ACUTE HEART FAILURE

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DISCLOSURES

- I have no relevant disclosures

LEARNING OBJECTIVES

- 1. Gain better understanding of the physiology of congestive heart failure as well as its presentation and diagnosis
- 2. Learn about the important developments in CHF pharmacotherapeutics
- 3. Develop a framework for approaching CHF in the hospital

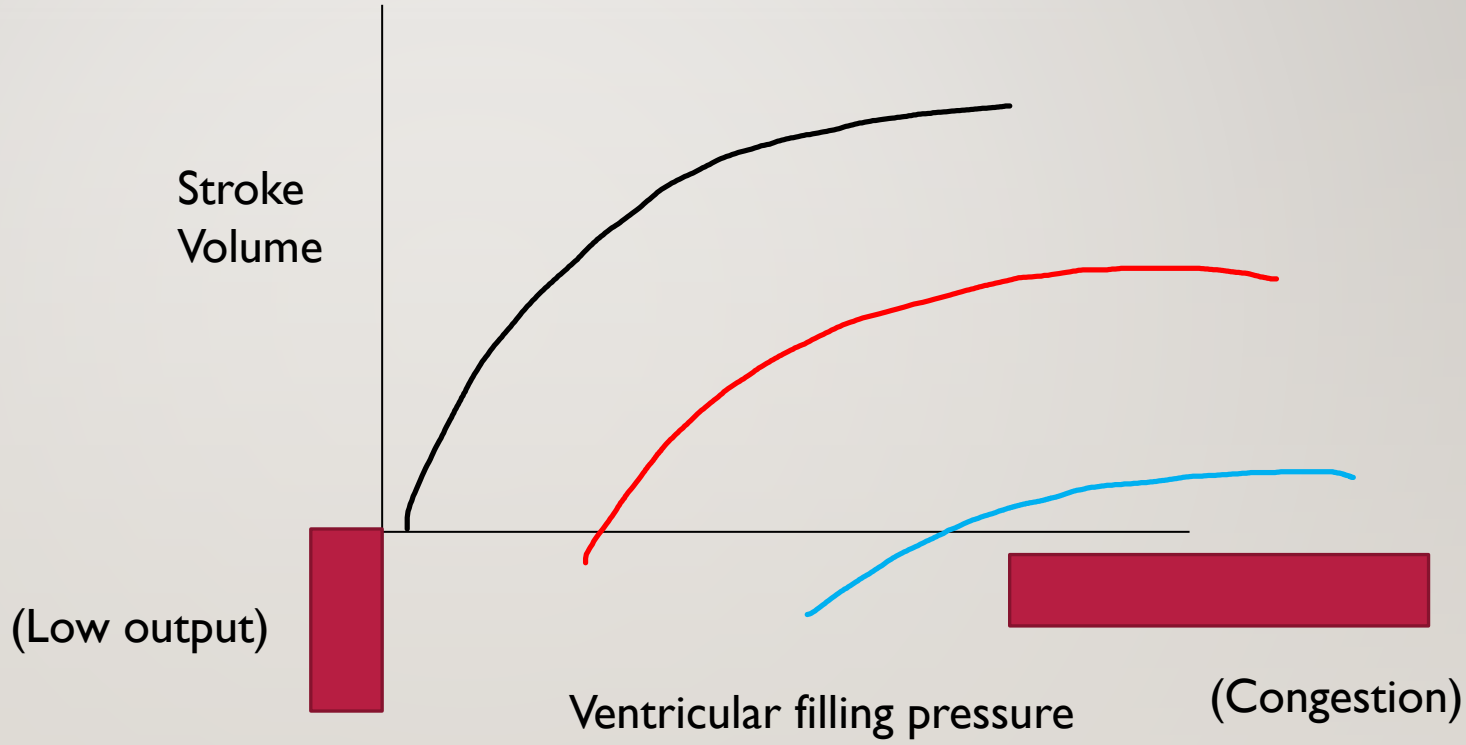
OVERVIEW

- Part 1: Congestive Heart Failure Review
  - Definitions
  - Epidemiology
  - Pathophysiology
  - Clinical findings
  - Pharmacotherapy
- Part 2: CHF in the Hospital
  - Admission
  - Hospital course
  - Discharge

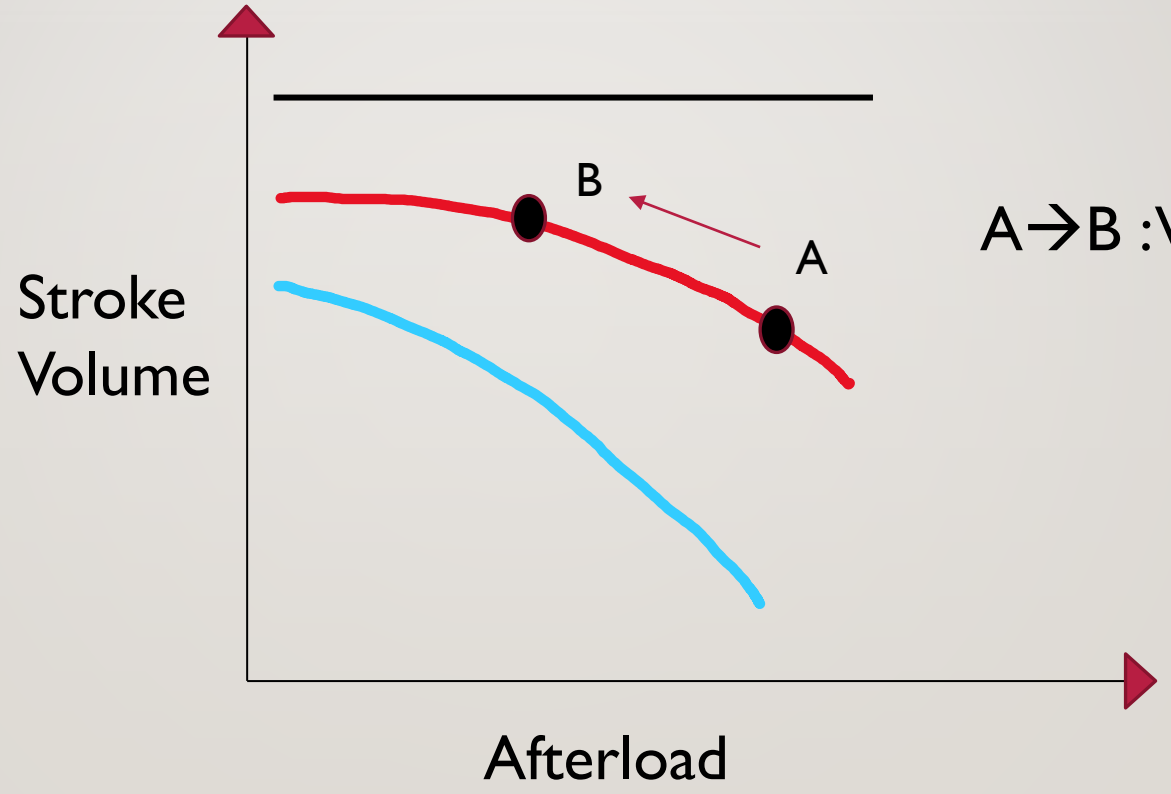
DEFINITIONS & TERMINOLOGY

- Failure of heart to pump blood at sufficient supply to match body's demand or ability to do so only at pathologically elevated filling pressures
- Systolic HF: inability to expel blood
- Diastolic HF: impaired relaxation and abnormal ventricular filling
- HFrEF: EF < 40%
- HF moderately reduced (mid-range) EF (HFmrEF): EF 40-49%
- HFpEF: EF > 50%
- GDMT = Guideline-Directed Medical Therapy
- RAS = Renin-angiotensin system
- MRA = Mineralocorticoid receptor antagonist

FRANK-STARLING RELATIONSHIP



EFFECT OF AFTERLOAD ON LV PERFORMANCE



A→B :Vasodilator effect

PATHOPHYSIOLOGY: MALADAPTATIONS TO DECREASED PERFUSION (↓CO)

- RAS activation: ↑Na & water retention (→ ↑preload), vasoconstriction
- ↑ ADH: ↑water retention
- ↑ Sympathetic input: vasoconstriction/↑SVR (↑afterload)

EPIDEMIOLOGY OF ACUTE HF

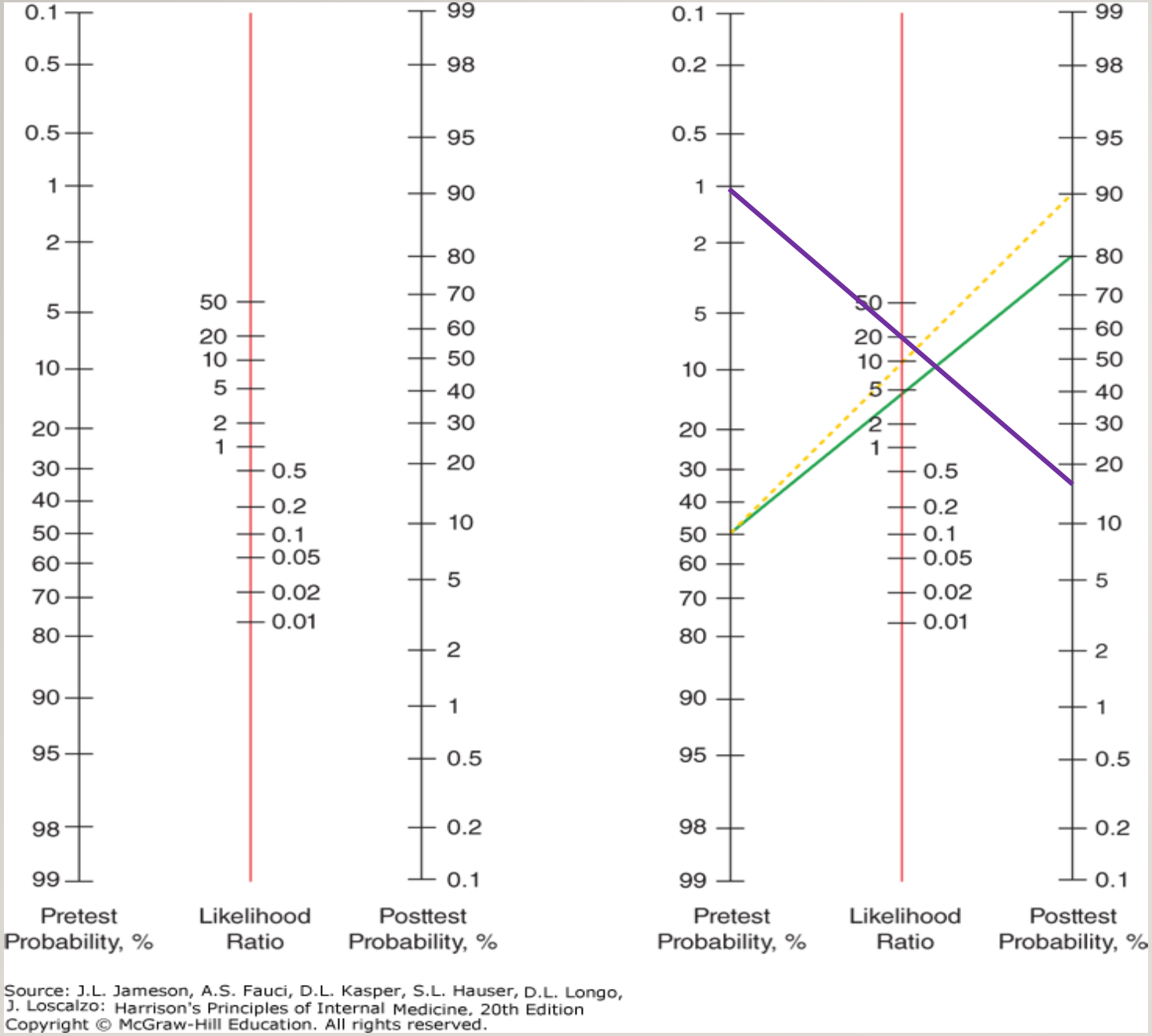
- Leading cause of hospitalization in patients > 65
- 50% of hospitalizations for HF are cases of HFpEF
- 30-day readmission rate of ~20%
- Inpatient mortality: 4-12%
- Post-discharge mortality: 10% at 90-day follow-up

ETIOLOGIES: PRECIPITANTS OF ACUTE HF

- Dietary indiscretion/med **nonadherence** (40%)
- **Ischemia** or infarction (10-15%)
- Renal failure (acute or progression of CKD): ↑preload
- Arrhythmia (**A.Fib**)
- Valvular disease (decompensated aortic stenosis→ ↑afterload)
- HTN crisis: ↑afterload
- Drugs (βB, CCB recent **increase in beta-blocker or non-DHP CCB** [eg, **diltiazem]**, NSAIDs), toxins (ETOH)
- Stress, infections, etc.

DIAGNOSTIC TESTS & MEDICAL DECISION MAKING (A BRIEF DIGRESSION)

- **Diagnostic Test**: any piece of information (history, physical, lab, imaging) that reduces uncertainty about a patient's diagnosis; tests change *probability* (no test is perfect)
- **Pretest Probability**: estimate of likelihood of diagnosis prior to a particular test (eg, prevalence, context)
- **Sensitivity** = high sensitivity helps rule out (SnOUT)
- **Specificity** = high specificity helps rule in (SpIN)
- **Likelihood Ratio:** How well a test differentiates patients with disease from those without disease
  - +LR: change in odds [of having x diagnosis] when finding is present = Sens / (1 – Sp)
  - -LR: change in odds when finding is absent = (1 – Sens) / Sp
- **Bayes' Rule: Pre-test probability x LR = Post-test probability**



BAYES' RULE APPLIED

- Test 1 (green): LR = 4
- Test 2 (yellow): LR = 9
- Test 3 (purple): LR = 20
- *Strong tests are most useful in patients with moderate pretest probability*

HISTORY: SUBTYPE BY SYMPTOMS

Low Output:

- Fatigue, weakness, anorexia, ΔMS

Congestive:

- Left-sided: Dyspnea (Sens 84%, Sp 34%), **orthopnea (Sp 77%)**, **PND (Sp 84%)**
- Right-sided: Peripheral edema, RUQ pain, bloating

CLINICAL FINDINGS: SIGNS

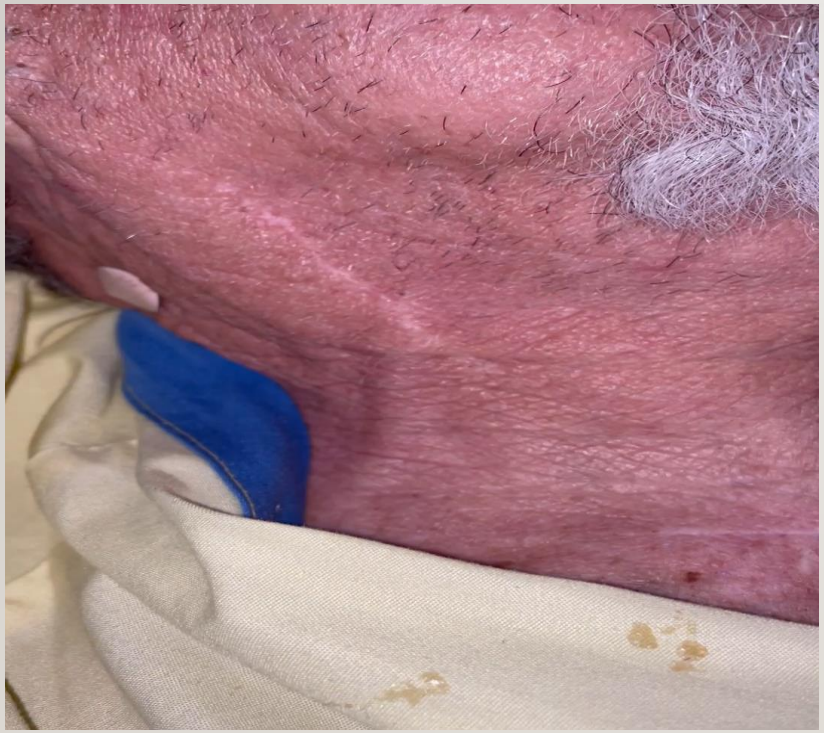
- Peripheral edema (Sens 50%, Sp 78%)
- Rales (Sens 60%, Sp 78%), dullness at bases (eg, 2/2 pleural effusion)
- Narrow pulse pressure
- Gallops: **S3** (**+LR 11**), S4 (+LR 1.6)
- HoTN, AMS, lethargy, cool extremities, abdominal pain, oliguria
- **JVD** (Sens 39%, **Sp 92%; +LR 5.1**)

PHYSICAL EXAM: JVP

- **Jugular venous pressure elevation: 80% of the time, JVP > 10 ~ PCWP > 22**
- Head of Bed at **45-degrees**:
  - No visible pulsations ~ RA pressure 5-8 cm H2O (normal)
  - Pulsations at **clavicle ~ 10cm** H2O
  - At **midneck ~ 15cm** H2O
  - Angle of **mandible ~ 20cm** H2O

  } **Abnormal**
- Venous waves: soft, rippling/undulating, dominant inward deflection
- Arterial waves: vigorous, dominant outward deflection

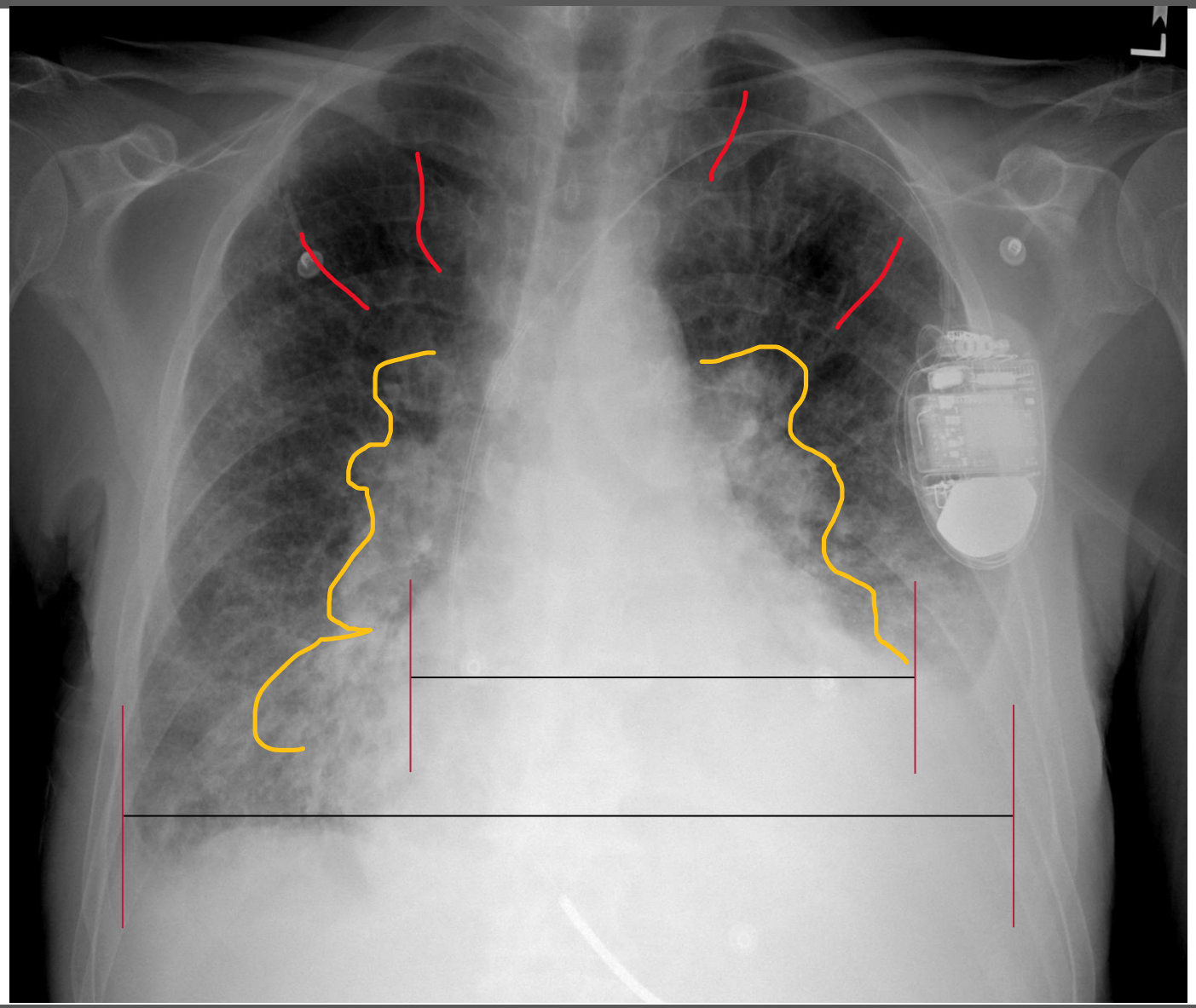
VENOUS WAVE (EJ IN THIS CASE)

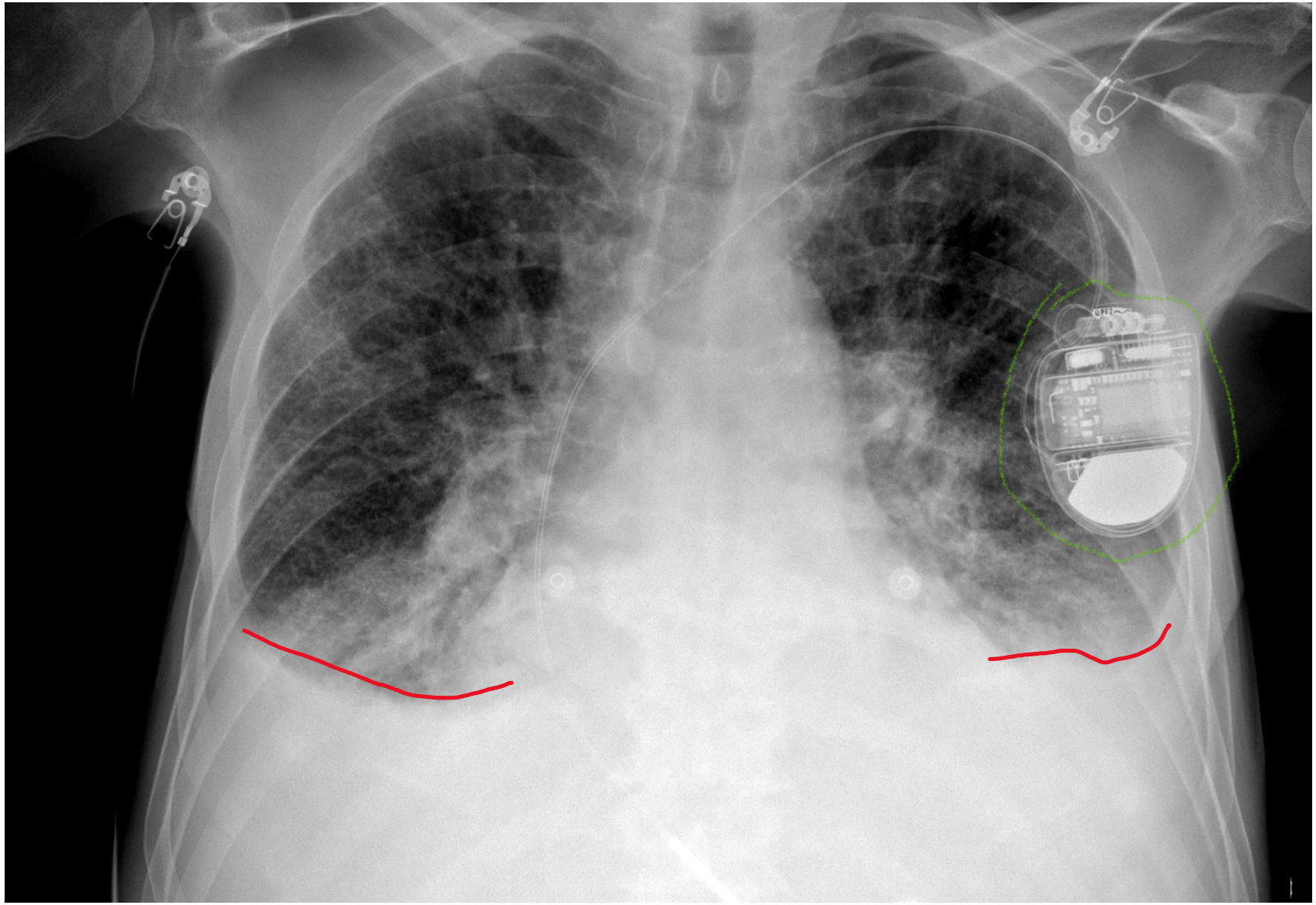


- Venous Waveforms:
  - Soft, undulating
  - Respirophasic
  - Height affected by head of bed elevation, RUQ pressure
  - Obliterates w/ palpation

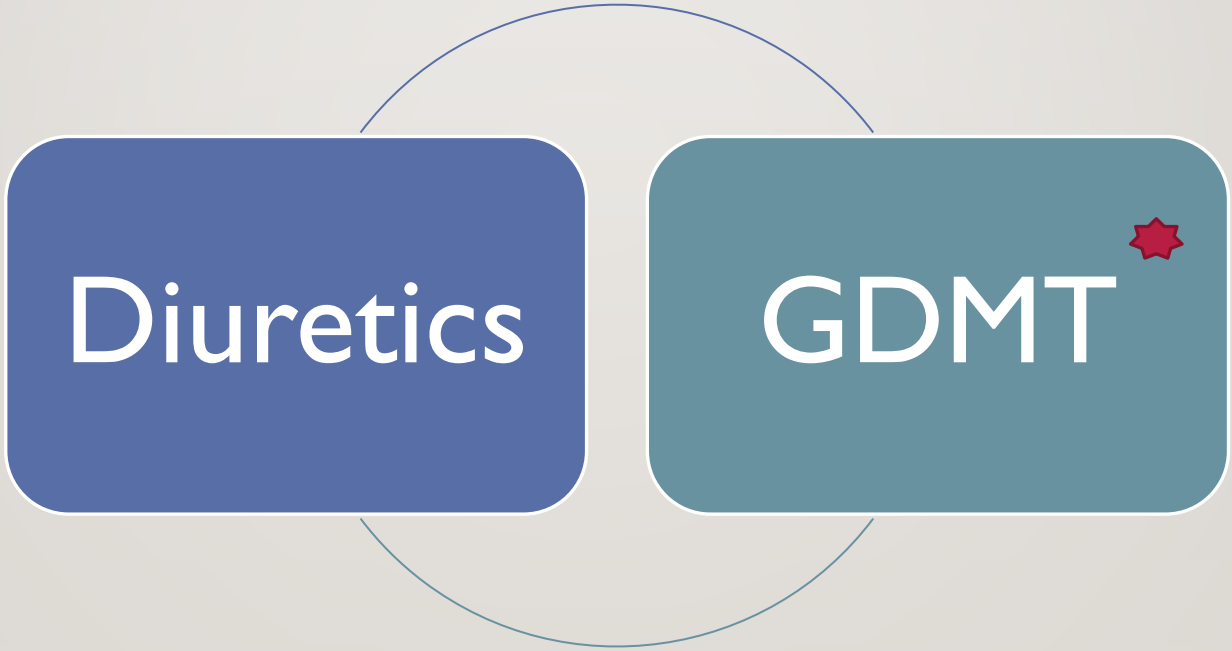
DIAGNOSTIC TESTS

- Labs:
  - Routine chemistry, LFTs, CBC (? Infxn or anemia); lactate if ? shock state
  - Troponin
  - **BNP: < 100pg/mL (-LR 0.09) has a high NPV for HF as cause of SOB**
- EKG
  - **AF (+LR 3.8)**, ischemia
- ECHO: for new dx or if suspicious for interval event leading to worsening EF
- CXR: **Pulmonary venous congestion (+LR 12)**, **interstitial edema (+LR 12)**; cardiomegaly, pleural effusions

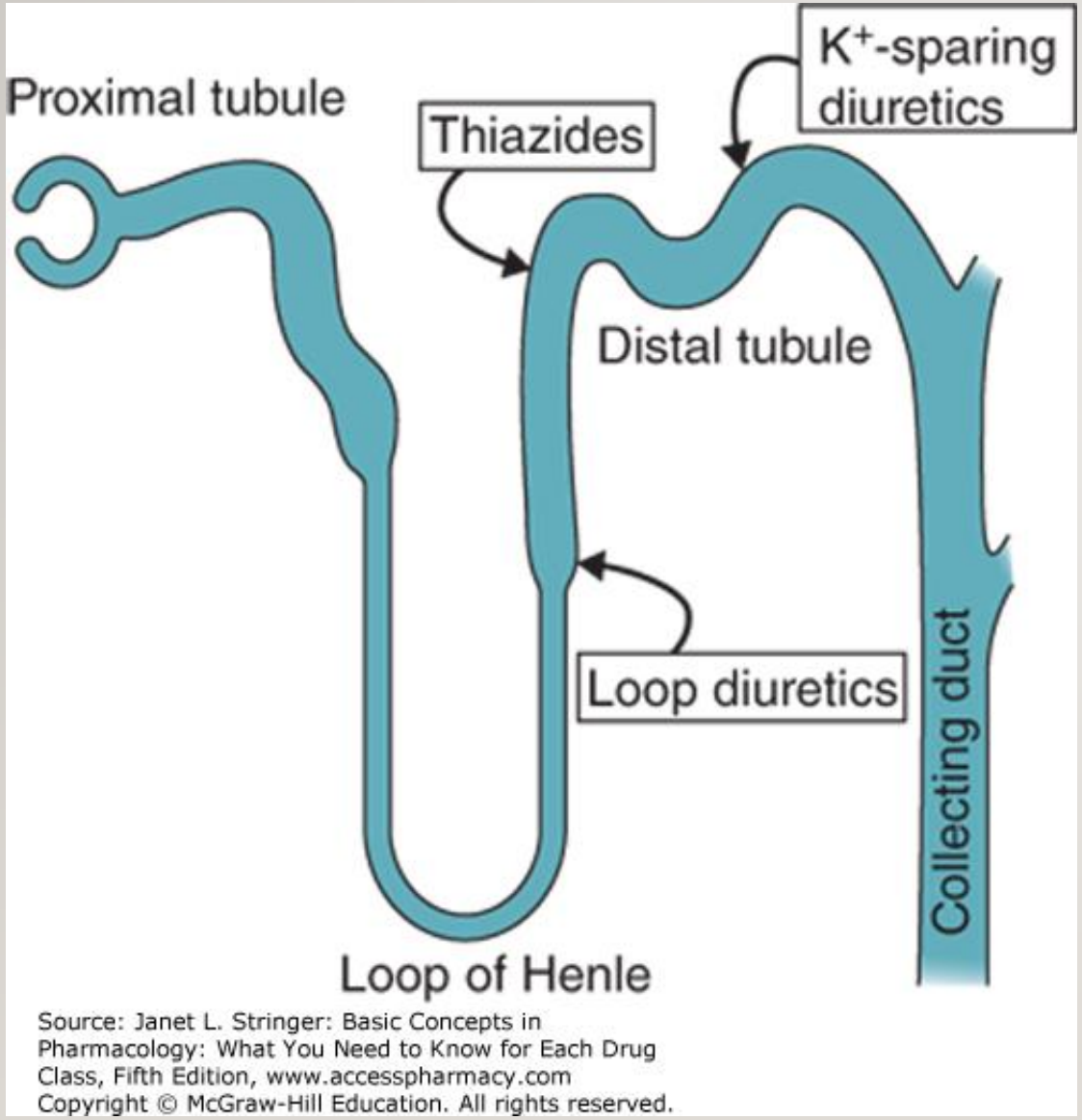




PHARMACOTHERAPY



GDMT discussions limited to pharmacotherapy



DIURETIC MECHANISMS

- H2O & Na excretion (natriuresis)
- Block Na reabsorption at different sites within the nephron; water follows
- Loops: ThAL (25% Na resabsorp.)
- Thiazides: DCT (5%)
- K-sparing (eg, Aldosterone antagonists): Collecting duct (1%)
- Synergy (eg, loop + thiazide): Sequential nephron blockade

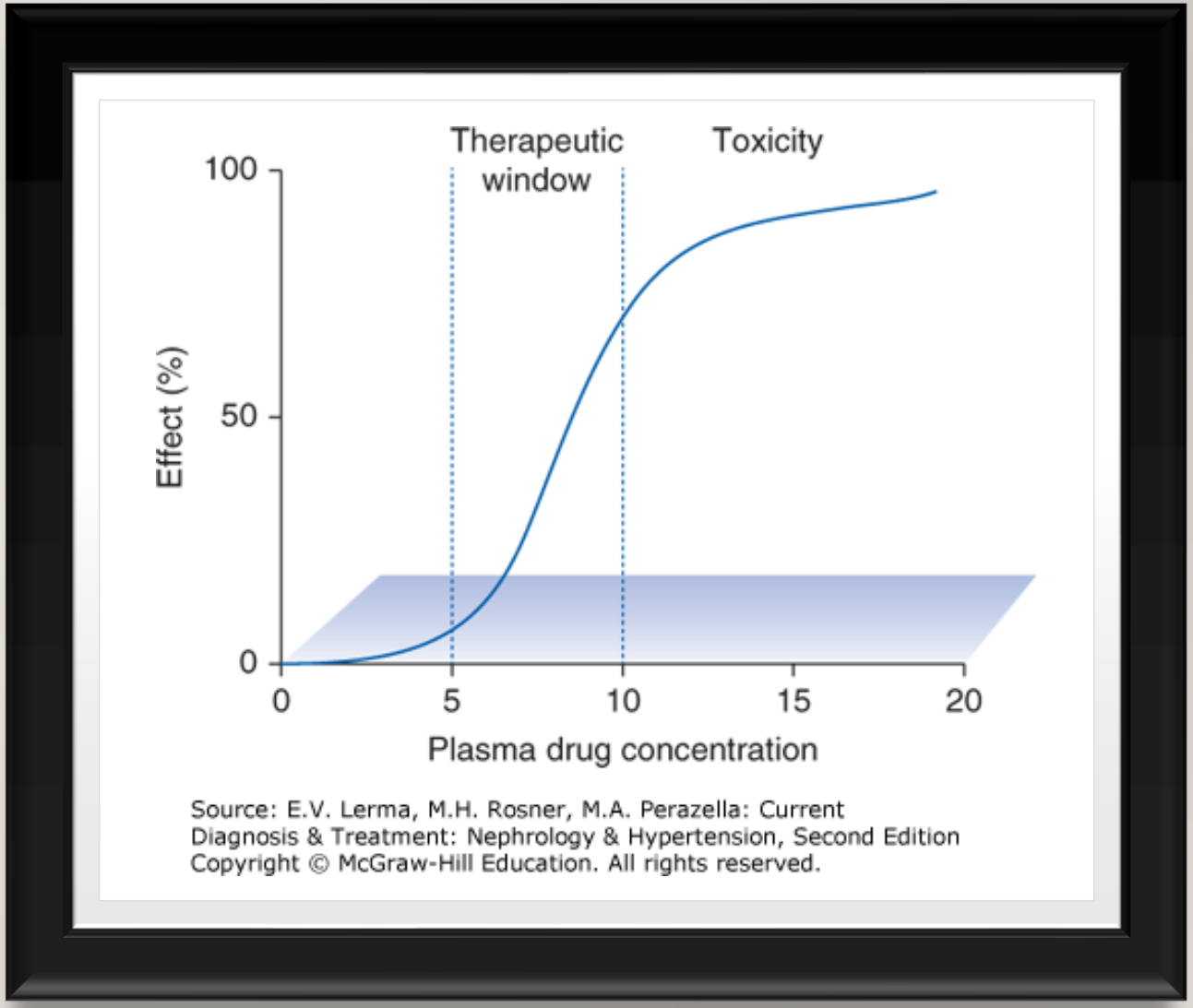
PHARMACOTHERAPY: LOOP DIURETICS

	INPATIENT DOSING	OUTPATIENT DOSING
Furosemide	• 40-160mg IV	• 20-80mg PO
Bumetanide	• 0.5-4mg IV	• 0.5-2mg PO
Torsemide	• N/A (no IV form)	• 10-40mg PO

40mg IV Lasix = 80mg PO Lasix = 20mg PO Torsemide = 1mg PO/IV Bumex

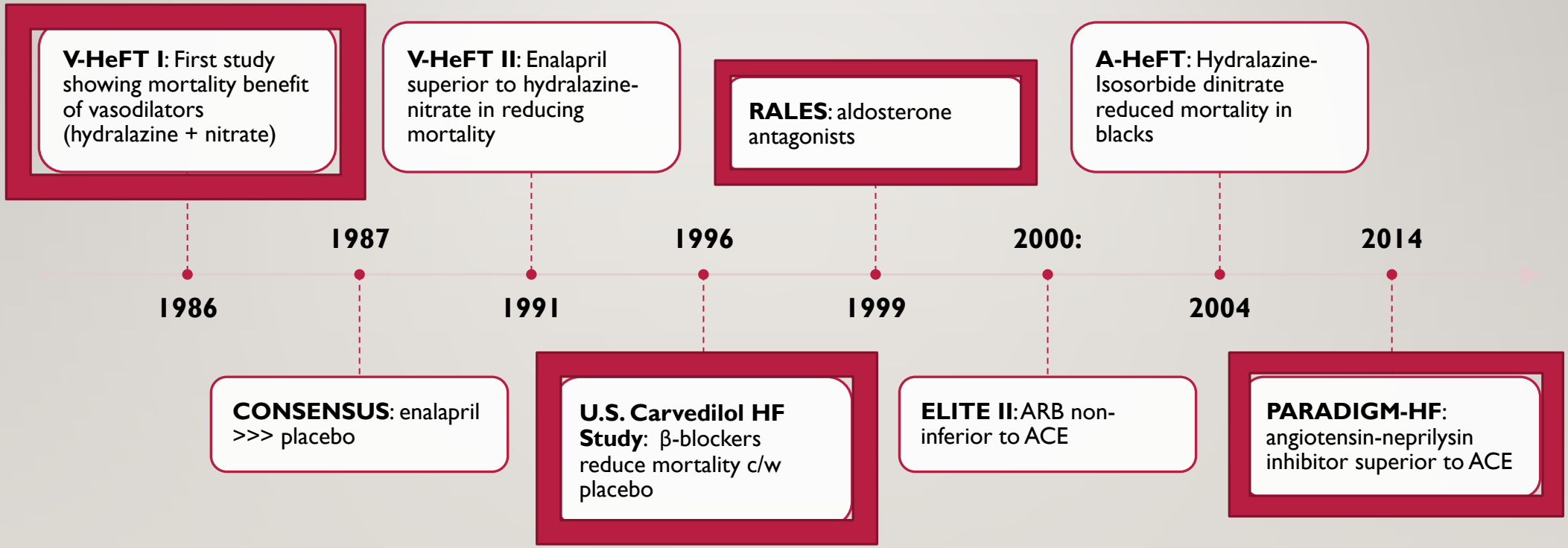
LOOP DIURETICS

- ***Sigmoidal dose response curve***; ↑ dose until diuresis effect, beyond which ↑'ing dose less effective
- Monitoring: ↑↑ Cr (small ↑ acceptable), ↑Na, ↓K, ↓Mg, ↓Ca; ototoxicty, hyperuricemia



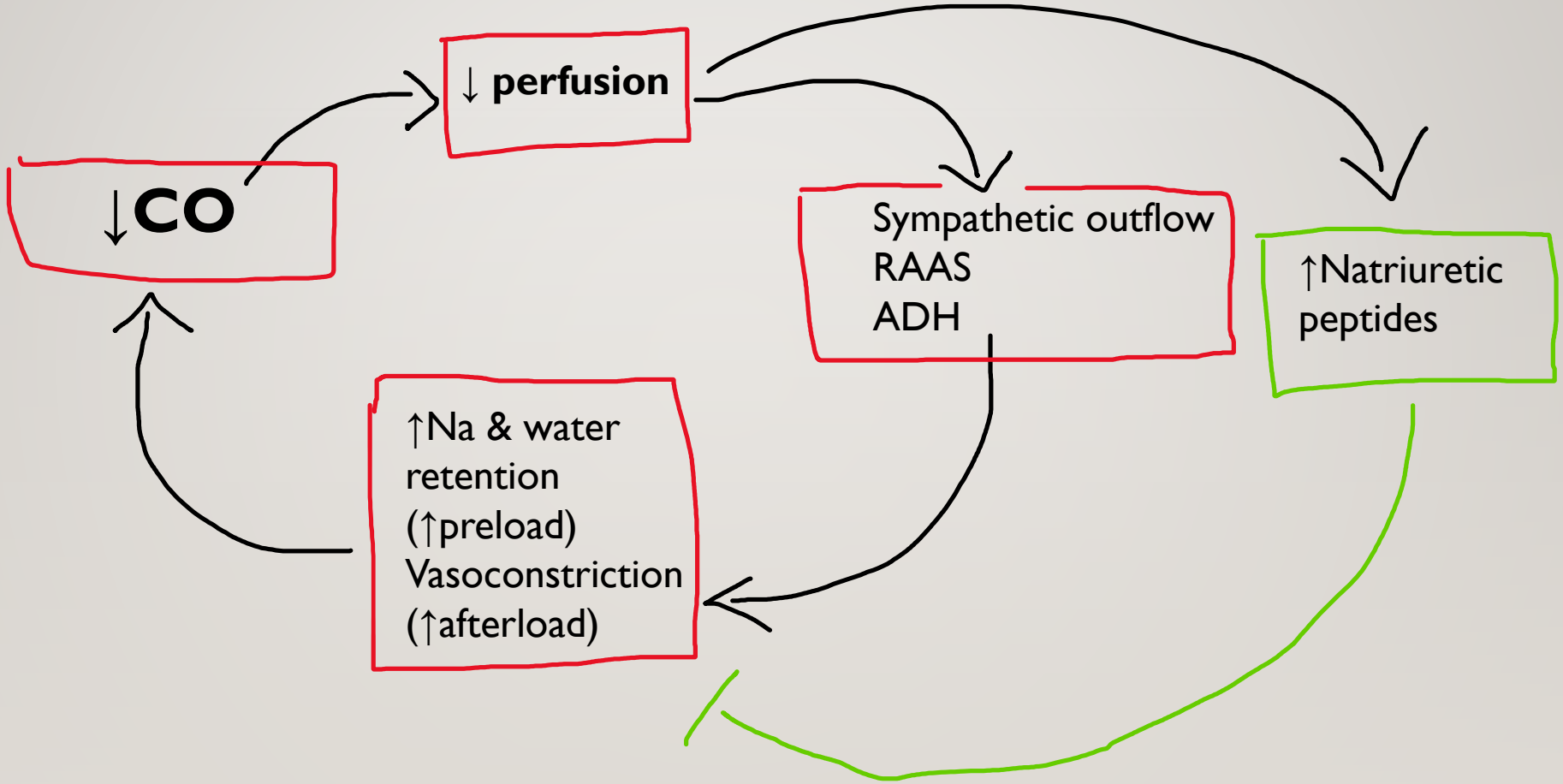
Source: E.V. Lerma, M.H. Rosner, M.A. Perazella: Current Diagnosis & Treatment: Nephrology & Hypertension, Second Edition

GDMT: HISTORICAL PERSPECTIVE



GDMT: EVIDENCE OF MORTALITY BENEFIT

RAS Inhibition: ACEI, ARB, ARNI	β-blockade: carvedilol, bisoprolol, metoprolol succinate	MRA: spironolactone and eplerenone	Hydralazine + Nitrate
• 20% relative risk reduction • NNT = 77	• 31% RR reduction • NNT = 28	• 25% RR reduction • NNT = 18	• 43% RR reduction • NNT = 21


↓ perfusion
↓CO
Sympathetic outflow
RAAS
ADH
↑Natriuretic peptides
↑Na & water retention
(↑preload)
Vasoconstriction
(↑afterload)

GDMT: ARNI: NEPRILYSIN INHIBITOR + ARB (SACUBITRIL-VALSARTAN)

- Dual action: blocks harmful effects of RAS activation AND prevents degradation of beneficial natriuretic peptides; vasodilation + natriuresis
- PARADIGM-HF (NEJM 2014): ↓CV mort & HF hosp c/w ACEI
- For patients meeting specific criteria-–no hx angioedema, absence of HoTN, K < 5—ARNI is first-line therapy
- For ACEI→ARNI, 36-hour washout recommended; no washout needed for ARB→ARNI
- Sacubitril 24mg/valsartan 26mg bid→→97mg/103mg (target dose)

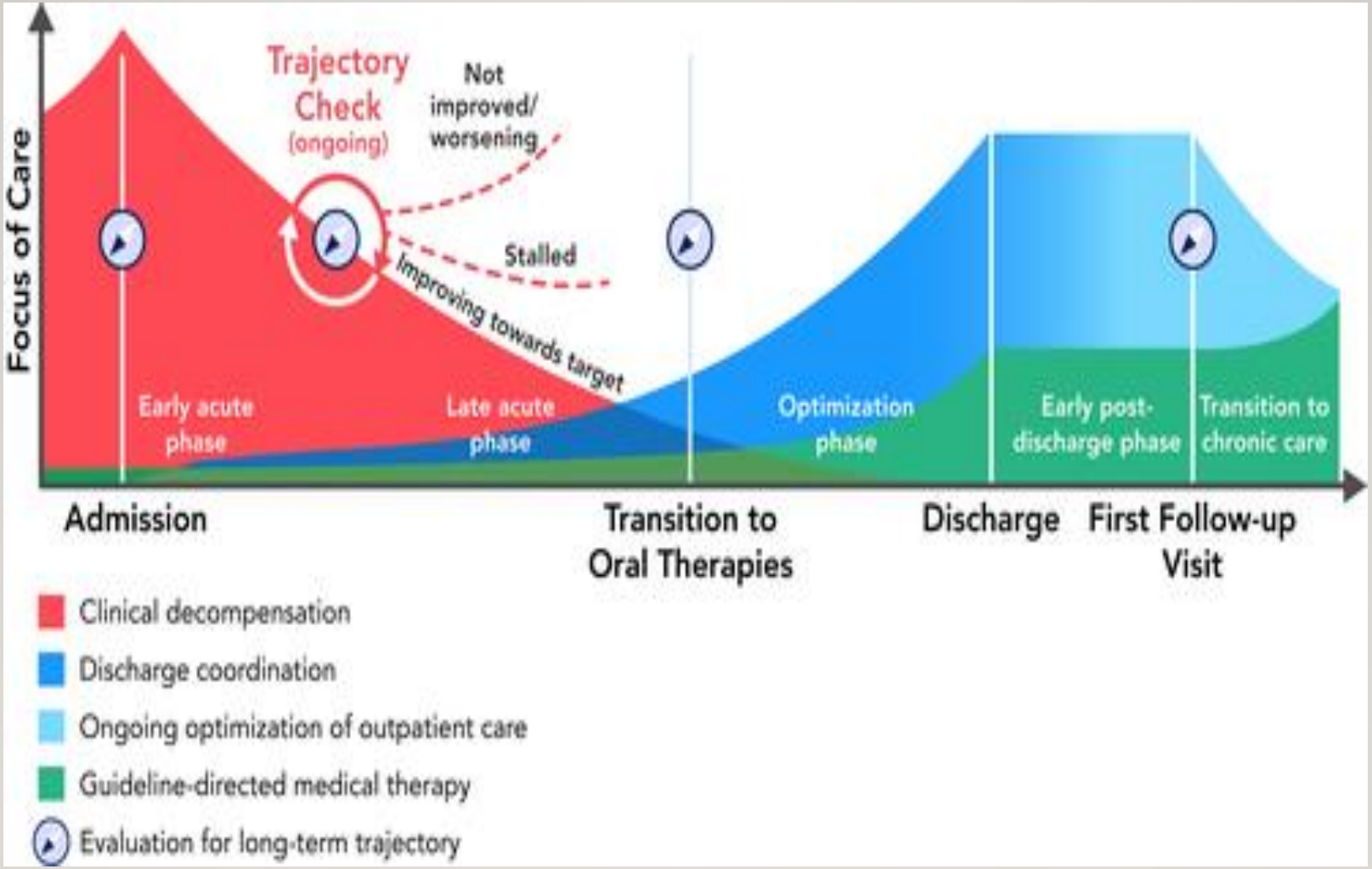
DIASTOLIC HF (HFPEF)

- No proven benefit of GDMT: TOPCAT (NEJM 2014): MRA ↓hospitalization w/o significant reduction in mort.
- Diuresis (poor LV compliance)
- BP control (↑afterload)
- Prevention of ischemia and tachycardia (↓diastolic filling time, loss of atrial kick in AF)
- Mortality ~ HFrEF

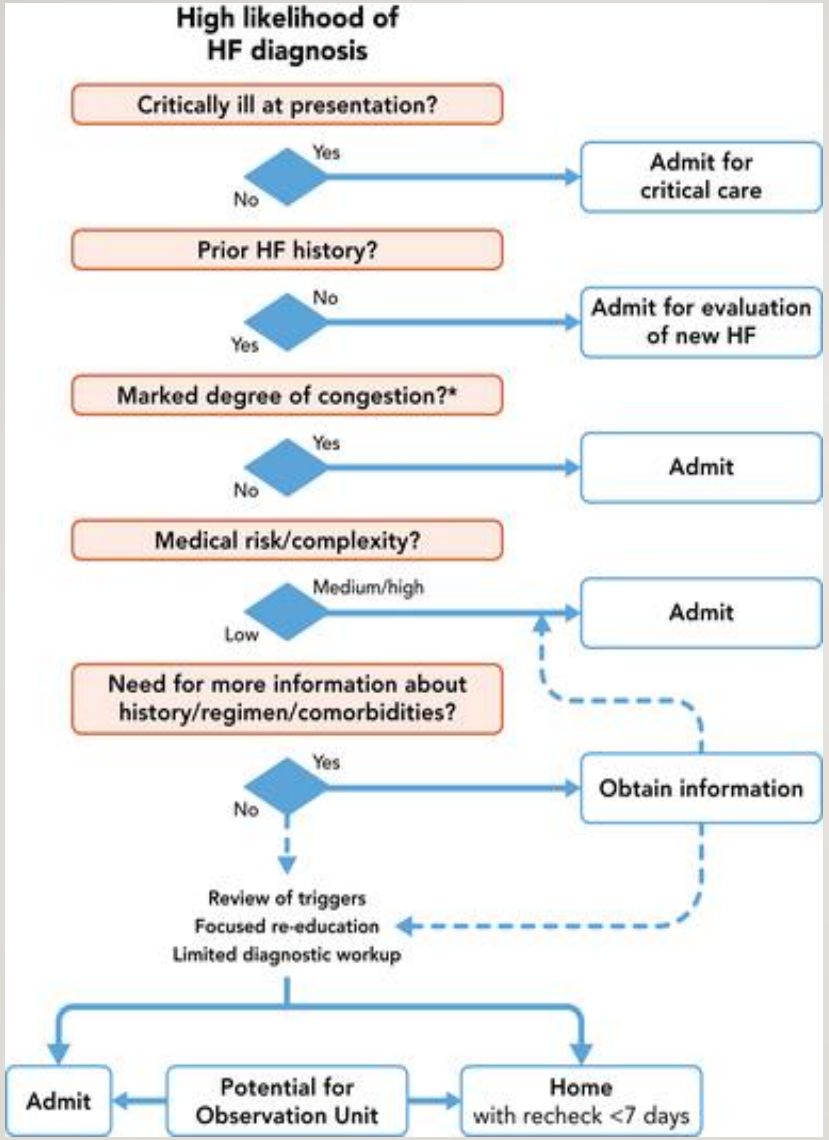
PART 2: CHF IN THE HOSPITAL

FRAMEWORK FOR HOSPITALIZATION: ADMISSION, TREATMENT/OPTIMIZATION, DISCHARGE

- Goals:
  - Reverse acute decompensation
  - Alter long-term trajectory to improve outcomes
- Trajectories
  - Improving toward target
  - Stalled after initial response
  - Not improving and/or worsening



Steven M. Hollenberg et al. *J Am Coll Cardiol* 2019; 74:1966-2011.



Steven M. Hollenberg et al. *J Am Coll Cardiol* 2019; 74:1966-2011.

CHF IN THE HOSPITAL: COMORBIDITIES

Cardiovascular:

- CAD
- AF, AFL
- CVA
- PAD
- Valvular Disease
- HTN

Systemic:

- DM
- CKD
- Liver Disease
- Chronic lung disease
- OSA

Psychosocial:

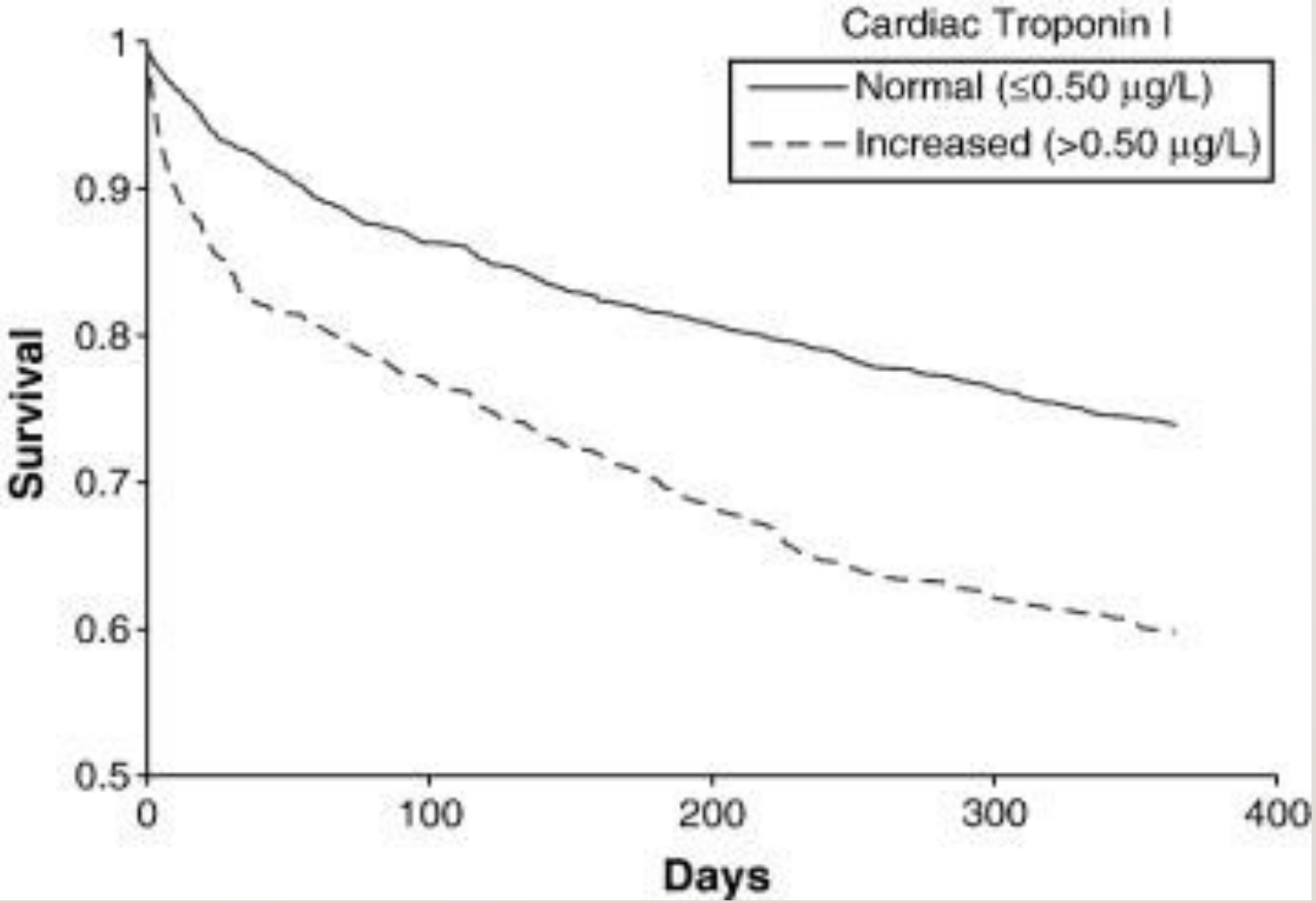
- Dementia
- Depression
- Substance use
- Inadequate social support

CHF IN THE HOSPITAL: ADMISSION: RISK STRATIFICATION

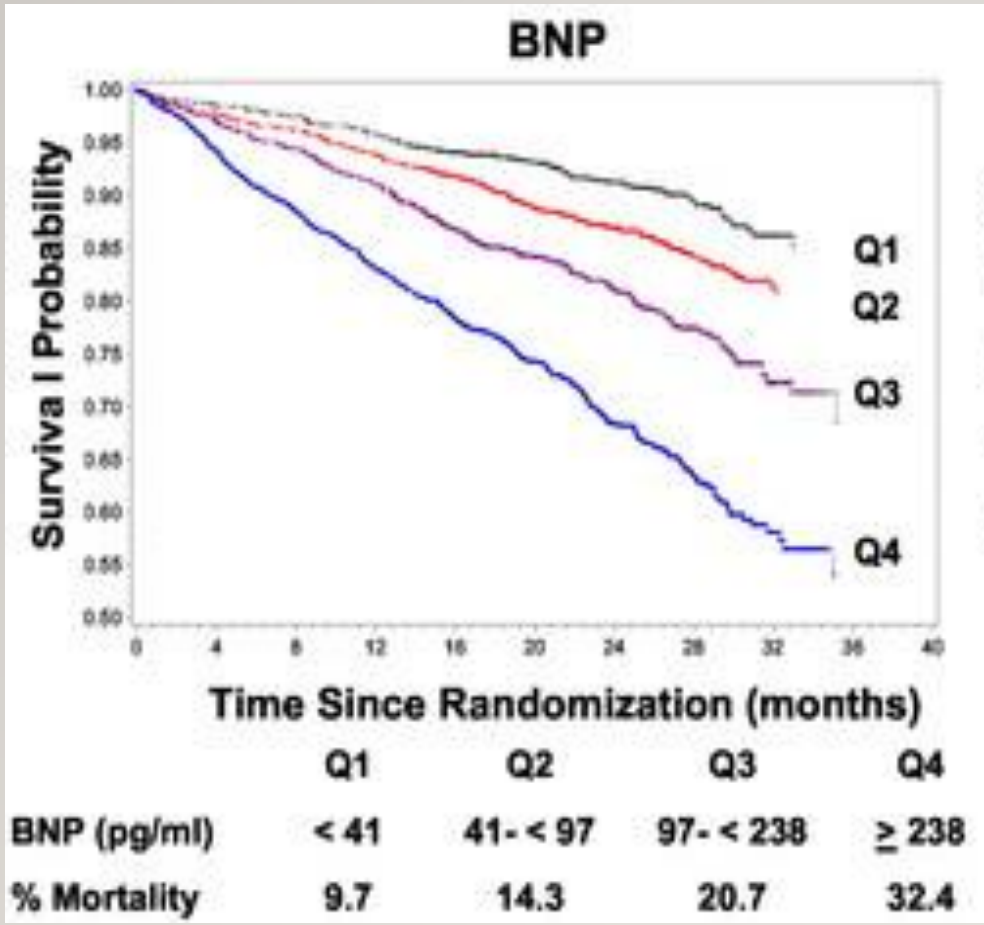
Lower Risk	Intermediate Risk	High Risk
• Normal BP and HR • Rapid resolution of sx in the ED • Normal renal, liver function; normal BNP and troponin	• New-onset HF • Low BP without shock, tachycardia • Lab abnormalities: ↑Cr, +troponin (without ACS), ↓Na, ↑BNP, ↑LFTs	• Hypoxia, respiratory distress, shock, severe comorbid condition (sepsis, ACS, stroke)

Collins SP, et al. J. Am Coll Cardiol HF 2015;3:737-47.

NON-ACS TROPONIN ELEVATIONS



- J. You et al., Am Heart J. (2007)
- Elevated cardiac troponin levels, measured here within first 48 hrs of admission for acute HF, were statistically significant predictors of mortality during hospitalization and at 1 year.
- Helps identify high-risk patients



	Q1	Q2	Q3	Q4
BNP (pg/ml)	< 41	41- < 97	97- < 238	≥ 238
% Mortality	9.7	14.3	20.7	32.4

Inder S. Anand. Circulation. Changes in Brain Natriuretic Peptide and Norepinephrine Over Time and Mortality and Morbidity in the Valsartan Heart Failure Trial (Val-HeFT), Volume: 107, Issue: 9, Pages: 1278-1283, DOI: (10.1161/01.CIR.0000054164.99881.00)

CHF IN THE HOSPITAL: ASSESSMENT OF CONGESTION & PERFUSION

Warm & Dry Compensated; consider alternate causes for SOB	**Warm & Wet** Needs diuresis; most common scenario for floor
Cold & Dry Needs inotropes; CCU	Cold & Wet Needs diuresis + inotropes; CCU

CHF IN THE HOSPITAL: GOAL SETTING

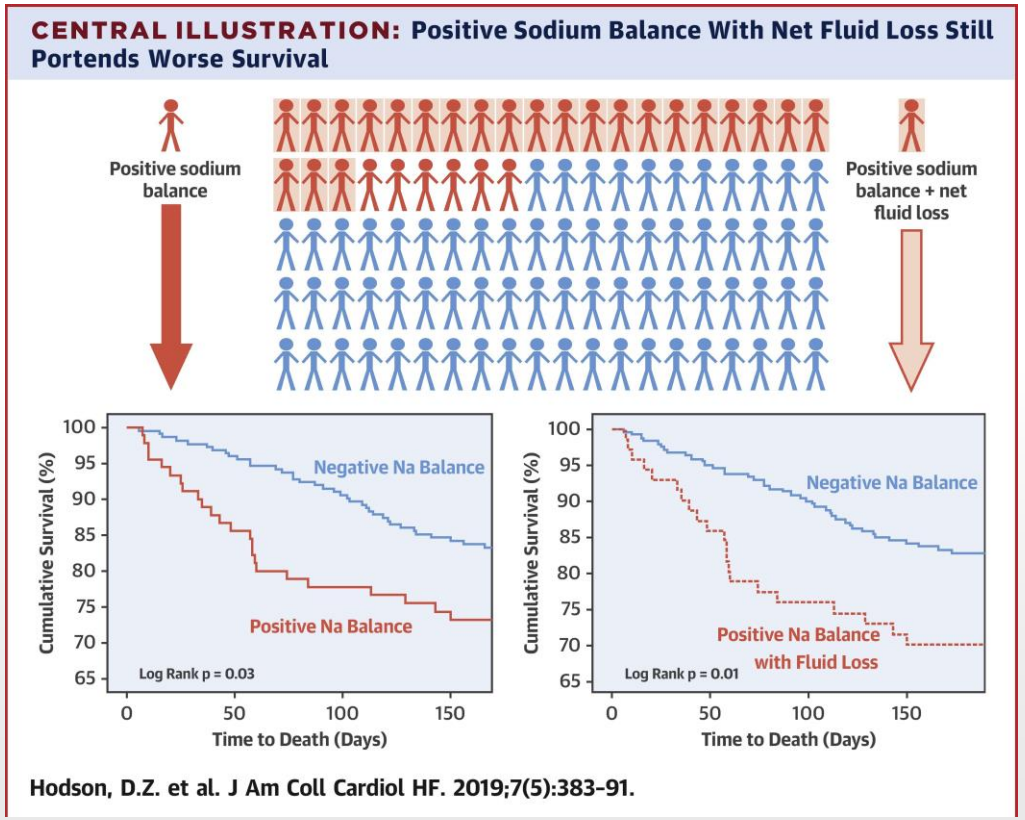
- Goals of hospitalization
  - Identify triggering event, evaluate & tx accordingly
  - Decongestion
    - The greater the degree of congestion, the longer the length of stay
  - GDMT optimization
  - Risk factor optimization
  - Identify patients at risk for bad outcome and counsel accordingly
    - Advanced therapies (transplant, mechanical circ. support, inotropes)
    - Palliative consultation, identification of surrogate decision makers

CHF IN THE HOSPITAL: DECONGESTION

- **Symptoms of congestion often improve before signs (need improvements in both)**
- Weight Δ (compare admission weight to prior "dry" weight)
  - Mehta RH, et al. Am J Cardiol (2009): Weight loss in the hospital correlates w/ decongestion but does not directly improve outcomes
- Natriuretic peptide-guided (BNP, NT-proBNP) treatment has not been shown to improve ACM or HF readmissions (Stienen S, et al. PRIMA II, *Circulation* 2018)
- Na excretion?

CHF IN THE HOSPITAL: DECONGESTION

- Hodson DZ, et al. ROSE-AHF Trial (JACC 2019)
  - ↑ Na excretion associated more closely w/ reduced mortality compared with UOP, net fluid balance, and weight loss
  - When Na output < dietary intake, even w/ net negative fluid balance, prognosis was worse
- ?: Diuretics targeted to natriuresis effect rather than UOP or weight loss



CHF IN THE HOSPITAL: DECONGESTION

- Goal: complete decongestion (JACC Guidelines 2019)
- Resolution of orthopnea & dyspnea at rest
- Resolution of edema
- JVP < 8cm (below clavicle)

CHF IN THE HOSPITAL: DECONGESTION

Loop diuretics:

- Convert outpatient PO regimen to IV, start IV dose at 1-2.5x total daily outpt dose
- Dose bid-tid

Serial monitoring of s/sx, electrolytes, daily weights, UOP, BP

- **Improving?** Continue diuretics, targeting congestion relief
- **Stalled?** Escalate loop diuretic by 50-100%, consider thiazide; consider expert consultation
- **Worsening?** Seek expert consultation

CHF IN THE HOSPITAL: DECONGESTION: DIET

- Fluid restriction (esp. if hyponatremia): 1.5 – 2 L/day
- Na restriction: 2-3 g/day
- Aggressive Na restriction→ ? increased mortality (JACC Heart Fail. 2016 Jan;4(1):24-35), no effect on weight loss (JAMA Intern. Med. 2013;173(12):1058-1064)

CHF IN THE HOSPITAL: NITRATES, MORPHINE?

- Nitrates:
  - Mech: venodilation→ ↓preload→ relief of congestive sx
  - Esp. in patients with ischemic sx and/or severe HTN
- Morphine:
  - Anxiolysis; venodilation (→ relief of congestive sx)
  - ? Benefit vs risk, eg of resp. fail. & mech. vent (Emerg Med J. 2008 Apr;25(4):205-9)

CHF IN THE HOSPITAL: GDMT

- Initiate or titrate as patients are improving toward target (decongestion)
- Previously on GDMT:
  - If possible, continue prior outpatient regimen
  - If contemplating switch to ARNI, consider changing ACEI to ARB early in hospitalization (no washout required w/ ARB)
  - Common reasons for withholding
    - ACE/ARB: HoTN, AKI, hyperkalemia
    - β-blocker: refractory congestion (halve dose), HoTN, recent inotrope use
- New start: *start low dose, titrate slowly; add Rx sequentially*

CHF IN THE HOSPITAL: GDMT

- RAS inhibitor: ARNI, ARB, ACEI
  - Watch BPs, Cr, K
- β-blocker (carvedilol, metoprolol succinate, bisoprolol)
  - Caution if at risk for, or recovering from, cardiogenic shock
- MRA:
  - Assuming adequate renal function and normal K
- Hydralazine-nitrate:
  - For patients intolerant of RAS inhibitor

CHF IN THE HOSPITAL: COMORBIDITY OPTIMIZATION

- CAD (ischemic CM): high-potency statin, antiplatelet
- HTN: Nitrates, amlodipine, hydralazine
- AF: Rhythm control often favored over rate control; anticoagulate
- OSA: CPAP
- Iron def. +/- anemia: AFFIRM-AHF (Lancet 2020): IV iron reduces risk of *HF hosp.*
  - No effect on risk of CV death
- DM: usual glycemic targets; role of SGLT-2i (next slide)

CHF IN THE HOSPITAL: SGLT2 INHIBITORS

- SGLT2 (Sodium-glucose cotransporter 2) receptors found in nephron (PCT), involved in glucose uptake
- In patients *with or without* T2DM, studies found a significant reduction in cardiovascular death and in HF hospitalizations in patients treated with dapagliflozin (DAPA-HF) or empagliflozin (EMPEROR-Reduced)
  - DAPA-HF (NEJM 2019): > 4500 patients with EF </= 40% randomized to dapagliflozin or placebo
  - Primary outcome (CV death or worsening HF): 16.3% in dapagliflozin vs 21.2% in placebo (HR 0.74, CI 0.65-0.85, $p < 0.001$)
- Especially useful in patients with HF + T2DM w/ est. ASCVD; may be used as adjunct in HF patients without DM but with persistent symptoms despite optimal medical therapy
- Slows progression of renal disease
- Risk of urogenital infection (*Fournier's*!), side effects of additional diuretic (glycosuric)

CHF IN THE HOSPITAL: DISCHARGE PLANNING

- Verify PO diuretic effectiveness (~24 hr)
- Maintenance diuretic dosing: goal of *fluid balance* rather than *net diuresis*
  - Consider torsemide or bumetanide in patients requiring high furosemide doses and in patients with "gut" edema
- Rescue diuretic plan for weight gain (eg, 2-5 lbs in < 1 week), sx of congestion
- Fluid restriction (2L or 64 oz)
- Potassium supplementation
  - Discretion in patients at high-risk for hyperkalemia (CKD, DM)
- GDMT:
  - Confirm patient tolerance of discharge regimen—check for orthostatic dizziness or hypotension
  - If prior therapy interrupted during hospitalization, uptitration may need to be continued several weeks post-discharge

CHF IN THE HOSPITAL: DISCHARGE DOCUMENTATION

- Suspected trigger for decompensation
- Updates to HF type (eg, new EF)
  - Don't forget to include specificity of diagnosis for coders, (eg, acute on chronic LV systolic HF), as well as CCs and MCCs related to acute HF
- Weight at d/c
- If residual congestion, document reason (eg, renal failure, hypotension, RV failure)
- BNP, Cr at d/c
- CHANGES TO OUTPATIENT MED REGIMEN

CHF IN THE HOSPITAL: DISCHARGE F/U

- Phone call in 2-3 days
  - Sx assessment
  - Prescription confirmation
  - Reinforce rescue plan
- Clinic appointment in 1-2 weeks
  - Clinical assessment
  - Laboratory assessment (esp. important if recent initiation or titration of diuretic or ACE/ARB/ARNI)
- ***1 in 5 patients will be readmitted within 30 days!***

TAKE-HOME POINTS

- Knowledge of heart failure pathophysiology aids in the diagnosis and management of HF at the clinical level
- There are robust evidence-based guidelines for the treatment of heart failure; knowledge of these guidelines are important, as HF is a commonly encountered problem in the hospital setting
- Application of a systematic framework can aid in the management of heart failure in the hospitalized patient.

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QUESTIONS?

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