Renal Labs and Imaging: Essential Guide for Student Providers

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RENAL LABS AND IMAGING: ESSENTIAL DIAGNOSTIC GUIDE

PA/Medical Student Handout

LEARNING OBJECTIVES

By the end of this module, you will be able to:

1. **Order appropriate labs** based on clinical presentation (new patient vs. follow-up)
2. **Understand renal function assessment** including eGFR, cystatin C, and creatinine limitations
3. **Interpret laboratory panels** for specific disease states (CKD, HTN, GN)
4. **Select optimal imaging modality** for common clinical scenarios
5. **Understand radiation exposure** and contrast considerations
6. **Interpret imaging findings** and recognize abnormalities
7. **Manage contrast-related risks** in patients with reduced kidney function

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SECTION 1: ESSENTIAL RENAL LABS

Lab Panels by Clinical Scenario

Panel 1: New Nephrotic Syndrome Patient **Order**: RFP, CBC, PTH, Mg, Uric Acid, Monoclonal Screen (SPEP), UA with Micro, Albumin-to-Creatinine Ratio (ACR), Protein-to-Creatinine Ratio (PCR)

Lab	Why Order?	What It Tells You
RFP	Renal function baseline	Creatinine, BUN, eGFR
CBC	Hematologic status	Anemia (hemolysis? bleeding?)
PTH	Mineral metabolism	Parathyroid status; renal osteodystrophy risk
Mg	Electrolyte screening	Hypomagnesemia common in proteinuria
Uric Acid	Gout risk; cell turnover	Can precipitate AKI during diuresis
SPEP	Screen for myeloma	Monoclonal protein? Light chain disease?

Lab	Why Order?	What It Tells You
UA with Micro	Urine pathology	RBC casts? (GN) WBC casts? (infection)
ACR	Quantify proteinuria	Better than dipstick; albumin-specific
PCR	Total proteinuria	Includes non-albumin proteins

Panel 2: Follow-Up CKD Patient (Stable) **Order**: RFP, CBC, PTH, Mg, Uric Acid, ACR

Frequency: Q3-6 months if stable; Q1-2 months if declining

Panel 3: Hypertension Workup **Order**: Cortisol (24-hour or late-night salivary), TSH, PTH, Plasma Free Metanephrines, Aldosterone-to-Renin Ratio

Test	When to Order	What It Identifies
24-hr Cortisol	Suspect Cushing's	Cortisol excess (HTN + weight gain + striae)
TSH	Screen for thyroid	Hypothyroidism can cause HTN
PTH	Screen for hypercalcemia	Hyperparathyroidism (HTN + hypercalcemia)
Plasma Metanephrines	Suspect pheochromocytoma	Catecholamine excess (episodic HTN, sweating)
Aldo-Renin Ratio	Suspect primary aldosteronism	Hypokalemia + HTN (resistant to therapy)

Panel 4: Glomerulonephritis Workup **Order**: C3, C4, Hepatitis Panel, ANA, ANCA, Anti-GBM Antibody, Anti-dsDNA Antibody, Anti-PLA2R Antibody

Antibody Test	Positive In	Clinical Significance
C3, C4	Lupus, membranoproliferative GN	Complement consumption; disease activity
ANA	Lupus; must-have for SLE diagnosis	ANA-negative SLE exists but rare (<5%)
Anti-dsDNA	Lupus (specific); lupus nephritis	High titers = lupus activity
ANCA	ANCA-associated vasculitis	PR3-ANCA (granulomatosis) vs. MPO-ANCA (microscopic polyangiitis)
Anti-GBM	Anti-GBM disease (Goodpasture)	Pulmonary-renal syndrome; urgent need for plasmapheresis
Anti-PLA2R	Membranous nephropathy	70-80% of cases; marker of disease remission
Hepatitis Panel	Screen before immunosuppression	Critical before starting azathioprine, mycophenolate

SECTION 2: UNDERSTANDING RENAL FUNCTION

The eGFR Equation

CKDEPI 2021 Equation (currently recommended):

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eGFR = 142 × (Serum Creatinine / λ)^α × (0.9938)^age × (0.7 if female)
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Where: - λ = 0.7 (females), 0.9 (males) - α = -0.241 (females), -0.302 (males)

Key Points: - eGFR predicts **GFR-based kidney function** (not tubular function) - eGFR becomes **less accurate** if: - Rapidly changing creatinine (AKI) - Extreme muscle mass (bodybuilders, amputees) - Liver cirrhosis - Pregnancy - Vegetarian diet (less creatinine production)

Cystatin C: Alternative Marker

Advantages of Cystatin C: - Produced at constant rate (independent of muscle mass) - Better in elderly, obese, or cachetic patients - Better predictor of cardiovascular events

Disadvantages: - More expensive than creatinine - Less standardized across labs - Still affected by inflammatory states, corticosteroid use

When to Use Cystatin C: - Borderline eGFR (45-60) for decision-making - Extreme body habitus - Elderly/frail patients with low muscle mass - When creatinine unreliable

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SECTION 3: RENAL IMAGING MODALITIES

Quick Reference: Which Imaging for What?

Clinical Scenario	BEST Modality	Why	Radiation	Contrast
Suspected stone	Non-contrast CT (gold standard)	98% sensitivity; fast	Yes (low)	NO
Hydronephrosis?	Renal ultrasound	Radiation-free; real-time	No	NO
Renal mass	CT with contrast (multiphasic)	Enhancement characterization	Yes	YES (iodine)
RAS (high suspicion)	CT angiography	94-100% sensitivity	Yes	YES (iodine)

Clinical Scenario	BEST Modality	Why	Radiation	Contrast
RAS (screening)	Duplex ultrasound	Low sensitivity but no radiation	No	NO
Scarring from pyelonephritis	DMSA scintigraphy	Gold standard for cortical pathology	Yes (nuclear)	NO
Obstruction vs non-obstruction?	Diuretic renogram	Functional assessment; F+20 protocol	Yes (nuclear)	NO
Detailed mass characterization	MRI with contrast	Best soft tissue; NO radiation	NO	YES (gadolinium)
Renal trauma?	CT with contrast	Full organ assessment	Yes	YES (iodine)
Transplant function	Duplex ultrasound + nuclear imaging	Perfusion + function	No/Yes	NO

COMPUTED TOMOGRAPHY

Non-Contrast CT (Best for Stones) Indications: - Suspected urolithiasis - Renal size/contour - Hydronephrosis assessment - Post-procedural complications

Advantages: - 98% sensitivity, 96-100% specificity for stones - NO contrast risk - Fast; can detect non-calcified pathology (blood, perfusion changes) - Low radiation dose achievable with modern protocols

Disadvantages: - Cannot characterize renal masses (no enhancement pattern) - Cannot assess renal function - Radiation exposure

Contrast-Enhanced CT (for Masses and Vascular) **Phases of Enhancement**: 1. **Arterial phase** (25-30 sec): Renal artery, hypervascular lesions 2. **Nephrographic phase** (80-100 sec): Peak parenchymal enhancement 3. **Delayed phase** (8-15 min): Collecting system, excretion

Clinical Uses: - Renal mass characterization (Bosniak classification for cysts) - CT angiography for RAS - Pyelonephritis, renal infarction - Transplant evaluation

Radiation Dose: 3-7 mSv (equivalent to 3 years background radiation)

CT Urography **Combines**: - Non-contrast phase (baseline, stones, blood) - Nephrographic phase (mass detection) - Delayed excretory phase (collecting system, ureters, bladder)

Best for: Hematuria evaluation; detailed urinary tract assessment

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RENAL ULTRASONOGRAPHY

Advantages: - NO radiation - Real-time imaging (can assess dynamics) - Bedside availability (POCUS) - Good for fluid assessment - Ideal in pregnancy, pediatrics

Disadvantages: - Operator-dependent (60-90% sensitivity range) - Reduced accuracy in obesity - Cannot assess contrast enhancement - Limited specificity for mass characterization

Key Measurements: - **Renal length**: Normal 9-13 cm (>9 cm preferred for biopsy) - **Cortical thickness**: Measured at level of hilum (normal >7-8 mm) - **Collecting system dilatation**: Anteroposterior pelvic diameter >10 mm suggests hydronephrosis (in context)

RENAL ARTERY DUPLEX ULTRASONOGRAPHY

For Renovascular Hypertension Screening:

Diagnostic Criteria: - **Peak Systolic Velocity (PSV)** >200 cm/s = significant stenosis (≥60%) - **Renal-Aortic Ratio (RAR)** >3.5 = additional evidence of stenosis - **End-Diastolic Velocity** >70 cm/s = hemodynamically significant

Sensitivity: 85-92% (in experienced hands) **Specificity**: 85-95%

Limitations: - Operator-dependent (learning curve: hundreds of exams) - Fails in 20-30% of obese patients - Cannot visualize accessory renal arteries reliably - Technical failure high in some institutions

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NUCLEAR MEDICINE IMAGING

Diuretic Renogram (Lasix Renogram) **What It Does**: Assesses **function** (not anatomy)

Protocol: 1. Give Tc-99m MAG3 radiopharmaceutical 2. Acquire images for 20 minutes (uptake phase) 3. Give furosemide at 20-minute mark (F+20 protocol) 4. Continue imaging 20 more minutes

Interpretation: - **Time-to-Peak (TTP)**: When renal activity peaks (normal <3 min) - **Half-Time (T1/2)** post-diuretic: Time for activity to drop 50% (normal <10 min) - **T1/2 >20 min** = obstructive pattern - **T1/2 10-20 min** = equivocal (may need repeat/further imaging)

Best For: Distinguishing obstructive from non-obstructive hydronephrosis

DMSA Scintigraphy **What It Does**: Images **kidney cortex** (high-resolution scarring assessment)

Uses: - Acute pyelonephritis (hypoperfusion areas) - Chronic scarring (from reflux or infection) - Differential renal function assessment - Pediatric pyelonephritis/reflux evaluation

Sensitivity: >95% for detecting scars >1 cm

SECTION 4: CONTRAST CONSIDERATIONS

Iodinated Contrast (Used in CT)

From "Contrast-Induced Nephropathy" to "Contrast-Associated Nephropathy" Paradigm Shift: - Old term: **Contrast-Induced Nephropathy (CIN)** - implied direct causal relationship - New term: **Contrast-Associated Nephropathy (CAN)** - acknowledges other factors - Current: **Contrast-Induced Acute Kidney Injury (CI-AKI)** when probable causal relationship

Key Insight: Many post-contrast creatinine elevations are due to **other factors** (illness severity, dehydration, other medications), not the contrast itself.

Risk Stratification **Low Risk** (Creatinine elevation <2%): - Normal renal function (eGFR >60) - No diabetes

Intermediate Risk (Creatinine elevation 5-10%): - eGFR 45-60 with diabetes OR eGFR 30-45 without diabetes - Age >75 - Heart failure

High Risk (Creatinine elevation 15-30%): - eGFR <30 - Diabetes + CKD - Multiple risk factors

Prevention: - **IV hydration** with normal saline (best evidence) - Sodium bicarbonate may help (controversial) - Metformin: Hold if eGFR <30; resume 48 hours post-contrast - NSAIDs: Hold 48 hours before and after - ACE-I/ARB: Can hold 24 hours before (optional)

Gadolinium-Based Contrast (Used in MRI)

The Nephrogenic Systemic Fibrosis (NSF) Risk **Group Classification** (Risk of NSF):

Group	Agents	NSF Risk	Recommendation
I (Highest)	Gadodiamide (Omniscan), Gadopentetate (Magnevist), Gadoversetamide (OptiMARK)	Higher risk	**CONTRAINDICATED** in eGFR <30
II (Lowest)	Gadoteridol (ProHance), Gadoterate (Dotarem), Gadobutrol (Gadavist)	Minimal/NO NSF cases	Can use in eGFR <30; prefer these
III (Intermediate)	Others	Unknown	Use cautiously; prefer Group II

Current Guidelines NEW (2024): Group II GBCAs can be used even in advanced CKD (eGFR <30) or dialysis patients because: - No unconfounded NSF cases reported with Group II agents - Risk of not getting diagnostic imaging may outweigh minimal NSF risk - Use lowest effective dose

Practical Approach: - Check eGFR before MRI - If eGFR <30: Use **Group II GBCA only** (ProHance, Dotarem, Gadavist) - If eGFR >30: Any group acceptable (Group II still preferred) - Dialysis patients: Can receive Group II GBCA; no need to time dialysis

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SECTION 5: CLINICAL INTERPRETATION

Reading a Renal CT Report

Standard Elements: 1. **Kidney size**: Length in cm (normal 9-13 cm) 2. **Cortical thickness**: Measured at hilum (normal >7 mm) 3. **Enhancement pattern**: Symmetric? Hypodense areas? 4. **Collecting system**: Dilated? Hydronephrosis present? 5. **Vascular**: Assess for stenosis, accessory arteries 6. **Retroperitoneum**: Free fluid? Mass? Fat stranding?

Red Flags: - Asymmetric renal atrophy ☐ suggests chronic vascular disease or scarring - Stranding around kidney ☐ infection, infarction, or hemorrhage - Enlarged kidney ☐ acute obstruction, acute infection, or infiltration

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SECTION 6: CLINICAL PEARLS

☐ **Non-contrast CT is gold standard** for suspected stones (98% sensitivity)

☐ **CT angiography superior to duplex** for diagnosing RAS (94-100% vs. 85-95%)

☐ **eGFR accurate when stable** but unreliable in AKI or extreme body habitus

☐ **Cystatin C useful** as complementary marker in borderline eGFR

☐ **Ultrasound BEST for** hydronephrosis screening, real-time assessment, pregnant patients

☐ **Nuclear imaging best for FUNCTION** (diuretic renogram for obstruction; DMSA for scars)

☐ **Group II gadolinium is safe** even in advanced CKD (no NSF cases reported)

☐ **IV hydration prevents** most contrast-related complications; more important than contrast selection

☐ **Post-contrast creatinine elevation** often has OTHER causes; not always "contrast-induced"

☐ **Diuretic renogram (F+20 protocol)** definitively distinguishes obstructive from non-obstructive hydronephrosis

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PRACTICE QUESTIONS

Question 1: A 45-year-old male with CKD Stage 3b (eGFR 38) presents with hematuria. You need to evaluate for renal masses. Which imaging is BEST?

A) Duplex ultrasound (no radiation)
B) Non-contrast CT (no iodine contrast)
C) Contrast-enhanced CT with iodine (multiplane imaging)
D) MRI with gadolinium

Answer: **C** - For renal mass characterization, **contrast-enhanced CT** is superior because: - Iodine contrast allows assessment of enhancement (key for benign vs. malignant) - eGFR 38 = **intermediate risk** for contrast-related AKI (5-10%), but manageable with IV hydration - CT faster and more available than MRI - MRI would be alternative if contrast contraindicated, but is NOT first-line

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Question 2: A 72-year-old woman with hypertension refractory to 3 agents has eGFR 42. You want to screen for renovascular hypertension. What is the BEST initial test?

A) Renal artery duplex ultrasound
B) Captopril renography
C) CT angiography
D) Start on alpha-blocker for "resistant HTN"

Answer: **A** - **Duplex ultrasound is appropriate first-line** because: - No radiation, no contrast - Sensitivity 85-92% (good enough for screening) - Low cost - Non-invasive - If positive ☐ confirm with CTA before intervention - If negative + high suspicion ☐ proceed to CTA - Duplex failure rate (20-30% in obese) means know your institution's capability

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Question 3: Labs show eGFR 65 by creatinine, but cystatin C suggests eGFR 52. What is the MOST likely explanation?

A) Patient has early diabetic kidney disease
B) Patient is a muscular bodybuilder with high creatinine production

C) Cystatin C is unreliable; always trust creatinine
D) Patient needs immediate dialysis referral

Answer: **B** - **Discordance between creatinine-based and cystatin C eGFR** suggests: - High muscle mass ☐ high creatinine production ☐ **eGFR overestimated by creatinine** - Cystatin C (muscle-independent) more accurate - Clinical decision: **Trust cystatin C (52)** rather than creatinine (65) - Implication: eGFR 52 = Stage 3b CKD; need closer monitoring/referral

In contrast, low muscle mass (elderly, cachetic) would show **higher cystatin C-based eGFR**, making creatinine-based eGFR the underestimate.

KEY TAKEAWAYS

☐ **Lab panels vary** by presentation (new vs. follow-up; suspected HTN vs. GN)

☐ **eGFR useful** for stable patients; unreliable in AKI, extreme body habitus

☐ **Cystatin C complementary** to creatinine; helps identify muscle mass issues

☐ **CT best for anatomy** (stones, masses, vasculature); ultrasound for real-time, radiation-free

☐ **Nuclear imaging best for FUNCTION** (diuretic renogram, DMSA)

☐ **Iodine contrast safe** in CKD with proper hydration; intermediate risk in Stage 3-4

☐ **Gadolinium safe** in advanced CKD if **Group II agent used**

☐ **Ultrasound is best** for pregnancy, pediatrics, real-time assessment

☐ **Duplex ultrasound limited** but appropriate for RAS screening in stable patients

☐ **Diuretic renogram definitive** for distinguishing obstructive vs. non-obstructive hydronephrosis

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See Also

Related Student Handouts

- CKD Overview and Classification
- AKI Workup and Diagnosis
- Secondary Hypertension (including RAS)
- Nephrolithiasis
- Kidney Biopsy Essentials
- Urinalysis

Clinical Content (01-Clinical-Medicine/Nephrology)

- Procedures and Diagnostics Hub
- CKD Hub - Full Clinical Reference
- AKI Hub - Full Clinical Reference
- Hypertension Management Hub

Butler-COM Resources

- Butler COM - Nephrology Deep Dive

RELATED CLINICAL NOTES

- CKD Staging and Management
- AKI Workup and Recovery
- RAS Diagnosis and Treatment
- Stone Disease Management

This handout is designed for PA/medical student education. Always consult current institutional protocols for imaging and lab ordering.