

Common complications of hemodialysis

血液透析中常見併發症介紹

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Outline

- ◆ **Dialysis disequilibrium syndrome**
- ◆ **Cramps**
- ◆ **Intradialytic hypotension (IDH)**
- ◆ **Intradialytic hypertension**
- ◆ **Hyperkalemia**
- ◆ **Pericardial disease**
- ◆ **Hemolysis**
- ◆ **Thrombocytopenia**
- ◆ **Pulmonary hypertension**
- ◆ **Air embolism**
- ◆ **Dialysis membrane reaction**

DIALYSIS DISEQUILIBRIUM SYNDROME

不平衡症候群

Pathogenesis

- Rapid osmolytes and fluid removal
- Fluid shifts into brain cells

Clinical Manifestations

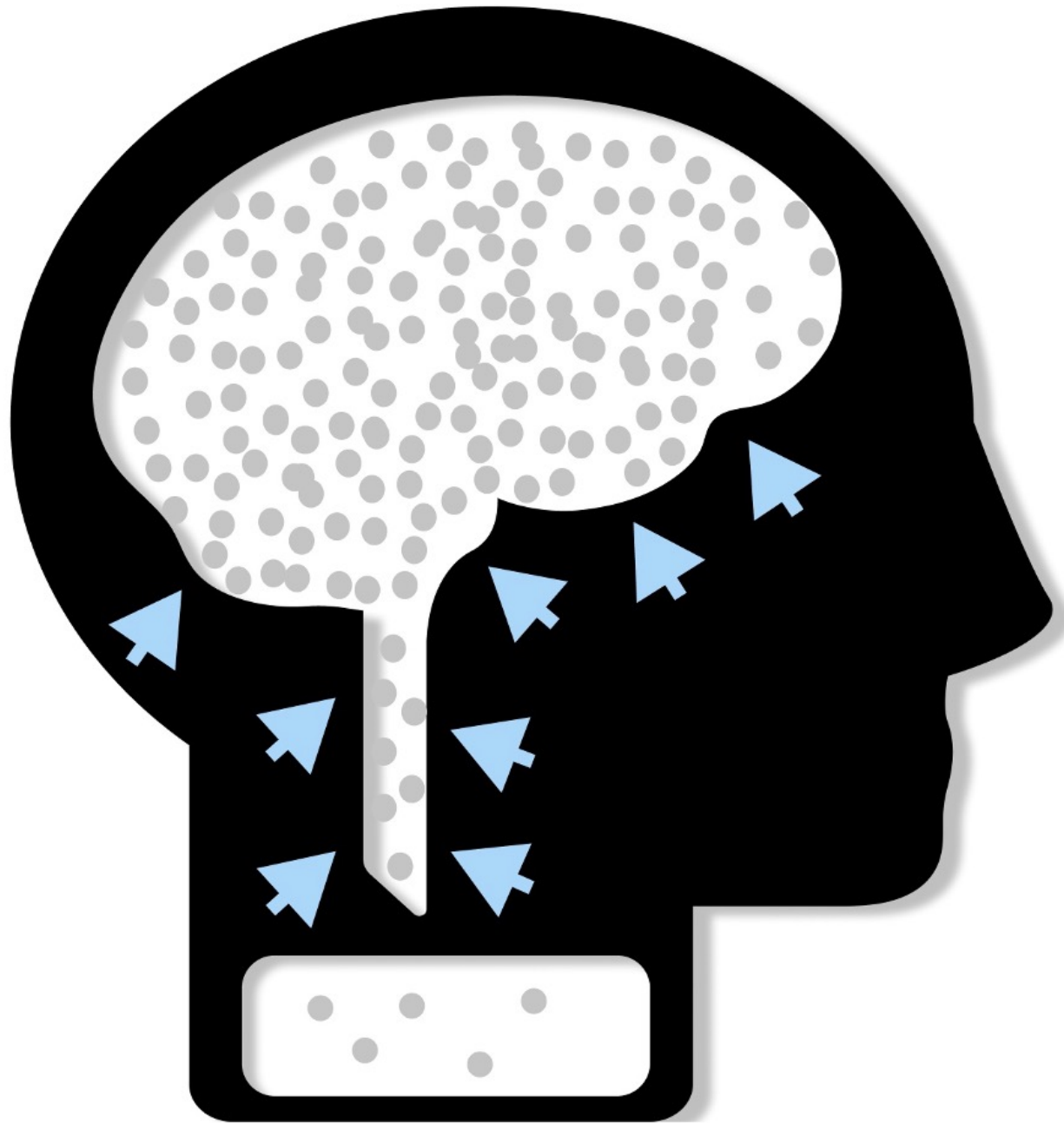
- Headache, nausea, blurred vision, confusion, seizures, coma
- MRI: demyelinating white matter injury

Risk Factors:

- high BUN, low bicarbonate
- brain injury (stroke, seizure, trauma), cerebral edema

Prevention

- Initial HD URR <30% with low Q_b, short treatment times
- Gradual uptitration of dialysis time
- Mannitol IV during first 1-3 HD session



Causes of Altered Mental Status in Dialysis Patients

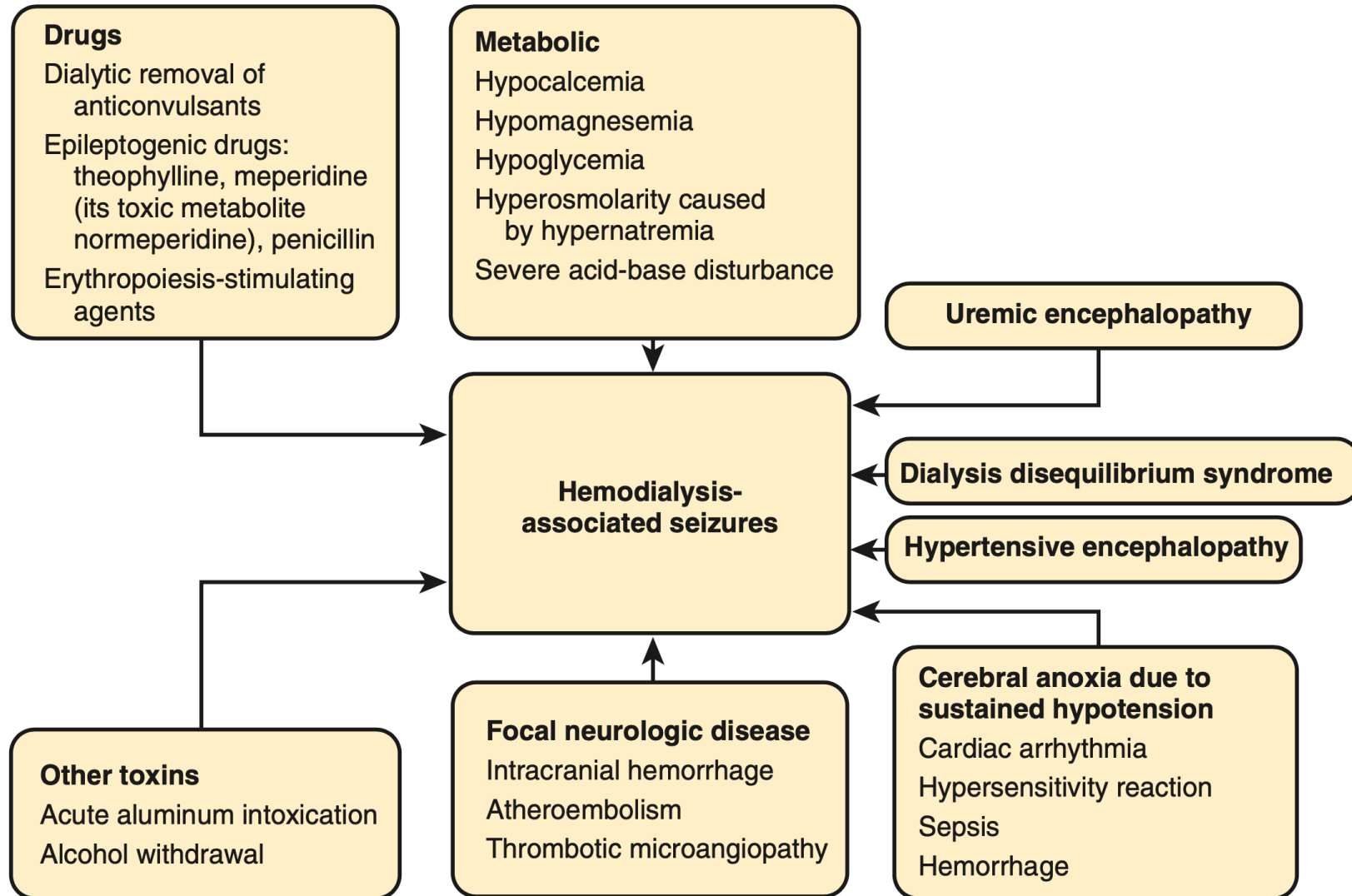
Structural Conditions

- Cerebrovascular accident (particularly hemorrhage)
- Subdural hematoma
- Intracerebral abscess
- Brain tumor

Metabolic Conditions

- Disequilibrium syndrome
 - Uremia
 - Drug effects
 - Meningitis
 - Hypertensive encephalopathy
 - Hypotension
 - Postictal state
 - Hyponatremia or hypernatremia
 - Hypercalcemia
 - Hypermagnesemia
 - Hypoglycemia
 - Severe hyperglycemia
 - Hypoxemia
 - Dialysis dementia
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Causes of hemodialysis-associated seizures



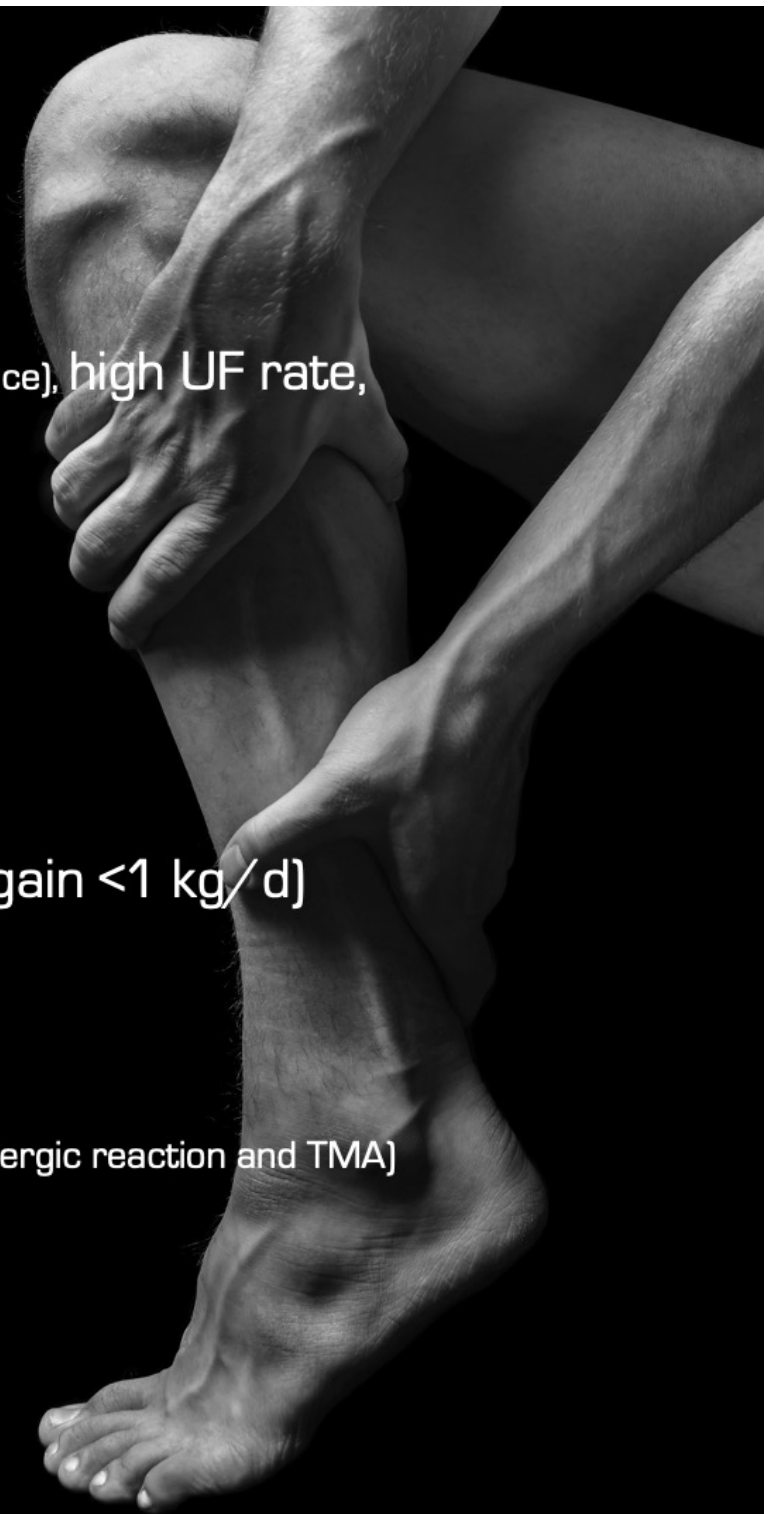
CRAMPS 抽筋

Causes:

- **High interdialytic weight gain** (dietary noncompliance), high UF rate, hypotension, hyponatremia, hypovolemia
- Carnitine deficiency
- cause of HD early termination

Treatment and Prevention

- N/S, 50% dextrose 25-50 mL
- Readdress DW, dietary counseling (weight gain <1 kg/d)
- Higher sodium dialysate or **Na modeling**
- dialysis time and/or frequency
- Vitamin E or **Carnitine**
- Not recommended : Quinine (may cause severe allergic reaction and TMA)



INTRADIALYTIC HYPOTENSION (IDH)

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Clinical Implication

- ↑ mortality , ↑ CV mortality
- Residual renal function loss , cerebral ischemia, access thrombosis
- **Myocardial stunning**: recurrent myocardial ischemia, regional wall motion abnormalities → fibrosis
- HD early termination → chronic hypervolemia → LVH, HF

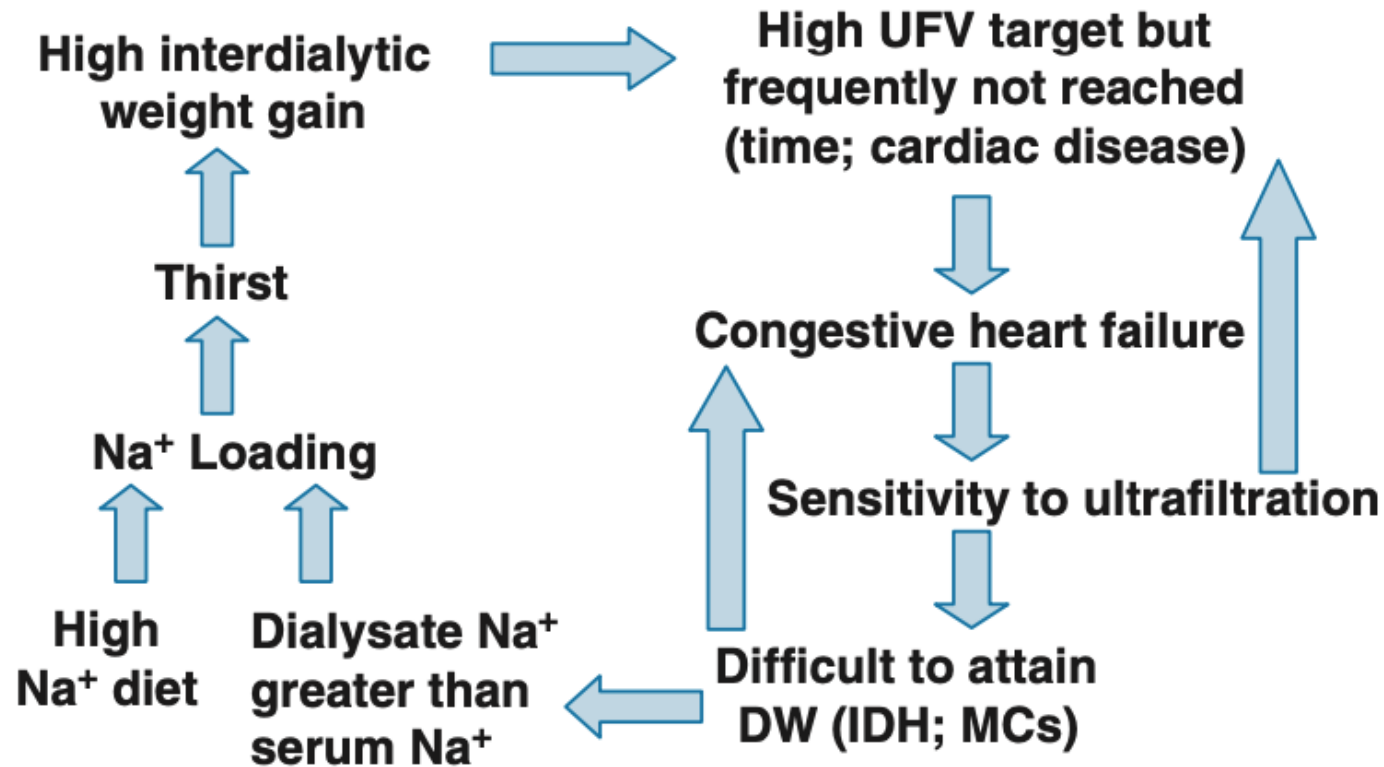
Causes

- Volume depletion, below dry BW
- High predialysis osmolality
- Dialysate: acetate, low Na, low Ca, high HCO: vasodilation
- Bleeding, distributive (sepsis, adrenal insufficiency), cardiogenic shock

Clinical Manifestation

- Asymptomatic
- Lightheadedness, N/V, cramps, hoarseness,
- **Vagal symptoms (yawning, sighing)**
- Stroke, myocardial and bowel ischemia

The relationship between salt, intradialytic weight gain (IDWG), and cardiac disease.



Risk Factors for Intradialytic Hypotension

Diabetes mellitus

Cardiovascular disease: left ventricular hypertrophy, diastolic dysfunction with or without congestive heart failure, left ventricular systolic dysfunction and congestive heart failure, valvular heart disease, pericardial disease (constrictive pericarditis or pericardial effusion)

Poor nutritional status and hypoalbuminemia

Uremic neuropathy or autonomic dysfunction

Severe anemia

High-volume ultrafiltration caused by high IDWG

Predialysis systolic blood pressure <100 mm Hg

Age 65 years or older

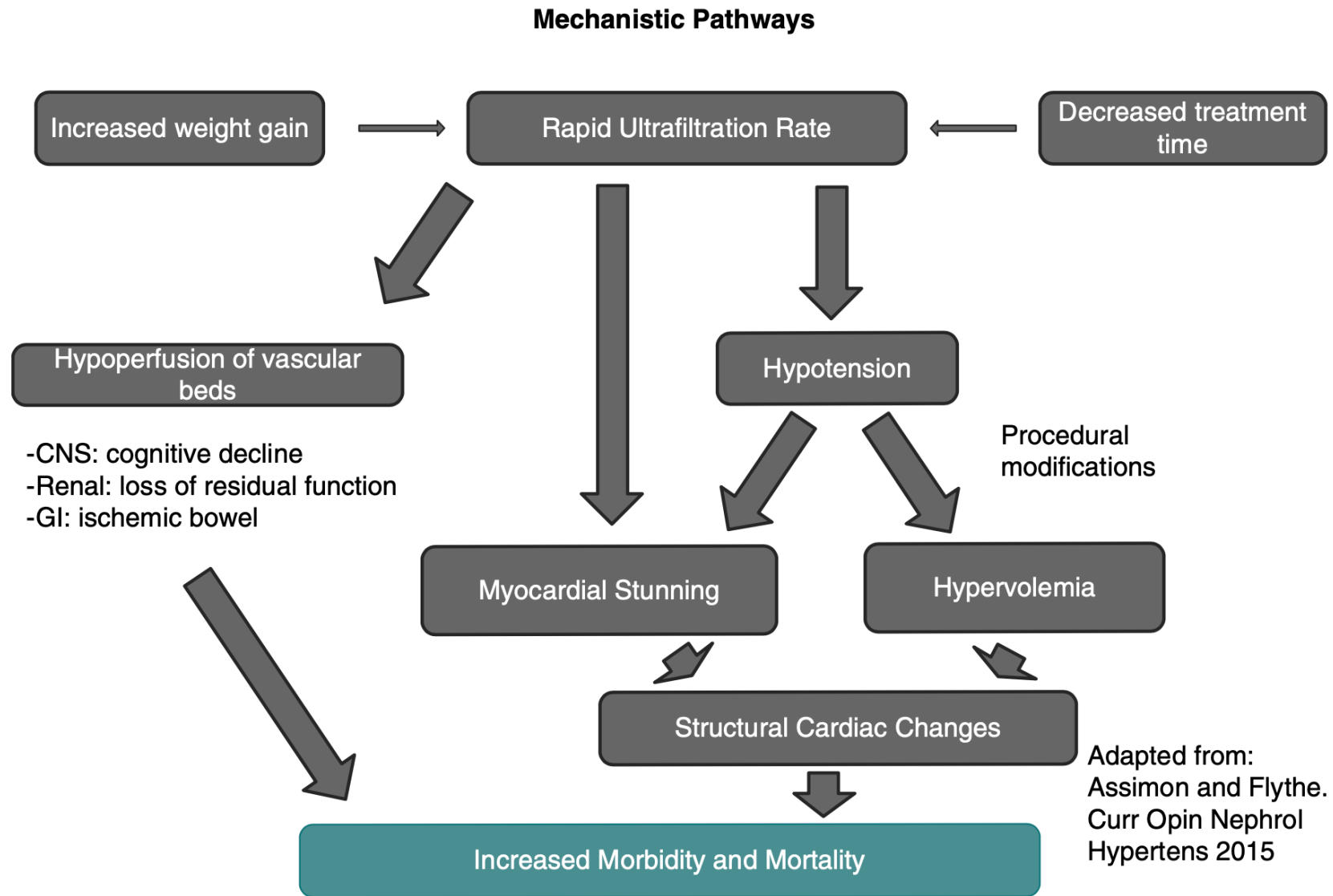
Female gender

Unrecognized dehydration, especially in patients losing weight rapidly

Differential Diagnosis of Hypotension in Hemodialysis Patients

Hypovolemia
Excessive fluid removal
Hemorrhage
Septicemia
Cardiogenic shock
Dysrhythmia
Pericardial tamponade
Myocardial infarction
Myocardial or valvular dysfunction
Electrolyte disorders
Hyperkalemia or hypokalemia
Hypercalcemia or hypocalcemia
Hypermagnesemia
Vascular instability
Drug-related
Dialysate-related
Autonomic neuropathy
Excessive access arteriovenous flow
Anaphylactoid reaction
Air embolism





Mechanistic pathway of myocardial stunning–associated morbidity and mortality.

Strategies to Prevent IDH

Ultrafiltration

↓UF rate , ↑dialysis time, additional HD session
Restrict fluid (<1 L/d) and Na intake
UF profiling/modeling
Reassess volume status

Osmolarity change

Na profiling/modeling: high Na dialysate
Sequential UF
Low Q_b

Vasoconstriction

Check antihypertensive
Dialysate **temperature** (35-35.5°C)
High **dialysate Ca**
Low dialysate bicarbonate
Midodrine: alpha1 agonist;
2.5-10 mg 15-30 min before HD; removed by HD;
Add additional small dose during HD; ↑ SBP of 12.4.
s/e: urinary retention, supine HTN

Others

Avoid food intake during HD
Manage anemia
Switch to PD
High predialysis BP does not prevent IDH

INTRADIALYTIC HYPERTENSION

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Clinical Implication

- Common: 21.3% HD session
- ↑ ambulatory BP
- ↑ Short-term mortality, hospitalization
- ↑ Long-term adverse CV events and death

Pathogenesis and Causes

- Volume overload: inadequate dialysis
- **Activation of the RAAS + SNS,**
- Removal of antihypertensives via dialysis
- High sodium dialysate
- High Na load from diet
- **ESA** ↑ endothelin-1; endothelial dysfunction

Management of Interdialytic Hypertension

Early ↓ **Target dry BW**
 BW reduction: ↓ 1 kg, ↓ SBP by 6.6, ↓ DBP by 3.3
 ↓ Dialysate Na
 Add Antihypertensives

Late Add or ↑ **nondialyzable RAAS inhibitor (ARB or fosinopril)**
 SNS blockade (α and β adrenergic blockade)
 Carvedilol 50 mg bid: ↓ ET-1 release



PERICARDIAL DISEASE 心包膜疾病

Cause

- Inadequate dialysis solute clearance > volume overload

Clinical Manifestations

- Dyspnea, pleuritic chest pain, fever, pericardial rubs
- Tachycardia, cardiac tamponade,

Workup

- Exclude other causes: infection, malignancy, autoimmune
- EKG: diffuse ST elevations, PR segment depression, low-voltage QRS
- Echocardiography

Treatment

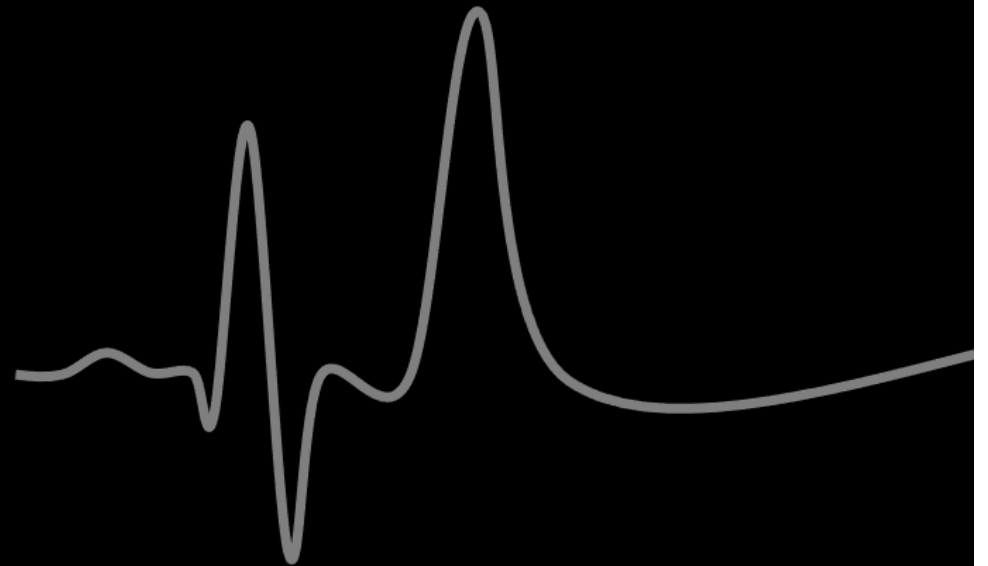
- Pericardiocentesis: tamponade, large effusions
- Intensive dialysis



HYPERKALEMIA 高血鉀

Background

- High pre-HD K \rightarrow mortality \uparrow
- Low K dialysate associate with **cardiac arrest**
- HD diffusive clearance is decided by serum-dialysis K gradient:
- HD pts have **more colonic K secretion** mediated by $\text{AII}/\text{aldosterone}$ [35% of daily intake is removed by colonic secretion]
- Each HD session removes 50-100 mEq K according to dialysate K, time, Q_b



Factors Affecting Potassium Removal during dialysis

A. Shifts K into cell thereby ↓ dialytic K removal

- Exogenous insulin
 - Glucose containing dialysate vs glucose free dialysate
 - Beta agonists
 - Correction of metabolic acidosis during dialysis
-

B. Shifts K to extracellular space or impairs cell K uptake thereby ↑ dialytic K removal

- Beta blockers
 - Alpha adrenergic receptor stimulation
 - Hypertonicity
-

Cause of hyperkalemia in HD patients

↑ Intake

Dietary indiscretion, transfusion

↑ Transcellular shift

Metabolic acidosis

Cell lysis: hemolysis, rhabdomyolysis, trauma, tumor lysis

Prolonged fasting: ↓ insulin secretion

Inadequate HD

Recirculation; Missed, shortened, or low dose (Qb, Qd) HD

↓ Renal K excretion

RAAS inhibitors, loss of residual function

↓ Colonic K secretion

Constipation: ↓ wet stool weight

Prevention

- Dietary K restriction: 2-3 g diet; d/c RAAS inhibitors
- Potassium exchange agents: sodium polystyrene sulfate, patiromer

HEMOLYSIS 溶血

Causes

- **Contamination**: chlorine, copper, bleach, formaldehyde, peroxide
- **Mechanical trauma** to RBCs : malfunction of the blood pump, kinked tube
- High flow through narrow needle
- Other causes: medication induced, TMA, autoimmune hemolysis

Clinical Manifestation

- Chest pain, dyspnea, back pain, bradycardia (hyperkalemia)
- Port wine appearance of blood in venous line
- **Acute anemia**

Management

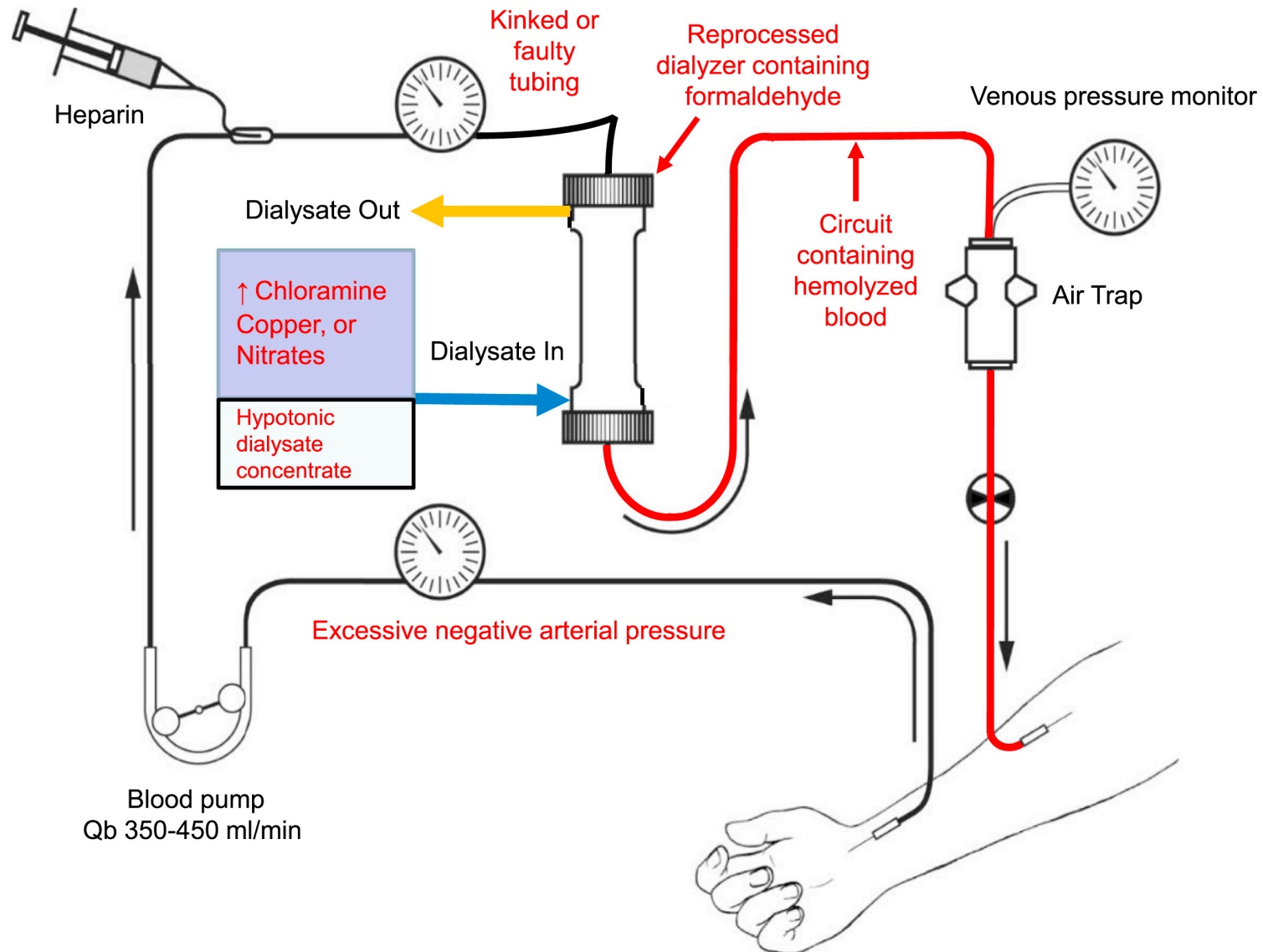
- If severe, stop HD
- do not return hemolyzed blood to patient
- Check K, Hb, LDH



Cause of hemolysis in dialysis

Cause	Source
Dialysis Contaminants and Composition Error	
Zinc and copper	Plumbing fixtures, piping
Chloramines and chlorine	Municipal water system additives Bleach contamination from inadequate flushing after disinfection of water system
Hydrogen peroxide	Contamination from inadequate flushing after disinfection of water system
Formaldehyde	Contamination from dialyzer reprocessing
Nitrate/nitrites	Well water contamination from domestic animal waste
Hypotonic dialysate	Inappropriate use of distilled water or custom dialysate baths made in pharmacy
Mechanical/Procedural Complications	
Small-gauge needles	When accessing new fistula in conjunction with inappropriately high blood flow rates
Kinked dialysis tubing	Defective tubing sets or improper positioning of blood lines
Blood pump cycling	Pressure variations on red cells inducing shear stress—of modest clinical significance
Defective blood warmer	Mechanical failure

possible site of hemolysis of dialysis circuit





THROMBOCYTOPENIA 血小板低下

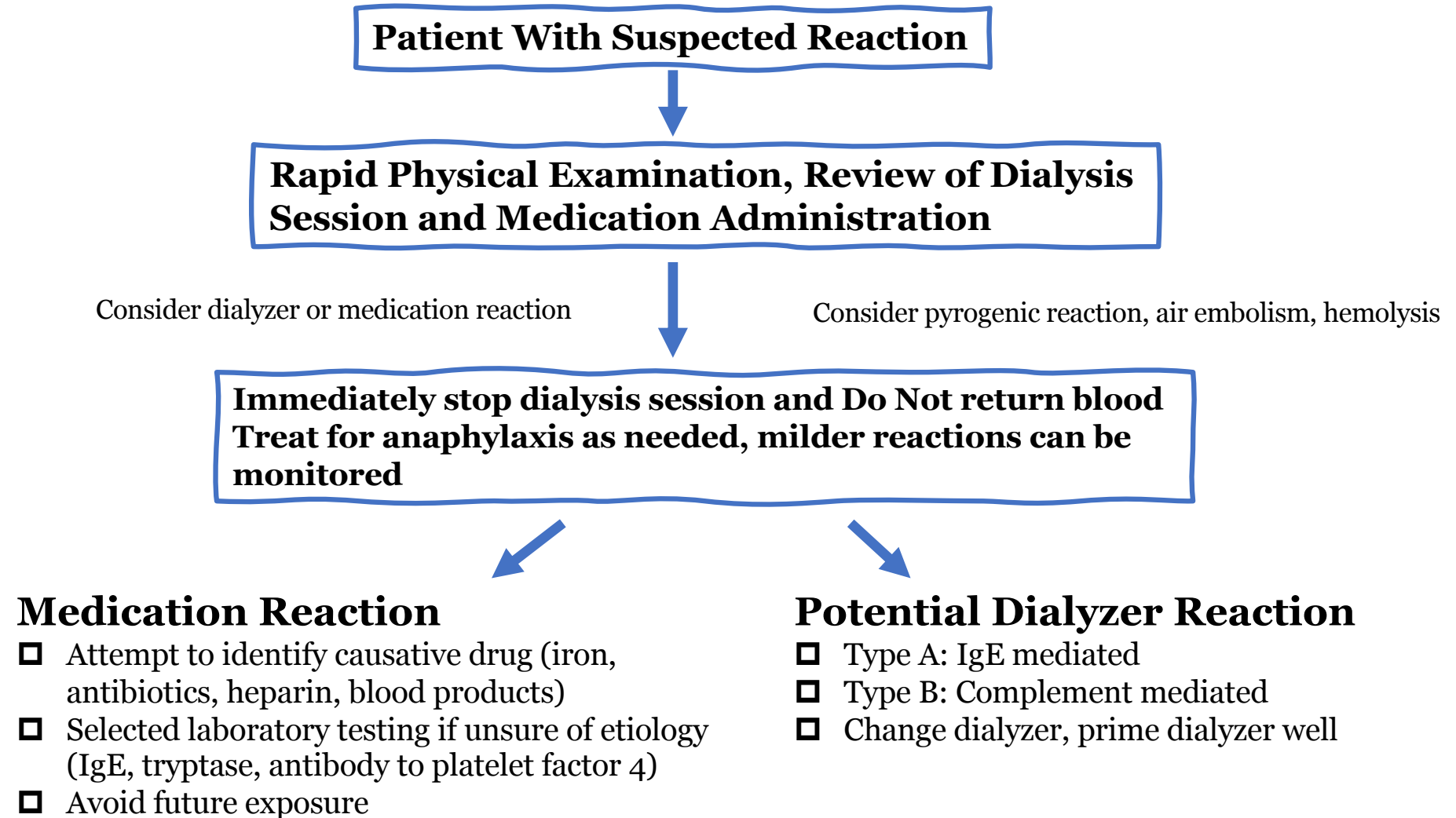
Cause

- Heparin induced: rinsing of the circuit, catheter lock

Treatment of Heparin-Induced Thrombocytopenia

- d/c heparin
- Check heparin-PF4 Ab by ELISA and serotonin release assay
- Consider nonheparin anticoagulation for **3-6 mo** if (+) thrombosis
- HD anticoagulation: heparin free HD
- Apixaban approved for Afib/ESRD can be considered

Approach reaction while undergoing hemodialysis



DIALYSIS MEMBRANE REACTION

TYPE A

Pathogenesis

- IgE-mediated type 1 hypersensitivity reaction (anaphylaxis) to ethylene oxide
- Non-IgE mediated anaphylactoid reaction to acrylonitrile membrane + ACEi use

Clinical Manifestation

- Typically, within the first few min of initiation of dialysis
- Burning at the access site, chest pain, dyspnea, bronchospasm, urticaria, hypotension

Treatment

- Stop dialysis immediately; do not return the blood in the extracorporeal circuit
- Epinephrine, IV steroids, and H1-blockers; proper sterilization for prevention

TYPE B

Pathogenesis

- Alternate pathway complement activation; PMN sequestration in the pulmonary vascular bed and degranulation with release of inflammatory cytokines

Clinical Manifestation

- Typically, within the first 30-45 min of initiation of dialysis;
- Chest and back pain
- More common with the modified cellulosic membranes than synthetic membranes
- Neutropenia during the event and have a postdialysis rebound neutrophilia

Treatment

- Symptomatic, supportive

Predictors of arrhythmias and sudden cardiac death (SCD) in ESRD

Bradyarrhythmias

- ❑ Age > 55 years
- ❑ Coronary artery disease
- ❑ Long QTc (males > 450ms, females > 470 ms)
- ❑ Prolonged PR interval
- ❑ Diabetes mellitus
- ❑ Long interdialytic period

Ventricular arrhythmias

- ❑ Age > 55 years
- ❑ Age > 55 years
- ❑ LV systolic dysfunction
- ❑ LV Hypertrophy
- ❑ LV Dilatation
- ❑ Hypertension
- ❑ Coronary artery disease
- ❑ Aggressive removal of potassium during dialysis

SCD

- ❑ Aggressive removal of potassium during dialysis
- ❑ Autonomic dysfunction
- ❑ LV hypertrophy

PULMONARY HYPERTENSION

Cause:

- Chronic volume overload or 1 venous return to the RV from a high flow AVF or AVE, typically in >2 L/min

Evaluation:

- Echocardiogram to evaluate for elevated RV pressures

Treatment:

- Attempt to reduce DW;
- Banding of AVF to reduce flow through the access

AIR EMBOLISM

Cause

- Air leak within the extracorporeal circuit

Symptoms

- Chest pain, dyspnea/wheezing, tachycardia, hypotension (can progress to overt shock)

Treatment

- Terminate dialysis
- Place patient in the left lateral decubitus position and in Trendelenburg (to trap air in RA/RV)
- Monitor oxygen saturation; supplemental high flow oxygen
- Echocardiogram and/or Chest CT angiogram (if needed) to confirm air embolism
- Vasopressors for shock; mechanical ventilation for respiratory therapy

透析
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症候群

低
血壓

高鉀

溶血

抽筋

高
血壓

心包
膜

血小板
低下

過敏
反應

肺
高壓

空氣
栓塞

SCD

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