Hemodialysis Emergencies

Dr Reyhane Motamedi Fard

Assistant Professor of Nephrology

Isfahan University Of Medical Sciences

Hemodialysis Emergencies

- Dialyzer reactions and other allergic reactions
- Dialysis Disequilibrium Syndrome
- Uremic pericarditis/dialysis-associated pericarditis
- Air embolism
- Venous needle dislodgement
- Vascular access hemorrhage
- Hemolysis
- Dialysis water
- contamination

Introduction

- Hemodialysis (HD) is a life-sustaining treatment for patients with kidney failure and severe acute kidney injury (AKI)
- Complications can occur at any steps of HD which can range from mild to life-threatening

Case 1

- A 68-year-old woman with hypertension, diabetes, and (CKD) stage 5 is initiated on HD due to volume overload refractory to diuretic agents.
- Ten minutes into her first treatment, she reports generalized pruritus, dyspnea, and chest pain. She is noted to have audible wheezing.
- Her blood pressure is 86/50 mm Hg (compared to 145/90 mm Hg prior to the start of dialysis).
- A dialyzer reaction is suspected.

Question 1

What are the appropriate next steps in the management of this patient?

a) Continue dialysis and administer intravenous antibiotics
b) Continue dialysis and administer albuterol through a nebulizer
c) Continue dialysis and administer intravenous corticosteroids and antihistamines
d) Stop dialysis and return blood in the extracorporeal circuit back to the patient
e) Stop dialysis without returning blood in the extracorporeal circuit back to the patient

Dialyzer Reactions and Other Allergic Reactions

Hypersensitivity reaction to dialyzer membrane or membrane sterilization method

- Type A
- Type B

Dialyzer Reactions and Other Allergic Reactions

Type A:

IgE-mediated anaphylaxis to ethylene oxide, formaldehyde, or polysulfone dialyzer; or high bradykinin levels from ACEI use with AN69 membrane

Dialyzer Reactions and Other Allergic Reactions

Type B:

complement activation by cuporphane or polysulfone/ polyethersulfone membrane

Dialyzer Reactions and Other Allergic Reactions

Clinical Presentation

Type A:

pruritus, urticaria , laryngeal edema ,bronchospasm, dyspnea ,chest pain, vomiting ,hypoxia , hypotension, or cardiac arrest usually occurring within first 20-30 min of HD session

Dialyzer Reactions and Other Allergic Reactions

Type B:

chest pain, back pain, nausea, or vomiting; symptoms less severe than in Type A

Dialyzer Reactions and Other Allergic Reactions

Management/ Prevention

Type A:

stop dialysis without returning blood from circuit to patient; fluids, epinephrine, corticosteroids, antihistamines if indicated; use different dialyzer and avoid ethylene oxide sterilization; avoid ACEI with AN69 dialyzers

Dialyzer Reactions and Other Allergic Reactions

Management/
Prevention

Type B:

switch to a different dialyzer

Case 2

- A 75-year-old man with hypertension, diabetes, CKD, and history of ischemic stroke is initiated on dialysis for nausea, decreased appetite, and hyperkalemia.
- Scr= 10.1 mg/dL; serum urea nitrogen=170 mg/dL; Na=128 mEq/L; K=7.2 mEq/L; H2CO3=12 mEq/L; and BS=101 mg/dL.

Case 2

- duration of 2 hours, a blood flow of 400 mL/min, a dialysate flow of 800 mL/min, a standard sodium dialysate, and a target ultrafiltration of 2 liters, low-efficiency dialyzer
- He subsequently develops a seizure. Dialysis is stopped immediately

Question 2

How could the prescription have been modified to reduce the risk of dialysis disequilibrium syndrome?

a) Reduce ultrafiltration goal

b) Reduce dialysate sodium concentration

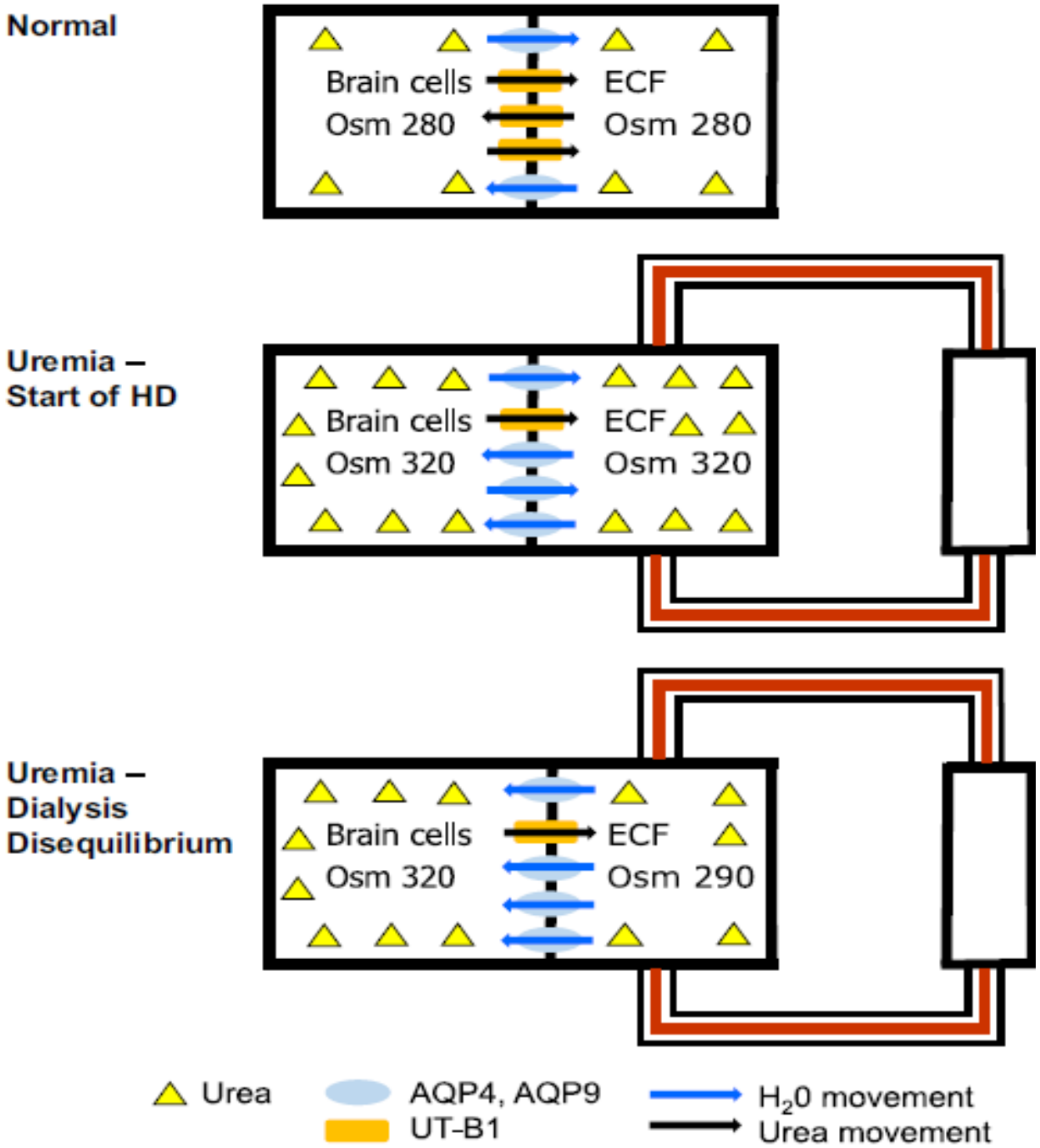
c) Reduce blood flow

d) Increase treatment time

Dialysis Disequilibrium Syndrome

Pathogenesis

Thought to be due to rapid reduction of serum osmolality relative to the CNS, which drives water into brain cells and results in cerebral edema


Normal
Brain cells
Osm 280
ECF
Osm 280
Uremia –
Start of HD
Brain cells
Osm 320
ECF
Osm 320
Uremia –
Dialysis
Disequilibrium
Brain cells
Osm 320
ECF
Osm 290
Urea
AQP4, AQP9
UT-B1
H20 movement
Urea movement

Dialysis Disequilibrium Syndrome

Clinical Presentation

Signs/symptoms:

headache,nausea/vomiting, confusion, agitation, seizures, coma, or death occurring during or soon after HD session

Dialysis Disequilibrium Syndrome

Risk factors

very high SUN	metabolic acidosis
first HD treatment	hyponatremia
Rapid SUN reduction	liver disease
extremes of age	pre-existing neurologic conditions

Dialysis Disequilibrium Syndrome

Management/ Prevention

Management:

stop HD, provide supportive care

Prevention:

avoid reducing SUN by more than 40% during a short period; initiate dialysis using low blood flow; consider using higher sodium dialysate; consider CKRT

Uremic pericarditis/ dialysis-associated pericarditis

Pericarditis in CKD patients has been classified

- Uremic pericarditis (defined as developing before or within 8 weeks of initiation of dialysis)
- Dialysis-associated pericarditis (defined as developing after 8 weeks on dialysis)

Uremic pericarditis/ dialysis-associated pericarditis

Clinical Presentation

Symptoms:

- pleuritic chest pain, fever, chills, dyspnea, cough, malaise

Signs:

- pericardial friction rub heard in most patients; diffuse ST-segment elevations rarely seen; echocardiogram with pericardial effusion; hypotension, tachycardia, pulsus paradoxus if tamponade present

Uremic pericarditis/ dialysis-associated pericarditis

Management/ Prevention

- Initiate HD for uremic pericarditis, intensify HD (daily for up to 10-14 d) for dialysis-associated pericarditis, avoid heparin with HD; do not dialyze if signs of tamponade
- Tamponade requires urgent intervention with pericardiocentesis (usually with drain placement) or pericardial window

Case 3

- A 70-year-old man starts HD with a non tunneled catheter for acute kidney injury occurring after coronary artery bypass surgery. He suddenly develops cough, hypoxia, and hypotension.
- Cardiac examination reveals a continuous murmur in systole and diastole.

Question 3

What is the most appropriate management step in addition to stopping HD?

a) Place patient on 100% oxygen

b) Start intravenous thrombolytic therapy

c) Start intravenous corticosteroids and antihistamines

d) Obtain echocardiogram

e) Place patient in reverse Trendelenburg position

Air Embolism

Pathogenesis

- Air enters bloodstream through dialysis circuit or through vascular access
- Causes include poor connection between arterial needle and circuit, defects in tubing in arterial portion of circuit, inadequate priming of dialyzer, improper medication administration, uncapped dialysis catheter, dialysis catheter placement/ removal

Air Embolism

Clinical Presentation

Air entering right heart/ pulmonary artery can cause pulmonary edema, hypoxia, cardiac arrest; a air in CNS can cause altered mental status, neurologic deficits, seizures, stroke, death

Air Embolism

Stop HD without returning blood from extracorporeal circuit, position patient supine, administer oxygen and (if needed) fluids and vasopressors

Air Embolism

Prevention

avoid very high blood flow rates

Venous needle dislodgement

Pathogenesis

Dislodgement of venous needle due to improper needle, poor cannulation technique, failure to secure blood lines, patient movement/needle removal; may go undetected if needles/blood lines are covered by blankets or other items or venous pressure alarm lower limit is too low

Venous needle dislodgement

Clinical Presentation

Blood loss, fatigue, pale skin, lightheadedness, shortness of breath, hypotension, cardiac arrest

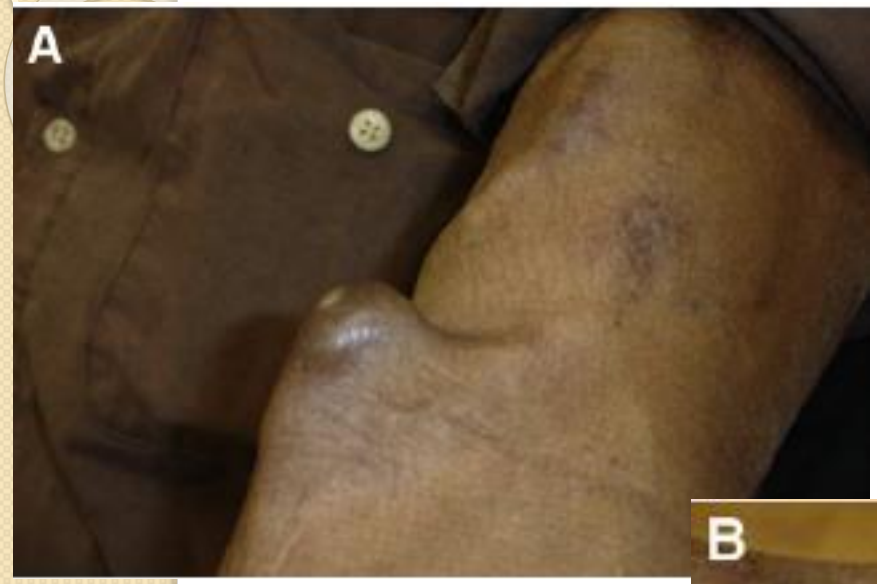
Venous needle dislodgement

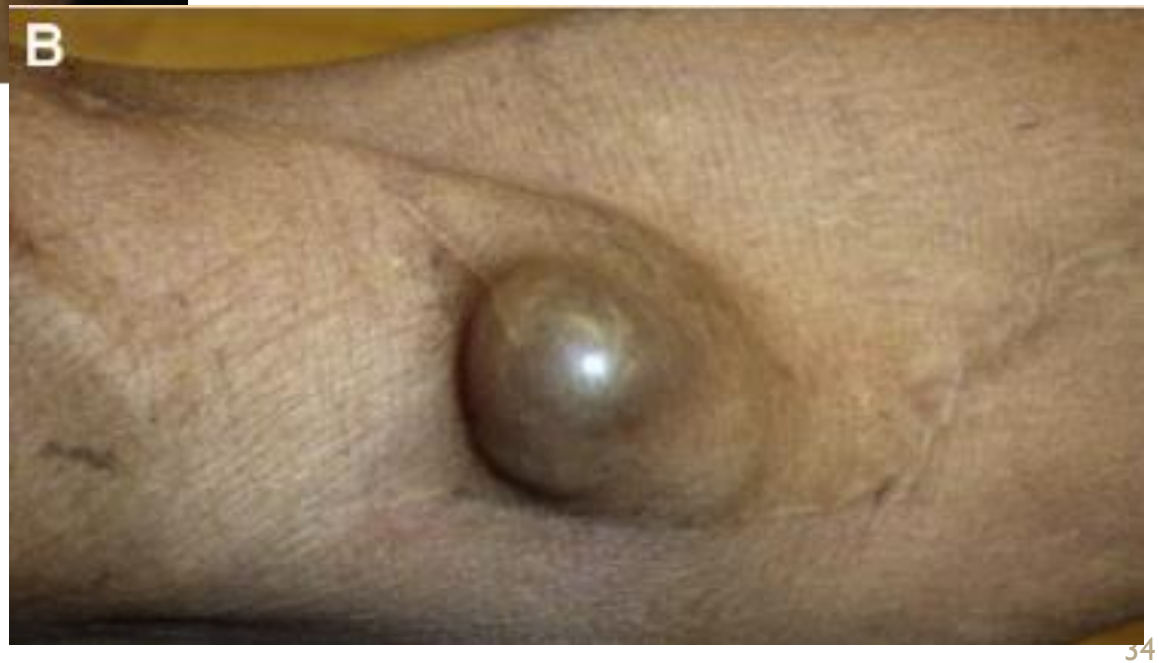
Transfuse blood, administer IV fluids and vasopressors as needed

Venous needle dislodgement

Secure needles and blood lines well and keep them visible at all times, monitor vascular access regularly, avoid adjusting venous alarm limits, consider blood leak detector

Vascular access hemorrhage





Vascular access hemorrhage

Rupture of AVF or AVG at aneurysm or pseudoaneurysm, CVC perforation, uncapped ports, disconnection from extracorporeal circuit, or accidental removal

Vascular access hemorrhage

Rapid blood loss, exsanguination

Vascular access hemorrhage

Apply direct continuous pressure to site; avoid tourniquets, blood pressure cuffs, and bandages; ligate ruptured AVFs/AVGs

Vascular access hemorrhage

Use proper cannulation technique (rope ladder); examine access regularly;

refer promptly to vascular surgeon

Case 4

- During a shift at a dialysis clinic, multiple patients develop abdominal pain, nausea, vomiting, and hypertension during their dialysis treatment. Examination of the extracorporeal circuit is notable for the blood having a cherry red color that is brighter than usual.
- The affected patients are transported to a local hospital where laboratory testing reveals hemoglobin levels ranging from 5-8 g/dL (compared to 10-11 g/dL previously) and mild to moderate hyperkalemia.

Question 4

Which of the following could have caused hemolysis in these patients?

a) Hypotonic dialysate

b) Kinked blood tubing

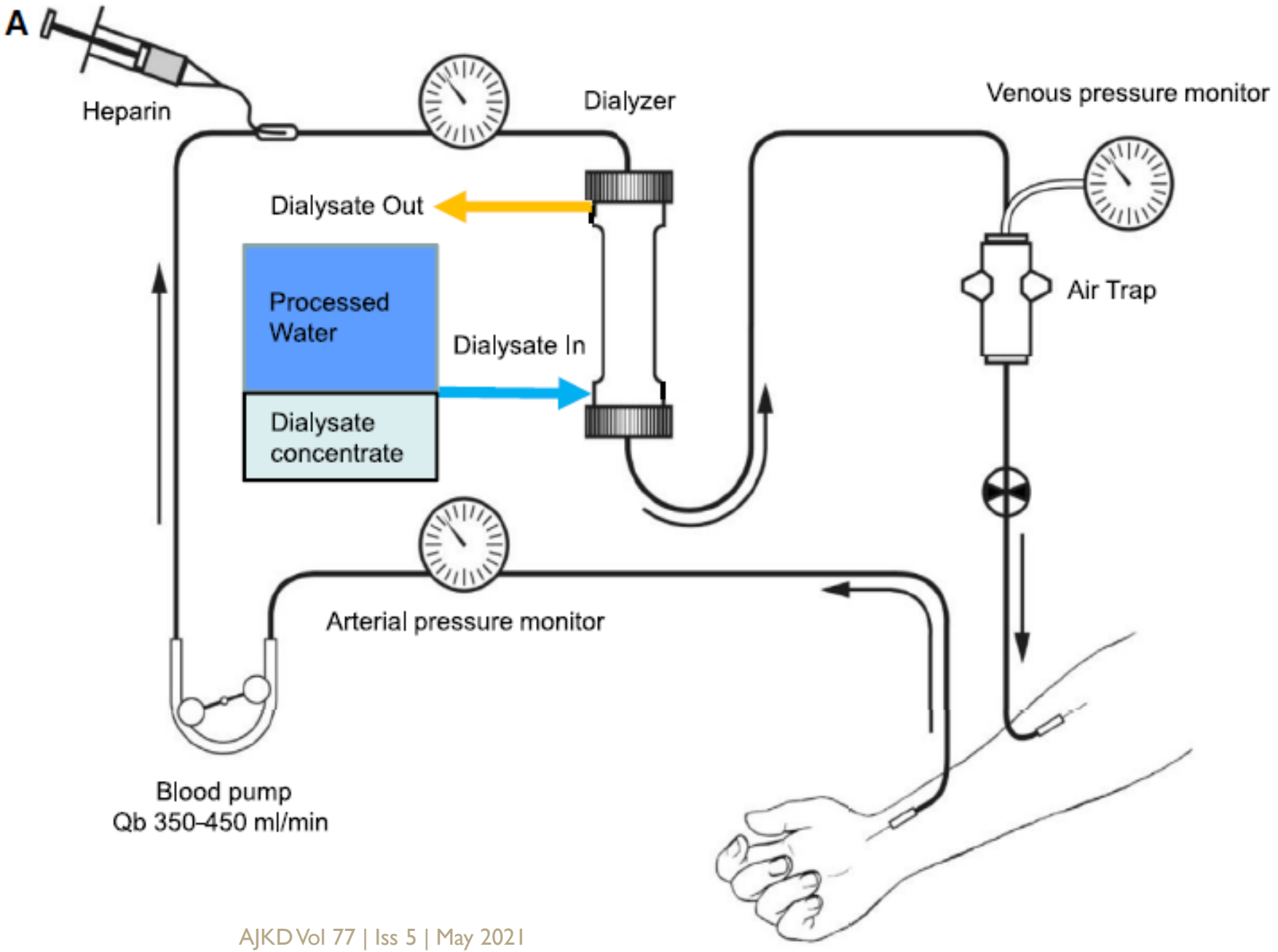
c) Chloramine exposure

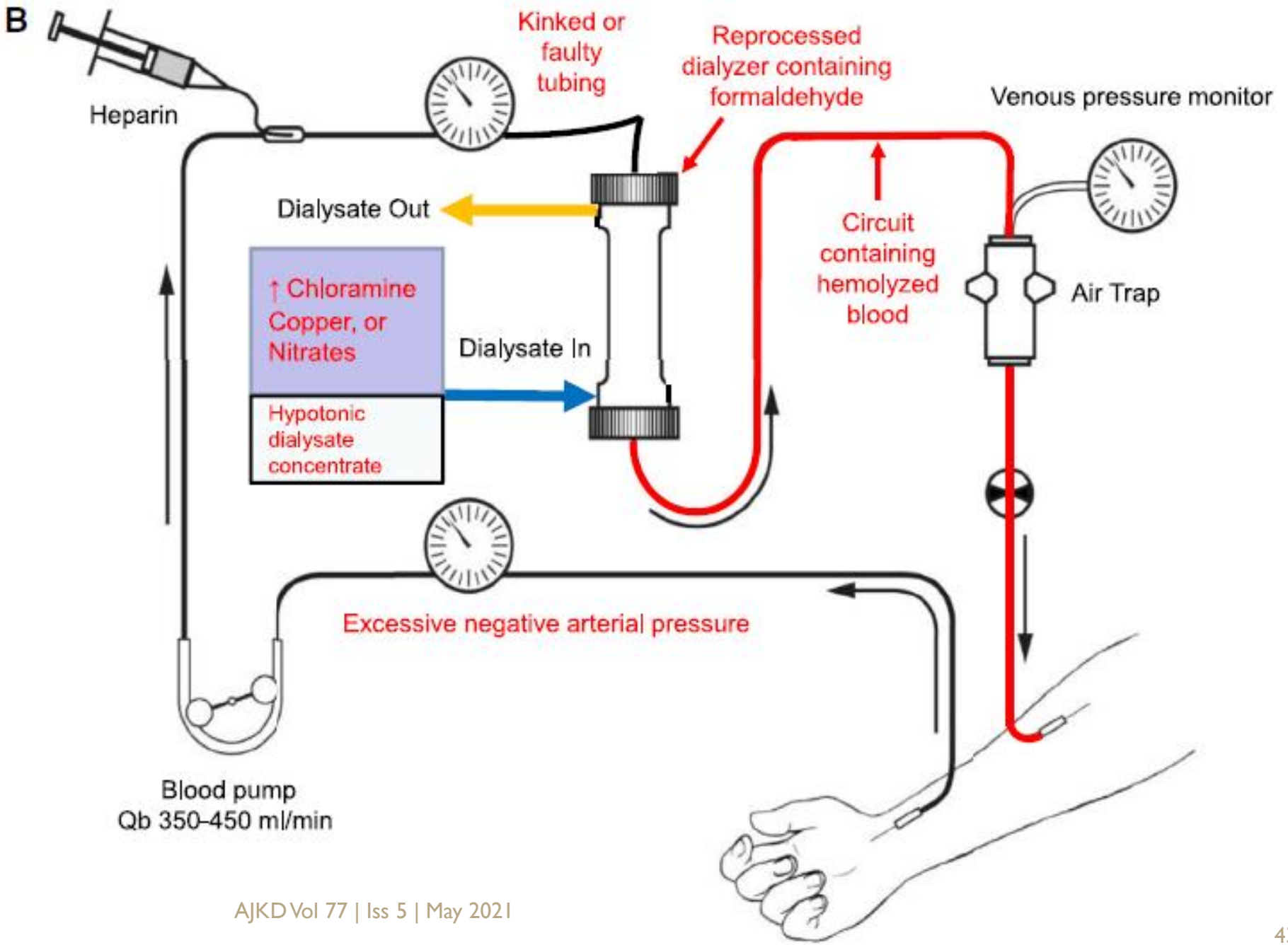
d) All of the above

Hemolysis

Pathogenesis

Red blood cell fragmentation due to high blood flow in smaller gauge needles, excessively negative arterial pressures, needle malposition, obstructed or kinked tubing, contamination of dialysate with chloramine, copper, or nitrates; exposure to formaldehyde, high dialysate temperature, hypotonic dialysate


A
Heparin
Dialyzer
Venous pressure monitor
Dialysate Out
Processed Water
Dialysate In
Dialysate concentrate
Air Trap
Arterial pressure monitor
Blood pump
Qb 350-450 ml/min


B
Heparin
Kinked or faulty tubing
Reprocessed dialyzer containing formaldehyde
Venous pressure monitor
Dialysate Out
↑ Chloramine Copper, or Nitrates
Dialysate In
Hypotonic dialysate concentrate
Circuit containing hemolyzed blood
Air Trap
Excessive negative arterial pressure
Blood pump
Qb 350–450 ml/min

Hemolysis

Signs/symptoms:

nausea, vomiting, diarrhea, abdominal/back/chest pain, dyspnea, chills, hypertension, arrhythmias, acute coronary syndromes, respiratory distress, severe necrotizing pancreatitis, death

Hemolysis

Clinical Presentation

Key features:

cherry red blood in extracorporeal circuit, pink serum due to free hemoglobin Laboratory findings: decreased hemoglobin and haptoglobin; increased LDH, bilirubin, and potassium

Hemolysis

Management

stop HD
without returning blood to patient, transfuse blood, dialyze for hyperkalemia

Hemolysis

Prevention

Follow protocols for monitoring water, HD machines, and HD circuit; use appropriate blood flow rates, avoid compression of tubing; if hemolysis occurs, thorough evaluation to identify cause

Dialysis water contamination

- The typical HD patient is exposed to more than 400 L of dialysate per week
- When 1 or more components of the water treatment system fail, or there is significant contamination of the water supply, the product water may be unsuitable for dialysis

Table 1. Components of Water Treatment Systems

Component[a]	Purpose/Mechanism
Pretreatment	
Temperature-blending valve	Control water temperature to ensure optimal function of reverse osmosis unit(s) by blending heated water with cold water
Multimedia depth filtration	Remove solid materials through filters that contain sand and/or coal
Activated carbon filter	Remove organic matter and chlorine/chloramine by adsorption
Softener	Remove calcium and magnesium ions by resin exchange
Water treatment	
Reverse osmosis	Remove organic and inorganic solutes by forcing water through a very tight membrane
Deionization	Remove inorganic ions by ion exchange using cationic and anionic resins
Ultraviolet	Kill bacteria through ultraviolet radiation
Endotoxin-retentive filter	Remove bacteria and endotoxin

Dialysis water contamination: chloramine, hydrogen peroxide

- Elevated chloramine levels can occur if the carbon tanks are exhausted or the chloramine level in the water supply exceeds the filtering capacity.

- For mild cases, monitoring of methemoglobin levels may be sufficient.
- For severe cases, methylene blue is the first-line therapy

Dialysis water contamination: fluoride

- Fluoride is removed by reverse osmosis and deionization.
- Fluoride toxicity in HD patients has occurred due to exhausted deionization resins and accidental overfluoridation of water at a water treatment plant

Dialysis water contamination: fluoride

- Signs and symptoms of fluoride toxicity :
  - pruritus, chest pain, nausea, vomiting, diarrhea, syncope, tetany, and ventricular fibrillation leading to cardiac arrest
- Fluoride binds to calcium and magnesium, causing hypocalcemia and hypomagnesemia.
- It also causes hyperkalemia, oxidative stress, cell cycle arrest, and apoptosis; the exact mechanisms are unknown

Dialysis water contamination: aluminum

- Exhausted deionization resins, high levels in water supply
- Acute aluminum exposure causes severe neurotoxicity, which can manifest as seizures, myoclonus, and encephalopathy.
- Treatment includes HD and chelation with deferoxamine.

Dialysis water contamination: copper

- Exhausted deionization resins, high levels in water supply (copper pipes)
- Copper intoxication manifesting as myalgias, abdominal pain, diarrhea, acidosis, pancreatitis, hemolysis, and methemoglobinemia
- Treatment includes supportive care, possible chelation

Dialysis water contamination: bacteria/endotoxin

- Contamination of dialysate with microorganisms can also cause serious complications
- Endotoxin is removed by reverse osmosis and by endotoxin filters
- Outbreaks of bacteremia or pyogenic reactions have occurred in the setting of dialyzer reuse

Arrhythmia

- Cardiac arrest and arrhythmia are the most common causes of death in kidney failure

Arrhythmia

Pathogenesis

Frequent exposure to proarrhythmic triggers, including:

rapid changes in serum potassium, changes in serum calcium, and metabolic alkalosis, occurring in the setting of coronary artery disease and structural heart disease

Arrhythmia

Bradycardia, asystole, atrial fibrillation
ventricular tachycardia/fibrillation

Arrhythmia

Management:

CPR

Prevention:

Avoid low potassium and low calcium dialysate, avoid metabolic alkalosis, limit UFR, lower dialysate temperature, consider frequent HD; consider pacemaker/ICD if indicated