FLUIDS/ELECTROLYTES

Sahir Kalim, MD MMSc

Department of Medicine, Division of Nephrology, Massachusetts General Hospital
Harvard Medical School

Dr. Kalim has no potential conflicts of interest to disclose.

CASE 1

- A 63 year old man presents to clinic complaining of weakness and fatigue
- PMH notable for CAD, hypertension, type 2 DM
- He notes some intermittent vomiting over the past two days
- You send serum chemistry studies

QUESTION

His laboratory results reveal:

- Na 143 K 4
- Cl 97 HCO_3 24
- BUN 30 Cr 1.2
- Glu 90 Ca 9.0

Which of the following can you diagnose?

A. Normal acid-base status

B. Metabolic acidosis

C. Metabolic alkalosis

D. Metabolic acidosis and alkalosis

E. Need a blood gas

ANSWER

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ANSWER

His laboratory results reveal:

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- Cl 97 HCO_3 24
- BUN 30 Cr 1.2
- Glu 90 Ca 9.0

Anion gap = 143 - 97 - 24 = 22

Normal AG ~ 10 meq/L

Albumin adj normal AG = alb (g/dL) x 2.5

AG is elevated

BUT…HCO_3 is normal!

high

32

normal

HCO_3

23

low

high

32

normal

23

low

HCO_3

metabolic acidosis

high

32

normal

23

low

HCO_3

high

32

normal

HCO_3

23

low

high

32

normal

23

low

metabolic alkalosis

HCO_3

high

32

normal

23

low

HCO_3

high

32

normal

HCO_3

23

low

high

32

normal

23

low

metabolic alkalosis

HCO_3

metabolic acidosis

high

32

normal

23

low

metabolic alkalosis

HCO_3

metabolic acidosis

elevated AG

QUESTION

Which of the following is NOT a potential cause of an anion gap metabolic acidosis?

A. Increased lactic acid production from bowel ischemia

B. Ethylene glycol ingestion

C. Acetaminophen ingestion

D. Acetazolamide ingestion

E. C and D

F. A and D

ANSWER

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A. Increased lactic acid production from bowel ischemia

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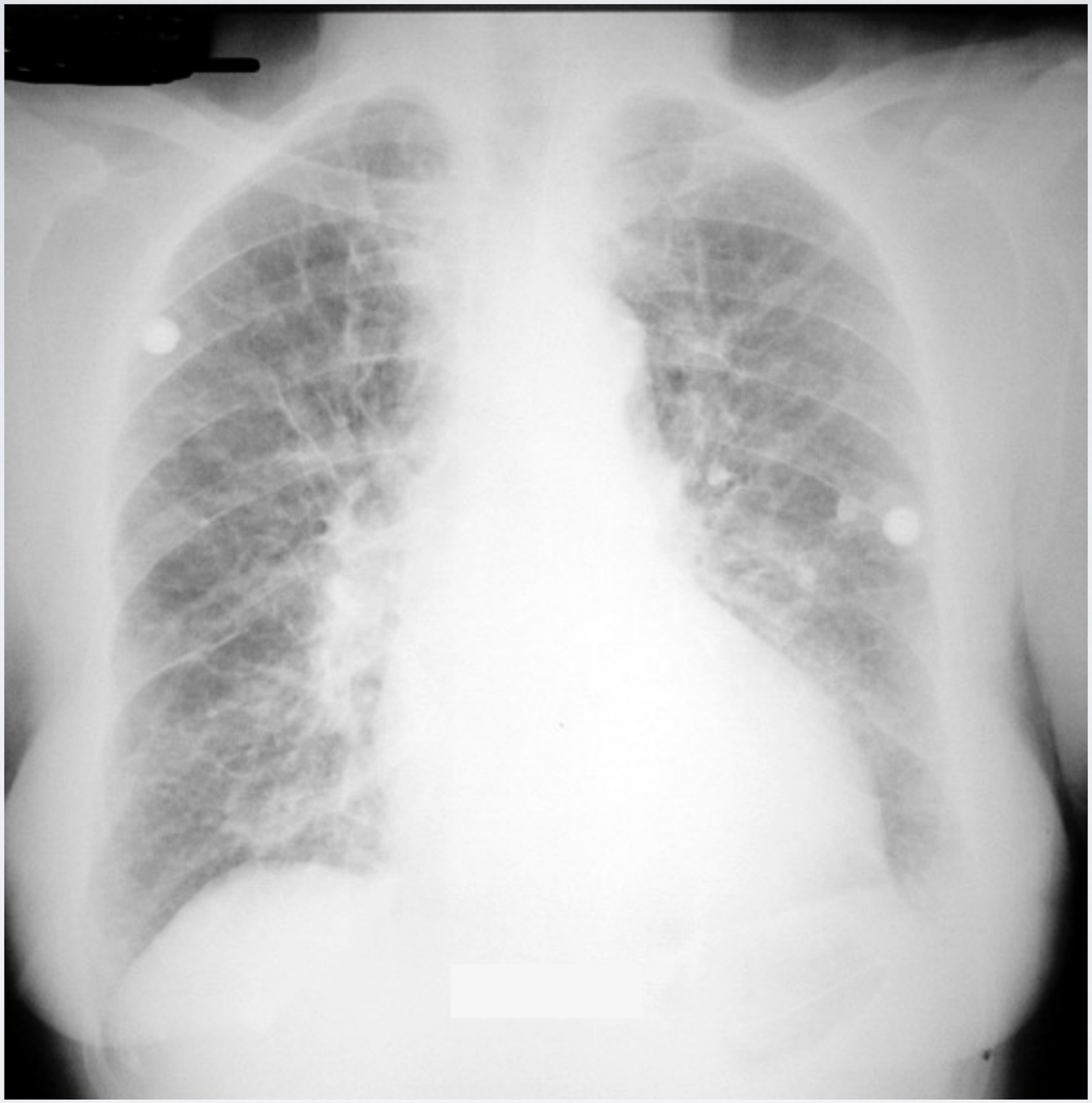
F. A and D

CAUSES OF AG ACIDOSIS

- Lactate
- Ketones
- Ingestions: methanol, ethylene glycol, propylene glycol, ASA
- Pyroglutamic acid
- Renal failure

CASE 2

- A 60 year old woman with longstanding type 2 DM complicated by ESRD presents with a 5 day history of lethargy and cough.
- Chest X-ray shows perihilar fullness without overt edema
- She is not febrile.



QUESTION

Her laboratory results reveal:

- Na 121 K 4.5
- Cl 92 HCO_3 25
- BUN 36 Cr 3
- Glu 900 Ca 8.7

What should be the next step?

A. Start IV normal saline

B. Start hypertonic (3%) saline

C. Start insulin

D. A and C

E. A and B

F. Immediate hemodialysis

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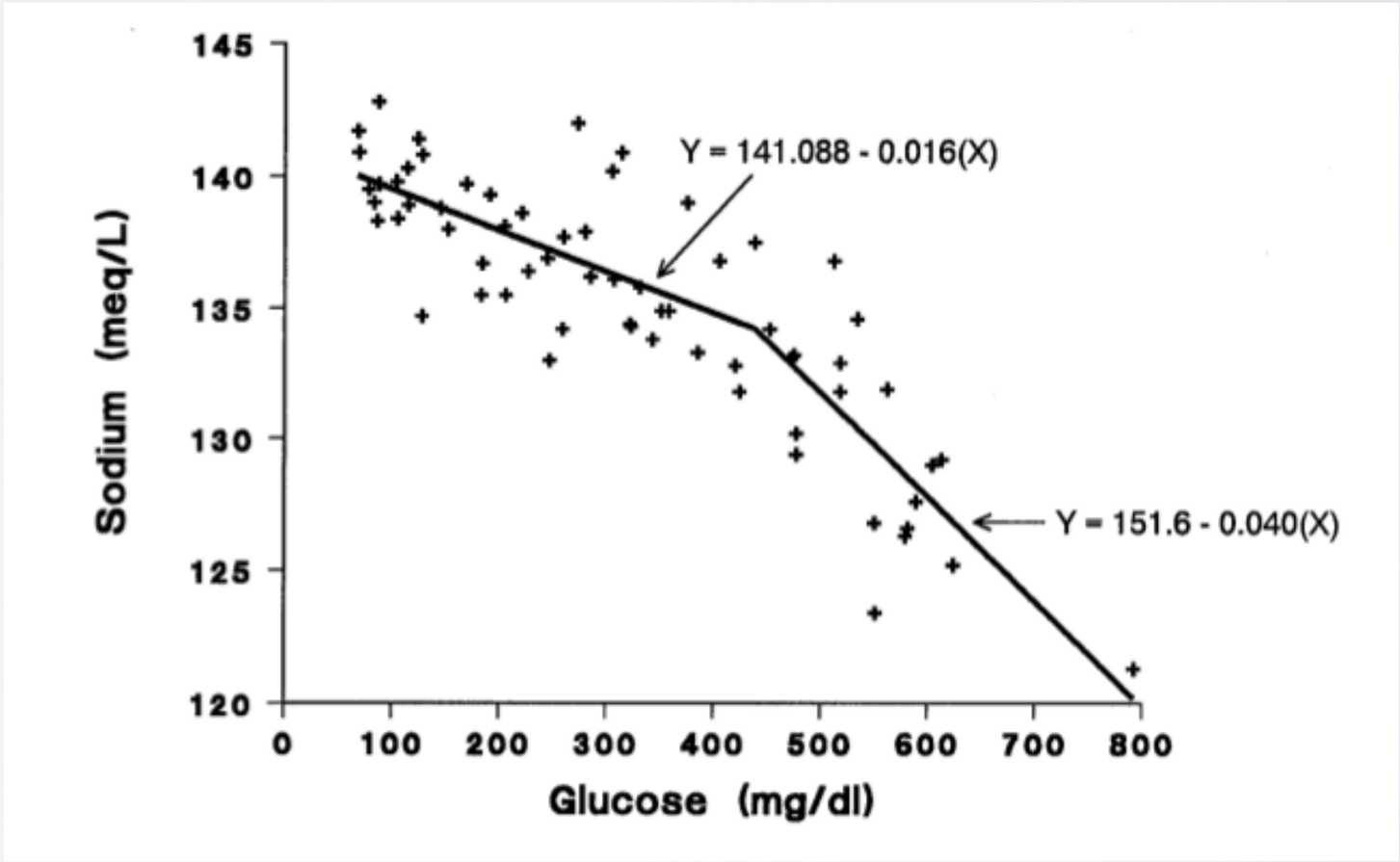
Average: Na drops by ~ 2.4 meq/L for every 100 mg/dl increase in glucose



Hillier TA, et al. Am J Med, 1999

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Corrected Na: 121 + (2.4 x 8) ~ 140 meq/L

Calculated osmolality:
(121 x 2) + (36/2.8) + 900/18) = 305

ANSWER

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Check serum osmolality

Verify that hyponatremia is “real”. Should be lo

check for hypothyroidism and adrenal insufficiency

Specific causes of hyponatremia

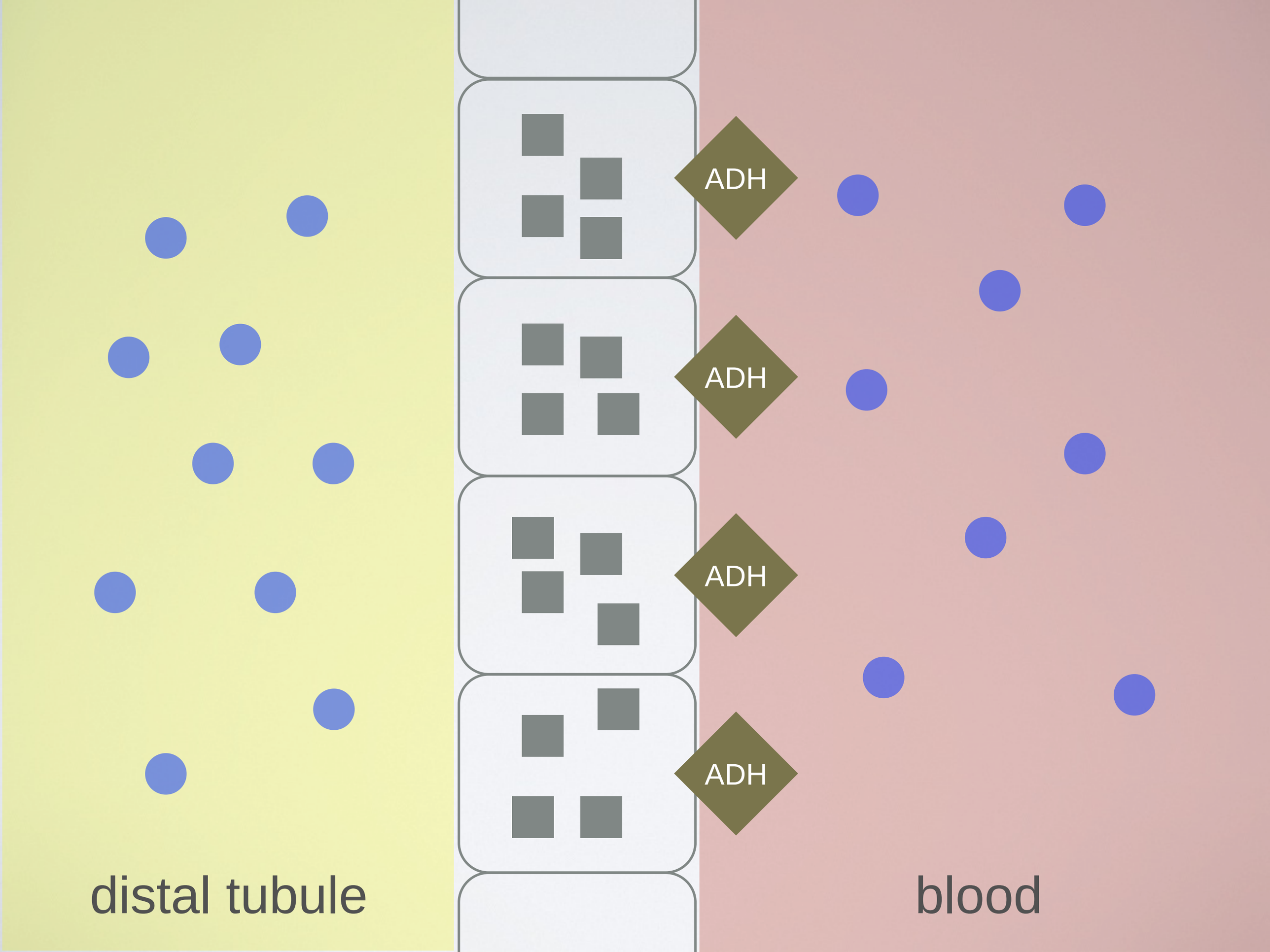
evaluate ADH status

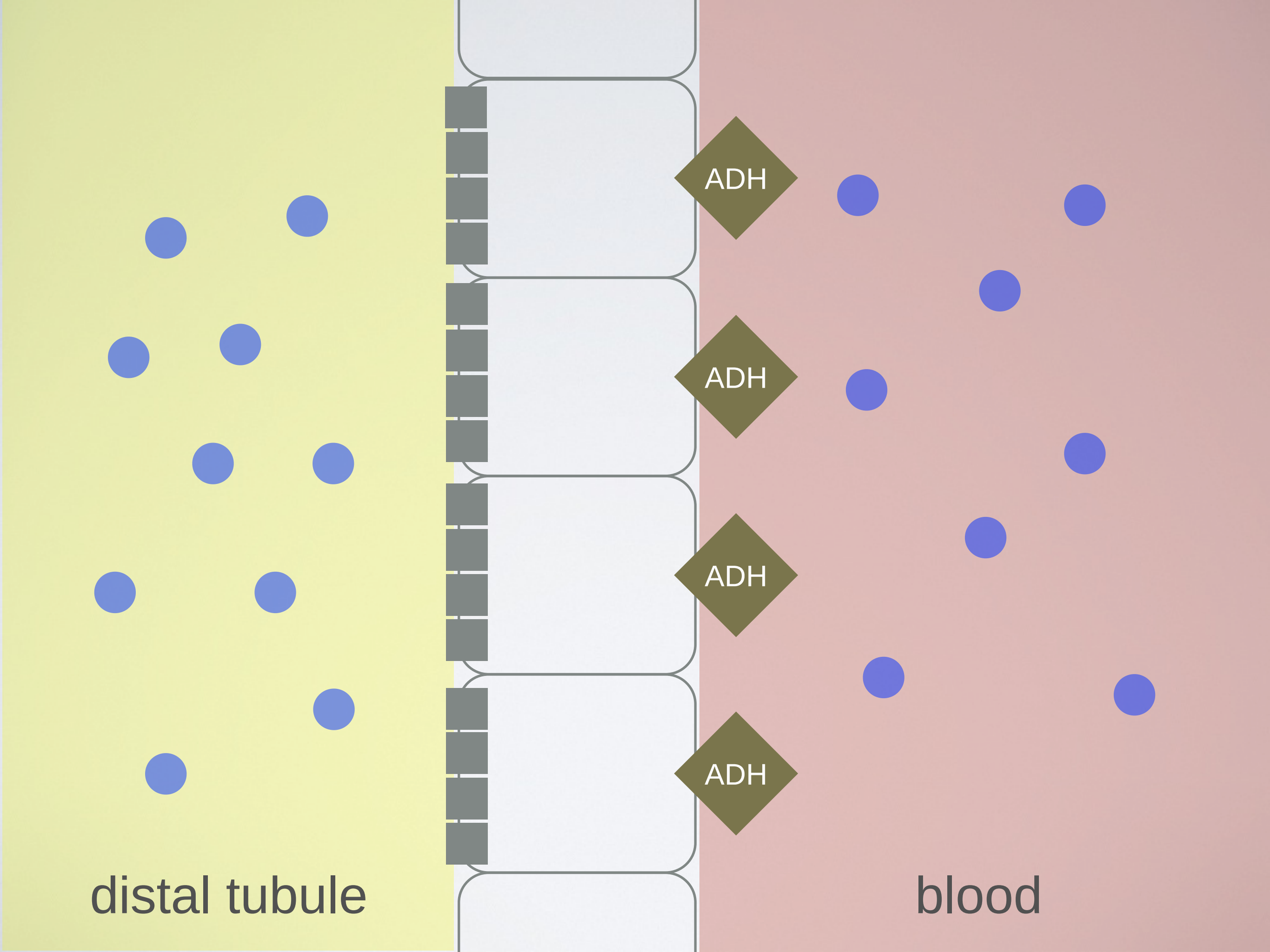
Idenitifes mechanism of hyponatremia

ADH ADH ADH ADH

distal tubule

blood


ADH
ADH
ADH
distal tubule
blood


ADH
ADH
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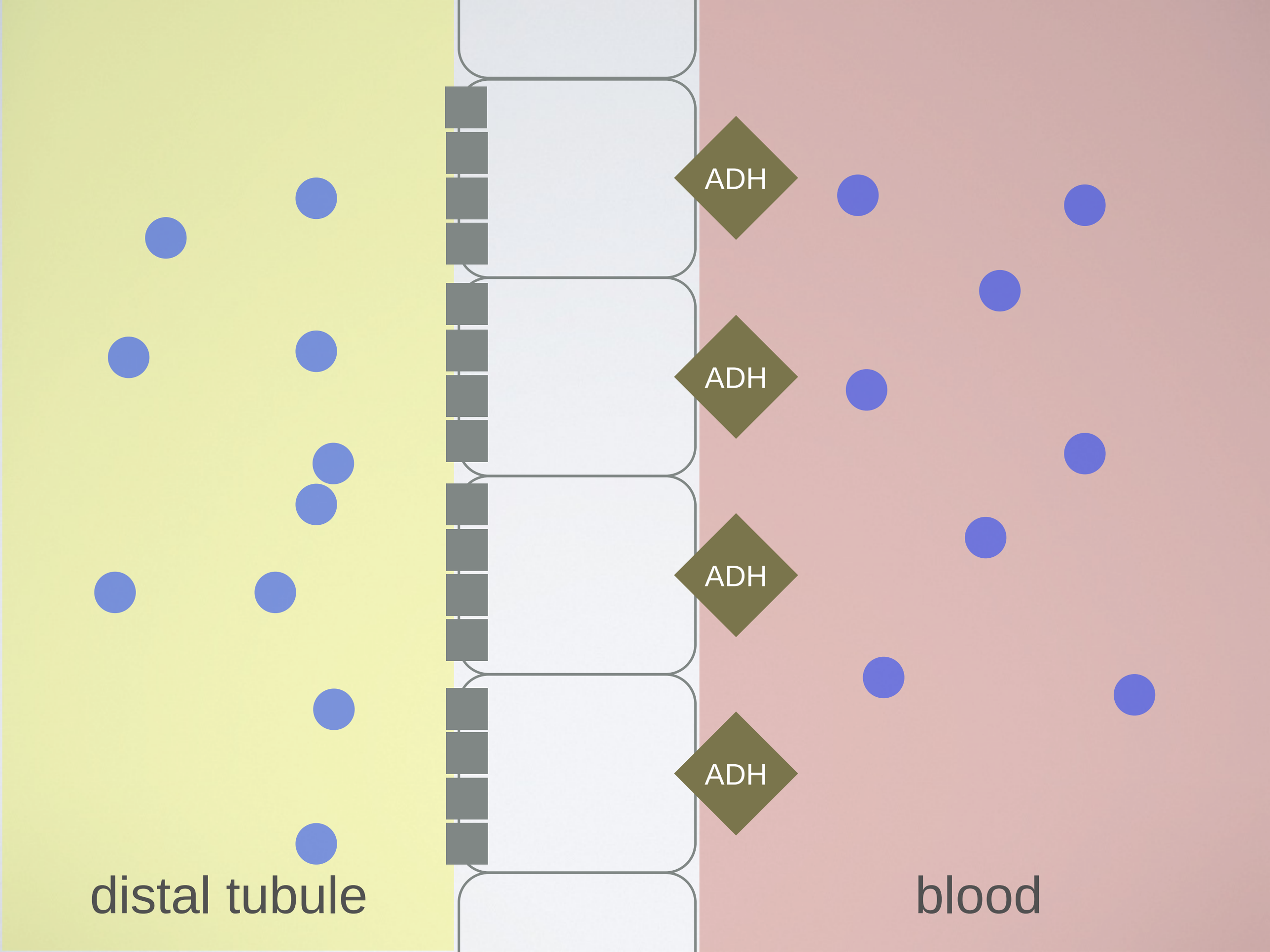
distal tubule
blood


ADH
ADH
ADH
distal tubule
blood

ADH

ADH

ADH

distal tubule

blood

HYPONATREMIA: ADH

- Role of ADH is to retain water from urine
  - Check urine osmolality
  - Goal is to assess degree of ADH activity

HYPONATREMIA: ADH

What is the urine osmolality?

Low (< 100)	Intermediate (100-300)	High (> 300)
ADH suppressed Stop drinking water Ensure adequate osmolar intake	unclear picture need context	ADH active Determine cause Is there an “appropriate” stimulus?

VOLUME STATUS

- What is the effective circulating volume status?
- Check urine sodium (caution if on diuretics)
- If low (e.g. <25), what is the true volume status?
- True volume depletion vs. CHF vs. liver disease

TREATMENT

- Is the patient symptomatic (altered mental status, seizures)
- YES: Get to a hospital ASAP and treat
- NO: How acute? How severe?

MILD HYPONATREMIA

- Stop the thiazides
- Avoid volume depletion
- Consider drug causes, especially psych drugs
- Cut back on water intake

SEVERE HYPONATREMIA

- Stop the thiazides
- Avoid volume depletion
- Consider drug causes, especially psych drugs
- Cut back on water intake

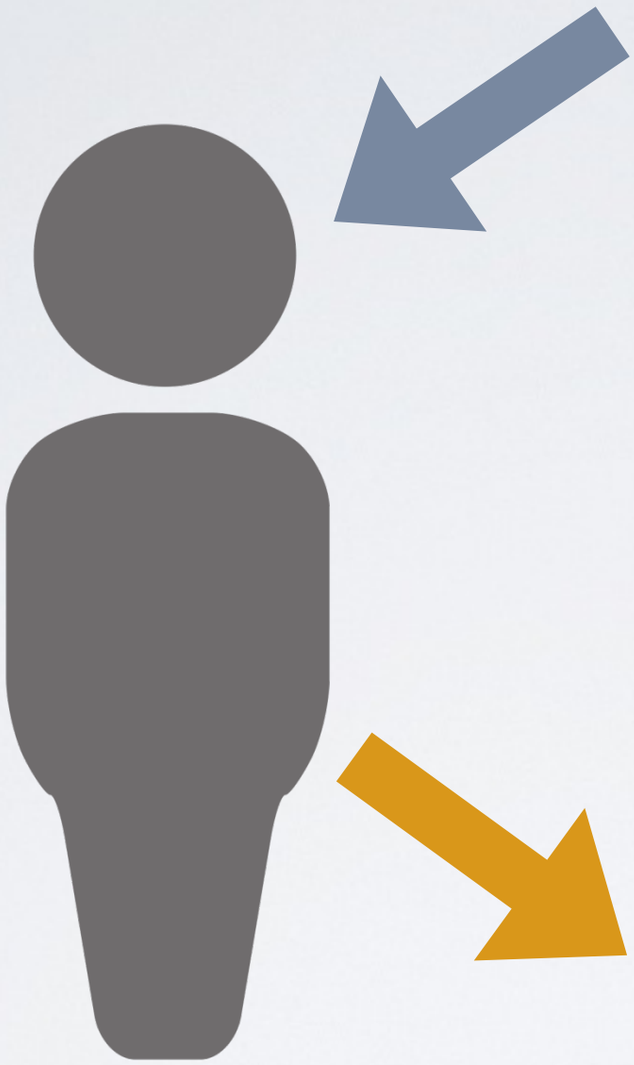
SEVERE HYPONATREMIA

- Caution with normal saline if urine osms are > 300, especially if not clearly volume depleted
- Close monitoring of serum sodium
- Mainstay of therapy is water restriction
- May need hypertonic saline ± ddAVP if symptomatic
- Goal rate of correction is 4-6 meq/L/day

Minimal effect on sodium

Normal Saline

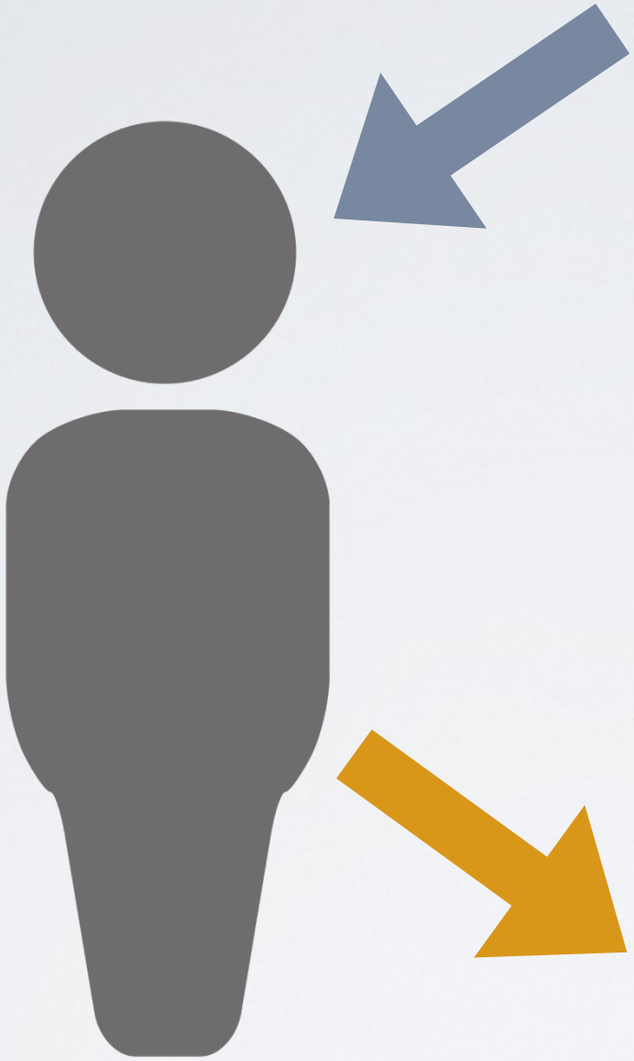
304 mOsm/kg



Isoosmolar urine

304 mOsm/kg

Sodium falls



Normal Saline

304 mOsm/kg

Concentrated urine

608 mOsm/kg

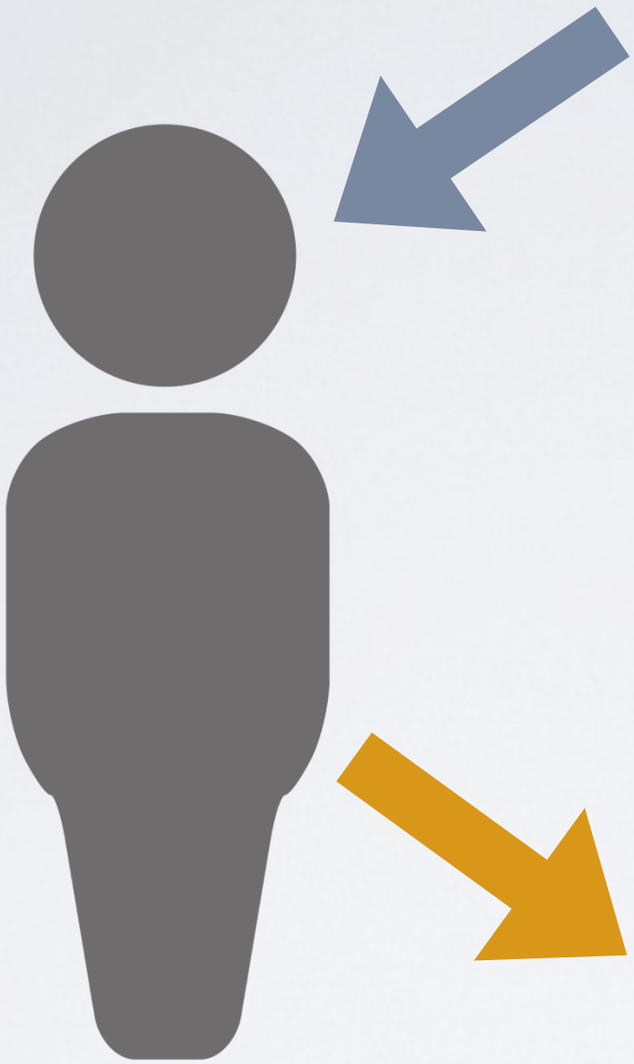
patient becomes volume replete

stimulus for ADH is removed

urine osmolality falls

water excreted

Sodium rises



Normal Saline

304 mOsm/kg

Dilute urine

100 mOsm/kg

Risk: Osmotic demyelination syndrome

CASE 3

- A 55 year old man with hypertension.
- Here for routine outpatient visit
- Medications include amlodipine, HCTZ, atenolol.

QUESTION

His laboratory results reveal:

- Na 140 K 3.0
- Cl 105 HCO_3 25
- BUN 15 Cr 1
- Glu 90 Ca 9

What should be the next step?

A. Admit for IV potassium

B. Stop HCTZ

C. Check magnesium

D. Refer to nephrology

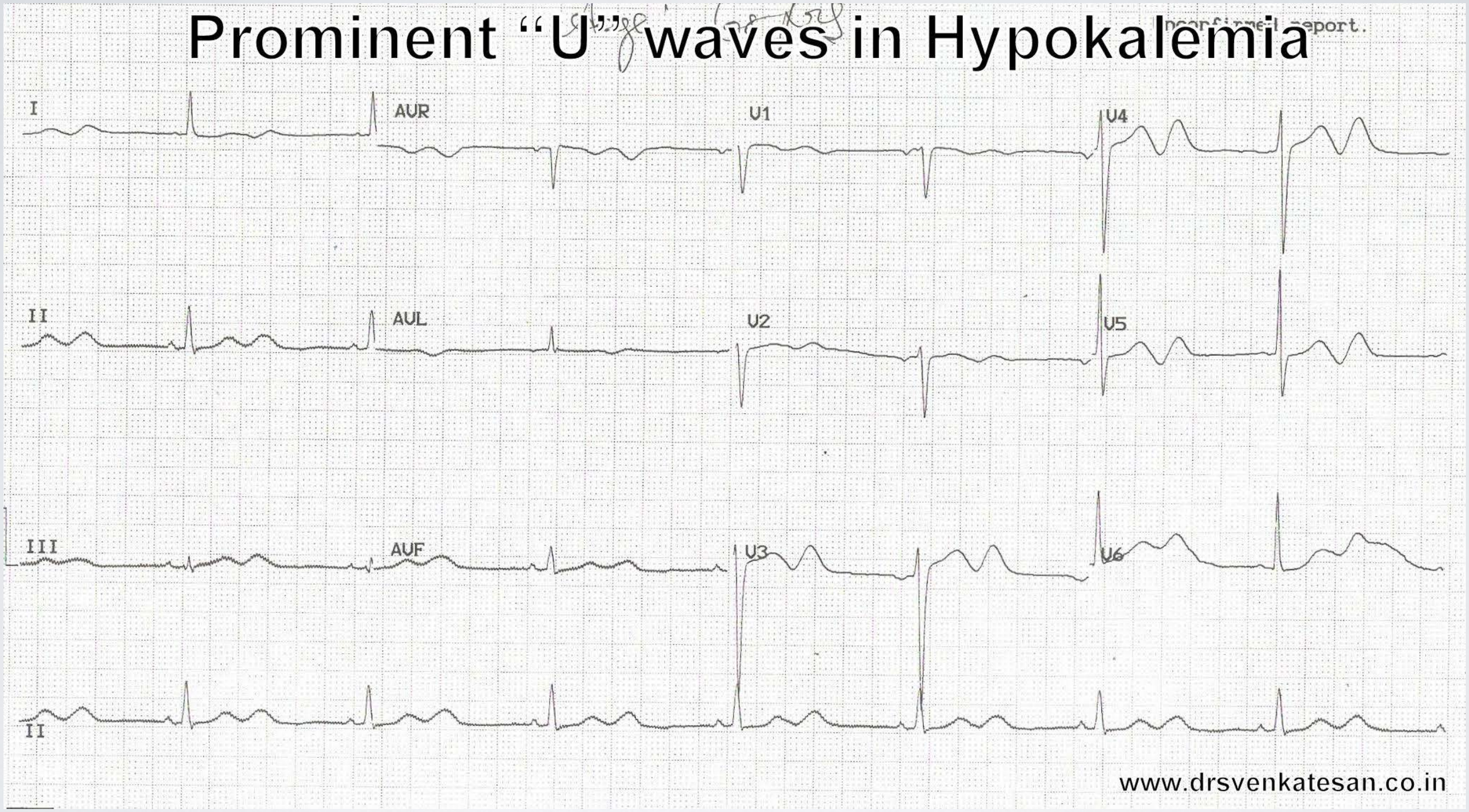
E. Ask more questions

F. Banana-rich diet

SYMPTOMATIC?

- Muscle weakness
- Cramping
- Fasciculations/tetany
- Ileus
- EKG changes: QT prolongation, T wave flattening, U-wave, premature beats, heart block, cardiac arrest

Prominent “U” waves in Hypokalemia



http://drsvenkatesan.files.wordpress.com/

CAUSES

- GI causes (esp. diarrhea)
- Renal causes (esp. medications)
- Endocrine causes (via actions on kidney)

GI CAUSES

- Diarrhea (including laxative abuse)
- Vomiting (via kidney)

RENAL CAUSES

- Magnesium deficiency
- Diuretics
- Increased sodium delivery
- Rare genetic diseases or channel disorders

ENDOCRINE CAUSES

- Hyperaldosteronism (primary or secondary, including renovascular disease)

- Cushing’s

Food	Potassium (mg)
Banana	
Broccoli (1/2 cup)	
Chicken (3 oz)	
Orange juice (1 cup)	
Peanut butter (2 tbsp)	
Potato (baked)	
Tomato	

Food	Potassium
Banana	451
Broccoli (1/2 cup)	104
Chicken (3 oz)	210
Orange juice (1 cup)	503
Peanut butter (2 tbsp)	240
Potato (baked)	845
Tomato	445

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Broccoli (1/2 cup)	104
Chicken (3 oz)	210
Peanut butter (2 tbsp)	240
Tomato	445
Banana	451
Orange juice (1 cup)	503
Potato (baked)	845

CASE 4

- A 62 year old man with h/o CAD, progressive CHF, CKD stage 3, and type 2 DM presents for a routine physical
- He has had a recent gastrointestinal illness with some nausea and intermittent loose stools.
- Medications include: metoprolol, furosemide, lisinopril, atorvastatin, and aspirin.

QUESTION

His laboratory results reveal:

- Na 143 K 4.0
- Cl 100 HCO_3 35
- BUN 30 Cr 1.4
- Glu 90 Ca 8.7
- UCl 50, repeat 10

Which of the following is the most likely cause of metabolic alkalosis?

A. Diarrhea

B. Milk-Alkali syndrome

C. Contraction alkalosis

D. Bartter syndrome

E. Gitelman syndrome

ANSWER

Her laboratory results reveal:

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METABOLIC ALKALOSIS

- GI: vomiting, suction
- Renal: Mineralocorticoid excess, diuretics, Barrter/Gitelman syndromes, post-hypercapnea, milk alkali syndrome
- Shift: hypokalemia
- Iatrogenic
- Contraction: diuresis, other fluid losses

URINE CHLORIDE

- Low (< 20) in vomiting, NG suction, post-diuretics, laxative abuse
- High during diuretic use, hyperaldosteronism (or apparent mineralocorticoid excess: Liddle’s, licorice, mutations), Barrter, Gitelman

THANK YOU