- Definition

RIFLE Criteria by Acute Dialysis Quality Initiative (ADQI)	
Risk	Serum Cr 1.5-2x Baseline >50% GFR UOP <0.5mL/kg/hr >6hrs
Injury	Serum Cr 2-3x Baseline 25-50% GFR UOP <0.5mL/kg/hr >12hrs
Failure	Serum Cr >3x Baseline <25% GFR UOP <0.5mL/kg/hr >24hrs or Anuric >12hrs
Loss	Need for RRT >4wks
ESRD	Need for RRT >3mos

- S/S/Complications & Tx (similar to CKD)

	Pre or Acute Post	Intra or Chronic Post	
		ATN	AIN
Serum BUN:Cr • False High Cr w/ nl GFR: Certain meds inhibit Cr secretion and thus there GFR is normal (cimetidine, trimethoprim, cefoxitin, ketoacids) • False High BUN w/ nl GFR: GIB, high catabolic state like sepsis, steroids, high protein, severe CM, etc (in general never look at BUN during AKI)	>20:1	<20:1 (tubules are impaired in their ability to absorb urea)	
FE_{Na} % **FE_{BUN} %** NB FE_{Na} (remember "FUN") NB FE_{Na} is useless when pt is taking a diuretic b/c the diuretic is increasing Na excretion therefore FE_{Na} for pre-renal ARF and glomerular ARF would be >1 when it should be <1 therefore measure FE_{BUN} which is not affected by the diuretic (it doesn't matter for all the other causes b/c the FE_{Na} is already >1)	<1 <35	>2 (<1 pigment and contrast ATN) >35	>2 >35
Urine Na (mEq/L) NB there is an obligatory loss of Na in CKD, elderly, diuretic use, etc	<20	>40	Variable
Sediment NB Post-renal causes often have hematuria and pyuria but w/o casts	Hyaline Casts	Pigmented Granular Muddy Brown Cell Casts	WBC w/ Casts esp Lymphocytes if NSAIDs or Eosinophils if Abx
Proteinuria	Trace	Mod	Mod
Urine Osm	>>450 (suggesting that the kidney is trying to hold onto fluid)	<<350 (suggesting a loss of concentrating ability)	?

- Etiology
  - **Pre-Renal** (40% Out-Pt, 70% In-Pt)
    - **Decreased EAV**: Hemorrhage, 3rd Spacing, Insensible Losses, GI Loss, Renal Loss (diuresis), Hypoalbuminemia, Decreased CO (CHF), Systemic Vasodilation (anesthetics, antihypertensives), Abdominal Compartment Syndrome (massive fluid resuscitation during a code results in intra-abdominal fluid that compresses renal vessels)
    - **Renal *Artery* Obstruction**: Atherosclerosis or Fibromuscular Dysplasia aka RAS, HTN, Aorta Cross Clamping during CABG, Dissecting Aneurysm, Embolus, Thrombus, Vasculitis, Vasoconstriction (contrast, hypercalcemia, amphotericin B, calcineurin inhibitors)
    - **Impaired Renal *Arteriole* Autoregulation in the presence of Borderline Hypovolemia** (when there is a drop in BP several systems kick in including RAAS, Sympathetic NS, ADH, etc resulting in pre/afferent arteriole dilation via PGI2 and NO and post/efferent arteriole vasoconstriction via AII to maintain GFR, there is also a tubuloglomerular communication resulting in increased proximal tubule reabsorption, this autoregulation can maintain GFR until MAP <60mm)
      - Afferent
        - Hepatorenal Syndrome (refer)
        - NSAIDs (PGs dilate afferent arteriole increasing GFR thus NSAIDs constrict decreasing GFR)

- Efferent
    - ACE-I/ARB/DRI (AII constricts efferent arteriole increasing GFR thus ACE-I/ARBs dilate decreasing GFR)

- **Intra-Renal** (55% Out-Pt, 10% In-Pt)
    - **Acute Tubular Nephritis (ATN)** (injury to tubule cells resulting in sloughing of cells into lumen causing obstruction and increased proximal pressure which decreases glomerular filtration, "Acute Tubular Necrosis" is not a great term b/c sometimes there is injury but no necrosis, in general ischemic is better than nephrotoxic) (85%)
        - **Ischemia** 65% (prolonged, progressive, severe pre-renal failure resulting in ischemia of renal tissue and subsequent ATN esp at the corticomedullary junction specifically the S3 segment of the proximal tubule and thick ascending limb of the LOH b/c they require the most ATP to function, has been divided into four phases: (1) Initiation 1wk, (2) Extension 1wk, (3) Maintenance 1wk, (4) Recovery, diuresis often precedes recovery b/c the tubules are dysfunctional similar to post-obstructive diuresis)
        - **Tubular Toxins** 35% (why is the kidney so prone to toxin damage? (1) 25% of CO goes to kidney and (2) the kidney is designed to secrete toxins into tubules so that they can be metabolized and excreted and thus they are concentrated there)
            - Pigments (Hemolysis =Hb, Rhabdomyolysis=Mb) (iron moiety causes oxidative cell injury, check other parameters like CPK, LDH, haptoglobin, etc, Tx: alkalinize the urine D5W + 3amps $NaHCO_3$, NB alkalinization can promote calcium phosphate crystal formation in tubules so it is not advocated anymore)
            - GNR Toxins
            - Medications (there are five big ones but many others)
                - Aminoglycosides (hypomagnesemia, takes >1wk to take effect)
                - Amphotericin B (hypomagnesemia, distal RTA)
                - Cisplatin (hypomagnesemia)
                - Foscarnet (nephrogenic DI, hypocalcemia, hypomagnesemia)
                - Tenofovir, Adefovir, Cidofovir (Fanconi's)
            - Heavy Metals (Cadmium, Pb, Hg)
            - Toxins (CCl_4, Ethylene Glycol, Insecticides, Mushrooms)
            - Contrast (2% risk if nl pt to 20% risk if pt w/ DM or prior renal dz, multifactorial mechanism, RFs (high osm ~1400mOsm > low osm ~700mOsm > iso osm ~150mOsm aka Visipaq, >75cc, intraterial injection), occurs w/in 1-2d, peaks w/in 3-5d and recovers over 1-2wks, prophylaxis w/ hypotonic 1/4NS + 1ampNaHCO3 (controversial) and NAC (controversial))
    - **Acute Interstitial Nephritis (AIN)** (10%)
        - **Drug Reaction** (70%)
            - Allergic Type (several days after exposure but delayed reactions have been described, mild proteinuria, + F/rash/eos w/ Hansel's stain, Tx w/ steroids if active inflammation on Bx, lower r/o CKD): 1° Some Abx (pen/cephs esp methicillin & amoxicillin, sulfas, rifampin), Some AEDs (phenytoin), All Diuretics, ACE-I, Tylenol, Some H2B/PPIs, etc
            - NSAID Type (several weeks/months after exposure, nephritic proteinuria, NO F/rash/eos but + lymphs, steroids never helpful, higher r/o CKD): All NSAIDs
        - **Infection** (Pyelonephritis vs Systemic) (15%)
            - Bacterial: any fulminant bacterial pyelonephritis or unusual bacteria like Legionella, Cornyebacterium, Leptospira, Rickettsia, Yersinia, Scarlet Fever aka Councilman's Nephritis, etc
            - Viral: CMV/EBV, BK virus in renal transplant pts, Hanta Virus, Pumuula Virus, etc
            - Fungal: Candida, Histo, etc
        - **Tubulointerstitial Nephritis & Uveitis (TINU) Syndrome** (5%)
            - seen in adolescent girls, concurrent BM noncaseating granulomas and fever
        - **Infiltrative** (1%)
            - Sarcoid, Lymphoma, Sjogren's etc
    - **Glomerular Disease** (4%)
        - **Rapidly Progressive GN (RPGN)** (over weeks) to **Acute GN** (over days)
            - Mechanism: rapidly progressive to acute disruption of the integrity of the capillary wall and Bowman's capsule → crescentic formation (passage of cells and/or fibrin from capillaries into Bowman space followed by proliferation of parietal cells of Bowman capsule and an influx of monocytes such that they appear as half-moon "globs" → crescents grow rapidly compressing capillary loops leading to quick renal failure → glomerulosclerosis occurs
            - Types
                - **Type I (smooth IF, nl complement)** Ig against GBM (Anti-GBM/Goodpasture's)
                - **Type II (granular IF, variable complement)** Ig+Ag deposition in GBM (MemPGN, MesPGN, Post-Strep GN, Lupus Nephritis)

                - **Type III (negative IF hence "Pauci-Immune", nl complement)** ANCA in GBM (Small Vessel Vasculitides: Wegener's/MAP/CSS)
            - S/S: non-specific lethargy and then when you check their Cr and UA they are in overt AKI
            - Dx: Renal Panel, UA, c/p-ANCA, C3/C4, Renal Bx w/ LM/IF/EM
            - Tx: methylprednisone IV 10mg/kg/d divided TID x3d then prednisone PO 1mg/kg/d x30d then gradual taper over 6-12mo, consider Tx for specific causes, consider plasma exchange, Cytoxan, RRT
        - **Small Vessel** (Large/Medium Vessel Vasculitides, Increased Plasma Viscosity, Cholesterol Emboli Syndrome, DIC/HUS/TTP, Scleroderma Renal Crisis, Pre-Eclampsia, Severe HTN, SCD, Transplant Rejection) (1%)
    - **Post-Renal aka Obstructive Nephropathy** (5% Out-Pt, 20% In-Pt)
        - **Congenital** (pediatric population)
            - Ureter
                - Ureteropelvic Junction Obstruction (an aperistaltic segment of the ureter that fails to propel urine out of the pelvis into the ureter)
                - Ureteral Folds/Valves
                - VesiCoUreteral Reflux (VCUR) most common urologic pediatric anomaly, retrograde passage of urine from bladder to ureter
                - Vesicoureteral Junction Obstruction
            - Bladder
                - Neuropathy (Spina Bifida)
                - Bladder Diverticula
            - Urethra
                - Urethral Diverticula
                - Posterior Uretheral Folds
        - **Acquired** (adults population)
            - Tubular
                - Nephrolithiasis (refer)
                - Medication Crystals (Indinavir, Sulfadiazine, MTX, Acyclovir/Foscavir, Methyldopa, Triamterene)
                - Other Crystals (Polyethylene Glycol Intoxication forming Ca Oxalate)
                - Antibodies (Multiple Myeloma Ig Light Chain)
            - Ureter
                - Malignancy w/ LAD of the urinary tract system
                - Sloughed off Papilla from Papillary Necrosis 2/2 SCD, etc
                - Retroperitoneal Fibrosis 2/2 idiopathic, drug induced, iatrogenic, etc
                - Pregnancy (not so much 2/2 physical obstruction of R ureter by gestational uterus but by reduced peristalsis mediated by progesterone)
                - AAA
                - Malignancy w/ LAD of the ab/pelvic cavity
                - Adhesions
                - Stricture
            - Bladder
                - Malignancy
                - Blood Clot
                - Obstructed Bladder Catheter
                - Neuropathy (anticholinergics, DM, CVA, MS, etc)
            - Urethra
                - Structure
                - BPH/Prostate Cancer (refer)
        - Complications
            - Infection → Abscess, Sepsis, Xanthogranulomatous Pyelo, etc
            - Post-Obstructive Diuresis (initially there is enuria to oliguria to anuria but as urea is retained during the obstruction and then the obstruction is relieved the urea causes a pronounced diuresis, also there is impaired concentrating ability of tubules b/c they are damaged)
            - Post-Obstructive RTA Type I

- General Tx
    - Same as CKD
    - Things To Do First
        - Always determine baseline Cr to see if AKI vs CKD vs A-on-CKD
        - Place foley and determine if oliguric (<400ml/d) or anuria (<100mL/d), it is clearly known that oliguric AKI carries much worse prognosis than non-oliguric AKI so some people believe that converting oliguric pts to non-oliguric pts would provide a survival advantage, many people try to do this by giving lasix but in the end it has been found to not be that helpful as only <10% of furosemide reaches site of action in renal tubule and if there, there is so little filtrate to act on that it doesn't do much (JAMA 2002; 288:2547)
        - Rule out Pre/Post Renal Causes then assess Intra-Renal Causes

- Pre-Renal: EAV expansion w/ IVF challenge and optimize HD, early on it was suggested that low dose dopamine (<2mcg/kg/min) preferentially vasodilated certain organs specifically the kidney and that as you increase dose there is more inotropic/chronotropic effects and a change from vasodilation to vasoconstriction b/c of more alpha effects BUT THIS IS NOT THE CASE and in fact low dose dopamine has deleterious effects like immune/endocrine dysfunction and vasoconstricts other organs like the GI tract therefore don't use in AKI pts with the theory that it increases renal blood flow (Annals 2005; 142:510)
- Post-Renal: often there is palpable kidney/bladder on PEx w/ flank pain, check Renal Us to r/o hydronephrosis, place foley, if questionable prostate obstruction give alpha-adrenergic antagonists which relaxes prostate, consult urology, call IR for nephrostomy tubes

  - NB many studies have looked at giving medicines for AKI including ANP, dopamine, endothelium antagonist, adenosine antagonist, CCB, etc but they have no effect or possibly worsen AKI, the only agents that are equivocal are bicarb and NAC

- Assess underlying cause above
- Assess Need for Emergent RRT w/ "AEIOU"
  - **A**cid-Base Disturbance
  - **E**lectrolytes (refractory hyperK, etc)
  - **I**ntoxications (aspirin, ethylene glycol, Li, methanol, etc)
  - **O**verload of Volume
  - **U**remia (based on clinical symptoms NEVER on Cr or BUN)
  - There is a theoretical concern that HD can be detrimental to the kidneys in AKI b/c of periodic hypotension and activation of the inflammatory cascade by the blood-dialyzer interface