Complications of hemodialysis

Prof. Ashraf MA Bakr

Vice president for Students Affairs, Mansoura University

Prof of pediatrics, Mansoura Faculty of Medicine

Consultant, Pediatric Nephrology Unit, Mansoura University Children’s Hospital

Mansoura, Egypt
• The advance in technology and the delay in kidney transplant lead to the prolongation of period of hemodialysis in children with CKD and the emergence of many complications.
# Common complications

<table>
<thead>
<tr>
<th>Patient Complications</th>
<th>Technical Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hypotension (20-30%)</td>
<td>• Clotting</td>
</tr>
<tr>
<td>• Muscle Cramps</td>
<td>• Blood leak</td>
</tr>
<tr>
<td>• Disequilibrium Syndrome</td>
<td>• Power failure</td>
</tr>
<tr>
<td>• Nausea and Vomiting</td>
<td>• Hemolysis</td>
</tr>
<tr>
<td>• Headache</td>
<td>• Air Embolism</td>
</tr>
<tr>
<td>• Chest Pain</td>
<td>- Air in bloodlines</td>
</tr>
<tr>
<td>• Itching</td>
<td>• Exsanguination</td>
</tr>
<tr>
<td>• Fever and Chills</td>
<td>• Dialyzer reactions</td>
</tr>
<tr>
<td>• Pyrogen reaction</td>
<td></td>
</tr>
<tr>
<td>• Hypertension</td>
<td></td>
</tr>
</tbody>
</table>
Cardiovascular complications

- Intradialytic hypotension (IDH)
- Paradoxic (intradialytic) hypertension
- Cardiac arrhythmias
Cardiovascular complications

Adverse outcomes

- Intradialytic hypotension
  - Recurrent myocardial stunning
    - Myocardial fibrosis
      - Systolic dysfunction
        - Cardiovascular death
  - Intradialytic hypertension
    - Endothelial-cell dysfunction
      - Atherosclerosis
      - Arteriosclerosis
        - Ischemic heart disease
      - Left ventricular hypertrophy
        - Cardiovascular death
Cardiovascular complications

Adverse outcomes

Causes of Death on Dialysis

- Arrhythmia / Cardiac arrest: 40%
- Other cardiac: 3%
- Septicemia: 8%
- Other infection: 3%
- CHF: 3%
- CVA: 3%
- AMI and ASHD: 5%
- All other causes: 18%
- Withdrawal: 17%
Intradialytic hypotension (IDH)

20-30%
Intradialytic hypotension (IDH)

**Definition**

*KDOQI Clinical Practice Guidelines for Cardiovascular Disease in Dialysis Patients*

- A decrease in systolic blood pressure by $\geq 20$ mm Hg or a decrease in MAP by 10 mm Hg
- *associated with symptoms* that include: abdominal discomfort; yawning; sighing; nausea; vomiting; muscle cramps; restlessness; dizziness or fainting; and anxiety
Intradialytic hypotension (IDH)

**Signs & symptoms**

- Yawning
- Dizziness, headache, and fainting
- Pale skin
- Stiff neck
- Sweating and fever
- Shortness and shallow of breath
- Irregular heartbeat
- Diarrhea or vomiting
- Seizures
- Cramps
- Thirst, fatigue, and depression
Intradialytic hypotension (IDH)

Mechanisms

- Excessive fluid removal
  - Ultrafiltration rate $>0.35$ ml/min/kg
  - $>1.5$ l/h in a 70-kg patient
  - Decrease in plasma volume $>20$

- Reduced plasma refilling rate

- Reduced effective circulating volume

- Impaired vasoconstriction

- Intradialytic venous pooling

- Increase in core body temperature

- Anemia

- Patient-related factors
  - Autonomic neuropathy (e.g., diabetic, uremic)
  - Antihypertensive medications
  - Lack of appropriate rise in plasma norepinephrine ("sympathetic failure")
  - Decreased sensitivity of the renin-angiotensin and arginine-vasopressin systems
  - Food ingestion (splanchnic vasodilation)
  - Tissue ischemia (adenosine mediated)
  - Bacterial sepsis

- Dialysis-related factors
  - Acetate dialysate vasodilation (adenosine mediated)
  - Low dialysate sodium and/or ionized calcium concentrations
  - Complement activation (C3a and C5a mediated)
  - Cytokine generation (interleukin-1 and nitric oxide mediated)

- Hemorrhage

- Cardiac factors
  - Myocardial infarction
  - Structural heart disease
  - Arrhythmias
  - Pericardial tamponade

- Hemolysis

- Dialysis reaction

- Air embolism
Intradialytic hypotension (IDH)

Management

**BP pattern**
- <30 mm Hg BP ↓
- temporary or sustained

**Baseline IDH event treatment**
- Trendelenburg position
- IV fluid†
- decrease or zero UFR
- shorten treatment (TTT)

**Event: HD Prescription**
- (UFR, Dialysate: Na, Ca++, dialysate temperature)

**Symptoms**
- present*
- absent

**Patient Data**
- predialysis BP
- initial temperature
- medications status
- eating during treatment
- % interdialytic weight gain

**Subsequent treatment approach**
- adjust pre HD meds
- limit TUF and UFR (50 ml/kg, ≤3%)
- decide on Na modeling‡
- utilize UF profiling
- adjust Ca++ in bath
- determine “Hct threshold”
- adjust dialysate temp (cool: 35°C)
- add additional treatment/week
- work-up for ischemic risk

**Consider pharmacologic intervention§**

**Patient education¶**
- Consider IUF, HF, HDF, PD

* nausea, sweating, cramping, visual abnormalities, chest pain, etc.
† hypertonic saline, normal saline, hydroxyethyl starch, mannitol, albumin
‡ linear, stepwise, exponential
§ florinef, carnitine, pseudoephedrine, proamatine (midodrine), caffeine
¶ ↓ interdialytic weight gain, ↑ number of treatments or total treatment time
Paradoxical (intradialytic) hypertension

8-30% (no pediatric no.)

Definitions

- ↑MAP of ≥15 mmHg during or immediately post dialysis
- Hypertension during 2\textsuperscript{nd} or 3\textsuperscript{rd} hr of HD after significant UF removed
- ↑BP that is resistant to UF
“Optimal control of blood pressure in HD patients is via volume control NOT the use of antihypertensive agents”
Cardiac Arrhythmias

5-60%
VENTRICULAR ARRHYTHMIA

- **Triggers:**
  - Sympathetic hyperactivity
  - Electrolyte disturbances
  - Acid-base disorders
  - Uremic toxins
  - In HD: variation of fluids and electrolytes

- **Associated factors:**
  - Age
  - Desnutrition

- **Left Ventricular Hypertrophy**
- **Heart Failure**
- **Vascular Calcification**
- **Atherosclerosis**
Patients who suffered a cardiac arrest at the time of dialysis were twice as likely to be dialysed against a 0 or 1.0 mEq/l potassium dialysate compared to controls, despite no difference in pre-dialysis serum potassium levels but levels below 4.0 mEq/l or higher than 5.6 mEq/l were associated with increased mortality.
Prevention of sudden death in dialysis patients.

- Reduction of:
  - Cardiac hypertrophy & fibrosis
  - Fatal arrhythmia
  - Heart rate variability

- Avoiding low K dialysate & rapid electrolyte shifts:

- To avoid:
  - QT dispersion
  - Reentrant arrhythmias
  - Premature VES

- Prevention of sudden death

- External & implantable defibrillator

- Beta blockers

- To avoid:
  - Cardiac hypertrophy & fibrosis
  - Antifibrillatory activity
  - Ventricular arrhythmia
  - Heart rate variability
  - Increase in baroreflex sensitivity
  - Reduced risk of acute MI

ACEI and ARBs

Blood Purif 2010:30:135-145
Neuromuscular complications

- Dialysis disequilibrium syndrome
- Hemodialysis-associated seizure (HAS)
- Muscle cramps
- Hemodialysis-related headache
CNS disorder described in dialysis patients characterized by neurological symptoms of varying severity due to cerebral edema.
Risk factors

- 1st session hemodialysis
- Extreme age: child or aging
- High BUN level: > 125 mg/dl
- CNS disorder (stroke, tumor, dementia, hypo Na), head injury (subdural hematoma) ....

Seminars in Dialysis—Vol 20, No 3 2008 pp. 493–498
Dialysis disequilibrium syndrome

Pathogenesis

Paradoxical CSF acidemia

Organic osmolytes (idiogenic osmoles)
Clinical diagnosis: fatigue, mild headache, nausea, vomiting, disturbed consciousness, convulsions... coma.

Common mild...Self limited, fatal... if severe

Diagnosis

Clinical diagnosis (during HD, after HD) + risk factor Exclusion other condition
Prevention

Children starting chronic dialysis or patients with acute kidney injury

Slow and gentle HD to allow for the gradual reduction in plasma uremic toxin levels over a series of dialysis treatments.

- Dialyzers: smaller (less efficient)
- Dialysis time: 2 h
- Blood flow rate: 2–3 mL/kg/min
- Dialysate flow rate: maintaining the 2:1 dialysate: blood flow rate ratio.
- Fluid overload: Sequential HD (consider CRRT)
Children on maintenance HD suffering from recurrent episodes of DDS

Higher dialysate sodium concentrations: increase in dialysate Na linear or stepwise manner from 135–137 mmol/L to 142–148 mmol/L over the course of the dialysis session.

- The most evidence-based maneuver
- Counterbalance the rapid \( \downarrow \) in plasma osmolality from urea purification.
- May stimulate thirst causing \( \uparrow \) interdialytic weight gain and hypertension.
Hemodialysis-associated seizure (HAS)

Usually reported as generalized tonic-clonic seizures

7%–50%
Hemodialysis-associated seizure (HAS) 

Causes

- **Drugs**
  - Dialytic removal of anticonvulsants
  - Epileptogenic drugs: theophylline, meperidine (its toxic metabolite normeperidine), penicillin
  - Erythropoiesis-stimulating agents

- **Metabolic**
  - Hypocalcemia
  - Hypomagnesemia
  - Hypoglycemia
  - Hyperosmolarity caused by hypernatremia
  - Severe acid–base disturbance

- **Uremic encephalopathy**
- **Dialysis disequilibrium syndrome**
- **Hypertensive encephalopathy**
- **Cerebral anoxia due to sustained hypotension**
  - Cardiac arrhythmia
  - Hypersensitivity reaction
  - Sepsis
  - Hemorrhage

- **Other toxins**
  - Acute aluminum intoxication
  - Alcohol withdrawal

- **Focal neurologic disease**
  - Intracranial hemorrhage
  - Atheroembolism
  - Thrombotic microangiopathy
Hemodialysis-associated seizure (HAS) Prevention

Potential prophylactic use of benzodiazepines for hemodialysis-associated seizures

© IPNA 2000

Ferah Sönmez · Sevgi Mir · Sarenur Tütüncüoğlu

BRIEF REPORT
Mechanisms:
• Rapid ultrafiltration
• Intradialytic hypotension
• Tissue hypoxia

35-86% Lower extremities

Management of Cramps
• Minimize interdialytic wt gain & need for excessive UF, prevent dialysis hypotension, higher sodium dialysate, or sodium profiling.
• IV saline (normal or hypertonic); IV 50% dextrose are very effective (but saline will contribute to HPN & volume overload).
• Local massage offers some relief.
• Carnitine supplementation & quinine sulphate may help some pts. Quinine is best used 2 h before dialysis. Vitamin E (400iu).
• Some pts respond to diazepam, carbamazepine, amitriptyline, phenytoin, or alcohol.
Hemodialysis-related headache

5-10%
# Hemodialysis-related headache

## Diagnosis

<table>
<thead>
<tr>
<th>Diagnostic criteria of dialysis headache</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. At least 3 attacks of acute headache fulfilling criteria C and D</td>
</tr>
<tr>
<td>B. Patient is on hemodialysis</td>
</tr>
<tr>
<td>C. Evidence of causation demonstrated by at least two of the following</td>
</tr>
<tr>
<td>1. Each headache developing during a hemodialysis session</td>
</tr>
<tr>
<td>2. At least one of the following</td>
</tr>
<tr>
<td>a) Each headache worsening during the dialysis session</td>
</tr>
<tr>
<td>b) Each headache resolving within 72hr after the end of the dialysis session</td>
</tr>
<tr>
<td>3. Headache episodes cease altogether after successful KT and termination of HD</td>
</tr>
<tr>
<td>D. Not better accounted by another The International Classification of Headache Disorders, 3rd edition diagnosis</td>
</tr>
</tbody>
</table>
Inadequate dialysis
Hypotension
Early manifestation of CKD
Fluid and electrolyte changes
Non-dialysis causes
Dialyzer reactions

5-15%
Management of N&V, headache

- Treat & prevent hypotension
- **Antiemetics & paracetamol** may help if not precipitated by hypotension
- Reduction of BFR (by 25-30%) during 1st hr of HD sometimes useful (but overall dialysis time must be lengthened to maintain dose of dialysis)
- Use bicarbonate rather than acetate dialysis
Diagnostic criteria

1. Pruritus appears shortly before the onset of dialysis, or at any time, without evidence of any other active disease that could explain the pruritus.

2. More than or equal to three episodes of itch during a period of <2 weeks, with the symptom appearing a few times a day, lasting at least few minutes, and troubling the patient.

3. Appearance of an itch in a regular pattern during a period of 6 months, but less frequently than listed above.
1) Abnormalities stemming from renal failure/dialysis

Pruritogenic substances
- Uremic substances
- Elevated serum Ca and P
- Secondary hyperparathyroidism

Dialysis-related
- Activation of complements by hemodialysis membrane
- EOG sterilization
- Drugs such as heparin

Allergic reactions

3) Abnormalities of itch control involving the CNS

Endogenous opioids

C fiber elongation in skin
- Lowered itch threshold
- Skin hypersensitivity

Dry skin
- Decreased water content in corneal layer
- Diminished perspiration
- Depressed sebaceous gland secretion

Mediators for itching
- Histamine, Substance P
- Interleukin 1, 2
- Tryptase, TNF-α

2) Abnormalities of the skin
Pruritus in Hemodialysis Patients

Dryness without rash
- Moisturizer

Peripheral Type
- Use of antihistamine or anti-allergic drug considered depending on condition

Central Pruritus
- Accompanied by inflammation caused by dryness and scratch or dryness and secondary eczematization
- Opioid μ agonist (Nalfurafine hydrochloride)
- Opioid κ agonist

Scratch
- Histamine
- Anti-histamine
- Opioid μ receptor
- Opioid κ receptor
- Inhibit

Attempts at administering topical steroid by tapering from strong to weak or by dose reduction or discontinuation (Assessment of itching continued at 2-week intervals)
- Moisturizer
- Moisturizer + Nalfurafine
- Moisturizer

Subsequent assessment of itching made at 4-week intervals

Fig. 1 Treatment algorithms according to cause
Physical treatment

- Phototherapy
- Acupuncture
- Sauna
Dialyzer reactions
# Dialyzer reactions

<table>
<thead>
<tr>
<th></th>
<th>Type A Anaphylactic</th>
<th>Type B Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incidence</strong></td>
<td>Rare (max 5/100000 dialyses)</td>
<td>Common (3-5/100 dialysis)</td>
</tr>
<tr>
<td><strong>Onset</strong></td>
<td>Usually 1&lt;sup&gt;st&lt;/sup&gt; min. Up to 30 min</td>
<td>30-60min</td>
</tr>
<tr>
<td><strong>Symptoms</strong></td>
<td>Moderate-severe Anaphylaxis Itching, urticaria, cough, abdominal cramps, dyspnoea, burning collapse, death</td>
<td>Mild Chest pain, back pain</td>
</tr>
<tr>
<td><strong>Causes</strong></td>
<td>Ethylene oxide (previously common, now rare; patients often have IgE anti-ethylene oxide antibodies) ACE inhibitors and AN69 membranes (activation of bradykini system by membrane amplified by ACEI) Bacterial contamination of dialysis in high flux dialysis Reused dialyzers (bacterial contamination, endotoxin, unknown causes) Heparin allergy (rare) Acetate dialysate</td>
<td>Unknown Complement activation?</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Stop dialysis immediately Clamp lines and discard Cardiopulmonary resuscitation if necessary Intravenous antihistamines, steroids and adrenaline (SC/IM) if severe</td>
<td>Exclude other causes of chest pain Supportive O2 Continue dialysis</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>Can be fatal-seek cause</td>
<td>Symptoms usually resolve after 30-69 min</td>
</tr>
</tbody>
</table>
Hemodialysis is a necessary evil for many patients with ESRD, and one that is fraught with complications, with outcomes that are inferior to transplantation.

Hemodialysis is a life-sustaining procedure for the treatment of ESRD.

Although technical advances in hemodialysis (HD) have made the procedure increasingly safe and well tolerated, there are still important acute complications that will be encountered by physicians responsible for patients receiving HD in both acute and chronic clinical settings.

- IDH
- Cardiac arrhythmia
- HAS
- Cramps
- Vomiting & nausea
- Itching
- Dialyzer reactions
Complications of hemodialysis

• EARLY RECOGNIZE
• TRY TO PREVENT
• APPROPRIATELY TREAT
How Evil Are You?

Take This Quiz
Let's Take a Quiz
MCQ

1- Which of following statement is TRUE:

A. Parenteral infusion of hypotonic saline is effective in treating dialysis cramps
B. Cerebral edema is not a consistent finding is dialysis disequilibrium syndrome
C. Optimal control of blood pressure in HD patients is via volume control, not the use of antihypertensive agents
D. None of the above
2- If inter dialysis wt gain is >3%, the most prudent approach to ensuring patient safety is:

A. Scheduling him for additional session
B. Increase the UFR
C. Decrease dialysate Na
D. None of the above
3- Which of the following is minimally dialyzable or nondialyzable medications:

A. Angiotensin receptor blockers
B. Calcium channel blockers
C. Clonidine and carvedilol.
D. None of the above
Thank you!!