Brigham and Women's Hospital
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DIALYSIS: A CASE-BASED CLINICAL REVIEW AND UPDATE

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Disclosures

- Nothing to disclose

Learning Objectives

At the end of this presentation, learners will be able to:

- Apply principles of dialysis-related care to the overall management of dialysis patients
- Identify atypical cases of renal osteodystrophy
- Describe the principles of dialysis de-escalation
- Manage acute hyperkalemia in a hemodialysis patient
- List medications that commonly cause altered mental status in dialysis patients
- Explain to patients the risks of high interdialytic weight gain
- Manage chronic kidney disease-associated pruritus
- Define dialysis disequilibrium

Case 1

A 33-year-old man with ESKD presents to the Emergency Department with pulsatile bleeding from an AVG in his left arm after hemodialysis earlier that day. One week prior to presentation, he had been evaluated by his vascular surgeon for a presumed skin infection over the graft and had been started on vancomycin. The patient was incidentally noted to have painless swelling of his left mandible of six months' duration. He also complains of back pain for which he has been taking hydromorphone that he obtained from a friend.

Case 1
Past Medical History

- ESKD
  - Biopsy-proven interstitial nephritis
- Hepatitis C
- Hypertension
- Asthma
- Substance use disorder
- Depression
- Anxiety

Case 1
Outpatient Medications

- Acetaminophen
- Albuterol
- Clonazepam
- Clonidine
- Hydromorphone
- Labetalol
- Methadone
- Sevelamer carbonate
- Vancomycin
- Erythropoietin per protocol

Case 1
Physical Examination

- BP 185/110 mm Hg; HR 104, regular; T 100.0 F
- Chest clear
- Regular rate and rhythm
- Abdomen benign
- No peripheral edema
- No active bleeding from AVG
- Left mandibular swelling

Case 1
Oral Examination

Lerman MA et al. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2012: 113384-390

Case 1
Laboratory Data

- WBC 4.2K
- Creatinine 6.7 mg/dL
- Calcium 9.0 mg/dL
- PO_4 8.1 mg/dL
- Hemoglobin 8.7 g/dL
- AST 24 U/L (10-50)
- ALT 26 U/L (10-50)
- Alkaline phosphatase 291 U/L (40-130)

Hospital Course

The patient was admitted to the medicine service for treatment of a presumed dental abscess. Antibiotics were broadened to include Gram negative coverage and anerobic coverage with the addition of levofloxacin and clindamycin.

Specialists come riding in . . .
Case 1 Question (Audience Response)

He is seen the next day by the nephrology fellow and attending who are skeptical of the diagnosis. What additional diagnostic laboratory test do they request?

A) Blood cultures
B) Erythrocyte sedimentation rate
C) Ferritin
D) ANCA
E) Parathyroid hormone

Specialists come riding in . . .
Case 1 Question (Audience Response)

He is seen the next day by the nephrology fellow and attending who are skeptical of the diagnosis. What additional diagnostic laboratory test do they request?

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B) Erythrocyte sedimentation rate

C) Ferritin

D) ANCA

E) Parathyroid hormone

Parathyroid hormone level

Intact PTH 2190 pg/mL

Further dialysis history

- Outpatient dialysis records show that PTH has been > 2000 for more than one year.
- He has been prescribed cinacalcet but he has never filled the prescription.
- Vitamin D analogues have been held because of persistent hyperphosphatemia.
- He has been referred to an endocrine surgeon for consideration of parathyroidectomy but never kept the appointment.

Rugger Jersey Spine

Lerman MA et al. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2012: 113384-390

Rugger Jersey spine

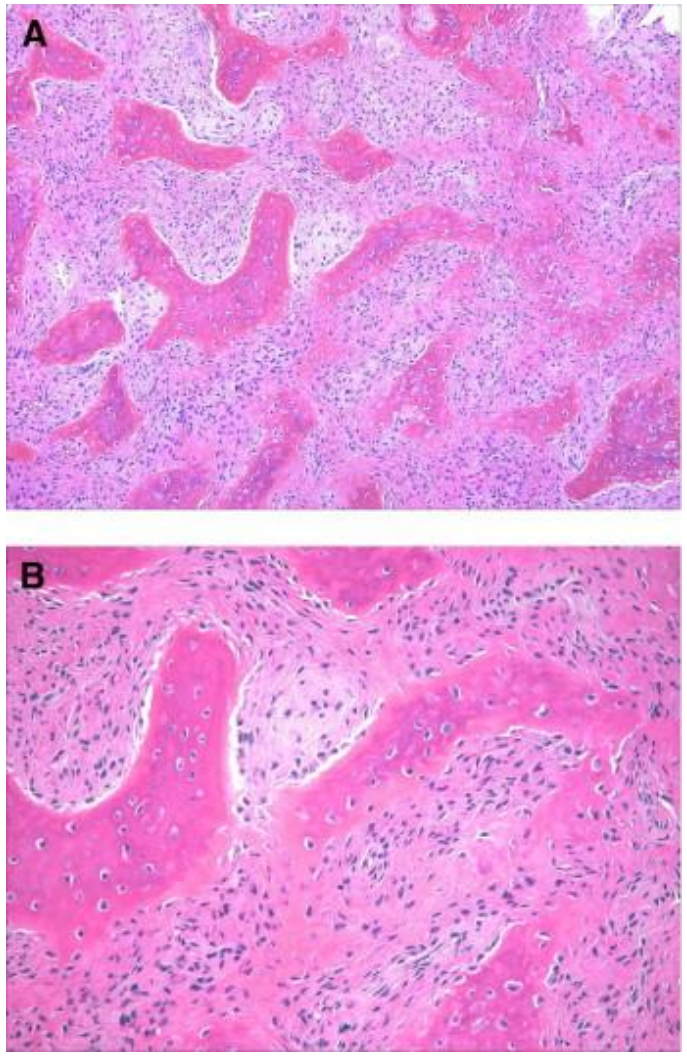
Rugger jersey spine describes the prominent endplate densities at multiple contiguous vertebral levels to produce an alternating sclerotic-lucent-sclerotic appearance. This mimics the horizontal stripes of a rugby jersey.

This finding is pathognomonic of renal osteodystrophy in the setting of hyperparathyroidism.

https://radiopaedia.org/articles/rugger-jersey-spine-hyperparathyroidism-1?lang=us

Lerman MA et al. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2012: 113384-390

Bone Biopsy



Lerman MA et al. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology 2012: 113384-390

Case 1 Follow-up

Patient never presented for evaluation for parathyroidectomy. His hyperparathyroidism became progressively worse with debilitating back pain and muscle weakness such that he became wheelchair-bound.

He died at age 38.

CKD-MBD masquerading as metastasis

A 68-year-old woman with ESKD of undetermined etiology has been on incenter hemodialysis for 10 years. She presents to the hospital after a fall at home. She complains of neck pain and undergoes CT imaging of her head and cervical spine. CT findings:

- No acute intracranial findings
- No acute fracture, or traumatic malalignment of the cervical spine. Focal lytic lesions involving predominately C1-C5 vertebral bodies and posterior elements, new since 11/25/2022. Findings can be seen with multiple myeloma or metastasis, amongst other etiologies.

Medicine Team's Plan

Focal lytic lesions in C-spine

Incidentally found. Concerning for MM vs. metastatic malignancy. Will send SPEP, UPEP, free light chains, ESR/CRP. Will discuss age-appropriate cancer screening with her.

Specialists come riding in . . .

She is seen the next day by the nephrology fellow and attending who review the outpatient nephrology record:

- PTH 4126 pg/mL
- Alkaline phosphatase 313 U/L

Case 1 Take Home Messages

- Medicine teams may anchor on a diagnosis because of
  - Lack of knowledge of dialysis-specific alternative diagnoses
  - Lack of access to collateral dialysis history
- We as nephrologists must consider and weigh in on the whole patient
- Always review the outpatient dialysis history from the outpatient unit

Case 2

A 51-year-old man with no significant past medical history presents to Urgent Care with left leg swelling and shortness of breath in August 2019. He has not seen a doctor in more than 20 years. The clinician is concerned about a pulmonary embolism and refers him to the ED. He had a CT-PE that was negative and lower extremity ultrasound that was negative for DVT. BP on presentation to the ED was 224/117 mm Hg.

Case 2
Family and Social History

- No family history of kidney disease
- Former smoker
  - Quit smoking 9 years prior
- MSM

Case 2
Physical Examination

- Well appearing, in no acute distress
- Conjunctival pallor
- RRR, no pericardial friction rub
- Clear lungs
- Abdomen soft and nontender
- No peripheral edema; ecchymoses on left lower extremity on lateral aspect of popliteal fossa with associated swelling and pain on palpation

Case 2
Labs

- K^+ 4.4 mEq/L
- CO_2 20 mmol/L
- BUN 109 mg/dL
- Creatinine 11.59 mg/dL
- Hemoglobin 8.0 g/dL
- PO_4 8.5 g/dL
- Anion gap 25
- NT-pro BNP > 70,000

Case 2
Additional Labs

- ANCA negative
- C3 98 (90-180) mg/dL
- C4 27 (10-40) mg/dL
- Anti-GBM negative
- ANA negative
- HIV negative
- Hepatitis B and C negative

Case 2
Renal Imaging

FINDINGS
Right kidney
Size: 10.7 cm
No hydronephrosis
Increased echogenicity
Left kidney
Size: 10.2 cm
No hydronephrosis
Increased echogenicity
Bladder
Decompressed with a Foley catheter
IMPRESSION:
Increased echogenicity of bilateral renal cortices, consistent
with parenchymal disease.

Case 2
Hospital Course

- BP controlled with labetalol
- Plans made for tunneled dialysis catheter

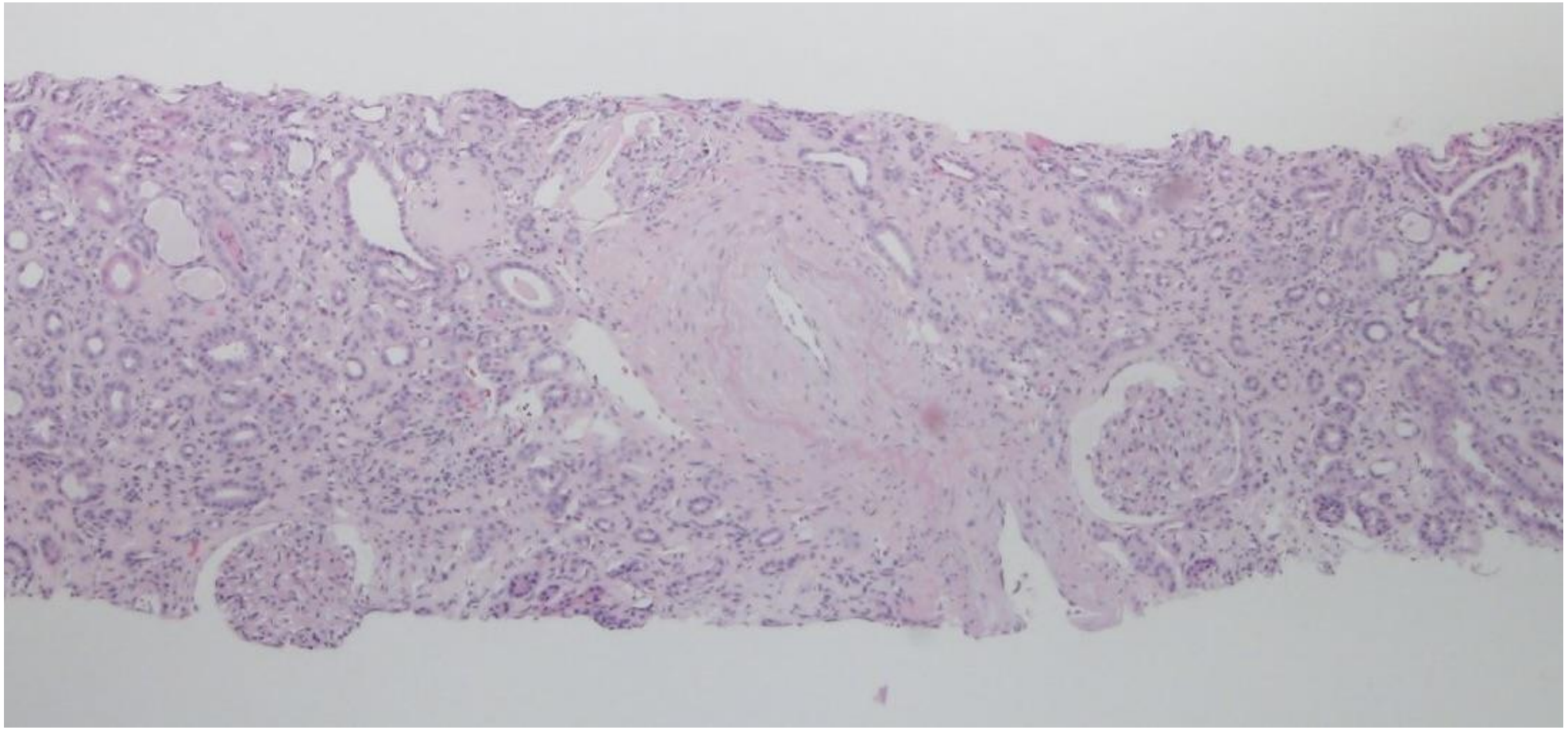
Case 2 Question 1 (Audience Response)

Should this patient have a kidney biopsy?

A) Yes

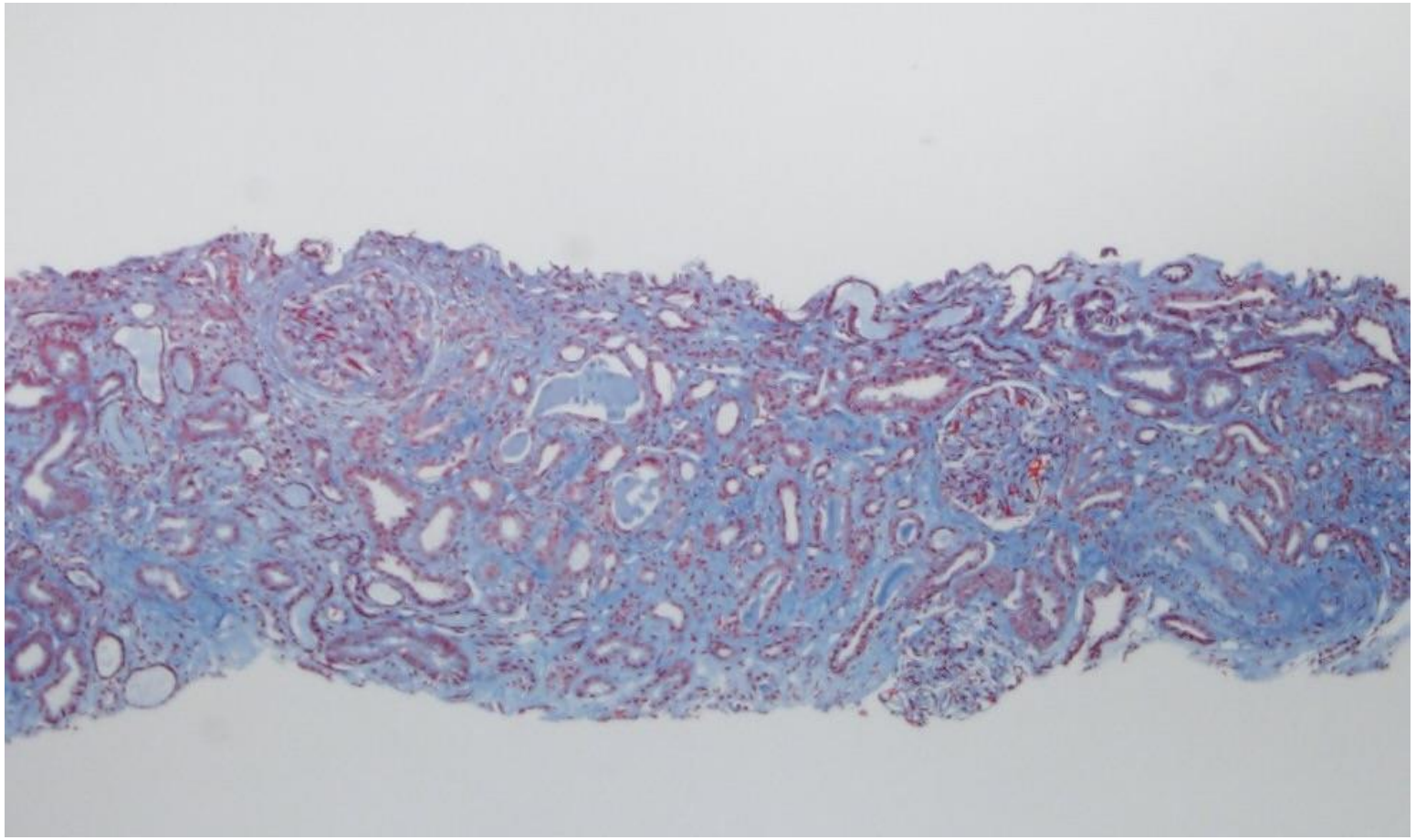
B) No

Kidney Biopsy (H & E)



Slide courtesy of Dr. Astrid Weins

Kidney Biopsy (Trichrome)



Slide courtesy of Dr. Astrid Weins

Kidney Biopsy

PATHOLOGIC DIAGNOSIS:

KIDNEY BIOPSY (NEEDLE)

SEVERE VASCULAR SCLEROSIS WITH SEVERE ARTERIOLAR REMODELING WITH FOCAL "ONION SKIN" LESIONS AND EXTENSIVE GLOMERULAR CAPILLARY WALL REMODELING, MOST LIKELY REPRESENTING A HEALED OR CHRONIC THROMBOTIC ANGIOPATHY (SEE NOTE)

ACUTE TUBULAR INJURY WITH FOCAL TUBULAR NECROSIS, LIKELY ISCHEMIC

ADVANCED CHRONIC CHANGES OF THE PARENCHYMA, INCLUDING:
- FOCAL GLOBAL GLOMERULOSCLEROSIS (20% OF GLOMERULI)
- DIFFUSE GLOMERULAR HYPOPERFUSION
- ADVANCED TUBULAR ATROPHY AND INTERSTITIAL FIBROSIS (80% OF THE CORTEX)
- SEVERE ARTERIAL AND ARTERIOLAR SCLEROSIS WITH ONION SKINNING

Case 2 Question 2 (Audience Response)

Based upon this biopsy, does this patient have end-stage kidney disease requiring long-term dialysis or acute kidney injury with possibility of recovery of renal function?

A) ESKD

B) AKI

Case 2
Follow-up

Patient is started on hemodialysis via a tunneled dialysis catheter. He stabilizes with good blood pressure control and is referred to an outpatient dialysis clinic in another state to be closer to family. He returns to Boston in November 2019, which is where I met him. In January 2020, he had a PD catheter placed and begins training for PD. Clinically, he does very well on peritoneal dialysis.

Prescription: 4 exchanges x 2L over 9 hours

Solute Clearance

Date	PD Class	Sex	Hgt cm	Wgt kg	V/Wt %	BSA	GFR est	nPNA	Serum				Effl.	Urine		Urea			Creatinine		
									Urea	Creat	Gluc	Alb	vol	vol	coll	KpT/V	KrT/V	Total	KpCr	KrCr	Total
02/11/20	CCPD	M	178		68.4	1.9	56.1	1.15	75	7.9			9536	1300	24	1.08	0.93	2.01	23.04	77.48	79.16
06/09/20	CCPD	M	178		69.31	1.9	83.8	1.06	72	5.6	126	4.3	8300	800	24	0.88	1.01	1.89	21.69	129.99	105.49
10/14/20	CCPD	M	178		80.11	1.9	106.	1.03	59	5.4	97	4.5	9008	800	24	1.01	1.2	2.21	21.23	168.74	127.99
02/02/21	CCPD	M	178		65.55	1.9	82.1	0.98	62	5.4	90	4.4	8324	700	24	0.96	1.02	1.98	20.6	126.2	102.7
05/19/21	CCPD	M	178						67	5.1	109			0							
06/01/21	CCPD	M	178		67.49	1.9	102.	1.09	56	4.9	96	4.6	9387	1100	24	1.09	1.42	2.51	17.07	152.84	120.05
10/04/21	CCPD	M	178		66.98	1.9	90.8	1.09	65	5.2	98	4.7	9256	1000	24	1	1.16	2.16	19.25	138.27	110.07
02/01/22	CCPD	M	178		61.73	1.9	86.5	0.94	54	4.9	124	4.7	9288	700	24	1.03	1.11	2.14	19.3	131.81	105.82
06/01/22	CCPD	M	178		68.3	1.9	131.	1.21	53	4.2	95	4.5	9293	1275	24	0.99	2.02	3.01	16.89	187.37	148.16
10/03/22	CCPD	M	178	80.3	62.79	1.9	119.	1.19	53	4.2	100	4.6	9367	1425	24	1	1.97	2.97	17.03	166.23	136.76
01/05/23	CCPD	M	178	79.4	64.67	1.9	135.	1.17	47	3.9	81	4.4	9533	1500	24	1.08	2.18	3.25	15.55	190.89	151.41
05/01/23	CCPD	M	178	75.9	61.72	1.9	128.	1.19	47	4	100	4.7	9376	1750	24	1.06	2.25	3.31	16.41	172.6	144.52
08/15/23	CCPD	M	178	71.3	65.47	1.9	126.	1.13	46	4.1			9540	1675	24	1.21	2	3.21	19.25	179.37	146
12/19/23	CCPD	M	178	74	61.43	1.9	129.	1.15	45	3.7			8950	1700	24	1.16	2.19	3.35	26.17	178.34	155.84

Case 2 Question 3 (Audience Response)

As his residual renal function improves, which of the following strategies might be used in de-intensifying his PD prescription?

A) Weekends free from dialysis

B) Fewer exchanges

C) Smaller fill volume

D) Any of the above

Case 2
Further follow-up

We chose to give the patient weekends off from dialysis.

Remember that the calculated peritoneal Kt/V assumes 7 days per week of dialysis.

What is his peritoneal Kt/V with 5 days of dialysis?

- Dialysate urea = 33 mg/dL
- BUN = 53 mg/dL
- D/P urea = 0.62
- TBW = 40.9
- Drain volume = 9.4L
- 9.4 L (0.62)/40.9 L = 0.14
- Weekly Kt/V for 5 days = 0.14 x 5 = 0.72

What is his renal Kt/V?

- Urine urea nitrogen = 428 mg/dL
- BUN = 53 mg/dL
- U/P urea = 8.1
- TBW = 40.9
- Urine volume = 1.4 L
- 1.4 L(8.1)/40.9 = 0.28
- Weekly Kt/V_r = 1.9

What is his total Kt/V?

- 1.9 + 0.72 = 2.62 with 5 days per week of PD

Case 2
Further follow-up

December 2023 Labs:
BUN 45 mg/dL

Creatinine 3.7 mg/dL

Kt/Vr 2.19

Albumin consistently > 4

No ESA requirement with hemoglobin > 12 g/dL

No PO_4 binder requirement

Decision made to stop dialysis

Most recent BUN/Cr: 64/3.69 mg/dL

Patient has returned to full-time work.

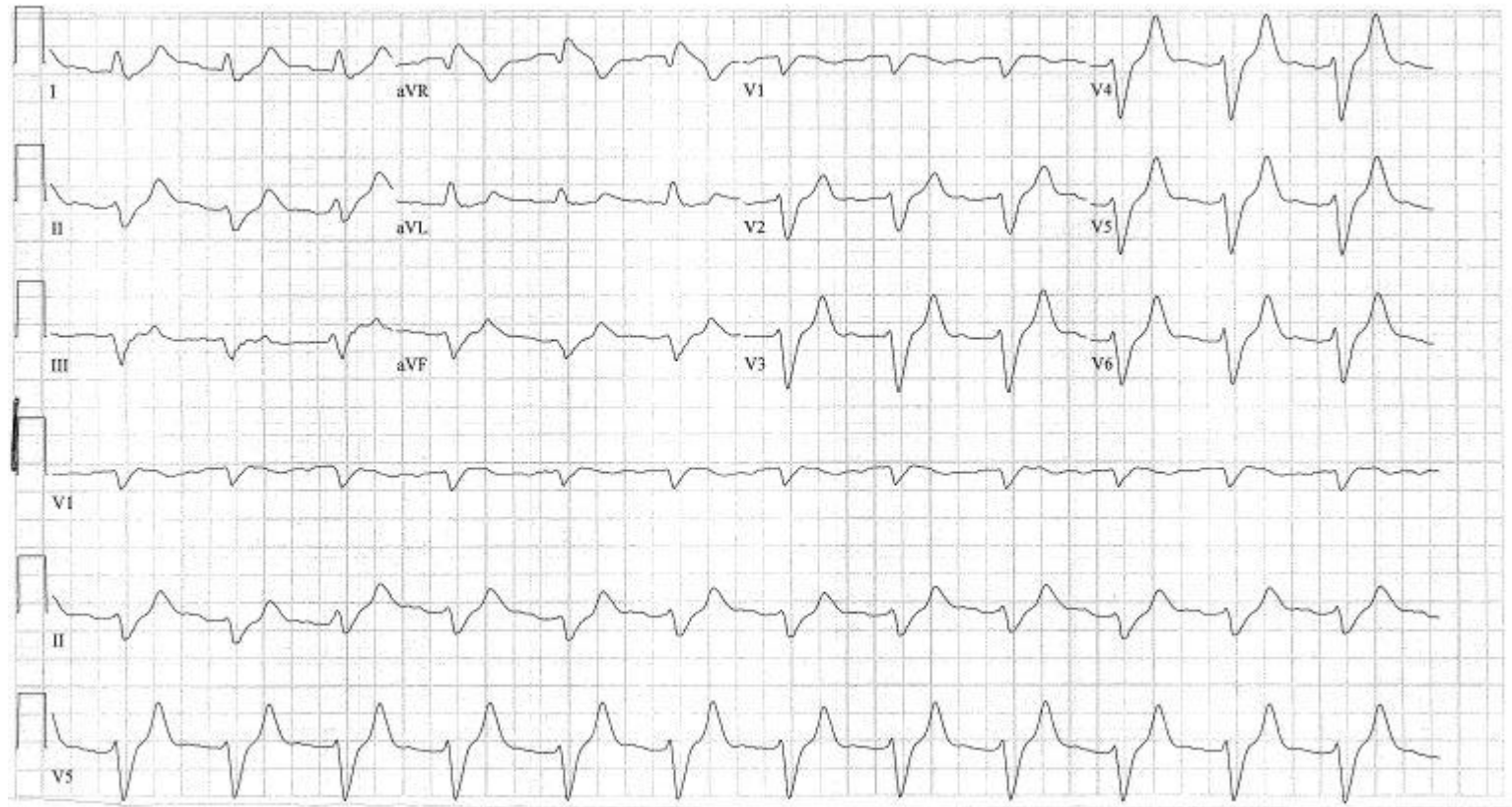
Case 2 Take Home Messages

- Monitor for recovery of residual renal function
- Consider de-intensifying dialysis prescription if renal function recovers
- Remember to calculate the peritoneal Kt/V based upon the number of days that the patient is actually dialyzing.

Case 3

A 53-year-old man with ESRD on HD for five years, diabetes mellitus type 2, and morbid obesity is at a rehabilitation facility, preparing to go to dialysis on a Tuesday, after having missed dialysis on Saturday, when he passes out. He is brought to the hospital where his initial EKG is as shown on the next slide.

Case 3: Electrocardiogram



Case 3 Question 1 (Audience Response):

What is the most likely explanation for this patient's presentation?

A) Anemia
B) Hypercalcemia
C) Hyperkalemia
D) Hyperphosphatemia

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Case 3 Question 1 Explanation

The greatest period of vulnerability to arrhythmias is after the long two-day interdialytic interval, i.e., Monday morning for M-W-F patients and Tuesday morning for T-Th-S patients. This patient has had an interdialytic interval of *four* days. He has been on hemodialysis for five years and likely has no residual renal function. Therefore hyperkalemia is the most likely explanation for this patient's presentation.

Case 3 Continued

In the Emergency Department, the patient develops increased work of breathing, hypoxemia, and hypercapnia and is intubated and mechanically ventilated.

- Na^+ 135 mEq/L
- K^+ 9.3 mEq/L
- Cl^- 94 mEq/L
- CO_2 21 mmol/L
- Glucose 221 mg/dL
- VBG: 85/56/7.16

Case 3 Continued

In the Emergency Department, the patient received the following therapies:

- Calcium gluconate (1 ampule = 1000 mg)
- Insulin (10 units IV)
- D50 (1 ampule= 25 grams)
- Sodium bicarbonate (2 ampules = 100 mEq bicarbonate)
- Albuterol nebulizer (20 mg)

Case 3 Question 2 (Audience Response):

What potassium bath would you use for emergent hemodialysis in this patient?

A) 0 K^+
B) 4 K^+
C) 3.0 K^+ x 1 hour, 2.0K^+ x 1 hour, 1.0K^+ x 2 hours

Case 3 Question 2 (Audience Response):

What potassium bath would you use for emergent hemodialysis in this patient?

A) ~~2.0 K^+~~

B) ~~4.0 K^+~~

C) 3.0 K^+ x 1 hour, 2.0K^+ x 1 hour, 1.0K^+ x 2 hours

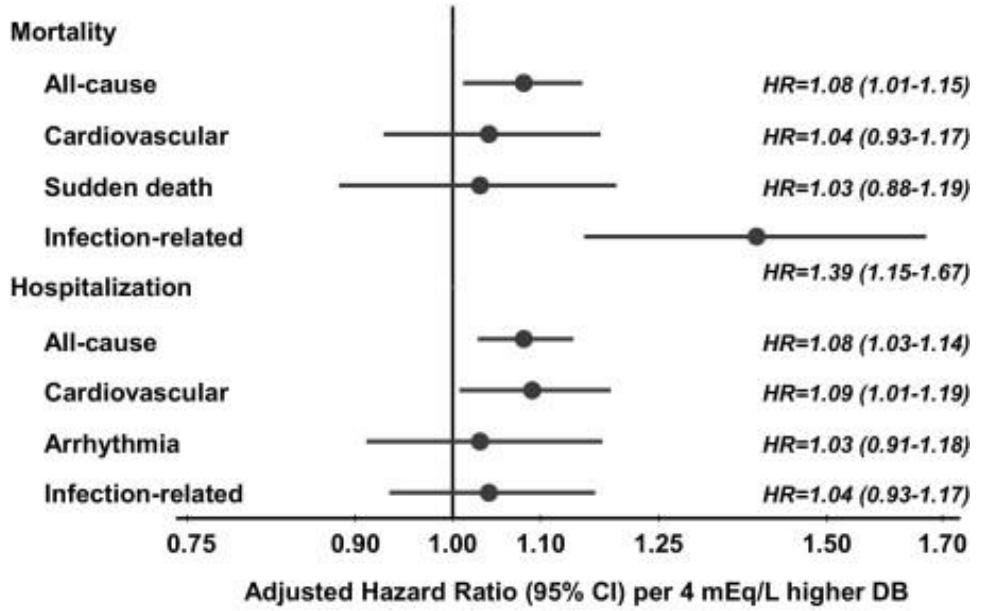
Case 3 Question 2 Explanation

A zero potassium bath would pose too great an anti-arrhythmic risk from lowering the potassium too quickly, while a 4.0 K^+ bath might not provide enough of a concentration gradient for a starting potassium of 9.3. We favor the use of a gradual lowering of the dialysate potassium in order to more slowly lower the potassium over the course of the dialysis procedure.

Electrolyte Composition in Dialysis: It's not just about potassium

- Rapid correction of metabolic acidosis may lead to a precipitous drop in the ionized calcium
- Pre-existing metabolic alkalosis coupled with hypokalemia may be associated with more sudden cardiac death
  - Ionized hypocalcemia → prolonged QT interval
  - More sudden cardiac death in patients with a pre-HD bicarbonate concentration > 27 in those dialyzing with a di-acetate dry concentrate
  - Delivered total buffer = dialysate bicarbonate + 4 (liquid concentrate) or 8 (di-acetate dry concentrate)

Association of dialysate bicarbonate concentration with mortality in the Dialysis Outcomes and Practice Patterns Study (DOPPS)



Tentori F et al. Am J Kidney Dis 2013; 62: 738-46

June 29, 2018 | 2 min read

SAVE

Jury awards $383.5 million in GranuFlo-linked patient deaths

ADD TOPIC TO EMAIL ALERTS

A jury in Denver awarded families of three DaVita Kidney Care patients $383.5 million in a wrongful death lawsuit linked to the dialysis provider's use of the acid concentrate GranuFlo. DaVita said in a statement that it will appeal the verdict.

Case 4

A 62-year-old man with ESRD secondary to scleroderma is admitted to the hospital with shortness of breath.

Past Medical History

- ESRD
- Scleroderma
- COPD
- Peripheral arterial disease
- Recurrent pleural effusion
- Malnutrition

Case 4
Hospital Course

- Diagnosed with pulmonary emboli → started on IV heparin
- Pneumonia treated with cefepime
- Ileus
- GI bleeding
- Sacral wound

Dermatology Consult

Dermatology Recommendations

- “Please start patient on IV acyclovir for HSV infection. Recommend touching base with pharmacy for appropriate dosing in HD patient”
- “Can transition to valacyclovir at discharge. Treatment duration will be until lesions heal”
- Patient started on acyclovir 5 mg/kg q 24 hours

Altered Mental Status

- Four days later patient develops altered mental status
- Sent for stat head CT
- Upon return from head CT, patient is anxious and confused and says, “I died down there.”

Case 4 Question (Audience Response)

What is the most likely explanation for the patient's altered mental status?

A) Inadequate dialysis

B) Cefepime

C) Acyclovir

Case 4 Question (Audience Response)

What is the most likely explanation for the patient's altered mental status?

A) Inadequate dialysis

B) Cefepime

C) Acyclovir

Altered mental status in a dialysis patient

Always think about medications

- Acyclovir
- Cefepime
- Narcotics
- Gabapentin
- Amantadine
- Baclofen


Baclofen
in CKD&ESRD

Acyclovir neurotoxicity

DIAGNOSTIC DILEMMA
Aimee K. Zaas, MD
Thomas J. Marrie, MD, Section Editors

THE AMERICAN JOURNAL of MEDICINE®

Death Delusions and Myoclonus: Acyclovir Toxicity

James L. Gentry III, MD, Cecily Peterson, MD
Department of Internal Medicine, Duke University Hospital, Durham, NC.

Clinical features of acyclovir neurotoxicity

- Disturbances in consciousness
- Seizures
- Myoclonus
- Coma
- Death delusions
  - “Le delire de negation” or Cotard’s syndrome
  - A more specific neuropsychiatric symptom

Gentry JL and Peterson C. Am J Med 2015; 128: 692-694

Diagnosis and Management

- Diagnosis may be confirmed by measurement of metabolite 9-carboxymethoxymethylguanine
- Discontinuation of drug
- Hemodialysis

Case 5

A 64-year-old man on HD presents to the ED with headache and his found to have a blood pressure of 240/100 mm Hg. He had a similar presentation at a different hospital three days prior, at which time he was given his usual blood pressure medications and discharged home.

In the ED he had a head CT that was negative for any intracranial process.

His admission weight is 86 kg.

Case 5
Past Medical History

- ESRD
- Hypertension
- Diabetes mellitus type 2
- BPH
- CML

Case 5
Medications

- Amlodipine 10 mg daily
- Carvedilol 50 mg twice daily
- Hydralazine 20 mg three times daily
- Insulin glargine 10 units SQ nightly
- Losartan 25 mg daily
- Tamsulosin 0.4 mg po QHS
- Torsemide 100 mg daily
- Asciminib 20 mg twice daily
- Renal multivitamin 1 po daily
- Sevelamer carbonate 800 mg po tid with meals
- Sodium zirconium cyclosilicate 10 grams daily
- Methoxy polyethylene glycol-epoetin beta per protocol

Case 5
Dialysis Prescription and History

- High flux polysulfone dialyzer
- 3.5 hours
- Qb 400
- Qd 800
- 140 Na^{+}, 2.0K^{+}, 2.5Ca^{++}, 43 mmol/L total buffer
- EDW 81 kg

- Does not miss dialysis treatments
- Typical interdialytic weight gain 4-5 kg
- Typical ultrafiltration 4-5 kg

Case 5 Question (Audience Response):

What is the next best step to improve this patient's fluid management?

A) Increase the dialysate sodium to 145 mEq/L
B) Increase dialysate calcium to 3.5 mEq/L
C) Increase time on dialysis
D) Change to a larger surface area dialyzer
E) Reduce dietary sodium intake
F) Both C and E

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F) Both C and E

Case 5 Explanation

- Increasing his dialysate sodium may exacerbate the issue of excessive IDWG.
- Increasing the dialysate calcium sometimes help with hypotension, but that is not the issue in this case.
- A larger surface area dialyzer will help urea clearance, but that is not the issue in this case.
- Longer time on dialysis may help to reduce cramping, allow him to reach his dry weight, and lower the UF rate.
- Reduction in dietary sodium will reduce IDWG

Issues with this patient

- Excessive IDWG
  - IDWG should be lower than 4-4.5% of dry weight
- Poorly controlled blood pressure
- Relatively short treatment time

What is the UF rate?

- Fluid removed per body weight per unit time expressed in mL/kg/hour
- Pre-weight 86 kg
- Fluid removal 5 L
- 5000 mL/86 kg/3.5 hours= 16.6

Online UFR calculators

I want to take off this much fluid:

5 Liters

My weight before treatment:

86 Kilograms

My treatments are this long:

3.5 Hours

My doctor says I have heart problems:

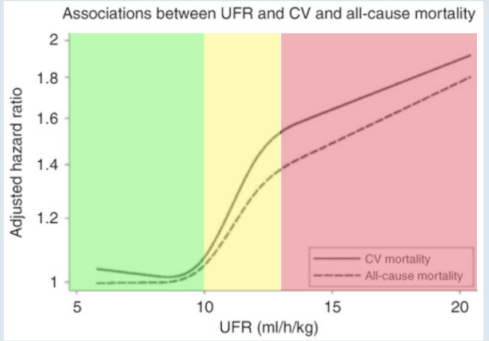
☐ Yes

Calculate

Your Ultrafiltration Rate (UFR):

16.6 ml/Kg/hour

You are in the DANGER zone! If you have **cramps**, headaches, or feel dizzy, you may have **"organ stunning,"** which can cause permanent harm. To be in the green, reduce water weight to 3.0 liters, increase HD time to 5.8 hours, or both.

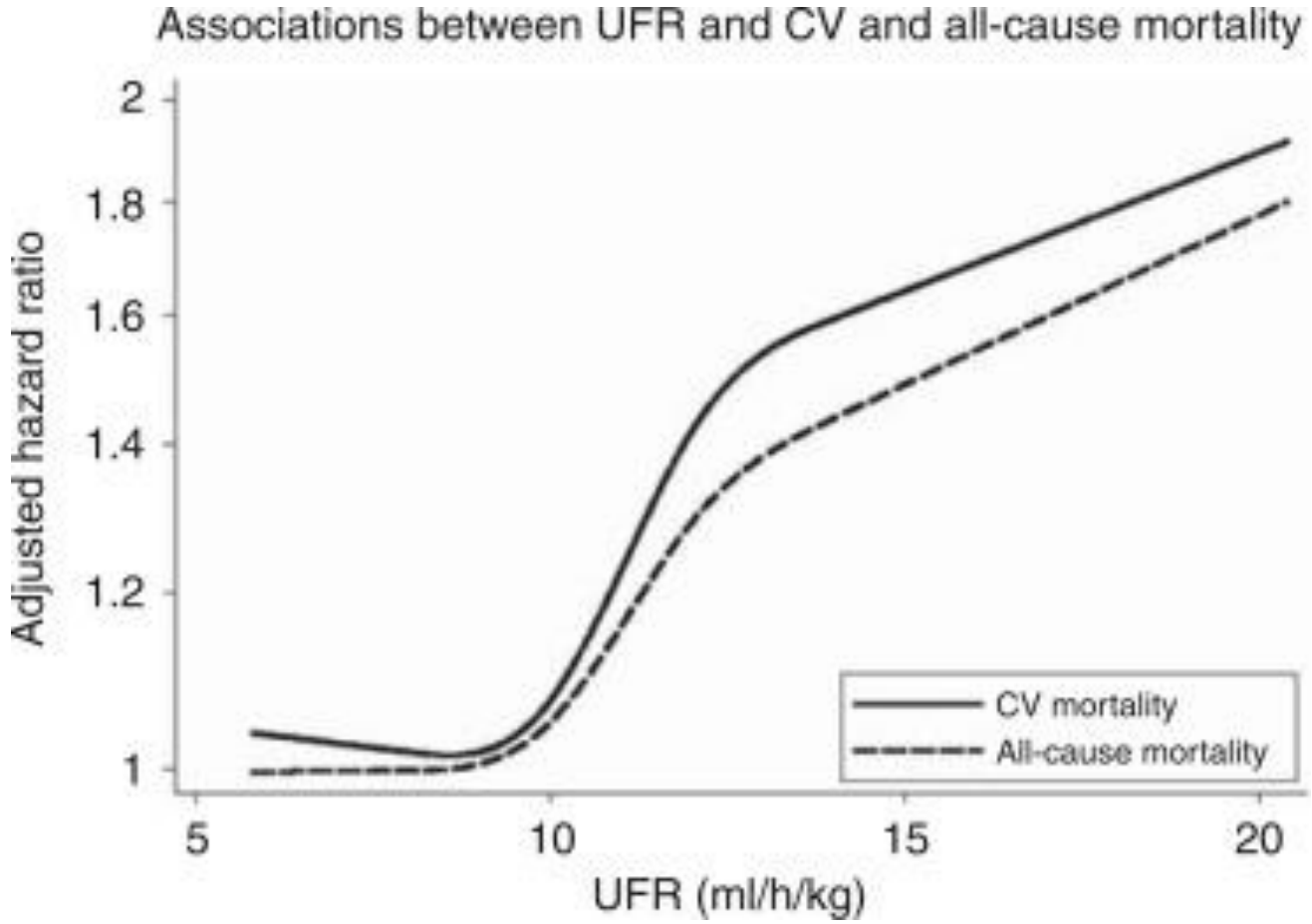


Flythe JE, Kimmel SE, Brunelli SM. Rapid fluid removal during dialysis is associated with cardiovascular morbidity and mortality. Kidney Int. 2011;79(2):250-7

http://www.homedialysis.org/ufr-calculator

Relationship between UFR and mortality

High ultrafiltration rates may be associated with higher all-cause and CV mortality



Flythe JE et al Kidney Int 2011; 79: 250-257

The Price of High IDWG

- Higher risk of all-cause and cardiovascular death
- Cardiovascular risk
  - LVH
  - Cardiovascular events including CVA
  - Congestive heart failure
- Patient quality of life
  - More extra sessions for volume control

Bossola M et al J Ren Nutr 2018; 28: 293-301

Studies of the effect of low-salt diet on IDWG

Author	Type of Study	Number of Patients	Type of Treatment	Achievement of Salt Restriction	Duration	Outcome
Rigby-Mathews et al., 1999[38]	Crossover	28	1 g of salt daily	Yes	2 d	Lower IDWG with low-salt diet (value not reported)
Rigby, 2000[24]	Randomized, controlled	Control: 28 Treatment: 28	Control: habitual diet Treatment: 1 g/d of salt	Yes	48 h	Lower IDWG with low-salt diet (value not reported)
Maduell and Navarro, 2000[27]	Case-control	15	Usual salt intake for 1 wk and low-salt diet for the following week	Yes	2 wk	IDWG decreased from 2.26 ± 0.7-1.78 ± 0.5 kg ($P < .001$)*
Kayikcioglu et al., 2009[39]	Comparison of 2 hemodialysis units	394	Center A: salt restriction (5 g/d) Center B: salt restriction not emphasized	Yes	Cross-sectional	Lower IDWG in patients of Center A (2.29 ± 0.83 kg) than in patients of Center B (3.31 ± 1.12 kg) ($P = .0001$)*
Rodriguez-Telini et al., 2014[40]	Randomized, controlled	Control: 18 Treatment: 21	Control: habitual diet Treatment: 2 g of sodium restriction on their habitual diet	Unknown	16 wk	No change in IDWG in controls (baseline: 2.6 [1.7-3.5] kg; 16 wk: 2.7 [1.4-3.2] kg) and in treated patients (baseline: 2.5 [2.3-3.4] kg; 16 wk: 2.7 [2.1-3.5] kg). $P = .95$ and .11, respectively (within groups)**
Sevick et al., 2016[41]	Randomized, controlled	Control: 86 Treatment: 93	Control: nutritional counseling Treatment: nutritional counseling plus social cognitive theory–based behavioral counseling aimed at reducing dietary sodium intake	No	16 wk	No change in IDWG in controls (baseline: 1.1 [1-1.2] kg; 16 wk: 1.1 [1-1.2] kg) and in treated patients (baseline: 1.1 [1-1.2] kg; 16 wk: 1.1 [1.1-1.2] kg). $P = .90$ and .95, respectively**
Sakai et al., 2017[42]	Single arm	48	Nutritional counseling	Yes	48 mo	Reduction of IDWG ratio(%) in 77% of patients+

Data are expressed as * mean ± SD and ** median [95% CI]. + IDWG ratio (%) = average of 12 measurements (3 times/wk for 4 wks) of IDWG/dry weight × 100; decrease defined as a change >0.5%.

One gram of salt amounts to 394 mg of sodium.

Case 6

A 59-year-old woman with ESKD secondary to diabetes mellitus, on hemodialysis for 13 years, presents to her primary care provider with complaints of itching.

Case 6-Medications

- Sevelamer carbonate 1600 mg po qAC
- Hydroxyzine 10 mg po qhs
- Gabapentin 300 mg po three times weekly after dialysis
- Calcitriol 0.5 ug three times weekly
- Amlodipine 10 mg po daily
- Erythropoietin 6000 units IV three times weekly

Case 6 Labs

- spKt/V 1.4
- Calcium 8.5 mg/dL
- Phosphorous 5.1 mg/dL
- PTH 251 pg/mL
- Hemoglobin 10.9 g/dL

Case 6: Physical Examination

Case 6: Question

Which of the following is the most likely diagnosis of her skin lesion?

A. Calciphylaxis
B. Shingles
C. Acquired perforating dermatosis
D. Calcinosis cutis

Case 6: Question

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Case 3: Question Answer

- The correct answer is C.
- This patient has a crater-shaped nodular eruption occurring in the setting of diabetes mellitus and ESKD. The most likely diagnosis is therefore acquired perforating dermatosis.

Pruritus and skin disorders in CKD

- Pruritus and other skin disorders are common in chronic kidney disease
- Minor annoyance for some patients but may be debilitating in others
- Preferred nomenclature: “CKD-aP” not “uremic pruritus”
- Co-management with primary care is critical for patients with ESKD
  - Not possible to do a full skin examination in the dialysis clinic

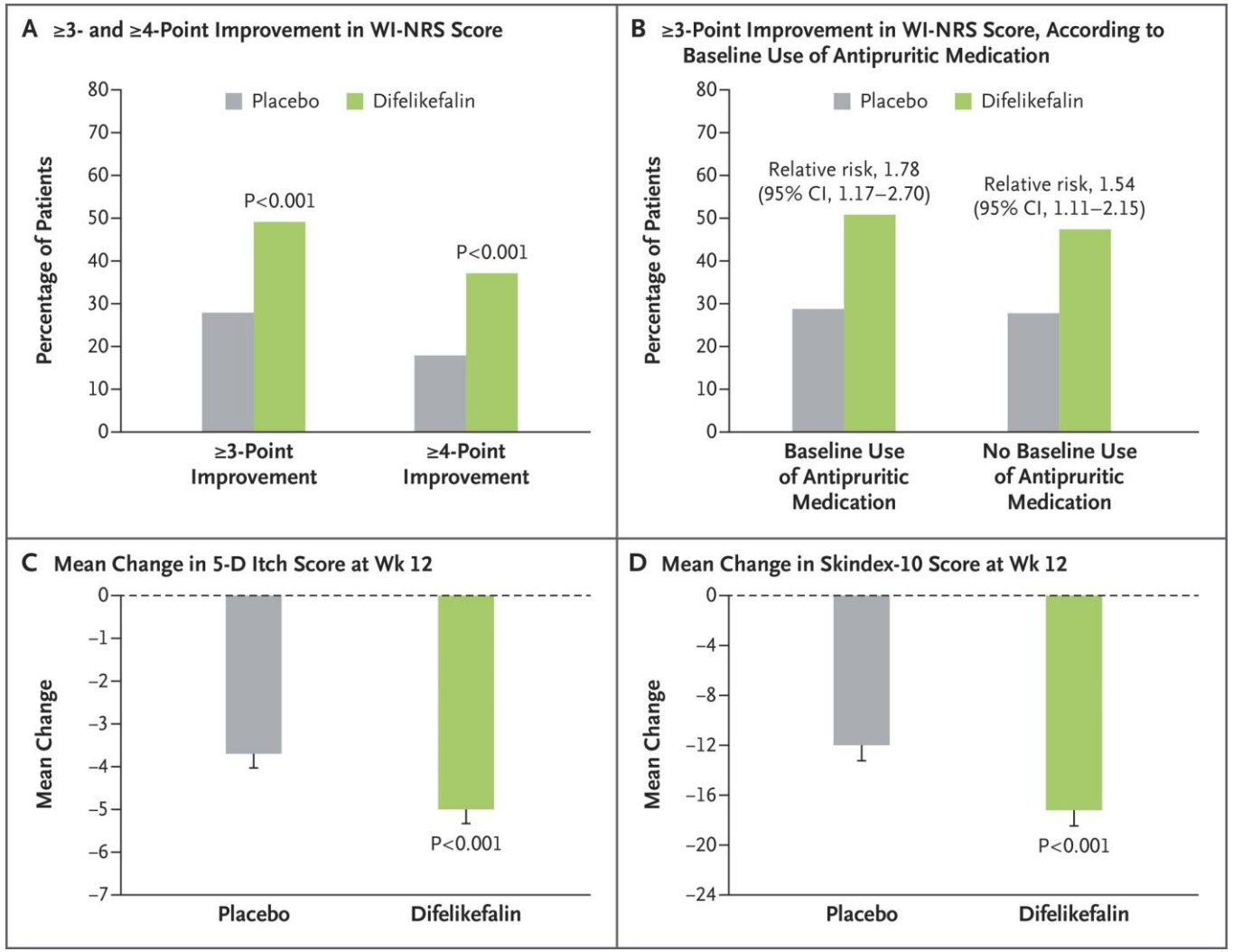
Risk factors for CKD-aP

- Inadequate dialysis
- Metabolic derangements
  - Hyperphosphatemia
  - Hyperparathyroidism
- Malnutrition/Inflammation
  - Low serum albumin
  - High ferritin
  - High CRP
- Hepatitis B
- Hepatitis C

Treatments for CKD-aP

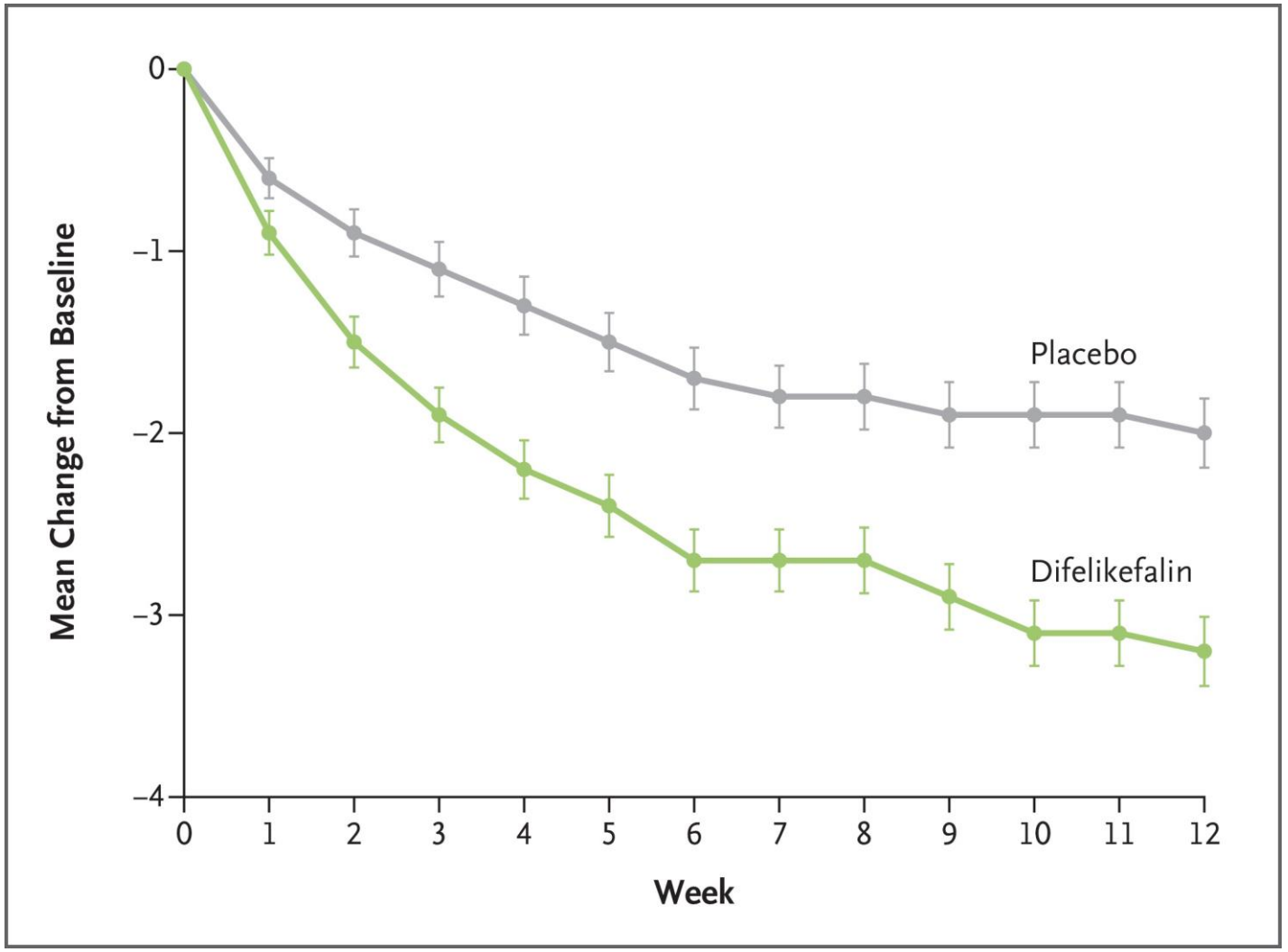
- Emollients
  - Should be applied to the wet or damp skin after bathing
- Topical analgesics
  - Pramoxine
- Antihistamines
  - Diphenhydramine
  - Hydroxyzine
  - Cetirizine
- Cromolyn sodium
- Gabapentinoids
  - Gabapentin
  - Pregabalin
- Opioid agonists and antagonists

Treatment with Difelikefalin



Fishbane S et al. N Engl J Med 2020; 382: 222-232

Difelikefalin: Mean Change in WI-NRS Score



Fishbane S et al. N Engl J Med 2020; 382: 222-232

Acquired perforating dermatosis

- Presents with pruritic to painful nodules in a patient with known risk factors
- Primary risk factors: Diabetes mellitus and CKD
- Lesions may be precipitated or worsened by scratching
  - Treating pruritus is key in preventing the development of APD

Treatment of APD

- Adequate dialysis
- Phosphate control
- Glycemic control
- Topical therapies
  - Emollients
  - Topical or intralesional corticosteroids
  - Keratolytics
    - Salicylic acid (2-10%)
    - Urea (10-40%)
  - Topical retinoids
- Antihistamines
- Systemic retinoids
- Allopurinol
- UV phototherapy

Case 7

SJ is a 68-year-old woman with a 5-year history of ESRD and a long history of EtOH use disorder. She has been sober for the last year. She frequently misses dialysis and when she does attend her sessions, she signs off earlier than her prescribed time.

Case 7

She presents to the Emergency Department complaining of weakness and nausea. She has not dialyzed for one week.

Case 7: Physical Examination

- Thin elderly woman weighing 44 kg
- BP 180/80 mm Hg; HR 100; T 96.5 degrees F
- Basilar crackles
- Regular rhythm with no pericardial friction rub
- Soft, nontender abdomen; normal bowel sounds
- 1+ pitting lower extremity edema
- Tortuous and aneurysmal left arm AVF
- Normal mental status

Case 7: Labs

- K^+ 6.1 mEq/L
- CO_2 16 mEq/L
- BUN 150 mg/dL
- Creatinine 10.1 mg/dL
- PO_4 7.2 mg/dL
- Calcium 7.3 mg/dL
- Albumin 3.2 g/dL
- EtOH undetectable
- WBC 5.2 K/uL
- Hemoglobin 8.4 g/dL
- Platelets 190K

Case 7

- Fellow’s dialysis prescription:
  - F80
  - 4 hours
  - Qb 400
  - Qd 800
  - 2.0 K+
  - UF to dry weight

Case 7: Outcome

- About 2 hours into her treatment, the patient has a generalized tonic-clonic seizure. Dialysis is terminated.
- Seizure breaks with a dose of intravenous lorazepam.

Case 7 Question (Audience Response):

What is the most likely explanation for this patient's seizure?

A) Brain tumor
B) Dialysis disequilibrium
C) Uremic encephalitis
D) CO_2 retention

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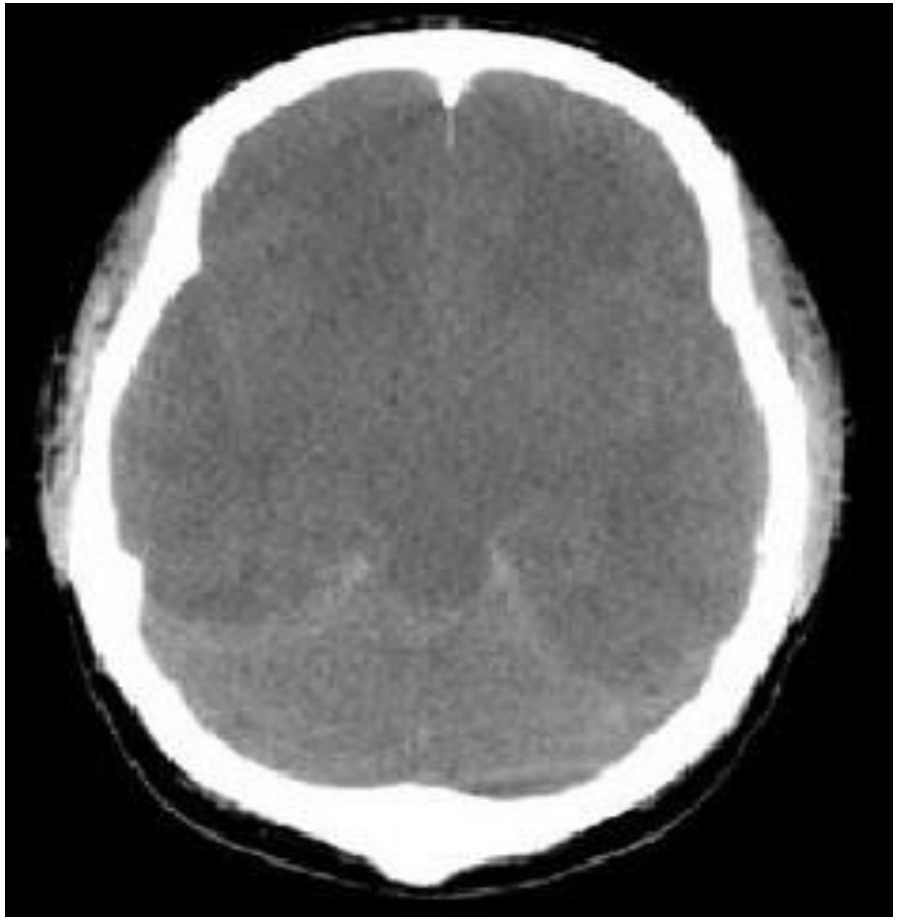
Cerebral edema: most severe outcome



Bagshaw SM *et al* 2004; BMC Nephrol. 5: 9

Dialysis disequilibrium

- A set of neurologic signs and symptoms that may occur in patients undergoing HD.
- Symptoms may be mild (headache, restlessness) to severe (disorientation, seizures).
- Pathophysiology
  - Changes in cerebral osmolality
  - Changes in CSF pH (decrease in pH during HD)

Arieff AI Kidney Int 1994; 45: 629-635

Dialysis disequilibrium

- Greater risk in patients with pre-existent neurologic disease
  - Stroke
  - Head trauma
  - Malignant hypertension

Bagshaw SM *et al* 2004; BMC Nephrol. 5: 9

Prevention of dialysis disequilibrium

- Start “gentle”
  - Low Qb
  - Low Qd
  - Smaller dialyzer
  - Osmotic agents (mannitol)

Take Home Messages

- Review outpatient records to identify long-standing renal osteodystrophy
- Monitor for signs of renal recovery and de-escalate dialysis as appropriate
- Gradually lower the potassium in cases of severe hyperkalemia in order to reduce the risk of arrythmias
- Review medications to identify potential causes of altered mental status in dialysis patients
- Monitor ultrafiltration rates in patients with high interdialytic weight gains
- Co-manage dialysis associated pruritus with primary care providers
- Take steps to avoid dialysis disequilbrium

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