Cardiogenic Shock Acute Heart failure

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Objectives

- Case presentations
  - Recognize cardiogenic shock
  - Management strategies
- Cardiorenal syndrome
  - Understanding diuretic usage strategies
- Physical examination in acute heart failure

Case Presentation

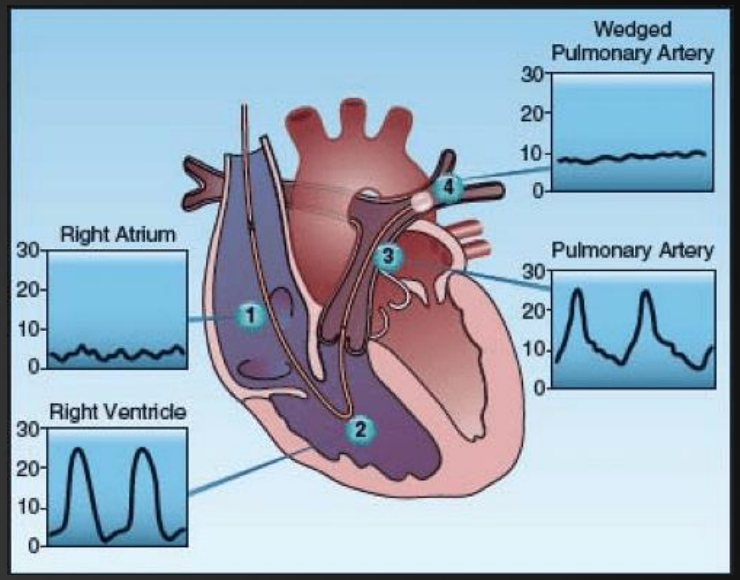
- 38 year old history of remote methamphetamine use. No CAD, presents with increasing dyspnea, weight gain.
- BP 100/64, pulse 92, O2 sats 98% on RA
- No gallops. JVD angle of the mandible, Soft holosystolic murmur 2/6
- Warm extremities. Anasarca present
- Started on bumetanide drip at 1mg/hour, low dose inotrope
- Daily chlorothiazide IV
- Paroxysmal SVT
- Lost ~ 15 lbs in 6 days. Preserved renal function. Transaminases and bilirubin normal Lactate normal
- Echocardiogram LVEF 10%, RV function moderate to severely reduced
- Elevated JVD, increasing dyspnea holding IV chlorothiazide abdominal distention

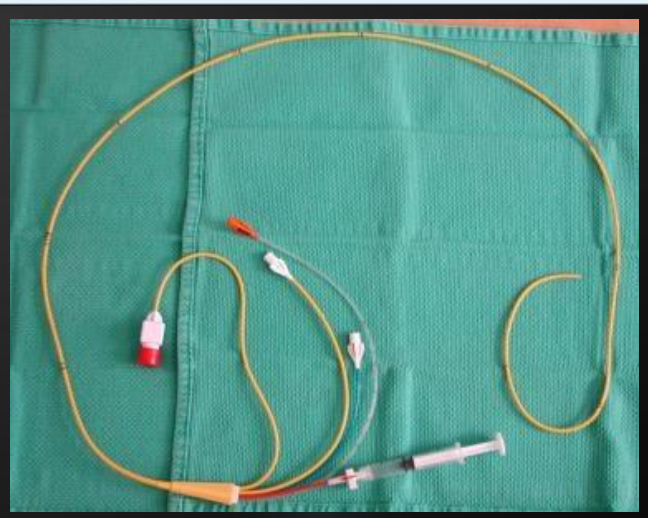
Right Heart Catheterization performed

- Hemodynamic data
- Blood pressure 93/51 mm Hg Mean 70 mmHg
- Right atrial pressure A wave 29 V wave 30 mean of 26 mmHg
- RV pressure 46/13 mmHg
- PA pressure 46/26 mean of 35 mmHg
- Pulmonary capillary wedge pressure A-wave 30 V wave 30 mean of 26 mm Hg

- PA saturation 48 %
- Aortic saturation 96 %

- Thermodilution cardiac output 4.9 l/min cardiac index 2.5 l/min/m²
- Fick cardiac output 2.7 l/min cardiac index 1.4 l/min/m²

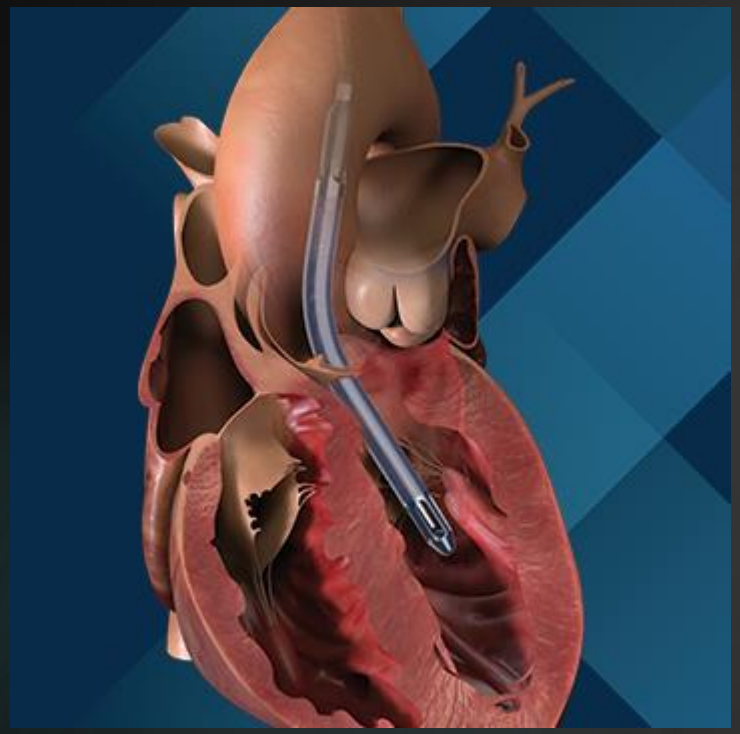


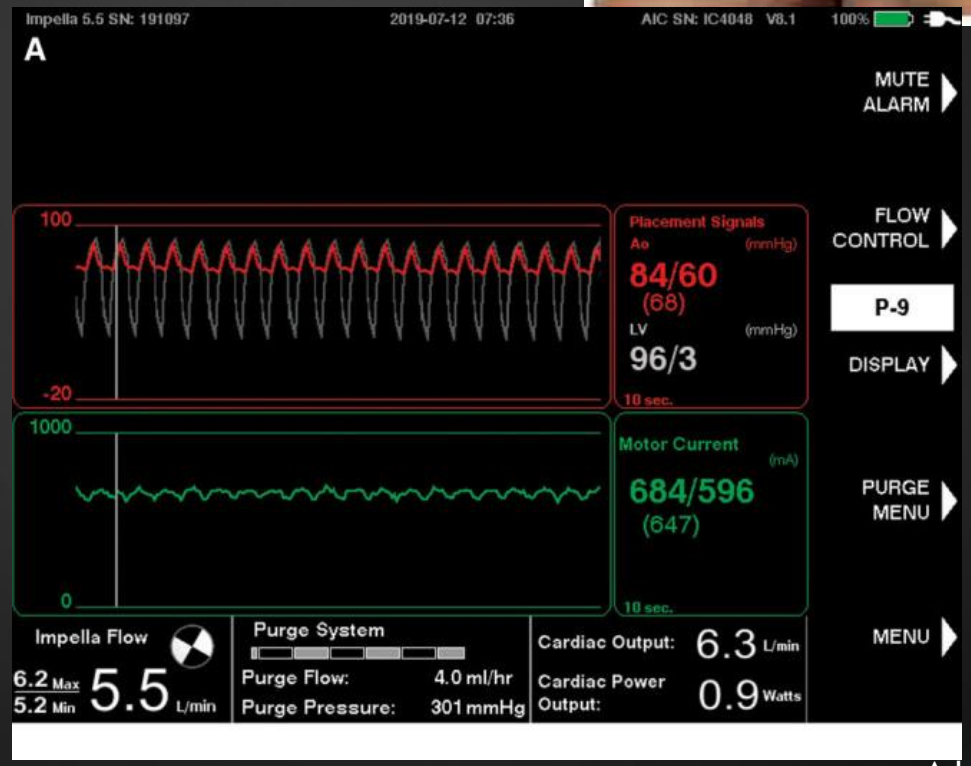


What would you do next ?

1. Continue current bumetanide drip and thiazide diuretics
2. Switch to oral diuretics and add losartan or Entresto therapy with beta blockers
3. Increase inotropic therapy
4. List for heart transplantation
5. Temporary mechanical circulatory support such as Impella or intra aortic balloon pump

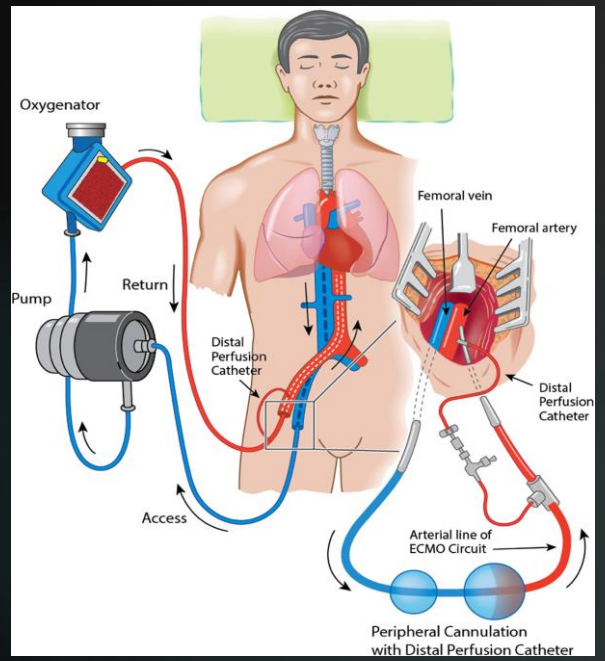
Impella 5.5 Smart Assist



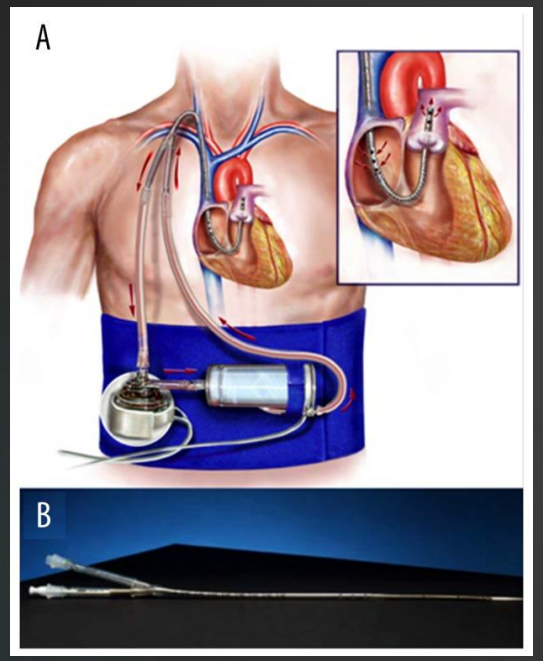


Abiomed

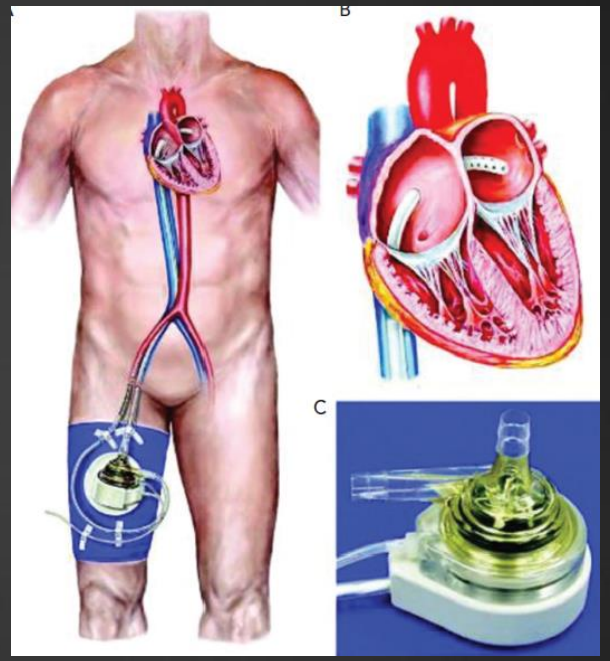
Temporary Mechanical Circulatory Support



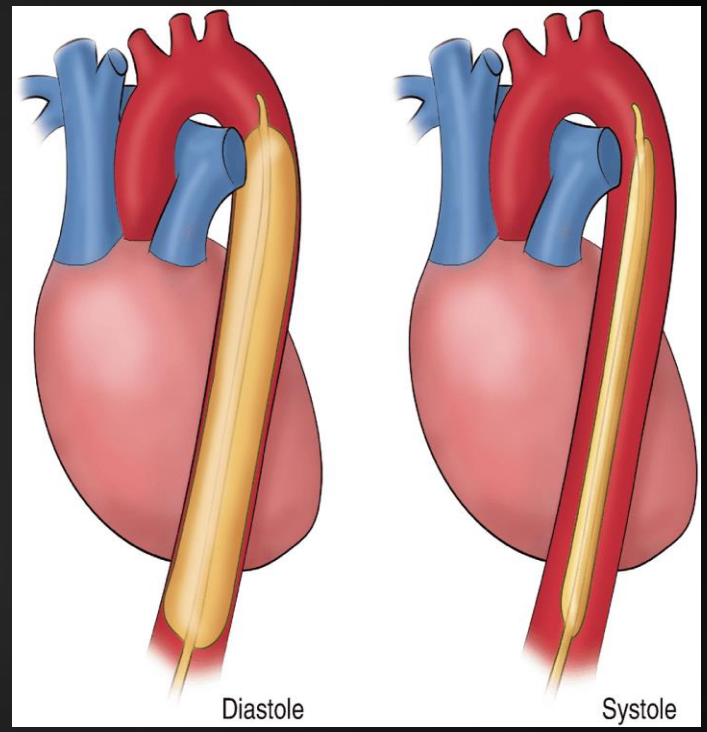
VA ECMO



Protek DUO
Right Heart failure



TandemHeart



Intra Aortic
Balloon Pump

Impella placement through Right Axillary Artery 5.5 L

- Impella was placed
  - Elevated filling pressures despite weight loss and aggressive diuresis
  - Help assess RV function with LV unloading
  - Impella 5.5 L provides LV flow > 5.0L/min
  - Axillary approach facilitates ambulation and rehabilitation

  - Repeat hemodynamics with Impella in place, bumetanide IV pushes, milrinone 0.25 ug
    - RA 4, PA 34/18, Mean 22, PCW 17 . Flows 5.4 L /min on Impella.
    - Ambulating in the hallway 2-3 laps without stop

Definition

- Cardiogenic shock is a syndrome
  - Sustained tissue hypoperfusion
  - High in-hospital mortality

Stages of Cardiogenic Shock (CS)

- Pre-CS
- CS
- Refractory CS

Pre CS

Hypoperfusion

- Oliguria
- Cold extremities
- Alerted mental status
- Increased lactate
- SBP> 90 mm Hg

CS

Hypoperfusion +

- SBP < 90 mm Hg
- Need for devices or inotropes
- CI < 2.2L/min/m2
- Increased filling pressures

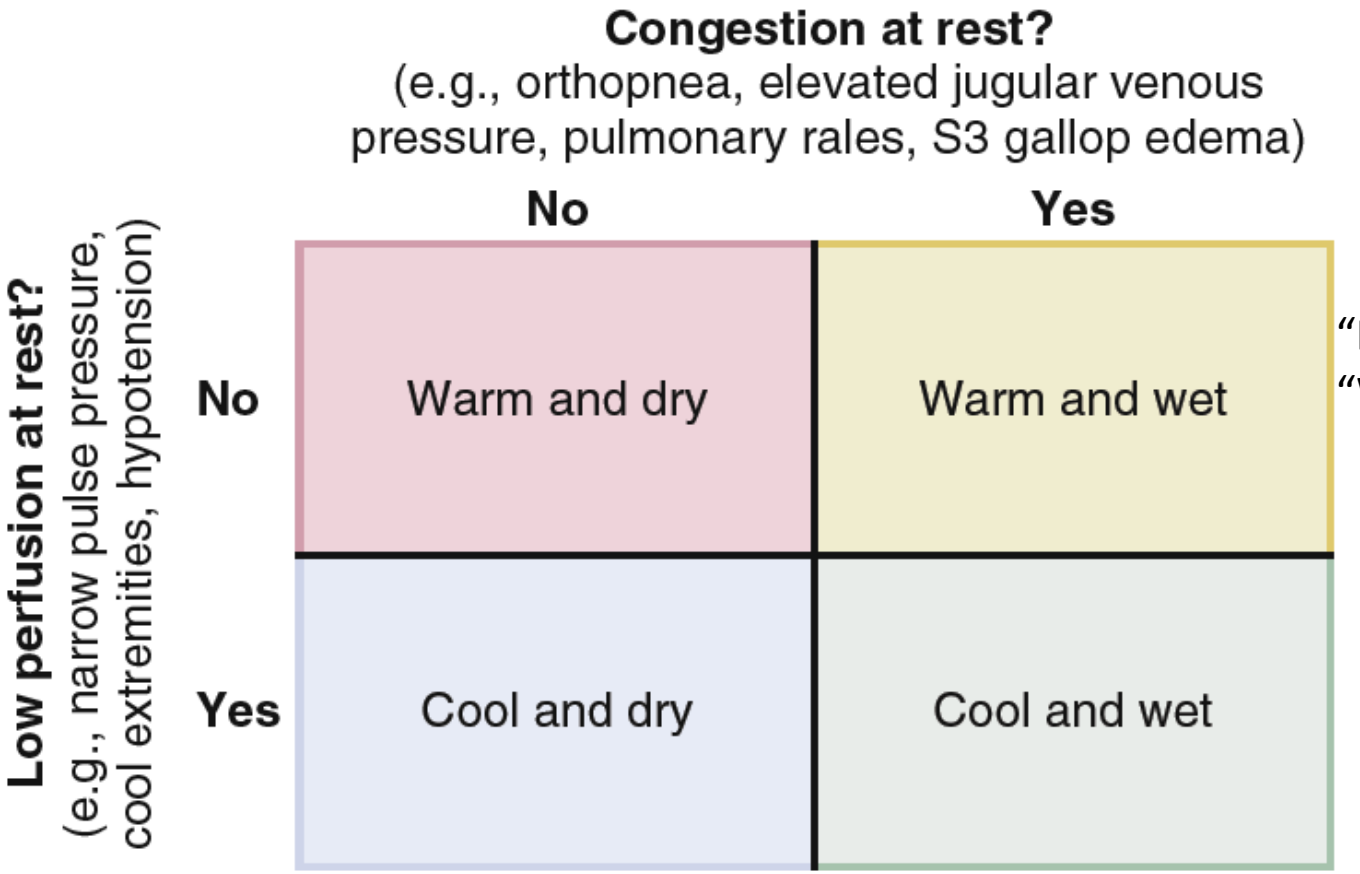
Refractory CS

Hypoperfusion +

- Hemodynamics same
- Ongoing tissue hypoperfusion despite 2 vasoactive meds and or devices

Nat Rev Cardiol 2016;13(8):481–92.
SHOCK registry Am J Med 2000;108:374-80

Categorizing patients with heart failure (HF) on the basis of perfusion (warm versus cold) and presence of congestion



"Dry/warm" (uncongested with normal perfusion)
"Wet/warm" (congested with normal perfusion

Dry/cold" (uncongested but hypo perfused)
Wet/cold" (cardiogenic shock)

J Am Coll Cardiol. 2003;41:1797

Points to Consider Evaluating Patient in Cardiogenic shock

- Thorough patient evaluation
  - Look for features of shock
    - Cooler extremities
    - Accuracy of blood pressure readings
    - Sedate or obtunded mental status
    - Cool and wet or cool and dry profile
    - Decreasing urine output
    - Elevated lactate levels
    - Evidence of high filling pressures and low mixed venous saturations

Case in point

- 33 year old Non ischemic DCM, admitted with increasing fluid, weight gain of 10lbs, dyspnea. LVEF of 26%
- Two hospital admissions in the last month
- Doses of po Lasix increased to 80 mg twice daily- less urine output ~ 1 week ago
- Meds: lisinopril 10mg, carvedilol 6.25 mg bid Compliant

Case

- Exam: BP 110/72, HR 86, O2-96, wt. 300 lbs
- IJ mid neck, soft s3, anasarca, few crackles. Distended abdomen, warm extremities
- Na 133, K 4,2; Initial creatinine 1.1 Bun 22
- Lasix drip at 10 mg/hour, lost 2 lbs in 24 hours
- Still edematous, and dyspneic.

Follow up labs in 12 hours BUN 26, create 1.6, Na 132

Best Next Step

1. Add inotrope such as dobutamine or milrinone
2. Change furosemide to bumetanide drip
3. Right heart catheterization to better assess filling pressures
4. Increase furosemide drip dose
5. Increase carvedilol and lisinopril
6. Add spironolactone

Acute on Chronic HF

- 73 year old ischemic cardiomyopathy. LVEF 25 % for over 10 years. Functional class III. No chest pain. Increasing dyspnea
- On oral meds –Torsemide 20 mg twice daily, carvedilol 6.25 mg twice daily, Entresto low tier twice daily, spironolactone 25 mg once daily.
- Recent worsening of renal function 26/ 2.6 to 28/ 2.8
- Increasing fatigue, weight loss of 6 lbs. in 3 months
- Entresto stopped-pt felt worse, went back on ½ tablet twice daily, diuretic increased. BP has been 90-100 mm Hg systolic
- He had refused advanced HF treatments including LVAD or heart transplant in the past
- Decision to do right heart catheterization

Right Heart Catheterization

Hemodynamic data: 10/28/2020
Blood pressure 108/68 mean 82 mmHg, heart rate 60 bpm
RA 5 mmHg
RV 67/0 mmHg
PA 65/14, mean 35 mmHg
Pulmonary capillary mean 19 mmHg.

Thermodilution cardiac output 4.9 L/min, cardiac index 2.5 L/min/m²
Fick cardiac output 5.4 L/min, cardiac index 2.7 L/min/m²

Hemodynamic data 7/28/2022
Blood pressure 119/50 mm Hg, 92 bpm
RA 21 mmHg
RV pressure 98/6 mmHg
PA pressure 110/30 mean of 58 mmHg
Pulmonary capillary wedge pressure mean of 36 mm Hg

Thermodilution cardiac output 3.6l/min cardiac index 1.8 l/min/m²
Fick cardiac output 4.0 l/min cardiac index 2.0 l/min/m²

PVR 5.5 Wood units
Systemic vascular resistance 1324 dynes per second

What would you do next ?

1. Insert Impella 5.5 to reduce filling pressures
2. Intra aortic balloon pump reduces after load, should be primary choice
3. Both right side pressure and left side pressure is elevated with low cardiac output consider Veno-Arterial Extra corporeal membrane oxygenation
4. IV diuretics with inotropes
5. Start CRRT or hemodialysis to better remove fluid and improve filling pressures

What we did

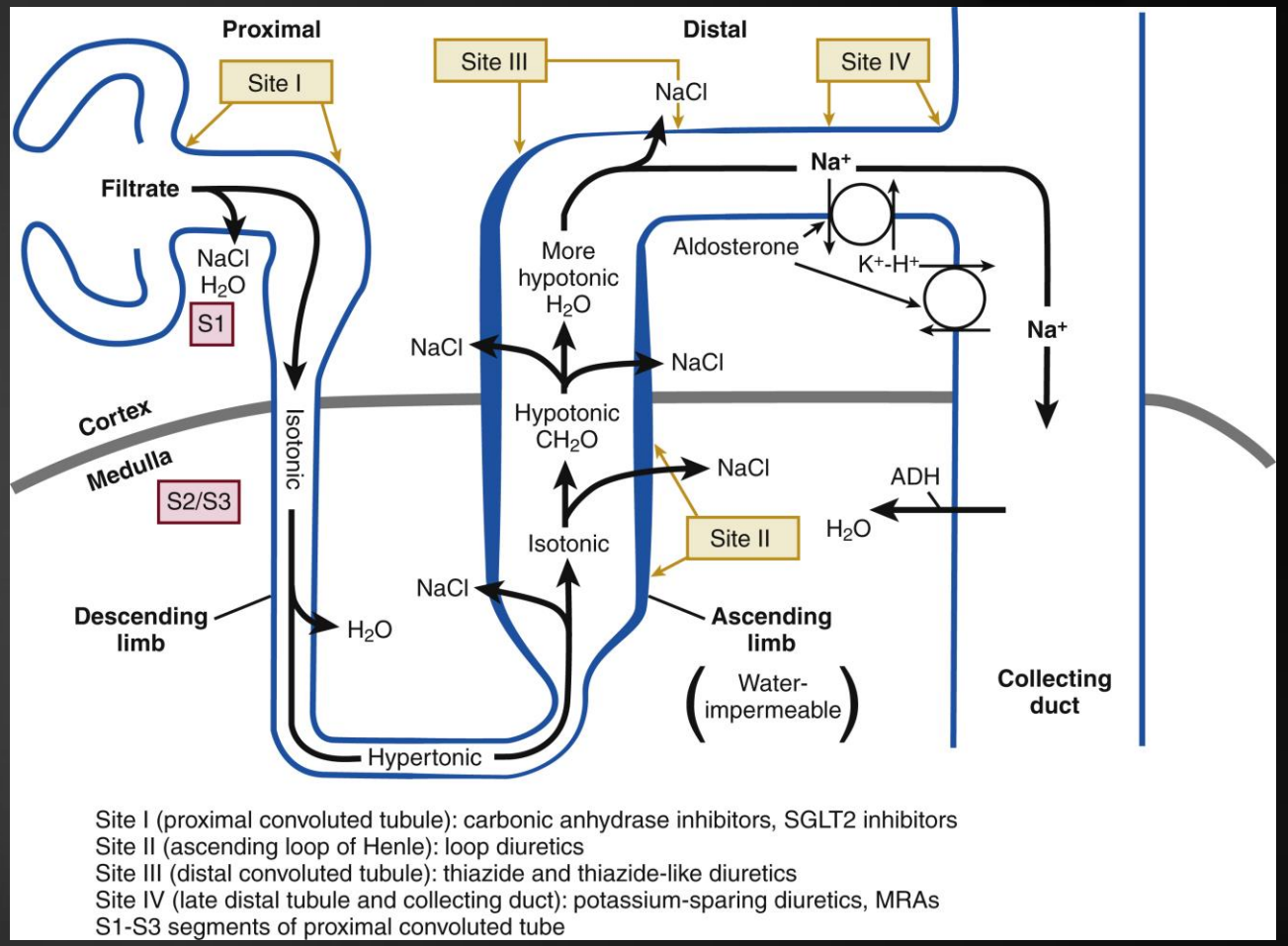
- Bumetanide 1mg/hour
- Milrinone 0.25 ug/kg/min
- Monitor I and O
- Symptoms improving
- Weight decreased by 10 lbs. in 3 days
- Switched to oral torsemide, milrinone weaned off, oral hydralazine and nitrates
- Palliative care and currently made DNR
- Pt. was ambulatory

What happened to the creatinine?

BUN	29	←	32	←	29	←	36
Creat	2.17		2.81		2.64		3.06

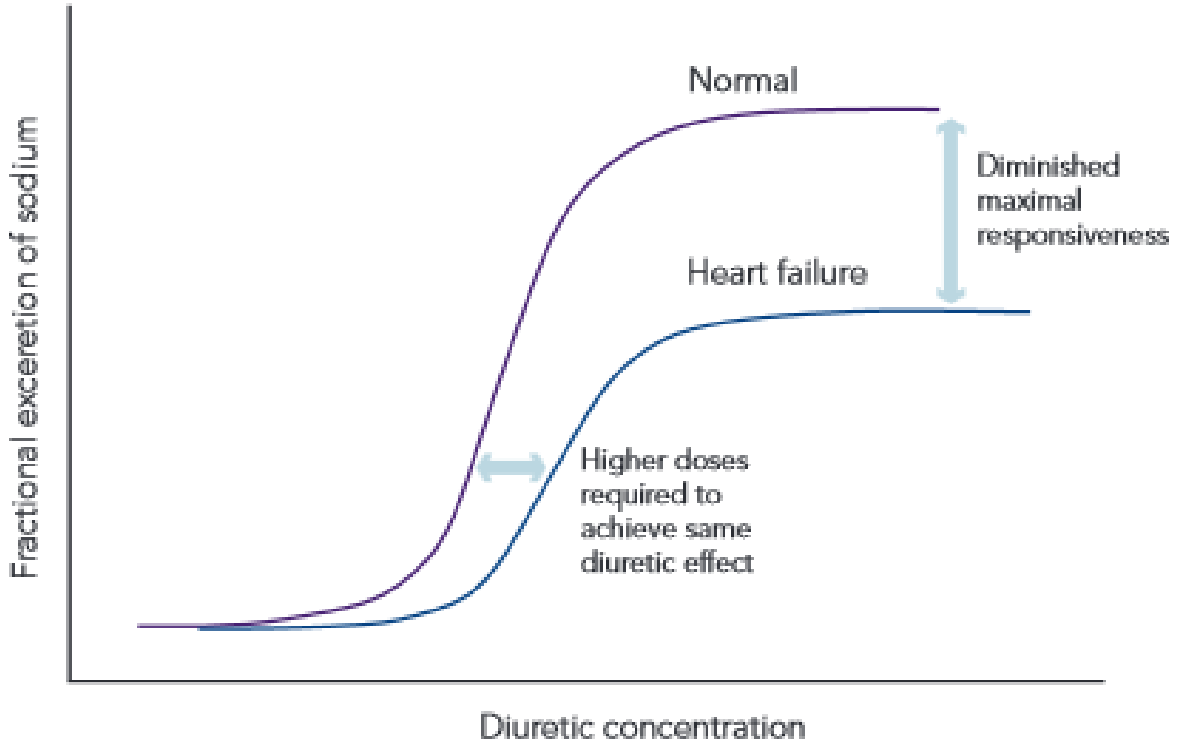
Loop Diuretics

- Threshold drugs-Steep dose response relationship
- Dependent on renal blood flow - proximal tubular secretion to deliver to site of action
- Bioavailability of furosemide 40-70%; bumetanide and torsemide greater than 80%
- Act as venodilators, but systemic vascular resistance may rise due to RAS



Site I (proximal convoluted tubule): carbonic anhydrase inhibitors, SGLT2 inhibitors
Site II (ascending loop of Henle): loop diuretics
Site III (distal convoluted tubule): thiazide and thiazide-like diuretics
Site IV (late distal tubule and collecting duct): potassium-sparing diuretics, MRAs
S1-S3 segments of proximal convoluted tube

Figure 1: Schematic of a Dose-response Curve of Loop Diuretics in Heart Failure Patients Compared with Controls



In heart failure patients, higher doses are required to achieve a given diuretic effect and the maximal effect is blunted. Adapted, with permission, from Ellison[21] and reprinted, with permission, from Felker Reproduced with permission from Felker.[22]

Pathophysiology Of Diuretic Resistance In Heart Failure

- Oral absorption of loop diuretics is impaired
- Renal insufficiency decreases diuretic efficacy
- Reduced renal blood flow in HF reduces diuretic delivery
- Braking Phenomenon
  - Rebound sodium reabsorption
  - Hypertrophy of the distal tubular cells

Cardiology 2001;96:132
Am J Med 1999;106:59G

Braking Phenomenon

Consider using loop diuretics twice daily

Braking phenomenon

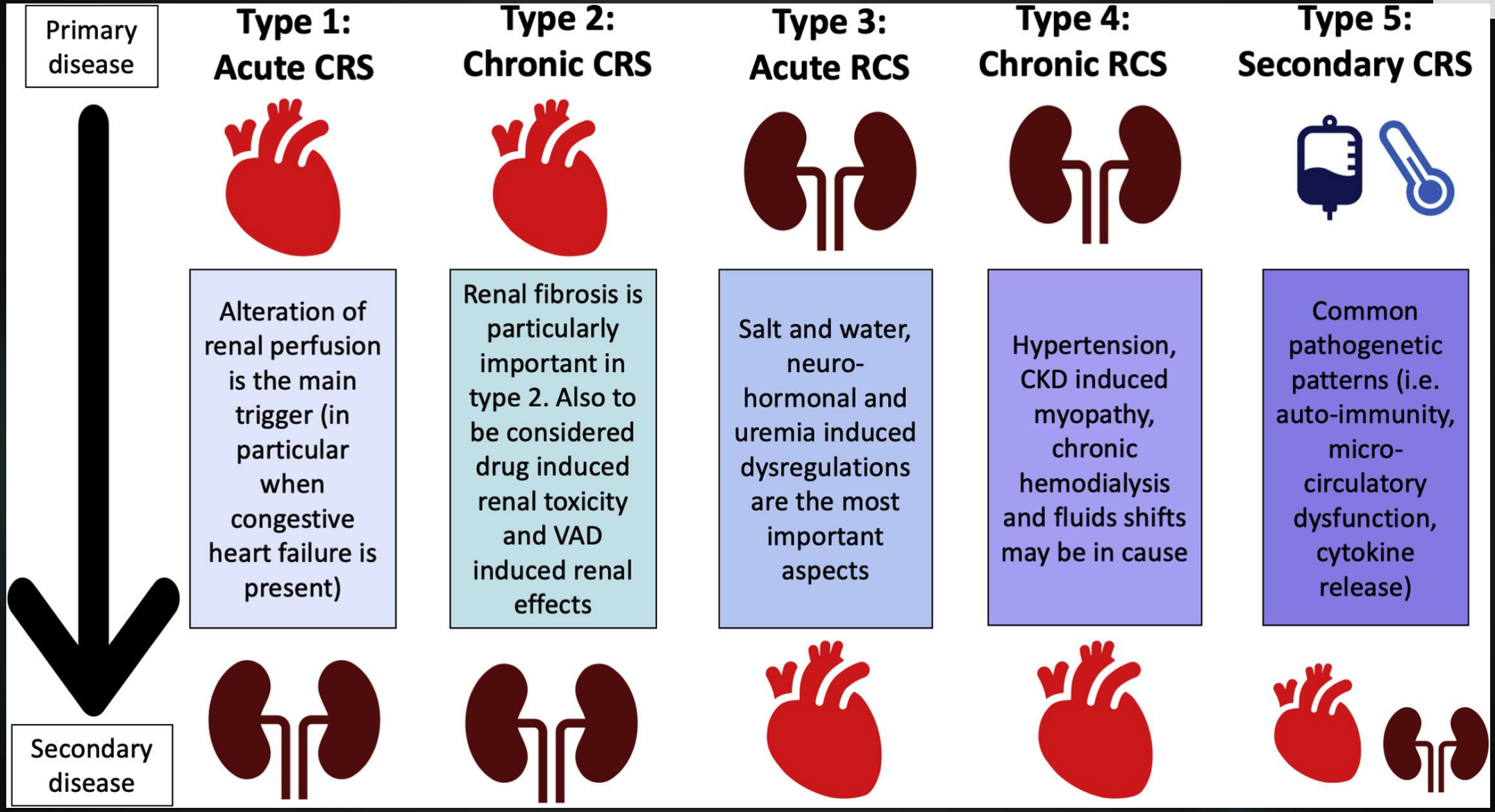
- A physiological response to volume reduction caused by diuretics.

Volume reduction

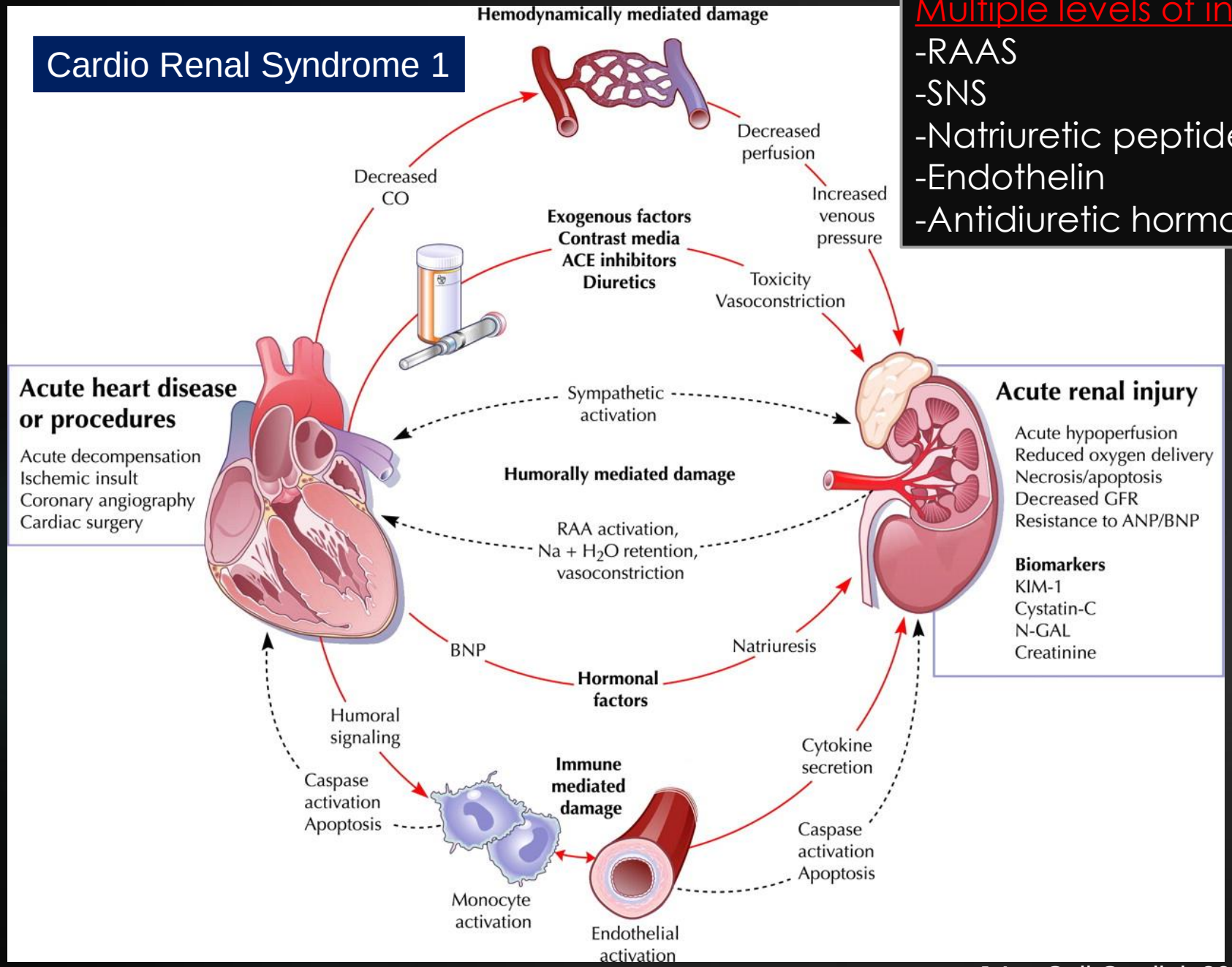
1) Increased sodium reabsorption in the proximal renal tubules
2) Increased renin release

Progressive decline in the extent of natriuresis

Cardiorenal Syndrome



Cardio Renal Syndrome 1



Multiple levels of interaction

-RAAS

-SNS

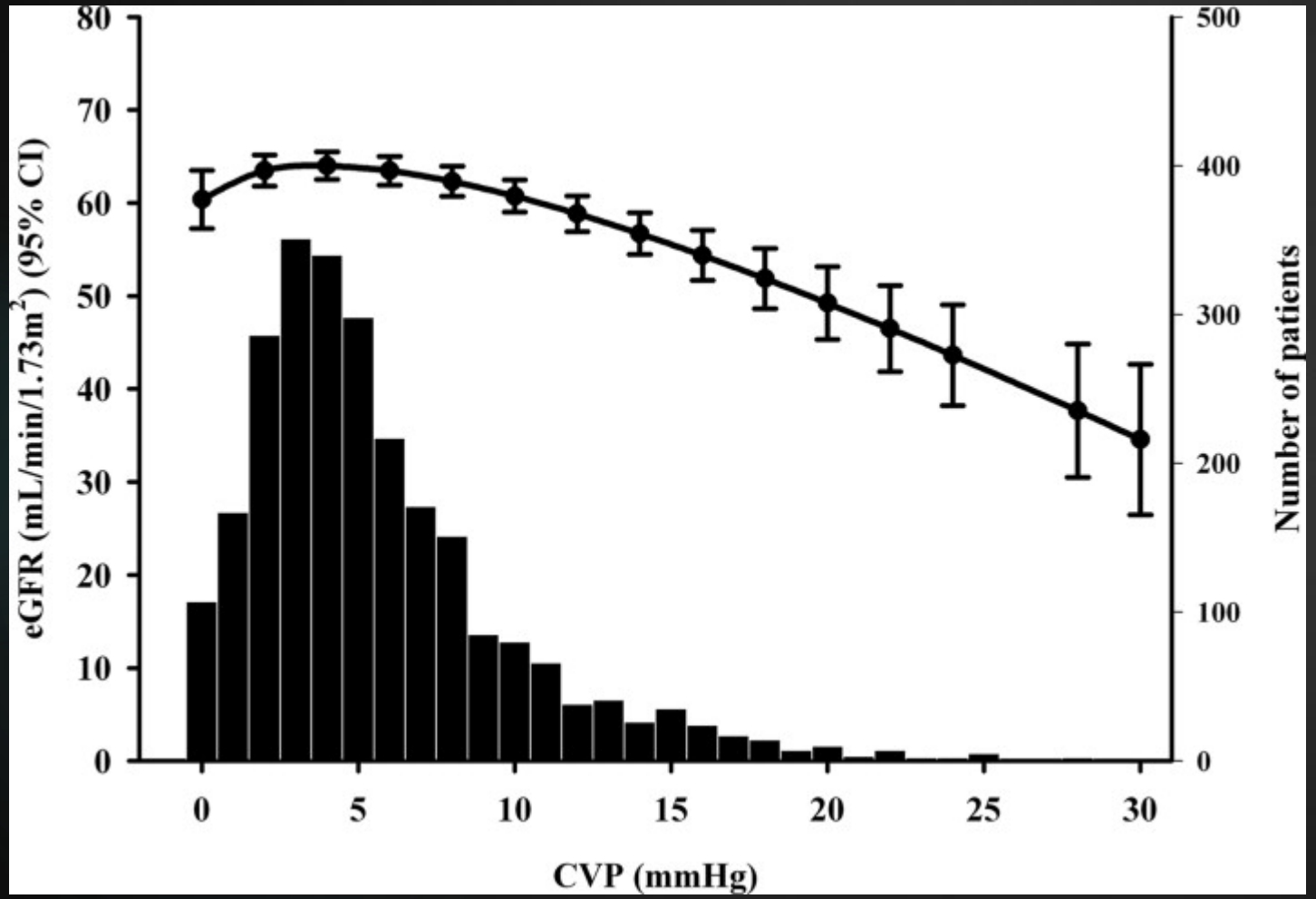
-Natriuretic peptides

-Endothelin

-Antidiuretic hormone

J Am Coll Cardiol, 2008; 52:1527-1539

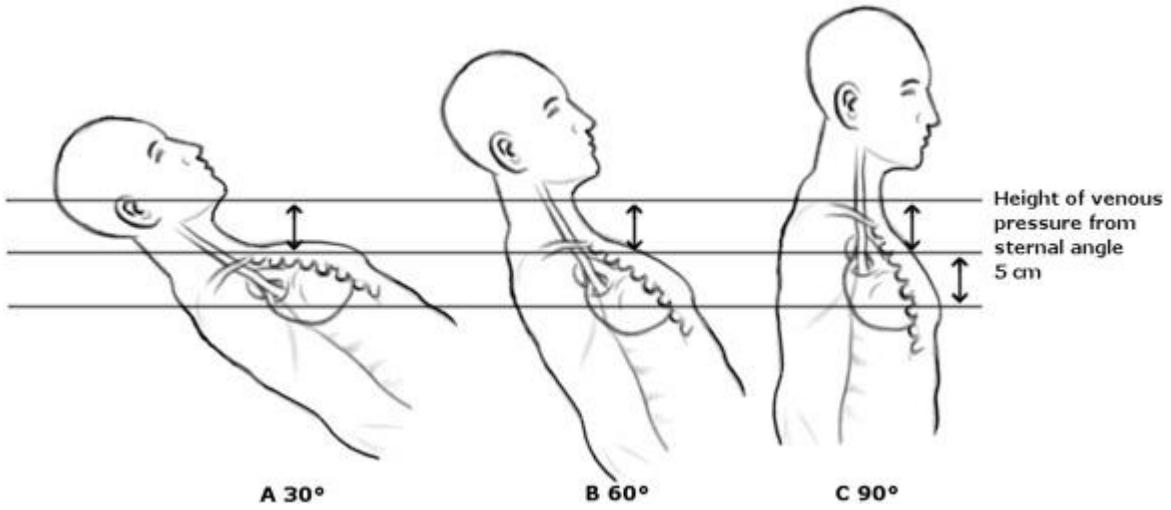
Relationship Between Central Venous Pressure (CVP) and Estimated GFR

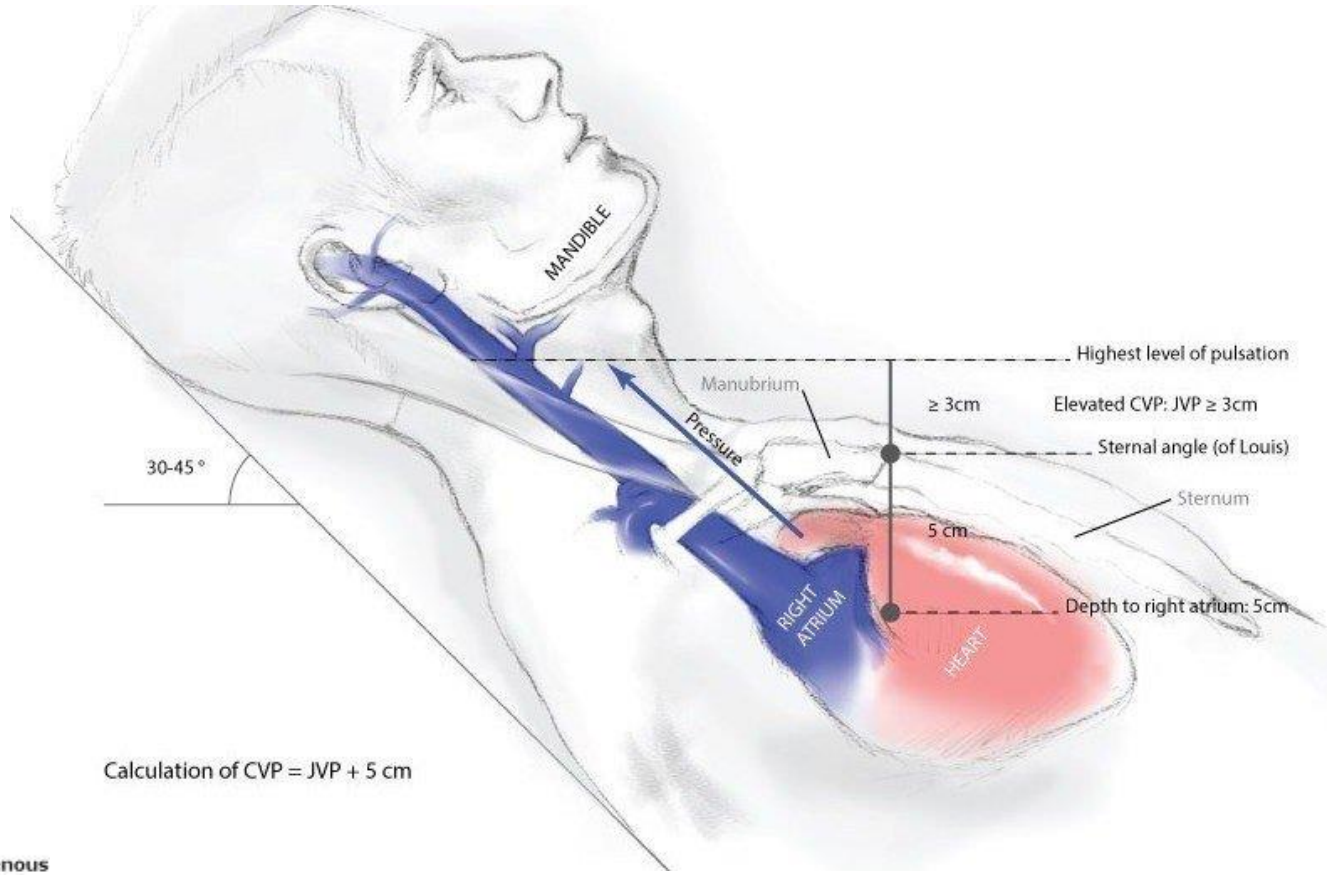


JACC 2009; 53: 597-599

Jugular Venous Pulse JVP

Elevated JVP detect systemic congestion, but there is good sensitivity (70%) and specificity (79%) between high JVP and elevated left-sided filling pressure





Signs and Symptoms of Chronic Heart Failure

Symptoms due to excess fluid accumulation	Symptoms due to a reduction in cardiac output	Physical Findings in heart failure
• cough, • wheezing, • dyspnea, • orthopnea, • paroxysmal nocturnal dyspnea, • lower extremity edema, • abdominal pain from hepatic congestion, • Ascites(abdominal distension)	• fatigue, • weakness, • decreased exercise tolerance • palpitations • fainting/syncope	• Tachcyardia (Increased heart ra • Third heart sound besides the " and "dub"(S3 gallop) • Irregular or alternating pulse • Tachypnea (increased breathing rate) • laterally displaced apical impul • Heart murmurs • Elevated jugular venous pressu positive hepato-jugular reflux • Cyanosed lips and tongues (blu

TABLE 2. Clinical signs and symptoms of chronic heart failure

Signs	Symptoms
More specific	More typical
» Laterally displaced apex beat » Elevated jugular venous pressure » Third heart sound » Hepatojugular reflex	» Breathlessness » Orthopnoea » Paroxysmal nocturnal dyspnoea » Reduced exercise tolerance » Fatigue » Ankle swelling
Less specific	Less typical
» Tachycardia » Irregular pulse » Murmur » Narrow pulse pressure » Tachypnoea » Bi-basal lung crepitations » Reduced air entry and dullness to percussion at lung bases (pleural effusion) » Cheyne-Stokes respiration » Pleural effusion » Peripheral oedema » Weight gain » Weight loss » Cachexia » Hepatomegaly » Ascites » Cold extremities » Oliguria	» Nocturnal cough » Wheezing » Bloated feeling » Loss of appetite » Confusion » Depression » Palpitations » Dizziness » Syncope » Bendopnea » Pain

Cardiovascular Exam

General
Vital signs
Carotid pulse
Jugular venous pressure
Lungs
Cardiac-palpation and auscultation
Abdomen
Periphery
Neurological

Carefully performed physical examination provides unique information to the clinician
Oversights in the physical examination are a major contributor to missed or delayed diagnosis
Clinical signs of congestion provide independent predictors of prognosis

Symptomatic left ventricular systolic dysfunction with

- Recent episode of **atrial fibrillation**
- **Congestive signs** (i.e., peripheral edema, jugular venous distension, a third heart sound, and pulmonary rales) were associated with **worse prognosis**

Comparing the 3rd and 4th heart sounds

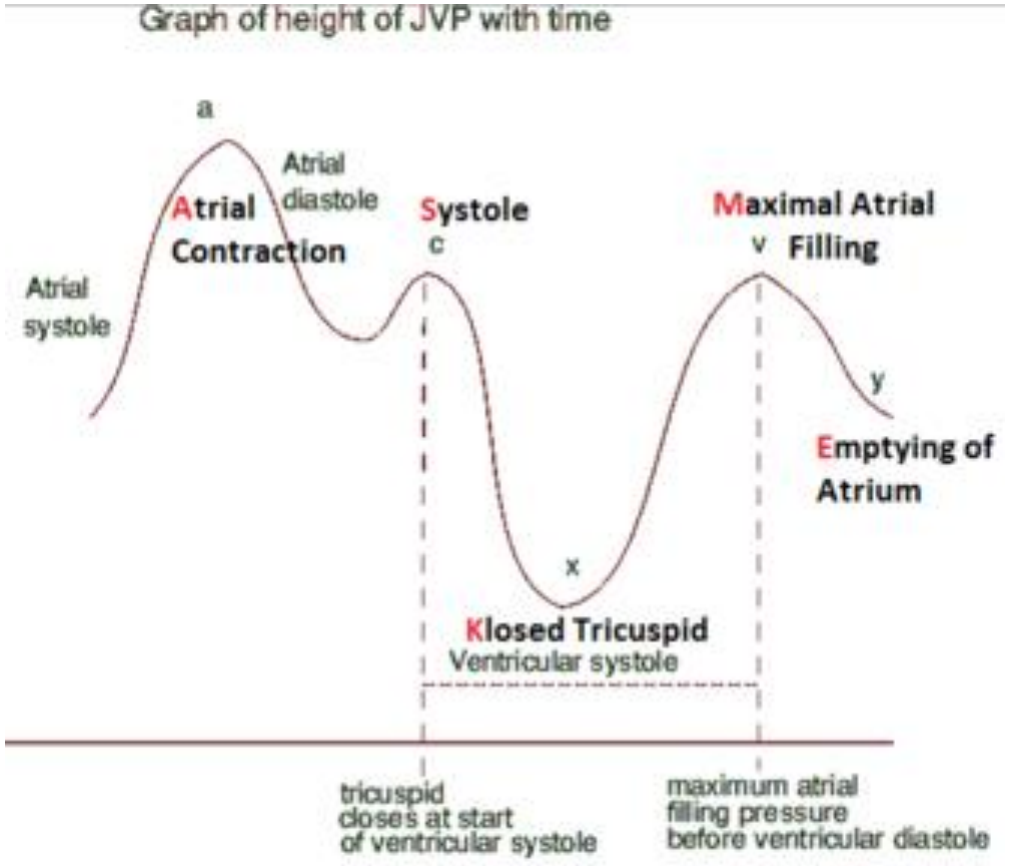
LearnTheHeart.com

S3 - "ventricular gallop"	S4 - "atrial gallop"
Occurs in early diastole	Occurs in late diastole
Occurs during passive LV filling	Occurs during active LV filling
May be normal at times	Almost always abnormal
Requires a very compliant LV	Requires a non-compliant LV
Can be a sign of systolic CHF	Can be a sign of diastolic CHF

Clinical Exam Validity

H&P FINDING	FREQUENCY	SENSITIVITY	SPECIFICITY	PREDICTIVE VALUE		LR		
				POSITIVE	NEGATIVE	POSITIVE	NEGATIVE	OR (95% CI)
Values expressed as percentages unless otherwise indicated. LR indicates likelihood ratio; OR, odds ratio.								
Rales (≥1/3 lung fields)	26/192	15	89	69	38	1.32	1.04	1.4 (0.6, 3.4)
S3	123/192	62	32	61	33	0.92	0.85	0.8 (0.4, 1.5)
Ascites (moderate/massive)	31/192	21	92	81	40	2.44	1.15	2.8 (1.1, 7.3)
Edema (≥2+)	73/192	41	66	67	40	1.20	1.11	1.3 (0.7, 2.5)
Orthopnea (≥2 pillows)	157/192	86	25	66	51	1.15	1.80	2.1 (1, 4.4)
Hepatomegaly (>4 finger breadths)	23/191	15	93	78	39	2.13	1.09	2.3 (0.8, 6.6)
Hepatojugular reflux	147/186	83	27	65	49	1.13	1.54	1.7 (0.9, 3.5)
JVP ≥12 mm Hg	101/186	65	64	75	52	1.79	1.82	3.3 (1.8, 6.1)
JVP <8 mm Hg	18/186	4.3	81	28	33	0.23	0.85	0.2

JVP Related Exam in HF

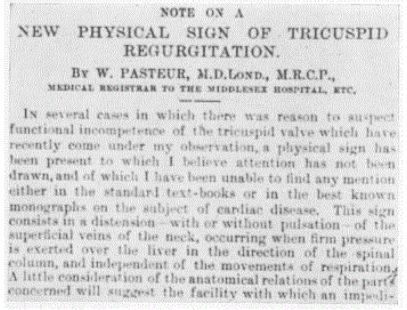


Kussmaul's sign: ↑JVP with inspiration

Kussmaul's sign can be a sign of constrictive pericarditis, restrictive cardiomyopathy, severe tricuspid regurgitation, or a primary RV cardiomyopathy.

Distention of the neck veins when pressure is applied over the liver -Hepato-Jugular reflux

Pressure applied over the RUQ in HF cause sustained JVP elevation



NOTE ON A
NEW PHYSICAL SIGN OF TRICUSPID REGURGITATION.

By W. PASTEUR, M.D.Lond., M.R.C.P.,
MEDICAL REGISTRAR TO THE MIDDLESEX HOSPITAL, ETC.

In several cases in which there was reason to suspect functional incompetence of the tricuspid valve which have recently come under my observation, a physical sign has been present to which I believe attention has not been drawn, and of which I have been unable to find any mention either in the standard text-books or in the best known monographs on the subject of cardiac disease. This sign consists in a distension—with or without pulsation—of the superficial veins of the neck, occurring when firm pressure is exerted over the liver in the direction of the spinal column, and independent of the movements of respiration. A little consideration of the anatomical relations of the parts concerned will suggest the facility with which an impedi-

Fig. 1.—The hepatojugular reflux was originally reported as a manifestation of tricuspid regurgitation by William Pasteur.

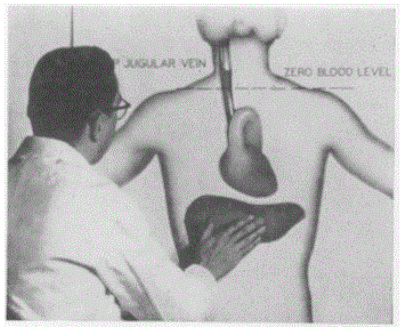


Fig. 2.—This sign consists of an elevation of the pulsating level in the deep neck veins or distention of the superficial neck veins when pressure is exerted over the liver.

Question -Acute Congestive HF

1. All are true except
    1. There blood pressure is generally normal or hypertensive
    2. Shortness of breath is the presenting symptom
    3. Neck veins are generally elevated
    4. Require inotropes frequently
    5. Diuresis should promptly improve symptoms

Summary

- Know your patient
- Thorough examination and accurate documentation helps identify early signs of deterioration
- Keep your exam skills sharp
- Optimize medical therapy and treat comorbidities
- Renal dysfunction in HF suggest worsening inflammatory milieu
- Optimal dosing of diuretics in HF is essential to improving volume status
- Patient education and family awareness