



Load-Bearing Walls: Getting Cardiovascular Therapy Right the First Time

Katelyn Galli, PharmD, BCCP

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Disclosures

- Katelyn Galli PharmD has no relationships with ineligible companies.

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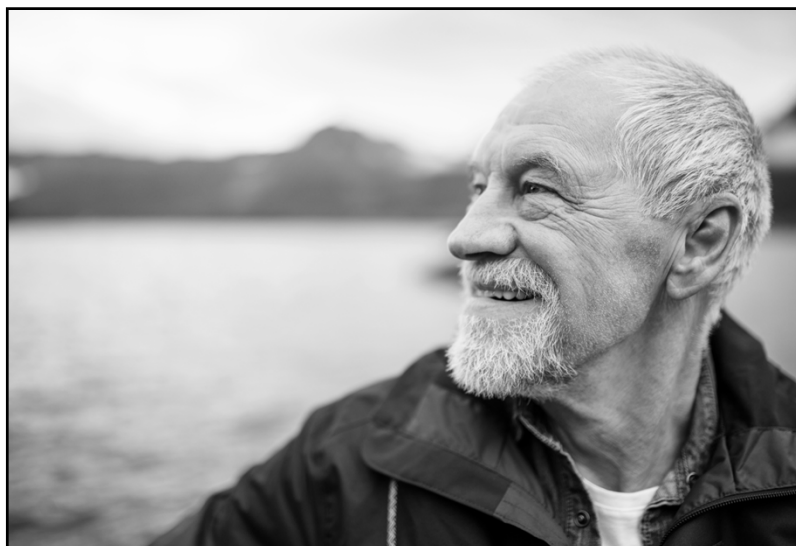


Framing the Problem

- Cardiovascular medications among the **highest risk medication classes** associated with preventable adverse drug events (ADEs)
- High prevalence across
 - Hospitalized patients
 - Transitions of care
 - Older adults
- Risk factors
 - Narrow therapeutic indices
 - Pharmacokinetic variability
 - System complexity

Budnitz DS, et al. *JAMA*. 2006;296(15):1858-1866.

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Meet Our Patient: Jack

68 yo male

PMH:

- HFrEF (EF 30%)
- CAD s/p PCI (3 years ago)
- HTN
- T2DM
- CKD stage 3b (SCr 1.8 mg/dL, eGFR ~35 mL/min)
- Paroxysmal AF

Home Medications:

- Lisinopril 20 mg daily
- Metoprolol succinate 100 mg daily
- Spironolactone 25 mg daily
- Furosemide 40 mg daily
- Apixaban 5 mg BID
- Atorvastatin 40 mg nightly

Social Factors:

- Lives alone
- Limited health literacy
- Uses 2 different pharmacies
- Transportation barriers

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Objectives

Identify	Identify high-risk cardiovascular medications that are most commonly associated with preventable adverse drug events amid transitions of care
Describe	Describe evidence-based principles for precise cardiovascular medication dosing, including clinically relevant pharmacokinetic considerations that influence drug and dose selection
Explain	Explain the benefits and limitations of clinical decision support tools in cardiovascular pharmacotherapy
Recognize	Recognize common system-level and cognitive factors contributing to cardiovascular medication near misses and adverse effects

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High Risk Medication Classes

- Anticoagulants
- Antiarrhythmics
- Beta blockers
- Calcium channel blockers
- RAAS inhibitors
- Diuretics
- Digoxin

Budnitz DS, et al. JAMA. 2006; Budnitz DS, et al. N Engl J Med. 2011

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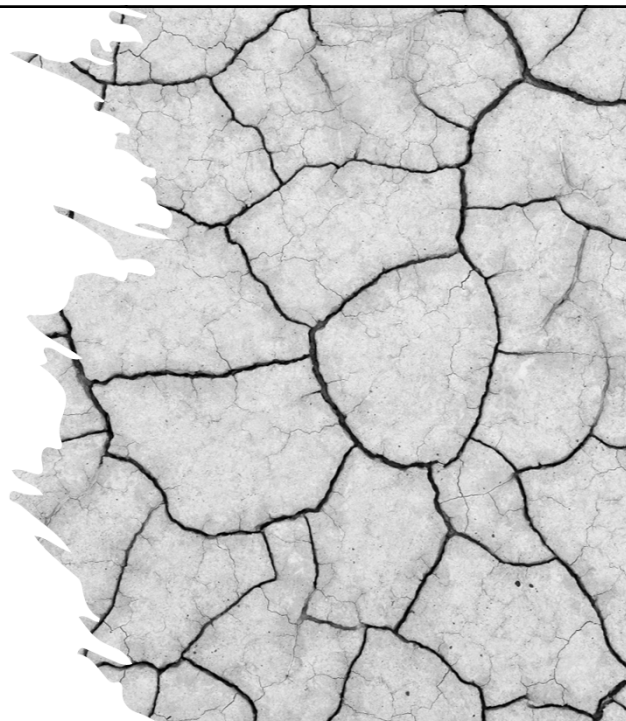
Which of the following medication classes are implicated most often in ADEs in your practice? (Obj. #1)

- Anticoagulants
- Antiarrhythmics
- Beta blockers
- Calcium channel blockers
- Digoxin
- Diuretics
- RAAS inhibitors

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Cracks in Transitions of Care

- Medication reconciliation failures
- Incomplete documentation
- Dose changes not communicated
- Renal function changes
- Duplicate therapy



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Which of the following medications would be considered high risk for error during the medication reconciliation process? (Obj. #1)

- Apixaban
- Citalopram
- Fexofenadine
- Levothyroxine

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Precision Dosing

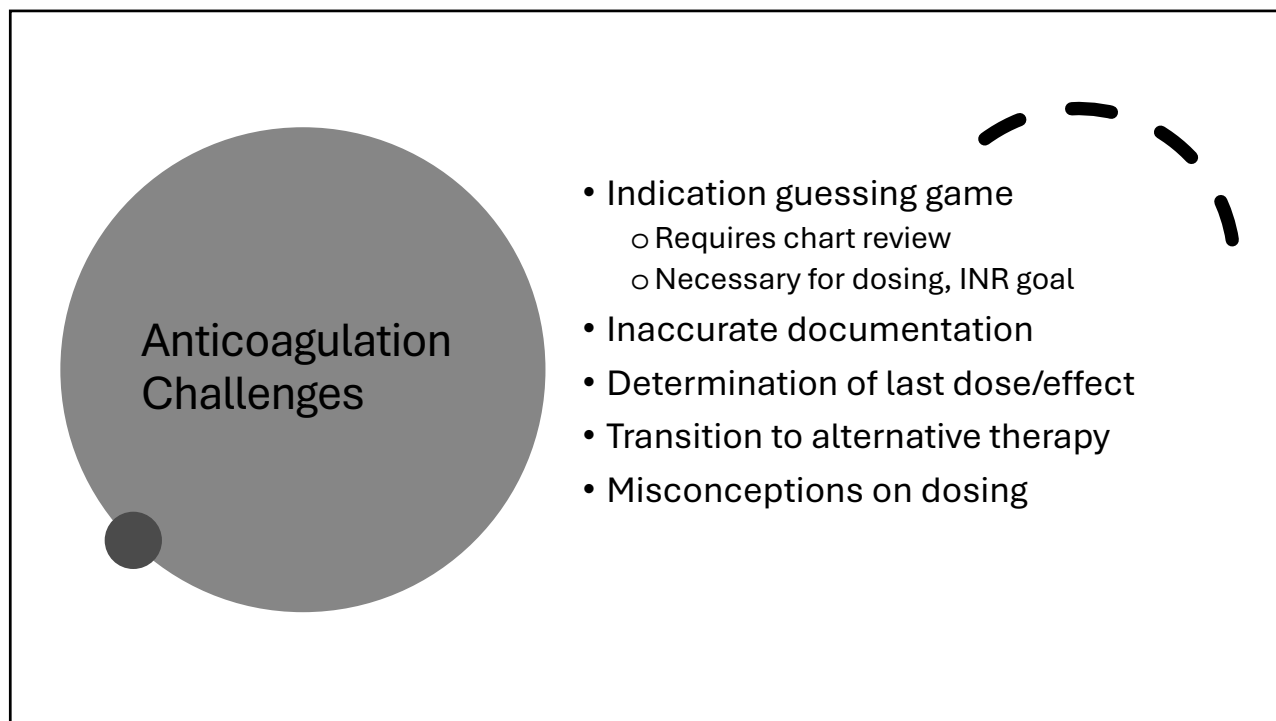
- Pharmacokinetic considerations
 - Absorption changes
 - Organ function
 - Drug-drug interactions
- Pharmacodynamic considerations
 - Patient hemodynamics
 - Drug-drug interactions
- Evidence based medicine!

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Anticoagulants and Antiplatelets

Examples: warfarin, DOACs, P2Y12 inhibitors, heparins

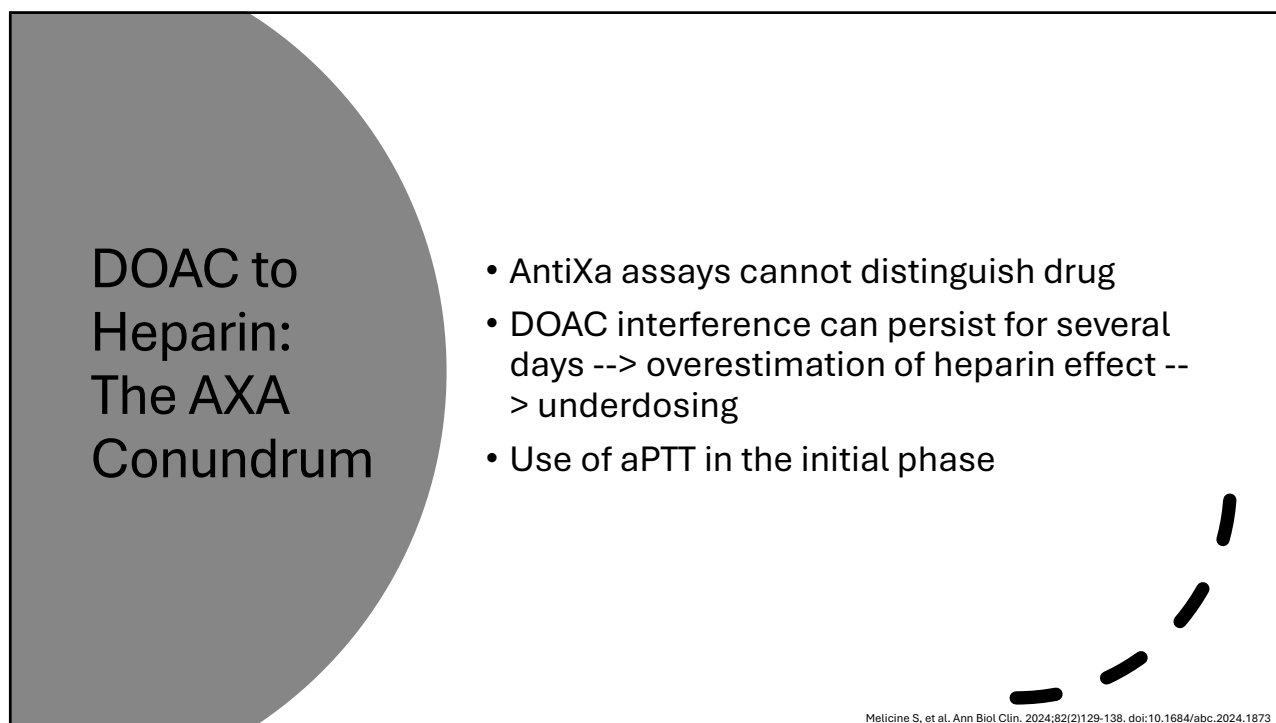
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Anticoagulation Challenges

- Indication guessing game
 - Requires chart review
 - Necessary for dosing, INR goal
- Inaccurate documentation
- Determination of last dose/effect
- Transition to alternative therapy
- Misconceptions on dosing

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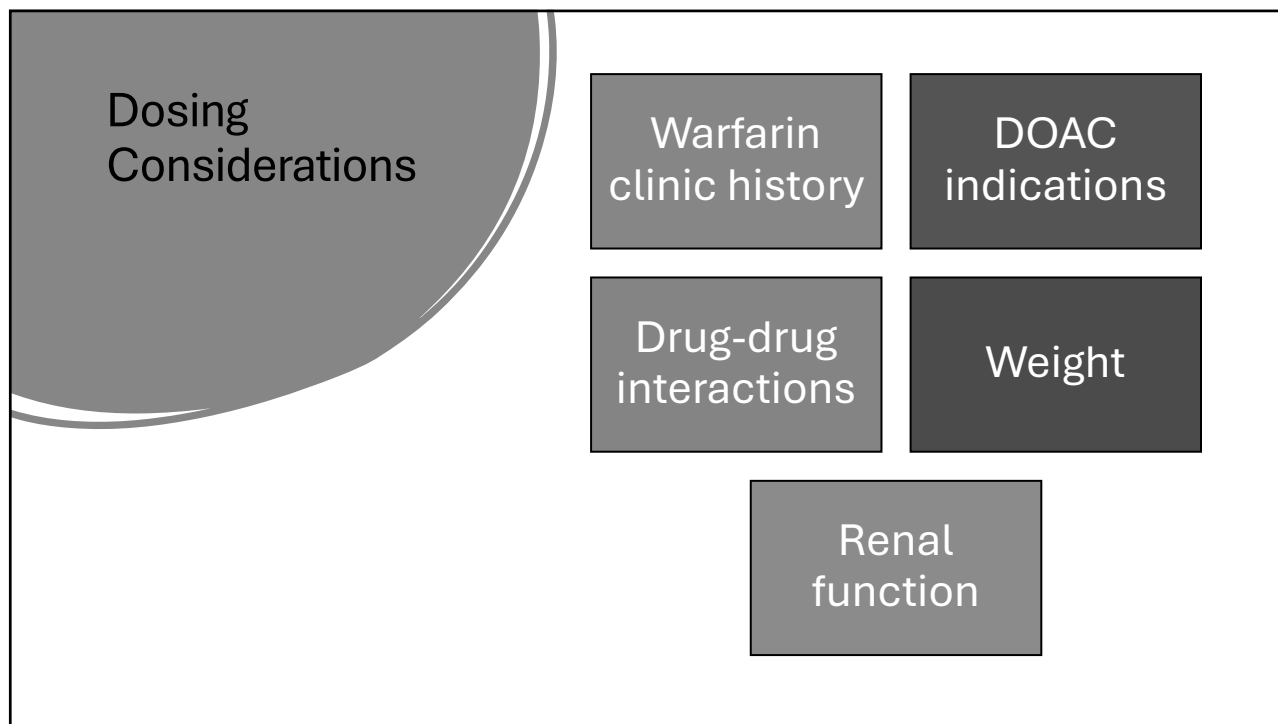


DOAC to Heparin:
The AXA
Conundrum

- AntiXa assays cannot distinguish drug
- DOAC interference can persist for several days --> overestimation of heparin effect --> underdosing
- Use of aPTT in the initial phase

Meicincine S, et al. Ann Biol Clin. 2024;82(2):129-138. doi:10.1684/abc.2024.1873

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The complex block features a large grey circle on the left labeled "Inappropriate DOAC Dosing". To its right, a dashed arc is positioned above a list of bullet points:

- 12-15% DOACs are inappropriately dose reduced
 - Older adults
 - CKD
 - "Perceived frailty"
- Outcomes
 - Increased stroke risk in subpopulations
 - Increased mortality risk (HR ~1.37)

Below the list, a grey box contains the text: "Can you point me to the study that promotes reduced dosing in higher bleeding risk?"

Shen NN, et al. Front Pharmacol. 2021; Rymmer JA et al. JAMA Netw Open. 2023; Sugrue A, et al. Am J Cardiol. 2021

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Absorption Considerations

- Tube feeds
- Protein drinks (e.g. Boost, Ensure)
- GI Surgery
 - Bariatric
 - Intestinal Removals

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Acute Surgical GI Considerations

Surgery Type	Apixaban	Rivaroxaban	Dabigatran	Edoxaban	Warfarin	Clinical Interpretation
Gastric surgery (e.g. gastrectomy, sleeve)	Minimal impact	↓ absorption	↓ absorption	Minimal–moderate impact	Minimal impact	apixaban/warfarin preferred
Roux-en-Y Gastric Bypass (RYGB)	↓ exposure early; variable	↓ absorption	↓ absorption	↓ absorption	Unaffected	warfarin preferred
Proximal small bowel resection (duodenum/jejunum)	↓ absorption	↓ absorption	↓ ↓ absorption	↓ absorption	Variable	warfarin or parenteral anticoagulation preferred
Distal ileum resection	Mild impact	Mild–moderate impact	Mild impact	Mild impact	May affect vitamin K absorption	acceptable DOAC use
Short bowel syndrome	↓ / variable	↓ / variable	↓ / variable	↓ / variable	Variable	warfarin preferred
Colectomy	Minimal impact	Minimal impact	Minimal impact	Minimal impact	Minimal impact	No preference

Kushnir M, J Thromb Thrombolysis, 2016; Steele KE, Surg Obes Relat Dis, 2022; Mueck W, Clin Pharmacokinet, 2014; Martin KA, Am J Med, 2017; Owens JA, Ann Pharmacother, 2021; Mueck W, Clin Pharmacokinet, 2014

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Too Many Choices to Choose From!

- Remember: Patient-Centered Care!
- Considerations
 - Insurance formularies
 - Patient compliance
 - Nutrition
 - Past medical history

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Back to Jack!

CC: acute decompensated HF with hypervolemia

Clinical course: optimization of diuresis with furosemide 40mg IV TID

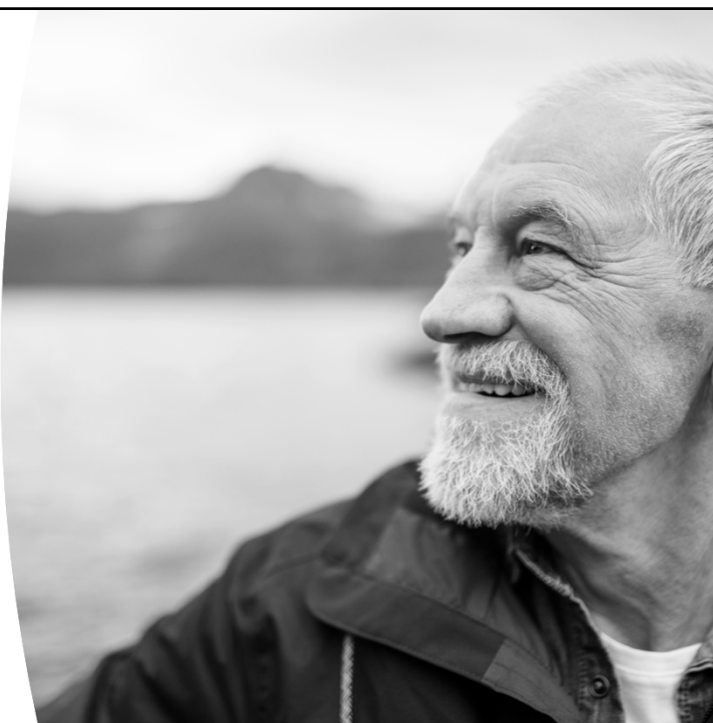
I/O: Net – 1.5 L/day

Day 2 of admission: urine output decreases

Relevant labs:

BUN increased to 57

SCr increased 2.52 (baseline 1.8)



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Upon daily chart review, you identify that Jack has an AKI and review his medications for necessary adjustments. Which of the following is most appropriate regarding his apixaban? (Obj. #2)

- Continue to hold anticoagulation given increased bleeding risk
- Restart apixaban at reduced dose of 2.5mg BID
- Stop apixaban and start rivaroxaban 15mg daily instead
- Consider transitioning to heparin via aPTT measurement until AKI resolves

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Rate Control and Antiarrhythmics

e.g. Beta-blockers, calcium channel blockers, amiodarone, dofetilide

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Common Problems

- Abrupt discontinuation
 - Incorrect indications
 - Incorrect formulation conversions
 - Drug-drug interactions
 - QTc prolongation
 - Organ dysfunction affecting clearance/dosing
 - Lack of appropriate monitoring
-

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Beta-Blockers

Consider:

- Hemodynamics
- Renal function
- Drug-drug interactions

Agent	β 1 Selectivity	Lipophilicity	Metabolism	Half-life
Metoprolol	β 1 selective	Moderate	Hepatic (CYP2D6)	3–7 hr (IR)
Atenolol	β 1 selective	Low (hydrophilic)	Renal	6–9 hr
Bisoprolol	β 1 selective	Moderate	Hepatic + renal	10–12 hr
Carvedilol	Nonselective (β 1/ β 2) + α 1 blockade	High	Hepatic (CYP2D6, 2C9)	7–10 hr
Labetalol	Nonselective + α 1 blockade	Moderate	Hepatic	6–8 hr
Propranolol	Nonselective	High	Hepatic (first-pass)	3–6 hr
Nadolol	Nonselective	Low	Renal	20–24 hr
Esmolol	β 1 selective	Low	Plasma esterases	~9 min

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Amiodarone

- QTc prolongation can occur, but torsades risk is low
- Chronic toxicity --> consider in older patients
 - Baseline labs: TSH, CXR, LFTs, PFTs
- Intravenous Risk > PO
 - Order sets to limit IV to 24 hours
 - In-line filters to reduce phlebitis risk
- TOC Concerns
 - Oral load doses and prescriptions
 - Dosing availability (100mg = \$)

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Dofetilide and Sotalol

- Inpatient initiation required --> QTc prolongation risk
 - Note – Dose adjustments change inpatient requirements
- ECG monitoring
 - Incorporate into order set
 - Admin instructions for nursing
 - Trust the cardiologist!
- Pharmacist role:
 - Electrolyte monitoring
 - Drug-drug interactions
 - Acquisition
 - Counseling



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Back to Jack!

Hospital course day 3: Jack is in active AF. His metoprolol is at the maximum tolerated dose for his blood pressure.

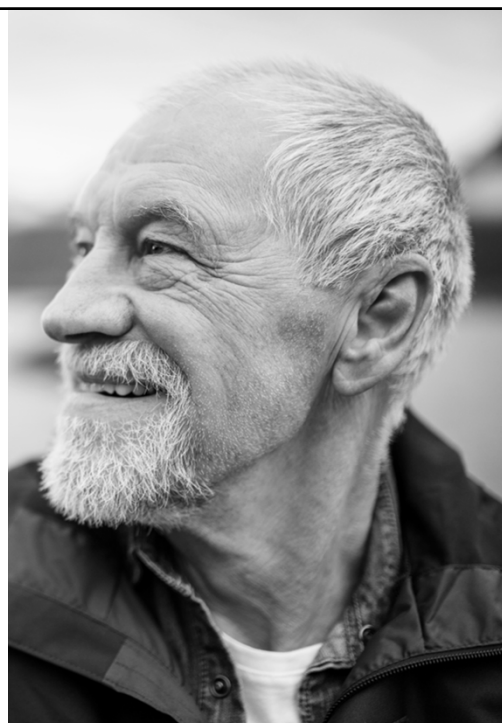
ECG: atrial fibrillation, QTc 451msec

HR: 110 bpm

BP: 98/72 mmHg

Active Medications:

- Metoprolol tartrate 50 mg BID
- Spironolactone 25 mg daily
- Furosemide 40 mg IV BID
- Unfractionated heparin infusion
- Atorvastatin 40 mg nightly



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The team decides to start Jack on oral amiodarone 400mg TID x 3 days, 200 mg TID x 3 days, then 200 mg daily. Which of the following is most important for the pharmacist to ensure at discharge? (Obj. #2)

- Ensure the prescription is sent to the patient's home pharmacy for easy refills
- Make sure an ECG is checked 2 hours after each dose
- Confirm that thyroid function tests are ordered and assessed before starting the amiodarone
- Suggest starting sotalol instead for better rate control

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RAAS-Inhibitors

e.g. ACE-inhibitors, spironolactone, ARBs

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Common Problems

Adverse Drug Reactions

- Hyperkalemia
- Acute kidney injury
- Angioedema

Often held for surgeries, procedures

Transition between agents

Utilizing optimal doses

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Benefits

- Identify drug interactions
- Flag renal dosing errors
- Prevent duplicate therapy
- Standardize evidence-based prescribing
- Evidence of benefit
- Reduction in medication errors
- Improved dosing adherence
- Earlier detection of contraindications

A slide with a dark grey background on the left and a white background on the right. The dark grey background contains a plus sign, a solid dot, and an open circle. The word 'Benefits' is written in a large, bold, black font. To the right, a list of seven bullet points is displayed in a black font.

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Limitations

- Alert fatigue
- Overabundance of low-value alerts
- Overrides exceeding 80–90% in some systems
- Lack of patient-specific nuance
- Inaccurate medication reconciliation
- Missing outpatient data


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Informatics Optimization




Integration of anticoagulant indication requirement in order entry

DOAC: NVAF vs VTE
Warfarin: INR goal
Heparin: High dose vs. Low dose



Integration of labs and monitoring in order sets



Ensure significant drug interactions are input for alerts

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Which strategy can optimize clinical decision support for high-risk cardiac medications? (Obj. #3)

- Prevent ordering of any anticoagulant except apixaban to ensure standardization
- Integrate most recent SCr values and dosing recommendations into sotalol orders
- Block order entry of amiodarone by prescribers if all baseline labs are not checked
- Ensure all drug-drug interactions are integrated into CPOE and order verification

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Role of Pharmacists



Interpreting alerts




Prioritizing clinically meaningful signals



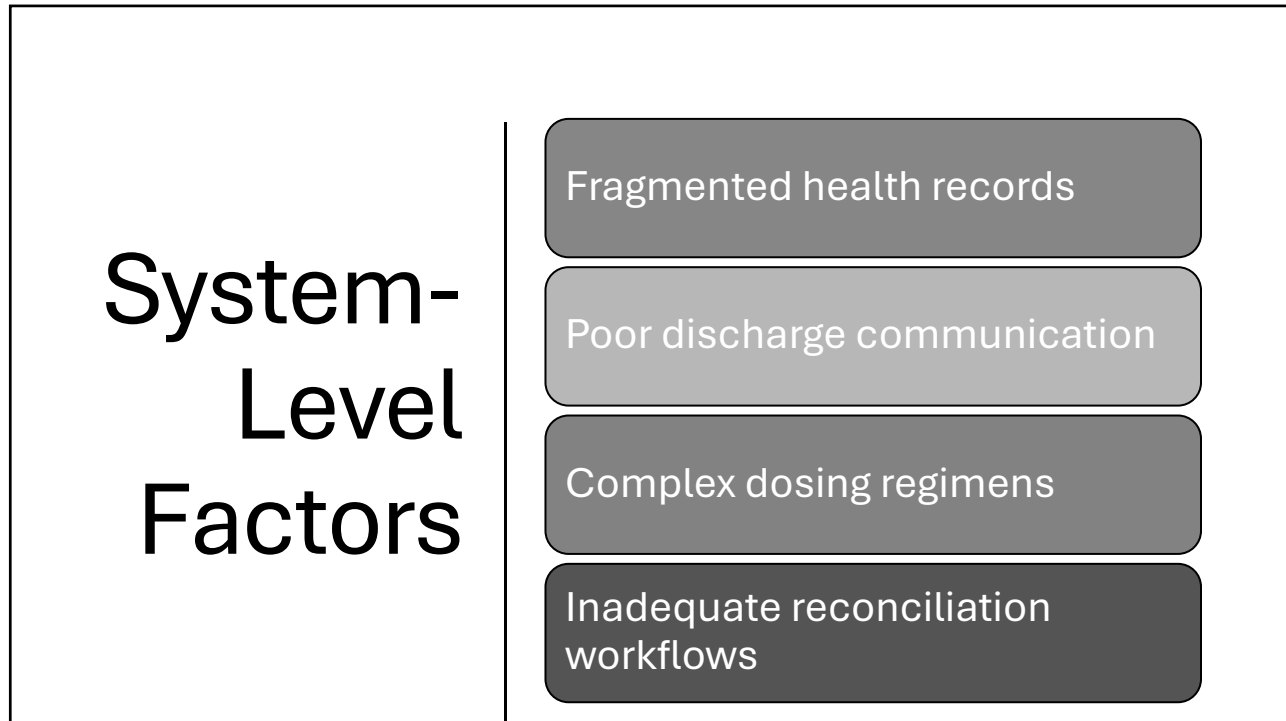
Optimizing CDS design and governance

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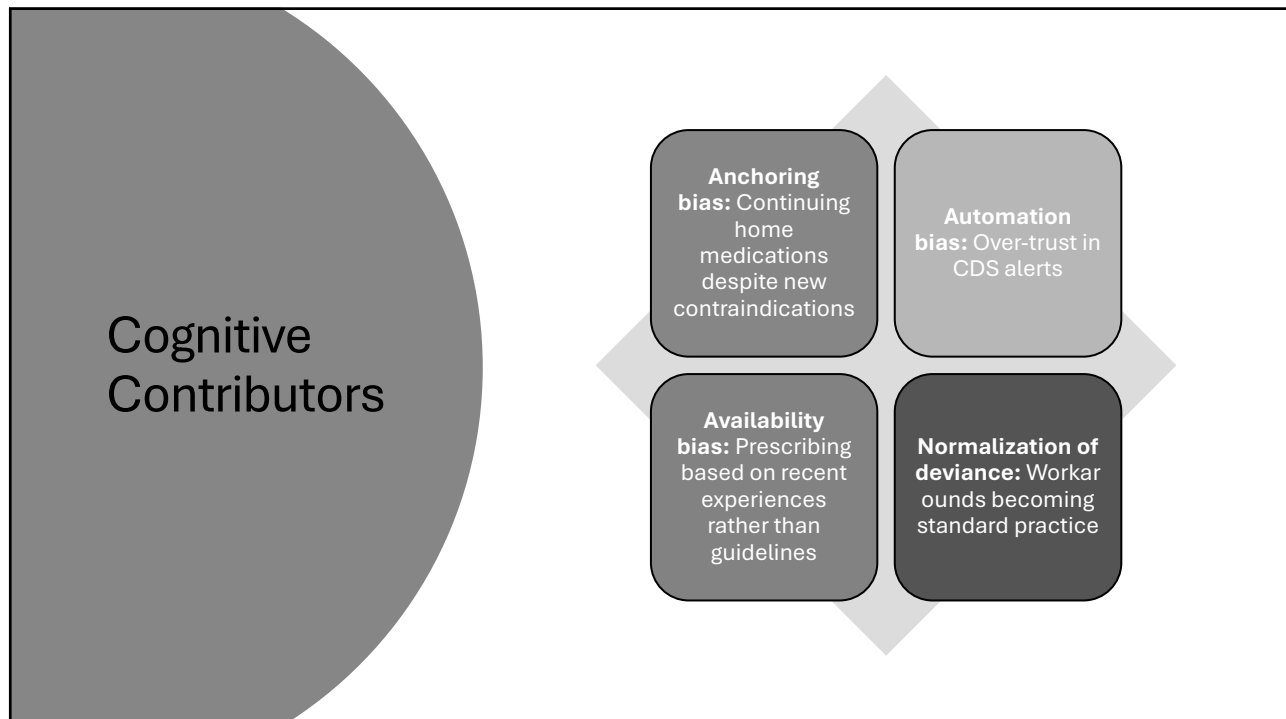


Causes of Adverse Drug
Near Misses

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The Epic medical record has the advantage of having access from outside health systems. The VAMC has a secure medical record that cannot be accessed. Jack gets most of his care and his medications at the VA. Which of the following factors increases his risk for experiencing medication errors? (Obj. #4)

- Fragmented medical records
- Use of a single pharmacy
- Singular primary care provider prescribing all medications
- Poor insurance coverage

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Jack's SCr is stable but remains elevated. Following diuresis, he is found to be cachectic and euvolemic with a "dry" weight of 58 kg. You recommend decreasing his apixaban to 2.5 mg BID but receive pushback from the provider as "this was his home dose." What kind of bias does this reflect? (Obj. #4)

- Anchoring bias
- Automation bias
- Availability bias
- Confirmation bias

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Pharmacist Safety Strategies

- +
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-
- **During transitions of care**
 - Structured medication reconciliation
 - High-risk medication review
- **Precision dosing**
 - Verify renal function trends
 - Evaluate drug interactions
 - Confirm indication and dosing rationale
- **CDS optimization**
 - Customize alerts
 - Monitor override rates
 - Advocate for pharmacist-led review
- **Culture of safety**
 - Encourage reporting of near misses
 - Learn from system failures rather than individual blame

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Final Thoughts

- Small dosing or reconciliation errors can cause
 - Hemodynamic instability
 - Arrhythmias
 - Bleeding
 - Renal injury
- Pharmacists play a central role in **reinforcing the structural integrity of medication safety.**

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