Cardiorenal Syndrome

And “Renocardiac” Syndrome
A Vicious Cycle

Cardiorenal and “Renocardiac” Syndrome

- 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
A sick heart makes a sick kidney and a sick kidney makes a sicker heart and so on.
Change in serum creatinine versus change in intra-abdominal pressure

- Change in sCr: serum creatinine
- Change in IAP: intra-abdominal pressure

Decreased cardiac output

- Increases renal sodium reabsorption
- Increases renal potassium secretion
- Increases renal hydrogen secretion
- Increases uptake of potassium by muscle cell
- Increases intravascular volume and BP
- Prolonged excess is pathological:
  - Hypertension
  - Hypokalemia
  - Metabolic alkalosis

Water always follows sodium so concentration minimally changed.
Antidiuretic Hormone

- Concerned with reabsorption of water without sodium
- Maximum output when S. osm. >295 (max. urine osm. 1200)
- Absent when S. osm. <280 (min. urine osm. 50)
- Decreased EPV overrides osmolality stimulus
- Maintains S. osm. between 285 and 290

Sodium concentration decreases when ADH present.

EPV = Effective plasma volume

Determinants of Sodium Excretion

- Mechanical factors (sodium excretion decreased or increased depending on condition)
  - Filtered load of sodium
  - *Systemic arterial pressure
  - *GFR
  - Tubular damage – decreased sodium reabsorption

- Hormonal factors
  - Brain natriuretic peptide (increases sodium excretion)
  - *Aldosterone (decreases sodium excretion)

- Renal vascular resistance
  - *Angiotensin II (decreases sodium excretion)
  - *Sympathetic nervous system (decreases sodium excretion)
  - *Prostaglandins (increases sodium excretion)

*Renal perfusion is the final common pathway for sodium excretion
Hyponatremia
Basic Mechanisms

- **Loss of water with greater loss of sodium (no edema) - hypovolemia**
  - **Causes** - GI loss, diuretics and intake of free water
  - **Lab** - low urine sodium (< 20), urine osm high (> 400)
  - **Treatment** - NS

- **Excess water with normal total body sodium (no edema)**
  - **Causes** - psychogenic polydipsia (PP), SIADH
  - **Lab** - normal urine sodium (> 40), PP - urine osm low (< 280), SIADH - urine osm high (> 400)
  - **Treatment** - fluid restriction, 3% saline + furosemide for both, SIADH - ADH receptor blocker

- **Excess of sodium with greater excess of water (edema) - hypervolemia**
  - **Causes** - CHF, Cirrhosis, nephrosis
  - **Lab** - low urine sodium (< 20), urine osm high (> 400)
  - **Treatment** - diuretics, sodium and fluid restriction

---

Differential Diagnosis of Oliguria

<table>
<thead>
<tr>
<th>Finding</th>
<th>Volume depletion</th>
<th>CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine sodium</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>FeNa</td>
<td>&lt; 1%</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>BUN/creatinine ratio</td>
<td>&gt; 15</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>Urine specific gravity</td>
<td>&gt; 1.020</td>
<td>&gt; 1.020</td>
</tr>
<tr>
<td>Urine osmolality</td>
<td>&gt; 400</td>
<td>&gt; 400</td>
</tr>
<tr>
<td>Urinary sediment</td>
<td>Normal or hyaline casts</td>
<td>Normal or hyaline casts</td>
</tr>
</tbody>
</table>
Hypertension
Hypervolemia

Hyperkalemia?
Anemia

Cytokines?
Vascular calcification
High calcium × phosphorus product
Hyperparathyroidism

Inflammatory state?

Hypertension
Hypervolemia

Uremic toxins?

A sick kidney makes a sick heart
and on and on until death do they part.

and a sick heart makes a sicker kidney

Fluid excess
Anemia of CKD
Erythropoietin (EPO) Deficiency

Chronic Kidney Disease (CKD)

Cardiovascular Disease (CVD)

The Critical Links
Causes of Edema Due to Decreased Renal Perfusion

- Left heart failure
- Right heart failure
- Primary renal sodium retention
  - Renal disease, including nephrotic syndrome
  - Drugs: minoxidil, CCBs, NSAIDs, estrogens, fludrocortisones
- Venous obstruction
  - Cirrhosis or hepatic venous obstruction
  - Local venous obstruction
- Hypothyroidism

Major Findings in Edematous States

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Pulmonary edema</th>
<th>BNP (&gt; 100)</th>
<th>CVP</th>
<th>Urine sodium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left-sided heart failure</td>
<td>+</td>
<td>Increased</td>
<td>Increased</td>
<td>Low</td>
</tr>
<tr>
<td>Right-sided heart failure</td>
<td>+/-</td>
<td>Increased</td>
<td>Increased</td>
<td>Low</td>
</tr>
<tr>
<td>Renal disease</td>
<td>+/-</td>
<td>Increased</td>
<td>Increased</td>
<td>High</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>-</td>
<td>Normal</td>
<td>Normal</td>
<td>Low</td>
</tr>
</tbody>
</table>
Pulmonary edema with Preserved LV Function

- With increased LVEDP
  - Renal failure
  - Diastolic dysfunction
  - Valve disease
  - Pulmonary hypertension – frequently causes pulmonary edema
- With normal LVEDP
  - ARDS
  - Generalized inflammation
    - Aspiration
    - Interstitial pneumonitis
    - Allergic
    - Infectious

Making the Determination of Wet or Dry

- Chest X-ray – must relate it to patient as a whole. Don’t blindly follow the radiologist
- Examine the patient
  - Peripheral edema
  - Dyspnea
  - Rales
  - S3 Gallop
  - Positive tilt
  - Fever
- History of CHF
Making the Determination of Wet or Dry (Cont.)

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

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 know CKD stage 4
- Baseline creat. 2.8 and now 4.2
- Severely SOB and no history CHF
- Echocardiogram 4 months 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
- 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
Adverse Renal Effects of Treatment

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

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.
- May need to push ACE and diuretic even if creatinine goes up
- Pneumonia is grossly over-diagnosed in the patient with significant renal insufficiency. By radiologists! Beware of phrase multifocal pneumonia.