Complications during Hemodialysis

- The most common complications during hemodialysis are, in descending order of frequency,:
- hypotension,
- cramps,
- nausea and vomiting,
- headache,
- chest pain,
- back pain,
- and itching

INTRADIALYTIC HYPOTENSION

- can cause distressing symptoms,
- poor long-term outcomes
- increased risk of access thrombosis
- various definitions for IDH, including :
- nadir(lowest) systolic BP less than 90 mm Hg,
- fall in systolic BP of 20 or 30 mm Hg,
- nadir be most useful as this has the strongest association with increased mortality

Causes of Intradialytic Hypotension

- **1-Volume-related**
- a. Large weight gain (high ultrafiltration rate)
- b. Short weekly dialysis time (high ultrafiltration rate)
- c. Excessively low target (“dry”) weight
- **2. Inadequate vasoconstriction**
- a. High dialysis solution temperature
- b. Autonomic neuropathy
- c. Antihypertensive medications
- d. Eating during treatment
- e. Anemia

- **3. Cardiac factors**
- a. Diastolic dysfunction
- **4. Uncommon causes**
- a. Pericardial tamponade
- b. Myocardial infarction
- c. Occult hemorrhage
- d. Septicemia
- e. Dialyzer reaction
- f. Hemolysis
- g. Air embolism

IDH related to blood volume changes

- **Avoid large interdialytic weight gains**
- salt restriction
- **Increasing weekly treatment time**
- KDOQI 2006 recommend treatment time not be reduced below 3 hours (for thrice-weekly dialysis) in patients with little or no residual urine output, regardless of how high their *Kt/V*
- European Best Practice Guidelines recommend : 4 hours of therapy should be provided for all patients on a three-per-week regardless of body size

- Increasing dialysis frequency without increasing weekly dialysis time does not always reduce IDH,

- in one study the degree of myocardial stunning was reduced with short daily hemodialysis

- **Maintaining and increasing urinary volume**
- diuretic therapy
- **Choose target weight carefully**
- Bioimpedance devices, measurement of serum atrial natriuretic factor levels, and pulmonary ultrasound
- **Use an appropriate dialysis solution sodium level**
- Dialysis solution sodium level is less than that of plasma causing an acute reduction in the blood volume
- Higher dialysis solution sodium levels limit the reduction in blood volume
- but increase IDWG, blood pressure, and post dialysis thirst.

- sodium modeling (or sodium gradient dialysis):
- High dialysis solution sodium early in treatment (145–155 mM)
- with a progressive fall (linear, step, or logarithmic) to lower levels (135–140 mM) at the end of treatment
- But Uncertain benefit
- “individualized” dialysis solution sodium :
- high dialysis solution sodium (>142 mmol/L) may benefit frail patients

at high risk for IDH

Hypotension related to lack of vasoconstriction

- **Lower dialysis solution temperature:**
- 35.5°C–36.0°C are better initial choices
- individualizing dialysis solution temperature : tympanic membrane temperature is measured,and the dialysis solution temperature is set 0.5°C below this level.
- is associated with a shorter post dialysis recovery time,better maintenance of blood pressure, reduced myocardial stunning, and less evidence of progressive ischemia-related brain white matter damage

- Hemodiafiltration is associated with a better tolerance to ultrafiltration and less IDH than hemodialysis.

- due to the cooling effect of the replacement solution

- **Avoid intradialytic food ingestion in hypotension-prone patients:**
- "food effect"on blood pressure probably lasts at least 2 hours
- should avoid eating just before or during a dialysis session
- **Minimize tissue ischemia during dialysis:**
- Severe hypotension can therefore amplify itself: Hypotension → ischemia →adenosine release → impaired norepinephrine release →vasodilation → hypotension.
- patients with low hematocrit levels (e.g., <20%–25%) are very susceptible to dialysis hypotension
- **Use of nasal oxygen**

- **Midodrine:**
- orally acting α-adrenergic agonist,
- reduces the frequency of IDH
- 10 mg orally
- 1.5–2 hours before a dialysis session
- use of as much as 40 mg has been reported
- Active cardiac ischemia(but not simply coronary artery disease) is a contraindication.
- Concomitant use of α-adrenergic blockers renders midodrine ineffective.
- its effect does not seem additive to that of using cool dialysate

- **Sertraline**:
- 4 to 6 weeks of therapy with the selective serotonin reuptake inhibitor sertraline reduces the frequency of IDH
- improves autonomic function
- Like midodrine, sertraline was not shown to give added protection against IDH when cool dialysate

- **Antihypertensive medication**:
- those with vasodilatory properties are more problematic
- **Dialysis fluid potassium level**:
- low concentration (1 mEq/L) of dialysis fluid potassium is associated with more frequent IDH, perhaps via autonomic effects.
  Fludrocortisone:
- In low random aldosterone levels with low pre dialysis blood pressures and refractory IDH with normal cosyntropin test
- no improvement with fludrocortisone in normal levels of adrenal hormones

- **Vasopressin:**
- in dialysis patients, the Vasopressin increase is often suboptimal.
- Vasopressin constricts splanchnic vessels,
- such constriction may help to redistribute blood volume centrally during fluid removal

Hypotension related to cardiac factors

- **Diastolic dysfunction:**
- is common in dialysis patients
- using verapamil as an antihypertensive agent may reduce the frequency of IDH in such patients
- **Dialysis solution calcium** :
- 1.75 mM increases cardiac contractility and helps maintain intradialytic blood pressure better than a level of 1.25 mM, especially in patients with cardiac disease
- in the chronic setting use of high dialysis solution calcium levels may contribute to vascular calcification,
- magnesium levels may impact dialysis hypotension

Detection of hypotension

- Blood pressure must be monitored on a regular basis throughout the hemodialysis session

- Whether this is done hourly, half-hourly, or on a more frequent basis depends on the individual case

Management of the acute hypotensive episode

- is straightforward
- placed in the Trendelenburg position (if respiratory status allows this) and
- a bolus of 0.9% saline (100 mL or more,) should be rapidly administered through the blood line
- Ultrafiltration rate should be reduced to as near zero
- Ultrafiltration can be resumed (at a slower rate, initially) once vital signs have stabilized.
- an alternative to saline, glucose, mannitol, or albumin solutions can be used to treat the hypotensive episode;

- IDH may respond better to rapid administration of hypertonic saline than to slower administration of an equivalent sodium load administered as 0.9% saline;
- tonicity-induced increase in vasopressin levels is the likely basis for the differential effects

- Nasal oxygen administration is not generally of benefit during hypotensive episodes,
- though it may have value in selected patients

Strategy to Help Prevent Hypotension During Dialysis

- **1.** Use a dialysis solution temperature of 35.5°C or individualize and set dialysis solution temperature at 0.5°C below the patient's average predialysis tympanic membrane temperature.
- **2.** Review dietary sodium intake and any other reasons for excess fluid intake. Fluid intake should ideally be <1 L per day in anuric patients.
- If predialysis serum sodium is low, consider the level of dialysis solution sodium versus serum sodium.
- **3.** If substantial residual kidney function exists, consider increasing urine volume using diuretics.
- **4.** Extend weekly dialysis time if ultrafiltration rate is >13 mL / kg per hour.
- **5.** Consider raising the patient's target weight.
- **6.** In refractory cases, consider a trial of higher (140–145 mM) dialysis sodium, as tolerated, especially if a high IDWG is not a problem. If a high IDWG is present, consider cautiously lowering dialysis sodium level.

- **7.** Give daily dose of antihypertensive medications after, not before, dialysis ; change therapy to shorter-acting agents.
- **8.** Assess the benefits of a predialysis hemoglobin level consistently = 10–11 g/dL

(100–110 g/L).

- **9.** Do not give food or glucose orally during, or immediately preceding, dialysis to hypotension-prone patients.
- **10.** Consider use of a blood volume monitor.
- **11.** Consider a trial of midodrine or sertraline.
- **12.** Consider use of a higher (e.g., 3.0 mM) potassium dialysis solution if predialysis levels allow.

MUSCLE CRAMPS

- is more common during the first month of dialysis
- is more common in patients with a low cardiac index.
- **Etiology :**
- unknown.
- four most important predisposing factors are :
- hypotension,
- hypovolemia (patient below dry weight),
- High ultrafiltration rate (large weight gain),
- and use of low-sodium

- The frequency of cramping increases logarithmically with the weight loss requirements

- weight losses of 2%, 4%, and 6% have been associated with cramping frequencies of 2%, 26%, and 49%, respectively

- obscure elevations in serum creatinine phosphokinase levels on routine monthly laboratory tests
- Hypomagnesemia may cause treatment-resistant muscle cramping. Hypocalcemia should also be considered as a potential cause especially in patients treated with :
- relatively low-calcium dialysis solution (1.25 mM)
- and calciumfree phosphate binders
- and/or cinacalcet.
- Predialysis hypokalemia will be exacerbated by the usual level of dialysis solution potassium (2 mM) and may precipitate cramping as well

Management

- 0.9% saline
- Hypertonic solutions (saline, glucose, mannitol) may be more effective
- Hypertonic glucose administration is preferred
- Mannitol may accumulate in dialysis patients,
- Nifedipine (10 mg) sometimes can reverse cramping in hemodynamically stable patients
- Forced stretching of the muscle involved (e.g.,ankle flexion for calf cramping)
- Massage varies in its utility on an individual basis

Prevention:

- Prevention of hypotensive episodes
- 1. **Stretching exercises :**
- first-line treatment for both dialysis-related cramps and nocturnal cramps
- 2. **Dialysate sodium :**
- frequency of cramping is inversely related to the dialysis solution sodium level
- Raising sodium levels to just below the threshold for induction of
- postdialysis thirst
- use of sodium gradient dialysis not effective

- 3. **Dialysate magnesium:**
- Avoiding low pre dialysis levels of magnesium, calcium, and potassium in dialysis solution
- Magnesium supplements have not been shown to be useful in non uremic subjects and magnesium should be given with great caution to dialysis patients
- Osvaren (calcium acetate/magnesium carbonate) as a phosphate binder compared with sevelamer showed no change in the incidence of cramps

- 4. **Biotin:**
- 1 mg per day improve intradialytic cramps, despite baseline serum levels being higher than in control subjects
- 5. **Carnitine, oxazepam, and vitamin E.**
- oxazepam (5–10 mg, given 2 hours prior to dialysis)
- 6. **Compression devices**.
- 7. **Quinine**
- is now inadvisable because of its association with thrombocytopenia, hypersensitivity reactions, and QT prolongation

NAUSEA AND VOMITING

- **Etiology :**
- occurs in up to 10% of routine dialysis
- cause is multifactorial
- Most episodes in stable patients are probably related to hypotension
- early manifestation of the disequilibrium syndrome
- Both type A and type B varieties of dialyzer reactions
- Gastroparesis, very common in diabetes
- but also seen in nondiabetic patients,
- is exacerbated by hemodialysis

- Contaminated dialysis solution
- or incorrectly formulated dialysis solution (high sodium ,calcium)
- Dialysis patients appear to develop nausea and vomiting more readily than other patients (e.g., with an upper respiratory infection, narcotic usage, hypercalcemia)

Management

- first step is to treat any associated hypotension.

- Antiemetics

Prevention

- Avoidance of hypotension

- Persistent symptoms unrelated may benefit from metoclopramide single predialysis dose of 5–10 mg

ITCHING

- precipitated or exacerbated by dialysis
- Viral (or drug induced) hepatitis and scabies
- make sure that dialysis is adequate, and that a *Kt/V* of at least 1.2
- elevated serum calcium or phosphorus levels and/or substantially elevated parathyroid hormone (PTH) level

Management

- using antihistamines
- general moisturizing and lubrication the first line of therapy
- reductions in phosphorus, calcium (to the lower end of the normal range), and PTH levels
- *Kt/V* of at least 1.2(the evidence that higher *Kt/V* improves pruritus is not strong)
- Gabapentin (or pregabalin),
- UVB (ultraviolet light B) therapy,
- oral charcoal,
- or nalfuralfine might be the next line
- followed by naltrexone or tacrolimus ointment

DISEQUILIBRIUM SYNDROME

- **Definition**
- The disequilibrium syndrome is a set of systemic and neurologic symptoms
- often associated with characteristic electroencephalographic findings
- can occur either during or following dialysis
- Early manifestations include: nausea, vomiting, restlessness, and headache
- More serious manifestations include : seizures, obtundation, and coma

- **Etiology :**
- is controversial.
- it is related to an acute increase in brain water content.
- When the plasma solute level is rapidly lowered during dialysis, water shifts from the plasma into brain
- acute changes in the pH of the cerebrospinal fluid
- full-blown disequilibrium syndrome,including coma and/or seizures, can still be precipitated when an acutely uremic patient is dialyzed

Management

- **Mild disequilibrium.**
- blood flow rate should be reduced to decrease the efficiency of solute removal and pH change
- terminating the dialysis session earlier than planned
- Hypertonic sodium chloride or glucose solutions
- **Severe disequilibrium.**
- dialysis should be stopped.
- The management of coma is supportive.
- If coma is due to disequilibrium , then the patient should improve within 24 hours

Prevention

- **In an acute dialysis setting:**
- should not prescribe an overly aggressive treatment session
- The target reduction in the plasma urea nitrogen level should initially be limited to about **40%**.
- Use of a low-sodium dialysis solution(more than 2–3 mM less than the plasma sodium level) may exacerbate cerebral edema and should be avoided

- In hypernatremic patients : should **not** attempt to correct the plasma sodium concentration and the uremia at the same time
- initially with a dialysis solution sodium value close to the plasma level
- and then
- correct the hypernatremia slowly postdialysis by administering 5% dextrose

- **In a chronic dialysis setting :**
- use of a dialysis solution with a sodium concentration of at least 140 mM.
- symptom frequency to be similar with a dialysate glucose concentration of 200 versus 100 mg/dL

DIALYZER REACTIONS:

- In the past, many of these reactions were grouped under the term “first-use” syndrome because they presented much more often when new (as opposed to reused) dialyzers were employed
- similar reactions occur with reused dialyzers
- two varieties:
- an anaphylactic type (type A)
- a nonspecific type (type B)

Type A (anaphylactic type)

- **Manifestations :**
- a full-blown, severe reaction = manifestations are those of anaphylaxis.
- Dyspnea, a sense of impending doom, and a feeling of warmth at the fistula site or throughout the body
- Cardiac arrest and even death
- Milder cases may present only with itching, urticarial , cough, sneezing,
- Coryza , or watery eyes.
- Gastrointestinal manifestations, such as abdominal cramping or diarrhea,

- history of atopy and/or with eosinophilia are prone to develop these reactions
- usually begin during the first few minutes
- but onset may occasionally be delayed for up to 30 minutes or more
- **Etiology :**
- **Ethylene oxide**. used by manufacturers to sterilize dialyzers in the past
- Manufacturers currently use a variety of methods of sterilization (gamma radiation, steam, electron beam) , and when ethylene oxide is used, little residual compound is left in the dialyzers.
- now uncommon.

- **AN69-associated reactions.**
- In patients dialyzed with the AN69 (acrylonitrile-sodium methallyl sulfonate) membrane who were also taking angiotensin-converting enzyme (ACE) inhibitors
- The reactions are mediated by the bradykinin system
- negatively charged AN69 membrane activates the bradykinin
- ACE inhibitors block bradykinin inactivation
- Plasma bradykinin levels, higher
- The bradykinin effect should be less pronounced with angiotensin receptor blockers than with ACE inhibitors

- **Contaminated dialysis solution :**
- Dialysis solution contamination with high levels of bacteria and endotoxin, particularly with the use of high-flux dialyzers
- occur promptly(within 2 minutes) of initiating dialysis;
- complement mediated reactions are more delayed (15–30 minutes)
- Fever and chills are common symptoms
- **Reuse :**
- Often linked to inadequate dialyzer disinfection

- **Heparin:**
- occasionally been associated with allergic reactions, including urticarial , nasal congestion ,wheezing , and even anaphylaxis
- A trial of heparin-free dialysis or citrate anticoagulation should be considered
- Low-molecular-weight heparins are not a safe substitute owing to cross-reactivity with heparin

- Type A reactions tend to occur more readily in patients with mild to moderate eosinophilia

- due to sudden eosinophil degranulation with release of broncho constrictive and other mediators

Management

- stop dialysis immediately,
- clamp the blood lines,
- and discard the dialyzer and blood lines *without returning the contained blood*.
- cardiorespiratory support
- intravenous antihistamines, steroids, and epinephrine can be given.

Prevention

- For all patients, proper rinsing of dialyzers prior to use is important to eliminate residual ethylene oxide
- In a patient with a history of type A reaction to an ethylene oxide–sterilized dialyzer, the dialyzer type can be changed
- predialysis administration of antihistamines may be of benefit.
- Placing the patient on a reuse program
- Changing or stopping heparin,
- trying a less complement-activating membrane,
- and substituting an angiotensin receptor–blocking agent for an ACE inhibitor

Nonspecific type B dialyzer reactions

- principal manifestations of a type B reaction are chest pain, sometimes accompanied by back pain
- usually 20–40 minutes after starting dialysis
- much less severe than type A reactions
- Complement activation

- **diagnosis of a type B dialyzer reaction is one of exclusion**

Management

- is supportive
- Nasal oxygen should be given

- Myocardial ischemia and angina pectoris should be considered

- Dialysis can usually be continued
- **Prevention**: Trying a different dialyzer membrane may be of value