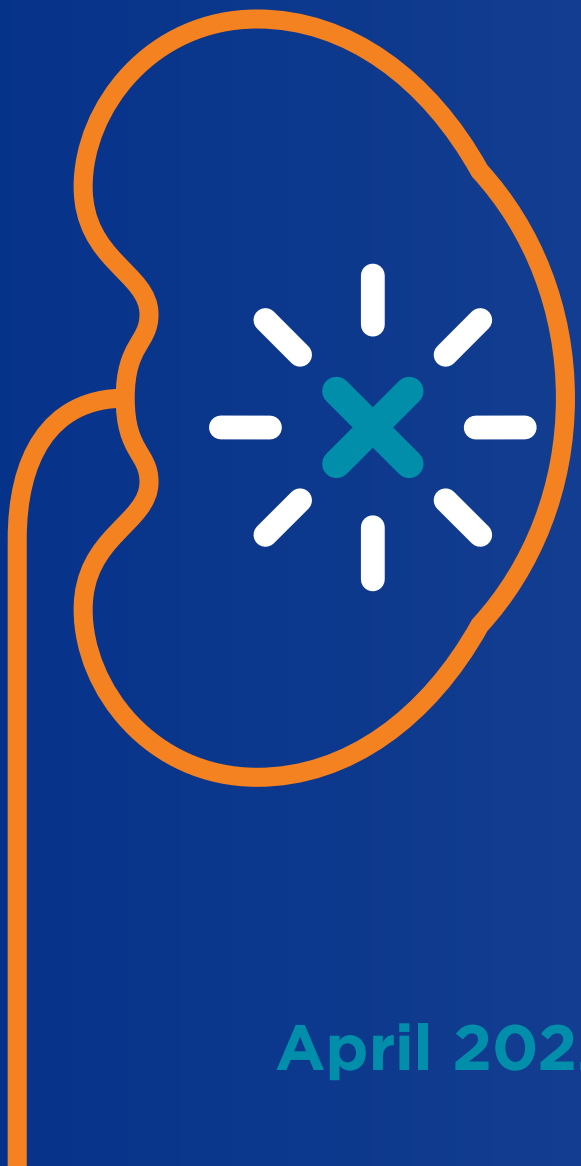
KHI KIDNEY HEALTH INITIATIVE

Biomarkers Reported to be Useful in Acute Kidney Injury



Prepared by
NEXIGHT GROUP

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Biomarkers Reported to be Useful in AKI

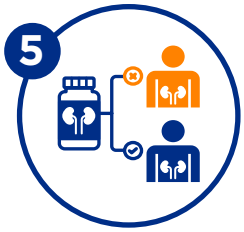
The below table provides an overview of potential biomarkers, including what they can be used to measure and a summary of relevant studies. Each biomarker may have value for one or more of the following use cases:

Diagnose and monitor kidney injury at an early stage
(Diagnostic, Safety, Monitoring)

Predict which patients are more susceptible to developing acute kidney injury (AKI) in response to a therapeutic or procedure
(Predictive, Susceptibility/Risk)

Identify AKI patients who are likely to progress to chronic kidney disease (CKD) and/or end-stage kidney disease (ESKD)
(Susceptibility/Risk, Prognostic)

Measure response to a therapeutic intervention for AKI
(Pharmacodynamic/ Response)



Predict which patients will have a positive response to an intervention to prevent or treat AKI
(Predictive)

The U.S. Food and Drug Administration (FDA) also offers a full list of qualified biomarkers.

For historical examples of how early biomarkers have evolved into validated endpoints that can serve as the basis for approval or licensure, see the FDA Table of Surrogate Endpoints.

Note: The **Relevant References** are not intended to be comprehensive. Please check PubMed for additional references.

α1-microglobulin (A1M)

Urinary Biomarker

Used for

- Detecting proximal renal tubule dysfunction and injury
- Determining kidney's ability to withstand injury; elevated levels suggest decreased proximal tubular re-absorptive capacity

Relevant References

- Coca, Steven G. "Kidney Injury Biomarkers with Clinical Utility: Has Godot Finally Arrived?" *American Journal of Nephrology* 50, no. 5 (2019): 357–60. https://doi.org/10.1159/000502899.
- Devarajan, Prasad, Catherine D. Krawczeski, Mai T. Nguyen, Thelma Kathman, Zhu Wang, and Chirag R. Parikh. "Proteomic Identification of Early Biomarkers of Acute Kidney Injury After Cardiac Surgery in Children." *American Journal of Kidney Diseases* 56, no. 4 (2010): 632–42. https://doi.org/10.1053/j.ajkd.2010.04.014.
- Jotwani, Vasantha, Rebecca Scherzer, Alison Abraham, Michelle M. Estrella, Michael Bennett, Mardge H. Cohen, Marek Nowicki, et al. "Association of Urineα1-Microglobulin with Kidney Function Decline and Mortality in HIV-Infected Women." *Clinical Journal of the American Society of Nephrology* 10, no. 1 (2014): 63–73. https://doi.org/10.2215/cjn.03220314.
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- O'Seaghdha, Conall M., Shih-Jen Hwang, Martin G. Larson, James B. Meigs, Ramachandran S. Vasan, and Caroline S. Fox. "Analysis of a Urinary Biomarker Panel for Incident Kidney Disease and Clinical Outcomes." *Journal of the American Society of Nephrology* 24, no. 11 (November 2013): 1880–88. https://doi.org/10.1681/ASN.2013010019.
- Terzi, I., V. Papaioannou, N. Papanas, C. Dragoumanis, A. Petala, and V. Theodorou. "Alpha1-Microglobulin as an Early Biomarker of Sepsis-Associated Acute Kidney Injury: a Prospective Cohort Study." *Hippokratia* 18, no. 3 (2014). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4309149/.

β2-microglobulin (B2M)

Blood Biomarker Urinary Biomarker

Used for

- Detecting proximal renal tubule dysfunction and injury
- Determining kidney's ability to withstand injury

Relevant References

- Barton, Kevin T, Aadil Kakajiwala, Dennis J Dietzen, Charles W. Goss, Hongjie Gu, and Vikas R. Dharnidharka. "Using the Newer Kidney Disease: Improving Global Outcomes Criteria, Beta-2-Microglobulin Levels Associate with Severity of Acute Kidney Injury." *Clinical Kidney Journal* 11, no. 6 (2018): 797–802. https://doi.org/10.1093/ckj/sfy056.
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- Da, Yi, K. Akalya, Tanusya Murali, Anantharaman Vathsala, Chuen-Seng Tan, Sanmay Low, Hui-Ning Lim, et al. "Serial Quantification of Urinary Protein Biomarkers to Predict Drug-Induced Acute Kidney Injury." *Current Drug Metabolism* 20, no. 8 (2019): 656–64. https://doi.org/10.2174/1389200220666190711114504.
- Tarrant, J. "Emerging Translatable Safety Biomarkers." *Comprehensive Medicinal Chemistry* III, 2017, 255–84. https://doi.org/10.1016/b978-0-12-409547-2.12387-x.
- Wang, Rui, Hongtao Hu, Shuang Hu, Hong He, and Hua Shui. "β2-Microglobulin Is an Independent Indicator of Acute Kidney Injury and Outcomes in Patients with Intracerebral Hemorrhage." *Medicine* 99, no. 8 (2020). https://doi.org/10.1097/md.0000000000019212.
- Zhang, William R., and Chirag R. Parikh. "Biomarkers of Acute and Chronic Kidney Disease." *Annual Review of Physiology* 81, no. 1 (2019): 309–33. https://doi.org/10.1146/annurev-physiol-020518-114605.

α-glutathione S-transferase (GST)

Urinary Biomarker

Used for

- Detecting proximal tubule injury

Relevant References

- Mcmahon, Blaithin A., Jay L. Koyner, and Patrick T. Murray. "Urinary Glutathione S-Transferases in the Pathogenesis and Diagnostic Evaluation of Acute Kidney Injury Following Cardiac Surgery: a Critical Review." *Current Opinion in Critical Care* 16, no. 6 (2010): 550–55. https://doi.org/10.1097/mcc.0b013e32833fdd9a.
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π- glutathione S-transferase (GST)

Urinary Biomarker

Used for

- Detecting distal tubule injury

Relevant References

- Mcmahon, Blaithin A., Jay L. Koyner, and Patrick T. Murray. "Urinary Glutathione S-Transferases in the Pathogenesis and Diagnostic Evaluation of Acute Kidney Injury Following Cardiac Surgery: a Critical Review." *Current Opinion in Critical Care* 16, no. 6 (2010): 550–55. https://doi.org/10.1097/mcc.0b013e32833fdd9a.
- Shu, Kai-Hsiang, Chih-Hsien Wang, Che-Hsiung Wu, Tao-Min Huang, Pei-Chen Wu, Chien-Heng Lai, Li-Jung Tseng, Pi-Ru Tsai, Rory Connolly, and Vin-Cent Wu. "Urinary π-Glutathione S-Transferase Predicts Advanced Acute Kidney Injury Following Cardiovascular Surgery." *Scientific Reports* 6, no. 1 (2016). https://doi.org/10.1038/srep26335.
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Angiopoietin 1 and 2 (Ang-1 and Ang-2)

Blood Biomarker

Used for

- Identifying the existence or higher risk of AKI, particularly sepsis-induced AKI

Relevant References

- Jongman, Rianne M., Jan Van Klarenbosch, Grietje Molema, Jan G. Zijlstra, Adrianus J. De Vries, and Matijs Van Meurs. "Angiopoietin/Tie2 Dysbalance Is Associated with Acute Kidney Injury after Cardiac Surgery Assisted by Cardiopulmonary Bypass." *Plos One* 10, no. 8 (2015). https://doi.org/10.1371/journal.pone.0136205.
- Robinson-Cohen, Cassianne, Ronit Katz, Brenda L. Price, Susanna Harju-Baker, Carmen Mikacenic, Jonathan Himmelfarb, W. Conrad Liles, and Mark M. Wurfel. "Association of Markers of Endothelial Dysregulation Ang1 and Ang2 with Acute Kidney Injury in Critically Ill Patients." *Critical Care* 20, no. 1 (2016). https://doi.org/10.1186/s13054-016-1385-3.
- Woolf, Adrian S., Luigi Gnudi, and David A. Long. "Roles of Angiopoietins in Kidney Development and Disease: Figure 1." *Journal of the American Society of Nephrology* 20, no. 2 (2008): 239–44. https://doi.org/10.1681/asn.2008020243.

Brain natriuretic peptide (BNP) and N-terminal pro b-type natriuretic peptide (NT-proBNP)

Blood Biomarker

Used for

- Early prediction of AKI

Relevant References

- Fiorentino, Marco, Fadi A. Tohme, Raghavan Murugan, and John A. Kellum. "Plasma Biomarkers in Predicting Renal Recovery from Acute Kidney Injury in Critically Ill Patients." *Blood Purification* 48, no. 3 (2019): 253–61. https://doi.org/10.1159/000500423.
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Chemokine ligand 14 (CCL14)

Urinary Biomarker

Used for

- Predicting persistent stage-3 AKI

Relevant References

- Hoste, Eric, Azra Bihorac, Ali Al-Khafaji, Luis M. Ortega, Marlies Ostermann, Michael Haase, Kai Zacharowski, et al. "Identification and Validation of Biomarkers of Persistent Acute Kidney Injury: the RUBY Study." *Intensive Care Medicine* 46, no. 5 (2020): 943–53. https://doi.org/10.1007/s00134-019-05919-0.

Cysteine-rich protein (Cyr61)

Urinary Biomarker

Used for

- Detecting glomerular kidney injury

Relevant References

- Lai, Chun-Fu, Shuei-Liong Lin, Wen-Chih Chiang, Yung-Ming Chen, Vin-Cent Wu, Guang-Huar Young, Wen-Jo Ko, Min-Liang Kuo, Tun-Jun Tsai, and Kwan-Dun Wu. "Blockade of Cysteine-Rich Protein 61 Attenuates Renal Inflammation and Fibrosis after Ischemic Kidney Injury." *American Journal of Physiology-Renal Physiology* 307, no. 5 (2014).
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- Vaidya, V.S., J.V. Bonventre, and M.A. Ferguson. "Biomarkers of Acute Kidney Injury." *Comprehensive Toxicology*, 2010, 197–211. https://doi.org/10.1016/b978-0-08-046884-6.00806-x.

Dickkopf-3 (DKK3)

Urinary Biomarker

Used for

- Detection of the pre-injury phase of kidney injury and renal tubular stress (when measured preoperatively)

Relevant References

- "Dickkopf-Related Protein 3 (DKK3) Predicts AKI." EurekAlert! American Association for the Advancement of Science (AAAS), 2019. ERA-EDTA. https://www.eurekalert.org/pub_releases/2019-06/e-dp3061419.php.
- Oh, Dong-Jin. "A Long Journey for Acute Kidney Injury Biomarkers." *Renal Failure* 42, no. 1 (2020): 154–65. https://doi.org/10.1080/0886022x.2020.1721300.
- Schunk, Stefan J., Alexander Zarbock, Melanie Meersch, Mira Küllmar, John A. Kellum, David Schmit, Martina Wagner, et al. "Association between Urinary Dickkopf-3, Acute Kidney Injury, and Subsequent Loss of Kidney Function in Patients Undergoing Cardiac Surgery: an Observational Cohort Study." *The Lancet* 394, no. 10197 (2019): 488–96. https://doi.org/10.1016/s0140-6736(19)30769-x.

Epidermal growth factor (EGF)

Urinary Biomarker

Used for

- Predicting renal injury

Relevant References

- Defreitas, Marissa J., Wacharee Seeherunvong, Chryso P. Katsoufis, Satish Ramachandrarao, Shahnaz Duara, Salih Yasin, Gaston Zilleruelo, Maria M. Rodriguez, and Carolyn L. Abitbol. "Longitudinal Patterns of Urine Biomarkers in Infants across Gestational Ages." *Pediatric Nephrology* 31, no. 7 (2016): 1179–88. https://doi.org/10.1007/s00467-016-3327-3.
- Hanna, Mina, Patrick D. Brophy, Peter J. Giannone, Mandar S. Joshi, John A. Bauer, and Satish Ramachandrarao. "Early Urinary Biomarkers of Acute Kidney Injury in Preterm Infants." *Pediatric Research* 80, no. 2 (2016): 218–23. https://doi.org/10.1038/pr.2016.70.

Fetuin A

Blood Biomarker Urinary Biomarker

Used for

- Detecting structural renal injury

Relevant References

- Ragab, Seham M., and Eman A. Badr. "Evaluation of Serum and Urine Fetuin-A Levels in Children with Acute Lymphoblastic Leukemia during and after High-Dose Methotrexate Therapy: Relation to Toxicity." *Hematology* 21, no. 2 (2015): 78–91. https://doi.org/10.1179/1607845415y.0000000042.
- Zhou, H., T. Pisitkun, A. Aponte, P.S.T. Yuen, J.D. Hoffert, H. Yasuda, X. Hu, et al. "Exosomal Fetuin-A Identified by Proteomics: A Novel Urinary Biomarker for Detecting Acute Kidney Injury." *Kidney International* 70, no. 10 (2006): 1847–57. https://doi.org/10.1038/sj.ki.5001874.

Fluorescent GFR tracer agent measured via transdermal monitoring (Medibeacon)

Blood Biomarker

Used for

- Measuring uptake of fluorescent tracer processed by the kidney with the intent of real-time GFR monitoring

Relevant References

- McMahon, B. A., & Rosner, M. H. (2020). GFR measurement and chemotherapy dosing in patients with kidney disease and cancer. Kidney360, 1(2), 141–150. https://doi.org/10.34067/kid.0000952019.
- Medibeacon, accessed July 8, 2020. https://www.medibeacon.com/.
- Shieh, J.-J., Rochelle Riley, I., & Dorshow, R. B. (2018). Clinical analysis and quantitation of MB-102, a novel fluorescence tracer agent, in human plasma. Analytical Methods, 10(20), 2376–2383. https://doi.org/10.1039/c8ay00576a.

Hepcidin

Blood Biomarker Urinary Biomarker

Used for

- Detecting iron trafficking

Relevant References

- Choi, Nora, Claudio Rigatto, Michael Zappitelli, Ang Gao, Simon Christie, Brett Hiebert, Rakesh C. Arora, and Julie Ho. "Urinary Hepcidin-25 Is Elevated in Patients That Avoid Acute Kidney Injury Following Cardiac Surgery." *Canadian Journal of Kidney Health and Disease* 5 (2018): 205435811774422. https://doi.org/10.1177/2054358117744224.
- Goyal, Kamal Kumar, Abhijeet Saha, Puneet Kaur Sahi, Manpreet Kaur, Nand Kishore Dubey, Parul Goyal, and Ashish Dutt Upadhayay. "Hepcidin and Proinflammatory Markers in Children with Chronic Kidney Disease: A Case-Control Study." *Clinical Nephrology* 89, no. 5 (2018): 363–70. https://doi.org/10.5414/cn109132.

H-FABP

Blood Biomarker

Used for

- Risk stratification of AKI and mortality after cardiac surgery

Relevant References

- Kavsak, Peter A., Richard Whitlock, Heather Thiessen-Philbrook, and Chirag R. Parikh. "Perioperative Heart-Type Fatty Acid Binding Protein Concentration Cutoffs for the Identification of Severe Acute Kidney Injury in Patients Undergoing Cardiac Surgery." *Clinical Chemistry and Laboratory Medicine (CCLM)* 57, no. 2 (2018). https://doi.org/10.1515/cclm-2018-0547.
- Schaub, Jennifer A., Amit X. Garg, Steven G. Coca, Jeffrey M. Testani, Michael G. Shlipak, John Eikelboom, Peter Kavsak, et al. "Perioperative Heart-Type Fatty Acid Binding Protein Is Associated with Acute Kidney Injury after Cardiac Surgery." *Kidney International* 88, no. 3 (2015): 576–83. https://doi.org/10.1038/ki.2015.104.

Interleukin-18 (IL-18)

Urinary Biomarker

Used for

- Detecting tubular inflammation
- Detecting proximal tubular injury

Relevant References

- Koyner, Jay L., Amit X. Garg, Steven G. Coca, Kyaw Sint, Heather Thiessen-Philbrook, Uptal D. Patel, Michael G. Shlipak, and Chirag R. Parikh. "Biomarkers Predict Progression of Acute Kidney Injury after Cardiac Surgery." *Journal of the American Society of Nephrology* 23, no. 5 (2012): 905–14. https://doi.org/10.1681/asn.2011090907.
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- Liu, Xiaoqin, Yi Guan, Sheng Xu, Qingzhao Li, Yuanbo Sun, Ruijie Han, and Chunyang Jiang. "Early Predictors of Acute Kidney Injury: A Narrative Review." *Kidney and Blood Pressure Research* 41, no. 5 (2016): 680–700. https://doi.org/10.1159/000447937.
- Parikh, Chirag R., Edward Abraham, Marek Ancukiewicz, and Charles L. Edelstein. "Urine IL-18 Is an Early Diagnostic Marker for Acute Kidney Injury and Predicts Mortality in the Intensive Care Unit." *Journal of the American Society of Nephrology* 16, no. 10 (2005): 3046–52. https://doi.org/10.1681/asn.2005030236.

Kidney Safety Composite Measure Biomarker panel

Urinary Biomarker

- Kidney Injury Molecule-1 (KIM-1)
- Clusterin (CLU)
- Cystatin-C (CysC)
- N-Acetyl-beta-D-Glucosaminidase (NAG)
- Neutrophil Gelatinase-Associated Lipocalin (NGAL)
- Osteopontin (OPN)

Used for

- Detecting injury in the proximal tubule (urine KIM-1, CysC, NAG), distal tubule (urine NGAL, OPN), or both (urine CLU)

Relevant References

- "FNIH Biomarkers Consortium and Critical Path Institute Achieve the First Ever Qualification of a Clinical Safety Biomarker by the U.S. Food and Drug Administration." Critical Path Institute, 2018. Accessed July 30, 2020. https://c-path.org/fnih-biomarkers-consortium-and-critical-path-institute-achieve-the-first-ever-qualification-of-a-clinical-safety-biomarker-by-the-u-s-food-and-drug-administration/.

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- Foundation for the National Institutes of Health, and Critical Path Institute. *User's Guide: Kidney Safety Composite Measure Biomarker for Use in Clinical Development.* Critical Path Institute. Accessed 2020. https://c-path.org/wp-content/uploads/2019/05/ksp-compositecou-userguide-v1.1_20190515.pdf.
    - This publication provides background and references for characteristics and performance of each of these markers both individually as well as in the aggregate

KIM-1:

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- Han, W. K., Bailly, V., Abichandani, R., Thadhani, R., & Bonventre, J. V. (2002). Kidney injury molecule-1 (KIM-1): A novel biomarker for human renal proximal tubule injury. *Kidney International*, 62(1), 237–244. https://doi.org/10.1046/j.1523-1755.2002.00433.x.
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CLU:

- Guo, J., Guan, Q., Liu, X., Wang, H., Gleave, M. E., Nguan, C. Y., & Du, C. (2016). Relationship of clusterin with renal inflammation and fibrosis after the recovery phase of ischemia-reperfusion injury. *BMC Nephrology*, 17(1). https://doi.org/10.1186/s12882-016-0348-x.
- Pais, G. M., Avedissian, S. N., O'Donnell, J. N., Rhodes, N. J., Lodise, T. P., Prozialeck, W. C., Lamar, P. C., Cluff, C., Gulati, A., Fitzgerald, J. C., Downes, K. J., Zuppa, A. F., & Scheetz, M. H. (2019). Comparative performance of urinary biomarkers for vancomycin-induced kidney injury according to timeline of injury. *Antimicrobial Agents and Chemotherapy*, 63(7). https://doi.org/10.1128/aac.00079-19.
- Vinken, P., Starckx, S., Barale-Thomas, E., Looszova, A., Sonee, M., Goeminne, N., Versmissen, L., Buyens, K., & Lampo, A. (2012). Tissue kim-1 and urinary clusterin as early indicators of cisplatin-induced acute kidney injury in rats. *Toxicologic Pathology*, 40(7), 1049–1062. https://doi.org/10.1177/0192623312444765.

CysC:

- Kar, S., Paglialunga, S., & Islam, R. (2018). Cystatin C is a more reliable biomarker for determining eGFR to support drug development studies. *The Journal of Clinical Pharmacology*, 58(10), 1239–1247. https://doi.org/10.1002/jcph.1132.
- Onopiuk, A., Tokarzewicz, A., & Gorodkiewicz, E. (2015). Cystatin C: a kidney function biomarker. *Advances in Clinical Chemistry*, 57–69. https://doi.org/10.1016/bs.acc.2014.11.007.
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NAG:

- Jiang, C., Qi, C., Sun, K., Xia, L., Xue, W., & Huang, Y. (2012). Diagnostic value of N-acetyl-β-D-glucosaminidase for the early prediction of acute kidney injury after percutaneous nephrolithotripsy. *Experimental and Therapeutic Medicine*, 5(1), 197–200. https://doi.org/10.3892/etm.2012.737.
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Kidney Safety Composite Measure Biomarker panel

Urinary Biomarker

Relevant References, continued

NGAL:

- Devarajan, P. (2010). Neutrophil gelatinase-associated lipocalin: A promising biomarker for Human Acute Kidney Injury. *Biomarkers in Medicine*, 4(2), 265–280. https://doi.org/10.2217/bmm.10.12.
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Osteopontin (OPN)

- Kaleta, B. (2018). The role of Osteopontin in kidney diseases. *Inflammation Research*, 68(2), 93–102. https://doi.org/10.1007/s00011-018-1200-5.
- Pais, G. M., Avedissian, S. N., O'Donnell, J. N., Rhodes, N. J., Lodise, T. P., Prozialeck, W. C., Lamar, P. C., Cluff, C., Gulati, A., Fitzgerald, J. C., Downes, K. J., Zuppa, A. F., & Scheetz, M. H. (2019). Comparative performance of urinary biomarkers for vancomycin-induced kidney injury according to timeline of injury. *Antimicrobial Agents and Chemotherapy*, 63(7). https://doi.org/10.1128/aac.00079-19.

Liver-type fatty acid-binding protein (L-FABP)

Urinary Biomarker

Used for

- Detecting proximal tubular injury

Relevant References

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Microalbumin

Urinary Biomarker

Used for

- Detecting functional injury
- Detecting glomerular injury

Relevant References

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Monocyte chemoattractant protein 1 (MCP-1)

Urinary Biomarker

Used for

- Detecting kidney inflammation
- Detecting proximal tubular injury

Relevant References

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NephroCheck test panel (Astute Medical)

Urinary Biomarker

- Tissue inhibitor of metalloproteinases 2 (TIMP 2)
- Insulin-like growth factor-binding protein 7 (IGFBP-7)

Used for

- Detecting tubular cell injury
- Detecting gap 1 cell cycle arrest

Relevant References

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Netrin-1 (Ntn1)

Urinary Biomarker

Used for

- Detecting distal tubule injury

Relevant References

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Renal Papillary Antigen-1 (RPA-1)

Urinary Biomarker

Used for

- Detecting drug-induced collecting duct injury

Relevant References

- Woodcock, Janet. Biomarker Qualification Decision Letter to Syril D. Pettit, Washington, DC 20005, September 22, 2010. https://www.fda.gov/media/82521/download.

Retinol binding protein (RBP)

Urinary Biomarker

Used for

- Detecting tubular injury

Relevant References

- Tolkoff-Rubin, N. E., Rubin, R. H., & Bonventre, J. V. (1988). Noninvasive Renal Diagnostic Studies. *Clinics in Laboratory Medicine*, 8(3), 507–526. https://doi.org/10.1016/s0272-2712(18)30671-1.
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Sodium (UNa)

Urinary Biomarker

Used for

- Detection of structural kidney injury
- Detection of decreased tubular function

Relevant References

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Sodium/hydrogen exchanger isoform (NHE3)

Urinary Biomarker

Used for

- Detection of tubular injury

Relevant References

- Cheyron, Damien Du, Cédric Daubin, Josiane Poggioli, Michel Ramakers, Pascal Houillier, Pierre Charbonneau, and Michel Paillard. "Urinary Measurement of Na+/H+ Exchanger Isoform 3 (NHE3) Protein as New Marker of Tubule Injury in Critically Ill Patients with ARF." *American Journal of Kidney Diseases* 42, no. 3 (2003): 497–506. https://doi.org/10.1016/s0272-6386(03)00744-3.

Soluble Urokinase-type Plasminogen Activator Receptor (suPAR)

Blood Biomarker

Used for

- Identifying the activation of inflammatory and immune systems in response to a renal disease

Relevant References

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Total Protein

Urinary Biomarker

Used for

- Detecting glomerular or tubular injury
- Predicting patient outcomes

Relevant References

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Trefoil factor 3 (TFF3)

Urinary Biomarker

Used for

- Detecting proximal tubular injury
- Detecting ongoing kidney repair

Relevant References

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Tumor Necrosis Factor alpha (TNF-α)

Blood Biomarker | Urinary Biomarker

Used for

- Predicting AKI, AKI outcomes, and progression

Relevant References

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Tumor necrosis factor receptor 1 (TNFR1)

Blood Biomarker

Used for

- Predicting AKI and AKI severity

Relevant References

- Huang, P., Z. Zhu, S. Shen, L. Su, M.M. Wurfel, J.D. Christie, N. Meyer, C.S. Calfee, M.. Matthay, and D.C. Christiani. "Serum Tumor Necrosis Factor Receptor 1 Is Associated with Acute Kidney Injury in Acute Respiratory Distress Syndrome Patients." B23. *Critical Care: Step Across This Line - Microbiome, Genetics, And Other Biomarkers In Acute Critical Illness*, 2019. https://doi.org/10.1164/ajrccm-conference.2019.199.1_meetingabstracts.a2716.
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Tumor necrosis factor receptor 2 (TNFR2)

Blood Biomarker

Used for

- Predicting AKI progression
- Detection of ischemic reperfusion injury

Relevant References

- Holditch, Sara J., Carolyn N. Brown, Andrew M. Lombardi, Khoa N. Nguyen, and Charles L. Edelstein. "Recent Advances in Models, Mechanisms, Biomarkers, and Interventions in Cisplatin-Induced Acute Kidney Injury." *International Journal of Molecular Sciences* 20, no. 12 (2019): 3011. https://doi.org/10.3390/ijms20123011.
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Uromodulin (uMOD)

Urinary Biomarker

Used for

- Detecting Loop of Henle injury

Relevant References

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Visible fluorescent injectate measured via blood draw (VFI) (FAST Biomedical)

Blood Biomarker

Used for

- Measuring uptake of fluorescent tracer processed by the kidney with the intent of real-time GFR monitoring

Relevant References

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YKL 40

Urinary Biomarker

Used for

- Detecting tubular damage
- Detecting kidney repair

Relevant References

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* The relevant references are not intended to be comprehensive. Please check PubMed for additional references.

Biomarkers Reported to be Useful in Acute Kidney Injury

Prepared by
NEXIGHT GROUP