

Fundamentals of Critical Care Nephrology

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Acute Kidney Injury

Acute kidney injury (AKI) is an abrupt but often reversible drop in the glomerular filtration rate with a resulting impairment in waste product excretion, water/electrolyte homeostasis, and/or acid base regulation. AKI is estimated to impact approximately 20% of critically ill adults. One set of **diagnostic** criteria is detailed below.

Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Staging System [1]

AKI Stage	Serum Creatinine	OR*	Urine Output
Stage 1	1.5 to 1.9 times baseline [†] OR Increase by ≥ 0.3 mg/dL		<0.5 mL/kg/hour for 6-12 hours
Stage 2	2.0 to 2.9 times baseline		<0.5 mL/kg/hour for ≥ 12 hours
Stage 3	≥ 3 times baseline OR ≥ 4 mg/dL		<0.3 mL/kg/hour for ≥ 24 hours OR anuria for ≥ 12 hours OR initiation of RRT

*Criteria can be fulfilled for either creatinine or urine output.

[†]Baseline values are defined as being "known or presumed" to have occurred within the past seven days.

RRT, renal replacement therapy.

AKI has numerous potential **etiologies**, each of which falls into one or more of the following categories:

Categories	Potential Etiologies
Pre-renal: decreased renal perfusion pressure	Hypotension, hypovolemia, hypoperfusion secondary to reduced cardiac function
Intrinsic: renal vascular, glomerular, or tubulo-interstitial disease	Acute tubular necrosis (ATN), acute interstitial nephritis (AIN)
Post-renal: obstructed urinary flow or obstructive nephropathy	Occluded Foley catheter, large renal calculi

Stepwise **evaluation** of AKI in the intensive care unit (ICU) can be undertaken as follows:

Step	Elements	Comments
1	Exclude obstruction	Uncommon but easily remedied; consider ultrasound if high suspicion
2	Evaluate hemodynamics	Volume, mean arterial pressure, cardiac output; consider fluid/pressor/inotrope challenge
3	Urine studies	Urinalysis and urine microscopy. Casts are suggestive of ATN; Urine eosinophils are indicative AIN; consider if patient is on beta-lactam antibiotics
4	Furosemide stress test	Looking for response to adequate furosemide dose (see next page) >200 mL in 2 hours: argues against AKI progression <200 mL in 2 hours: suggests AKI progression, potential need for RRT

Management of AKI centers around the reversal of the underlying cause. Other interventions include:

- Avoidance and/or discontinuation of nephrotoxic medications (e.g., vancomycin, aminoglycosides, NSAIDs, calcineurin inhibitors, etc.)
- Careful dose adjustment of renally cleared medications in consultation with a pharmacist
- Maintenance of euvolemia
 - Not all AKI is due to hypovolemia; avoid volume overload
 - Use balanced crystalloids when needed
- Avoidance of overzealous electrolyte repletion as renal function worsens

- Maintenance of adequate MAP (>65 mm Hg) and consideration of higher targets in chronically hypertensive patients (~80 mm Hg)
- Consideration of RRT (see below)

Volume Overload and Diuretics

- Volume overload is common in critically ill adults. Total body volume and weight typically increase for the first seven days after ICU admission due in large part to IV fluid and medication diluents
- Volume overload
 - Impairs organ perfusion and slows recovery from critical illness
 - Increases intra-compartmental pressures and central venous pressure
 - Causes AKI
- Strategies for mitigation include
 - Avoidance of excessive IV fluids; use goal-directed volume replacement
 - Earlier utilization of vasopressors
 - Use of diuretics to address symptomatic volume overload and return to euvolemia
- Loop diuretics promote excretion of filtered sodium and induce natriuresis
 - Furosemide 40 mg IV, furosemide 80 mg PO, bumetanide 1 mg, and torsemide 15 mg are roughly equivalent
 - In healthy adults without renal failure, furosemide 40 mg IV is maximally effective
 - In adults with AKI, a starting dose of 80 mg IV should be considered; a dose of 200 mg IV is considered maximally effective
- Thiazide diuretics, such as metolazone and chlorothiazide, are used in critical care settings in conjunction with loop diuretics for patients who prove refractory to loop agents alone. Their time to peak effect is 4-6 hours, and they should be given well before loop agents.

Hyperkalemia

- Check EKG: peaked T waves require decreasing total body potassium ASAP
- Initial management: shift potassium into cells and stabilize membranes with calcium gluconate or calcium chloride 1 gram IV; sodium bicarbonate 150 mEq IV, especially if metabolic acidosis is present; albuterol 10-20 mg in 4 mL saline nebulizer; insulin 10 U IV and glucose
- Remove potassium: furosemide 20 mg IV if urinating; kayexalate 30-60 grams PO; patiromer 8.4-25.2 g PO daily; dialysis, especially if patient is obtunded and cannot tolerate enteral intake
- Determine underlying cause: for example, AKI and drugs (e.g., spironolactone, Bactrim, rarely heparin)

Indications for Urgent or Emergent Renal Replacement Therapy

- Metabolic or electrolyte imbalances not amenable to medical therapy
 - Examples: Severe metabolic acidosis, refractory hyperkalemia
- Severe fluid overload leading to end-organ impairment
 - Examples: Pulmonary edema with respiratory failure, congestive heart failure
- Symptomatic uremia evidenced by bleeding, pericarditis, encephalopathy, etc.

AKI and Other Renal Considerations in Patients with COVID-19

- Approximately 20% of critically ill adults with COVID-19 develop AKI [2], with ATN being the most common cause; this is comparable to the overall incidence of AKI in other causes of critical illness
- Remdesivir dosing is unclear in AKI; patients w/ creatinine clearance <30 mL/min are excluded from most trials
- Indications for RRT in COVID-19 are the same as those in other conditions [3]
- A conservative fluid management strategy has been recommended [4]
 - Watch “ins and outs” closely; place a Foley catheter
 - Not all AKI is due to hypovolemia; fluid overload will slow recovery
 - Employ empiric assessments of volume status: passive leg raise, point-of-care echocardiography, etc.
 - Record dry weight and consider diuresis to dry weight
 - Correct electrolyte derangements, especially with diuresis, to avoid arrhythmia

References

1. Levey AS, Coresh J, Bolton K, et al. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002;39(2Suppl 1):S1-S266.
2. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5,700 patients hospitalized with COVID-19 in the New York City area. *JAMA*. 2020;323(20):2052-2059.
3. COVID-19 Treatment Guidelines Panel. Coronavirus Disease 2019 (COVID-19) Treatment Guidelines. National Institutes of Health. <https://www.covid19treatmentguidelines.nih.gov/>. Accessed Sept 4, 2020.
4. European Society of Intensive Care Medicine. Important Announcement of new SSC Guidelines – COVID-19. <https://www.esicm.org/ssc-covid19-guidelines/>. Accessed Sept 4, 2020.