Chronic Kidney Disease

Chronic Kidney Disease (Chronic Renal Failure)

- **Definitions**
  Kidney damage for **≥ *3 months***, as defined by structural or functional abnormalities of the kidney, with or without decreased GFR

- ***GFR < 60 mL/min/1.73 m^2 for ≥ 3 months, with or without kidney damage***

Definition of CKD

Abnormalities of kidney structure or function (defined by markers of kidney injury or decreased GFR) present for > 3 months with implications for health. *(Either criterion is sufficient for diagnosis):*

1. Markers of kidney damage (one or more):

- Albuminuria (AER ≥ 30mg/24hrs; ACR ≥ 30mg/g)
- Urine sediment abnormalities
- Electrolyte and other abnormalities due to tubular disorders
- Abnormalities detected by histology
- Structural abnormalities detected by imaging
- History of prior kidney transplantation

2. GFR < 60 mL/min/1.73m^2

* GFR = glomerular filtration rate; AER = albumin excretion rate; ACR = albumin-to-creatinine ratio

Modified from KDOQI Clinical Practice Guidelines for the Evaluation and Management of Chronic Kidney Disease:(2013)

Classification of CKD

Stage	Estimated GFR (mL/min/1.73 m^2)	Comment
1	≥90	Normal GFR w/ proteinuria
2	60–89	Age-related decline in GFR w/proteinuria
3A 3B*	30–59	Low risk of progression to kidney failure
4	15–29	High risk of progression to kidney failure
5 5D 5T	<15	Kidney failure

*Because of greater cardiovascular disease risk and risk of disease progression at lower *eGFRs*, CKD Stage 3 is sub-divided into Stages 3A (45–59 mL/min/1.73 m^2) and 3B (30–44 mL/min/1.73 m^2. CKD Stage 5 includes patients that may require or are undergoing kidney replacement therapy. Designations 5D and 5T indicate end-stage renal disease patients who undergo chronic dialysis (5D) treatment or have undergone kidney transplantation (5T).

Staging of CKD classified by the CGA system: Cause, GFR category, Albuminuria category

			A1	A2	A3
			<30 m/g <3 mg/mmol	30-300 m/g 3-30 mg/mmol	>300 mg/g >30 mg/mmol
CKD stage	**G1**	≥90 ml/min per 1.73 m^2	Low risk	Moderately increased risk	High risk
	G2	60- 89 ml/min per 1.73 m^2	Low risk	Moderately increased risk	High risk
	G3a	45-59 ml/min per 1.73 m^2	Moderately increased risk	High risk	Very high risk
	G3b	30-44 ml/min per 1.73 m^2	High risk	Very high risk	Very high risk
	G4	15-29 ml/min per 1.73 m^2	Very high risk	Very high risk	Very high risk
	G5	<15 ml/min per 1.73 m^2	Very high risk	Very high risk	Very high risk

Epidemiology

- 19 million Americans have CKD
- Approx 435,000 have ESRD/HD

- Annual mortality rate for ESRD: 24%

Etiology

- Episodes of ARF (usually acute tubular necrosis) often lead, eventually, to CKD
  - Over time, combinations of acute renal insults are additive and lead to CKD
  - The definition of CKD requires that at least 3 months of renal failure have occurred
    - Causes of Acute Renal Failure (ARF)
      - Prerenal azotemia - renal hypoperfusion, usually with acute tubular necrosis
      - Intrinsic Renal Disease, usually glomerular disease
      - Postrenal azotemia - obstruction of some type

Common Underlying Causes of CKD

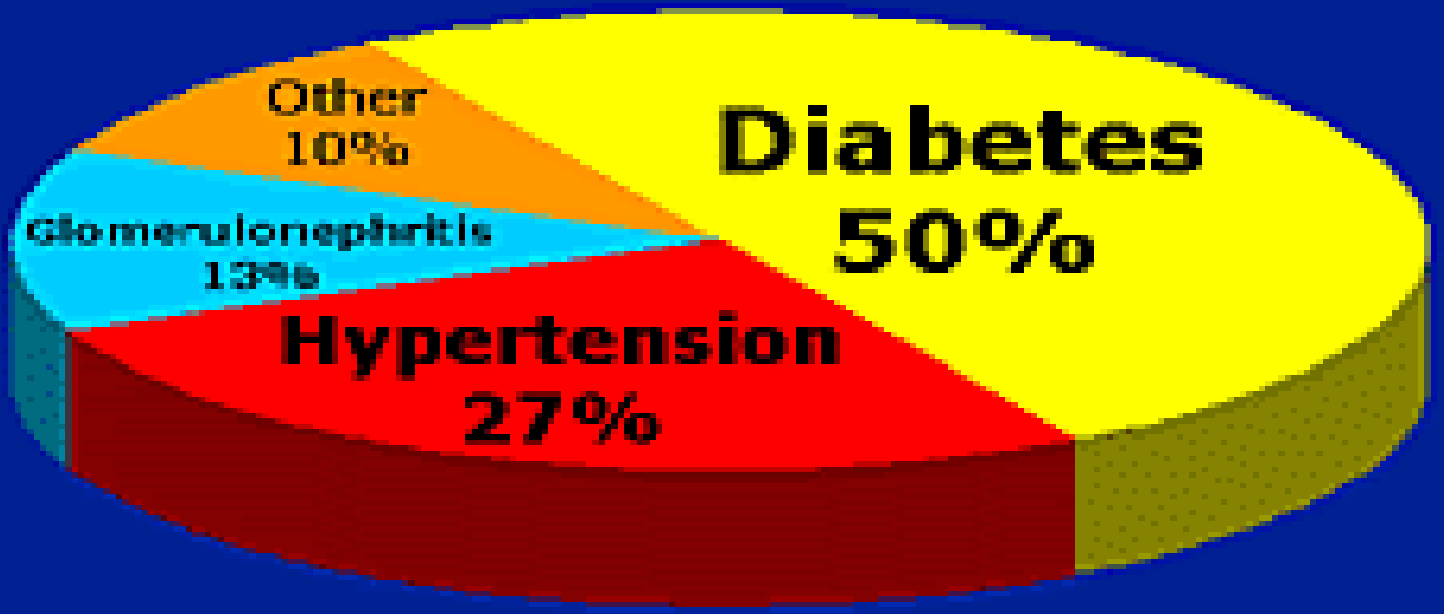
Diabetes, HTN and Glomerulonephritis cause 75% of CKD

- Diabetes: most common cause of ESRD
  - Over 30% cases ESRD are primarily to diabetes
- Hypertension causes about 25-30% ESRD cases
- Glomerulonephritis accounts for ~10% cases
- Polycystic Kidney Disease - about 5% of cases
- Rapidly progressive glomerulonephritis (vasculitis) - about 2% of cases
- Renal (glomerular) deposition diseases
- Renal Vascular Disease - renal artery stenosis, atherosclerotic vs. fibromuscular

Causes of CKD

- Additional Causes of CRF
  - **Medications** - especially causing tubulointerstitial diseases (common ARF, rare CRF)
  - **Analgesic Nephropathy** over many years
  - **Pregnancy** - high incidence of increased creatinine and **HTN** during pregnancy in CRF

Primary Diagnoses for Patients Who Start Dialysis



United States Renal Data System (USRDS)
2000 Annual Data Report • WWW.USRDS.ORG

Common Risk Factors for CKD

Diabetes

Hypertension

Age **> 55 years**

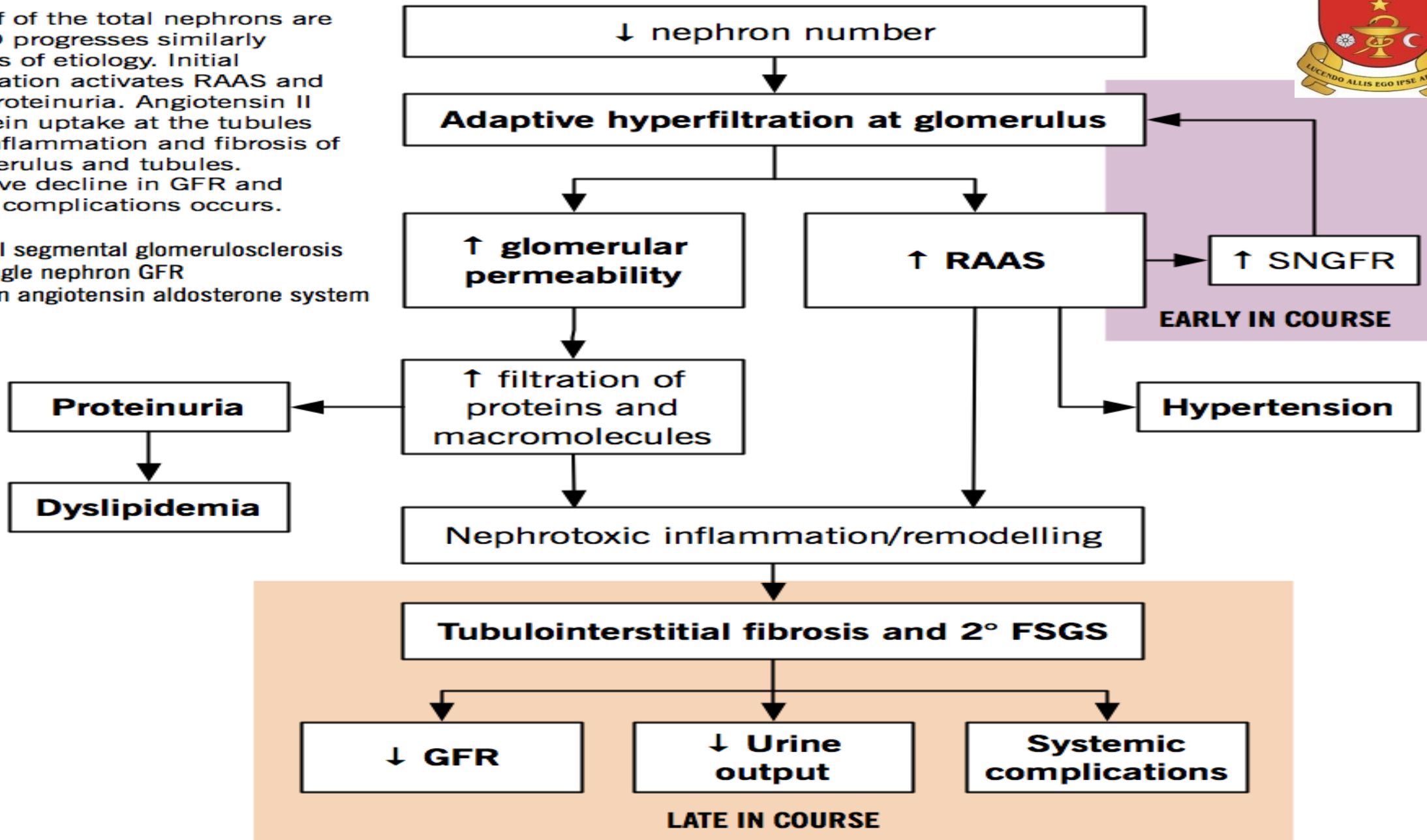
Family history of kidney disease

Obesity or metabolic syndrome

Pathogenesis of chronic kidney disease

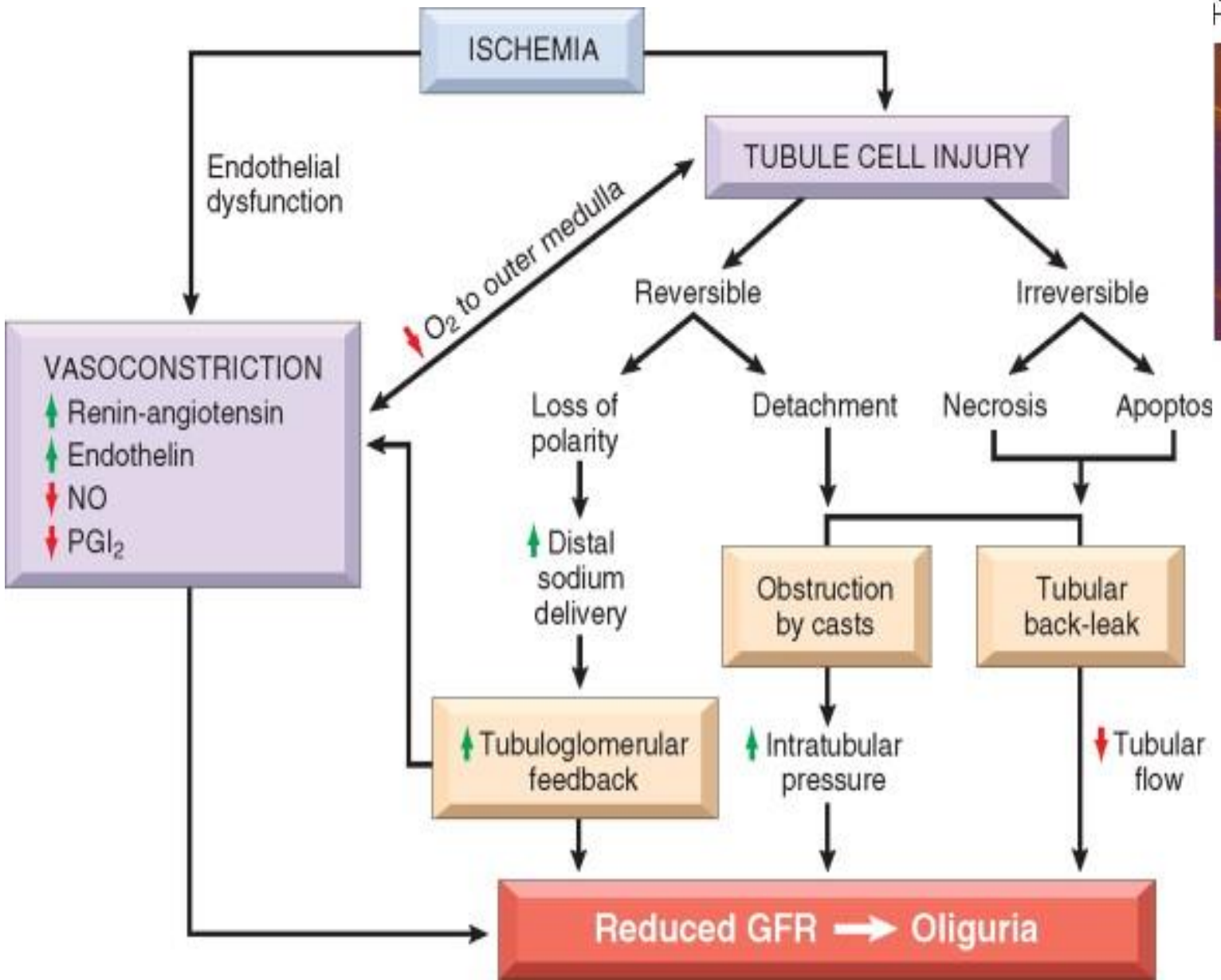
Once half of the total nephrons are lost, CKD progresses similarly regardless of etiology. Initial hyperfiltration activates RAAS and causes proteinuria. Angiotensin II and protein uptake at the tubules causes inflammation and fibrosis of the glomerulus and tubules. Progressive decline in GFR and systemic complications occurs.

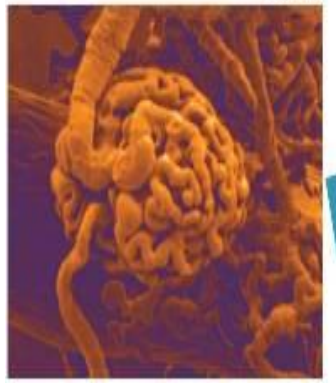
FSGS Focal segmental glomerulosclerosis
SNGFR Single nephron GFR
RAAS Renin angiotensin aldosterone system

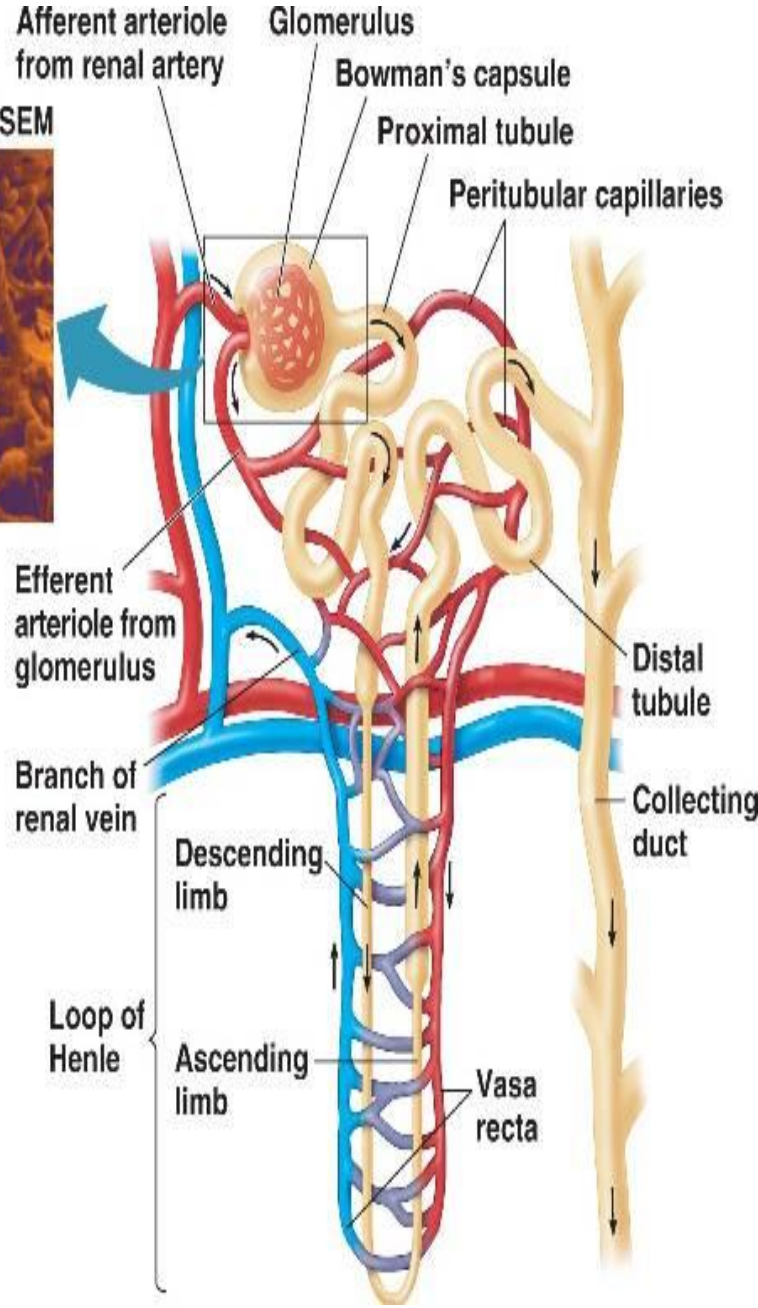


Pathophysiology

- **Repeated injury** to kidney







Albumin Contribution

Normal glomeruli structure limits proteins from filtering through the urine

- Progression of glomeruli injury leads to increased capillary filtration of albumin
- The liver compensates and increases albumin production - to replace albumin lost in urine
- This leads to increased synthesis of lipoproteins by the liver secondary to the compensatory increase in albumin production, and
- results in increased LDL levels – predisposing to atherosclerosis
- Atherosclerosis further increases glomeruli injury

Inflammation

- Inflammatory response can be triggered by: tissue injury, infections, toxins, immune responses and/or Angiotensin II
- Can be acute or chronic
- Can affect the renal pelvis and interstitial tissue as in pyelonephritis
- Can affect the glomeruli as in glomerulonephritis

Functional Changes of CRF

The Kidneys are unable to:

- Regulate fluids and electrolytes
- Balance fluid volume and RAAS
- Control blood pressure
- Eliminate urea and other wastes
- Synthesize erythropoietin
- Regulate serum phosphate and calcium levels

Uremic Syndrome

1. Symptomatic azotemia
2. Fever, Malaise
3. Anorexia, Nausea
4. Mild neural dysfunction
5. Uremic pruritus

Uremia

Water and mineral imbalance

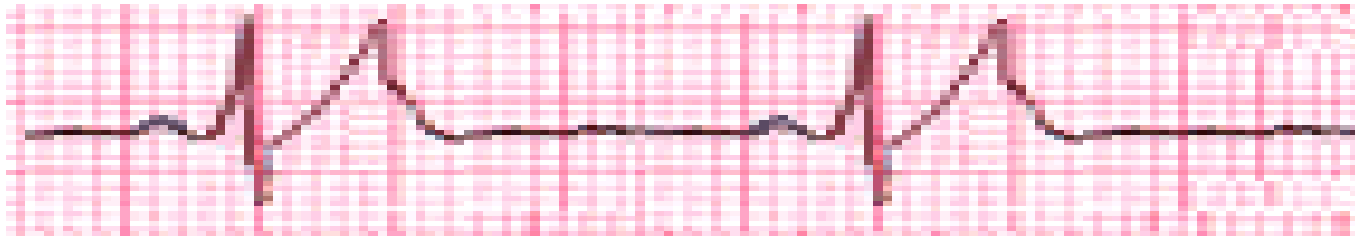
- **water loss / water retention**
- **↓ Na (dilution, distribution, depletion)**
- **↑ K (retention)**

edema ± dehydration

weakness, fatigue

dyspepsia (anorexia, morning nausea, vomiting, diarrhea)

arrhythmia, pericarditis



Signs & Symptoms

- **General**
  - Fatigue & malaise
  - Edema
- **Ophthalmologic**
  - AV nicking
- **Cardiac**
  - HTN
  - Heart failure
  - Pericarditis
  - CAD
- **GI**
  - Anorexia
  - Nausea/vomiting
- **Skin**
  - Pruritus
  - Pallor
- **Neurological**
  - MS changes
  - Seizures

Key Aspects of the Medical History in Evaluating Patients with CKD

- Prior kidney disease or dialysis
- Incidental albuminuria or hematuria (microscopic or gross) in the past
- Urinary symptoms such as nocturia, frequency, polyuria, urgency, hesitancy; a history of foamy/frothy urine may indicate prior heavy proteinuria
- History of nephrolithiasis
- Family history of kidney disease
- Diseases that share risk factors with CKD: DM, HTN, CAD, PAD, heart failure
- Systemic diseases that might affect kidney (e.g., rheumatologic diseases, especially SLE, Sjögren's, Systemic Sclerosis)
- History of use of medications that might affect renal function: OTC (especially NSAIDs and herbal medications) or prescription (e.g., lithium, calcineurin inhibitors)

Clinical manifestations in different stages

CKD stage	eGFR	Clinical manifestations
1	≥ 90	-Symptoms due to primary renal disease - HTN more often comparative with patients without CKD
2	60-89	- Symptoms due to primary renal disease - HTN frequently
3	30-59	- HTN (in 50-60% of cases) - Decrease of calcium absorption - Decrease of phosphate excretion - Increase of PTH - Decrease of 25(OH)D and/or 1,25(OH) 2D - Renal anemia - Left ventricular hypertrophy

Clinical manifestations in different stages

CKD stage	eGFR	Clinical manifestations
4	15-29	Symptoms from previous stage, more pronounced, plus: - Metabolic acidosis - hyperkalemia - malnutrition - Decrease in libido
5	<15	Severe symptoms from previous stage, plus: - hydro-saline retention causing apparent CF - anorexia - vomiting - pruritus

Neuromuscular disturbances

- Fatigue
- Sleep disorders
- Headache
- Impaired mentation
- Lethargy
- Asterixis
- Muscular irritability
- Peripheral neuropathy
- Restless legs syndrome
- Myoclonus
- Seizures
- Coma
- Muscle cramps
- Dialysis disequilibrium syndrome
- Myopathy

Cardiovascular and pulmonary disturbances

- Arterial hypertension
- Congestive heart failure or pulmonary edema
- Pericarditis
- Hypertrophic or dilated cardiomyopathy
- Uremic lung
- Accelerated atherosclerosis
- Hypotension and arrhythmias
- Vascular calcification

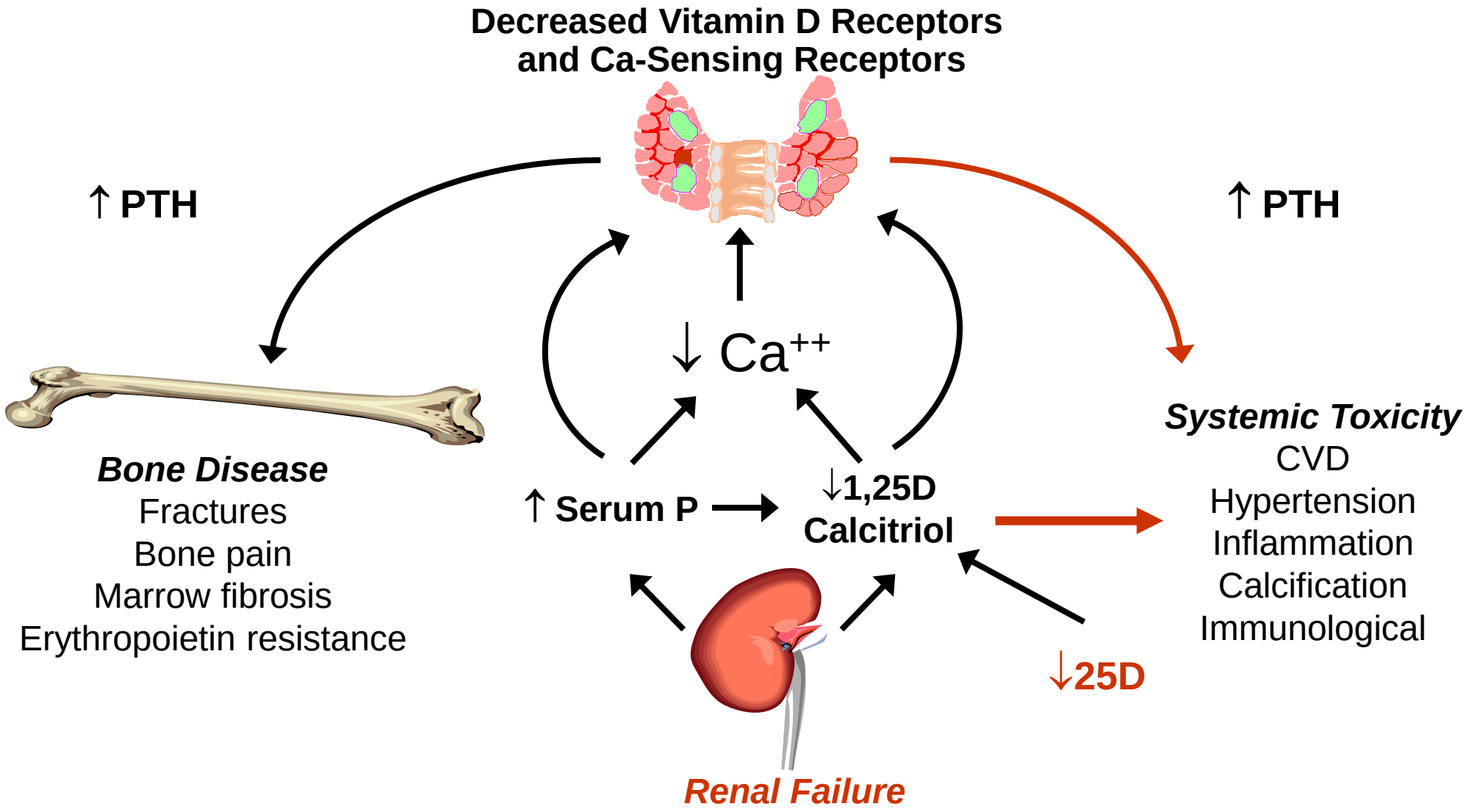
Gastrointestinal disturbances

- Anorexia
- Nausea and vomiting
- Gastroenteritis
- Peptic ulcer
- Gastrointestinal bleeding
- Idiopathic ascites
- Peritonitis

Endocrine-metabolic disturbances

- Secondary hyperparathyroidism
- Adynamic bone
- Vitamin D–deficient osteomalacia
- Carbohydrate resistance
- Hyperuricemia
- Hypertriglyceridemia
- Increased Lp(a) level
- Decreased high-density lipoprotein level
- Protein-energy malnutrition
- Impaired growth and development
- Infertility and sexual dysfunction
- Amenorrhea
- β_2-Microglobulin–associated amyloidosis

Feedback Loops in SHPT

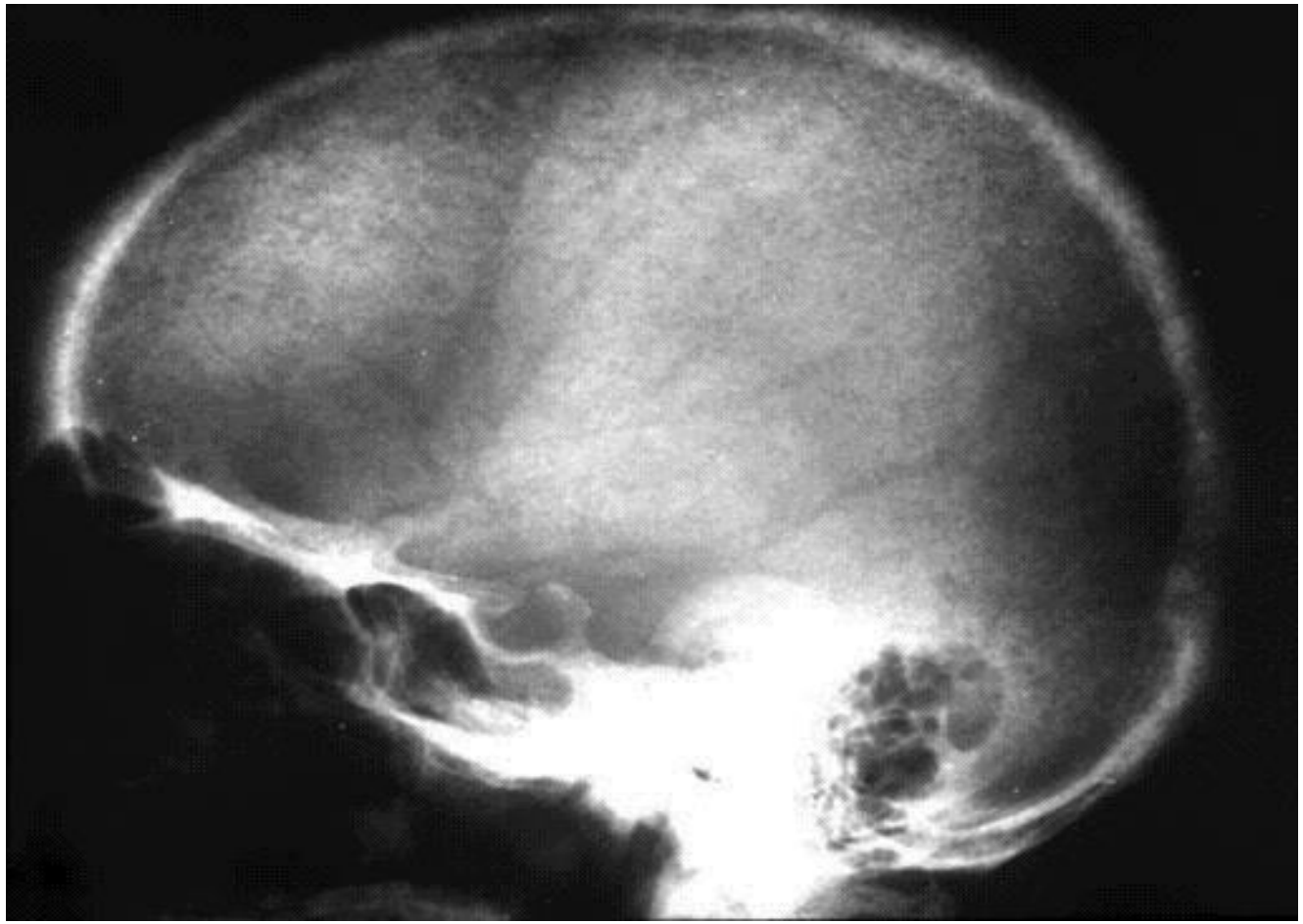


Ca = calcium; CVD = cardiovascular disease; P = phosphorus.

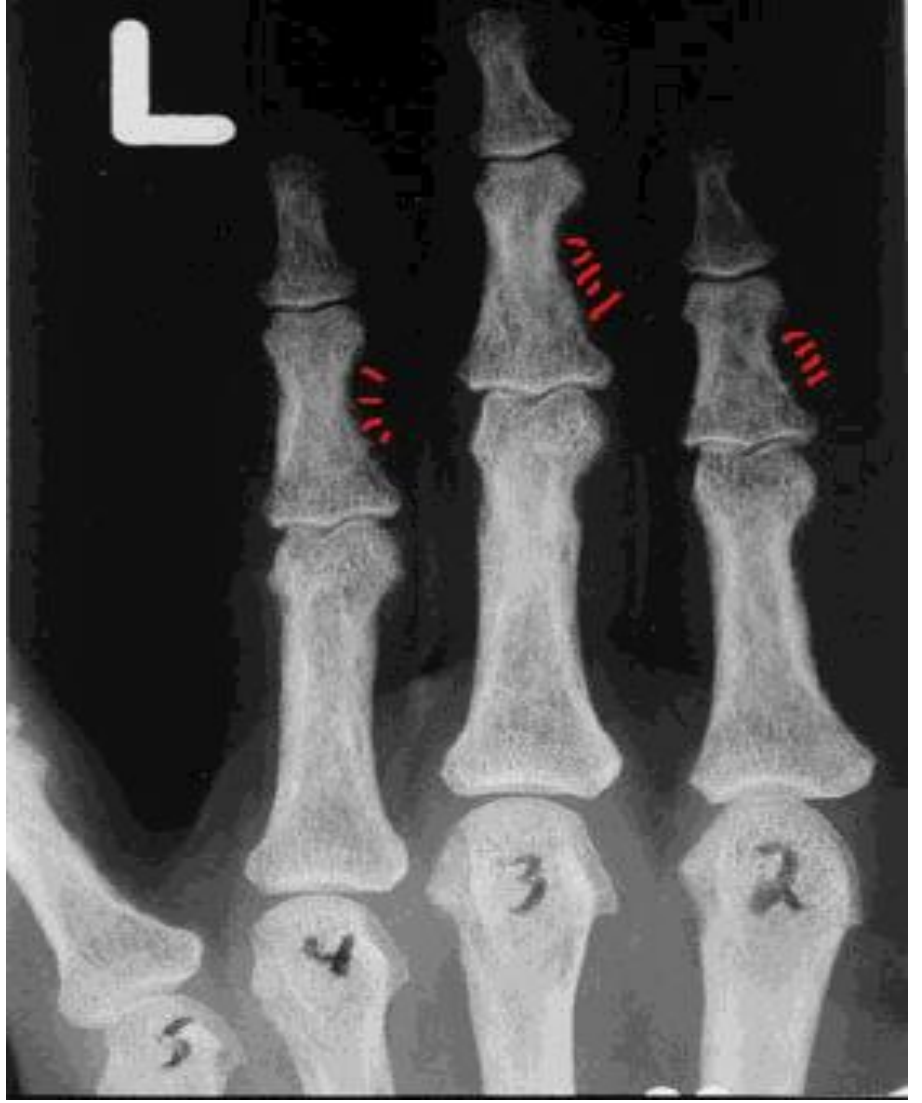
Courtesy of Kevin Martin, MB, BCh.

Uremia

Renal osteodystrophy



„Salt and peper“ scull



Increased parathyroid activity leading to characteristic

subperiosteal resorption

Dermatologic disturbances

- Pallor
- Hyperpigmentation
- Pruritus
- Ecchymosis
- Nephrogenic fibrosing dermopathy
- Uremic frost

Fluid and electrolyte disturbances

- Volume expansion
- Hyponatremia
- Hyperkalemia
- Hyperphosphat-emia

Hematologic and immunologic disturbances

- Anemia
- Lymphocytopenia
- Bleeding diathesis
- Increased susceptibility to infection
- Leukopenia
- Thrombocytopenia

Diagnosis of CKD

There are two phases:

- Diagnosis of CKD - clinically, laboratory, imagistic and stadialization of CKD;
- Identification of causal nephropathy.

Laboratory tests.

Relevant laboratory tests for CKD include:

- GFR,
- urinalysis, (hematuria, proteinuria and/or albuminuria, urine microscopy)
- spot urine albumin-to-creatinine ratio.
- Electrolytes, acid-base balance
- Other tests to reveal organ damage in CKD

The *eGFR* is primarily determined by serum creatinine (SCr), and the preferred method for estimating GFR is the body surface area-normalized, 4-variable, Modification of Diet in Renal Disease Study (MDRD) Equation based on SCr, age, gender, and ethnicity.

MDRD (Modification in Diet and Renal Disease Study) 4 variable equation

GFR (mL/min/1.73 m^2) = **186 x** (SCr) $^{-1.154}$ x (Age) $^{-0.203}$ x (0.742 if female) x (1.210 if African-American)

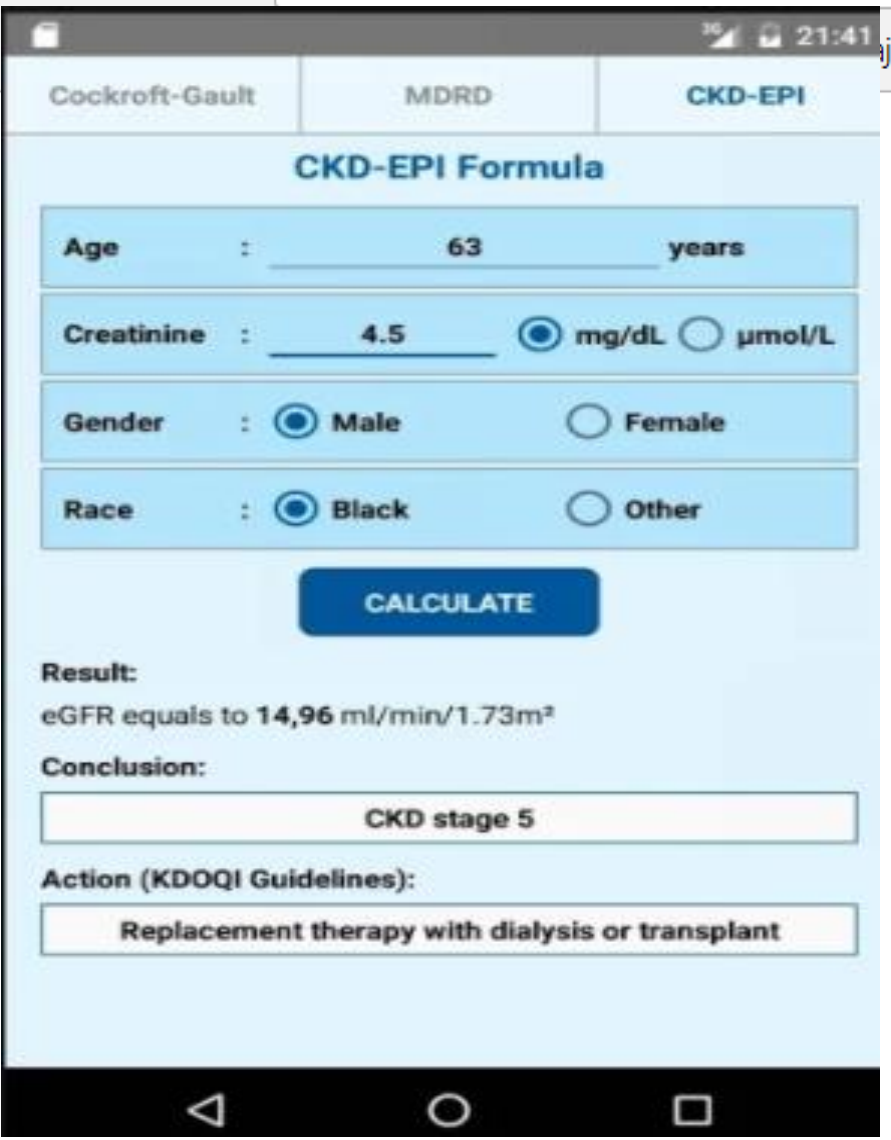
CKD-EPI (Epidemiology Collaboration) equation

GFR = 141 X $\min(SCr/\kappa,1)^{\alpha}$ X $\max(SCr/\kappa,1)^{-1.209}$ X 0.993 X 1.018 [if female] X 1.159 [if black]

The Cockcroft and Gault formula (1973)

C_{Cr}={((l 40–age) x weight)/(72xS_{Cr})}x 0.85 (if female)

Online CKD EPI & MDRD GFR Calculator (with SI Units):
http://www.kidney.org/professionals/kdoqi/gfr_calculator.cfm



MDRD GFR Calculator - (SI Units Version)

by Stephen Z. Fadem, M.D., FACP, FASN

Serum creatinine 113
mg/dL µmol/L

Creatinine methods recalibrated to be traceable to IDMS.

Age 65 years

Race African American All other races*

Gender Male Female

GFR Value:45 mL/min/1.73 m^2

(Age, Race, Gender, Plasma creatinine)

Chronic kidney disease (GFR less than 60 or kidney damage for at least three months)

*All ethnic groups other than African American

NOTE: The estimated GFR values above 60 mL/min/1.73 m2 should be interpreted as "above 60 mL/min/1.73 m^2," not an exact number.

Back to MDRD GFR
Pediatric Calculator
Cockcroft-Gault Calculator
Cockcroft-Gault Calculator (defaults to SI Units)
MDRD Calculator - Extended - Defaults to SI Units
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- Urinary abnormalities, electrolyte imbalances, uncontrolled HTN, or metabolic abnormalities constitute reasons to initiate nephrologic consultation.

- ***Glomerular Filtration Rate (GFR)***
- MDRD Study GFR <60 mL/min/1.73 m^2
- Cockroft-Gault CrCl <60 mL/min/1.73 m^2

- ***Serum Creatinine (SCr)***
- Males – 1.5-1.7 mg/dL on two separate occasions, separated by at least 2 wk, unless AKI/ARF is established
- Females –1.1-1.3 mg/dL on two separate occasions, separated by at least 2 wk, unless AKI/ARF is established

Ultrasound

- Ultrasound of the kidneys in CKD evaluation - the size and echogenicity of kidneys have important prognostic value.
- Findings such as stones, masses, or hydronephrosis should prompt urologic evaluation.
- Significant renovascular abnormalities should be referred to nephrologist.
- Renal ultrasound may be considered in all patients with eGFR < 60 both for evaluation and establishing a baseline.

Ultrasound is *strongly recommended in a patient with any* of the following:

- Symptoms or signs consistent with obstruction
- Family history of cystic kidney disease, especially if age > 20
- Rapid progression of CKD or significant change in the rate of progression of CKD

- Renal ultrasound *with Doppler should be considered for* patients with resistant hypertension, bruit on physical exam, or finding of asymmetric kidney sizes on initial ultrasound or other imaging study.

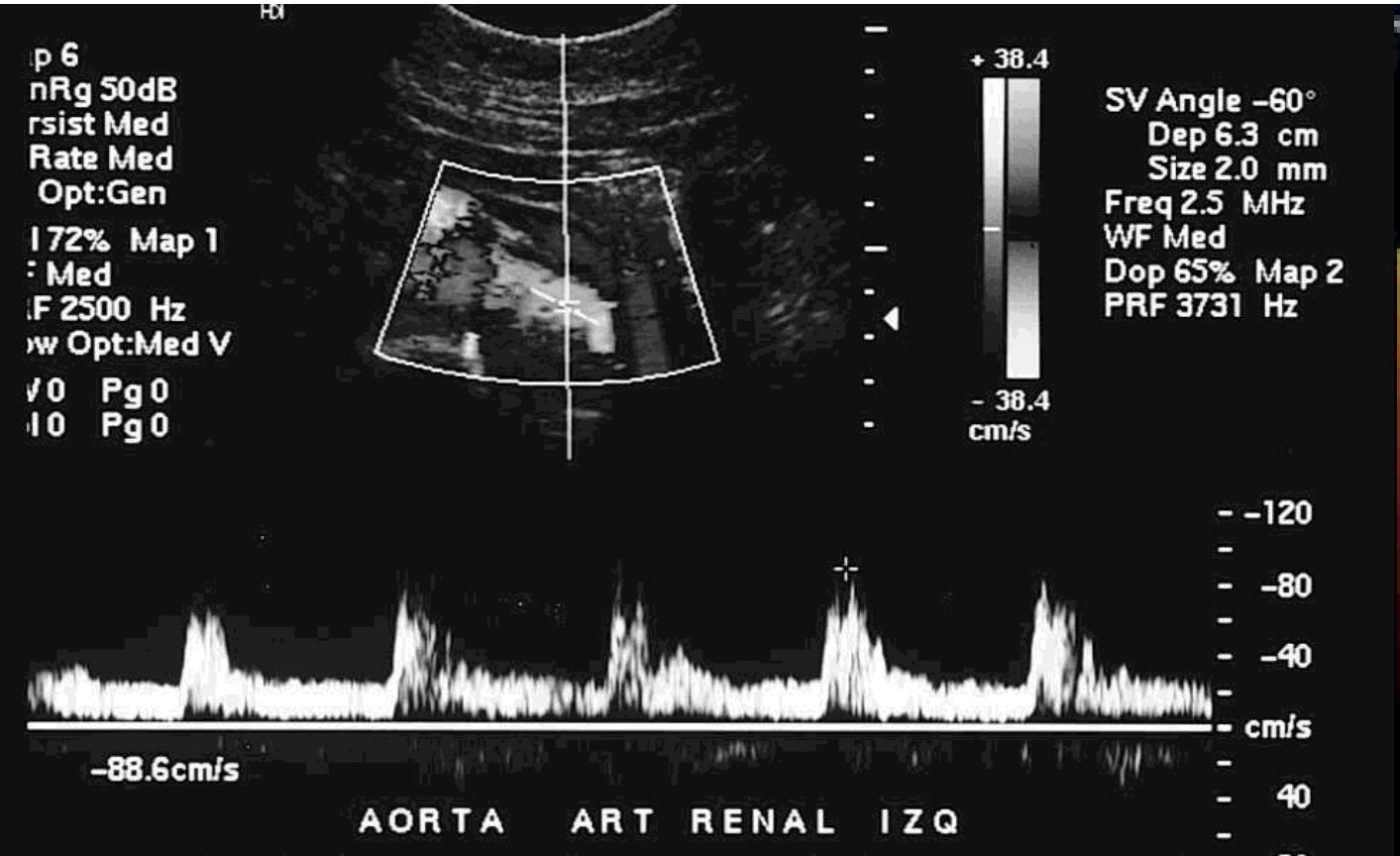
Graphic procedures

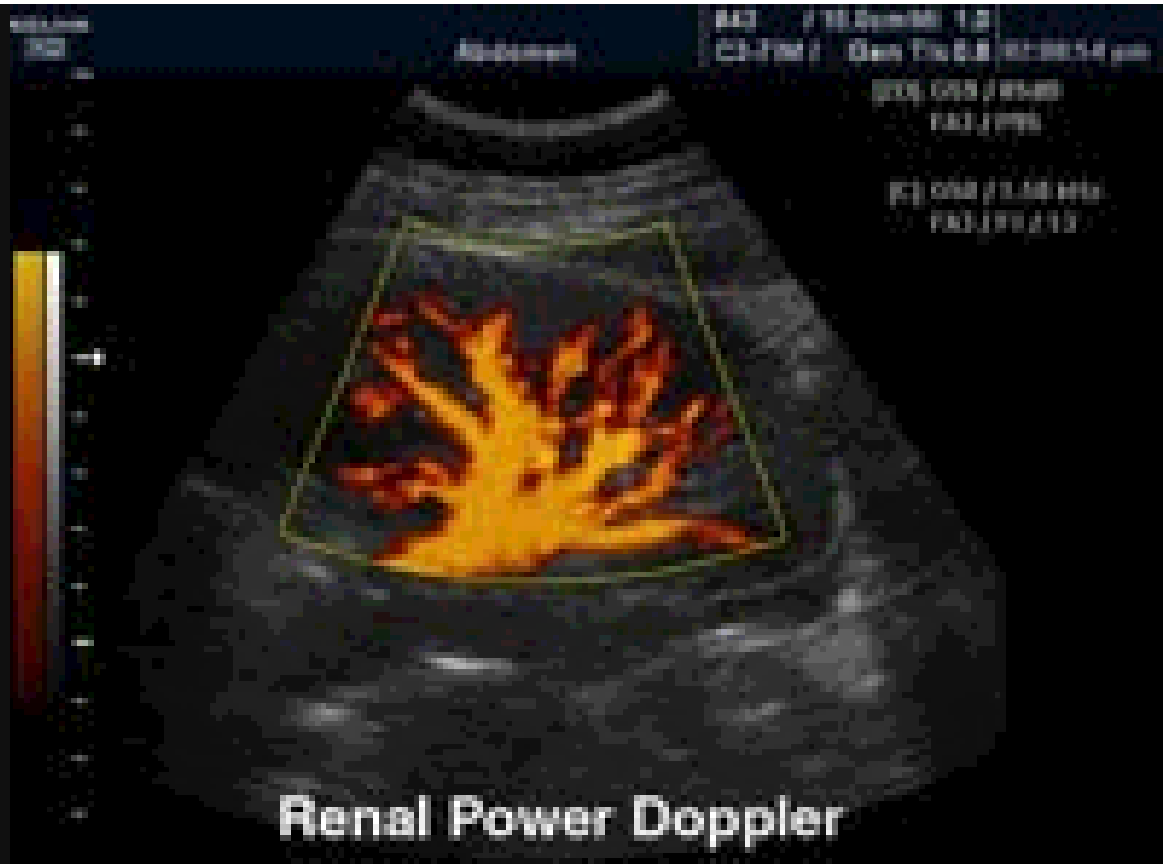
1. Ultrasonography

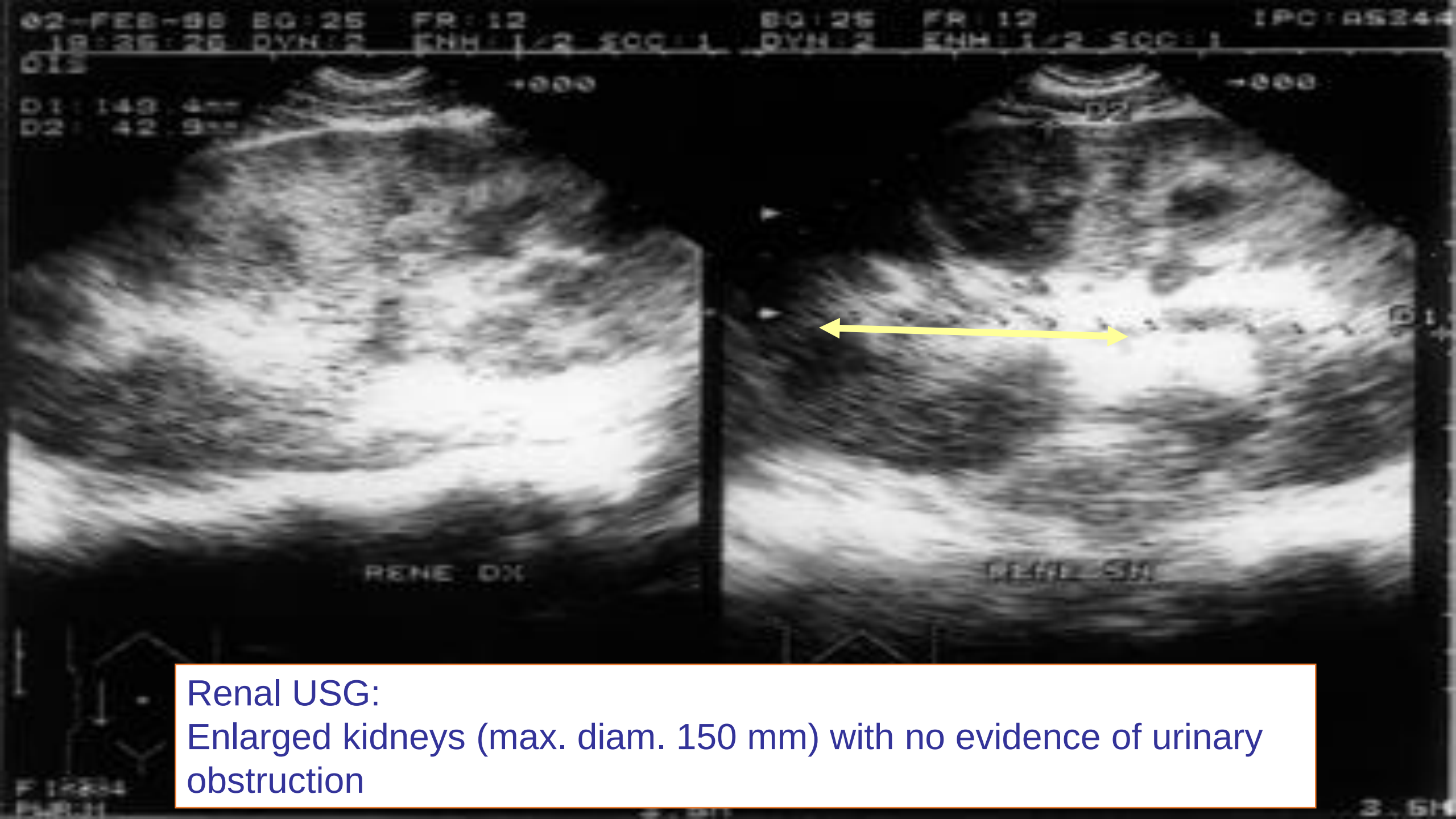
Basic graphic examination

2D USG: Size, shape, localization, symmetry, tumors, lymphonodi...)

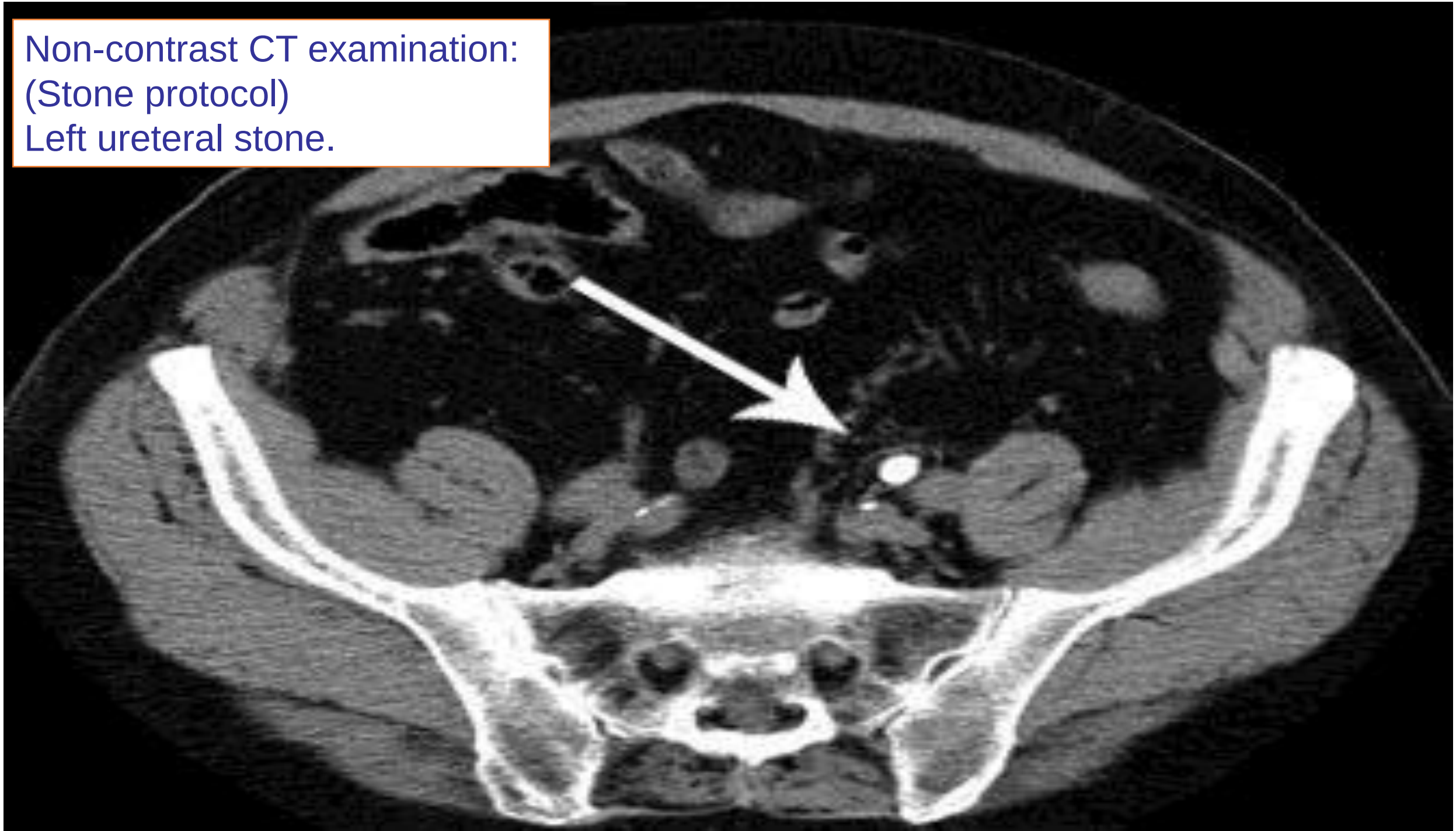
Doppler / Color Doppler: aa. renalis (stenosis)



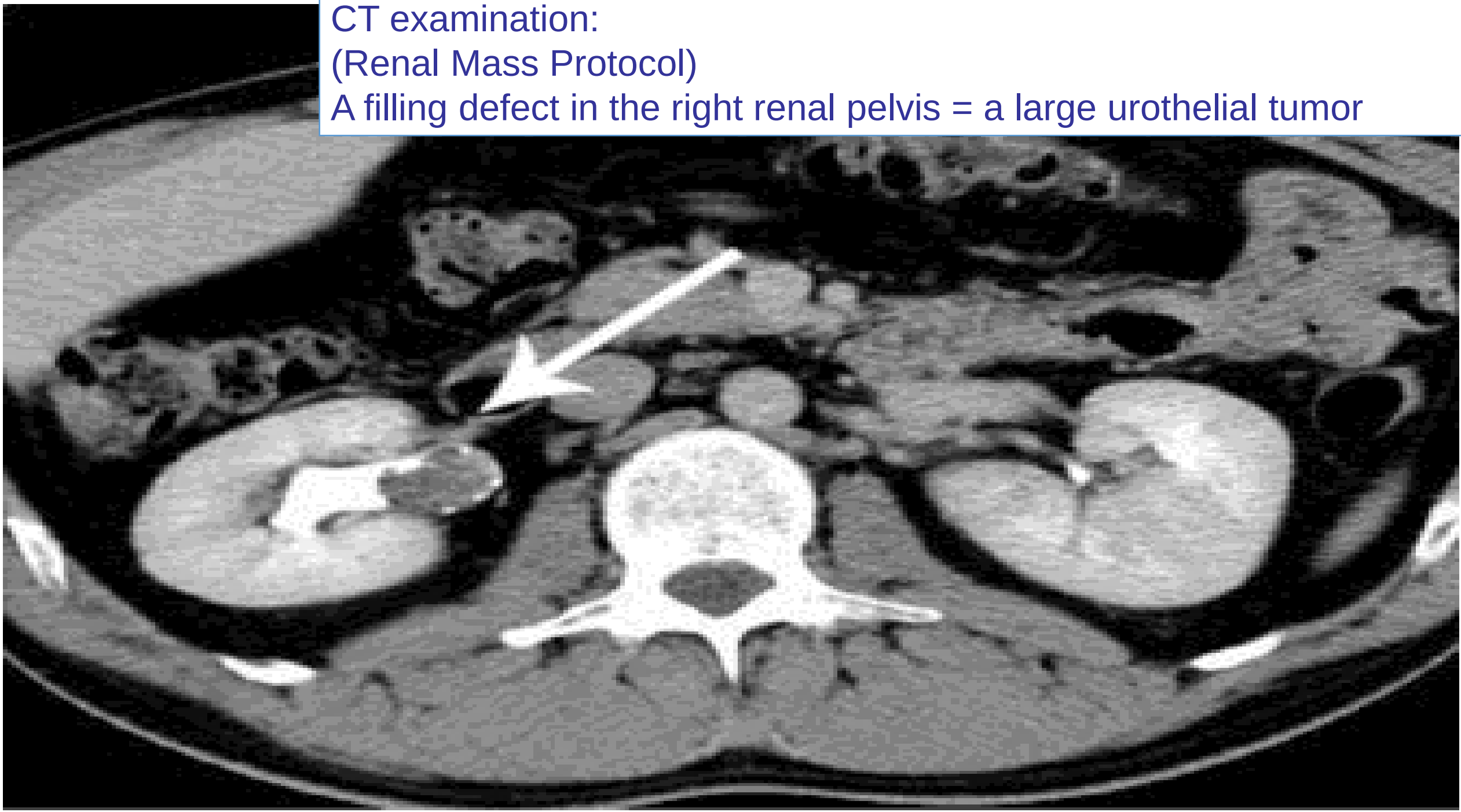




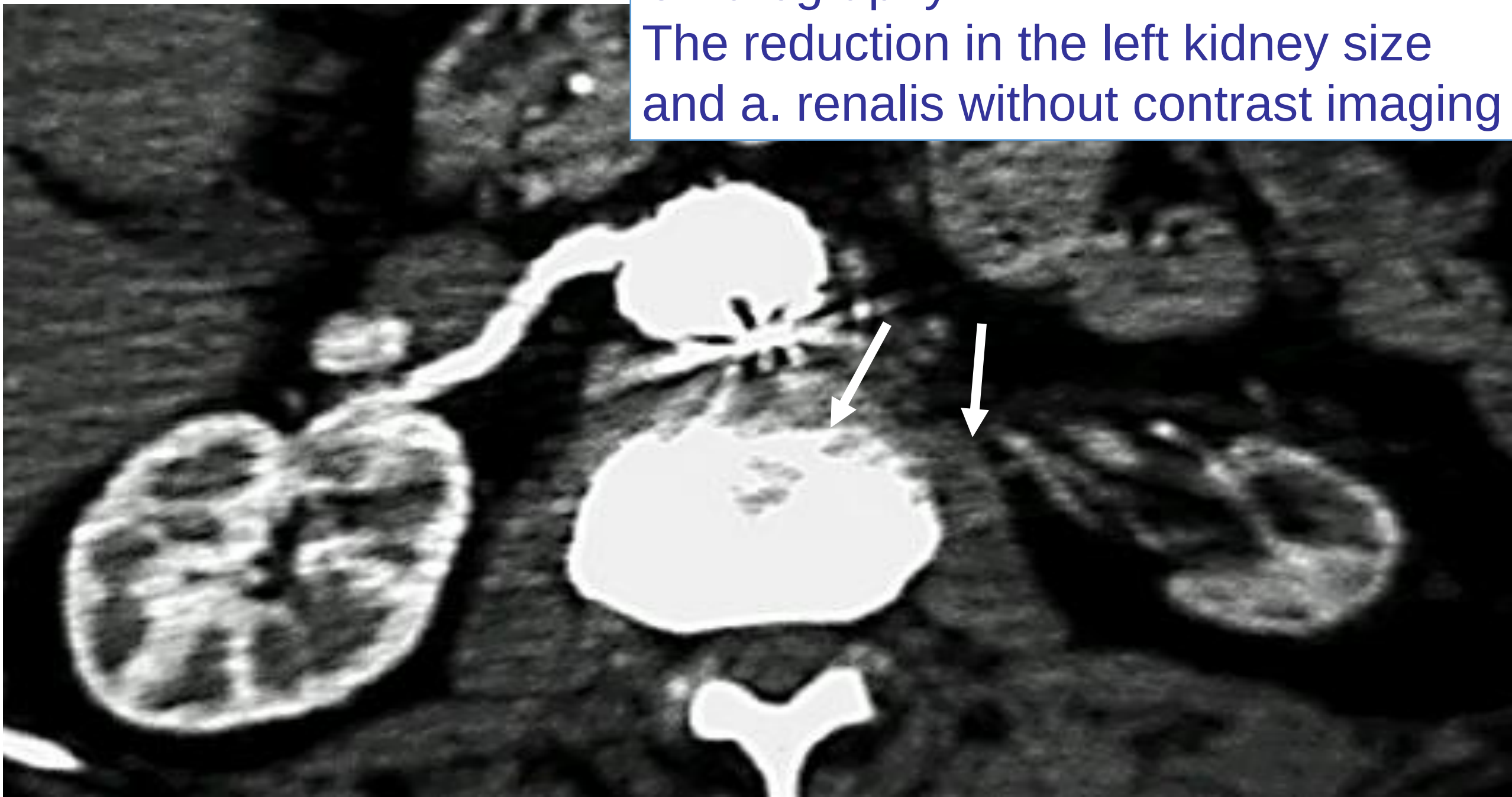
Renal USG:
Enlarged kidneys (max. diam. 150 mm) with no evidence of urinary obstruction


Non-contrast CT examination:
(Stone protocol)
Left ureteral stone.

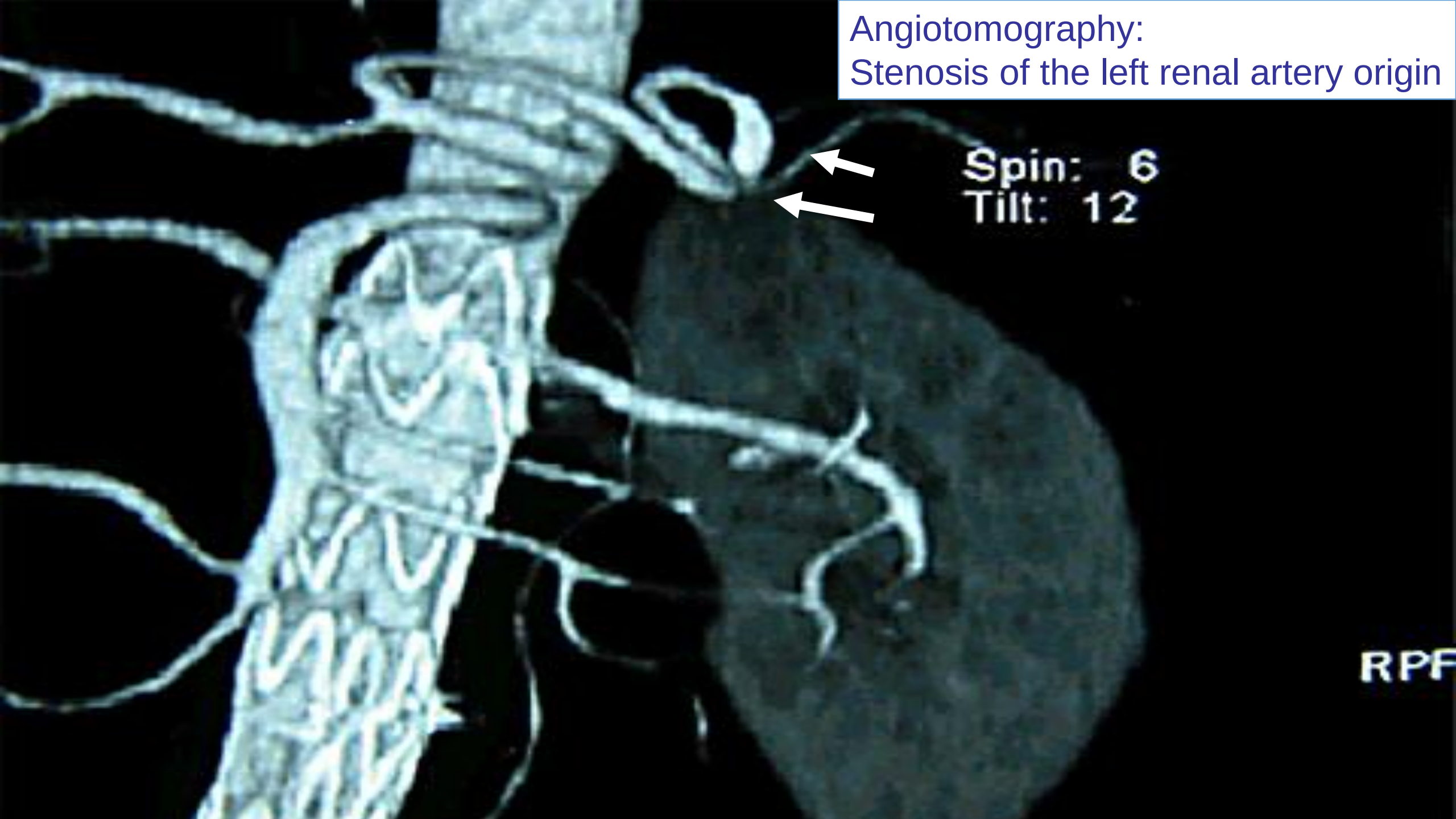
CT examination:
(Renal Mass Protocol)
A filling defect in the right renal pelvis = a large urothelial tumor

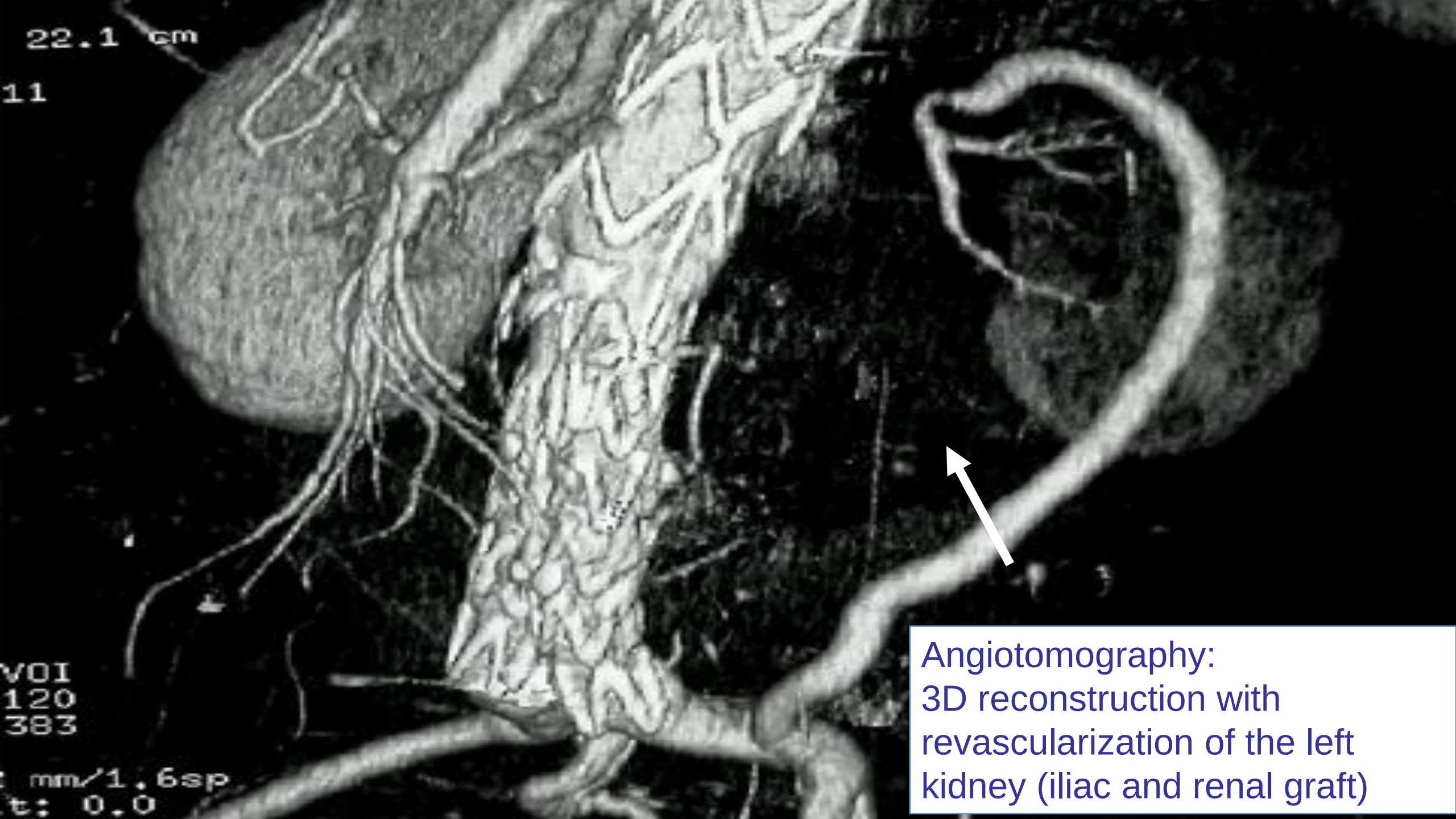


CT urography:
The reduction in the left kidney size and a. renalis without contrast imaging



Angiotomography:
Stenosis of the left renal artery origin

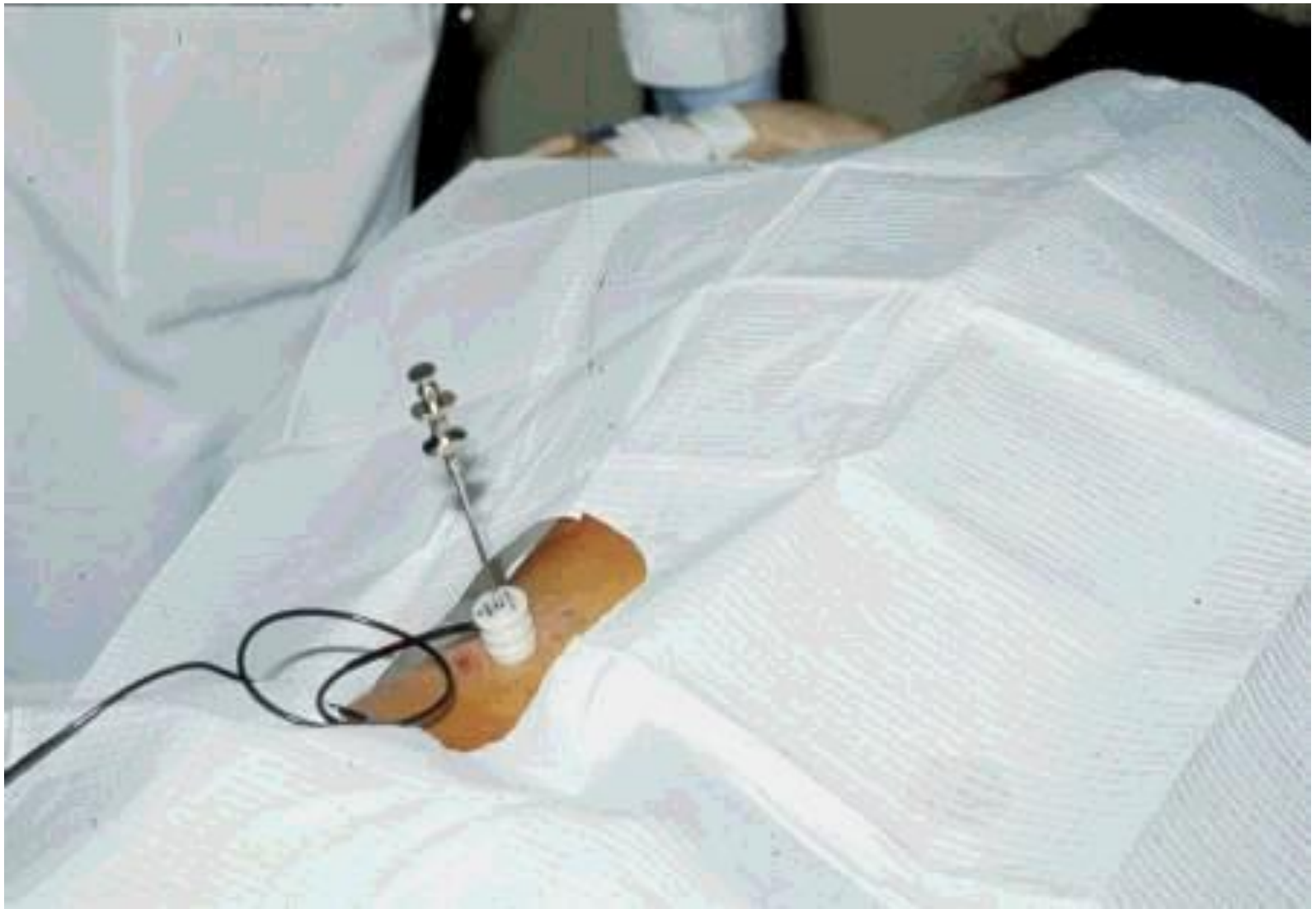


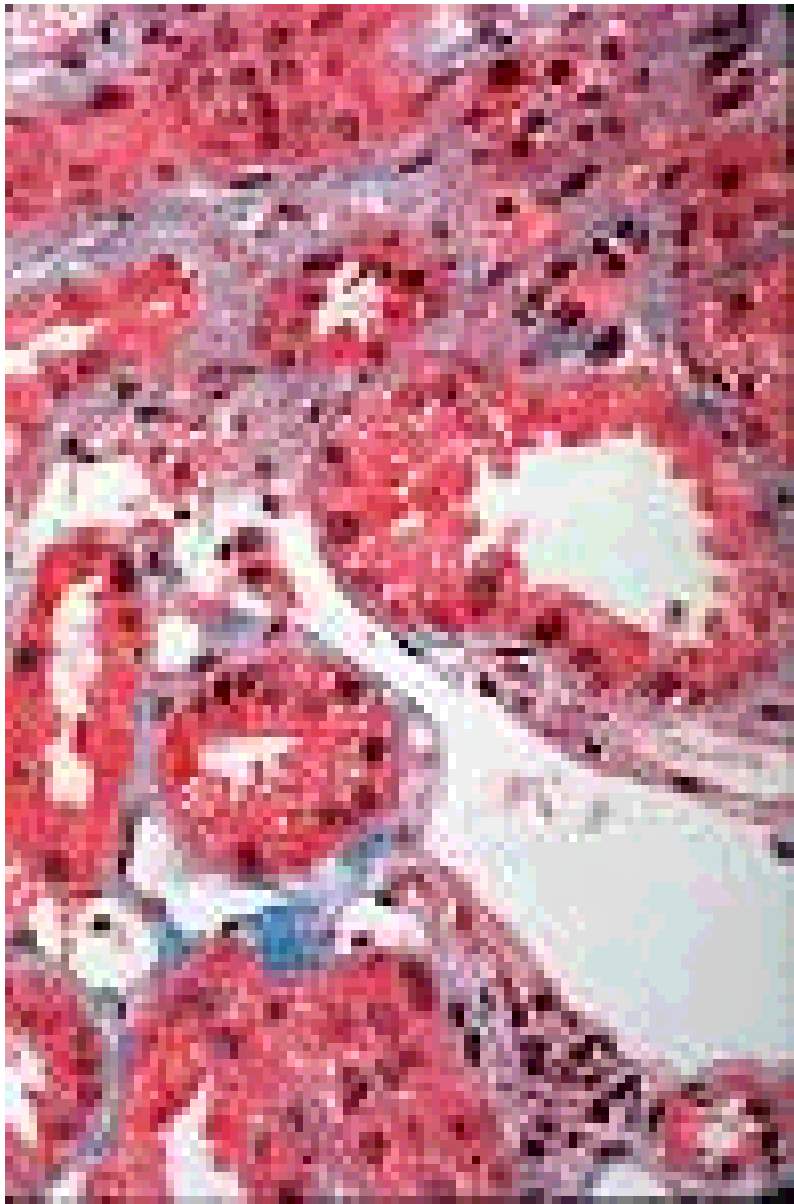


Angiotomography:
3D reconstruction with revascularization of the left kidney (iliac and renal graft)

Biopsy

Percutaneous renal biopsy





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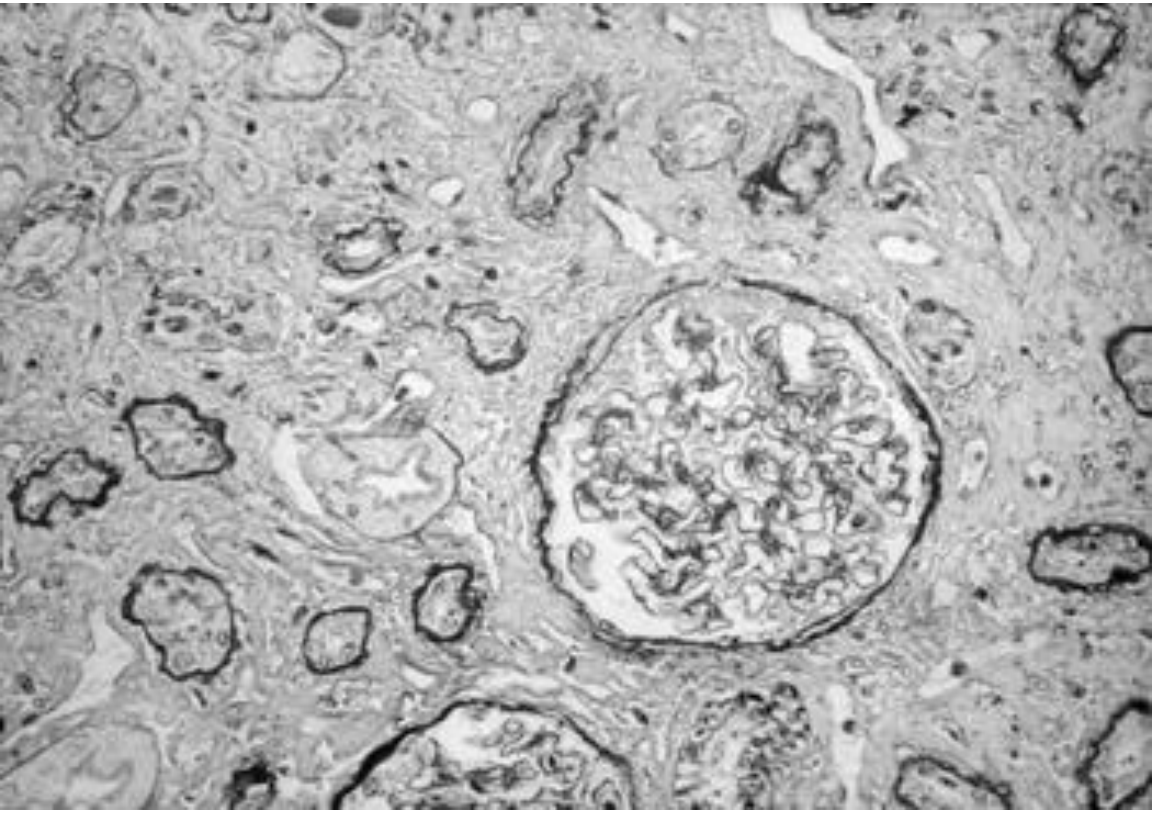
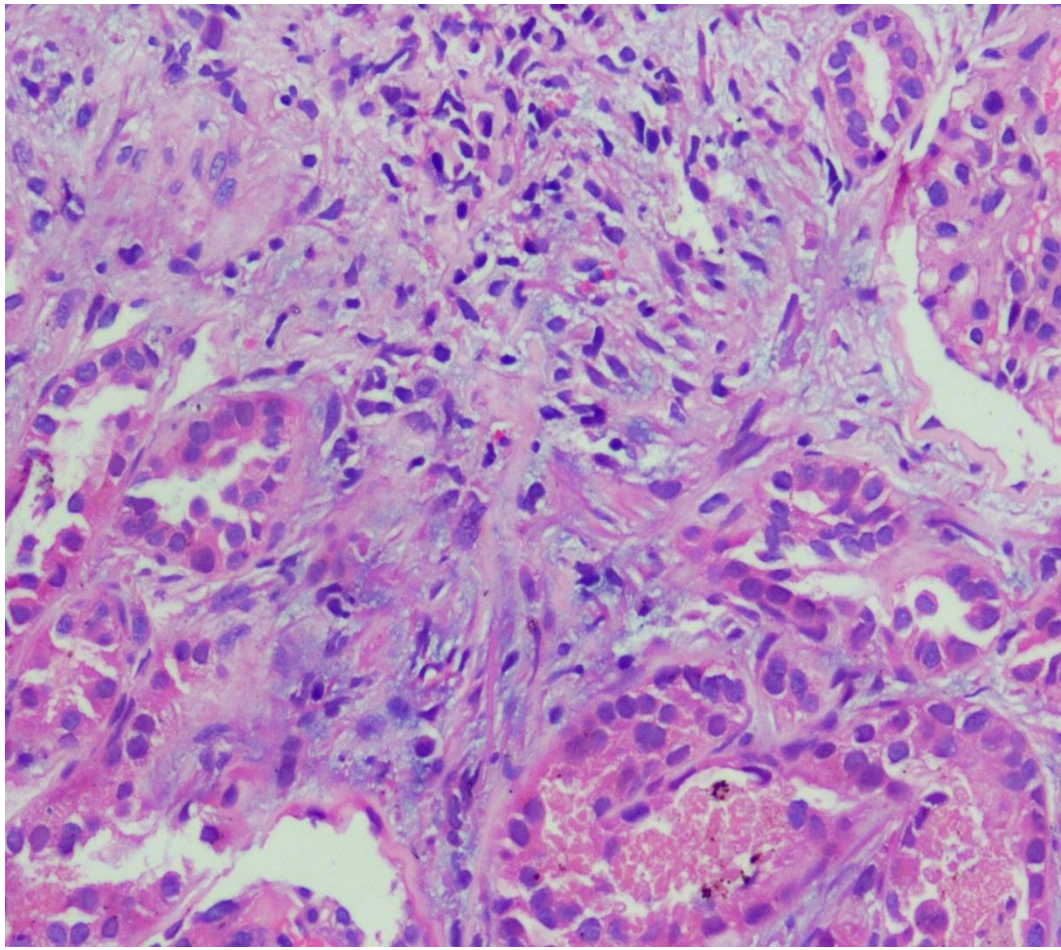
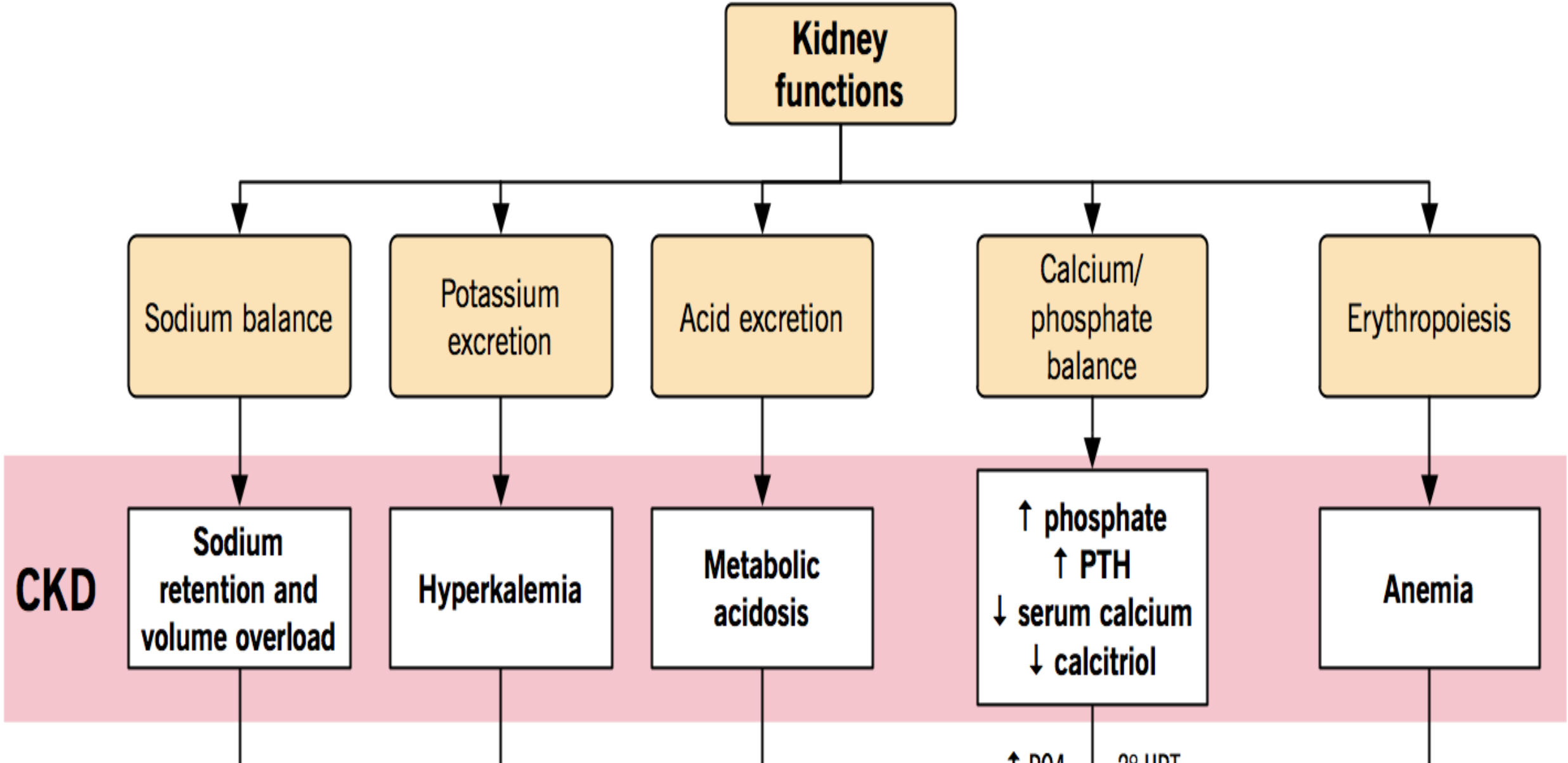


Diffuse interstitial fibrosis and tubular atrophy



Tubulointerstitial nephritis

Complications of CKD

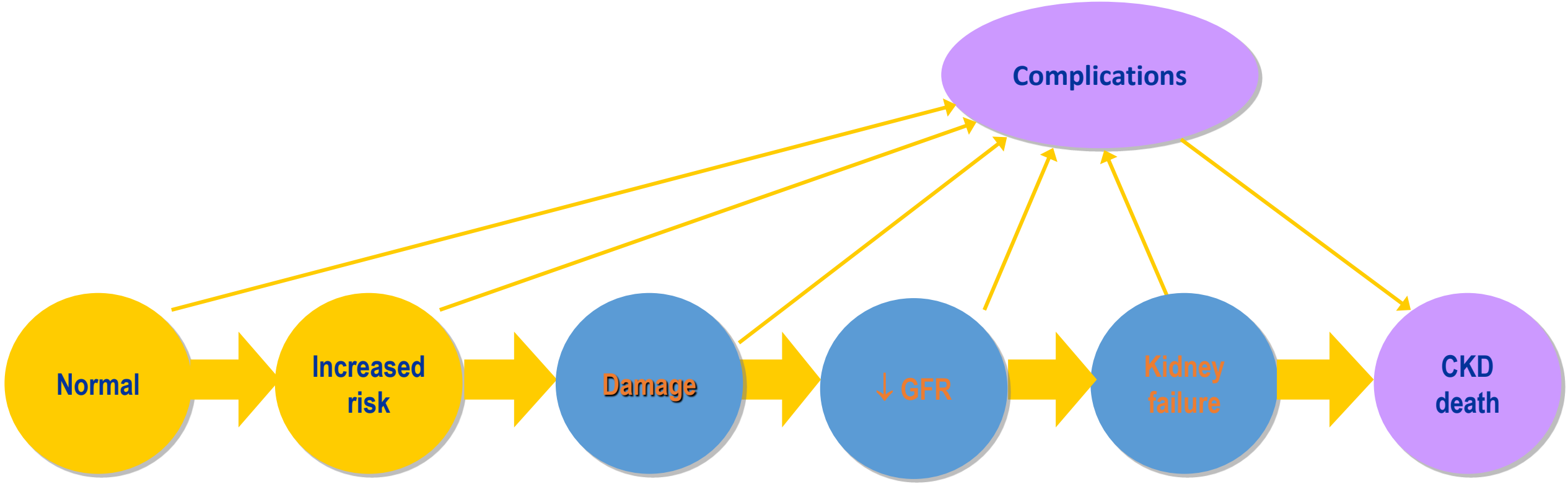


Management of CKD

Targets:

- slowing down the rate of CKD progression;
- prophylaxis / therapy of complications;
- patient preparation for renal substitutive therapy (dialysis, peritoneal dialysis or renal transplant).

Stages in Progression of Chronic Kidney Disease and Therapeutic Strategies



Screening for CKD risk factors

CKD risk reduction; Screening for CKD

Diagnosis & treatment; Treat comorbid conditions; Slow progression

Estimate progression; Treat complications; Prepare for replacement

Replacement by dialysis & transplant

Management of CKD

- The direct management of CKD focuses on renin angiotensin aldosterone blockade (RAAS) and blood pressure control.
- Management also includes optimal management of common comorbid conditions such as diabetes and addressing cardiovascular risk factors to decrease risk for CVD.
- Also essential are patient education and a multidisciplinary approach to disease management that utilizes dieticians and social workers in addition to physicians

Treatment of CKD at 3-4 stages (pre-dialysis)

1. Hygienic-dietetic specific recommendations
2. Control of Hypertension
3. Correction of anemia
4. Correction of changes in phosphor - calcium (mineral) metabolism
5. Statins
6. Correction of aggravation CKD factors
7. Correction of acidosis (if RA<20mEq/l)
8. Antiviral treatment (in HBV or HCV hepatitis)
9. Patient preparation to dialysis.

Diet in CKD, stages 3-4

- **Caloric input** ≈ 35cal/kg/day, less in obese and aged patients (apr. 32 cal/kg/day);
- **Fluids intake:** diurezis + 500 ml/day
- **Hypoproteic** (0,6-0,8 g/kg/day)
- **Hyposodic** (2-3 g/day) in hypertensive patients or with cardiac failure
- **Normal potassium intake** in diuresis > 1000ml and eGFR > 10ml/min,
- Limited in anorganic phosphates
- **Hypolipidic**

Control of high blood pressure

- RAAS therapy with either an angiotensin ***converting enzyme inhibitor*** (ACEI) or an ***angiotensin receptor blocker*** (ARB) is recommended for patients with CKD to prevent or decrease the rate of progression to ESRD.
- An ACEI or ARB should be the ***first line agent for antihypertensive therapy*** for CKD patients and is recommended for ***patients with albuminuria*** regardless of need for blood pressure control.
- Dual therapy with an ACEI and an ARB should be considered only for patients with severe albuminuria (> 1g/day).

- Initial selection of a specific drug should be based on cost, potential side effects, and patient preference
- With decreasing kidney function, starting doses for both ACEIs and ARBs are lower.
- When starting an ACEI or an ARB, monitoring blood pressure, potassium, and serum creatinine levels is important.
- Potassium and/or serum creatinine are expected to increase when starting or changing the dose of an ACEI or an ARB.

ACE inhibitors

Mechanism of action

- It blocks the conversion of angiotensin I into angiotensin II, resulting in vasodilatation and lowering of blood pressure. Alternative pathways producing angiotensin II are not impaired.
- Generally, the increased ACE dose does not alter the peak effect but may extend the response time.

Side effects

- Impaired renal function in renal artery stenosis and hypovolemia.
- Hypotension.
- Hyperkalemia occurs most commonly in patients with impaired renal function.
- Coughing (Bradykinin-induced cough reflex)
- Angioneurotic edema. Rarely.
- A reduced secretion of erythropoietin that may cause or worsen anemia.
- Rash and altered taste (particularly Captopril)

ACE inhibitors

Medicine	Dose mg/day (t/day)
Captopril	50–150 (2-3)
Enalapril	5–40 (1-2)
Lisinopril	10–40 (1)
Ramipril	2,5–20 (1-2)
Perindopril	4–8 (1-2)
Benasepril	10–40 (1-2)
Trandolapril	1–4 (1)
Fosinopril	10–40 (1)
Moexipril	7,5–30 (1)
Spirapril	3–6 (1)
Quinapril	10–40 (1)

Angiotensin receptor blockers (ARB)

Mechanism of action.

- There are two subtypes of A2 receptors.

- Activation of AT1 receptor by A2 leads to vasoconstriction and myocardial and arterial wall enlargement

- The functions of the AT2 receptor, however, are less well known.

- ***Sartans block the AT1 receptors, thus inhibiting the vasoconstrictor effect of angiotensin 2.***

Adverse effects

- It is commonly very well tolerated, whereas the adverse effects are similar to ACEI

- Cases of angioedema have been reported

- Altered taste

- Contraindicated in pregnancy

Angiotensin receptor blockers (ARB)

Medicine	Dose mg/day (t/day)
Losartan	25–100 (1-2)
Valsartan	80–320 (1)
Candesartan	8–32 (1)
Irbesartan	150–300 (1)
Telmisartan	20–80 (1)
Eprosartan	400–800 (1-2)
Olmesartan	20–40 (1)

Calcium chanel blockers (ARB)

Mechanism of action.

- It blocks voltage dependent L-type $Ca2^+$ channels → impairs calcium entry into smooth muscle cells → impairs smooth muscle contraction → reduces vascular resistance → leads to arterial vasodilatation
- Dihydropyridines are more selective for $Ca2^+$ channels in smooth muscle cells, showing a stronger vasodilatory effect
- Nondihydropyridines block $Ca2^+$ channels from myocytes and decrease the cardiac output.
- Other effects: reduce aldosterone secretion, as well as the growth and proliferation of smooth muscle cells
- Moderately increase the natriuretic effect
- Most drugs have a short-term effect, thus requiring multiple doses or a retarded form.

Adverse effects

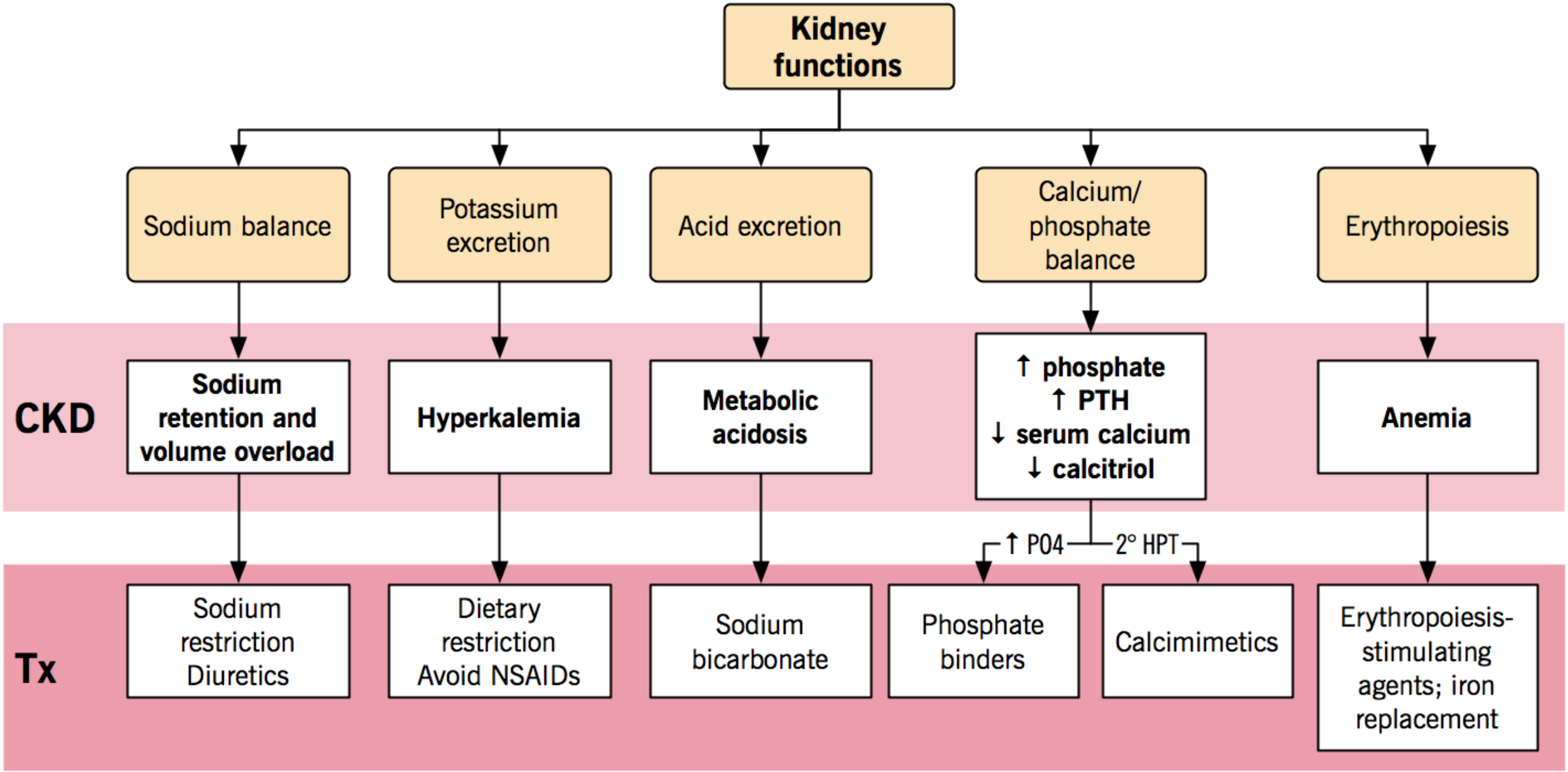
- Tachycardia, headaches, skin flushing
- Peripheral edema (dihydropyridines), which are dose-dependent due to uneven vasodilatation of both the arterioles and venous beds and not to fluid retention.
- Gingival hypertrophy
- Verapamil may cause constipation.

Calcium chanel blockers (ARB)

Medicine	Dose mg/day (t/day)
Nifedipine retard	10–20 (1-2)
Amlodipine	5–10 (1)
Felodipine	5–10 (1)
Isradipine	2,5–7,5 (3)
Nicardipine	20 (3)
Verapamil	40–80 (2-3)
Diltiazem retard	180–240 (1)

- **Diuretics** potentiate effect of IECA/ARB and decrease risk of hyperpotassemia. The loop diuretics are preferred – **Furosemide / Torasemide** if SCr > 2 mg%.
- **Non-dihydropyridine Calcium Blockers (Verapamil / Dilthiazem)** lower BP and assure nephroprotection via anti-proteinuric action (especially in diabetes patients).
- **Beta-blockers** in tachycardia > 84 b/min and undercontroled NTH with ACEIs + diuretic + Calcium blocker. Low doses of **Metoprolol**.
- A**lfa-beta blocker (Carvedilol)** lower proteinuria, does not change lipids profile and glucose tolerance.

Complications of CKD



Correction of anemia

Indications: patients with GFR <60 ml/min/1,73m^2 and Hb < 11g/dl

Targets:

- **Hb – 11-12 g/dl**
- **Serum ferritin – 200-500 ng/ml**
- **Transferrin saturation index (TAS) – 20-50%**

Treatment tactics in pre-dialysis patients

Initiation of treatment if:

- Hb <11 g/dl or
- Serum ferritin <200 ng/ml and TAS <20%

Correction of anemia

Iron containing medicines

- 200 mg iron/day in adults, per os, after a fasting period
- indications:

Serum ferritin < 100 ng/ml (absolute iron deficiency)

or

Serum ferritin >100 ng/ml and TAS < 20% (functional iron deficiency)

Correction of anemia

Initiate therapy with erythropoiesis stimulators if:

- normal parameters of iron metabolism are met (serum ferritin 200-500 ng/ml and TAS 20 -50%), but with Hb <11g/dl

Epoetinum beta s.c. x3/wk with initial dose:

100 UI/kg/wk if Hb > 7 g/dl

150 UI/kg/wk if Hb < 7 g/dl

- until Hb reaches 11–12g/dl, then
- reduced doses – maintenance therapy (50-75 UI/kg x1/wk) with monthly monitor of Hb.

Adjuvant therapy for anemia

- Folic acid 5 mg/day
- Vitamin B_{12} 100 µg/wk.

Correction of phosphate (mineral) metabolism disorders

Targets:

Phosphatemia:	2,7-4,6 mg/dl (GFR >15ml/min)
	3,5-5,5 mg/dl (GFR <15 ml/min)
Calcemia:	9,2-9,6 mg/dl
Ionic Calcium:	4,6-5,4 mg/dl
Ca x P Product	< 55 mg^2/dl^2
iPTH :	40-110 pg/ml (GFR =15-60 ml/min)
	150-300 pg/ml (GFR <15 ml/min)

Therapy

To reduce phosphatemia:

- Diet restriction of phosphates
- Intestinal phosphate chelators
- Adequate dialysis (stage 5 of CKD)

To rise calcemia and suppress synthesis of PTH:

- Calcium salts, act as phosphate chelators
- analogs of vitamin D (i.e. ***Calcitriol, Alfacalcidol***)

To suppress synthesis of PTH:

- Calcimimetics (***Cinacalcet, Etelcalcetide***)

Diet restriction of phosphates

- Phosphate intake 800-1000 mg/day if GFR < 30-40 ml/min, phosphatemia and/or iPTH are higher compared to target concentration accordingly to CKD stage.
- Food with increased phosphates:
  - **meat** (veal, venison, viscera),
  - **fish** (herring, sardines, mackerel, scallops, shrimp, fish paste),
  - **dairy products** (milk powder, condensed milk, cheddar cheese, yogurt, ice cream)
  - **cereals** (Muesli), bread, bran
  - soy products, nuts, seeds,
  - chocolate, soft drinks: Coca Cola, Pepsi Cola, beer.

Intestinal phosphate chelators

- Calcium salts
- Aluminum salts
- Phosphate chelators without calcium or aluminum (**Sevelamer**)

Calcium supplements

- Indicated in symptomatic hypocalcemia (serum Ca < 8,4 mg/dl), and if iPTH is higher than targets values in CKD.
- ***Calcium carbonate***
- ***Calcium acetate***

Vitamin D analogues

Active vitamin D (***Calcitriol***) or analogs administration is essential in hypocalcemia and to reduce concentration of plasmatic PTH.

Indications:

- Lower of vitamin D deficit (prophylaxis of secondary hyperparathyroidism), when iPTH rises under targets values in CKD and low concentration of vitamin D3;
- Pharmacologic suppression of parathyroid glands hyperfunction (treatment of secondary hyperparathyroidism).

Hypolipidemic treatment

Statins contribute to nephroprotection via:

- Lower serum lipids
- Pleiotropic effects (antiproliferative, antifibrotic, antiinflammatory, immunomodulator)

Indicated in patients with CKD stage 1-4 and LDL-cholesterol >100mg/dl.

Correction of aggravating factors of CKD

- Re-hydration if vomiting, diarrhea, fever etc.;
- Treatment of urinary tract infections -antibiotics accordingly to antibiogramms;
- Urinary tract obstruction removal (obstructive urolithiasis, prostatic hypertrophy etc.);
- Cardio-tonics in cardiac failure;
- Avoid administration of nephrotoxic medicines (aminoglycosides, NSAIDs etc.);

Correction of acidosis

Treatment of metabolic acidosis by alkali therapy is usually indicated to raise and maintain the plasma pH to greater than 7.20.

Indication: serum bicarbonate <22 mEq/L

Medicines:

- Calcium carbonate 6–12g/day
- Sodium bicarbonate 10–15g/day - per os
- Sodium bicarbonate 14‰ – i.v.

Formula to determine bicarbonate dose:

HCO_3^- deficit = deficit/L (desired serum HCO_3^- - measured HCO_3^-) × 0.5 × body weight (volume of distribution for HCO_3^-)

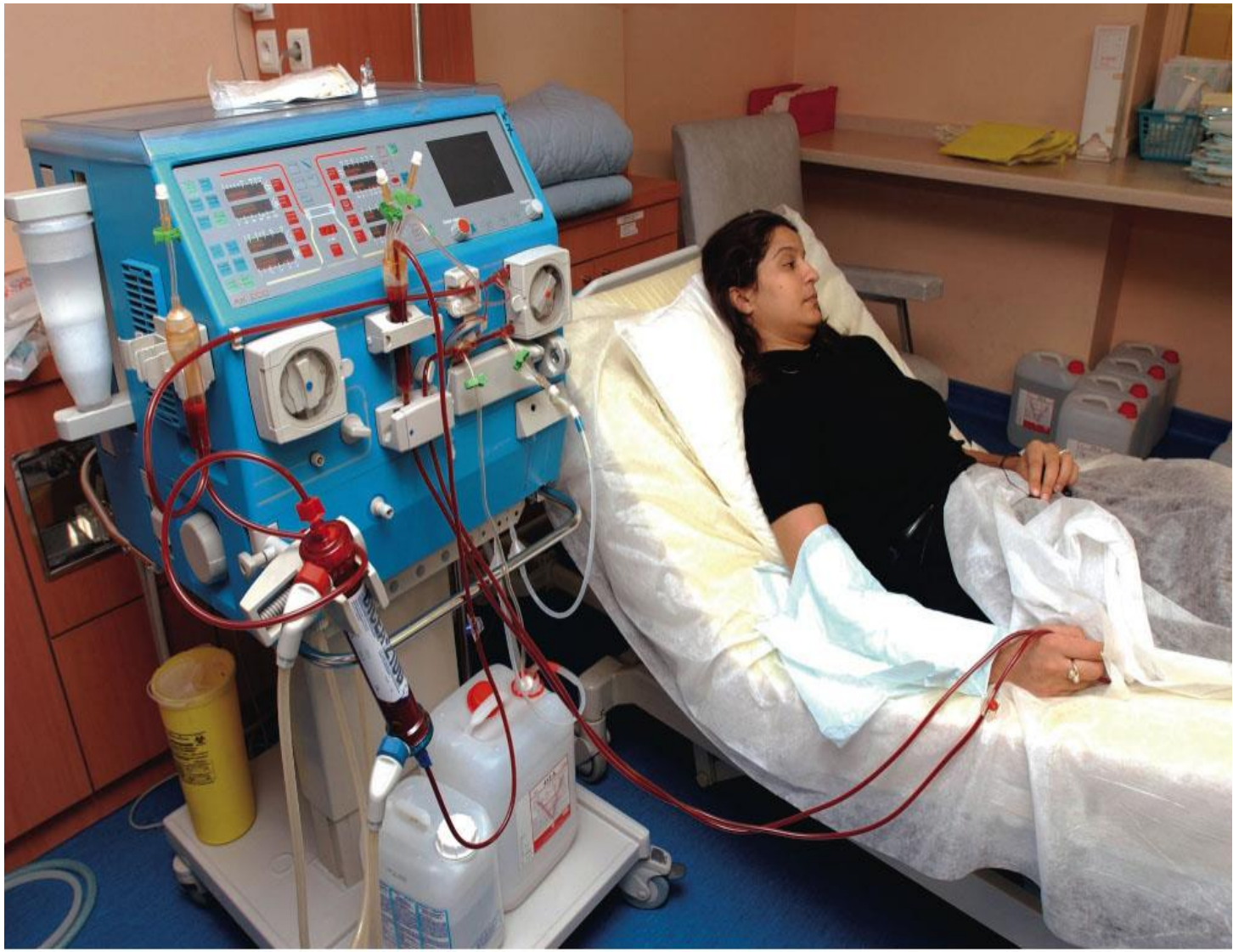
(100 ml sol. $NaHCO_3$ 14‰ = 16,8mmol bicarbonate).

Preparation for dialysis

- Psychological counseling;
- Training of patient with CKD;
- Avoid forearm vein due the need of arteriovenous fistula to start dialysis;
- Installation of arteriovenous fistula when eGFR is 20-25 ml/min/1,73 m^2.

Dialysis

- Removes excess fluid & wastes from blood
- Blood is circulated though a dialyzer
- Blood is bathed by dialysate
- Hemodialysis & peritoneal dialysis



Dialysis

- **Hemodialysis**
  - Lasts 3-4 hours
  - 3 times/week
  - Complications
    - Infections
    - Blood clotting
    - Hypotension
    - Muscle cramping
    - Headaches, weakness
    - Nausea & vomiting
    - Agitation
- **Peritoneal dialysis**
  - Vascular access not required
  - Fewer dietary restrictions
  - Can be scheduled when convenient
- Acute failure
  - Continuous renal replacement therapy (CRRT)

Kidney Transplants

- Restores function
- Allows a more liberal diet
- Frees patient from dialysis
- Immunosuppressive drug therapy
  - Many side effects affecting nutrition
- Protein & energy requirements increase
- Control CHO & lipids
- Sodium, potassium, & phosphorus intakes liberalized
- Calcium supplementation
- Be alert for potential food borne infection

Suggested frequency of evaluation (number of times per year) by eGFR and albuminuria category

eGFR categories (mL/min/1.73m²) Description and range				Urine ACR categories Description and range		
				A1	A2	A3
				Normal to mildly increased	Moderately increased	Severely increased
				<3mg/mmol	3-30mg/mmol	>30mg/mmol
	G1	Normal or High	≥90	1 if CKD	1	2
	G2	Mildly decreased	60-89	1 if CKD	1	2
	G3a	Mildly to moderately decreased	45-59	1	2	3
	G3b	Moderately to severely decreased	30-44	2	3	3
	G4	Severely decreased	15-29	3	3	4+
	G5	Kidney failure	<15	4+	4+	4+