Biomarkers Reported to be Useful in Acute Kidney Injury
Acknowledgements

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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:

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

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

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

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

5. **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.
**β2-microglobulin (B2M)**

**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**

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

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**α1-microglobulin (A1M)**

**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**

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**β2-microglobulin (B2M)**

**Used for**
- Detecting proximal renal tubule dysfunction and injury
- Determining kidney’s ability to withstand injury

**Relevant References**
### α-glutathione S-transferase (GST)

**Used for**
- Detecting proximal tubule injury

**Relevant References**

### π- glutathione S-transferase (GST)

**Used for**
- Detecting distal tubule injury

**Relevant References**

### Angiopoietin 1 and 2 (Ang-1 and Ang-2)

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

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

Used for
• Early prediction of AKI

Relevant References

Chemokine ligand 14 (CCL14)

Used for
• Predicting persistent stage-3 AKI

Relevant References

Cysteine-rich protein (Cyr61)

Used for
• Detecting glomerular kidney injury

Relevant References

Dickkopf-3 (DKK3)

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

Relevant References
Epidermal growth factor (EGF)

**Used for**
- Predicting renal injury

**Relevant References**

Fetuin A

**Used for**
- Detecting structural renal injury

**Relevant References**

Fluorescent GFR tracer agent measured via transdermal monitoring (Medibeacon)

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

**Relevant References**

Hepcidin

**Used for**
- Detecting iron trafficking

**Relevant References**
**Kidney Safety Composite Measure Biomarker panel**

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**Kidney Injury Molecule-1 (KIM-1)**

- Risk stratification of AKI and mortality after cardiac surgery

**Clusterin (CLU)**

**Cystatin-C (CysC)**

**N-Acetyl-beta-D-Glucosaminidase (NAG)**

**Neutrophil Gelatinase-Associated Lipocalin (NGAL)**

**Osteopontin (OPN)**

**Interleukin-18 (IL-18)**

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**H-FABP**

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Kidney Safety Composite Measure Biomarker panel

Relevant References, continued


- 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:**


**CLU:**


**CysC:**


**NAG:**


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

**Used for**
- Detecting proximal tubular injury

**Relevant References**

Osteopontin (OPN)

**Relevant References**

NGAL:

**Relevant References**

Osteopontin (OPN)

**Relevant References**
NephroCheck test panel (Astute Medical)

**Used for**
- Detecting tubular cell injury
- Detecting gap 1 cell cycle arrest

**Relevant References**

Microalbumin

**Used for**
- Detecting functional injury
- Detecting glomerular injury

**Relevant References**

Monocyte chemoattractant protein 1 (MCP-1)

**Used for**
- Detecting kidney inflammation
- Detecting proximal tubular injury

**Relevant References**
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| Used for         | • Detection of structural kidney injury  

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<th>Urinary Biomarker</th>
<th>Sodium/hydrogen exchanger isoform (NHE3)</th>
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**Soluble Urokinase-type Plasminogen Activator Receptor (suPAR)**

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

**Relevant References**

**Total Protein**

**Used for**
- Detecting glomerular or tubular injury
- Predicting patient outcomes

**Relevant References**

**Trefoil factor 3 (TFF3)**

**Used for**
- Detecting proximal tubular injury
- Detecting ongoing kidney repair

**Relevant References**
### Tumor Necrosis Factor alpha (TNF-α)

**Used for**
- Predicting AKI, AKI outcomes, and progression

**Relevant References**

### Tumor Necrosis Factor receptor 1 (TNFR1)

**Used for**
- Predicting AKI and AKI severity

**Relevant References**

### Tumor Necrosis Factor receptor 2 (TNFR2)

**Used for**
- Predicting AKI progression
- Detection of ischemic reperfusion injury

**Relevant References**
- Lee, Hyung Ho, Young In Cho, Sook Young Kim, Young Eun Yoon, Kyung Sup Kim, Sung Joon Hong, and Woong Kyu Han. “TNF-α-Induced Inflammation Stimulates Apolipoprotein-A4 via Activation of TNFR2 and NF-KB Signaling in Kidney Tubular Cells.” Scientific Reports 7, no. 1 (2017). [https://doi.org/10.1038/s41598-017-08785-2](https://doi.org/10.1038/s41598-017-08785-2).
**Uromodulin (uMOD)**

**Used for**

- Detecting Loop of Henle injury

**Relevant References**


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**Visible fluorescent injectate measured via blood draw (VFI)**

**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**


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