA DE SOPORTE RENAL EN EL POSTOPERATORIO DE CIRUGÍA CARDIOVASCULAR EN UNA CLÍNICA DE IV NIVEL EN EL PERIODO 2020-2023

Daniel Ospina Herrera
Código estudiantil: 20191140100032

Trabajo de Investigación presentado como requisito para optar el título de:
ESPECIALISTA EN NEFROLOGÍA

Tutores:
OMAR DE JESUS CABARCA BARBOSA
MD | Internista | NEF

CARLOS GUIDO MUSSO
MD | Internista | NEF | PhD Med

HENRY J GONZALEZ-TORRES
Bio | Spc App Stat | MSc Bio (GenPop) | PhD (c) BioMed

RESUMEN

La lesión renal aguda (LRA) se considera un síndrome y se define como un rápido aumento de la creatinina sérica, y/o una disminución de la producción de orina (1) las principales causas son sepsis, cirugía mayor, shock cardiogénico, hipovolemia, inducido por fármacos, síndrome hepatorrenal y uropatía obstructiva. Dentro de las cirugías mayores se destaca la cirugía cardiovascular.

Objetivo: Evaluar la incidencia de lesión renal aguda y el requerimiento de terapia de soporte renal en el postoperatorio de cirugía cardiovascular en una clínica de iv nivel en el periodo 2020-2023

Metodología: Se realizó un estudio analítico, de corte transversal retrospectivo. Se describieron las variables mediante sumarios estadísticos. Se utilizó la prueba Wilcox para comparar medianas entre dos grupos. Para analizar las variables categóricas, se utilizó la prueba exacta de Fisher o el Chisq. test. Se realizó un análisis de regresión logística multivariada, ajustada por método “Backward” y OR, IC95%. Se consideró un valor de $p < 0.05$ para significancia estadística.

Resultados: En un estudio de 137 pacientes sometidos a cirugía cardiovascular, la mayoría masculinos con mediana de edad de 62 años, la hipertensión arterial fue la comorbilidad más frecuente (60%). Pacientes con lesión renal aguda (LRA) mostraron mayor prevalencia de diabetes tipo 2 y cirugía de Bentall. En relación con la circulación extracorpórea (BCEC) y la tasa de filtración glomerular (TFG), el 80% de los pacientes con LRA habían sido sometidos a BCEC.

Conclusión: Estos resultados subrayan la importancia de considerar la LRA y el uso de BCEC como factores críticos al evaluar el riesgo de mortalidad en pacientes sometidos a cirugía cardiovascular.

Palabras clave: Lesión renal aguda, Cirugía cardiovascular, Terapia de reemplazo renal.

ABSTRACT

Acute kidney injury (AKI) is considered a syndrome and is defined as a rapid increase in serum creatinine and/or a decrease in urine production. The main causes include sepsis, major surgery, cardiogenic shock, hypovolemia, drug-induced, hepatorenal syndrome, and obstructive uropathy. Major cardiovascular surgery stands out among the major surgeries.

Objective: To evaluate the incidence of acute kidney injury and the need for renal support therapy in the postoperative period of cardiovascular surgery at a level IV clinic from 2020 to 2023.

Methodology: A retrospective analytical cross-sectional study was conducted. Variables were described using statistical summaries. The Wilcox test was used to compare medians between two groups. The Fisher's exact test or the Chi-square test was used to analyze categorical variables. Multivariate logistic regression analysis, adjusted by the "Backward" method and presented as odds ratios (OR)

with a 95% confidence interval (CI), was performed. A p-value < 0.05 was considered statistically significant.
Results: In a study of 137 patients undergoing cardiovascular surgery, mostly male with a median age of 62 years, arterial hypertension was the most common comorbidity (60%). Patients with acute kidney injury (AKI) showed a higher prevalence of type 2 diabetes and Bentall surgery. Regarding extracorporeal circulation (ECC) and glomerular filtration rate (GFR), 80% of AKI patients had undergone ECC.
Conclusion: These results emphasize the importance of considering AKI and ECC as critical factors when assessing the risk of mortality in patients undergoing cardiovascular surgery.

Key Words: Acute kidney injury, Cardiovascular surgery, Renal replacement therapy.

REFERENCIAS BIBLIOGRÁFICAS

1. Ronco C, Bellomo R, Kellum JA. Acute kidney injury. Lancet [Internet]. 2019;394(10212):1949–64. Available from: http://dx.doi.org/10.1016/S0140-6736(19)32563-2
2. Gainza FJ. INSUFICIENCIA RENAL AGUDA. Nefrol Al Dia. 2012;7:309–34.
3. Pickkers P, Darmon M, Hoste E, Joannidis M, Legrand M, Ostermann M, et al. Acute kidney injury in the critically ill: an updated review on pathophysiology and management. Intensive Care Med [Internet]. 2021;47(8):835–50. Available from: https://doi.org/10.1007/s00134-021-06454-7
4. Murillo-brambila D. Utilidad clínica de la reserva funcional renal. Diálisis y Traspl. 2015;36(1).
5. It F, Graded N, Graded N, Graded N, Ckd W. KDIGO Section 2: AKI Definition. Kidney Int Suppl. 2012;2(1):19–36.
6. Hoste EAJ, Bagshaw SM, Bellomo R, Cely CM, Colman R, Cruz DN, et al. Epidemiology of acute kidney injury in critically ill patients: the multinational AKI-EPI study. Intensive Care Med. 2015;41(8):1411–23.

7. Ellison DH, Bia MJ. Acute Renal Failure in Critically Ill Patients. J Intensive Care Med. 1987;2(1):8–24.
8. Liu KD, Palevsky PM. Postoperative kidney injury. Clin J Am Soc Nephrol. 2022;17(4):570–1.
9. Gumbert SD, Kork F, Jackson ML, Vanga N, Ghebremichael SJ, Wang CY, et al. Perioperative Acute Kidney Injury. Anesthesiology. 2020;132(1):180–204.
10. O'Neal JB, Shaw AD, Billings FT. Acute kidney injury following cardiac surgery: Current understanding and future directions. Crit Care [Internet]. 2016;20(1):1–9. Available from: http://dx.doi.org/10.1186/s13054-016-1352-z
11. Ali TZ, Khan I, Simpson W, Prescott G, Townend J, Smith W, et al. Incidence and outcomes in acute kidney injury: A comprehensive population-based study. J Am Soc Nephrol. 2007;18(4):1292–8.
12. Kheterpal S, Tremper KK, Heung M, Rosenberg AL, Englesbe M, Shanks AM, et al. Development and validation of an acute kidney injury risk index for patients undergoing general surgery: Results from a national data set. Anesthesiology. 2009;110(3):505–15.
13. Hu J, Chen R, Liu S, Yu X, Zou J, Ding X. Global Incidence and Outcomes of Adult Patients with Acute Kidney Injury after Cardiac Surgery: A Systematic Review and Meta-Analysis. J Cardiothorac Vasc Anesth [Internet]. 2016;30(1):82–9. Available from: http://dx.doi.org/10.1053/j.jvca.2015.06.017
14. Hansen MK, Gammelager H, Mikkelsen MM, Hjortdal VE, Layton JB, Johnsen SP, et al. Post-operative acute kidney injury and five-year risk of death, myocardial infarction, and stroke among elective cardiac surgical patients: A cohort study. Crit Care. 2013;17(6).
15. Chávez-Iñiguez JS, García-García G, Lombardi R. Epidemiología y desenlaces de la lesión renal aguda en latinoamérica. Gac Med Mex. 2018;154:S6–14.
16. Lombi F, Varela CF, Martinez R, Greloni G, Campolo Girard V, Rosa Diez G. Lesión renal aguda en Latinoamérica en la era del big data. Nefrología. 2017;37(5):461–4.

17. Cely JE, Mendoza EJ, Pérez LC, Mateus JM, Luque GA, Contreras JA, et al. Trabajos originales en Colombia de lesión renal aguda ¿Qué hay disponible a nivel nacional? Rev Repert Med y Cirugía. 2019;28(2):75–80.
18. Moreno Daza A, Insuasty MI, Londoño Trujillo D, D'Achiardi R, García Padilla P. Características clínicas de los pacientes de la unidad de cuidados intensivos del Hospital Universitario de San Ignacio con insuficiencia renal aguda y factores asociados con mortalidad. Acta Médica Colomb. 2019;36(4):168–72.
19. Vargas JG, Rodríguez MP, García PK, Ruiz Á. Predicción de aparición de injuria renal aguda después de cirugía cardiovascular en la unidad de cuidados intensivos del Hospital Universitario San Ignacio. Acta Médica Colomb. 2019;35(4):166–74.
20. Kellum JA, Romagnani P, Ashuntantang G, Ronco C, Zarbock A, Anders HJ. Acute kidney injury. Nat Rev Dis Prim [Internet]. 2021;7(1). Available from: http://dx.doi.org/10.1038/s41572-021-00284-z
21. Levey AS, James MT. Acute KidneyInjury. Ann Intern Med. 2017;167(9):ITC65–79.
22. Walther CP, Podoll AS, Finkel KW. Summary of clinical practice guidelines for acute kidney injury. Hosp Pract (1995). 2014;42(1):7–14.
23. Mercado MG, Smith DK, Guard EL. Acute kidney injury: Diagnosis and management. Am Fam Physician. 2019;100(11):687–94.
24. Neyra JA, Chawla LS. Acute Kidney Disease to Chronic Kidney Disease. Crit Care Clin [Internet]. 2021;37(2):453–74. Available from: https://doi.org/10.1016/j.ccc.2020.11.013
25. Jacob J, Dannenhoffer J, Rutter A. Acute Kidney Injury. Prim Care - Clin Off Pract. 2020;47(4):571–84.
26. CONSTANZO L. FISIOLOGIA 7MA EDICION. 2008. 282 p.
27. Simonetto DA, Gines P, Kamath PS. Hepatorenal syndrome: pathophysiology, diagnosis, and management. BMJ. 2020;370:m2687.
28. Ruiz-Del-Arbol L, Monescillo A, Arocena C, Valer P, Ginès P, Moreira V, et al. Circulatory function and hepatorenal syndrome in cirrhosis. Hepatology.

2005;42(2):439–47.

29. Kumar U, Wettersten N, Garimella PS. Cardiorenal Syndrome: Pathophysiology. Cardiol Clin [Internet]. 2019;37(3):251–65. Available from: https://doi.org/10.1016/j.ccl.2019.04.001
30. Kislitsina ON, Rich JD, Wilcox JE, Pham DT, Churyla A, Vorovich EB, et al. Shock – Classification and Pathophysiological Principles of Therapeutics. Curr Cardiol Rev. 2018;15(2):102–13.
31. Rn AF. Lesión renal aguda. 2018;
32. Capítulo ÍDEL, Clínica A. 28 - Fisiopatología de la lesión renal aguda [Internet]. Eleventh E. Brenner y Rector. El riÃ±Ã³n. Elsevier Espa8#241;a, S.L.U.; 2023. 906–939 p. Available from: http://dx.doi.org/10.1016/B978-84-9113-896-9/00028-1
33. Manrique-Caballero CL, Del Rio-Pertuz G, Gomez H. Sepsis-Associated Acute Kidney Injury. Crit Care Clin. 2021;37(2):279–301.
34. Kumar S, Bruce A. Molitori. Renal Endothelial Injury and Microvascular Dysfunction in Acute Kidney Injury. Physiol Behav. 2017;176(3):139–48.
35. Peerapornratana S, Manrique-Caballero CL, Gómez H, Kellum JA. Acute kidney injury from sepsis: current concepts, epidemiology, pathophysiology, prevention and treatment. Kidney Int [Internet]. 2019;96(5):1083–99. Available from: https://doi.org/10.1016/j.kint.2019.05.026
36. Gaut JP, Liapis H. Acute kidney injury pathology and pathophysiology: A retrospective review. Clin Kidney J. 2021;14(2):526–36.
37. Basile DP, Anderson MD, Sutton TA. Pathophysiology of acute kidney injury. Compr Physiol. 2012;2(2):1303–53.
38. Kodner CM, Kudrimoti A. Diagnosis and management of acute interstitial nephritis. Am Fam Physician. 2003;67(12):2527-2534+2539.
39. Belliere J, Meyer N, Mazieres J, Ollier S, Boulinguez S, Delas A, et al. Acute interstitial nephritis related to immune checkpoint inhibitors. Br J Cancer [Internet]. 2016;115(12):1457–61. Available from: http://dx.doi.org/10.1038/bjc.2016.358
40. Moledina DG, Perazella MA. PPIs and kidney disease: from AIN to CKD. J

Nephrol. 2016;29(5):611–6.

41. Haller H. Thrombotic microangiopathy and the kidneys. Nephrologe. 2019;14(2):100–7.
42. Yoon SY, Kim JS, Jeong KH, Kim SK. Acute Kidney Injury: Biomarker-Guided Diagnosis and Management. Med. 2022;58(3):1–11.
43. Albert C, Haase M, Albert A, Zapf A, Braun-Dullaeus RC, Haase-Fielitz A. Biomarker-Guided Risk Assessment for Acute Kidney Injury: Time for Clinical Implementation? Ann Lab Med. 2020;41(1):1–15.
44. Ostermann M, Zarbock A, Goldstein S, Kashani K, Macedo E, Murugan R, et al. Recommendations on Acute Kidney Injury Biomarkers From the Acute Disease Quality Initiative Consensus Conference: A Consensus Statement. JAMA Netw open. 2020;3(10):e2019209.
45. Ortega LM, Heung M. The use of cell cycle arrest biomarkers in the early detection of acute kidney injury. Is this the new renal troponin? Nefrologia. 2018;38(4):361–7.
46. William R. Zhang1 CRP. Biomarkers of Acute and Chronic Kidney Disease. Physiol Behav. 2017;176(3):139–48.
47. Ostermann M, Liu K, Kashani K. Fluid Management in Acute Kidney Injury. Chest [Internet]. 2019;156(3):594–603. Available from: https://doi.org/10.1016/j.chest.2019.04.004
48. Gumz ML, Rabinowitz L. Una visión integrada de la homeostasis del potasio. N Engl J Med. 2015;373(1):60–72.
49. Cases A, Escolar G. Diatesis hemorragica en la uremia. Nefrologia. 1998;18(4):270–82.
50. McMahon BA, Chawla LS. The furosemide stress test: current use and future potential. Ren Fail [Internet]. 2021;43(1):830–9. Available from: https://doi.org/10.1080/0886022X.2021.1906701
51. Novak JE, Ellison DH. Diuretics in States of Volume Overload: Core Curriculum 2022. Am J Kidney Dis [Internet]. 2022;80(2):264–76. Available from: https://doi.org/10.1053/j.ajkd.2021.09.029
52. Ostermann M. Críticos y Daño Renal Agudo Indicaciones y momento de

inicio de KRT. 2023;

53. García-tornel MJ, Cañas AC, Hernández TC, Manuel J, Ayala C, Romero JMC, et al. Cirugía cardiovascular. Definición, organización, actividad, estándares y recomendaciones. Cir Cardiovasc. 2012;19(1):15–38.
54. Jiménez Rivera JJ, Llanos Jorge C, López Gude MJ, Pérez Vela JL. Manejo perioperatorio en cirugía cardiovascular. Med Intensiva. 2021;45(3):175–83.
55. Doty, Donald B. MD. Setup for Cardiac surgery. Card Surg Oper Tech. 2021;16–37.
56. Holman WL, Timpa J, Kirklin JK. Origins and Evolution of Extracorporeal Circulation: JACC Historical Breakthroughs in Perspective. J Am Coll Cardiol. 2022;79(16):1606–22.
57. Rubio M. Circulación extracorpórea. Conceptos básicos. Rev Conarec [Internet]. 2014;30(125):146–50. Available from: http://adm.meducatium.com.ar/contenido/articulos/14901460150_1030/pdf/14901460150.pdf
58. Sniecinski RM, Levy JH. Anticoagulation management associated with extracorporeal circulation. Best Pract Res Clin Anaesthesiol [Internet]. 2015;29(2):189–202. Available from: http://dx.doi.org/10.1016/j.bpa.2015.03.005
59. Arzamendi D, Freixa X, Puig M. Mecanismo de acción de los fármacos antitrombóticos. 2006;
60. Royston D. Anticoagulant and antiplatelet therapy [Internet]. Second Edi. Pharmacology and Physiology for Anesthesia: Foundations and Clinical Application. Elsevier Inc.; 2018. 870–894 p. Available from: https://doi.org/10.1016/B978-0-323-48110-6.00045-4
61. Giavarina D, Carta M, Soffiati G, Fabbri A, Manfredi J, Gasparotto E. Monitoring high-dose heparin levels by ACT and HMT during extracorporeal circulation: Diagnostic accuracy of three compact monitors. Perfusion. 2002;17(1):23–6.
62. Toeg H, Rubens FD. 2. Técnicas de canulación para bypass cardiopulmonar [Internet]. Second Edi. Atlas de tÃ©cnicas quirÃºrgicas en cardiologÃ-a.

Elsevier Espa8#241;a, S.L.U.; 2023. 14–30 p. Available from: http://dx.doi.org/10.1016/B978-84-9113-469-5/00002-7

63. Graves K. Perfusion safety in Europe: Managing risks, learning from mistakes. Perfusion. 2005;20(4):209–15.
64. Groom RC, Fitzgerald D, Gutsche CCPJT, Ramakrishna H. Dispositicos de cicrculacion extracorporea, incluida La Oxigenación Por Membrana Extracorpórea. 2020;664–84.
65. Grocott HP, Stafford-smith FM, Mora-mangano FCT. Manejo de la circulación extracorpórea y protección de órganos. 2023;608–63.
66. Dobson GP, Faggian G, Onorati F, Vinten-Johansen J. Hyperkalemic cardioplegia for adult and pediatric surgery: end of an era? Front Physiol. 2013;4(August):1–28.
67. Bradić J, Andjić M, Novaković J, Jeremić N, Jakovljević V. Cardioplegia in Open Heart Surgery: Age Matters. J Clin Med. 2023;12(4).
68. Valenzuela C, Tamargo J, Delpon E, Perez O. Farmacos antiarritmicos. Ars Pharm. 1995;36(4):507–26.
69. Aurélio M, Oliveira B De, Fernandes De Godoy M, Marcolino Braile D, Marques De Lima-Oliveira AP. Polarizing cardioplegic solution: state of the art. Hear Surg Serv Cardiol Cardiovasc. 2005;20(1):69–74.
70. Ali JM, Miles LF, Abu-Omar Y, Galhardo C, Falter F. Global cardioplegia practices: Results from the global cardiopulmonary bypass survey. J Extra Corpor Technol. 2018;50(2):83–93.
71. Sunde K. Therapeutic hypothermia in cardiac arrest. Rev Esp Cardiol. 2013;66(5):346–9.
72. Krukenkamp IB. Cold and warm blood cardioplegia. Scand Cardiovasc J. 1993;27(S41):45–53.
73. Fan Y, Zhang AM, Xiao Y Bin, Weng YG, Hetzer R. Warm versus cold cardioplegia for heart surgery: a meta-analysis. Eur J Cardio-thoracic Surg. 2010;37(4):912–9.
74. Donald B. Doty MD JRDM. CORONARY ARTERY BYPASS GRFATING. Card surgey, Oper techinique. 2023;

75. Dehn T, Davies WR, Wallwork J, Weir I. Coronary artery bypass. Ann R Coll Surg Engl. 2006;88(2):99–102.
76. Lawton JS, Tamis-Holland JE, Bangalore S, Bates ER, Beckie TM, Bischoff JM, et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization: Executive Summary: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2022;145(3):E4–17.
77. Lindman BR, Bonow RO, Otto CM. PART VIII DISEASES OF THE HEART VALVES 72 Aortic Valve Stenosis [Internet]. Twelveth E. Braunwald's Heart Disease, 2 Vol Set. Elsevier Inc.; 2023. 1399–1418 p. Available from: https://doi.org/10.1016/B978-0-323-72219-3.00072-4
78. Otto CM, Nishimura RA, Bonow RO, Carabello BA, rwin JP, Gentile F, et al. 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Vol. 143, Circulation. 2021. 72–227 p.
79. Rosengart TK, Aberle CM, Ryan C. Acquired Heart Disease: Valvular [Internet]. Twenty Fir. Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice. Elsevier; 2023. 1711–1742 p. Available from: http://dx.doi.org/10.1016/B978-0-323-64062-6.00061-X
80. Donald B. Doty M.D. JRDMD. Aortic Valvel replacement. Card Surg Oper Tech. 2018;
81. Boccaccio G. MITRAL VALVE RECONSTRUCTION. Card Surg Oper Tech. 2019;88–95.
82. Schubert SA, Mehaffey JH, Charles EJ, Kron IL. Mitral Valve Repair: The French Correction Versus the American Correction. Surg Clin North Am. 2017;97(4):867–88.
83. James H. Mitral Valve Replacement. Cirugía cardíaca técnica Oper. 2021;366–71.
84. Isselbacher EM, Preventza O, Hamilton Black J, Augoustides JG, Beck AW, Bolen MA, et al. 2022 ACC/AHA Guideline for the Diagnosis and

Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. J Am Coll Cardiol. 2022;80(24):e223–393.

85. Galdó SN, Puerta RR. 120 - Control posquirúrgico en la cirugía vascular de aorta [Internet]. Second Edi. Tratado de medicina intensiva. Elsevier Espa8#241;a, S.L.U.; 2023. 885–893 p. Available from: http://dx.doi.org/10.1016/B978-84-9113-588-3/00120-3
86. Shemin RJ. Capítulo 14 - Procedimiento de Bentall [Internet]. Second Edi. Atlas de tÃ©cnicas quirÃºrgicas en cardiologÃ-a. Elsevier Espa8#241;a, S.L.U.; 2023. 215–224 p. Available from: http://dx.doi.org/10.1016/B978-84-9113-469-5/00014-3
87. Mao H, Katz N, Ariyanon W, Blanca-Martos L, Adýbelli Z, Giuliani A, et al. Cardiac surgery-associated acute kidney injury. Blood Purif. 2014;37(suppl 2):34–50.
88. Taylor KM. SIRS - The systemic inflammatory response syndrome after cardiac operations. Ann Thorac Surg. 1996;61(6):1607–8.
89. Baufreton C, Corbeau JJ, Pinaud F. Réponse inflammatoire et perturbations hématologiques en chirurgie cardiaque : vers une circulation extracorporelle plus physiologique. Ann Fr Anesth Reanim. 2006;25(5):510–20.
90. Zakeri R, Freemantle N, Barnett V, Lipkin GW, Bonser RS, Graham TR, et al. Relation between mild renal dysfunction and outcomes after coronary artery bypass grafting. Circulation. 2005;112(9 SUPPL.):270–5.
91. Gaffney AM, Sladen RN. Acute kidney injury in cardiac surgery. Curr Opin Anaesthesiol. 2015;28(1):50–9.
92. Kumar AB, Suneja M, Bayman EO, Weide GD, Tarasi M. Association between postoperative acute kidney injury and duration of cardiopulmonary bypass: A meta-analysis. J Cardiothorac Vasc Anesth [Internet]. 2012;26(1):64–9. Available from: http://dx.doi.org/10.1053/j.jvca.2011.07.007
93. Ruggieri VG, Bounader K, Verhoye JP, Onorati F, Rubino AS, Gatti G, et al. Prognostic Impact of Prolonged Cross-Clamp Time in Coronary Artery Bypass Grafting. Hear Lung Circ. 2018;27(12):1476–82.

94. Lau G, Wald R, Sladen R, Mazer CD. Acute Kidney Injury in Cardiac Surgery and Cardiac Intensive Care. Semin Cardiothorac Vasc Anesth. 2015;19(4):270–87.
95. Grayson AD, Khater M, Jackson M, Fox MA. Valvular heart operation is an independent risk factor for acute renal failure. Ann Thorac Surg. 2003;75(6):1829–35.
96. Karkouti K, Wijeysundera DN, Yau TM, Callum JL, Cheng DC, Crowther M, et al. Acute kidney injury after cardiac surgery. Focus on modifiable risk factors. Circulation. 2009;119(4):495–502.
97. Xu J, Jiang W, Fang Y, Teng J, Ding X. Management of cardiac surgery-associated acute kidney injury. Contrib Nephrol. 2016;187:131–42.
98. Ranucci M, de Benedetti D, Bianchini C, Castelvecchio S, Ballotta A, Frigiola A, et al. Effects of fenoldopam infusion in complex cardiac surgical operations: A prospective, randomized, double-blind, placebo-controlled study. Minerva Anestesiol. 2010;76(4):249–59.
99. Rovin BH, Adler SG, Barratt J, Bridoux F, Burdge KA, Chan TM, et al. Executive summary of the KDIGO 2021 Guideline for the Management of Glomerular Diseases. Kidney Int. 2021 Oct 1;100(4):753–79.
100. Tomlinson LA, Clase CM. Sex and the Incidence and Prevalence of Kidney Disease. Clin J Am Soc Nephrol [Internet]. 2019 Nov 7;14(11):1557–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31649072
101. Yuan S-M, Jing H. Cardiac surgery and hypertension: a dangerous association that must be well known. Rev Bras Cir Cardiovasc [Internet]. 2011;26(2):273–81. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21894419
102. Clough RA, Leavitt BJ, Morton JR, Plume SK, Hernandez F, Nugent W, et al. The effect of comorbid illness on mortality outcomes in cardiac surgery. Arch Surg [Internet]. 2002 Apr;137(4):428–32; discussion 432-3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/11926947
103. Yuan S-M. Acute Kidney Injury after Cardiac Surgery: Risk Factors and Novel Biomarkers. Brazilian J Cardiovasc Surg [Internet]. 2019 Jun 1;34(3):352–60. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31310475
104 Menger J, Edlinger-Stanger M, Dworschak M, Steinlechner B. Postoperative management of patients undergoing cardiac surgery in Austria : A national survey on current clinical practice in hemodynamic monitoring and

postoperative management. Wien Klin Wochenschr [Internet]. 2018 Dec;130(23–24):716–21. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30374775

105. Engelman DT, Ben Ali W, Williams JB, Perrault LP, Reddy VS, Arora RC, et al. Guidelines for Perioperative Care in Cardiac Surgery. JAMA Surg [Internet]. 2019 Aug 1;154(8):755. Available from: https://jamanetwork.com/journals/jamasurgery/fullarticle/2732511
106 Wang R, Zhang H, Zhu Y, Chen W, Chen X. The impact of diabetes mellitus on acute kidney injury after coronary artery bypass grafting. J Cardiothorac Surg [Internet]. 2020 Oct 1;15(1):289. Available from: http://www.ncbi.nlm.nih.gov/pubmed/33004056
107 Ostermann M, Kunst G, Baker E, Weerapolchai K, Lumlertgul N. Cardiac Surgery Associated AKI Prevention Strategies and Medical Treatment for CSA-AKI. J Clin Med [Internet]. 2021 Nov 14;10(22). Available from: http://www.ncbi.nlm.nih.gov/pubmed/34830567
108. Jang M-S, Nam J-S, Jo J-Y, Kang C-H, Ryu SA, Lee E-H, et al. The relationship of preoperative estimated glomerular filtration rate and outcomes after cardiovascular surgery in patients with normal serum creatinine: a retrospective cohort study. BMC Anesthesiol [Internet]. 2019 May 29;19(1):88. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31138135
109 Sansone F, Morgante A, Ceresa F, Salamone G, Patanè F. Prognostic Implications of Acute Renal Failure after Surgery for Type A Acute Aortic Dissection. Aorta (Stamford, Conn) [Internet]. 2015 Jun;3(3):91–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27069938
110. Torrati FG, Dantas RAS. Circulação extracorpórea e complicações no período pós-operatório imediato de cirurgias cardíacas. Acta Paul Enferm [Internet]. 2012;25(3):340–5. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-21002012000300004&lng=pt&tlng=pt
111. Vives M, Hernandez A, Parramon F, Estanyol N, Pardina B, Muñoz A, et al. Acute kidney injury after cardiac surgery: prevalence, impact and management challenges. Int J Nephrol Renovasc Dis [Internet]. 2019;12:153–66. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31303781
112. Anastasiadis K, Murkin J, Antonitsis P, Bauer A, Ranucci M, Gygax E, et al. Use of minimal invasive extracorporeal circulation in cardiac surgery: principles, definitions and potential benefits. A position paper from the Minimal invasive Extra-Corporeal Technologies international Society (MiECTiS). Interact Cardiovasc Thorac Surg [Internet]. 2016 May;22(5):647–62. Available from: http://www.ncbi.nlm.nih.gov/pubmed/26819269
113. Yuruk K, Bezemer R, Euser M, Milstein DMJ, de Geus HHR, Scholten EW, et al. The effects of conventional extracorporeal circulation versus miniaturized extracorporeal circulation on microcirculation during cardiopulmonary bypass-assisted coronary artery bypass graft surgery. Interact Cardiovasc Thorac Surg [Internet]. 2012 Sep;15(3):364–70. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22700685

114. Chaudery H, MacDonald N, Ahmad T, Chandra S, Tantri A, Sivasakthi V, et al. Acute Kidney Injury and Risk of Death After Elective Surgery: Prospective Analysis of Data From an International Cohort Study. Anesth Analg [Internet]. 2019 May;128(5):1022–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30418232
115. Train M, Blanloeil Y, Dixneuf B, Moutel MG, Dupon H, Michaud JL, et al. [Heart surgery with extracorporeal circulation in hemodialyzed patients with renal insufficiency]. Cah Anesthesiol [Internet]. 1984 Mar;32(3):219–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6335668
116. Ortega-Loubon C, Fernández-Molina M, Carrascal-Hinojal Y, Fulquet-Carreras E. Cardiac surgery-associated acute kidney injury. Ann Card Anaesth [Internet]. 2016;19(4):687–98. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27716701