The Chronic Kidney Disease Patient on Hemodialysis: Mystery Solved—Information for the Provider

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Objectives

• List the criteria for the initiation of renal replacement therapy
• Describe the concepts & principles related to hemodialysis therapy
• Identify the laboratory results for an individual with chronic kidney disease
• Discuss the various accesses used for hemodialysis
• Describe the medical management of an individual on hemodialysis

Oh Great!!
I have another one of those hemodialysis patients on my list
Chronic Kidney Disease

- Involves progressive, irreversible loss of kidney function
- Glomerular filtration rate (GFR)
- Kidney damage
  - pathological abnormalities
  - markers of damage

Glomerular Filtration Rate (GFR)

- Best measure of kidney function
- Determines stage of kidney function
- Uses age, race, gender & serum creatinine

**CKD definition**

Criteria for Chronic Kidney Disease

- Kidney damage (≥1 for >3 mos)
  - Albuminuria (AER ≥30 mg/g; ACR ≥30 mg/g)
  - Urinary sediment abnormalities
  - Electrolyte and other abnormalities due to tubular disorders
  - Abnormalities detected by histology
  - Structural abnormalities detected by imaging
  - History of kidney transplantation

- Decreased GFR (≥3 mos)
  - GFR < 60 mL/min per 1.73 m² (GFR categories G3a-G5)

ACR = albumin-creatinine ratio; AER = albumin excretion rate; GFR = glomerular filtration rate.

Stages of Chronic Kidney Disease (CKD)

- Stage 1 with normal or high GFR (GFR > 90 mL/min)
- Stage 2 Mild CKD (GFR = 60-89 mL/min)
- Stage 3A Moderate CKD (GFR = 45-59 mL/min)
- Stage 3B Moderate CKD (GFR = 30-44 mL/min)
- Stage 4 Severe CKD (GFR = 15-29 mL/min)
- Stage 5 End Stage CKD (GFR <15 mL/min)
CKD By the Numbers

About 30 million US adults are estimated to have CKD and most are undiagnosed.

Kidney diseases are the ninth leading cause of death in the United States.

48% of people with severely reduced kidney function and not on dialysis are not aware of even having CKD.

Every 24 hours, about 340 people begin dialysis treatment for kidney failure.

In the United States, diabetes and high blood pressure are the leading cause of kidney failure, representing about 3 out of 4 new cases.

In 2016, treating Medicare beneficiaries with CKD cost over $79 billion, and treating people with ESRD cost an additional $35 billion.

https://www.cdc.gov
Slow the Progression of CKD

- Blood glucose control
  - HbA1C<7%
  - Screen for microalbuminuria yearly
  - Lifestyle changes
  - ACE inhibitor&/or ARB therapy to decrease albuminuria

- Blood pressure control
  - Reduces cardiovascular risk
  - BP<130/80 for all CKD

- Avoidance of nephrotoxic agents
  - Avoid NSAIDs
  - Avoid contrast dye
  - Antibiotics

Care of the CKD patient

- Referral to a nephrologist when CKD 4
- At CKD stage 4-education & options
- Rate of progression is not predictable
- Variability in CKD when uremic symptoms appear

Clinical Presentation

- Can be asymptomatic
- Hypertension
- Secondary hyperparathyroidism
- Proteinuria
- Anemia
- Metabolic acidosis
- Hyperkalemia
- Cardiovascular disease
- Bleeding
- Pruritis
- Pericarditis
- GI symptoms
- Malnutrition
- Dyslipidemia
- Neurological changes
Manifestations of Chronic Uremia

Management of CKD
Factors leading to hyperkalemia (K>5) include dietary indiscretion, protein catabolism, hemorrhage and medications
1. Veltassa (patiromer) 8.4gms-25.2gms daily
2. Kayexalate (sodium polystyrene sulfonate) 15-30gms
Factors leading to metabolic acidosis (CO2<22mEq/L) are impaired ammonia excretion, reduced tubular bicarbonate reabsorption & reduction in functional renal mass
1. Sodium bicarbonate tablets
Factors leading to volume overload are disruptions in sodium/water balance in the body
1. fluid/salt restriction
2. diuretics: thiazide, loop diuretics

Anemia of Chronic Kidney Disease
- Erythropoietin is the hormone that stimulates erythrocyte production
- Erythropoietin is produced by the kidneys
- When hemoglobin levels fall, hypoxia occurs which stimulates erythropoietin production and stimulates the bone marrow to make more red blood cells
- A normal RBC has a life span of 120 days
- Due to the toxic uremic environment, the RBC life span in dialysis patients is reduced 20%
Anemia of Chronic Kidney Disease

- Iron deficiency
- Blood loss
- Folate/Vitamin B12 deficiency

Treatment of Anemia

Erythropoietin Stimulating Agents
- Epogen/Procrit (epoetin alfa)
- Aranesp (darpoetin alfa)
- Mircera (methoxy polyethylene glycol-epoetin beta)

Iron Preparations
- Venofer (iron sucrose)
- Ferrlecit (sodium ferric gluconate complex)
- Feraheme (ferumoxytol)

Chronic Kidney Disease-Mineral & Bone Disorder (CKD-MBD)

- We used to call it renal osteodystrophy to describe bone problems
- CKD-MBD is a condition that affects bone, heart & blood vessels
- Abnormalities of calcium, phosphorus, PTH and vitamin D metabolism
- Abnormalities of bone turnover, mineralization, volume, linear growth & strength
- Vascular & soft tissue calcification
Calcium & Phosphorus Balance

- Kidneys balance calcium & phosphorus levels in the blood
- Kidneys activate a form of vitamin D (from food) & turn it into calcitriol (active form)
- Calcitriol helps kidneys maintain calcium levels & promote formation of bone
- Kidneys remove extra phosphorus
- Parathyroid glands secrete parathyroid hormone (PTH)
- PTH helps control calcium levels in the blood

Mineral & Bone Disorder

- Kidneys stop activating calcitriol → imbalance of calcium in the blood
- Kidneys do not remove phosphorus → phosphorus levels rise → phosphorus pulls calcium out of bone → bones weaken
- Parathyroid gland releases PTH into the blood which pulls calcium from the bones → raises blood calcium levels → starves bones of calcium

Renal Osteodystrophy
Mineral & Bone Disorder

- High phosphorus causes low calcium levels in blood
- Low calcium levels cause parathyroid gland to release PTH
- PTH removes calcium from bones & puts it in the blood causing increased calcium level & harm to bones
- Low calcitriol level also causes increased PTH level

Hyperphosphatemia

- Hyperphosphatemia (>5.5mg/dL) comes from reduced phosphorus excretion
- Stimulates the release of FGF-23 (fibroblast growth factor-23) which is a protein that acts on the kidney to increase phosphorus clearance. It causes a decrease in calcitriol levels which in turn increases PTH secretion
- High levels of phosphorus make hypocalcemia worse as phosphorus binds with calcium which is then deposited in the bones or soft tissue
Phosphate Binders

**Calcium based**
- Calcium carbonate – 650mg
- Tums – 500mg
- Calcium acetate (phos lo) – 667mg
  - Capsules or liquid

**Non calcium based**
- Renagel (sevelamer hydrochloride)
  - 400mg, 500mg tablet
- Renvela (sevelamer carbonate)
  - 800mg tablet, 0.8gm & 2 Agm packet
- Fosrenol (lanthanum carbonate)
  - 500, 715 & 1000mg tablet chewable
- Velphoro (sucroferric oxyhydroxide)
  - 500mg chewable
- Auryxia (ferric citrate)
  - 210mg tablet

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**Phosphate Binders**

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**Calcium**

- 8.4-9.5mg/dL
- Necessary for neuromuscular and cardiac function
- Cellular transport mechanisms & bone formation & maintenance
Treatment of Mineral Bone Disorder (MBD)

Hypercalcemia
investigation of causes include review of medications, adjustment or discontinuation of calcium containing products, consideration of secondary causes (malignancy)

Hypocalcemia
calcium supplement and/or administration of vitamin D products

Medications
• Rocaltrol- (oral) or Calcijex (IV) (calcitriol) reduce PTH levels
• Hectoral - (doxercalciferol) & Zemplar (paricalcitol) are activated forms of vitamin D & act like calcitriol
• Sensipar- (cinacalcet) calcimimetic which lowers PTH levels by imitating calcium’s effect on the gland

Parathyroid Hormone
Maintain calcium homeostasis by taking calcium out of bone & stimulating the kidneys to make more calcitriol
Secondary Hyperparathyroidism

- Parathyroid gland tries to keep everything in balance
- Kidneys can’t make calcitriol so calcium not absorbed from gut and instead more calcium is taken out of bone. This causes bones to weaken & soften
- High levels of calcium & phosphorus deposit in your heart, lungs and blood vessels

Why is this important?

- CKD is an international public health problem affecting 5-10% of the world population
- Cardiovascular disease is the leading cause of death in patients at all stages of CKD
- Vascular & valvular calcifications are strongly associated with cardiovascular morbidity and mortality
- Abnormalities in calcium, phosphorus, PTH and vitamin D metabolism are common in patients with CKD
- Changes may begin at CKD stage 3 but the rate of change & severity of abnormalities are variable among patients
- Therapy is focused on correcting abnormalities in order to limit their consequences

Initiation of Renal Replacement Therapy

- CKD 5
  - GFR<15mL/min but majority are <10mL/min at start
- Based on severity of symptoms & uremic complications
- Symptoms may vary from patient to patient
- Lab abnormalities indicating dysfunction in many organ systems (anemia, hyperparathyroidism & dyslipidemias)
Indications for Initiation of RRT

- Uncontrolled hyperkalemia
- Metabolic acidosis
- Fluid overload
- Gastrointestinal symptoms
- Neurologic symptoms

Preparation of Renal Replacement Therapy

- Risks & benefits need to be discussed with patient, family or support person
- Objective & unbiased approach
- Referral to an options educator for formal education on modality options
- Tour of the dialysis unit if possible
- Written information (if possible)
- Multidisciplinary team approach
- No therapy is also an option—may enlist palliative care
- Information on the web: CMS (Centers for Medicare & Medicaid Services), USRDS (United States Renal Data System), KDIGO (Kidney Disease: Improving Global Outcomes), NKF (National Kidney Foundation), NIDDK (National Institute of Diabetes and Digestive and Kidney Diseases)

Principles of Dialysis

- **Diffusion**—movement of a molecule from a region of higher solute concentration to a region of lower concentration
- **Osmosis**—movement of fluid from an area of lesser concentration to an area of greater concentration of solutes
  - Osmotic pressure—pressure needed to oppose this water movement
  - During dialysis, plasma proteins exert osmotic pressure & oppose water movement out of that compartment
- **Ultrafiltration**—process where plasma water is removed due to a pressure gradient between blood & dialysate compartments
  - Result of net transmembrane pressure (TMP) in the dialyzer that moves plasma water from the blood compartment to the dialysate compartment due to the net pressure gradient
Components of a Hemodialysis System

Blood pump
- Pumps blood through extracorporeal circuit

Dialyzer
- Blood & dialysate compartments separated by a semipermeable membrane
- Solutes, electrolytes & water cross the membrane

Dialysate delivery system
- System mixes water & concentrate to achieve dialysate composition

Dialysate composition (Bath)

Hemodialysis Machine

“Artificial Kidney”
Dialyzer (artificial kidney)

Osmosis and Diffusion Across Semipermeable Membrane

Dialysate Composition

- sodium: 135-145mEq/L
- potassium: 1-4mEq/L
- magnesium: 0-3mEq/L
- calcium: 0-3mEq/L
- chloride: 95-105mEq/L
- glucose: 100-250mg/dL
- buffer (bicarbonate): 25-40mEq/L
Hemodialysis Procedure

- Blood is removed from the body through a vascular access or catheter
- Approximately 200cc of blood is out of the body during dialysis
- Blood is moving into the dialyzer in one direction while the dialysate is moving in the opposite direction. They do not come in contact with each other
- The freshly dialyzed blood is returned to the patient
- Blood flow rate can be 150-500cc/minute
- Bag of normal saline is on the machine to provide fluid as needed
- May receive Heparin during the treatment to prevent clotting of dialysis lines or dialyzer
- At end of treatment, lines are flushed with normal saline to return as much blood as possible back to the patient

Hemodialysis Prescription

Treatment 3-4 hours 3 days a week in center
Length of treatment is based on measurement of adequacy of treatment
Routine labwork done monthly including sodium, potassium, bicarbonate, calcium, phosphorus & albumin. Hemoglobin may be checked more frequently. Parathyroid hormone level & iron studies may be monthly to every 3 months
Hepatitis B labs may be drawn monthly or yearly
Accurate measurement of pre dialysis & post dialysis weight
Lab work should always be drawn before treatment started as the dialysis bath may alter laboratory results
Physical assessment of the individual is imperative
Laboratory Values in CKD 5 Individuals on Hemodialysis

- **Anemia**
  - Hgb 10-11
  - Iron sat 20-30%
  - Ferritin 200-800

- **Mineral Bone Disorder**
  - Calcium 8.8-10
  - Phosphorus 3.5-5.5
  - PTH 300-600

- **Metabolic Acidosis**
  - Bicarbonate 22-26

- **Protein Energy Wasting**
  - Albumin 3.5-4

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Hemodialysis Access Catheter (temporary)

Hemodialysis Access Catheter (permanent)
What is This?

Fistula

Hemodialysis Access Fistula
Hemodialysis Access
Graft

Fistula Needles

HERO (Hemodialysis Reliable Outflow) Graft
Drug Therapy-Important Considerations

- Medication dosing can be challenging in CKD- in particular stage 4 and 5
- The absorption, distribution, metabolism and elimination of drugs can be altered in CKD
- Dose adjustments may involve decreasing the dose of the drug or increasing the interval of administration
- Before prescribing a medication-check with a pharmacist or drug reference to see if dose adjustment needed
- Medications with a high molecular weight or large particle size may not pass through the dialyzer membrane but low molecular weight or small particle size drugs do. In that case they are being "washed out" or removed while the individual is on the hemodialysis machine
- Timing of medication administration is important. For once a day drugs-if unsure give them after dialysis
- Digoxin, Gabapentin, Amoxicillin, Vancomycin & Gentamycin