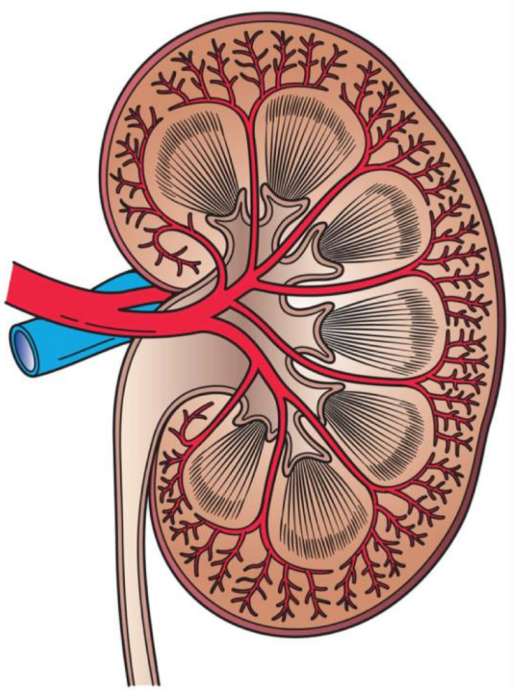
Avoiding Kidney Injury:

Overview,
Pathophysiology, &
Definitions



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Objectives

- Discuss incidence and impact of Acute Kidney Injury & Chronic Kidney Disease in surgical patients
- Review the pathophysiology related to AKI and CKD
- Identify definitions & stages of kidney disease
- Share registry definitions of kidney injury or failure & review ASPIRE AKI 01 measure
- For other recommendations to avoid AKI, reference additional toolkit components:
  - Avoiding Kidney Injury - Recommendations for Adult Surgical Patients
  - Avoiding Kidney Injury - Pediatrics
  - Avoiding Kidney Injury - Obstetrics
  - Avoiding Kidney Injury - Cardiac Surgery

AKI Incidence

13.3 million
Patients per year develop AKI worldwide [1]

1.7 million
Deaths per year worldwide attributed to AKI [1]

7-13%
Surgical patients suffer with AKI [2]

70%
mortality rate for patients with sepsis and AKI [3]

9%
Non-cardiac inpatient surgery patients develop AKI [4]

25%
Of trauma patients develop AKI [5]

52-56%
Of patients admitted to ICU after surgery [6]

Impact of AKI

- AKI can be an early indicator of multi-organ dysfunction with significant effects on mortality [7-9]
- Effects of AKI can last years and lead to development of chronic kidney disease or ESRD, even for patients whose creatinine improves at the time of discharge [2,5,10-11]

Cost of care for surgical patients: **$26,700** [38]

Cost of care for surgical patients **with AKI: $42,600** [38]

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AKI Impact

- In industrialized countries, acute kidney injury (all cause)...
  - Claims 300,000 lives annually
  - Contributes to 300,000 new CKD cases annually
  - Results in 170,000 end stage kidney disease diagnoses [12]
- In the United States alone, AKI costs an estimated $10 billion annually [13]
- Compared to postoperative patients without AKI, patients with AKI are associated with:

LOS increased from 8.6 to 15.8 days [37]

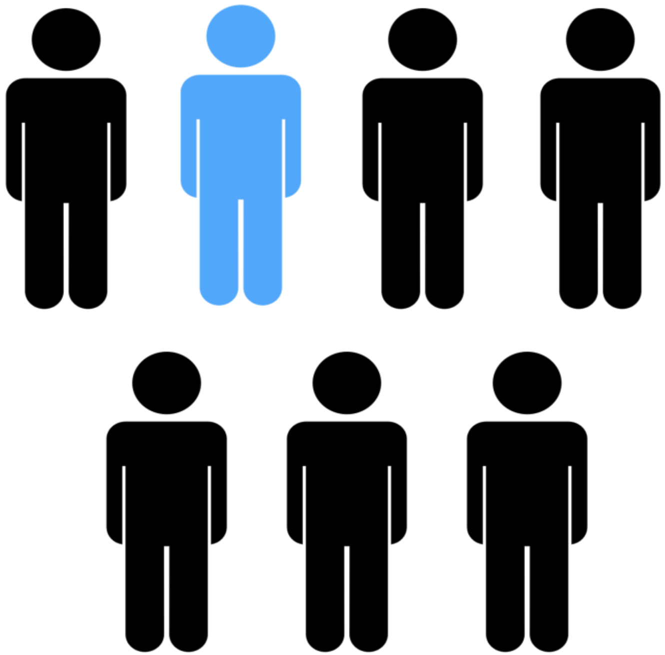
Mortality increased from 8% to 19% [37]

30 day readmission 13% vs 21% [37]

1yr ESRD .94% vs .05% [37]

CKD Incidence

- → Estimated global prevalence 11-13% [14]
- → Over 1 in 7 adults in the United States have CKD [15]
- → 90% do not know that they have CKD [15]
- → 9th Leading cause of death in the US [16]



CKD Impact

- 14.5% of Medicare patients age 65 and older have CKD [17]
- Medicare spent $120 billion on ESRD and CKD in 2019 (⅓ of all Medicare Fee for Service spending) [17]

Yearly Medicare spending per beneficiary with non-ESRD CKD is over $23,500, nearly double than for average Medicare beneficiary [17]

Pathophysiology of Kidney Disease

Kidney Disease Overview - Conditions that affect structure and function of the kidneys [18]

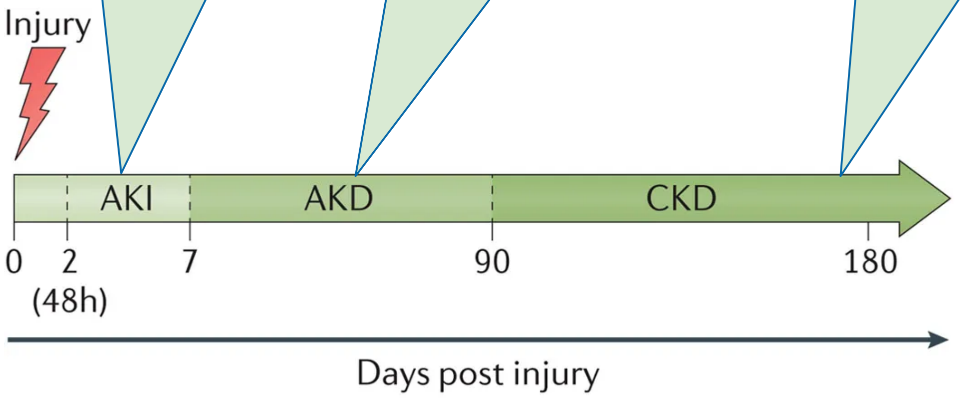
- Acute Kidney Injury
- Acute Kidney Disease
- Chronic Kidney Disease
- End Stage Renal Disease

Conditions can be categorized by length of time

Acute Kidney Injury
An abrupt decline in kidney function occurring over a period of 7 days or less [19]

Acute Kidney Disease
When acute kidney injury persists > 7 days [20]

Chronic Kidney Disease
Abnormalities in kidney structure or function that persist beyond 90 days [19]



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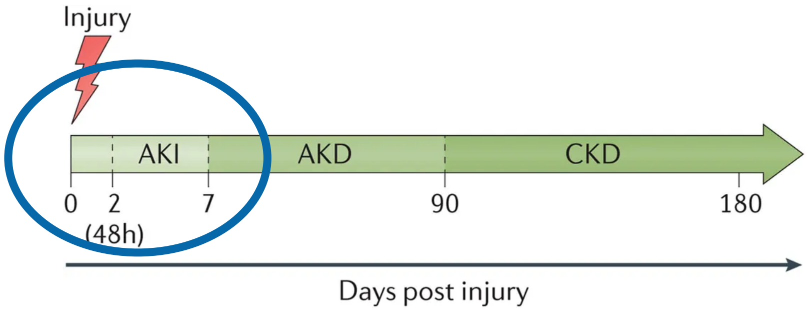
Acute Kidney Injury: General Definition

Acute Kidney Injury

An abrupt decline in kidney function occurring over a period of 7 days or less [19]

Several AKI Classification Systems Exist:[18]

a. **RIFLE** - Risk, Injury, Failure, Loss, End Stage - 2004
b. **AKIN** - Acute Kidney Injury Network - 2007
c. **KDIGO** - Kidney Disease Improving Global Outcomes- 2012



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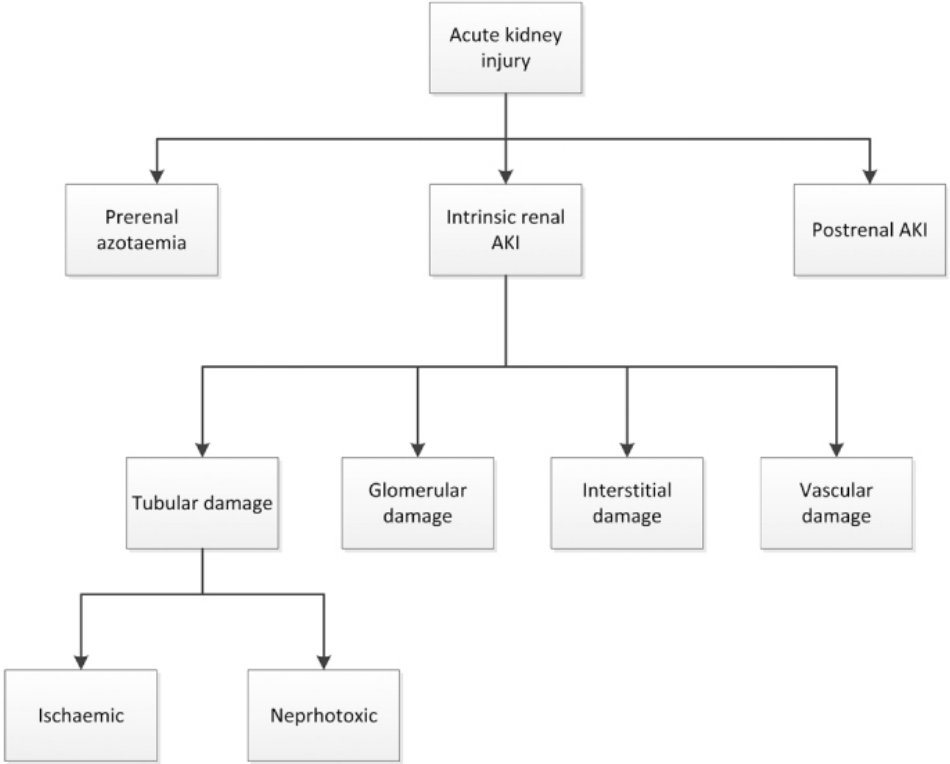
*See slides 6-12 for classification system criteria & slide 21 for biomarker explanation.

AKI Pathophysiology



- Historically, cause of disease was divided into prerenal, renal (intrinsic), and post renal [18]
- This approach does not account for multifactorial causes [18]

Image Source: Makris 2016

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Etiology: Prerenal

25% of cardiac output goes to the kidneys [7]

Renal hypoperfusion leads to decreased GFR as an adaptive response. Water, sodium, and urea retained to conserve volume [21]

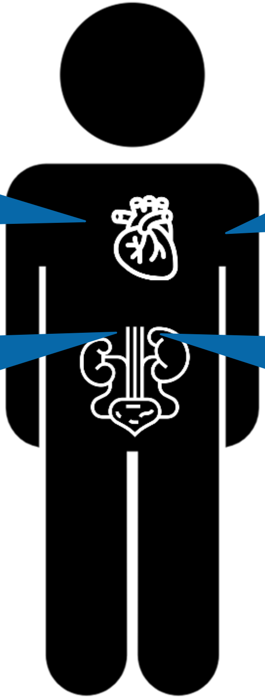
- Prerenal AKI is the result of hypovolemia or low cardiac output [18]
- No damage to renal parenchyma [7]
- Can progress to Intrinsic AKI if hypovolemia insult continues and damage occurs [22]

*Adapted from Makris 2016

Etiology: Prerenal Possible Causes [7]

Impaired Cardiac Function: Congestive heart failure, acute myocardial infarction, massive pulmonary embolism

Systemic Vasodilation: Anti-hypertensive medications, gram negative bacteremia, cirrhosis, anaphylaxis

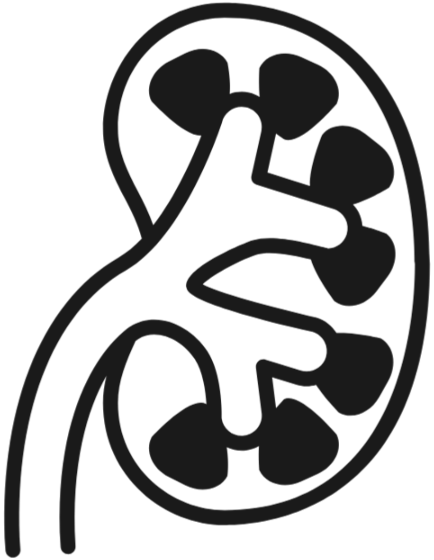


Increased Vascular resistance: Anesthesia, surgery, hepatorenal syndrome, NSAID medications, drugs that cause renal vasoconstriction

Hypovolemia: Hemorrhage, volume depletion, renal fluid loss (over-diuresis), third space (burns, peritonitis, muscle trauma)

Etiology: Renal (Intrinsic)

- Results of injury to kidney structures: tubules, glomeruli, the interstitium, and intra-renal blood vessels [7]
- Acute Tubular Necrosis (ATN) - AKI from damage to tubules. This is the most common type of Intrinsic AKI [7]

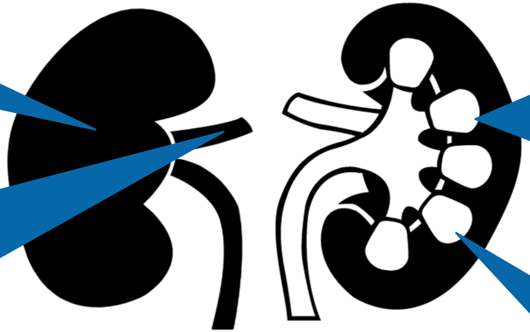


*Adapted from Makris 2016

Etiology: Intrinsic Possible Causes [7]

Interstitium: Infectious (bacterial, viral), medications (antibiotics, diuretics, NSAIDs, etc)

Vascular: Large vessels (bilateral renal artery stenosis, bilateral renal vein thrombosis), small vessels (vasculitis, malignant hypertension, atherosclerotic or thrombotic emboli, hemolytic uremic syndrome, thrombotic thrombocytopenic purpura)



Tubular: Renal ischemia (shock, complication of surgery, hemorrhage, trauma, bacteremia, pancreatitis, pregnancy), nephrotoxic drugs (antibiotics, antineoplastic drugs, contrast media, organic solvents, anesthetic drugs, heavy metals) endogenous toxins (myoglobin, hemoglobin, uric acid)

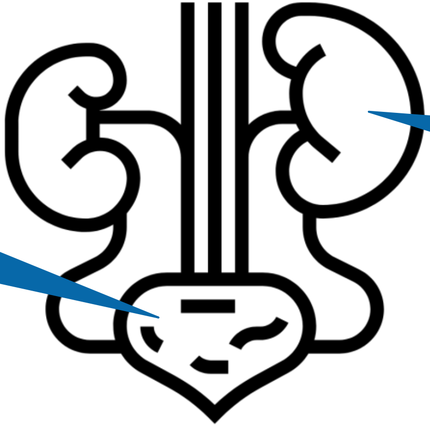
Glomerular: Acute post infectious glomerulonephritis, Lupus nephritis, IgA glomerulonephritis, infective endocarditis, Goodpasture syndrome, Wegener disease

Etiology: Postrenal

- Caused by blockage of urinary flow in the urinary tract [18]
- Obstruction → ↑ intratubular pressure and ↓GFR [22]
- Leads to build up in the kidney [22]
- Quick resolution = best chance of kidney recovery [7]

Etiology: Post Renal Possible Causes [7]

Extrarenal Obstruction:
Prostate hypertrophy, improperly placed catheter, bladder, prostate or cervical cancer, retroperitoneal fibrosis

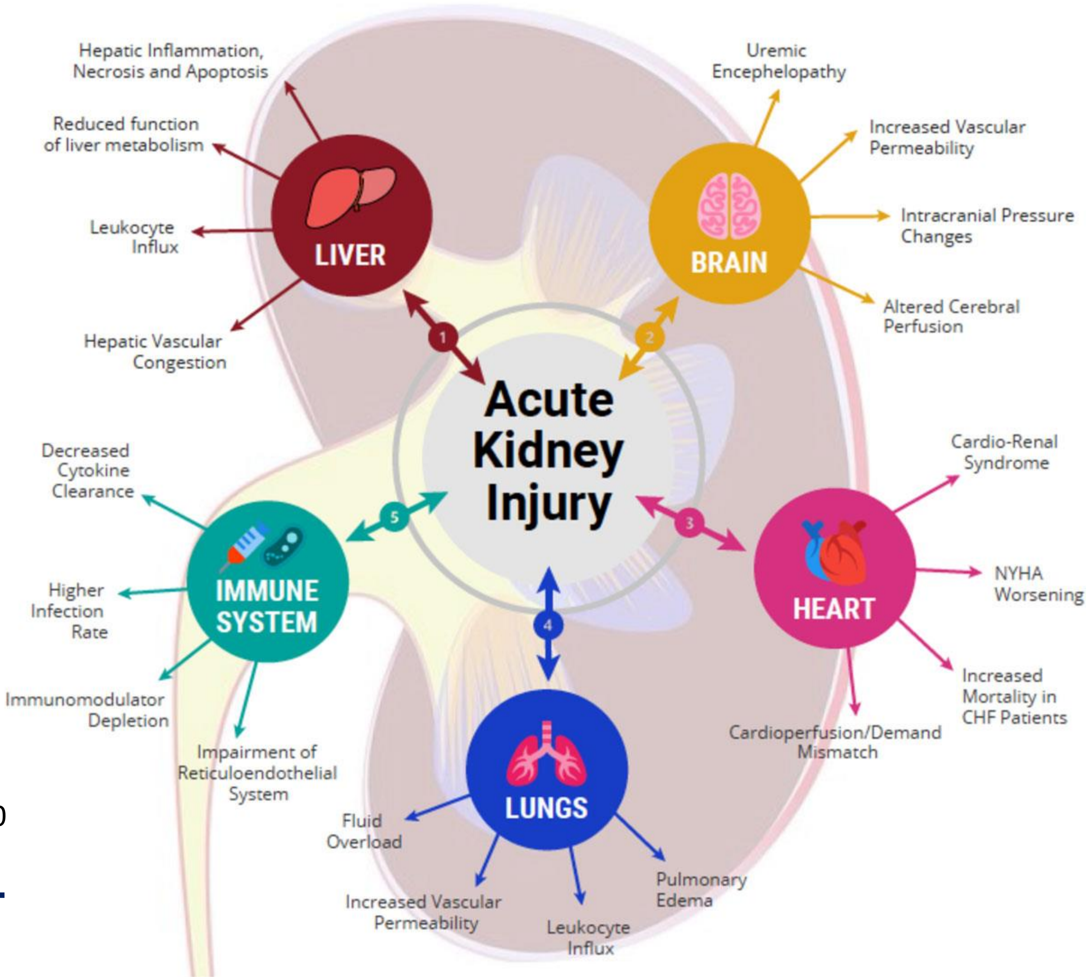


Intrarenal Obstruction:
Nephrolithiasis, blood clots, papillary necrosis

AKI Impact on Organ Function

*Image Source: Gumbert et al. *Anesthesiology* 2020

Consequences of acute kidney injury on remote organ functions



AKI Risk Factors

Categories of AKI Risk Factors

- Patient-related, such as:
  - Diabetes
  - Hypertension
  - Sepsis
- Procedure-related, such as:
  - Cardiopulmonary bypass & duration
  - Emergency Surgery
  - Organ Transplant
- Anesthesia-specific, such as:
  - Vasopressor use
  - Diuretic use
  - Hypotension

Patient Risk Factors [23-25]

- Preoperative level of kidney function
- Chronic Vascular Disease
- Arterial Hypertension
- Cardiac Failure/Cardiac Decompensation
- Diabetes (insulin or oral therapy requirements)
- Acute medical conditions (sepsis, major surgery, mechanical ventilation, hemodynamic instability)

- Hypertension
- Peripheral Vascular Disease
- Congestive Heart Failure
- Sepsis
- Ascites
- Cerebrovascular disease
- Mild to Moderate preoperative renal insufficiency
- Age >65
- COPD
- Chronic Kidney Disease
- BMI ≥ 25 (Overweight) (Ju 2018)

Patient-related risk factors are more strongly associated with mortality than the type of procedure [23]

Procedure Related Risk Factors [10, 23, 25]

- Gastric bypass surgery for morbid obesity- 8.5% incidence AKI
- Cardiopulmonary bypass (CPB) & duration
- Aortic cross clamping & duration
- Hemodilution (cardiac surgery)
- Duration of surgery
- Intraperitoneal surgery
- Repair of AAA
- Organ transplant (non-renal also)
  - Liver Transplant
    - 33% develop AKI
    - 17% require RRT
- Use of intra-aortic balloon pump
- Type of cardiac surgical procedure
- Intra-abdominal hypertension
- Emergency surgery
- Bleeding complications

Anesthesia-related Risk Factors

Potentially modifiable AKI risk factors in both cardiac and noncardiac surgery [10, 23, 25]

- Hemodilution
- Hemoglobin level
- Intraoperative transfusion
- Hypotension
- Inadequate oxygen delivery
- Use of diuretics
- Selective renal ischemia
- Ischemia reperfusion injury
- Bleeding complications
- Intraoperative Hypertension
- Nephrotoxic agents (eg abx, contrast agents)

Acute Kidney Injury Classification Systems

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AKI Classification Systems: RIFLE

- First attempt at a unifying definition for AKI (then called acute renal failure) [26]
- Published in 2004, RIFLE graded AKI Stages and provided taxonomies for both severity and recovery [10]
- Proposed 1 week timeframe for AKI Diagnosis [27]

	GFR Criteria	Urine output criteria	
Risk	Increased creatinine x1.5 or GFR decrease >25%	UO <0.5ml $kg^{-1}h^{-1}$x6h	High Sensitivity
Injury	Increased creatinine x2 or GFR decrease >50%	UO <0.5ml $kg^{-1}h^{-1}$x12h	
Failure	Increased creatinine x3 or GFR decrease >75% or creatinine ≥4mg per 100mL (acute rise of ≥0.5mg per 100ml dl)	UO < 0.3 $kg^{-1}h^{-1}$x24h or anuria x12h (Oliguria)	High Specificity
Loss	Persistent ARF = complete loss of renal function >4 weeks		
ESRD	End Stage Renal Disease (>3 months)		

Diagnostic criteria:
- 1 week timeframe for AKI diagnosis
- Grades patients based on the worse category for GFR/UO

Image Source: Ricci, Cruz, & Ronco *Kidney International* 2008

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AKI Classification Systems: RIFLE

- Previously over thirty different definitions of acute renal failure were in use [26]
- Caused shift in terminology: “Acute Renal Failure” → “Acute Kidney Injury”
- Highlighted importance of identifying changes in kidney function earlier to prevent failure [28]
- Validated in multiple studies for its ability to classify patients and was strongly tied to patient outcomes in the acutely ill [28]

AKI Classification Systems: RIFLE

Limitations

- Smaller increases in SCr than those defined in “Risk” (<1.5x) are associated with poor outcomes [27]
- Urine output component unreliable (may be influenced by other factors such as diuretic use) [27]
- When using estimated GFR in place of a true baseline GFR, the formulas that estimate GFR presume a “steady state” for GFR that is absent in patients with acutely changing kidney function [27]
- Urine output alone used for staging was not found to be an accurate predictor of AKI; Cr and urine output should be assessed together for accurate staging & as a predictor of ICU mortality [29]

AKI Classification Systems: Acute Kidney Injury Network (AKIN) [27,30]

RIFLE Criteria

	GFR Criteria	Urine output criteria	
Risk	Increased creatinine x1.5 or GFR decrease >25%	UO <0.5ml $kg^{-1}h^{-1}$x6h	High Sensitivity
Injury	Increased creatinine x2 or GFR decrease >50%	UO <0.5ml $kg^{-1}h^{-1}$x12h	
Failure	Increased creatinine x3 or GFR decrease >75% or creatinine ≥4mg per 100mL (acute rise of ≥0.5mg per 100ml dl)	UO < 0.3 $kg^{-1}h^{-1}$x24h or anuria x12h (Oliguria)	High Specificity
Loss	Persistent ARF = complete loss of renal function >4 weeks		
ESRD	End Stage Renal Disease (>3 months)		

Diagnostic criteria:
- 1 week timeframe for AKI diagnosis
- Grades patients based on the worse category for GFR/UO

Removed GFR

AKIN Criteria

	Cr Criteria	Urine output criteria
Stage 1	Increased creatinine x1.5 or ≥ 0.3mg/dl	UO <0.5ml/kg/hr x6 hr
Stage 2	Increased creatinine x2	UO <0.5ml/kg/hrx12h
Stage 3	Increased creatinine x3 or Cr ≥ 4 mg/dl (with acute rise of ≥0.5mg/dl)	UO < 0.3 ml/kg/hr x24h or anuria x12h (Oliguria)

New RRT Staging

Patients who receive renal replacement therapy (RRT) are considered to have met the criteria for stage 3 irrespective of the stage that they are in at the time of commencement of RRT

Introduced 48h timeframe

Diagnostic criteria:
- Serum creatinine measured over 48 hours
- Grades patients on urine output and change in SCr over 48 hours
- 7 day timeframe for staging AKI

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AKI Classification Systems: AKIN

- Introduced in 2007 to improve accuracy after RIFLE release [27]
- Relies on serum creatinine measured over 48 hours but does not use GFR
- Grades patients on urine output and change in SCr over 48 hours
- Higher diagnostic accuracy than RIFLE [30]

AKI Classification Systems: AKIN

Limitations

- 48 hour timeframe for diagnosis of AKI may miss slowly progressing AKI [27]
- While diagnosis of AKI is based on a change in SCr over 48 hours, a 1 week timeframe is used for staging AKI [27]

AKI Classification Systems: KDIGO Criteria (2012) [31]

UO criteria unchanged

SCr criteria mostly unchanged from AKIN

Removed acute rise criteria. Kept RRT criteria from AKIN

Kept SCr increase of ≥ 0.3 mg/dl within 48 hours from AKIN

Used 7 day timeframe for 1.5X increase in SCr from RIFLE

	Cr Criteria	Urine output criteria
1	Increased creatinine x1.5-1.9 from baseline or ≥ 0.3 mg/dl	UO <0.5ml/kg/hr for 6-12hr
2	Increased creatinine x2.0-2.9 from baseline	UO <0.5ml/kg/hr ≥ 12h
3	Increased creatinine x3 from baseline OR SCr ≥ 4.0mg/dl OR RRT	UO < 0.3 ml/kg/hr for ≥ 24h or anuria ≥ 12h

Diagnostic criteria for AKI:

- SCr increase ≥0.3mg/dl within 48h OR
- SCr increase ≥1.5 times baseline, which is known or presumed to have occured within the last 7 days OR
- Urine volume < 0.5 ml/kg for 6h

RIFLE - 2004

	GFR Criteria	Urine output criteria
Risk	Increased creatinine x1.5 or GFR decrease >25%	UO <0.5ml $kg^{-1}h^{-1}$x6h
Injury	Increased creatinine x2 or GFR decrease >50%	UO <0.5ml $kg^{-1}h^{-1}$x12h
Failure	Increased creatinine x3 or GFR decrease >75% or creatinine ≥4mg per 100mL (acute rise of ≥0.5mg per 100ml dl)	UO < 0.3 $kg^{-1}h^{-1}$x24h or anuria x12h (Oliguria)
Loss	Persistent ARF = complete loss of renal function >4 weeks	
ESRD	End Stage Renal Disease (>3 months)	

Diagnostic criteria:
- 7 day timeframe for AKI diagnosis
- Grades patients based on the worse

AKIN - 2007

	Cr Criteria	Urine output criteria
1	Increased creatinine x1.5 or ≥ 0.3mg/dl	UO <0.5ml/kg/hr x6 hr
2	Increased creatinine x2	UO <0.5ml/kg/hrx12h
3	Increased creatinine x3 or Cr ≥ 4 mg/dl (with acute rise of ≥0.5mg/dl)	UO < 0.3 ml/kg/hr x24h or anuria x12h (Oliguria)

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Diagnostic criteria:
- Serum creatinine measured over 48 hours
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- 7 day timeframe for staging AKI

KDIGO - 2012 [31]

	GFR Criteria	Urine output criteria
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3	Increased creatinine x3 from baseline OR SCr ≥ 4.0mg/dl OR RRT	UO < 0.3 ml/kg/hr for ≥ 24h or anuria ≥ 12h

Diagnostic criteria for AKI:
- SCr increase ≥0.3mg/dl within 48h OR
- SCr increase ≥1.5 times baseline, which is known or presumed to have occured within the last 7 days OR
- Urine volume < 0.5 ml/kg for 6h

Differences between RIFLE, AKIN, & KDIGO Staging/Criterion

- RIFLE, AKIN, & KDIGO have been shown to have similar predictive ability for in-hospital mortality [30]

- In one 2017 study, RIFLE and KDIGO diagnosed more patients with AKI than AKIN [30]

- AKIN may under diagnose AKI as compared to RIFLE and KDIGO [31]

Kidney Disease: Progression from AKI to CKD and/or Renal Failure

- KDIGO Clinical Practice Guideline for AKI (2012) recommends patients follow-up within 3 months after experiencing AKI after surgery to assess for progression to CKD [33]
- Patients who recover from AKI may not return to baseline kidney function - irreversible decline in kidney function is more likely for patients ≥ 65 years old [34]

34-53%

Of CKD patients who experience an episode of AKI after cardiac surgery will progress to a worse CKD class [32]

8x

Patients who develop AKI during surgery demonstrate an 8-fold increased risk of progression to CKD [23]

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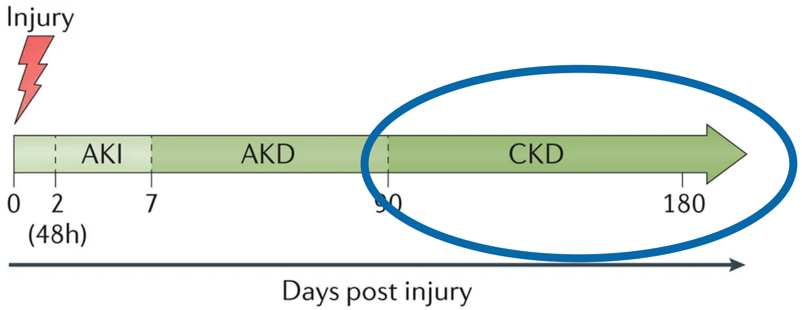
Chronic Kidney Disease

Chronic Kidney Disease Classification

Chronic Kidney Disease
Abnormalities in kidney structure or function that persist beyond 90 days

- CKD Classification based on:
  a. Presence or absence of systemic disease
  b. Location of pathology within kidney



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Chronic Kidney Disease Definition

- Abnormalities in kidney structure or function that persist beyond 90 days [19]
- Can result from a variety of causes of kidney damage
- Higher risk of end stage renal disease (ESRD) [33]

Criteria for CKD (either of the following present for >3 months)	
Markers of kidney damage (one or more)	Albuminuria (AER≥30mg/24h; ACR≥30mg/g [≥3mg/mmol]) Urine sediment abnormalities Electrolyte and other abnormalities due to tubular disorders Abnormalities detected by histology Structural abnormalities detected by imaging History of kidney transplantation
Decreased GFR	GFR<60ml/min/1.73m^2 (GFR categories G3a-G5)

KDIGO Criteria 2012

CKD Staging

GFR Categories in CKD

Category	GFR (ml/min/1.73m^2)	Terms
G1	>90	Normal or high
G2	60-89	Mildly decreased*
G3a	45-59	Mildly to moderately decreased
G3b	30-44	Moderately to severely decreased
G4	15-29	Severely decreased
G5	<15	Kidney Failure

*Relative to young adult level
In the absence of evidence of kidney damage, neither GFR category G1 or G2 fulfill the criteria for CKD

Albuminuria categories in CKD

Category	Albumin excretion rate	Albumin to creatinine ratio (Approximate equivalent)		Terms
A1	<30 mg/24h	<3 mg/mmol	<30 mg/g	Normal to mildly increased
A2	30-300 mg/24h	3-30 mg/mmol	30-300 mg/g	Moderately increased*
A3	>300 mg/24h	>30 mg/mmol	>300 mg/g	Severely increased**

*Relative to young adult level
**Including nephrotic syndrome (albumin excretion usually >2200mg/34 hours [ACR>220mg/g; >220mg/mmol])

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Figure Source: 2012 KDIGO Clinical Practice Guidelines for Chronic Kidney Disease

CKD Pathophysiology

	Examples of systemic diseases affecting the kidney	Examples of primary kidney disease (absence of systemic disease affecting the kidney)
Glomerular diseases	Diabetes, systemic autoimmune diseases, systemic infections, drugs, neoplasia (including amyloidosis)	Diffuse, focal or crescentic proliferative GN; focal and segmental glomerulosclerosis, membranous nephropathy, minimal change disease
Tubulointerstitial diseases	Systemic infections, autoimmune, sarcoidosis, drugs, urate, environmental toxins (lead, aristolochic acid), neoplasia (myeloma)	Urinary-tract infections, stones, obstruction
Vascular diseases	Atherosclerosis, hypertension, ischemia, cholesterol emboli, systemic vasculitis, thrombotic microangiopathy, systemic sclerosis	ANCA-associated renal limited vasculitis, fibromuscular dysplasia
Cystic and congenital diseases	Polycystic kidney disease, Alport syndrome, Fabry disease	Renal dysplasia, medullary cystic disease, pondocytopathies

Figure Source: 2012 KDIGO Clinical Practice Guidelines for Chronic Kidney Disease

Risk of Progression of AKI to CKD

- Risk of progression to *advanced chronic kidney disease* has been developed by an externally validated prediction model among hospital inpatients experiencing AKI, with all data available at the time of detection of acute kidney injury[39].

Prediction model of CKD progression after AKI

	Model 3
Predictors	Age, sex, AKI stage, Baseline Scr
Intercept	-9.1857
Age (years)	0.0126
Sex (female)	1.0218
AKI (KDIGO definition)	
Stage1	
Stage2	0.7893
Stage3	1.9232
Baseline Scr (mg/dL)	3.7321

p=e^(-9.1857+0.0126*age+1.0218*sex+0.7893*AKI2+1.9232*AKI3+3.7321*BaselineSCr)/(1+e^-9.1857+0.0126*age+1.0218*sex+0.7893*AKI2+1.9232*AKI3+3.7321*BaselineSCr)

where:

Age is continuous in years

Sex: male=0, female=1

Stage 1 AKI: AKI2=0 and AKI3=0

Stage 2 AKI: AKI2=1 and AKI3=0

Stage3 AKI: AKI2=0 and AKI3=1

Baseline Scr is continuous in mg/dL

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Emerging Research: Biomarkers

Biomarkers

Current research activities aim to identify new biomarkers, which are released before sCR increases and/or urinary output declines [23]

- The production and release of possible biomarkers of early tubular stress is triggered by surgical trauma, cardiopulmonary bypass, or other noxious events
- Several issues have to be addressed before these biomarkers can be introduced into daily clinical routine
  - Lack of sensitivity that is related to the etiological heterogeneity of AKI, and the lack of specificity that seems related to extrarenal causes for fluctuations in serum or urine concentration of the biomarkers
  - NGAL- neutrophil-gelatinase-associated lipcalin → considered the troponin of the kidneys, can only predict AKI in patients with prior normal kidney function
  - Tissues inhibitor of metalloproteinases-2 (TIMP-2)
  - Insulin-like growth factor binding protein (IGFBP7)

Subclinical AKI

- Recently defined with the introduction of biomarkers
- Increased biomarker presence without fulfilling KDIGO criteria is considered subclinical [35]
  - NGAL - neutrophil gelatinase-associated lipocalin
    - Excreted when there is tubular damage [35]
    - Proposed cut off for tubular damage 100-150 ng/mL
- Functional AKI meets KDIGO criteria but does not have biomarker increase
- Subclinical AKI are associated with adverse outcomes despite not meeting KDIGO AKI criteria [36]

	KDIGO Criteria	Biomarker Increase
Functional AKI	YES	✕
Subclinical AKI	✕	YES

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Registry Definitions: Kidney Disease

American College of Surgeons (ACS) - NSQIP

Progressive Renal Insufficiency

A rise in creatinine of >2 mg/dl from preoperative value, but with no requirement for preoperative (within the 2 week timeframe prior to surgery) or postoperative dialysis

Acute Renal Failure Requiring Dialysis

In a patient who did not require dialysis preoperatively (within the 2 week timeframe prior to surgery), worsening of renal dysfunction postoperatively requiring dialysis (hemodialysis, peritoneal dialysis, hemofiltration, hemodiafiltration, or ultrafiltration)

Source: ACS NSQIP Variable Definitions

American College of Surgeons (ACS) - Trauma

NTDB
NATIONAL TRAUMA DATA BANK

Acute Kidney Injury- Stage 3*

1. 3 times baseline (SCr) ***or***
2. Increase in SCr to ≥ 4.0 mg/dl (≥ 353.6 µmol/l) ***or***
3. Initiation of renal replacement therapy

*KDIGO Criterion Used

For patients < 18 years:

1. Decrease in eGFR to <35 ml/min per 1.73 m^2 ***or***
2. Urine output <0.3 ml/kg/h for > 24 hours ***or***
3. Anuria for > 12 hours

Source: NTDS 2020 Data Dictionary

Michigan Trauma Quality Improvement Program (MTQIP)

M·TQIP

Acute Renal Insufficiency

1) Rise in creatinine of >2 mg/dl from baseline value, but with no requirement for dialysis. *Assume a baseline value of 1.0 mg/dl in the absence of additional information regarding the patient's pre-injury renal function.*

Acute Kidney Injury*

1) Increase creatinine x3 or GFR decrease > 75% ***or***
2) Urine output criteria: UO < 0.3ml/kg/hr x 24 hours ***or***
3) Anuria x 12 hours ***or***
4) Requirement of renal replacement therapy

*RIFLE criterion used

Source: Michigan Trauma Quality Improvement Program Data Dictionary

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Society of Thoracic Surgeons- Cardiac

Post-op Renal Failure Definition:

1. Increase in serum creatinine level 3.0 x greater than baseline, or serum creatinine level ≥4 mg/dL (acute rise must be at least 0.5 mg/dl) ***or***

2. A new requirement for dialysis postoperatively

*KDIGO Stage 3 Criterion Used

Post-Op-Renal-Dialysis: New requirement for dialysis postoperatively, which may include hemodialysis, peritoneal dialysis

Post-Op-Dialysis Required After Discharge

Post-Op-Dialysis Duration

Source: STS Adult Cardiac Surgery Database Data Specifications

Registry Definitions: STS- Thoracic

The Society of Thoracic Surgeons

Renal Failure - KDIGO Stage 3 Criteria

1. Increase in serum creatinine level 3.0 x greater than baseline, or serum creatinine level >=4 mg/dL. Acute rise must be at least 0.5 mg/dl ***OR***

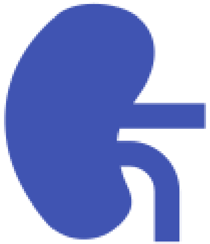
2. A new requirement for dialysis postoperatively

Source: STS General Thoracic Surgery Database Data Specifications

MPOG MULTICENTER PERIOPERATIVE OUTCOMES GROUP

MPOG Measure Definition: AKI 01

- ASPIRE Definition of AKI: Baseline creatinine increased more than 1.5 times within 7 postoperative days OR the baseline creatinine level increased by ≥ 0.3 mg/dL within 48 hours after anesthesia end.
- Baseline serum creatinine is defined as the most recent serum creatinine resulted in the last 60 days preoperatively.
- KDIGO Criterion used



Acute Kidney Injury

AKI-01: Acute Kidney Injury

Source: MPOG Measures-Acute Kidney Injury

Summary

1. Several definitions of AKI exist but KDIGO is most widely accepted

1. Adverse effects of AKI can last years, even for patients whose creatinine improves at the time of discharge [5,10-11]

1. Patient-related risk factors are more strongly associated with mortality than the type of procedure [23]

1. Surgical registries have begun to collect data regarding kidney injury, though definitions vary, these outcomes can be helpful for both quality improvement and research purposes.

1. For recommendations to avoid AKI, reference additional toolkit components:
   - Avoiding Kidney Injury - Recommendations for Adult Surgical Patients
   - Avoiding Kidney Injury - Pediatrics
   - Avoiding Kidney Injury - Obstetrics
   - Avoiding Kidney Injury - Cardiac Surgery

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