

Volume Control

In Cardiac and Renal Disease

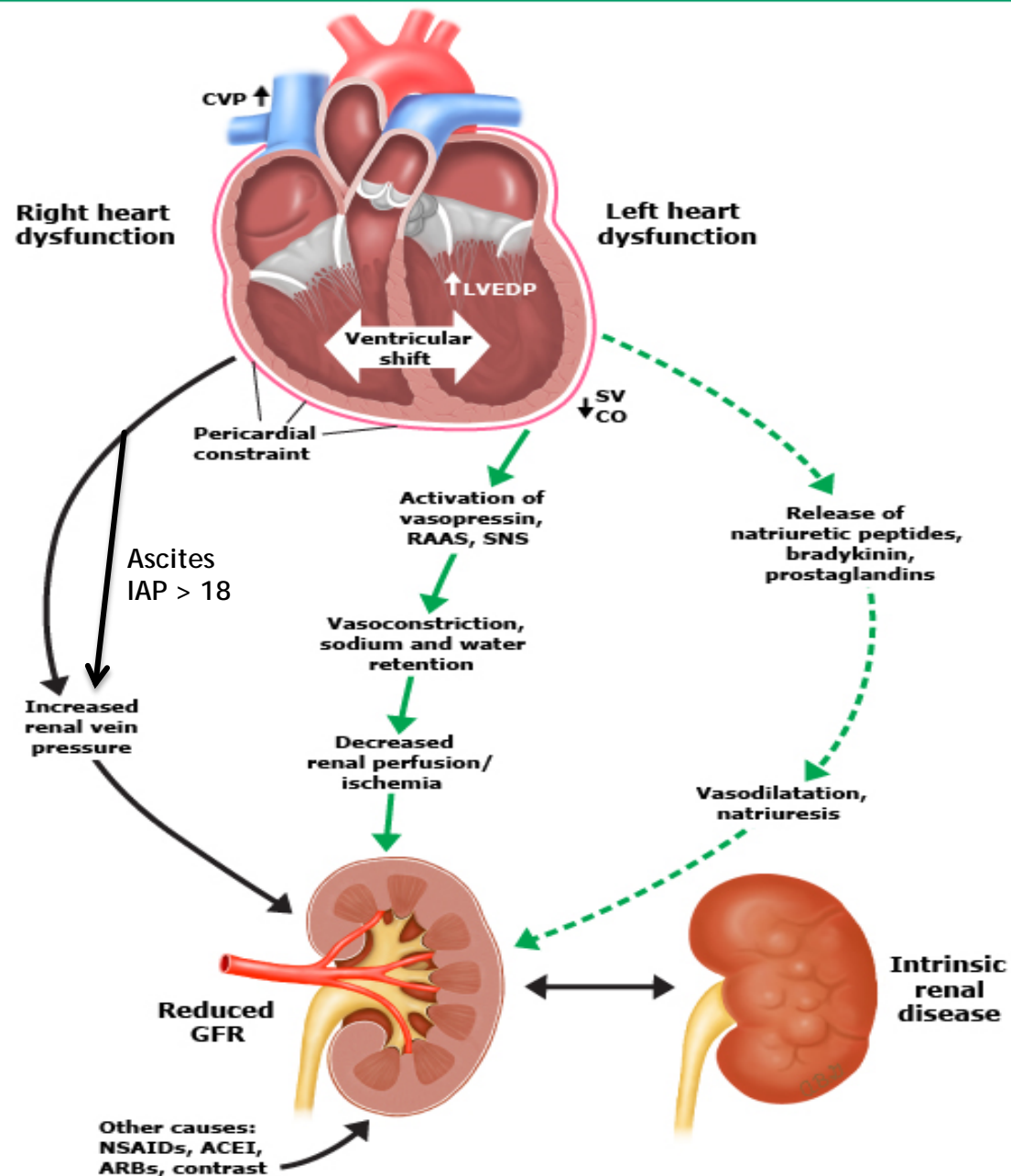
Cardiorenal and “Renocardiac” Syndromes

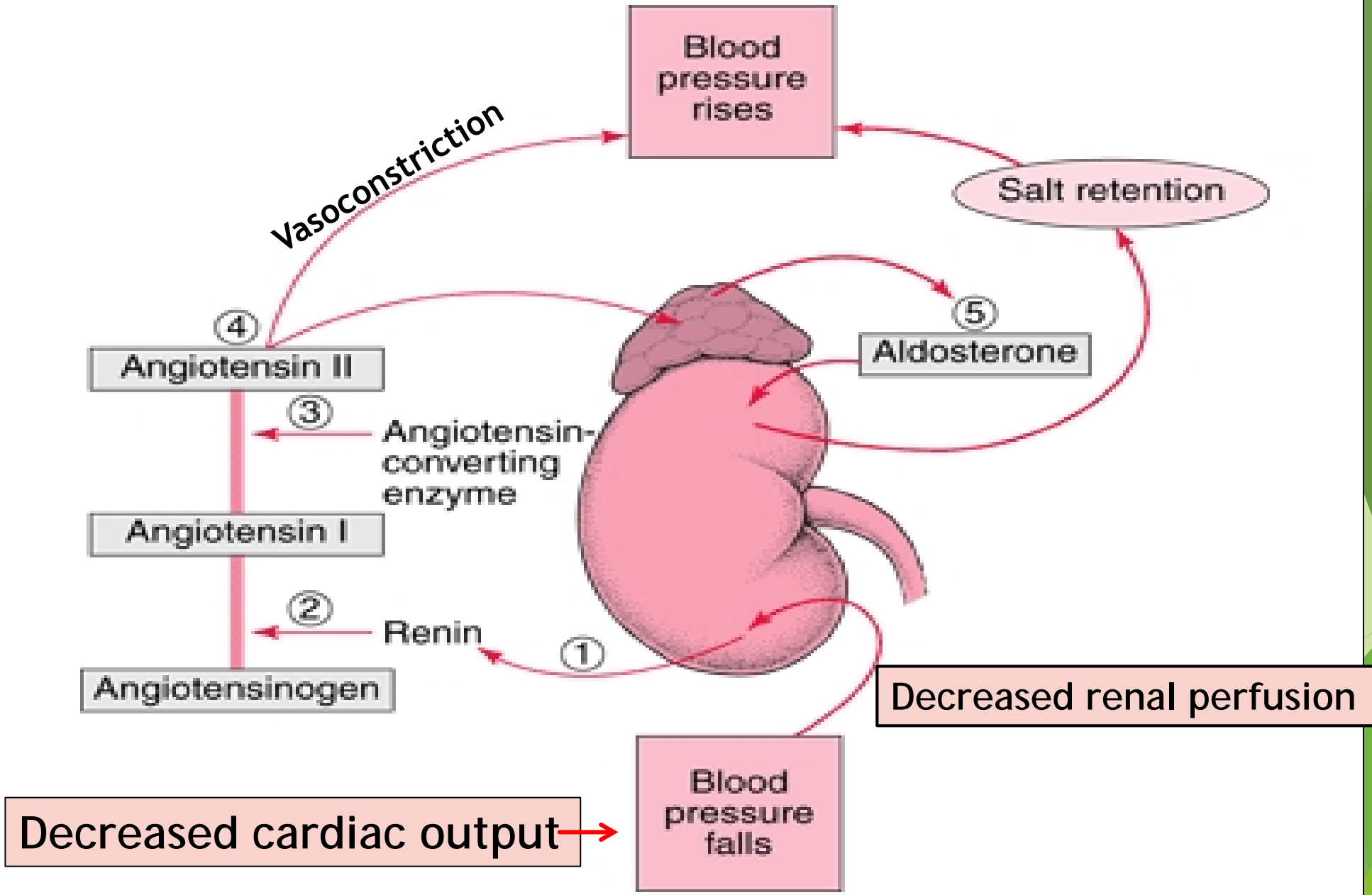
- ▶ Type 1 (acute) - Acute HF results in acute kidney injury
- ▶ Type 2 - Chronic cardiac dysfunction (eg, chronic HF) causes progressive chronic kidney disease
- ▶ Type 3 - Abrupt and primary worsening of kidney function causes acute cardiac dysfunction which may be manifested as heart failure
- ▶ Type 4 - Primary CKD contributes to cardiac dysfunction, which may be manifested as coronary artery disease, heart failure or arrhythmia
- ▶ Type 5 (secondary) - Acute or chronic systemic disorders (eg, sepsis or diabetes mellitus) that cause both cardiac and renal disease

Types of Heart Failure

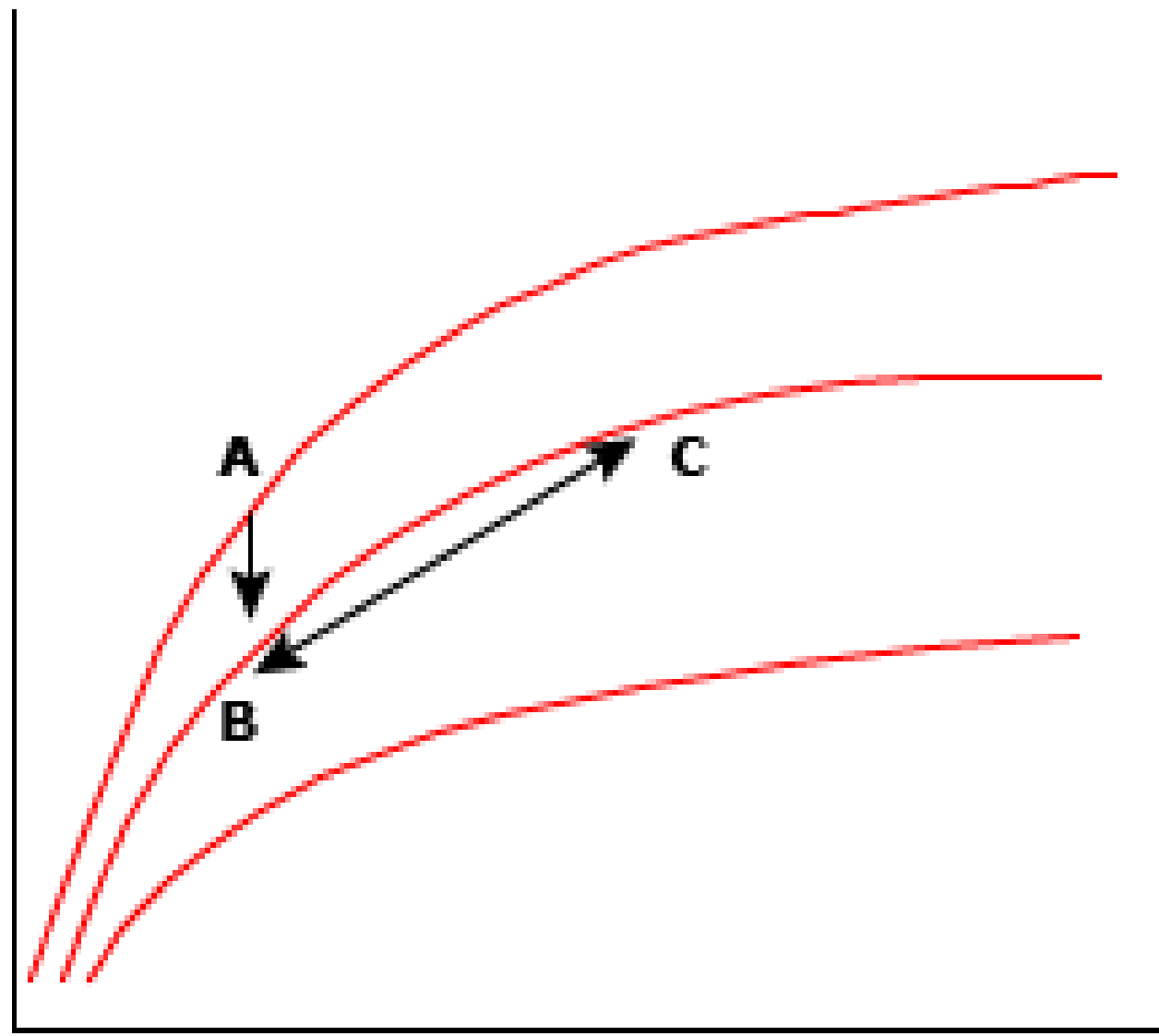
- ▶ Heart failure with reduced ejection fraction (HFrEF) - Left ventricular EF 40% or less
- ▶ Heart failure with midrange ejection fraction (HFmrEF) - Left ventricular EF 41-50%
- ▶ Heart failure with preserved ejection fraction (HFpEF) - Left ventricular EF >50%

A Sick Heart Makes A Sick Kidney





Stroke volume or cardiac output



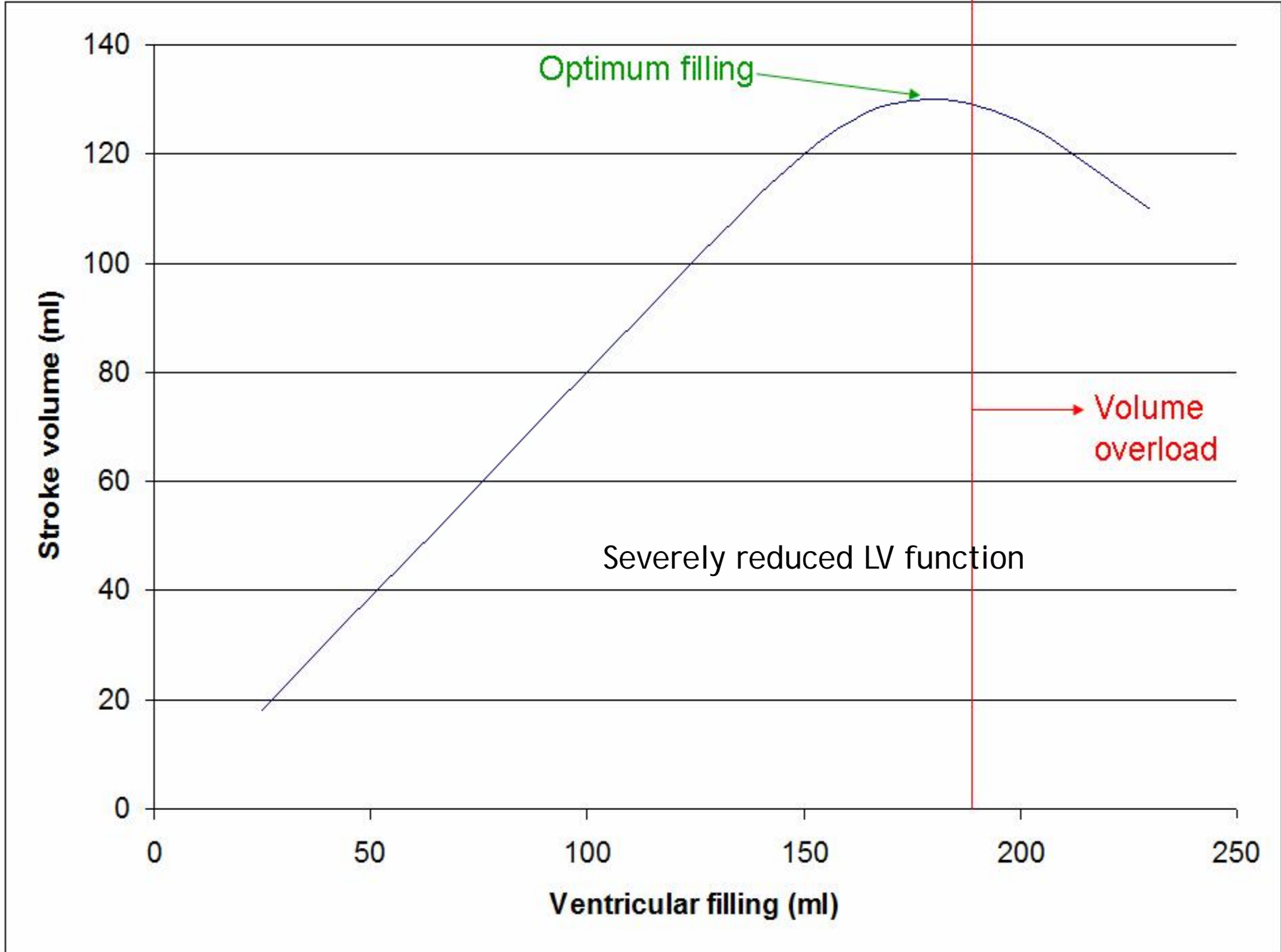
Normal

**Mild
dysfunction**

**Severe
dysfunction**

LVEDP or wedge pressure

Your text here



A sick kidney

makes a sick heart



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Hypertension
Hypervolemia

Cytokines?

Uremic toxins?

Hyperkalemia?

Anemia

Vascular calcification

High calcium X phosphorus product
Hyperparathyroidism

Inflammatory state?



"Renocardiac" Syndrome

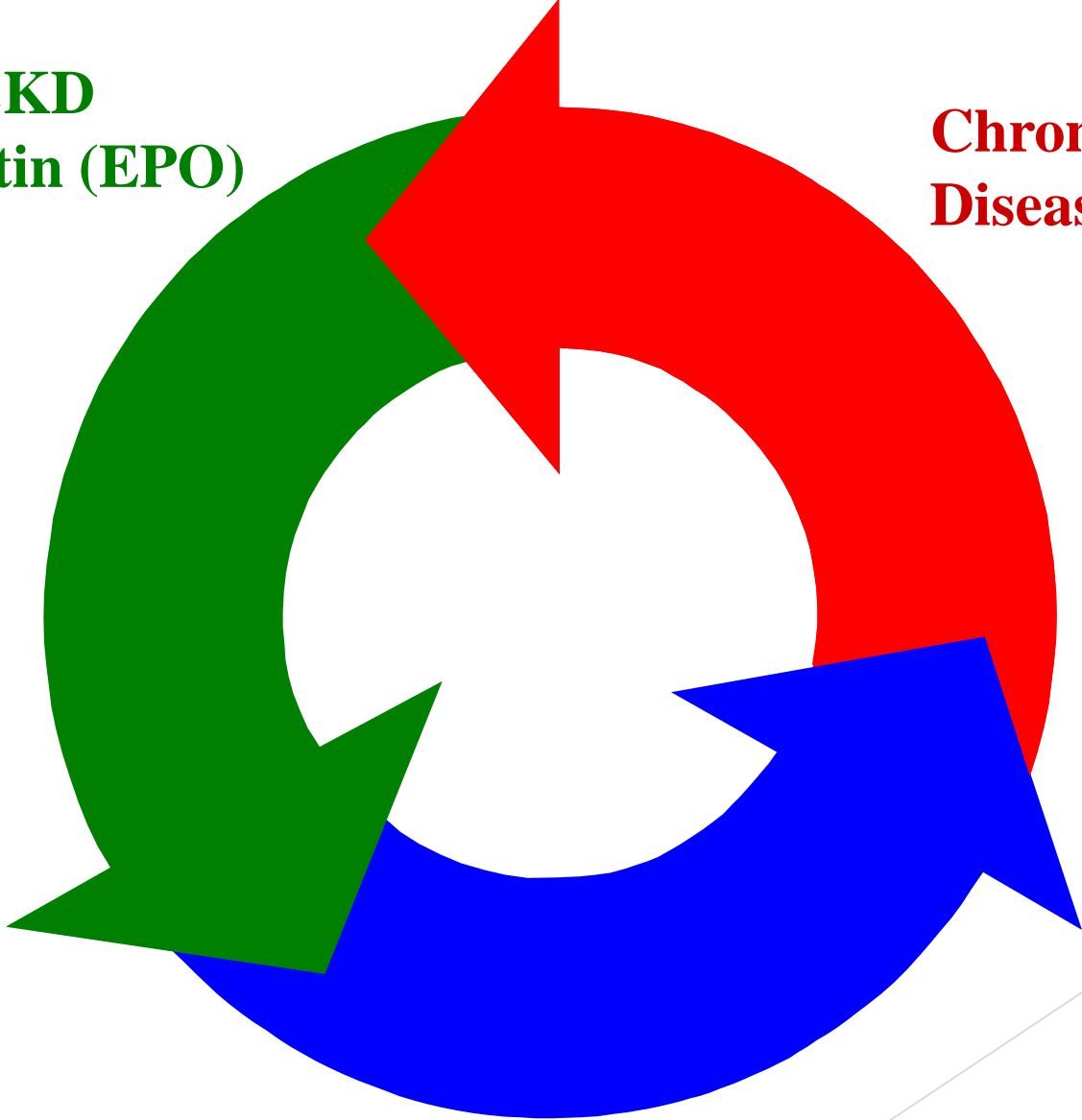
Mechanisms of “Renocardiac” Syndrome

- ▶ Volume retention and hypertension
- ▶ Anemia leading to greater cardiac work
- ▶ Phosphorous and calcium leading to vascular calcification and CAD
 - ▶ Phosphorous generally high in CKD
 - ▶ CaXPhos >55 leads to extraosseous calcification
 - ▶ PTH elevated increasing serum calcium
- ▶ Other Factors
 - ▶ Uremia itself
 - ▶ Cytokines?
 - ▶ Chronic hyperkalemia
 - ▶ Chronic inflammatory state (dialysis catheter)

The Critical Links

**Anemia of CKD
Erythropoietin (EPO)
Deficiency**

**Chronic Kidney
Disease (CKD)**



Cardiovascular Disease (CVD)

Pulmonary edema with Preserved LV Function

- ▶ With increased LVEDP
 - ▶ Renal failure
 - ▶ Diastolic dysfunction
 - ▶ Valve disease
- ▶ With normal LVEDP
 - ▶ Pulmonary hypertension
 - ▶ ARDS
 - ▶ Generalized inflammation
 - ▶ Aspiration
 - ▶ Interstitial pneumonitis
 - ▶ Allergic
 - ▶ Infectious

Finding for pulmonary edema with HFpEF with renal disease and HFrEF without renal disease

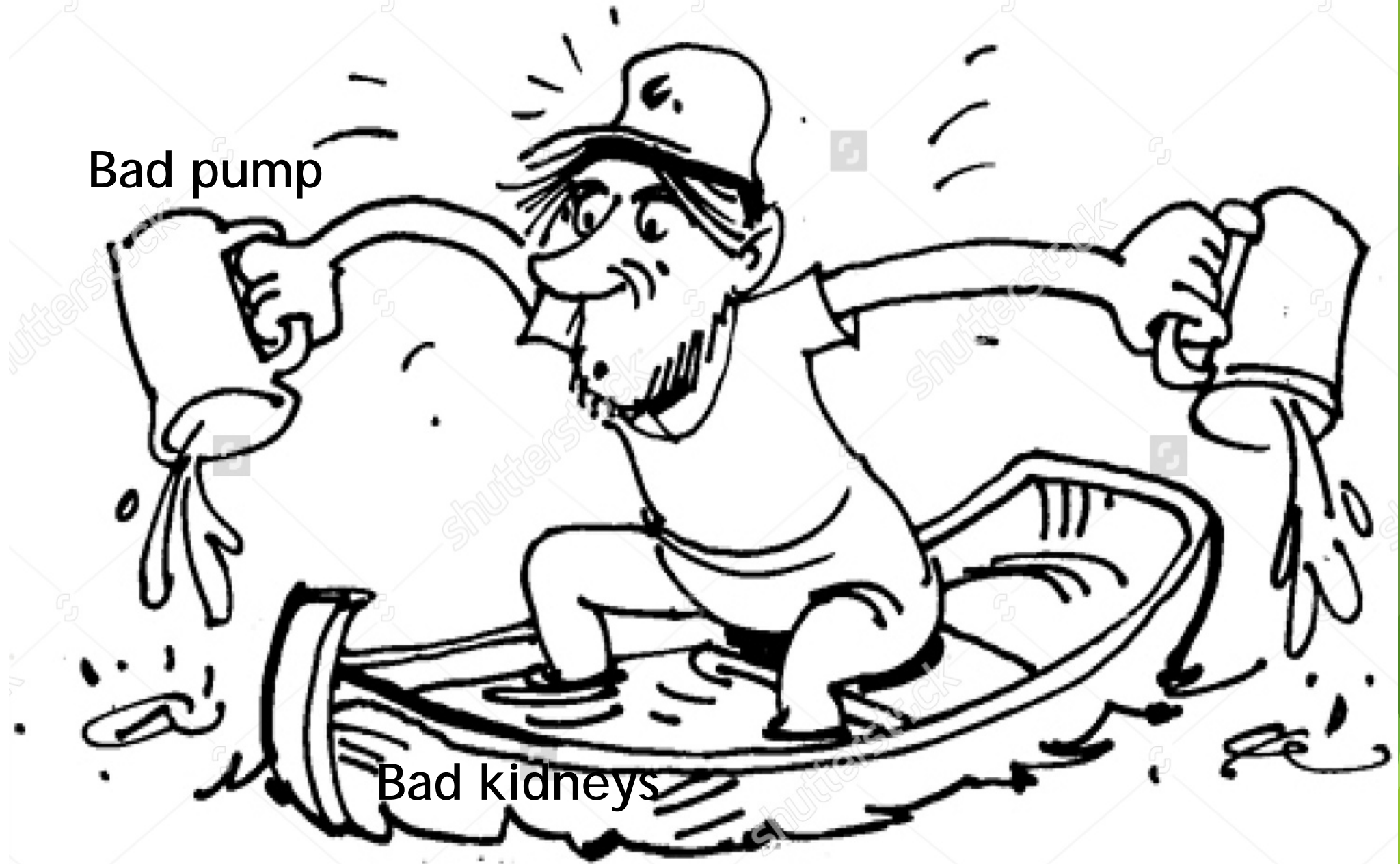
Pulmonary edema with HFpEF with renal disease

- ▶ Peripheral edema
- ▶ Dyspnea
- ▶ Hypertensive
- ▶ Low serum sodium - volume
- ▶ High urine sodium >40
- ▶ High BNP
- ▶ No S3 usually

Pulmonary edema with HFrEF without renal disease

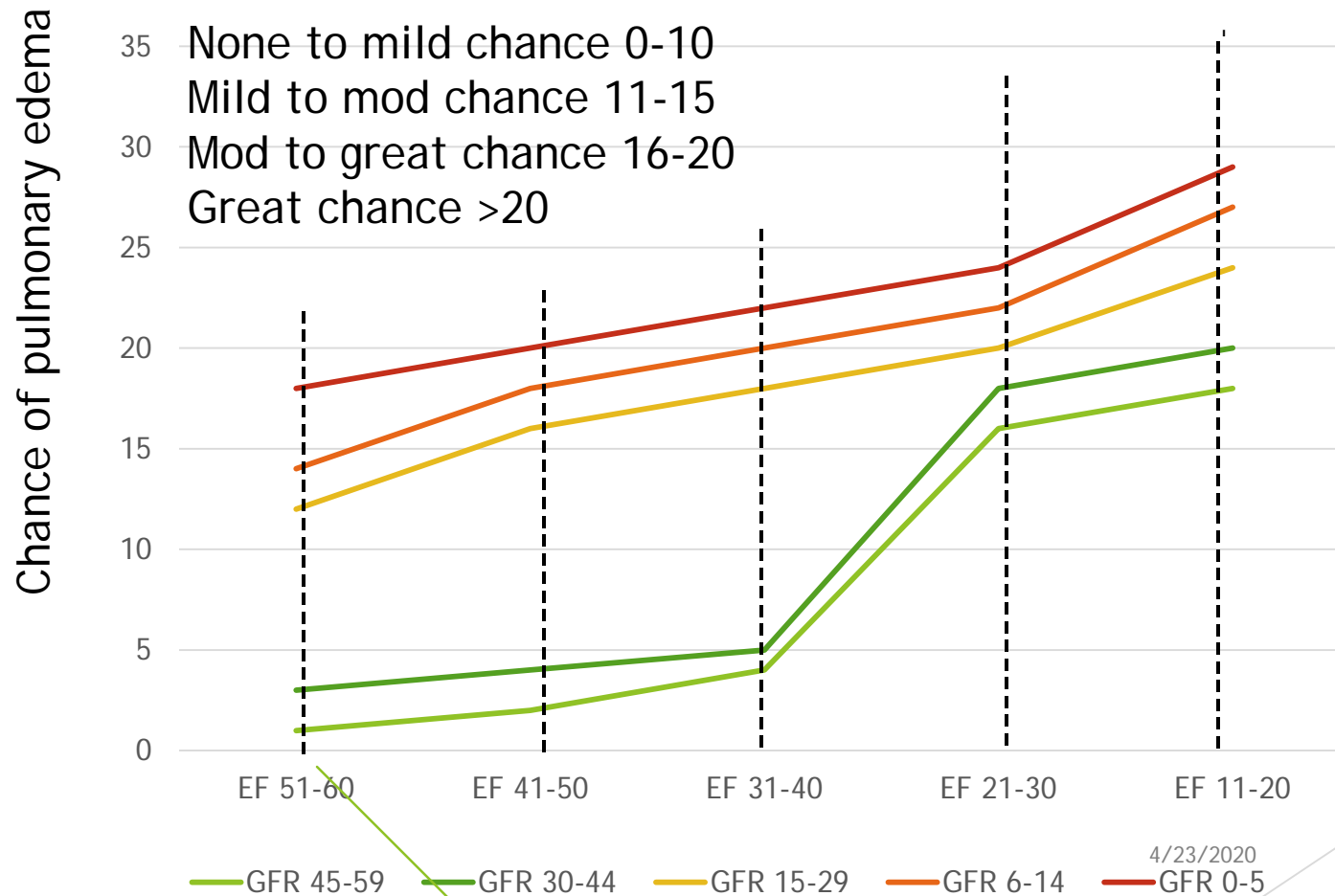
- ▶ Peripheral edema usually
- ▶ Dyspnea
- ▶ Normotensive or hypotensive
- ▶ Low serum sodium - ADH
- ▶ Low urine sodium <20
- ▶ High BNP
- ▶ S3 frequently

Bad pump



Bad kidneys

Pulmonary Edema and Impact of Renal Failure With Left Ventricular Function



Major Findings in Edematous States

| Disorder | Pulmonary edema | BNP (> 100) | CVP | Urine sodium |
|---------------------------|-----------------|-------------|-----------|--------------|
| Left-sided heart failure | + | Increased | Increased | Low |
| Right-sided heart failure | +/- | Increased | Increased | Low |
| Renal disease | +/- | Increased | Increased | High |
| Cirrhosis | - | Normal | Normal | Low |

Making the Determination of Wet or Dry

- ▶ Chest X-ray - must be relate to the patient as a whole.
 - ▶ Peripheral edema
 - ▶ Dyspnea
 - ▶ Rales
 - ▶ S3 Gallop
 - ▶ Positive tilt or not
 - ▶ Fever (pneumonia)
- ▶ History of CHF
- ▶ History of renal failure
- ▶ History of COPD

Making the Determination of Wet or Dry (Cont.)

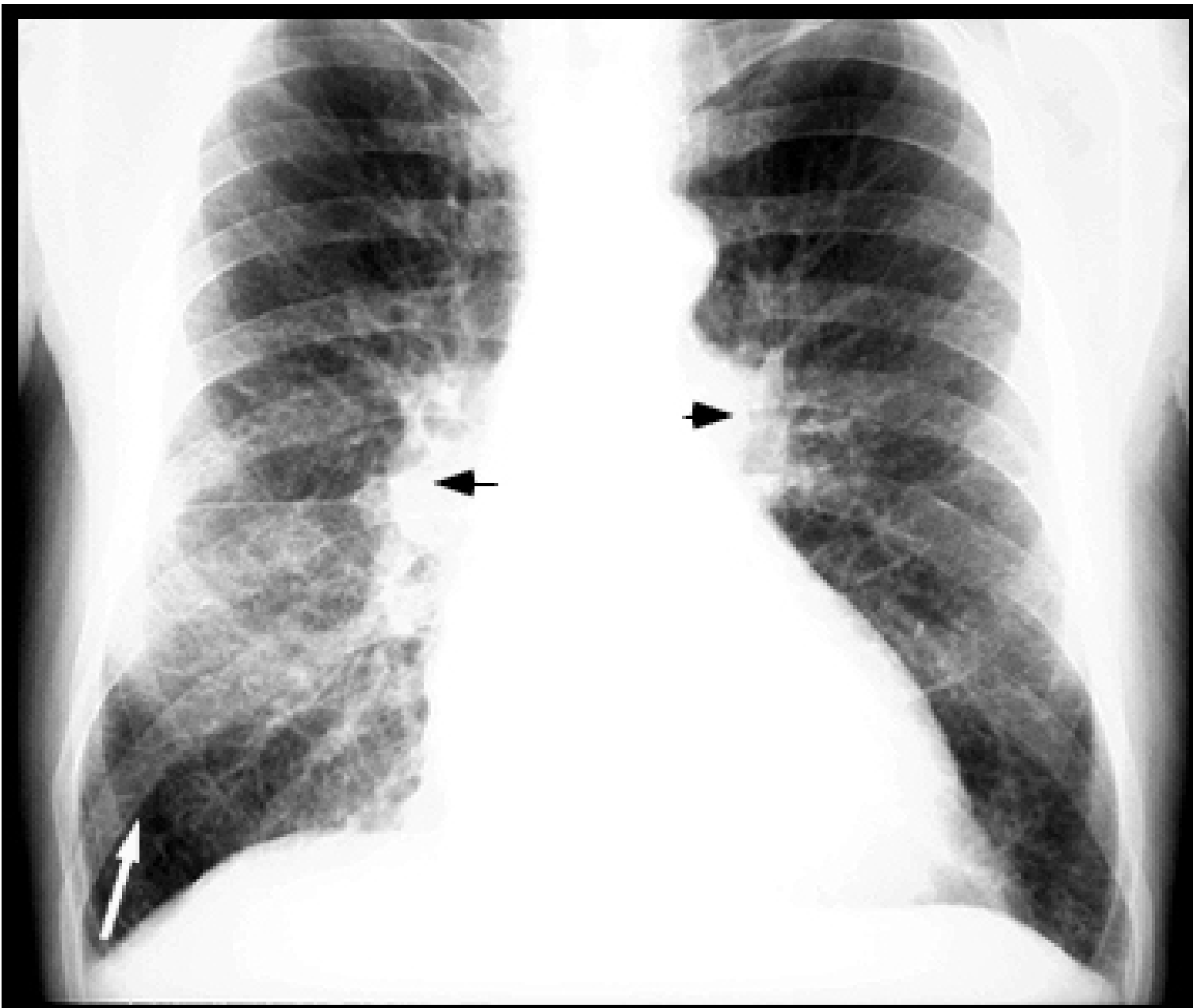
- ▶ Look at lab
 - ▶ BNP
 - ▶ Serum sodium
 - ▶ Serum albumin (nephrotic?)
 - ▶ Serum creatinine and BUN
 - ▶ Hgb, Wbc
 - ▶ Urine protein (protein/creatinine ratio - PCR)
- ▶ I&O and weight changes
- ▶ Echocardiogram - valve problems, EF
- ▶ Central Venous Pressure
- ▶ Pulmonary Wedge Pressure (Gold Standard)

Differential Diagnosis of Oliguria

| Finding | Volume depletion | CHF with reduced EF |
|------------------------|-------------------------|-------------------------|
| Urine sodium | < 20 | < 20 |
| FeNa | < 1% | < 1% |
| BUN/creatinine ratio | > 15 | > 15 |
| Urine specific gravity | > 1.020 | > 1.020 |
| Urine osmolality | > 400 | > 400 |
| Urinary sediment | Normal or hyaline casts | Normal or hyaline casts |

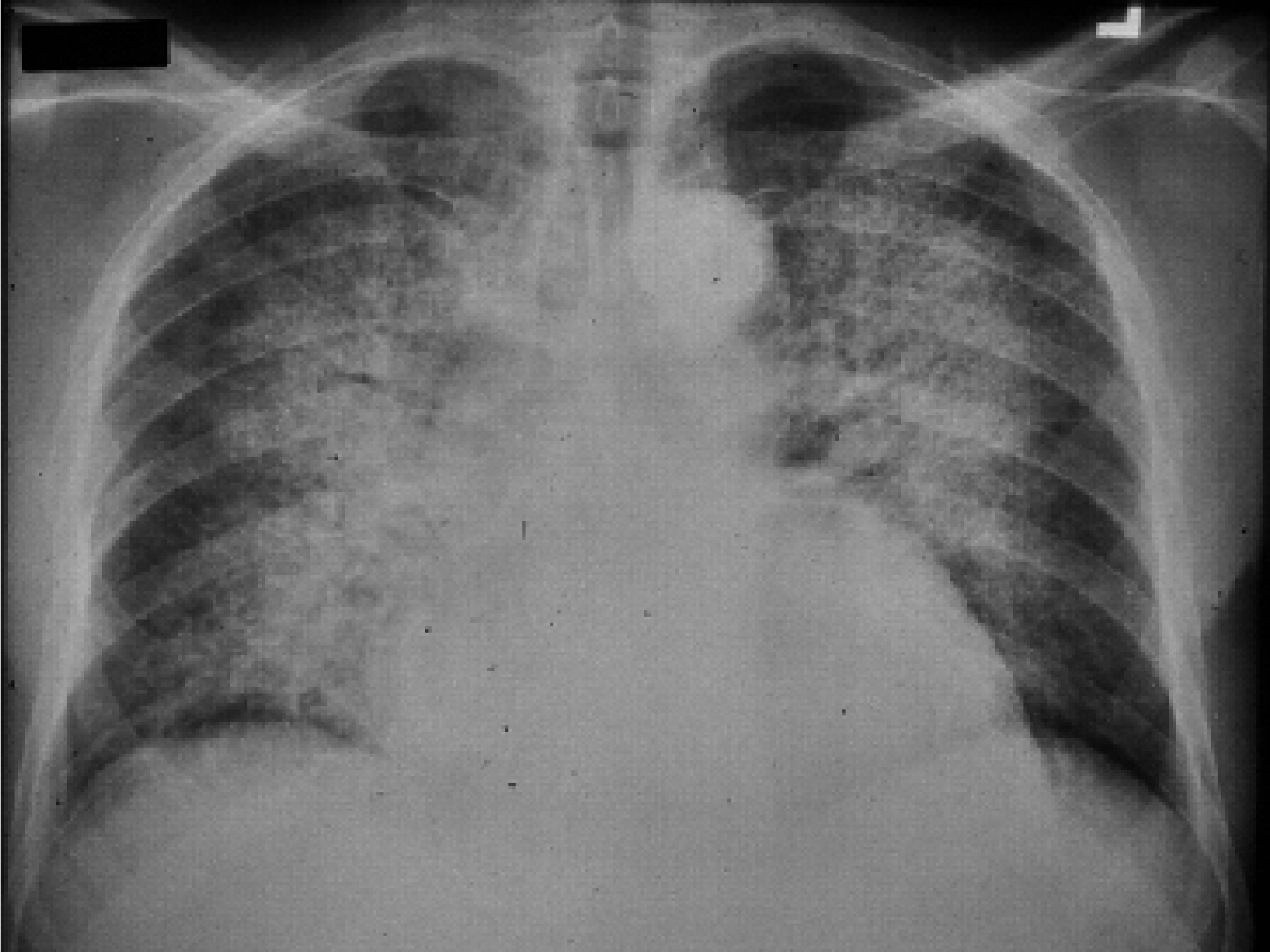
Case # 1

- ▶ 66 year old white male seen in ER for SOB
- ▶ Has not seen a doctor for 30 years
- ▶ Smoked 2 packs/day for 50 years
- ▶ 2+ PTE, No rales, BP 162/94, No S3, afebrile
- ▶ Painful to palpation right upper quadrant
- ▶ BUN 62, Creat. 1.5, BNP 420, Albumin 4.2, Na⁺ 136, Una 15, Hgb 14, Wbc 7.2
- ▶ Prefers not to lie down - "I can't breathe."
- ▶ Coughing up brownish sputum
- ▶ Has noted dark urine and less volume
- ▶ Nausea and vomiting for last 2 days
- ▶ Chest X-ray as follows



Case # 2

- ▶ 72 year old white female with known CKD stage 4
- ▶ Baseline creat. 2.8 and now 4.2
- ▶ Severely SOB and no history CHF
- ▶ Echocardiogram 4 years ago with EF 65%
- ▶ 2+ PTE, Rales, BP 106/54, No S3
- ▶ BUN 84, Creat. 4.2, BNP 850, Albumin 3.2, Na⁺ 124, Una 40, Hgb 8.6, Wbc 8.2
- ▶ Clear, light urine, but less volume
- ▶ Chest X-ray as follows



Drug Treatment of Combined Cardiac and Renal Disease

- ▶ Diuretics - usually loop type
- ▶ ACE inhibitor
- ▶ Beta blocker
- ▶ Vasodilator (hydralazine)
- ▶ Inotropic drugs (dobutamine, milrinone)
- ▶ Aldosterone blocker
- ▶ ADH blocker
- ▶ Dialysis (ultrafiltration)

Non-drug Treatment

- ▶ Sodium restriction - 2300 mg per day.
- ▶ Fluid restriction is secondary to sodium restriction
- ▶ Weigh daily - Call if gain or loss of 2 lbs in a day or 5 lbs in a week
- ▶ BP daily
 - ▶ Call if systolic BP <100 consistently
 - ▶ Call if systolic BP >150 consistently
- ▶ Frequent lab - basic metabolic panel - monthly

Treatment of Pulmonary Edema with HRpEF in Renal Disease

- ▶ Sodium and fluid restriction
- ▶ Control BP - a must. Diuretic may be all that's needed
- ▶ Diuretics - loop usually required
- ▶ Phosphate binders
- ▶ Potassium and phosphorous restriction (Renal diet)
- ▶ Weigh daily
- ▶ Dialysis if needed

Adverse Renal Effects of Treatment

- ▶ Diuretics and sodium restriction
 - ▶ Volume depletion
 - ▶ Renal hypoperfusion
 - ▶ Must weigh daily especially if HFrEF
 - ▶ Hypokalemia or hyperkalemia
- ▶ ACE inhibitor or ARBs
 - ▶ Efferent arterial dilation (decreased GFR)
 - ▶ Hypotension and renal hypoperfusion
 - ▶ Hyperkalemia
 - ▶ Check lab frequently
- ▶ Beta blocker, vasodilators
 - ▶ Hypotension
 - ▶ Bradycardia
 - ▶ Renal hypoperfusion

Some “Take Homes”

- ▶ Urine Na⁺ is low and urine osm is high in both volume depletion and CHF.
- ▶ ADH resorbs water without solute. Aldosterone resorbs sodium with water.
- ▶ Pulmonary edema can be present in the face of normal LV function:
 - ▶ Renal failure
 - ▶ Pulmonary hypertension
 - ▶ Diastolic dysfunction
 - ▶ Valve disease
 - ▶ ARDS
 - ▶ Generalized inflammation - eg aspiration, interstitial pneumonitis
- ▶ Left sided heart failure, pulmonary edema first then peripheral edema.
- ▶ Right sided heart failure, peripheral edema first then pulmonary edema.
- ▶ Cirrhosis, peripheral edema usually without pulmonary edema.
- ▶ Push ACE and diuretic even if creatinine goes up in patients with LV dysfunction
- ▶ Pneumonia is grossly over-diagnosed in the patient with significant renal insufficiency. By radiologists! Beware of phrase, “*multifocal* pneumonia.”