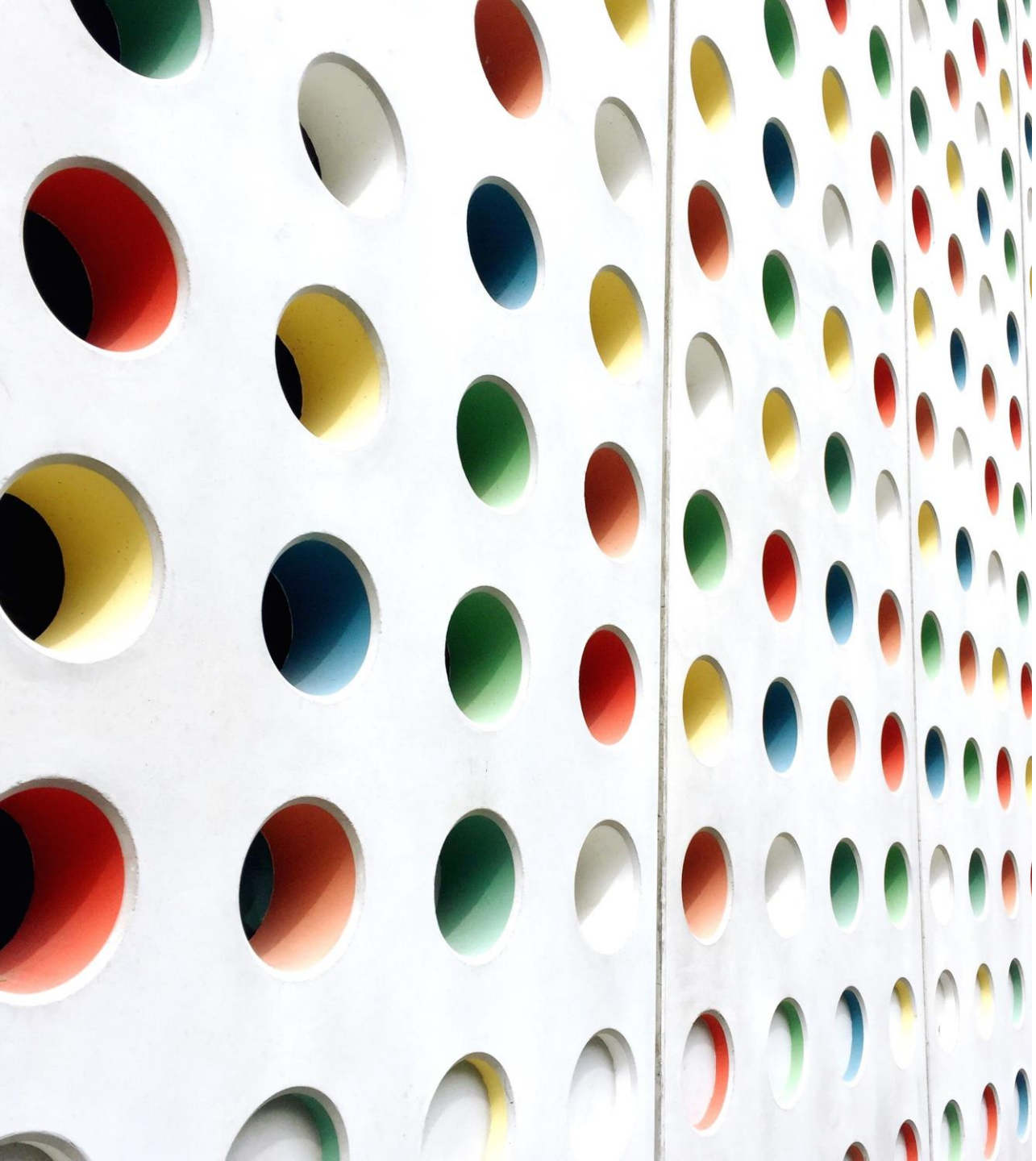

بسم الله الرحمن الرحیم



HEMODIALYSIS & COMPLICATION

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TECHNICAL ASPECTS OF HEMODIALYSIS

- Components used during a hemodialysis procedure:
  - Dialysis machine
  - Dialysis access
  - Supply of treated water in order to make dialysate
  - Dialyzer

- Dialysis machine consists of two major components:
  - (1) Blood pump and associated safety equipment for:
    - Blood pump to monitor pressures in the system
    - Ensure that air does not enter the blood circuit
  - (2) Dialysate pump, with associated safety devices to ensure that :
    - Dialysate is at the correct temperature
    - Has the correct concentration of electrolytes
    - Has not been exposed to blood from a leak in the dialyzer membrane

Dialysis Access

- Minimum blood flow rate that should be delivered is 300 mL/min
- Three different types of vascular access that can be used for HD:
  - **Arteriovenous (AV) fistula**, over a period of 4 to 8 weeks, fistula has matured—defined as a blood flow rate of at least 600 mL/min and a diameter of at least 6 mm
  - **Synthetic graft**
    - Surgical interposition of a synthetic blood vessel between an artery and a vein.
    - Grafts also have higher infection rates due to the presence of a foreign body
  - **Catheter**
    - At least desirable, because patients with this access have a higher rate of morbidity and mortality than do patients with either AV grafts or AV fistulas
- Preferred type of vascular access is an AV fistula.

Dialysate

- Physiologic solution that consists of both inorganic ions found in the body and glucose.
- Dialysate concentration of **Na** and **CL** is usually physiologic
- Concentration of **Mg** and **P** is usually less than physiologic to allow for removal of these substances on dialysis.
- **Bicarbonate** concentration is usually higher than the physiologic concentration to allow for the treatment of metabolic acidosis, which is common in patients undergoing dialysis.
- Typically, several different **K** and **Ca** concentrations are available so that rate of removal of these ions can be varied as clinical circumstances dictate.

Dialysate

Temperature	36.5°C; Low temperature (35–35.5°C) promote peripheral vasoconstriction and aid in hemodynamic stability during HD; s/e: cramps, chilling
Sodium (132–155 mEq/L)	Low Na: ↓ BP, IDWG (*Ren Fail* 2007;29:143); may cause cramps, N/V High Na: may stimulate thirst and ↑ IDWG Rapid Na reduction may cause cerebral edema Rapid Na rise may cause osmotic demyelination; safe correction limit is unclear: 15–20 (*Semin Dial* 2011;24:407) In severe hyponatremia CRRT with customized substitution fluid or postfilter hypotonic fluid may be considered (*CJASN* 2018;13:787)
Sodium profiling (modeling)	Higher dialysate Na (to allow for higher UF rate) → Lower dialysate Na Various profiles available: stepwise, linear, or exponential decline Stepwise profiling is effective (*Hemodial Int* 2017;21:312) s/e: potential Na loading → ↑ thirst and fluid intake with higher IDWG; a/w ↑ all-cause & CV mortality (*CJASN* 2019;14:385)
Potassium (0–4 mEq/L)	4: rarely used in advanced CKD 3: pre-HD K <4; 2: Pre-HD K 4–6 0–1: pre-HD K >6; a/w cardiac arrest (*KI* 2011;79:218; *CJASN* 2012;7:765)
Potassium profiling	Higher K initially → lower K later in treatment allows for gradual fall in serum K (*JASN* 2017;28:3441) with less K gradient (*NDT* 2018;33:1207)
Calcium (2–3.5 mEq/L)	2.5: typical 3.0–3.5: hypocalcemia in hungry bone syndrome after parathyroidectomy 2.0: hypercalcemia; a/w low BP, sudden cardiac death (*CJASN* 2013;8:797)
Bicarbonate (30–40 mEq/L)	35: typical; adjust to have pre-HD HCO3 level 21–22 (*AJKD*

Determines the rate of toxin removal

- Rate of toxin removal is traditionally measured by the removal of urea.
- Removal of urea during the hemodialysis session is increased by any of these factors:
  - **Higher blood flow rate and dialysis flow rate:** The higher the blood flow rate, the more urea diffusion that will occur per unit tim
  - **Higher efficiency of the dialyzer:** A higher-efficiency dialyzer typically has a large surface area, a thin membrane, and increased porosity
  - **Longer time on dialysis:** The longer the time for a single dialysis treatment, the more urea diffusion will occur
  - **Frequency of dialysis:** The standard form of in-center hemodialysis is three sessions per week

First Three Hemodialysis Sessions

Low intensity to prevent dialysis disequilibrium; avoid UF >2 L for 1st session

Examples of First Three Sessions of HD Initiation				
	Time (hr)	Qb (mL/min)	Qd (mL/min)	Needle, Dialyzer
1st	1.5–2	150–200	400	17 G, Low K_oA dialyzer
2nd	2.5–3	250–300	500	16 G
3rd	3–4	300–350	600	15 G, High K_oA dialyzer

COMPLICATIONS OF HEMODIALYSIS

- Most common complication of dialysis procedure is:
  - Hypotension prevalence 10% to 40%
- Intradialytic hypotension is often accompanied by:
  - Lightheadedness, Dizziness, Cramping, and Nausea.
- At times, there may be no symptoms until the patient's BP has dropped to very low, and potentially dangerous, levels.
- To help monitor for hypotension, BP is monitored during the dialysis treatment, usually every 30 to 60 minutes.

Treatments used to help minimize intradialytic hypotension

- Assessing dry weight on a regular basis
- Counseling the patient on:
  - Avoiding large fluid gains between dialysis treatments
  - Using a combination of a fluid-restricted and low-salt diet.
- Additional measures that may be beneficial include:
  - Increasing dialysis treatment time to decrease hourly ultrafiltration rate
  - Decreasing the dialysate temperature by 0.5°C to 2.0°C
  - Avoiding intradialytic food ingestion
  - Using midodrine (an alpha-adrenergic agonist) in patients who do not have active cardiac ischemia. Midodrine is ineffective if the patient is prescribed alpha-adrenergic blockers

COMPLICATIONS OF HEMODIALYSIS

- Other common complications include:
  - Cramping (5% to 30%)
  - Nausea and vomiting (5% to 10%)
  - Headache (5% to 10%)
  - Pruritus (1% to 5%)
  - Chest pain (1% to 5%)
  - Back pain (1% to 5%)
  - Fever and chills (,1%)

Table 51.3. Life-Threatening Reactions

REACTION	RISK FACTORS
Dialyzer reaction	See Question 30
Arrhythmias	Preexisting cardiovascular disease, hypotension, electrolyte imbalances, acidosis
Myocardial infarction	Preexisting cardiovascular disease, hypotension
Pericardial effusion	Recurrent or unexpected hypotension
Seizures	Severe hypertension, markedly elevated blood urea nitrogen levels
Intracranial bleeding	Preexisting vascular disease, hypertension
Hemolysis	Blood line obstruction/narrowing, problem with dialysate
Air embolism	Inadvertent air entry into the blood circuit

Anaphylactic Dialyzer Reactions &Treatment

- Type A or anaphylactic reactions and type B or nonspecific dialyzer reactions.
- Anaphylactic reactions:
  - Medical emergencies
  - Commonly manifested by:
    - Dyspnea
    - Feeling of warmth
    - Sense of impending catastrophe, and can be followed by cardiac arrest and death.
  - Milder symptoms include:
    - Watery eyes
    - Sneezing
    - Cough
    - Abdominal cramping
    - Diarrhea
    - Itching
    - Urticaria
  - Symptoms usually develop during first several minutes of dialysis, although symptoms can be delayed for more than 30 minutes.

Anaphylactic Dialyzer Reactions &Treatment

- There is a diverse etiology of anaphylactic reactions including :
  - Allergy to ethylene oxide (used to sterile dialyzers)
  - AN-69 dialysis membranes
  - Contaminated dialysis solutions
  - Heparin or dialyzer reuse

- Management :
  - Stop dialysis immediately
  - Clamp the blood lines
  - Disconnect the patient from the dialysis circuit
  - Discharge the blood lines and dialyzer without returning the blood to the patient.

- The patient may need emergency treatment for anaphylaxis if the reaction is severe. Avoidance of the offending agent is needed to prevent recurrent reactions.

Anaphylactic Dialyzer Reactions &Treatment

- Type B reactions:
  - Usually much less severe than type A reactions
  - Usually manifested by chest or back pain
  - Onset 20 to 60 minutes after the start of dialysis
- Management of type B reactions is supportive; consideration should be given to using a different dialyzer to prevent in the future.

Hemolysis During Hemodialysis

- Acute hemolysis is a medical emergency and can result from:
  - Problems with the blood tubing or needles
  - Problems with the dialysate
  - Any obstruction or narrowing of the blood line, as a result of kinks, manufacturing defects
  - Use of small-gauge needles in the presence of high blood flow rates, can cause hemolysis
  - Dialysate that has an incorrect electrolyte concentration, is too hot
  - Dialysate contaminated with chemicals also can cause hemolysis. Contaminants include:
    - Chloramine added to the city water supply
    - Formaldehyde or bleach used to reuse dialyzers
    - Inadequate water treatment resulting in the presence of fluoride, nitrate, zinc, or copper.

Manifestations of Hemolysis & Treatment

- Hemolysis may be suspected if:
  - Blood in the venous line is port wine in color
  - Plasma is pink in centrifuged samples
  - Marked drop in hemoglobin without an obvious source of bleeding.
- If hemolysis is suspected:
  - Dialysis session should be stopped immediately
  - Blood in the dialyzer and blood tubing should be discarded because it may have a **markedly elevated potassium level.**
  - Patients will need to be hospitalized to monitor the extent of hemolysis and to treat hyperkalemia.

Air embolism detected & Treatment

- Air embolism is a medical emergency that can lead to death if it is not recognized and promptly treated.

- Manifestations of air embolism depend on the positioning of the patient, and, thus, where the air embolism travels

- In seated patients, air enters the cerebral circulation, leading to central nervous system events, including loss of consciousness and death.

Air embolism detected & Treatment

- In recumbent patients, air enters cardiopulmonary system, leading to:
  - Dyspnea
  - Cough
  - Arrhythmias
  - Chest tightness
  - Acute cardiac and neurologic events.
- This emergency should be managed by:
  - Immediately clamping the blood line
  - Stopping the blood pump
  - Placing the patient in a recumbent position on the left side with the head and chest tilted downward
  - And administering 100% oxygen by mask or endotracheal tube.


TIME
TO SAY
GOODBYE