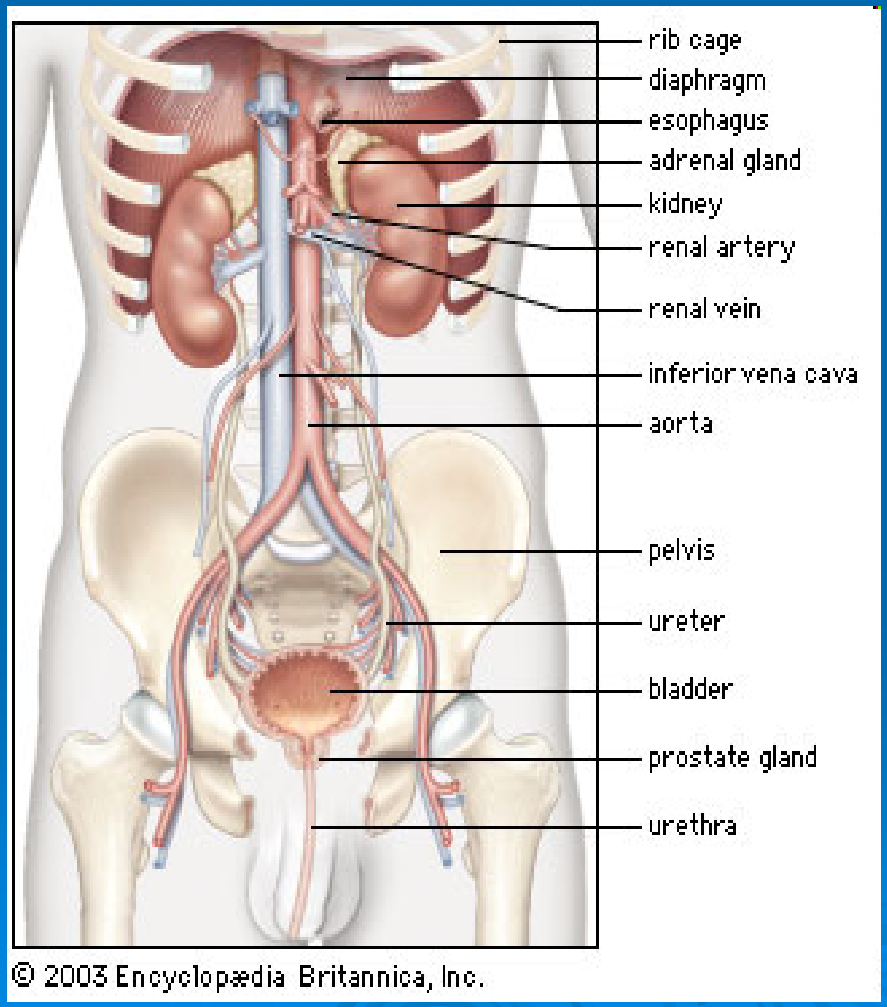
Renal Disease
A balancing act

Andy Funkhouser, PA-C, EMT-P
Harrisonburg Rescue Squad
Harrisonburg Medical Associates
Carilion Stonewall Jackson Hospital ED

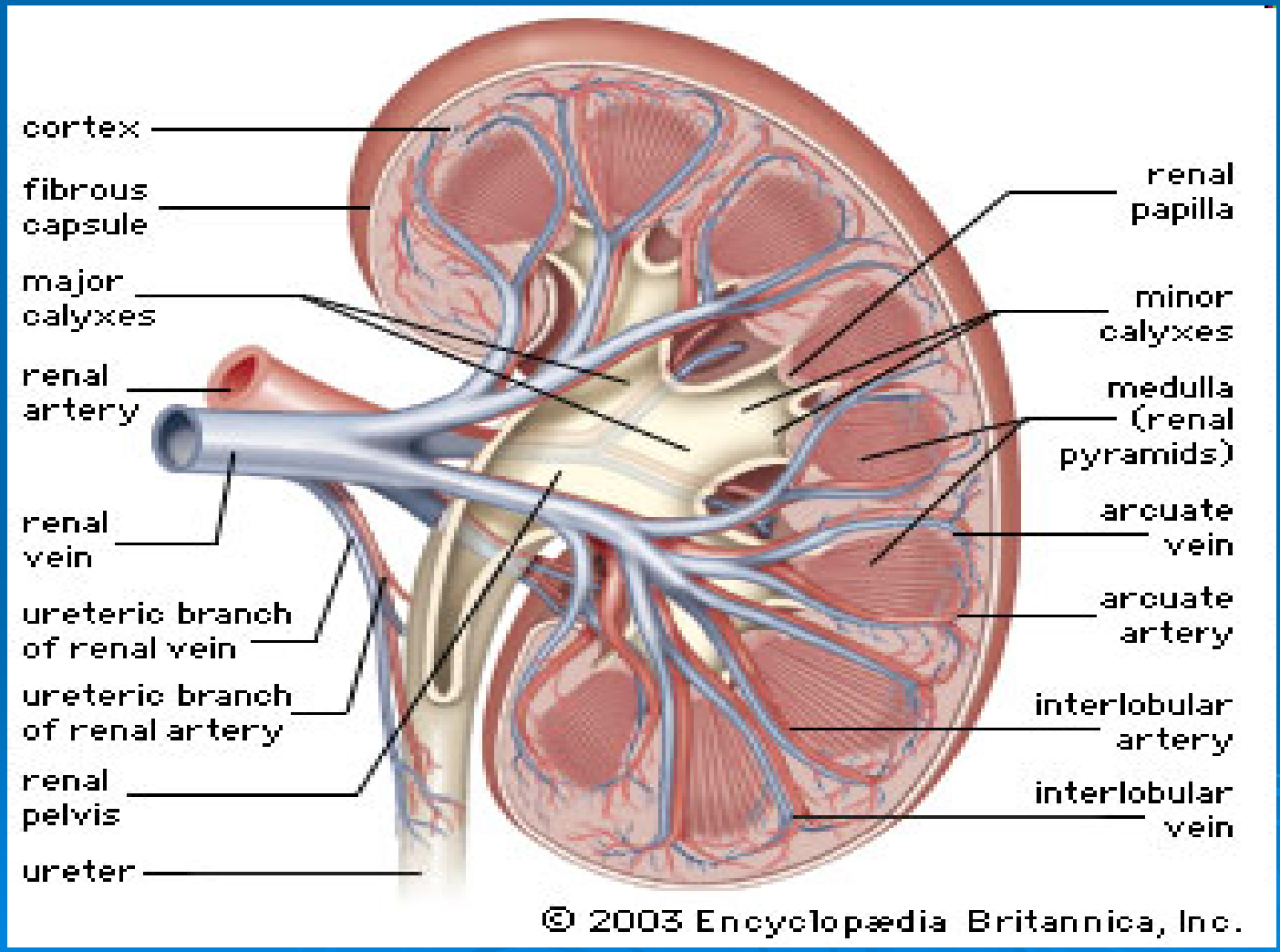
Objectives

- Learn a little something about renal A&P
- Who gets kidney disease
- What is dialysis
- Common dialysis related problems and management
- Have a good time

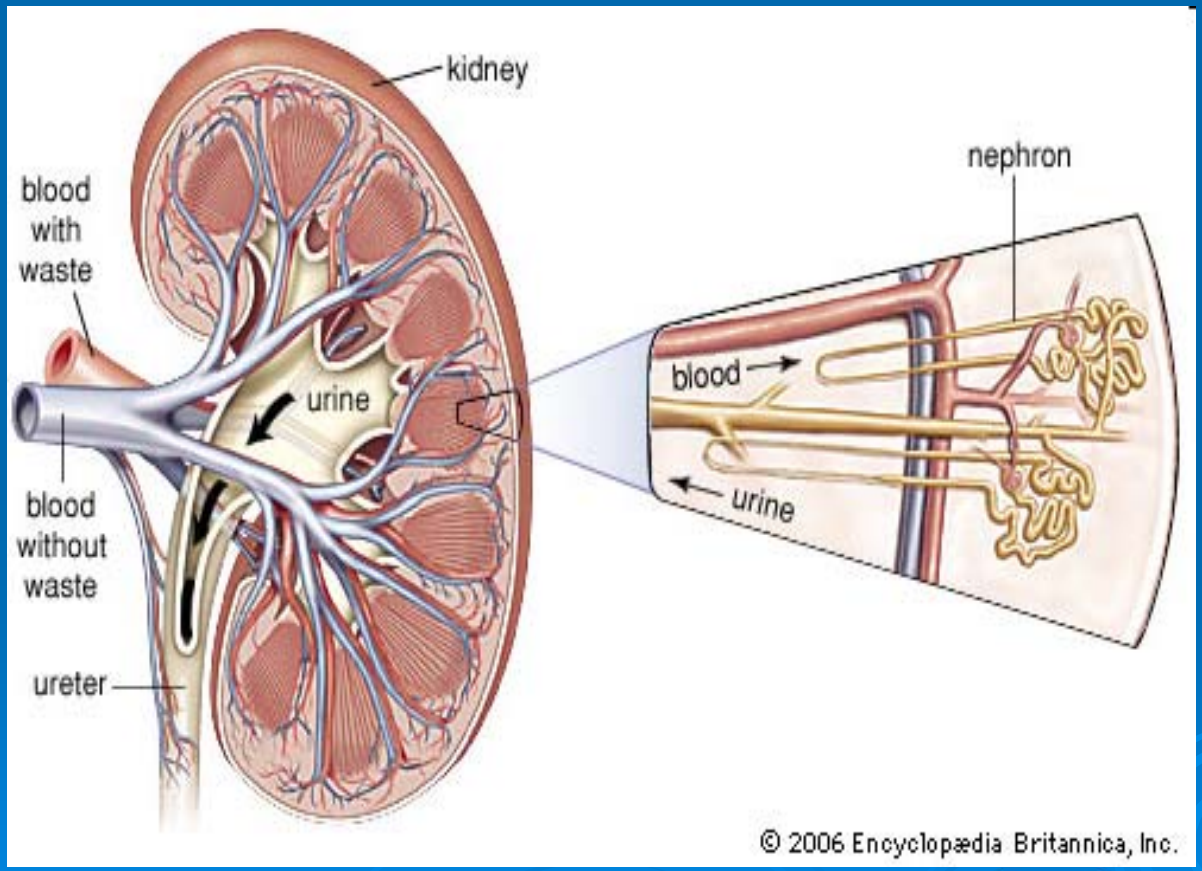
Renal Anatomy



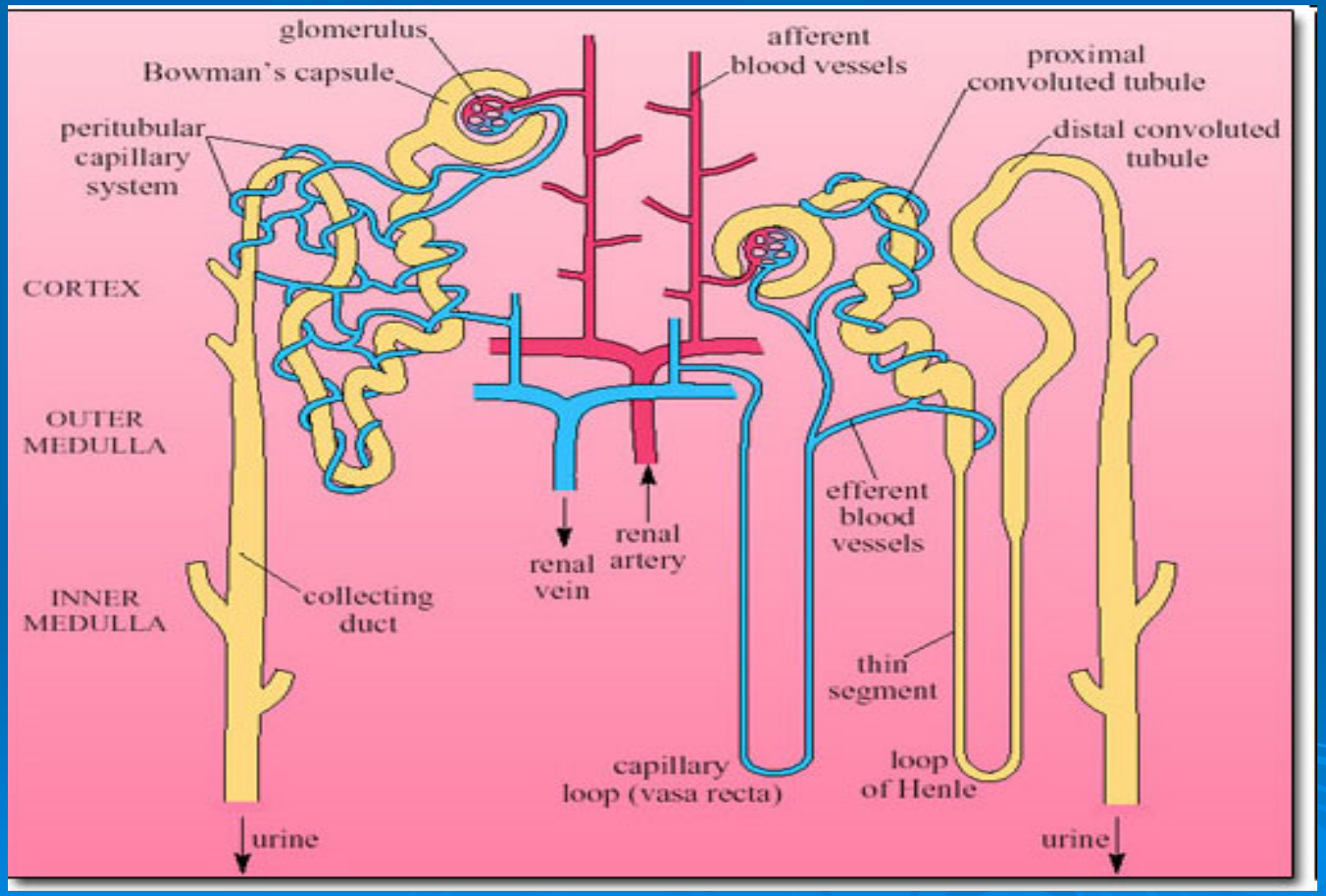
Renal anatomy



Renal Anatomy



The nephron


glomerulus
Bowman's capsule
peritubular capillary system
CORTEX
OUTER MEDULLA
INNER MEDULLA
collecting duct
urine
renal vein
renal artery
afferent blood vessels
capillary loop (vasa recta)
efferent blood vessels
proximal convoluted tubule
distal convoluted tubule
thin segment
loop of Henle
urine

Renal functions

Fluid balance

Acid Base balance

Electrolyte balance

Blood pressure

Excrete toxins

Hormone production

Time out for Diuretics

- All diuretics used to treat edema increase both Na and water excretion (water follows salt)

- Proximal Tubule
  - Carbonic anhydrase inhibitors (Acetazolamide)
    - Effect short lived
    - Metabolic acidosis side effect
- Loop
  - Furosemide (Lasix)
  - Bumetanide (Bumex)
  - Torsemide (Demadex)
    - Increase magnesium and calcium excretion
- Distal Tubule
  - Thiazides (HCTZ)
    - Less effective in renal disease
    - Increase magnesium excretion, inhibit calcium excretion
    - Useful in calcium kidney stones(?)

Diuretics

- Collecting Duct
  - Potassium Sparing
    - Triamterene
    - Amiloride
    - Spironolactone
      - SE- estrogenic gynecomastia
    - Eplerenone (Inspra)
- Osmotic Diuretics
  - Mannitol

Diuretics

- In order for most diuretics to be effective must restrict dietary NaCl
- Body adapts leading to diuretic resistance
- Complications – ECF volume depletion, hyponatremia, hypokalemia

Who is this TV doctor?

Renal failure

- Acute vs. Chronic
  - Acute – abrupt onset with potentially reversible causes
  - Chronic – slow process with renal decline over time. Typically not reversible. Decline may be slowed.

Staging Kidney Disease

Stage of progression

- Stage 1 Kidney damage with normal GFR >90
- Stage 2 Kidney damage with mild decrease in GFR 60 – 90
- Stage 3 Kidney damage with moderate decrease in GFR 30 – 59
- Stage 4 Severe decrease in GFR 15-29
- Stage 5 Kidney failure < 15

- GFR = Glomerular Filtration Rate (mL / min / 1.73 m^2)

Prevalence of Kidney disease

CKD Stage	U.S. population
Stage 1	5.9 million
Stage 2	5.3 million
Stage 3	7.6 million
Stage 4	0.4 million
Stage 5	0.3 million

Hard concept

- Just because you can urinate doesn't mean your kidneys function

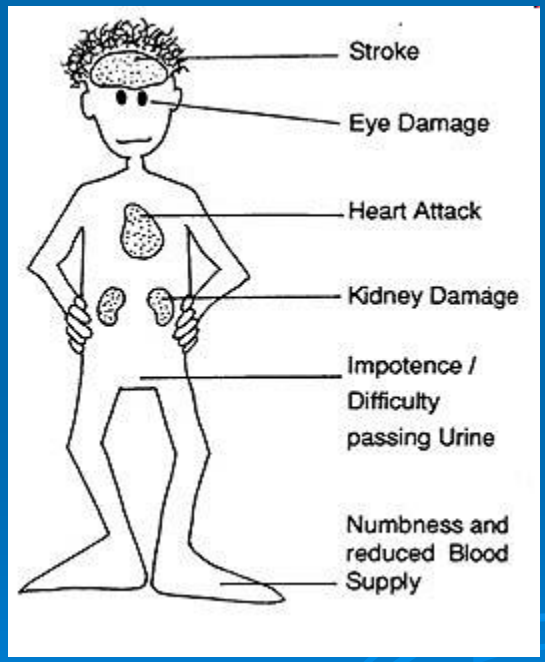
End Stage Renal Disease

- Causes (VINDICATE)
  - Vascular (Hypertension)
  - Infection / Inflammatory / Auto-Immune (Lupus)
  - Neoplasm (Primary / Metastatic) (Renal cancer)
  - Drugs (Lithium)
  - Iatrogenic (Contrast Dye)
  - Congenital / Developmental / Inherited (ADPKD)
  - Anatomic (renal agenesis)
  - Trauma
  - Environment / Endocrine / Exposure (Diabetes)

Polycystic Kidneys

End Stage Renal Disease

- Most common causes of ESRD
  - Hypertension
  - Diabetes



Why dialysis is started

- Uremic syndrome is symptoms of elevated nitrogenous and other waste products

  Symptoms of uremia
  - Nausea, early morning vomiting, anorexia,
  - Fatigued, weak,
  - Confused
  - pruritus

  Signs
  - Sallow skin color (urochrome pigment)
  - Wrist / Foot drop, tremor, restless legs, asterixis, myoclonus, seizures
  - Anemia, bleeding
  - Pericarditis

- Failure to clear volume
  - Signs of edema

- Metabolic acidosis

Types of dialysis

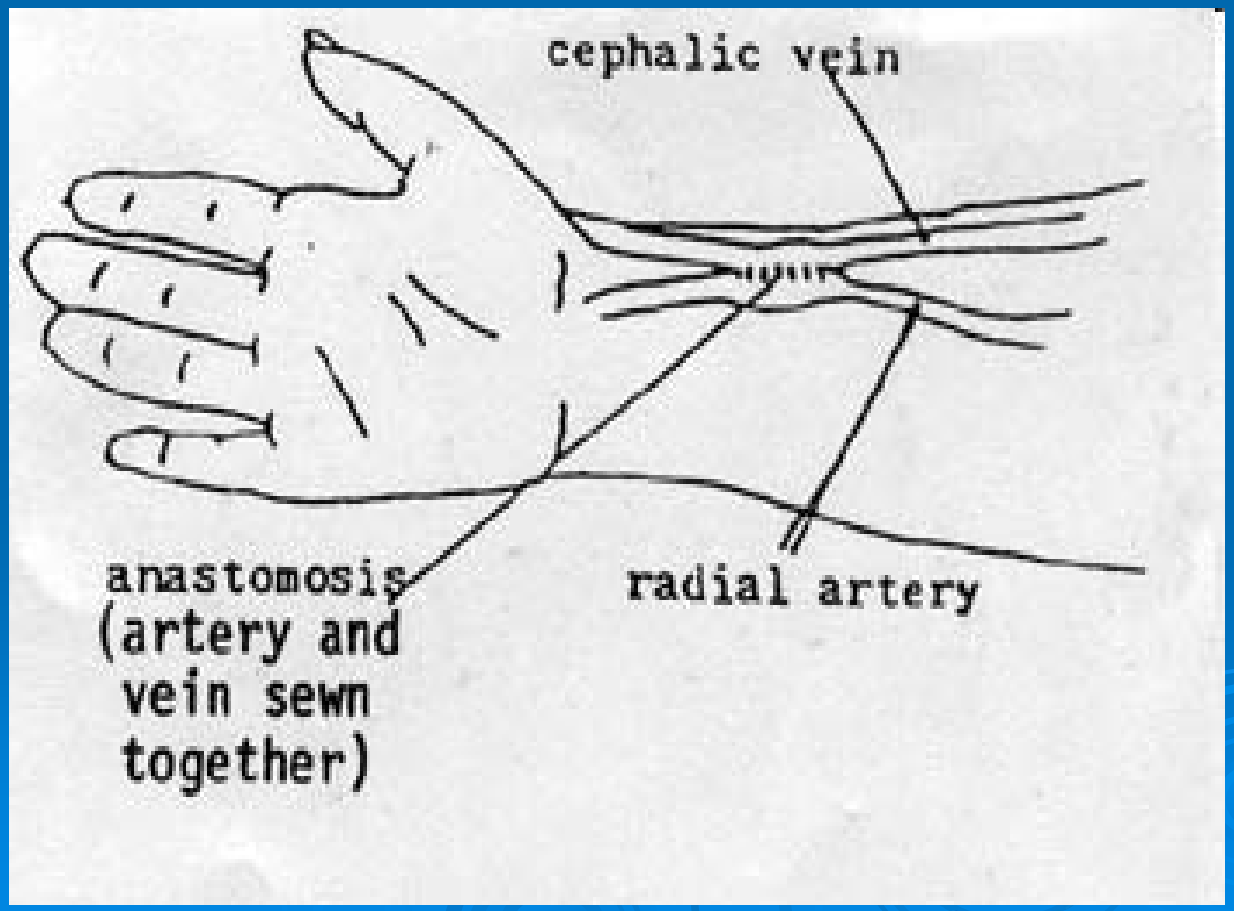
- Hemodialysis
  - Generally in-center
  - Starting to have more home hemodialysis patients
- Peritoneal dialysis
  - Continuous ambulatory peritoneal dialysis (CAPD)
  - Continuous cycling peritoneal dialysis (CCPD)

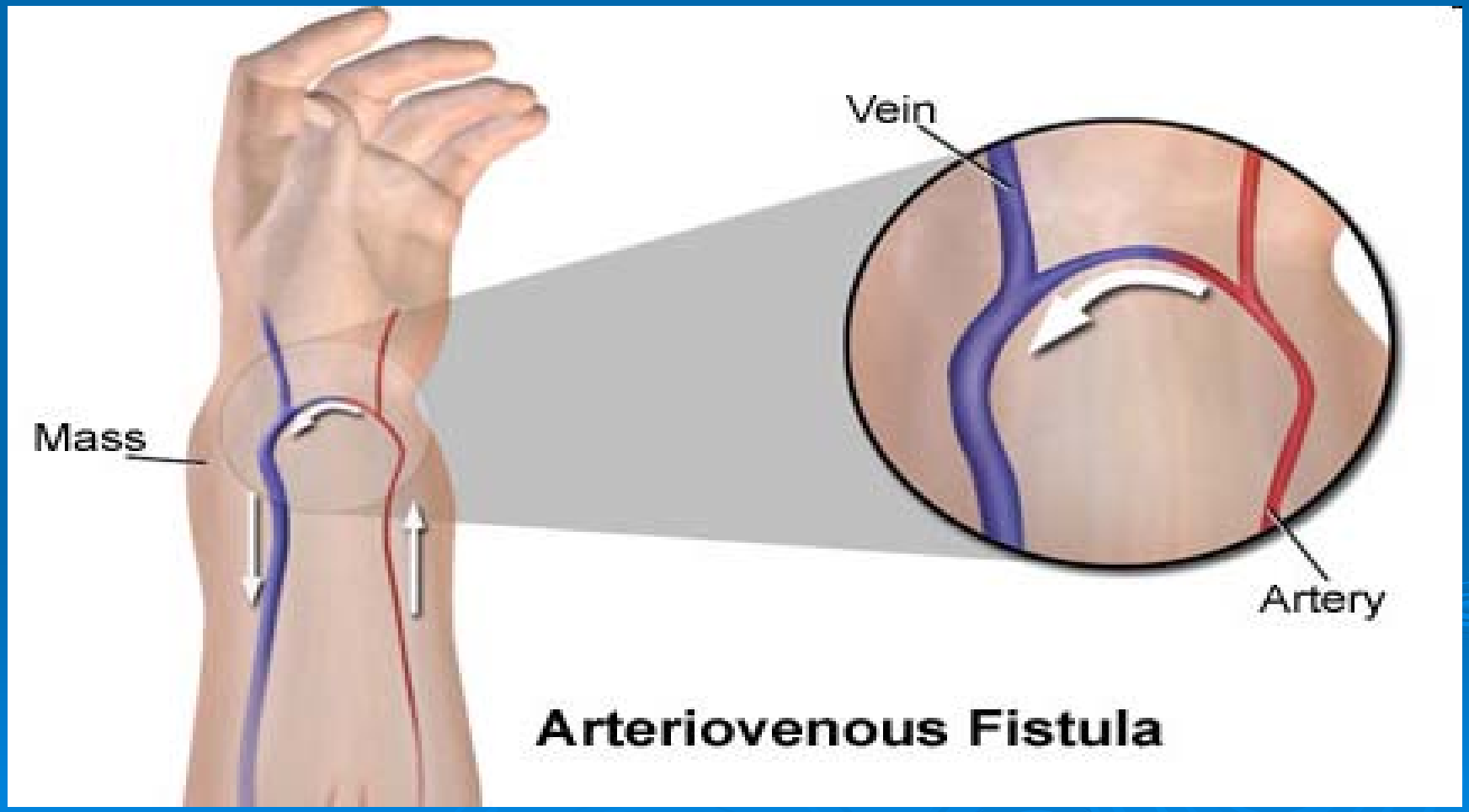
The hemodialysis process

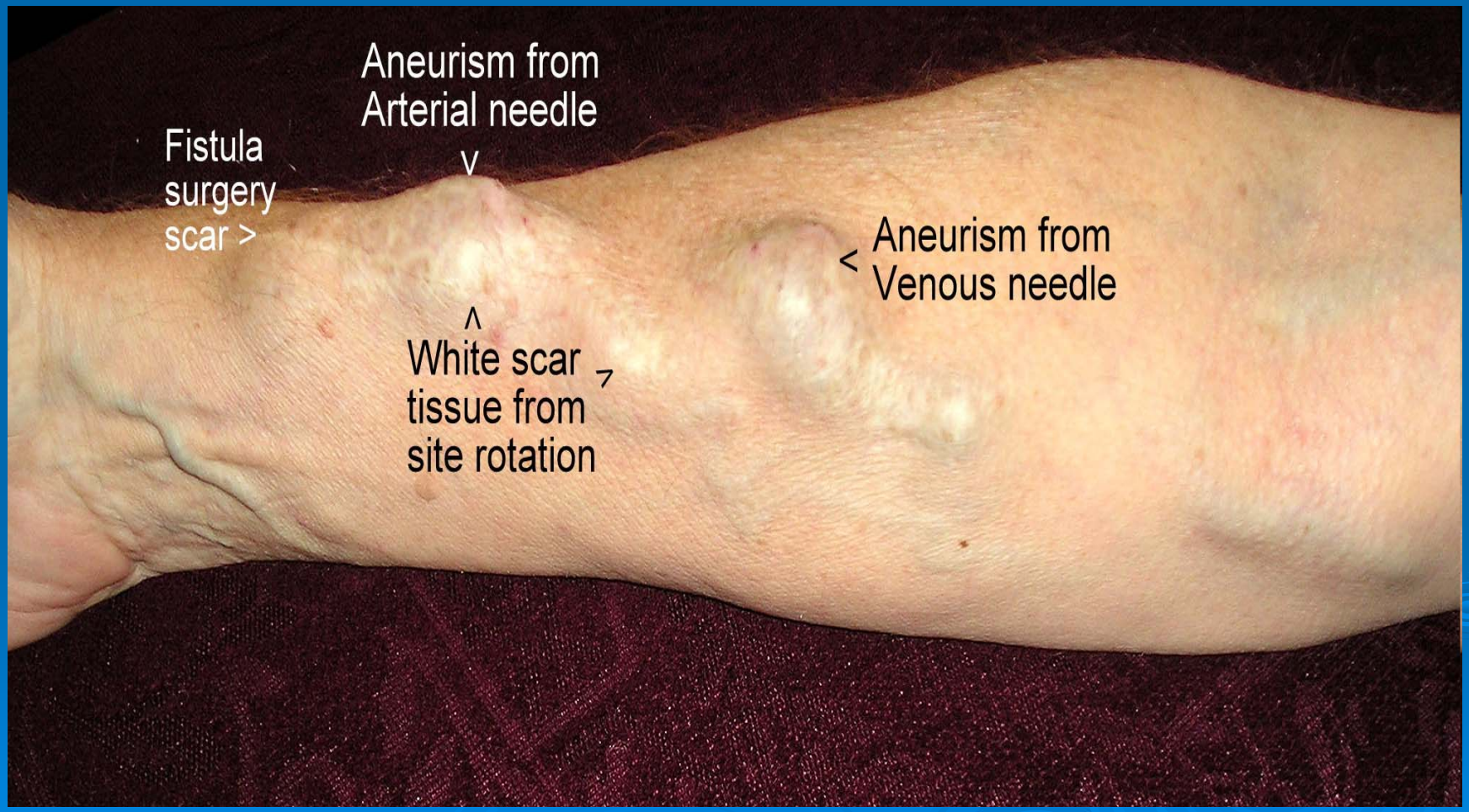
- Create a vascular access
- Remove blood
- Process through dialyzer. Remove toxins and fluid through a semi-permeable membrane by osmotic process
- Return blood

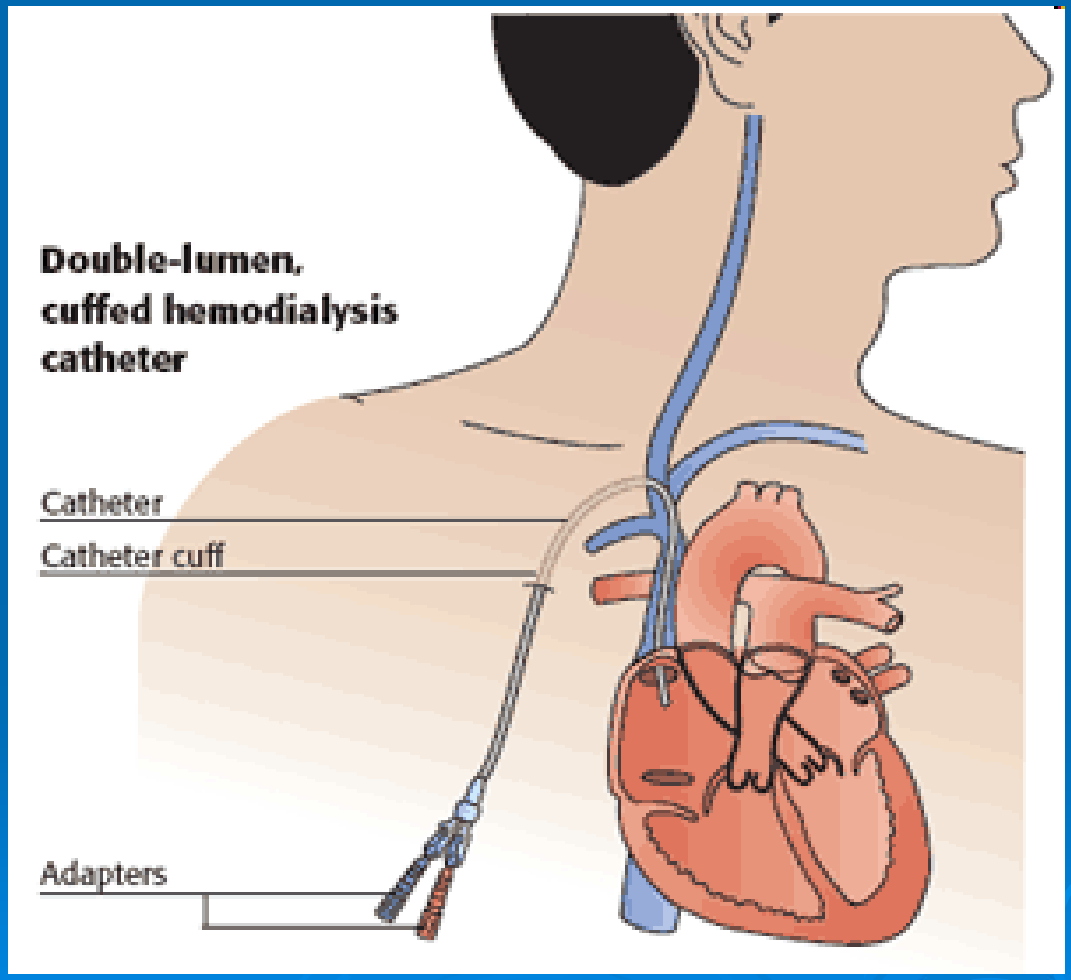
Vascular access

- AVF or graft
  - AVF – connecting an artery and a vein directly
  - Graft – using artificial material between the artery and vein
- Central dialysis line
  - Usually a duel lumen line tunneled under the skin to the internal jugular or the subclavian vein


cephalic vein
anastomosis
(artery and
vein sewn
together)
radial artery

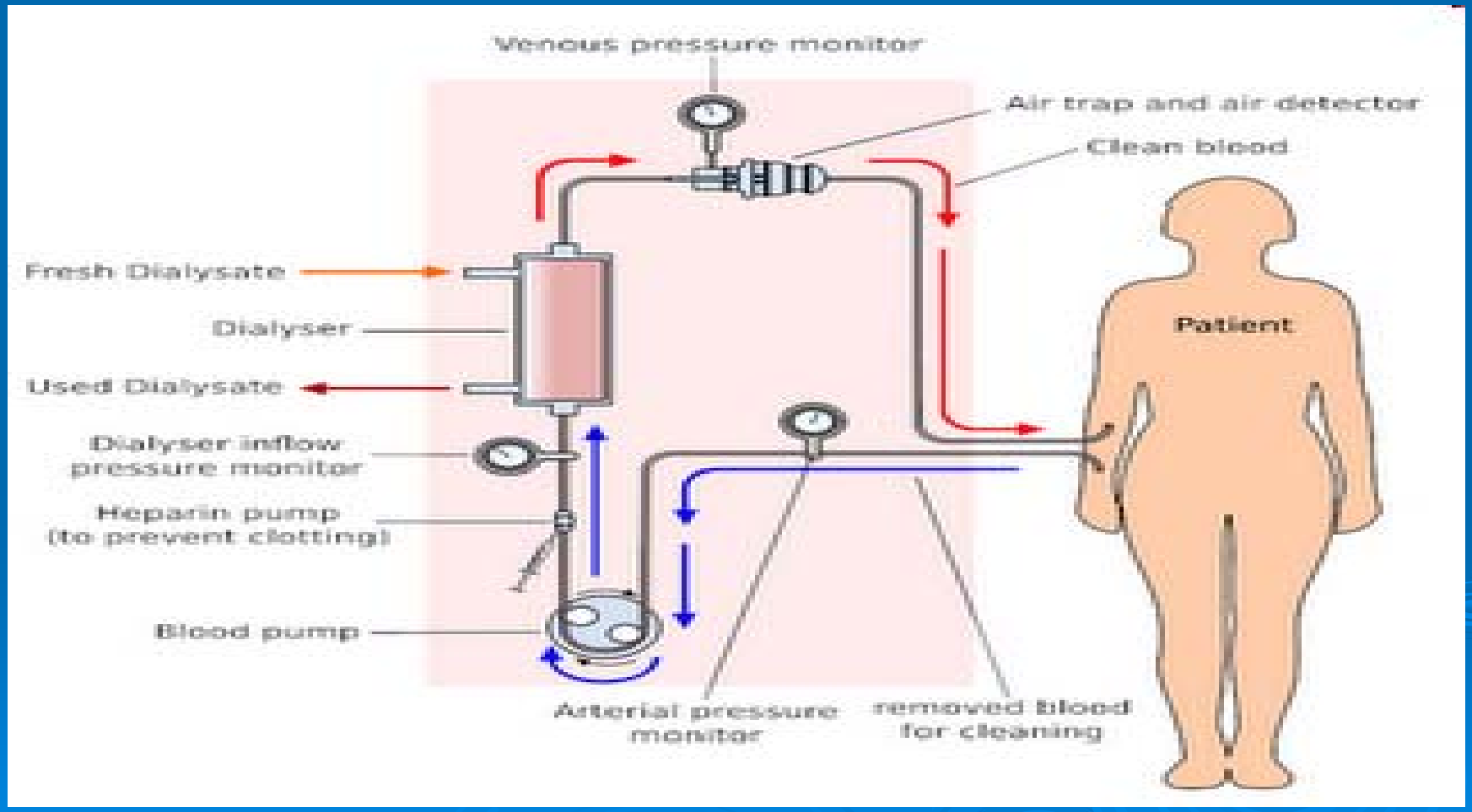

Vein
Mass
Artery
Arteriovenous Fistula


Aneurism from
Arterial needle
Fistula
surgery
scar >
Aneurism from
Venous needle
White scar
tissue from
site rotation


Double-lumen, cuffed hemodialysis catheter
Catheter
Catheter cuff
Adapters

Access no – no's

- Avoid starting IV's and taking blood pressures in the access arm
- Can be used in life or death situations
  - If allowed under protocols
  - Be super aseptic – greater risk of infections and most dialysis patients tend to be immune compromised.
  - Arterial side has a higher pressure
- Some patient have old AVF because the first quit working and needed replacement
  - If in doubt ask the patient

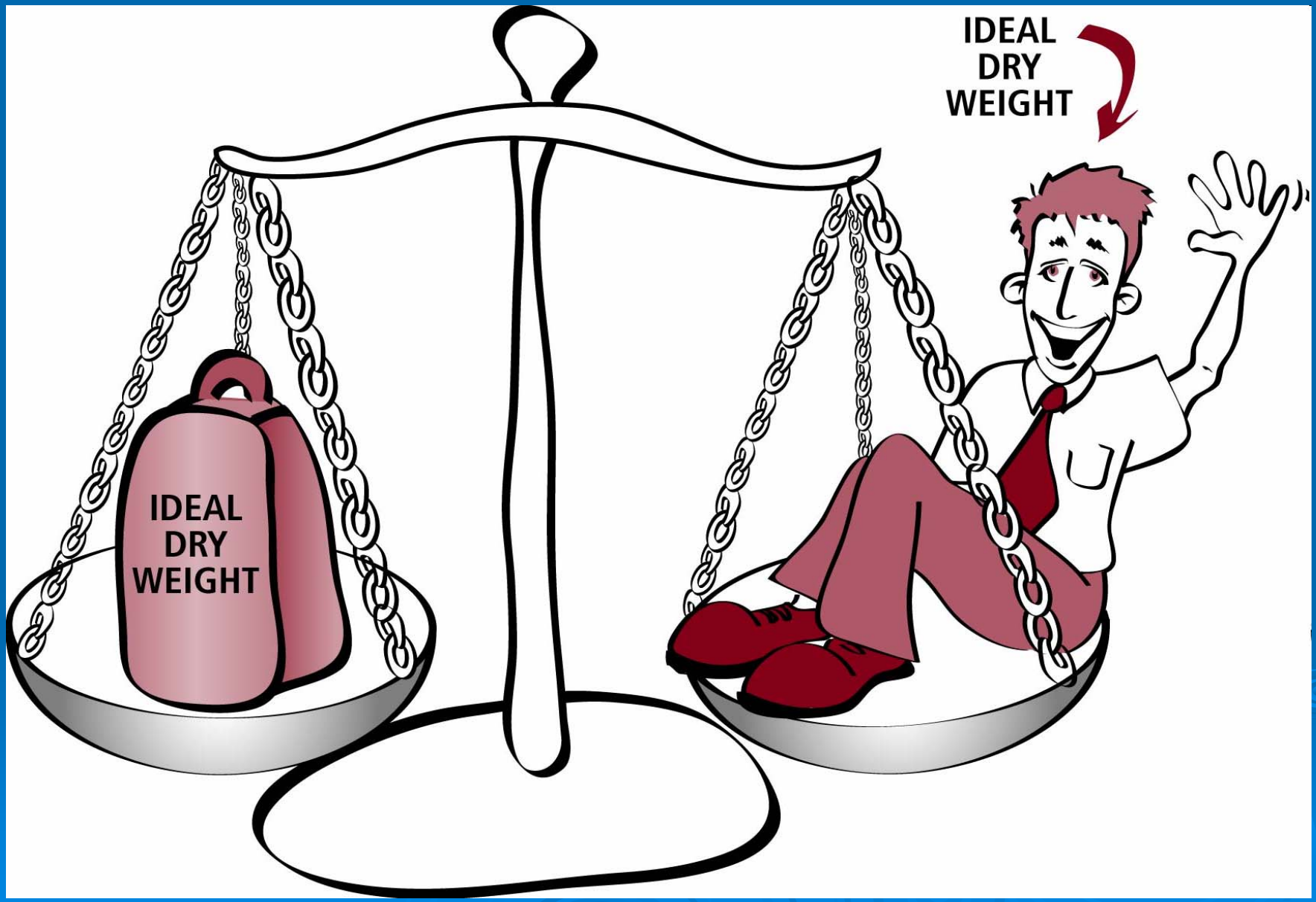

Venous pressure monitor
Air trap and air detector
Clean blood
Fresh Dialysate
Dialyser
Used Dialysate
Dialyser inflow pressure monitor
Heparin pump (to prevent clotting)
Blood pump
Patient
Arterial pressure monitor
removed blood for cleaning


THE ROLLING STONES

Target weight

- A magical number
  - What the patient's ideal "dry" weight is
- Residual function.

- One liter equals one kilogram


IDEAL
DRY
WEIGHT
IDEAL
DRY
WEIGHT

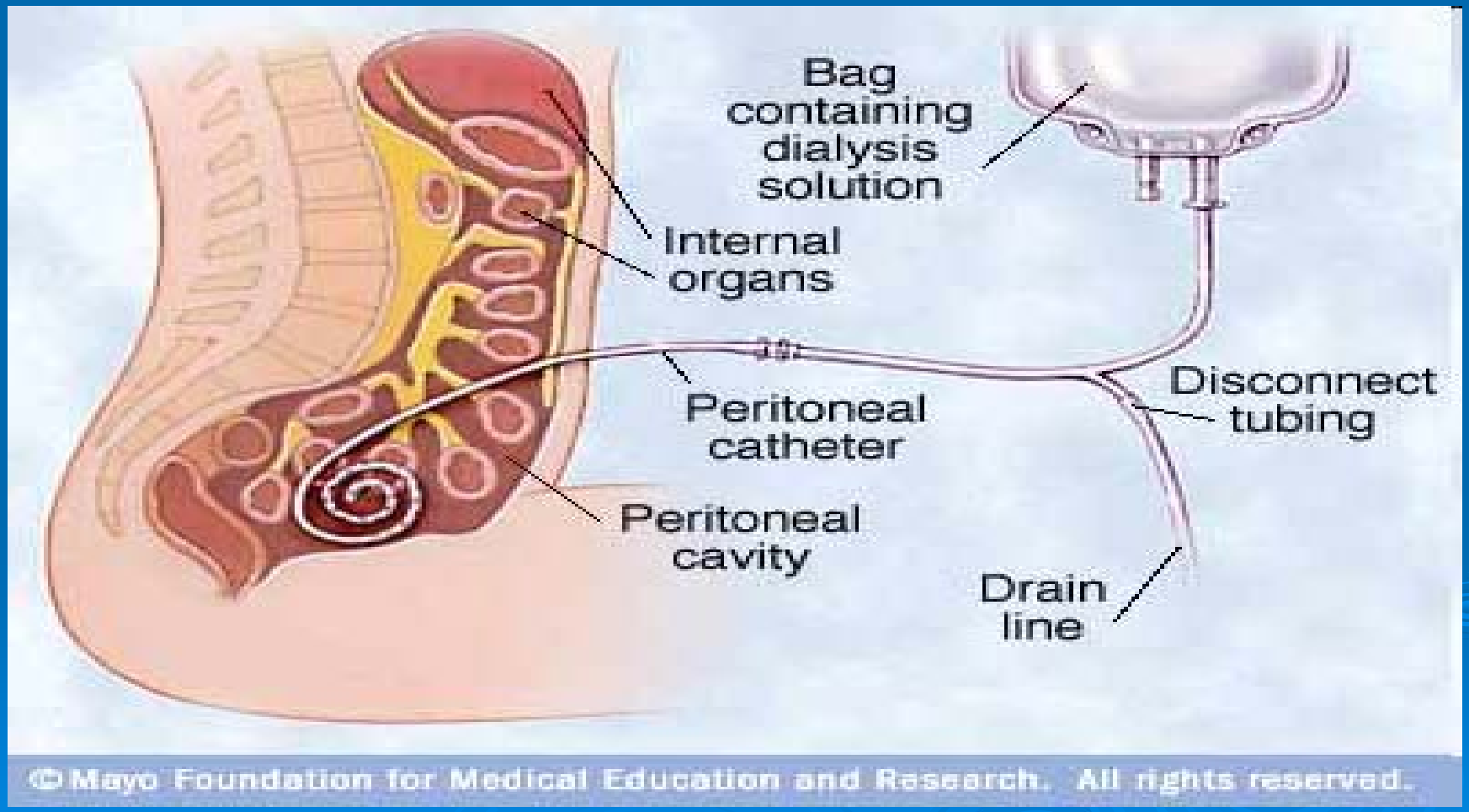
Dialysis removes volume

- Decrease intravascular volume first
- Then fluid must shift from interstitial space to refill that volume.
- Can get electrolyte shifts.
  - The change in volume and electrolytes may cause cramps

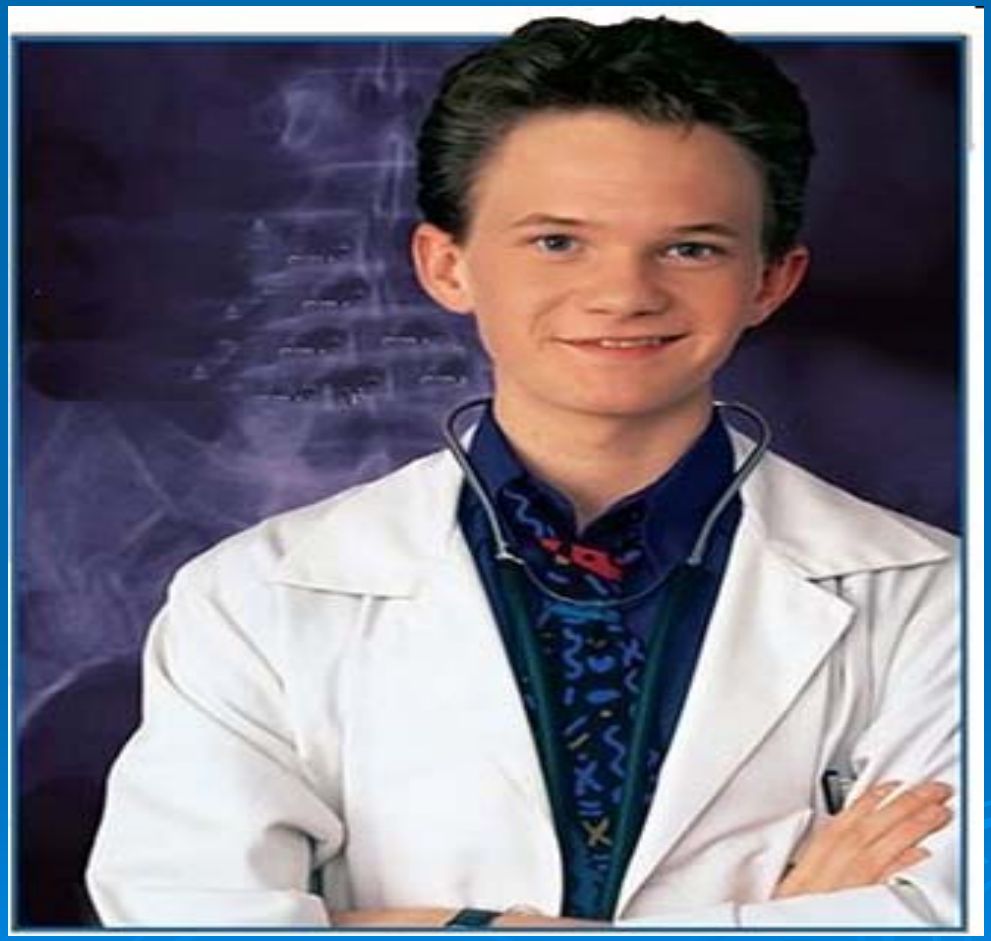
Peritoneal dialysis

- Using the peritoneal cavity as the semi-permeable membrane
- Place fluid in peritoneal cavity for a period of time (dwell time) and then empty or exchange for more fluid

Peritoneal dialysis



Who is this guy?



Fear of the dialysis call

Complicated sick patients

Dialysis emergencies

- Dialysis patients get sick like everybody else
  - Still die from cardiovascular disease
  - Still have low blood sugars
  - Still get infections
  - Still have strokes
  - Still get nausea, vomiting, diarrhea

Cardiac arrest / Arrhythmia

- Questions to ask
  - When was the last dialysis
    - Thinking hyperkalemia vs hypotension
- Why?
- Co-morbid issues
  - Hypertensive, ischemic and hypertrophic cardiomyopathy
  - Conduction system disease
  - Coronary artery disease
  - Pericardial disease
  - Medication toxicity (digitalis)
- Dialysis issues
  - Reduction in plasma K concentration
  - Transient hypercalcemia
  - Transient acidosis / alkalosis
  - Hypotension / hypoperfusion
  - Hypoxemia

Uremia

- If a patient has skipped treatments, may become uremic
  - Nausea, vomiting, diarrhea
  - weakness,
  - Dyspnea
  - Pruitis
  - Headache

anemia / blood loss

- Bleeding from a vascular access
  - Can be significant.
  - Direct pressure
  - Direct pressure!
  - Direct pressure!
  - Some patients may have coagulopathies, have problems with access stenosis, Coumadin, use of heparin during treatment

ESRD related anemia

- Dialysis patients are prone to anemia anyway
  - the kidneys fail to produce erythropoietin
  - red blood cells have a shortened survival
  - iron and folate deficiency,

Hypertension

- Not uncommon for dialysis patients to have elevated BP especially pre-dialysis (greatest amount of volume)
  - Be careful of symptoms of hypertensive urgency/emergency
  - End organ symptoms
    - Chest pain
    - HA, AMS

Hypotension

- What is normal
  - Some patients with autonomic neuropathy may have SBP in the 80 – 90 and be fine
  - Treat the symptoms not the numbers.
  - If fluid bolusing, think what was the pt hydration status before.
    - Give in small allotments (100 ml) and frequent reassessments.

Why do patient become hypotensive with dialysis

- Intravascular volume depleted faster than interstitial fluid shifts
- Occurs in 10-50% of treatments
- Most frequent complications of dialysis

- Symptoms
  - Dizziness, weakness, syncope, AMS, seizures, angina, myocardial ischemia, arrhythmia, myocardial ischemia

Intradialysis Hypotension

- Left ventricular dysfunction
- Pericardial tamponade
- Air embolism
- Autonomic dysfunction
- Inappropriate vasodilation
- Drugs (antihypertensive, narcotics, anxiolytics)
- Bleeding
- Acetate toxicity
- Hypoxemia
- Hypothermia
- Dialysis membrane hypersensitivity
- Vomiting/diarrhea
- Decreased oral intake
- Hypo-osmolality
- Electrolyte disorders

To add fluid or not to add fluid

- Based more on physical exam
  - Does the patient look and act wet
  - Does the patient look dry
  - What about blood pressure

edema

- Look at lower extremities
- Look at presacral area for bed bound patient

sepsis

- Always consider sepsis in dialysis patients with AMS, hypotension
  - Especially with a catheter
  - May have UTI
  - Skin infections

  - Second leading cause of death in dialysis patients

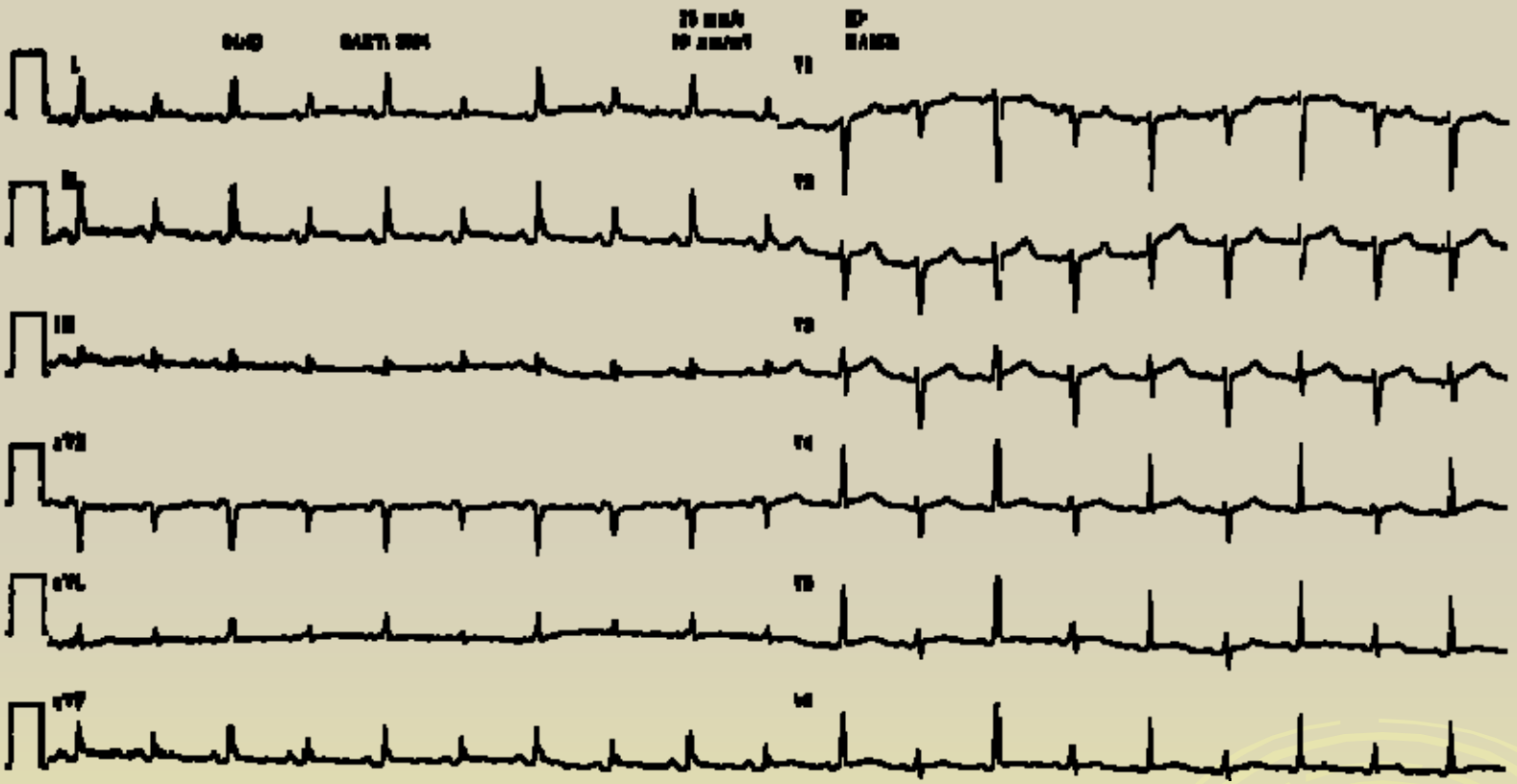
Uremic Pericarditis

- Chest pain
- Pericardial friction rub present on initial presentation in 90%
- May present as cardiac tamponade with volume depletion

Cardiac Tamponade

- Major complaint – dyspnea
  - Physical exam
    - Tachycardia, tachypnea with signs of low cardiac output
    - Pulse paradoxus
    - Jugular venous distension
  - EKG
    - Reduces QRS voltages
    - Electrical alternans
  - Treatment
    - Volume (Frank Starling)

Electrical Alternans



embolus

- Air or foreign body
  - Chest pain
  - Dyspnea
  - Hypotension
  - Diaphoresis
  - Confusion
- Treatment
  - Oxygen
  - Left lateral decubitus in trendelenburg

Withdrawl

- Dialysis is effective to remove some toxins/medications
  - EtOH
  - Anticonvulsants

hypoglycemia

- Be careful in treating a low sugar with OJ
  - Can lead to next slide
- Pts are typically fluid and food restricted to avoid volume overload, hyperkalemia and hyperphosphatemia.

Hyperkalemia

- Causes
  - Excessive dietary intake of K^+
  - Missed / ineffective dialysis
  - Severe acidosis
  - Rhabdomyolysis
  - Acute hemolysis
  - Drug Effects

Shift of K^+ from cell

- May be associated with acidosis
  - K^+ switches with H^+ . This action improves the acidosis but can make patient hyperkalemic.

Hyperkalemia symptoms

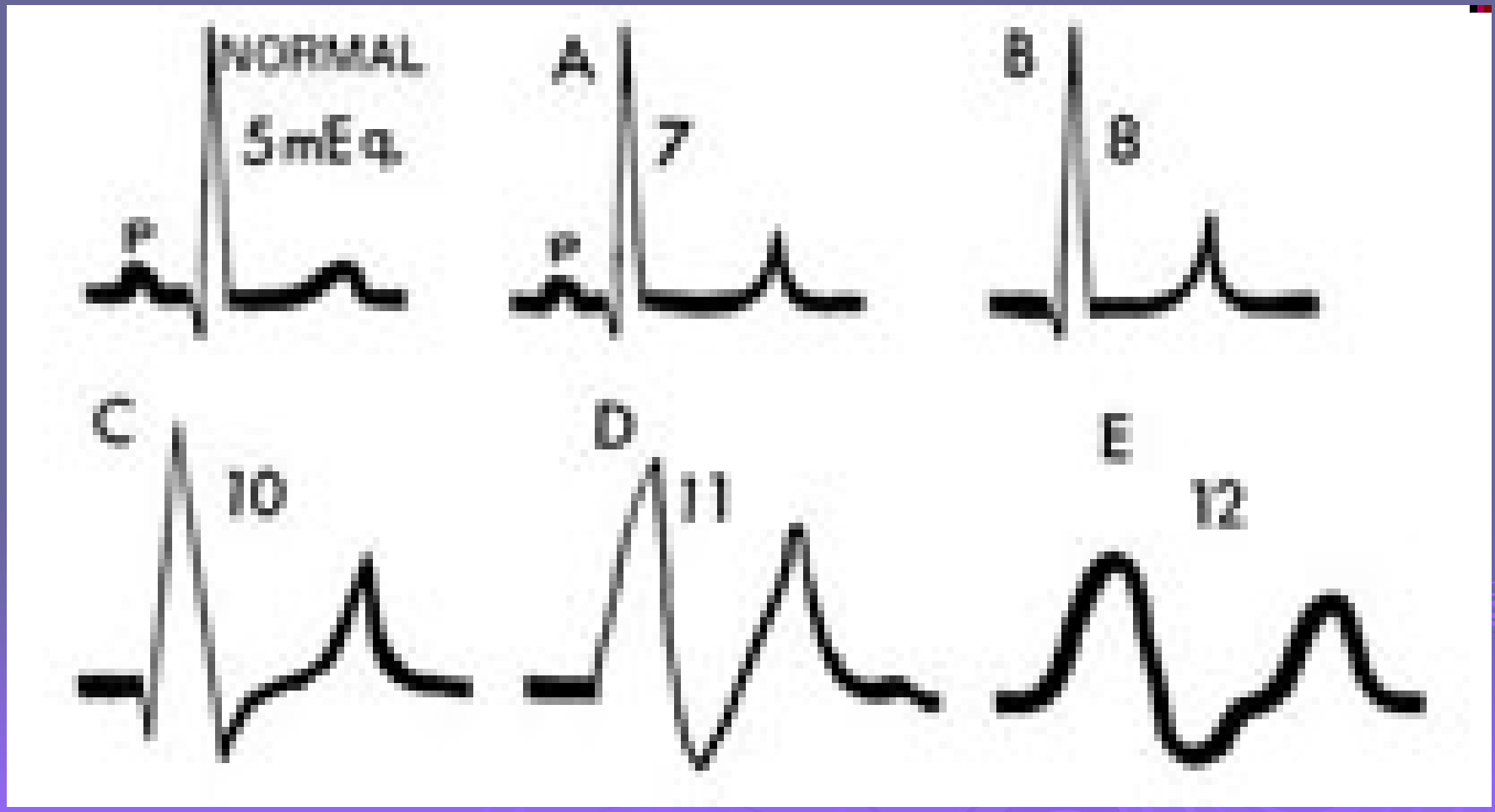
- Dysrhythmia
- Muscle weakness
- Hypotension
- Abdominal distention
- Diarrhea

- Fortunately dialysis patient are more tolerant of K+ changes

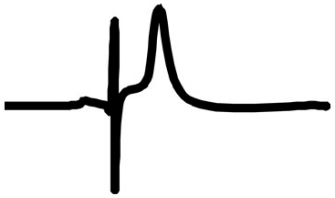
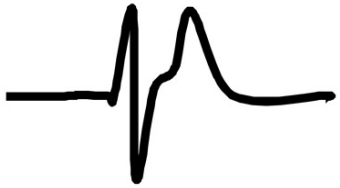
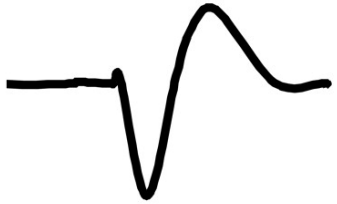
Hyperkalemic EKG changes

- Tall, narrow-based T waves (Best seen in II, III, V2, V3)
- PR interval prolongation
- ST segment depression
- QRS widening
- Atrial standstill
- Sine wave QRS complex
- V-Fib
- Asystole

Hyperkalemia EKG changes



Electrocardiographic (ECG) manifestations of hyperkalemia

Serum potassium	Typical ECG appearance	Possible ECG abnormalities
Mild (5.5-6.5 mEq/L)		Peaked T waves Prolonged PR segment
Moderate (6.5-8.0 mEq/L)		Loss of P wave Prolonged QRS complex ST-segment elevation Ectopic beats and escape rhythms
Severe (>8.0 mEq/L)		Progressive widening of QRS complex Sine wave Ventricular fibrillation Asystole Axis deviations Bundle branch blocks Fascicular blocks

Sood M M et al. Mayo Clin Proc. 2007;82:1553-1561

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Hyperkalemia Treament

- Three approaches to therapy
  - Antagonize K^+ effects on the heart
  - Drive K^+ into the cell
  - Remove K^+ from the body

Hyperkalemia treatment

- Calcium gluconate / Calcium chloride
  - Acts in 2-3 minutes, last < 1 hour
- Sodium bicarbonate
  - Works in 5-10 min
- D50 / Insulin
  - Works in 30 min
- Albuterol
  - Works in 15 minutes

Hyperkalemia treatment cont.

- Loop diuretic
  - May not work in dialysis patients
  - Works as soon as patient starts diuresis
- Sodium polystyrene sulfonate (Kayexalate)
  - Oral or rectal
  - Works in 1 – 2 hours
- Hemodialysis / peritoneal dialysis
- Hyperventilate if pt intubated (say what?)

Other electrolyte problems

- Hypokalemia
  - More likely due to vomiting / diarrhea
  - Arrhythmias
  - Can increase dig toxicity
- Hyponatremia
  - Intradialysis hypotension
  - Muscle cramps
  - Nausea and vomiting
- Hypocalcemia
  - Tetany, seizures
  - Dysrhythmias
- Hypercalcemia
  - Nausea, vomiting, constipation
  - Weakness
  - Altered mental status, seizures, coma

Questions to ask the dialysis nurses

- How much fluid did the patient have on
  - What is the pre-dialysis weight
  - What is the target weight
- How long was the patient on dialysis
- How low did the patient's blood pressure go
- What is the patient's temp

Summary

- Dialysis patient get sicker, quicker
- Do good assessments (History and PE)

- Think volume
- Think sepsis
- Think hyperkalemia

Where did I steal my information from

- Renal failure and Dialysis Patients: What EMS provider should know www.emsresponder.com accessed 9/18/2009
- Primer on Kidney Diseases 4th ed National Kidney Foundation c. 2005
- Current Medical Diagnosis and Treatment
- Handbook of Dialysis 4th Edition
- AHA Handbook of Emergency Cardiovascular Care 2005

Who is this?

Questions