Bölüm
15

POSTOPERATİF BÖBREK HASARI

Şule ARICAN

Dr. Öğrt.Üyesi, Necmettin Erbakan Ünv. Meram Tıp Fakültesi,
drsulearican@hotmail.com

► Tanımı;

Böbrek fonksiyon bozukluğu majör cerrahi sonrası artmış morbidite ve mortalite ile ilişkili sık görülen bir komplikasyondur. Akut böbrek hasarı (ABH) terimi, böbrek fonksiyonunun hızlı bir şekilde bozulmasını tanımlamak için kullanılır. Bu hızlı bozulma, üre ve kreatinin gibi plazma atık ürünlerinin birikmesine neden olur. ABH tanımı, serum kreatinin (sCr) ve idrar üretimindeki değişikliklere dayanmaktadır. Çoğu tanım böbrek fonksiyonunun belirteçleri olarak idrar çıkışı ve sCr kullanır, çünkü bunlar böbreklere özgüdür ve kolayca ölçülür. Serum kreatinin konsantrasyonları yetersiz böbrek fonksiyonunu yansıtır. Postoperatif ABH glomerüler filtrasyon hızında (GFR), ameliyatın 1. haftasında plazma atık ürünlerinin birikmesine yol açan ani bir düşüş olarak tanımlanır (Lewington & Cerda & Mehta, 2013; Bellomo & Kellum &Ronco, 2012; KDIGO, 2012, Ozrazgat-Baslanti & et al. 2016).

tır. Kesin olarak faydalı kanıtların bulunmaması ve vazodilatör tedavinin olası olumsuz etkileri göz önüne alındığında, ortak öneri ABH'yi önlemek veya tedavi etmek için kullanılmalarına karşıdır (KDIGO & 2012; Zacharias et al & 2013).

Renal replasman tedavisi

Hiperkalemi, hiperüremi, metabolik asidoz ve aşırı sıvı yüklenmesi böbrek replasmanının endikasyonlarıdır, ancak hangi değerlerde tedavi uygulaması gerektiği belirsizdir. Renal replasman tedavisinin ne zaman kesilmesi gerektiği de belirsizdir. Gözlemsel çalışmalar, idrar çıkışının yeterli böbrek fonksiyonunun makul bir işareti olduğunu göstermektedir.

Bir replasman tekniğinin diğerinden daha üstün olduğuna dair kanıt yoktur. Teknikler geniş olarak gruplandırılmıştır: sürekli tedaviler; aralıklı tedaviler; ve bunların bir karışımı. Sürekli tedavilerin hemodinamik olarak dengesiz hastaları riske atma olasılığı daha düşüktür. Uygulamada, kullanılan teknik aşinalık ve bulunabilirlik tarafından yönetilir (KDIGO & 2012; Ronco et al & 2015; Joannidis, Forni & 2011; Wu et al & 2008; Uchino et al & 2009).

Sonuç olarak; Perioperatif ABH ameliyatın ciddi bir komplikasyonudur. Hem kısa hem de uzun vadeli zararlı etkilerle ilişkilidir. Perioperatif ABH patofizyolojisi karmaşıktır, başta gelen nedenleri iskemi ve inflamasyonun birleşimini içerir. ABH'nın hızlı bir şekilde tanımlanması için yeni biyobelirteçler önerilmiştir, bunlar böbrek fonksiyonları bozulmadan erken müdahale uygulanmasına olanak sağlar. Hastaya ait faktörler, ilaçlar, ameliyatlar ve müdahaleler, kalp veya nakil ameliyatları ve kontrast boya kullanımı ABH riskini arttırır. Bütün risk faktörleri ameliyat öncesinde optimize edilmelidir. Ameliyat sırasında, hipotansiyonun kısa süreleri bile böbreği risk altına sokar. İdrar çıkışı postoperatif ABH'yi öngörmemektedir.

► KAYNAKÇA

Au V, Feit J, Barasch J, Sladen R. N, Wagener G. (2016) Urinary neutrophil gelatinase-associated lipocalin (NGAL) distinguishes sustained from transient acute kidney injury after general surgery. *Kidney Int. Rep. 1* (1) 3–9.

Aziz F, Azab A, Schaefer E, Reed AB. (2016) Endovascular repair of ruptured abdominal aortic aneurysm is associated with lower incidence of postoperative acute renal failure. *Ann Vasc Surg; 35* 147–155. doi: 10.1016/j.avsg.2016.01.021

Ball EF, Kara T. (2008) Epidemiology and outcome of acute kidney injury in New Zealand children. *J Paediatr Child Health; 44* (11) 642–646 doi: 10.1111/j.1440-1754.2008.01373

Bang J-Y, Lee JB, Yoon Y, Seo H-S, Song J-G, Hwang GS. (2014) Acute kidney injury after infrarenal abdominal aortic aneurysm surgery: a comparison of AKIN and RIFLE criteria for risk prediction. *Br J Anaesth; 113* (6) 993–1000 doi: 10.1093/bja/aeu320. Epub 2014 Sep 25.

Bayer O, Schwarzkopf D, Doenst T, Cook D, Kabisch B, Schelenz C, Bauer M, Riedemann NC, Sakr Y, Kohl M, Reinhart K, Hartog CS. (2013) Perioperative fluid therapy with tetrastarch and gelatin in cardiac surgery—a prospective sequential analysis. Crit *Care Med; 41* (11) 2532–2542 doi: 10.1097/CCM.0b013e3182978fb6.

Bellomo R, Kellum JA, Ronco C. (2012) Acute kidney injury. *Lancet; 380* (9843) 756–766 doi: 10.1016/S0140-6736(11)61454-2

Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P. (2004) Acute renal failure definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. *Crit Care; 8* (4) 204–212

Bellomo R,Wan L, May C. (2008) Vasoactive drugs and acute kidney injury. *Crit Care Med; 36* (4) 179–186 doi: 10.1097/CCM.0b013e318169167f.

Bentley ML, Corwin HL, Dasta J. (2010) Drug-induced acute kidney injury in the critically ill adult: recognition and prevention strategies. *Crit Care Med; 38* (3) 169–174

Bihorac A, Yavas S, Subbiah S, Hobson CE, Schold JD, Gabrielli A, Layon AJ, Segal MS. (2009) Long-term risk of mortality and acute kidney injury during hospitalization after major surgery. *Ann Surg; 249* (5) 851–858 doi: 10.1097/SLA.0b013e3181a40a0b.

Billings FT, Yu C, Byrne JG, Petracek MR, Pretorius M. (2014).Heme oxygenase-1 and acute kidney injury following cardiac surgery. *Cardiorenal Med. 4* (1) 12–21 doi: 10.1159/000357871.

Bishopric, N. H., Andreka P., Slepak T., Webster K.A. (2001) Molecular mechanisms of apoptosis in the cardiac myocyte. *Curr. Opin. Pharmacol. 1* (2) 141–150.

Biteker M, Dayan A, Tekkeşin Aİ, Can MM, Taycı İ, İlhan E, Şahin G. (2014) Incidence, risk factors, and outcomes of peri-operative acute kidney injury in noncardiac and nonvascular surgery. *American Journal of Surgery; 207* (1) 53–59. doi: 10.1016/j.amjsurg.2013.04.006.

Brienza N, Giglio MT, Marucci M, Fiore T. (2009) Does peri-operative hemodynamic optimization protect renal function in surgical patients? A meta-analytic study. *Critical Care Medicine;37* (6) 2079–2090. doi: 10.1097/CCM.0b013e3181a00a43.

Brown JR, Malenka DJ, DeVries JT, Robb JF, Jayne JE, Friedman BJ, Hettleman BD, Niles NW, Kaplan AV, Schoolwerth AC, Thompson CA. (2008) Transient and persistent renal dysfunction are predictors of survival after percutaneous coronary intervention: insights from the Dartmouth Dynamic Registry. *Catheter Cardiovasc Interv; 72* (3) 347–354 doi: 10.1002/ccd.21619.

Causey MW, Maykel JA, Hatch Q, Miller S, Steele SR. (2011) Identifying risk factors for renal failure and myocardial infarction following colorectal surgery. *J Surg Res.;170* (1) 32–37. doi: 10.1016/j.jss.2011.03.027.

Charlton JR, Portilla D, Okusa MD. (2014) A basic science view of acute kidney injury biomarkers. *Nephrol Dial Transplant; 29* (7) 1301–1311 doi: 10.1093/ndt/gft510.

Cheatham ML, Malbrain ML, Kirkpatrick A, Sugrue M, Parr M, De Waele J, Balogh Z, Leppäniemi A, Olvera C, Ivatury R, D'Amours S, Wendon J, Hillman K, Wilmer A. (2007) Results from the International Conference of Experts on Intra-abdominal Hypertension and Abdominal Compartment Syndrome. II. Recommendations. *Intensiv Care Med.;33* (6) 951–962.

Chowdhury AH, Cox EF, Francis ST, Lobo DN. (2012) A randomized, controlled, double-blind crossover study on the effects of 2-L infusions of 0.9% saline and Plasma-Lyte® on renal blood flow velocity and renal cortical tissue perfusion in healthy volunteers. *Ann Surg; 256* (1) 18–24 doi: 10.1097/SLA.0b013e318256be72.

Dalfino L, Tullo L, Donadio I, Malcangi V, Brienza N. (2008) Intra-abdominal hypertension and acute renal failure in critically ill patients. *Intensive Care Med; 34* (4) 707–713

De Backer D, Biston P, Devriendt J, Madl C, Chochrad D, Aldecoa C, Brasseur A, Defrance P, Gottignies P, Vincent JL; (2010) Comparison of dopamine and norepinephrine in the treatment of shock. *N Engl J Med; 362* (9) 779–789 doi: 10.1056/NEJMoa0907118.

Edelstein CL, Schrier RW. in Diseases of the Kidney and Urinary Tract 8th edn (ed. Schrier, R. W.) 930–961 (Lippincott Williams & Wilkins, 2007).

Endo A, Uchino S, Iwai K, Saito K, Sanui M, Takinami M, Uezono S. (2012) Intraoperative hyd-

roxyethyl starch 70/0.5 is not related to acute kidney injury in surgical patients: retrospective cohort study. *Anesth Analg; 115* (6) 1309–1314 doi: 10.1213/ANE.0b013e31826ba8d7.

Englberger L, Suri RM, Li Z, Casey ET, Daly RC, Dearani JA, Schaff HV. (2011) Clinical accuracy of RIFLE and Acute Kidney Injury Network (AKIN) criteria for acute kidney injury in patients undergoing cardiac surgery. *Crit Care; 15* (1) R16 doi: 10.1186/cc9960.

Ferguson, M. A Vaidya VS, Waikar SS, Collings FB, Sunderland KE, Gioules CJ, Bonventre JV. (2010)Urinary liver-type fatty acid-binding protein predicts adverse outcomes in acute kidney injury. *Kidney Int. 77* (8) 708–714. doi: 10.1038/ki.2009.422.

Friedrich JO, Adhikari N, Herridge MS, Beyene J. (2005) Meta-analysis: low-dose dopamine increases urine output but does not prevent renal dysfunction or death. *Ann Intern Med; 142* (7) 510–524

Fukazawa K, Lee HT. (2014) Volatile anesthetics and AKI: risks, mechanisms, and a potential therapeutic window. *J Am Soc Nephrol; 25* (5) 884–892 doi: 10.1681/ASN.2013111215.

Gillies MA, Habicher M, Jhanji S, Sander M, Mythen M, Hamilton M, Pearse RM. (2014) Incidence of postoperative death and acute kidney injury associated with i.v. 6% hydroxyethyl starch use: systematic review and meta-analysis. *Br J Anaesth; 112* (1) 25–34 doi: 10.1093/bja/aet303.

Golden D, Corbett J, Forni LG. (2016) Peri-operative renal dysfunction:prevention and management. *Anaesthesia.;71* (l1) 51–57.

Goren O, Matot I. (2015) Perioperative acute kidney injury. *Br J Anaesth;115* (2) 3–14. doi: 10.1093/bja/aev380.

Grams ME, Estrella MM, Coresh J, Brower RG, Liu KD (2011) Fluid balance, diuretic use, and mortality in acute kidney injury. *Clinicial Journal of the American Society of Nephrology; 6* (5)966–73. doi: 10.2215/CJN.08781010.

Hand WR, Whiteley JR, Epperson TI, Lauren Tam BS, Heather Crego RN, Bethany Wolf, Kenneth D Chavin, David J Taber, (2014) Hydroxyethyl starch and acute kidney injury in orthotopic liver transplantation: a single-center retrospective review. *Anesth Analg; 120* (3) 619–626 doi:10.1213/ANE.0000000000000374

Hartog CS, Natanson C, Sun J, Klein HG, Reinhart K. (2014) Concerns over use of hydroxyethyl starch solutions. *Br Med J; 349* (10) g5981 doi: 10.1136/bmj.g5981.

Heimbürger O, Stenvinkel P, Barany P. (2012) The enigma of decreased creatinine generation in acute kidney injury. *Nephrology Dialysis Transplantation; 27* (11) 3973–3974. doi: 10.1093/ndt/gfs459.

Hilmi IA, Damian D, Al-Khafaji A, Planinsic R, Boucek C, Sakai T, Chang CC , Kellum JA. (2015) Acute kidney injury following orthotopic liver transplantation: incidence, risk factors, and effects on patient and graft outcomes. *Br J Anaesth; 114* (6) 919–926 doi: 10.1093/bja/aeu556.

Hobson C, Ozrazgat-Baslanti T, Kuxhausen A, Thottakkara P, Efron PA, Moore FA, Moldawer LL, Segal MS, Bihorac A. (2015) Cost and mortality associated with postoperative acute kidney injury. *Ann Surg; 261* (6) 1207–1214. doi: 10.1097/SLA.0000000000000732.

Huddart S, Peden CJ, Swart M, McCormick B, Dickinson M, Mohammed MA, Quiney N (2015) Use of a pathway quality improvement care bundle to reduce mortality after emergency laparotomy. *British Journal of Surgery; 102* (1) 57–66. doi: 10.1002/bjs.9658.

Ishikawa S, Griesdale DE, Lohser J. (2012) Acute kidney injury after lung resection surgery: incidence and perioperative risk factors. *Anesth Analg; 114* (6) 1256–1262 doi: 10.1213/ANE.0b013e31824e2d20.

Jayaraman, R Sunder S, Sathi S, Gupta VK, Sharma N, Kanchi P, Gupta A, Daksh SK, Ram P, Mohamed A. (2014)Post cardiac surgery acute kidney injury: a woebegone status rejuvenated by the novel biomarkers. *Nephrourol. Mon. 6* (4) e19598. doi: 10.5812/numonthly.19598.

Jhaveri KD, Saratzis AN, Wanchoo R, Sarafidis PA. (2017) Endovascular aneurysm repair (EVAR) and transcatheter aortic valve replacement (TAVR)-associated acute kidney injury. *Kidney Int; 91* (6) 1312–1323. doi: 10.1016/j.kint.2016.11.030.

Joannidis M, Druml W, Forni LG, Groeneveld AB, Honore P, Oudemans-van Straaten HM, Ronco C, Schetz MR, Woittiez AJ (2010) Prevention of acute kidney injury and protection of re-

nal function in the intensive care unit: expert opinion of the working group for nephrology, ESICM. *Intensive Care Med; 36* (3) 392–411 doi: 10.1007/s00134-009-1678-y.

Joannidis M, Forni LG. (2011) Clinical review: timing of renal replacement therapy. *Critical Care; 15* (3) 223. doi: 10.1186/cc10109.

Joshi G, Cunningham A. (2013) Anesthesia for laparoscopic and robotic surgeries. In: Cullen B, Barash PB, Stoelting RK, Cahalan MK, Stock MC, Ortega R, editors. *Clinical anesthesia. Philadelphia: Lippincott Williams & Wilkins*;. p. 1257–73.

Karkouti K, Grocott HP, Hall R Jessen ME, Kruger C, Lerner AB, MacAdams C, Mazer CD, de Medicis É, Myles P, Ralley F, Rheault MR, Rochon A, Slaughter MS, Sternlicht A, Syed S, Waters T. (2014) Interrelationship of preoperative anemia, intraoperative anemia, and red blood cell transfusion as potentially modifiable risk factors for acute kidney injury in cardiac surgery: a historical multicentre cohort study. *Can J Anesth; 62* (4) 377–384 doi: 10.1007/s12630-014-0302-y.

Karkouti K. (2012)Transfusion and risk of acute kidney injury in cardiac surgery. *Br J Anaesth; 109* (1) 29–38 doi: 10.1093/bja/aes422.

Kateros K, Doulgerakis C, Galanakos SP, Sakellariou VI, Papadakis SA, Macheras GA. (2012) Analysis of kidney dysfunction in orthopaedic patients. *BMC Nephrol.;13*:101. doi: 10.1186/1471-2369-13-101.

Kheterpal S, Tremper KK, Heung M, Rosenberg AL, Englesbe M, Shanks AM, Campbell DA Jr. (2009) Development and validation of an acute kidney injury risk index for patients undergoing general surgery: results from a national data set. *Anesthesiology; 110* (3) 505–515 doi: 10.1097/ALN.0b013e3181979440.

Kidney Disease: Improving Global Outcomes (KDIGO) (2012) Acute Kidney Injury Work Group. KDIGO Clinical Practice Guideline for Acute Kidney Injury. *Kidney International; 2* 131–138.

Kim CS, Oak CY, Kim HY, Kang YU, Choi JS, Bae EH, Ma SK, Kweon SS, Kim SW. (2013) Incidence, predictive factors, and clinical outcomes of acute kidney injury after gastric surgery for gastric cancer. *PLoS One.;8* (12) e82289. doi: 10.1371/journal.pone.0082289.

Kim M, Brady JE, Li G. (2014) Variations in the risk of acute kidney injury across intraabdominal surgery procedures. *Anesth Analg; 119* (5) 1121–1132 doi: 10.1213/ANE.0000000000000425.

Kline J, Rachoin J-S. (2013) Acute kidney injury and chronic kidney disease: it's a two-way street. *Ren Fail; 35* (4) 452–455 doi: 10.3109/0886022X.2013.766572.

Koch A, Zacharowski P, Boehm O, Zacharowski K. (2009) Innate immunity, coagulation and surgery. *Front Biosci (Landmark Ed); 14* (1) 2970–2982.

Kokkoris S, Pipili C, Grapsa E, Kyprianou T, Nanas S. (2013) Novel biomarkers of acute kidney injury in the general adult ICU: a review. *Ren Fail; 35* (4) 579–591 doi: 10.3109/0886022X.2013.773835.

Kothmann E, Batterham AM, Owen SJ, Turley A. J, Cheesman M, Parry A, Danjoux G. (2010) Effect of shortterm exercise training on aerobic fitness in patients with abdominal aortic aneurysms: a pilot study. *British Journal of Anaesthesia; 103* (4) 505–510. doi:10.1093/bja/aep205

Krawczeski CD, Goldstein SL, Woo JG, Wang Y, Piyaphanee N, Ma Q, Bennett M, Devarajan P. (2011)Temporal relationship and predictive value of urinary acute kidney injury biomarkers after pediatric cardiopulmonary bypass. *J. Am. Coll. Cardiol. 58* (22) 2301–2309. doi: 10.1016/j.jacc.2011.08.017.

Kulkarni S, Jayachandran M, Davies A, Mamoun W, Al-Akraa M. (2005) Non-dilated obstructed pelvicalyceal system. *International Journal of Clinical Practice; 59* (8) 992–994.

Lassnigg A, Schmidlin D, Mouhieddine M, Bachmann LM, Druml W, Bauer P, Hiesmayr M. (2004) Minimal changes of serum creatinine predict prognosis in patients after cardiothoracic surgery: a prospective cohort study. *Journal of the American Society of Nephrology; 15* (6) 1597–1605.

Lee HT, Ota-Setlik A, Fu Y, Nasr SH, Emala CW. (2004) Differential protective effects of volatile anesthetics against renal ischemia reperfusion injury in vivo. *Anesthesiology; 101* (6) 1313–

1324
Legrand M, Pirracchio R, Rosa A, Petersen ML, Van der Laan M, Fabiani JN, Fernandez-gerlinger MP, Podglajen I, Safran D, Cholley B, Mainardi JL. (2013) Incidence, risk factors and prediction of post-operative acute kidney injury following cardiac surgery for active infective endocarditis: an observational study. *Crit Care; 17* (5) R220 doi: 10.1186/cc13041.
Lewington AJP, Cerdá J, Mehta RL. (2013) Raising awareness of acute kidney injury: a global perspective of a silent killer. *Kidney Int; 84* (3) 457–467 doi: 10.1038/ki.2013.153.
Malbrain ML, Chiumello D, Pelosi P, Bihari D, Innes R, Ranieri VM, Del Turco M, Wilmer A, Brienza N, Malcangi V, Cohen J, Japiassu A, De Keulenaer BL, Daelemans R, Jacquet L, Laterre PF, Frank G, de Souza P, Cesana B, Gattinoni L. (2005) Incidence and prognosis of intraabdominal hypertension in a mixed population of critically ill patients:a multiple-center epidemiological study. *Crit Care Med.;33* (2) 315–322.
Mammen C, Al Abbas A, Skippen P, Nadel H, Levine D, Collet JP, Matsell DG. (2012) Long-term risk of CKD in children surviving episodes of acute kidney injury in the intensive care unit: a prospective cohort study. *Am J Kidney Dis; 59* (4) 523–530 doi: 10.1053/j.ajkd.2011.10.048
Masoomi H, Carmichael JC, Dolich M, Mills S, Ketana N, Pigazzi A, Stamos MJ. (2012) Predictive factors of acute renal failure in colon and rectal surgery. *Am Surg.;78* (10) 1019–1023.
Matot I, Dery E, Bulgov Y, Cohen B, Paz J, Nesher N. (2013) Fluid management during video-assisted thoracoscopic surgery for lung resection: a randomized, controlled trial of effects on urinary output and postoperative renal function. *J Thorac Cardiovasc Surg; 146* (2) 461–466 doi: 10.1016/j.jtcvs.2013.02.015.
Matot I, Paskaleva R, Eid L, Cohen K, Khalaileh A, Elazary R, Keidar A. (2012) Effect of the volume of fluids administered on intraoperative oliguria in laparoscopic bariatric surgery: a randomized controlled trial. *Arch Surg; 147* (3) 228–234 doi: 10.1001/archsurg.2011.308.
Meersch M, Schmidt C, Van Aken H, Martens S, Rossaint J, Singbartl K, Görlich D, Kellum JA, Zarbock A. (2014) Urinary TIMP-2 and IGFBP7 as early biomarkers of acute kidney injury and renal recovery following cardiac surgery. *PLoS ONE; 9* (3) e93460 doi: 10.1371/journal.pone.0093460.
Mehta RL, Kellum JA, Shah SV, Molitoris BA, Ronco C, Warnock DG, Levin A (2007) Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. *Crit Care.;11* (2) R31.
Moghadamyeghaneh Z, Phelan MJ, Carmichael JC, Mills SD, Pigazzi A, Nguyen NT, Stamos MJ. (2014) Preoperative dehydration increases risk of postoperative acute renal failure in colon and rectal surgery. *J Gastrointest Surg;18* (12) 2178–85. doi: 10.1007/s11605-014-2661-7.
Myburgh JA, Finfer S, Bellomo R, Billot L, Cass A, Gattas D, Glass P, Lipman J, Liu B, McArthur C, McGuinness S, Rajbhandari D, Taylor CB, Webb SA. (2012) Hydroxyethyl starch or saline for fluid resuscitation in intensive care. *N Engl J Med; 367* (20) 1901–1911 doi: 10.1056/NEJMoa1209759.
Nadeem A, Salahuddin N, El Hazmi A, Joseph M, Bohlega B, Sallam H, Sheikh Y, Broering D. (2014) Chloride-liberal fluids are associated with acute kidney injury after liver transplantation. *Crit Care; 18* (6) 625 doi: 10.1186/s13054-014-0625-7.
Nguyen NT, Perez RV, Fleming N, Rivers R, Wolfe BM. (2002) Effect of prolonged pneumoperitoneum on intraoperative urine output during laparoscopic gastric bypass. *J Am Coll Surg; 195* (4) 476–483
O'Connor ME, Kirwan CJ, Pearse RM, Prowle JR. (2016) Incidence and associations of acute kidney injury after major abdominal surgery. *Intensive Care Med; 42* (4) 521–530. doi: 10.1007/s00134-015-4157-7.
Obata Y, Kamijo-Ikemori A, Ichikawa D, Sugaya T, Kimura K, Shibagaki Y, Tateda T. (2016) Clinical usefulness of urinary liver-type fatty-acid-binding protein as a perioperative marker of acute kidney injury in patients undergoing endovascular or open-abdominal aortic aneurysm repair. *J Anesth; 30* (1) 89–99. doi: 10.1007/s00540-015-2095-8.
O'Neal JB, Shaw AD, Billings FT. (2016) Acute kidney injury following cardiac surgery: current

understanding and future directions. *Crit. Care 20* (1) 187. doi: 10.1186/s13054-016-1352-z.

Ozrazgat-Baslanti T, Thottakkara P, Huber M, Berg K, Gravenstein N, Tighe P, Lipori G, Segal MS, Hobson C, Bihorac A. (2016) Acute and chronic kidney disease and cardiovascular mortality after major surgery. *Ann Surg; 264* (6) 987–996.

Payen D, de Pont AC, Sakr Y, Spies C, Reinhart K, Vincent JL; Sepsis Occurrence in Acutely Ill Patients (SOAP) Investigators (2008). A positive fluid balance is associated with a worse outcome in patients with acute renal failure. *Critical Care; 12* (3)R74. doi: 10.1186/cc6916.

Pearse R, Dawson D, Fawcett J, Rhodes A, Grounds RM, Bennett ED. (2005) Early goal-directed therapy after major surgery reduces complications and duration of hospital stay. A randomised, controlled trial. *Critical Care; 9* (6) 687–693.

Peco-Antic, A Ivanišević I, Vulićević I, Kotur-Stevuljević J, Ilić S, Ivanišević J, Miljković M, Kocev N. (2013)Biomarkers of acute kidney injury in pediatric cardiac surgery. *Clin. Biochem. 46* (13-14) 1244–1251. doi: 10.1016/j.clinbiochem.2013.07.008.

Perner A, Prowle J, JoannidisM, Young P, Hjortrup PB, Pettilä V. (2017) Fluid management in acute kidney injury. *Intensive Care Med; 43* (6) 807–815. doi: 10.1007/s00134-017-4817-x.

Prowle JR, Kam EP, Ahmad T, Smith NC, Protopapa K, Pearse RM. (2016) Preoperative renal dysfunction and mortality after non-cardiac surgery. *Br J Surg; 103* (10) 1316–1325. doi: 10.1002/bjs.10186.

Prowle JR, Liu YL, Licari E, Bagshaw SM, Egi M, Haase M, Haase-Fielitz A, Kellum JA, Cruz D, Ronco C, Tsutsui K, Uchino S, Bellomo R. (2011) Oliguria as predictive biomarker of acute kidney injury in critically ill patients. *Critical Care; 15* (4) R172. doi: 10.1186/cc10318.

Rodgers A, Walker N, Schug S, McKee A, Kehlet H, van Zundert A, Sage D, Futter M, Saville G, Clark T, MacMahon S. (2000) Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. *Br Med J; 321* (7275), 1493.

Ronco C, Ricci Z, De Backer D, Kellum JA, Taccone FS, Joannidis M, Pickkers P, Cantaluppi V, Turani F, Saudan P, Bellomo R, Joannes-Boyau O, Antonelli M, Payen D, Prowle JR, Vincent JL. (2015) Renal replacement therapy in acute kidney injury: controversy and consensus. *Critical Care; 19* (6) 146. doi: 10.1186/s13054-015-0850-8.

Schetz M, Gunst J, Van den Berghe G. (2014) The impact of using estimated GFR versus creatinine clearance on the evaluation of recovery from acute kidney injury in the ICU. *Intensive Care Medicine; 40* (11) 1709–1717. doi: 10.1007/s00134-014-3487-1

Serpa Neto A, Veelo DP, Peireira VG, de Assunção MS, Manetta JA, Espósito DC, Schultz MJ. (2014) Fluid resuscitation with hydroxyethyl starches in patients with sepsis is associated with an increased incidence of acute kidney injury and use of renal replacement therapy: a systematic review andmeta-analysis of the literature. *J CritCare; 29* (1) 185.e1–7 doi: 10.1016/j.jcrc.2013.09.031.

Severs D, Hoorn EJ, Rookmaaker MB. (2015) A critical appraisal of intravenous fluids: from the physiological basis to clinical evidence. *Nephrology Dialysis Transplantation; 30* (2) 178–187. doi: 10.1093/ndt/gfu005.

Shaw AD, Bagshaw SM, Goldstein SL, Scherer LA, Duan M, Schermer CR, Kellum JA. (2012) Major complications, mortality, and resource utilization after open abdominal surgery: 0.9% saline compared to Plasma-Lyte. *Annals of Surgery; 255* (5) 821–829. doi: 10.1097/SLA.0b013e31825074f5.

Sindhvananda W, Phisaiphun K, Prapongsena P. (2013) No renal protection from volatile-anesthetic preconditioning in open heart surgery. *J Anesth; 27* (1) 48–55 doi: 10.1007/s00540-012-1461-z.

Solomon R, Dauerman HL. (2010) Contrast-induced acute kidney injury. *Circulation; 122* (23) 2451–2455 doi: 10.1161/CIRCULATIONAHA.110.953851.

Stoner JD, Clanton TL, Aune SE, Angelos MG. (2007) O2 delivery and redox state are determinants of compartment-specific reactive O2 species in myocardial reperfusion. *Am. J. Physiol. Heart Circ. Physiol. 292* (1) 109–116.

Suneja M, Kumar AB. (2014) Obesity and perioperative acute kidney injury: a focused review. *J Crit Care; 29* (4) 694.e1–6 doi: 10.1016/j.jcrc.2014.02.021.

Symons JM. (2014) Moving beyond supportive care current status of specific therapies in pediatric acute kidney injury. *Pediatr Nephrol; 29* (2) 173–181 doi: 10.1007/s00467-013-2425-8.

Tagawa M, Ogata A, Hamano T. (2015) Pre- and/or intra-operative prescription of diuretics, but not renin-angiotensin-system inhibitors, is significantly associated with acute kidney injury after non-cardiac surgery: a retrospective cohort study. *PLoS ONE; 10* (7) e0132507 doi: 10.1371/journal.pone.0132507

Tomozawa A, Ishikawa S, Shiota N, Cholvisudhi P, Makita K. (2015) Perioperative risk factors for acute kidney injury after liver resection surgery: an historical cohort study. *Can J Anaesth.;62* (7) 753–761. doi: 10.1007/s12630-015-0397-9

Uchino S, Bellomo R, Morimatsu H, Morgera S, Schetz M, Tan I, Bouman C, Macedo E, Gibney N, Tolwani A, Straaten HO, Ronco C, Kellum JA. (2009) Discontinuation of continuous renal replacement therapy: a post hoc analysis of a prospective multicenter observational study. *Critical Care Medicine; 37* (9) 2576–2582 doi: 10.1097/CCM.0b013e3181a38241.

Varrier M, Ostermann M. (2014) Novel risk factors for acute kidney injury. *Curr Opin Nephrol Hypertens; 23* (6) 560–569 doi: 10.1097/MNH.0000000000000061.

Vercaemst, L. (2008).Hemolysis in cardiac surgery patients undergoing cardiopulmonary bypass: a review in search of a treatment algorithm.*J. Extra Corpor. Technol. 40* (4) 257–267

Vives M, Wijeysundera D, Marczin N, Monedero P, Rao V. (2014) Cardiac surgery-associated acute kidney injury. *Interact Cardiovasc Thorac Surg; 18* (5) 637–645 doi: 10.1093/icvts/ivu014.

Wald R, Waikar SS, Liangos O, Pereira BJ, Chertow GM, Jaber BL. (2006) Acute renal failure after endovascular vs open repair of abdominal aortic aneurysm. *J Vasc Surg; 43* (3) 460–466

Walsh M, Devereaux PJ, Garg AX, Kurz A, Turan A, Rodseth RN, Cywinski J, Thabane L, Sessler DI. (2013) Relationship between intraoperative mean arterial pressure and clinical outcomes after noncardiac surgery: toward an empirical definition of hypotension. *Anesthesiology; 119* (3) 507–515. doi: 10.1097/ALN.0b013e3182a10e26.

Wei C, Li L, Kim IK, Sun, P. (2014)NF-κB mediated miR-21 regulation in cardiomyocytes apoptosis under oxidative stress. *Free Radic. Res. 48* (3) 282–291. doi: 10.3109/10715762.2013.865839.

Wilson FP, Sheehan JM, Mariani LH, Berns JS. (2012) Creatinine generation is reduced in patients requiring continuous venovenous hemodialysis and independently predicts mortality. *Nephrology Dialysis Transplantation; 27* (11) 4088–4094. doi: 10.1093/ndt/gfr809

Wu VC, Ko WJ, Chang HW, Chen YW, Lin YF, Shiao CC, Chen YM, Chen YS, Tsai PR, Hu FC, Wang JY, Lin YH, Wu KD; (2008) Risk factors of early redialysis after weaning from postoperative acute renal replacement therapy. *Intensive Care Medicine; 34* (1) 101–108.

Yang B, Xu J, Xu F, Zou Z, Ye C, Mei C, Mao Z. (2014) Intravascular administration of mannitol for acute kidney injury prevention: a systematic review and meta-analysis. *PLoS ONE; 9* (1) e85029 doi: 10.1371/journal.pone.0085029.

Yunos NM, Bellomo R, Glassford N, Sutcliffe H, Lam Q, Bailey M. (2015) Chloride-liberal vs. chloride-restrictive intravenous fluid administration and acute kidney injury: an extended analysis. *Intensive Care Medicine; 41* (2) 257–264. doi: 10.1007/s00134-014-3593-0.

Yunos NM, Bellomo R, Hegarty C, Story D, Ho L, Bailey M. (2012) Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults. *JAMA; 308* (15) 1566–1572 doi: 10.1001/jama.2012.13356.

Zacharias M, Mugawar M, Herbison GP, Walker RJ, Hovhannisyan K, Sivalingam P, Conlon NP. (2013) Interventions for protecting renal function in the perioperative period. *Cochrane Database Syst Rev; 9* (11) CD003590 doi: 10.1002/14651858.CD003590.pub4.

Zarychanski R, Abou-Setta AM, Turgeon AF, Houston BL, McIntyre L, Marshall JC, Fergusson DA. (2013) Association of hydroxyethyl starch administration with mortality and acute kidney injury in critically ill patients requiring volume resuscitation: a systematic review and meta-analysis. *JAMA; 309* (7) 678–688 doi: 10.1001/jama.2013.430.