"Dialysis Days" Why So Many Test

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Objectives

1. Describe the dialysis methods.

- 2. Identify the laboratory tests required for dialysis management.
- 3. Correlate laboratory results with system physiology within the scope of dialysis management.





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Renal Blood Supply

Renal Artery Interlobar Arteries Arcuate Arteries Interlobular Arteries (Radial Arteries) Afferent Artenole **Glomerular** Capillaries Efferent Arteriole Peritubular Capillaries Interlobular Vein Arcuate Vein Interlobar Vein Renal Vein



Section of the human kidney showing the major vessels that supply the blood flow to the kidney and schematic of the microcirculatio of each n nephron.

Active Vs Passive



Urine Composition

- Normal ranges are wide as urine volume and solute composition can vary greatly depending on:
 - Diet
 - Physical activity
 - Health

Kidneys are principal organ for regulating body fluid composition



Solute Excretion

 Renal excretion is primary elimination route of soluble metabolic wastes

 Wastes exclusively excreted by kidneys can be used to assess kidney function (creatinine, urea)



Measures of Concentration

- Osmolality
 - Osmoles per kilogram (Osm/kg) (milliosmoles used for convenience)
 - 1 mole = 6.023 x 10²³ particles (Avogadros number)
 - Examples:
 - UREA
 - NaCl
- Affected by solute number, not size or weight
- Ultra filtrate
 - Glomerulus = isosmotic
 - Descending loop = Hyperosmotic
 - Ascending loop = Hypo-osmotic



Measures of Concentration

- Specific gravity
 - Comparison of density of urine to that of water

- Normally ranges from 1.002 to 1.035
- Depends on number of particles and mass



- Produce concentrated urine specimen
 - osmolality >800 mOsm
 - specific gravity >1.025

 More accurate reflection of kidney's concentrating ability, since only solute number affects it



Three most prevalent solutes:

- Urea
- Chloride
- Sodium

High Molecular Weight Solutes

- Glucose
- Protein
 - Present due to a disease process, NOT renal ability



- Glomerular Filtration Rate (GFR)
 - Volume of plasma in milliliters that is completely cleared of a substance per unit of time
 - Volume of plasma filtered directly affects volume and composition of urine excreted



• Creatinine Clearance

- Creatinine is a waste product of creatine in muscles, produced at a relatively constant rate and excreted by kidneys
- Requires a 24-hour urine creatinine (U) and serum creatinine (P) drawn sometime during urine collection period, urine volume (V), and an estimate of body surface area (from height and weight)



Physiology of CKD

- Progressive loss of renal function "appears" normal early in the disease
- Due to hypertrophy of remaining of healthy nephrons
- Not clinically recognizable until 80-85% of function lost
- Azotemia, acid-base imbalance, abnormal calcium and phosphate metabolism
- Progresses to end stage renal disease (ESRD)



Physiology of CKD

Etiology of Chronic Renal Failure

- Diabetes mellitus--28%
- Hypertension--25%
- Glomerulonephritis--21%
- Polycystic Kidney Disease
- Other
 - Obstruction
 - Infection



Staging of CKD

Glomerular Filtration Rate (GFR)

- Serum creatinine alone is not enough to assess the level of kidney function
- Prediction equation should take into account creatinine, age, gender, race, and body size

Stage	Kidney Damage	GFR
1	Normal	>90
2	Mild	60-89
3	Moderate	30-59
4	Severe	15-29
5	Kidney Failure	<15

ESRD = Dialysis





What is Dialysis?

- Renal Replacement Therapy (RRT)
 - removes waste
 - keep safe levels of minerals, electrolytes, and proteins
 - helps to regulate your blood pressure
- First used successfully in the 1940's
- Helpful for two different situations
 - Acute
 - Chronic



Uses

- Acute Kidney Injury (AKI)
 - sudden episode of kidney failure or kidney damage
 - Treated with IV fluids
 - needed for a short time



Uses

- Chronic Renal Failure/Chronic Kidney Disease (CKD)
 - AKA End Stage Renal Disease (ESRD)
 - 10-15% of your kidney function
 - eGFR <15mL/min</p>
 - only able to do some of the work of healthy kidneys
 - Lifelong requirement or until transplant



Types of Dialysis

- Hemodialysis
- Peritoneal Dialysis

Status of ESRD Treatments in the United States,



Hemodialysis

Blood containing waste materials



Image Source: https://www.kaikou.or.jp/kyoritsu/en/shinryo_jinzo04.html

Typical Schedule



• =Hospital treatment days for patient A

 $\times In$ principle, patients will undergo dialysis throughout their lives including holidays and New Year's.



Peritoneal Dialysis



Image Source: https://www.kaikou.or.jp/kyoritsu/en/shinryo_jinzo04.html

Types of Peritoneal Dialysis

- Continuous Ambulatory Peritoneal Dialysis (CAPD)
 - Multiple daily exchanges
- Automated Peritoneal Dialysis (APD)
 - automatically while the patient is sleeping





Effectiveness

- The following steps can help increase the effectiveness of your dialysis treatments:
 - complete your treatments according to your prescribed schedule
 - follow a customized eating plan
 - physical activity to boost strength and heart health
 - Communication about any medications, supplements, or herbal products
 - Discuss any concerns or side effects



Side Effects

Hemodialysis (HD)

- Blockage in your vascular access site (entrance point)
- Muscle cramps
- Hypotension
- Weakness, dizziness, or nausea
- Blood loss

Peritoneal Dialysis (PD)

- Hernia (weakness in your abdomen muscle, often presenting as a lump or swollen area)
- Weight gain



The difference between hemodialysis (HD) and peritoneal dialysis (PD)

SurgerySurgery to create shunt Approximately one hour under local anesthesiaSurgery to insert Tenckhoff catheter Approximately one hour under general anesthesiaTreatment MethodIntermittent / three times per week at a hospital / four hours per treatmentContinuous / dailyDialysis EfficiencyGoodGoldStress on the HeartMay be considerable in some casesMinnorDietary RestrictionsIntervitent on the very restrictedLoosely restrictedStatus when first introducedFluctuations in blood pressure / headaches / nauseaPressure in the abdomen / mastery of skillsBathingOnly on days with no dialysisNeed to clean the opening daily Risk of developing peritonitis Need to switch to Hafter 5 to 7 years on averagebisadvantagesJust need to go to the hospital Sen leave it up to the hospital staff Sen by medical professionals three times per weekSuitable for returning to work and society Loose dietary restrictions Good in the event of a natural disaster		Hemodialysis (HD)	Peritoneal Dialysis (PD)
Treatment MethodIntermittent / three times per week at a hospital / four hours per treatmentContinuous / dailyDialysis EfficiencyGoodSlow and gradualStress on the HeartMay be considerable in some casesMinorDietary RestrictionsFluctuations in blood pressure / headaches / nauseaPressure in the abdomen / mastery of skillsStatus when first introducedFluctuations in blood pressure / headaches / nauseaPressure in the abdomen / mastery of skillsBathingOnly on days with no dialysisNeed to clean the opening daily Risk of developing peritonitis Need to switch to HD after 5 to 7 years on averageDisadvantagesJust need to go to the hospital Seen by medical professionals three times per weekSuitable for returning to work and society Board in the event of a natural disaster	Surgery	Surgery to create shunt Approximately one hour under local anesthesia / out-patient surgery	Surgery to insert Tenckhoff catheter Approximately one hour under general anesthesia
Dialysis EfficiencyGoodSlow and gradualStress on the HeartMay be considerable in some casesMinorDietary RestrictionsVery restrictedLoosely restrictedStatus when first introducedFluctuations in blood pressure / headaches/ nauseaPressure in the abdomen / mastery of skillsBathingOnly on days with no dialysisNeed to clean the openning daily Strict dietary restrictions Considerable stress on the heart Infection of the shunt / issuesNeed to clean the opening daily Risk of developing peritonitis Need to switch to HD after 5 to 7 years on averageAdvantagesJust need to go to the hospital Seen by medical professionals three times per weekSuitable for returning to work and society Loose dietary restrictions Good in the event of a natural disaster	Treatment Method	Intermittent / three times per week at a hospital / four hours per treatment	Continuous / daily
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DisadvantagesPain from inserting needles Strict dietary restrictions Considerable stress on the heart Infection of the shunt / issuesNeed to clean the opening daily Risk of developing peritonitis Need to switch to HD after 5 to 7 years on averageAdvantagesJust need to go to the hospital Seen by medical professionals three times per weekSuitable for returning to work and society Loose dietary restrictions Good in the event of a natural disaster	Bathing	Only on days with no dialysis	Daily
Advantages Just need to go to the hospital Can leave it up to the hospital staff Seen by medical professionals three times per week Solution the event of a natural disaster	Disadvantages	Pain from inserting needles Strict dietary restrictions Considerable stress on the heart Infection of the shunt / issues	Need to clean the opening daily Risk of developing peritonitis Need to switch to HD after 5 to 7 years on average
	Advantages	Just need to go to the hospital Can leave it up to the hospital staff Seen by medical professionals three times per week	Suitable for returning to work and society Loose dietary restrictions Good in the event of a natural disaster
Freedom of MovementFree on days with no dialysisFree to move even during dialysis	Freedom of Movement	Free on days with no dialysis	Free to move even during dialysis



Dialysis Monitoring

- KDOQI Guidelines and Medicare reimbursement dictate current ordering practices for hemodialysis monitoring
 - Dialysis Adequacy
 - Anemia Management
 - Nutrition & Mineral Status



Lab Tests We'll Cover Include:

- Complete Blood Count (CBC)
- Hemoglobin (Hgb or Hb)
- Hematocrit (Hct)
- Ferritin
- Transferrin Saturation (TSAT)
- Calcium
- Phosphorus
- Potassium
- Sodium
- Blood Urea Nitrogen (BUN)
- Creatinine
- Glomerular Filtration Rate (GFR)
- Urea Reduction Ratio (URR)
- Kt/V

- Parathyroid Hormone (PTH)
- Calcium-Phosphorus Product (Ca x P)
- Urine Blood or Urine Hemoglobin (Heme)
- Creatinine Clearance
- Urine Albumin
- Microalbuminuria
- Albumin-to-creatinine ratio
- Serum Albumin
- Total Cholesterol
- High Density Lipoprotein (HDL)
- Low Density Lipoprotein (LDL)
- Triglycerides
- Fasting Blood Glucose (FBG)
- Hemoglobin A1c (HbA1c)

Dialysis Adequacy

- Functionality Tests
 - Urea reduction ratio (URR)
 - via BUN and Creatinine
 - Kt/V ratio
 - Time on dialysis



BUN & Creatinine

• waste products

Renal Disease: When BUN and Creatinine Are Too Much



Urea Reduction Ratio (URR)

- No fixed value
- Minimum URR is 65%

What's the Formula for URR?

In case you want to figure out your own URR, the formula is:

Predialysis BUN – Postdialysis BUN x 100

Predialysis BUN

For example:

$$\frac{96 - 31}{96} \times 100 = 67.7\%$$

Kt/V Ratio

- K = is the dialyzer clearance
- t = stands for time
- V = is the volume of water
- Mathematically derived from the URR
- More accurate than the URR
- Minimum Kt/V ratio of 1.2 (HD) and 1.7 (PD)



Time on Dialysis

12 hours per week on dialysis

93%

156 hours per week not on dialysis



Total hours in a week: 168

Adequacy Assessment

- (c) Standard: Assessment of treatment prescription. The adequacy of the patient's dialysis prescription, as described in § 494.90(a)(1), must be assessed on an ongoing basis as follows:
 - (1) Hemodialysis patients. At least monthly by calculating delivered Kt/V or an equivalent measure.
 - (2) Peritoneal dialysis patients. At least every 4 months by calculating delivered weekly Kt/V or an equivalent measure.



Anemia Management

- Anemia is among the most common complications of CKD and ESRD (Chen et al 2019)
- Develops from the decreased renal synthesis of erythropoietin (also iatrogenic)
- CBC ordered to specifically assess
 - Hgb
 - Hct
- Ferritin
- Transferrin Saturation





Hgb Goals



The Reference Interval is:

- 14 to 18 g/dL for healthy men
- 12 to 16 g/dL for healthy women
- It to 12 g/dL for men and women with kidney disease



Hct Goals



The Reference Interval is:

- 40% to 50% for healthy men
- 36% to 44% for healthy women
- 33% to 36% for men and women with kidney disease



Ferritin

- storage form of iron
- target ferritin value for those on HD is greater than 200 ug/L (reference 100-300 ug/L)
- high ferritin levels [600 1200 ug/L) are related to an unfavorable prognosis
- acute phase inflammatory mediator
 - ->50% of hemodialysis patients had ferritin levels of greater than 800 ug/mL in the United States

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Transferrin Goals

The Reference Interval is:Greater than 20%



latrogenic Anemia

- the development of anemia due to medical procedures
- at least 20 mL per patient for routine monthly evaluation
- approximately 250 350 mL annually
- 10-fold loss of blood in the dialyzer in routine hemodialysis



Anemia and Your Heart

- Muscles are starved for oxygen
- Heart grows fibers (fibrosis)
- Left Ventricular Hypertrophy
- Leads to CHF



EPO & Iron Therapy

The ESAs today are:

- EPOGEN® (Epoetin alfa) only for dialysis
- PROCRIT® (Epoetin alfa) the same as EPOGEN, but for CKD, not dialysis
- AranespTM (darbepoetin alfa) for both
- Mircera® (methoxy polyethylene glycolepoetin beta) for both



*Black Box Warning

Nutrition & Minerals

- Electrolytes
 - Sodium, Potassium
- Minerals
 - Calcium, Phospohorus
- Other
 - Albumin, Lipids, Cholesterol, HbA1c



Potassium

• allows your nerves and muscles to work







Sodium

- body's balance of fluid and water
- limit their salt intake



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PTH

Parathyroid glands Decreased blood calcium stimulates parathyroid hormone secretion

PTH

Ca+2 PTH

Increased blood calcium inhibits PTH secretion

Ca+2



Bloodstream





PTH

Ca+2

Calcium & Phosphorus



Bone Disease and PTH



General Health Tests

- Serum albumin
- Cholesterol
- Triglycerides
- Fasting blood glucose (FBG)
- Hemoglobin A1c (HbA1c)



Urine Test Family

- **If still urine producing
- Urine blood or urine hemoglobin (Heme)
- Creatinine clearance
- Urine albumin
- Microalbuminuria
- Albumin-to-creatinine ratio



Frequency of Testing

- Standard test ordering is mandated by Medicare reimbursement and KDOQI guidelines, CMS & Medicare to completed
 - Monthly (BUN, Creatinine, URR, Kt/V, Hgb, Hct, Alb, K+, Ca, Phos, glucose)
 - Quarterly (Ferritin, TSAT, PTH, HbA1c)
 - Biannually (Cholesterol, Trig, Lipids)



Benefits of Dialysis

- Prolongs life until transplant
- Five-year survival rate
 - -from 29% to 34% (HD)
 - -29% to 40% (PD)



Limitations of Dialysis

- Not a cure
- Risk of infection
- Cardiac mortality



Financial Burden

- In-center hemodialysis having the highest cost per patient of all modalities Exceed \$18 billion annually
- Standard test ordering is mandated
- Poorly controlled status leads to an increase in poor outcomes
- ESRD population: 34% admissions with 92% costs



QUESTIONS?

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