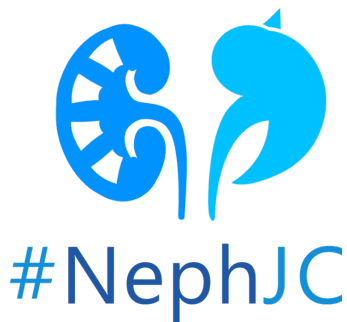




Nephrology Fellow Clinical Compendium



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Disclaimer- This guide is intended as an overview with salient details only. In order to provide high quality patient care it is important to maintain close and appropriate supervision.

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Chapter 5: Kidney Replacement Therapy

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Dialysis Catheter:

[Recent advances in temporary hemodialysis catheters review in KI](#)

- Identify type of catheter, tunneled or non-tunneled, trialysis or not, date of placement and location in note
- Catheter length by side:
 - Right Internal Jugular 15 cm
 - Left Internal Jugular 20 cm
 - Femoral 24 cm
- No clear maximum recommended duration of non-tunnelled femoral catheter and internal jugular catheter
- 5 days for femoral (2006 KDOQI vascular access guidelines)
- 7 days for the IJ catheter (2006 KDOQI vascular access guidelines)
- No patient should go home with temporary (non-tunneled) catheters.
- Most tunneled catheters are not meant to be permanent so need to have plan for fistula/graft or PD catheter placement prior to discharge.

Access-related Infection

Catheter-related infection

- Give vancomycin 15-20 mg/kg load AND gentamicin or tobramycin 2 mg/kg load (up to max 100 mg gentamicin) (or another antibiotic for gram neg). Antibiotics given in the last hour of HD.
- Maintenance: 10 mg/kg vanc; gent 1 mg/kg. Monitor levels (vanc trough 15-20, gent trough < 2.0). Levels measured before HD.
- Remove line ASAP with s/s of sepsis, persistent fever and bacteremia after 48 hrs, evidence of metastatic infectious, exit-site or tunnel infection, or difficult-to-cure pathogens, e.g. *staph aureus*, *Pseudomonas*, *Candida*/fungi, VRE, multiple-resistant pathogens.
 - Otherwise, need at least guidewire exchange 2-3 days after starting antibiotic AND resolution of fever.

AVF and AVG

Rule of 6's

6 weeks after the AV fistula has been placed, the fistula should:

- Be able to support a blood flow of 600 ml/min
- Be at a maximum of 6mm from the surface
- Have a diameter greater than 6 mm

(Failure to achieve any of these goals, may warrant further investigation)

Examining the access:

- [This is a nice post at RFN](#)
- [NephSim Cases](#)

Hemodialysis

For initial/acute HD prescriptions: **Initiation of treatment** to avoid dialysis disequilibrium syndrome (attending dependent) –

- 1st treatment: 90 min, Qb (blood flow rate) 150-200 ml/min, Qd (dialysate flow rate) 400 ml/min
- 2nd treatment: 3 hrs, Qb 300, Qd 600
- 3rd treatment: 3.5 to 4 hrs, Qb 350 to 400, Qd 800
- Consider mannitol in extreme cases (e.g. BUN > 150 to 200 or with altered mental status).
 - Mannitol dose 12.5 g IV q1 hour X 2 doses (be careful if hyperkalemia because can get solvent drag that can potentially worsen serum potassium)
- Alternatively consider using higher sodium bath (e.g. 145-150 meq/L).
- Also no heparin if concern for pericarditis
- Most units have specific dialyzer (generally smaller sized dialyzer) for first start dialysis so ask your dialysis unit charge nurse.

For chronic HD prescriptions

- **Qb**: 400-450 ml/min (if fistula/graft), if catheter 350 (sometimes to 400). Bare minimum Qb is 150 ml/min
- **Qd**: 600-800 ml/min (1.5x QB)

- Ask your inpatient dialysis unit for the dialyzers used and if there are any specific patient indications for instance which dialyzer is used for a first dialysis
- Dialyzer Optiflux H160 (180 for larger); alternate filters to be used if patient allergic (this can vary with different HD centers/machine brands)
- Temperature 37 C (can turn down 35.5 C if low blood pressure, but patient will feel this)
- Rule of 7 for K
 - usually 2 K bath (If K HIGH > 6.5-7 mEq/L range, discuss with attending before using 1 K bath)

Hemodialysis and sudden cardiac death and modifiable risk factors

- Na 140 meq/L (150 hypotension, consider sodium profiling)
- If chronic hypoNa: don't use Na bath more than 15 mEq/L difference. (if serum Na < 120, use 130 meq bath and reduce HD time with blood flow 1 ml/kg body weight per minute)

Sodium balance in hemodialysis

- If chronic hyperNa: no less than 3-5 mEq/L Na bath difference.
- Bicarb bath 35 mEq/L usually (Use higher bath, e.g. 37-40 meq/L if acidemic) (Use lower bicarb bath e.g. 25-30 in alkalemia. The bicarb bath may be able to go lower depending on the conductivity). Check ABG when in doubt. Be cautious of using high bicarb bath in patients with primary respiratory alkalosis (e.g. cirrhosis, sepsis, & pregnancy)

Bicarbonate balance and prescription in ESKD

UF goal depends on estimated dry weight & how much fluid removal will be tolerated by the patient. Usual max UF rate is 1 L/1hr or 10 ml/kg/h. UF should be zero if patient is hypotensive.

- Ca 2.5 mEq/L
- Chronic HD, use 2.5 Ca mEq/L
- Hypocalcemia, use 3 Ca mEq/L
- Calciphylaxis and hypercalcemia: 2.0 mEq/L (Ca bath can be lower in severe hypercalcemia-but would monitor ionized Ca)
- Hungry bone: 4.0 mEq/L Ca (very rarely done)
- For hypotensive type, prefer Na model, 35.5-36°C temp, 3.0 mEq/L calcium bath (if phos not too high).
- Prescribe heparin as infusion or bolus to prevent clotting of the dialyzer. Try to use if no contraindications esp. in non-critically ill patients. *If patient is allergic to heparin, you must tell dialysis RN!* Heparin lock of 1000 U/ml given each port for catheter.

- Infusion: Heparin 500-1000 U/hr infusion. Stop last hour of treatment
- Heparin 2000 unit bolus at start of dialysis, may repeat half-way through.
- Dysfunctional catheter: Consider using TPA (alteplase) 1 mg/ml: Infuse 1-2 mg into each catheter lumen; usual dwell for 1 hr to overnight. Minimal dwell is 30 min.
- If patient has hepatitis B, you must notify dialysis RN because the patient needs to be isolated.
- Adequacy: Kt/V > 1.2 or URR > 65%

Chronic Dialysis Note and Other Information related to Dialysis

When to initiate dialysis

Dialysis Adequacy

Always contact the outpatient dialysis unit and request for medication list and HD orders. Usually have the following in your note:

“ESKD on HD via [access type] for 4hr treatment, 140 Na/2 K/37 bicarb/ 2.5 Ca, QB 400, QD 800”

Address the following in your note: ESKD-HD days, Anemia, Bone-mineral metabolism, HTN/ Volume, Access

Anemia

From NephMadness Anemia Region 2021

	Laboratory Parameters*	Absolute Iron Deficiency	Functional Iron Deficiency
CKD	TSAT = serum iron/ total iron binding capacity	≤ 20%	≤ 20%
	Ferritin	≤100 ng/ml	≤ 500 ng/mL
	Target Hb	>10 g/dL	>10 g/dL
Kidney Failure	TSAT = serum iron/ total iron binding capacity	≤ 20%	≤ 20%
	Ferritin	≤ 200 ng/ml	≤ 500 ng/mL
	Target Hb	10-11.5 g/dL	10-11.5 g/dL

goal Hb 10-12 mg/dl ; (start when Hb < 9 g/dL or when patient is symptomatic)

Erythropoietin

Following are important trials focussing on Hb goals in CKD/ESKD:

- CHOIR
- CREATE
- TREAT

- **Epoetin-alfa** (Procrit, Epogen): 50 - 150 IU/kg SC or IV 1-3x/week at HD
- **Darbepoetin-alfa** (Aranesp): 0.45 mcg/kg once weekly or 0.75 mcg/kg once every 2 weeks.
- Do not increase the dose more frequently than once a month.
- If the Hb increases > 1 g/dL in 2 weeks or if Hb is above 11.5 g/dL, then decrease dose by 25%.
- Hold ESA when Hb above 12 g/dL.
- Use ESA with **CAUTION** in patients with active malignancy, a history of malignancy, or prior history of stroke

Iron repletion

From NephMadness Anemia Region 2021

	IV Iron	Elemental Iron	Maximum Single Dose	Infusion Time	Unique Side Effects
Traditional IV Iron Formulations	Iron sucrose	20 mg/mL	200 mg 500 mg	10 minutes 4 hours	Hypotension
	Iron gluconate	12.5 mg/mL	125 mg	60 minutes	Hypotension
	Iron dextran	50 mg/mL	20 mg/kg (max=100mg)	60 minutes	Anaphylaxis (requires test dose before use)
Novel IV Iron Formulations	Ferric Carboxymaltose	30 mg/mL	15mg/kg (max=1000 mg)	15 minutes	Anaphylaxis, hypertension and flushing
	Iron Isomaltoside	100 mg/mL	20 mg/kg	30-60 minutes	Anaphylaxis
	Ferumoxytol	30 mg/mL	510 mg	15-60 minutes	Anaphylaxis and hypotension

Aim for TSAT >20-30%, ferritin >100 (usually don't give IV iron if ferritin over 500-1200)

- Give a total of 1 gram of IV iron over 8-10 treatments.
- For patients with kidney failure, give IV iron sucrose (Venofer) 100 mg IV q dialysis for 8-10 doses OR ferric gluconate (Ferrlecit) 125 mg IV X 8 doses.
- For patients with CKD, to replete iron deficiency, IV iron sucrose 300 mg X 3 doses q 5days.
- AVOID administering IV iron to patients with active systemic infections.

Update on Anemia in ESKD and CKD

Bone mineral metabolism: Aim for ca/phos product < 55, corrected Ca 8.4- 10.2 mg/dl, phos 2.6-4.5 (or 5.5 mg/dl), iPTH 150-600 (2X-9X upper limit normal) (KDIGO Guidelines)

Treatment of CKD-MBD targeted at lowering high serum phosphate and maintaining serum calcium (KDIGO CKD-MBD 2017 Clinical Practice Guidelines)

- CKD G3a–G5D
 - treatment of CKD-MBD should be based on serial assessments of phosphate, calcium, and PTH levels, considered together (Not Graded).
 - suggest lowering elevated phosphate levels toward the normal range (2C).
 - suggest avoiding hypercalcemia (2C).
 - decisions about phosphate-lowering treatment should be based on progressively or persistently elevated serum phosphate (Not Graded).
 - suggest restricting the dose of calcium-based phosphate binders (2B).
 - suggest limiting dietary phosphate intake in the treatment of hyperphosphatemia alone or in combination with other treatments (2D).
 - reasonable to consider phosphate source (e.g., animal, vegetable, additives) in making dietary recommendations (Not Graded).
- ESKD on Dialysis
 - suggest using a dialysate calcium concentration between 1.25 and 1.50 mmol/l (2.5 and 3.0 mEq/l) (2C)

Treatment of abnormal PTH levels in CKD-MBD

- CKD G3a–G5 not on dialysis
 - the optimal PTH level is not known.
 - suggest that patients with levels of intact PTH progressively rising or persistently above the upper normal limit for the assay be evaluated for modifiable factors, including hyperphosphatemia, hypocalcemia, high phosphate intake, and **vitamin D deficiency** (2C).
 - **suggest that calcitriol and vitamin D analogs not be routinely used** (2C).
 - **reserve the use of calcitriol and vitamin D analogs for patients with CKD G4–G5 with severe and progressive hyperparathyroidism** (Not Graded).
- ESKD on Dialysis
 - for those requiring PTH-lowering therapy, we suggest calcimimetics, calcitriol, or vitamin D analogs, or a combination of calcimimetics with calcitriol or vitamin D analogs.

Phosphate binders

- Calcium based:
 - Calcium carbonate (Tums) 500 mg: 1-2 tab w/M
 - **Calcium acetate** (Phoslo) 667 mg: 1-3 tab three times daily with meals (max 9 tab/d)
- Non-calcium based:
 - **Sevelamer** (Renvela) 800 mg tab: 1-4 w/ meals. Powder form available.
 - Lanthanum (Fosrenol) 250-1000 mg three times daily w/ meals
 - For very high phos, amphogel (aluminum hydroxide) is very effective, but would not use more than 5-7 days to prevent aluminum toxicity (usual dose 300-600 mg three times daily). Do not use with bicitra or sucralfate as these substances increase aluminum absorption.

Active vitamin D and analogue inhibit PTH

Generic Name	Biology	Trade Name	PO Dose	IV Dose	PTH	Ca ²⁺	Phos	Comments	Cost *GoodRx /30 capsules
Cholecalciferol	Vitamin D3	Generic	600 to 800 units once daily (15-20 µg)	none	↓	↑↑	↑↑		\$10
Ergocalciferol	Vitamin D2	Calcitol	600 to 800 units once daily (15-20 µg)	none	↓	↑↑	↑↑		\$10
Calcitriol	1,25-dihydroxyvitamin D3	Vectical and Rocaltrol	0.25 - 1 µg once daily	0.5 - 4 µg per dialysis session	↓↓	↑↑	↑		\$10
Alfacalcidol	1,25-dihydroxyvitamin D3	Generic	0.5 µg - 1 µg daily	1 µg - 4 µg per dialysis	↓↓	↑↑	↑↑		\$20
Paricalcitol	Synthetic vitamin D2 analogue, 19-nor-1, 25(OH) ₂ D ₂	Zemplar	1 µg daily 2 µg QOD	0.04- 0.1 µg/kg (4-10 µg for 100 kg person) µg-IV per dialysis session Conversion- hectrol x2	↓↓↓	Minimal ↑	Minimal ↑	Does not induce Vit D receptor in gut, thus less Phos and Calcium absorption	\$40 \$400 per 25 ml of 5 mcg/ml
Doxercalciferol	synthetic vitamin D2 analogue that undergoes metabolic activation <i>in vivo</i> to form 1alpha,25-dihydroxyvitamin D2	Hectrol	1 µg - 3.5 µg daily	4 µg IV per dialysis session max is 20 µg per session Conversion- Zemplar/2	↓↓↓	↑↑	↑↑		\$100 \$400 per 100 ml of 2 mcg/ml

Role of Vitamin D in CKD stage 3 and 4

- If 25 (OH) D < 15 ng/mL , it should be treated irrespective of PTH (except if hypercalemic).

- If 25 (OH) D 15-20 ng/mL, may not require treatment if there is no evidence of counter-regulatory hormone activity

Treatment options for CKD MBD

- Calcitriol oral/IV 0.25-4 mcg
- **Paricalcitol** (Zemlar): 1-20 mcg IV three times weekly
- **Doxercalciferol** (Hectorol): 0.5-6 mcg IV three times weekly (or 2.5-20 mcg po 3x/wk)
- 1.75 mcg paricalcitol = 1 mcg doxercalciferol
- Hold active Vitamin D if phos high
- Cinacalcet (Sensipar) 30-120 mg: calcimimetic, given with dinner. Watch calcium (causes hypocalcemia).

Table from Nephrology Secrets, Fourth Edition.

Phosphate binder	Benefits	Hazards	Bone Biopsy Findings
Aluminum	Potent and effective Useful for short term in severe hyperphosphatemia	Dementia Low-turnover bone disease/ osteomalacia Anemia Should not be used as maintenance therapy	Markedly decreases turnover, markedly impairs mineralization, and moderately decreases volume
Calcium salt based	Effective Inexpensive Treats hypocalcemia Antacid properties useful for reflux and peptic ulcer disease	High calcium load Hypercalcemia Development of adynamic bone disease Extraosseous/vascular calcifications	May slightly decrease bone turnover, no effect on mineralization or volume

Sevelamer	<p>Effective</p> <p>No systemic absorption</p> <p>Lowers level of low-density lipoprotein cholesterol</p> <p>Lower risk of hypercalcemia</p> <p>Reduces aortic and coronary calcification versus calcium salts</p> <p>Lower risk of adynamic bone disease versus calcium salts</p>	<p>Expensive</p> <p>Binds bile acids</p> <p>May inhibit absorption of active vitamin D</p> <p>Not effective in acidic environment</p> <p>Gastrointestinal symptoms such as diarrhea/constipation</p> <p>High pill burden</p>	<p>May slightly increase bone turnover, no effect on mineralization, and may slightly increase bone volume</p>
Lanthanum carbonate	<p>Potent and effective over wide pH range</p> <p>Lack of hypercalcemia</p> <p>No evidence of increased risk of low bone turnover disease</p> <p>Reduced pill burden</p>	<p>Expensive</p> <p>Gastrointestinal symptoms such as dyspepsia</p>	<p>May increase bone turnover, no effect on mineralization, and increases in bone volume</p>
Ferric citrate	<p>Effective</p> <p>Significant absorption of iron that may decrease iron and ESA requirements</p> <p>Lack of hypercalcemia</p>	<p>Expensive</p> <p>Gastrointestinal symptoms such as diarrhea/dark stools</p> <p>High pill burden</p> <p>Potential for iron overload</p>	<p>Unknown</p>
Sucroferric oxyhydroxide	<p>Potent and effective over wide pH range</p> <p>Lack of hypercalcemia</p> <p>No significant systemic absorption</p> <p>Reduced pill burden</p>	<p>Expensive</p> <p>Gastrointestinal symptoms such as diarrhea/dark stools</p>	<p>Unknown</p>

HTN/BP volume

- Challenge EDW to help treat hypertension

Dialysis complications

Intradialytic hypotension

Table 1. Summary of management strategies for treatment and prevention of intradialytic hypotension

Management Strategies	Proposed Physiologic Mechanism to Counteract IDH
Immediate management (excluding acute medical emergencies)	
Stop ultrafiltration	Optimize plasma refill/augment preload
Trendelenburg position	Augment venous return/preload
Saline or albumin infusion	Augment venous return/preload
Consider reduction in blood flow (Qb) and dialysate flow (Qd)	Optimize plasma refill (minimize osmolar gradients)
First-line preventive measures	
Reassess estimated dry weight	Optimize plasma refill/augment preload
Reassess ultrafiltration rate	Optimize plasma refill/augment preload
Counsel about dietary sodium and fluid goals	Optimize plasma refill/augment preload
Avoid food ingestion during hemodialysis	Promote arteriolar vasoconstriction
Review antihypertensive regimen	Promote arteriolar vasoconstriction/optimize cardiac function
Review dialysate composition (Ca ²⁺ , Mg ²⁺ , Na ⁺ , HCO ₃ ⁻)	Promote arteriolar vasoconstriction/optimize cardiac function
Second-line preventive measures	
Prescribe dialysate cooling	Promote arteriolar vasoconstriction/optimize cardiac function
Evaluate for undiagnosed cardiac disease	Promote arteriolar vasoconstriction/optimize cardiac function
Increase dialysis treatment time	Optimize plasma refill/augment preload
Third-line preventive measures	
Initiate midodrine before hemodialysis	Promote arteriolar vasoconstriction/optimize cardiac function
Change dialysis modality	
Adapted from European Best Practice Guidelines (50).	

Reference —> [here](#)

***Hemodialysis Emergencies** including needle dislodgement, water system contamination, and allergic reactions.

Home Hemodialysis

[ASN Rx Review](#)

[International Society of Home Hemodialysis Rx](#)

[International Society of Home Hemodialysis Tool Kit](#)

Peritoneal Dialysis

Resources: [AJKD curriculum](#)

2019 ISPD guidelines--creating and maintaining optimal peritoneal dialysis access in the adult patient: [2019 update](#)

Review of pertinent topics at [Renal Fellow Network](#)

[On Demand Webinars on various PD topics](#)

[PD catheter insertion and complication videos](#)

International Society of Peritoneal Dialysis Peritonitis [Guidelines](#) and [Lectures](#)

[Video of exchange](#)

Basics

Types:

- APD (Automated PD, cycler)
- CAPD (Continuous Ambulatory PD)

Dextrose Solutions

- 1.5% (yellow)
 - 2.5% (green)
 - 4.25% (red)
-
- More concentrated means more UF (greater glucose/osmotic gradient)
 - If CAPD, usually need 4-5 exchanges of 2.0 – 2.5 L (e.g. 10 min fill, 30 min dwell, 20 min drain)
 - If APD, usually need 4-5 exchanges of 2-2.5 L overnight (need at least 90 min dwell time) and possible last fill or mid-day exchange of 2-2.5 L

Adequacy

- Aim for delivered weekly clearance minimum Kt/V urea of 1.7.
- Weekly Kt/V urea = $(D/P_{\text{urea}})(\text{PD volume})7d \times \text{BSA} / V_d \text{ of urea}$
- If urine output < 100 mL/day, use PD Kt/V only

PD Peritonitis: can be with or without cloudy effluent and may include symptoms including abdominal pain, fever and/or chills, diarrhea or constipation.

Diagnosis of peritonitis

Need 2/3 of criteria:

- **WBC > 100/uL with > 50% PMNs**, fluid should dwell 2-3 hrs
- Diffuse abdominal pain (occurs in 80%)
- Culture positive (check gram stain as well)

Treatment of peritonitis

- Add heparin 500-1000 U/L if fibrin strands noted in bags
- Suggested empiric antibiotics (empiric therapy recommended for gram-positive and gram-negative bacteria)
 - make sure antibiotics dwell for at least 6 hrs
 - Vancomycin 15-30 mg/kg IP loading dose (max 2 gm), 15 mg/kg q3-5 d.
 - Redose every 5-7 days
 - Gentamicin 40 mg IP or gent 0.6 mg/kg in 2L bag OR
 - Cefepime 2 gm IP load, 1 gm IP daily

- Refer to [ISPD guidelines](#) for antibiotic choice
- Fungal prophylaxis often advised
- Consider catheter removal in setting of relapsing peritonitis

Complications

Exit site and tunnel infections:

Empirical therapy

- always cover for *S aureus*
- most concerning *Pseudomonas* species and *S aureus*
- Oral often as effective as IP unless MRSA → [AJKD curriculum](#)
- Catheter related infections → [ISPD guidelines 2017](#)

“We suggest that exit-site infection is defined as the presence of purulent discharge, with or without erythema of the skin at the catheter-epidermal interface (not graded).

“We suggest that exit-site infection is defined as the presence of purulent discharge, with or without erythema of the skin at the catheter-epidermal interface (not graded)

We suggest that tunnel infection is defined as the presence of clinical inflammation or ultrasonographic evidence of collection along the catheter tunnel (not graded)

We recommend that prophylactic antibiotics be administered immediately before catheter insertion **(1A)**

We recommend daily topical application of antibiotic cream or ointment to the catheter exit site **(1A)**

We recommend that the exit site be cleansed at least twice weekly and every time after a shower **(1C)**

We suggest screening for nasal *S. aureus* carriage prior to PD catheter insertion **(2D)**

If nasal carriage of *S. aureus* is found in PD patients, we suggest treating by topical nasal application of mupirocin **(1B)**

We recommend that exit-site infection, except episodes caused by *Pseudomonas* species, be treated with at least 2 weeks of effective antibiotics **(1C)**

We recommend that exit-site infection caused by *Pseudomonas* species and any tunnel infection be treated with at least 3 weeks of effective antibiotics **(1C)**

We recommend simultaneous removal and reinsertion of the dialysis catheter with a new exit site under antibiotic coverage in PD patients with refractory exit-site or tunnel infection without peritonitis, defined as failure to respond after 3 weeks of effective antibiotic therapy **(1C)**

We suggest removal of the dialysis catheter in PD patients with exit-site infections that progress to, or occur simultaneously with, peritonitis **(2C)**

We suggest that, for patients who have undergone dialysis catheter removal for simultaneous exit-site or tunnel infection and peritonitis, any reinsertion of a PD catheter be performed at least 2 weeks after catheter removal and complete resolution of peritoneal symptoms **(2D)**

“We suggest that exit-site infection is defined as the presence of purulent discharge, with or without erythema of the skin at the catheter-epidermal interface (not graded).

EPS--rare but very serious complication of PD with significant morbidity and mortality. Diagnosed both clinically (symptoms may include bowel obstruction, abdominal mass, hemoperitoneum, failure to thrive, or UF failure and/or high transport status) and radiographically (CT recommended initially)--bowel encapsulation noted radiographically or pathologically (*AJKD curriculum*)