Haemodialysis Emergencies: Acute and Chronic Setting

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What I hope to cover today

- How common are these emergencies?
- Focus on the common:
  - Intradialytic hypotension
- Not forgetting the less common:
  - Dialysis disequilibrium
  - Haemolysis
  - Air embolus
  - Allergic reactions

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A Familiar Scenario

- 60 year old man on regular haemodialysis experiences chest pain and breathlessness 20 minutes into haemodialysis. His blood pressure has dropped to 90/50mmHg.

- What are the possible causes?
- (Acute coronary syndrome? Air embolism? Haemolysis? Dialyzer reaction?)
- Do we return the blood ?

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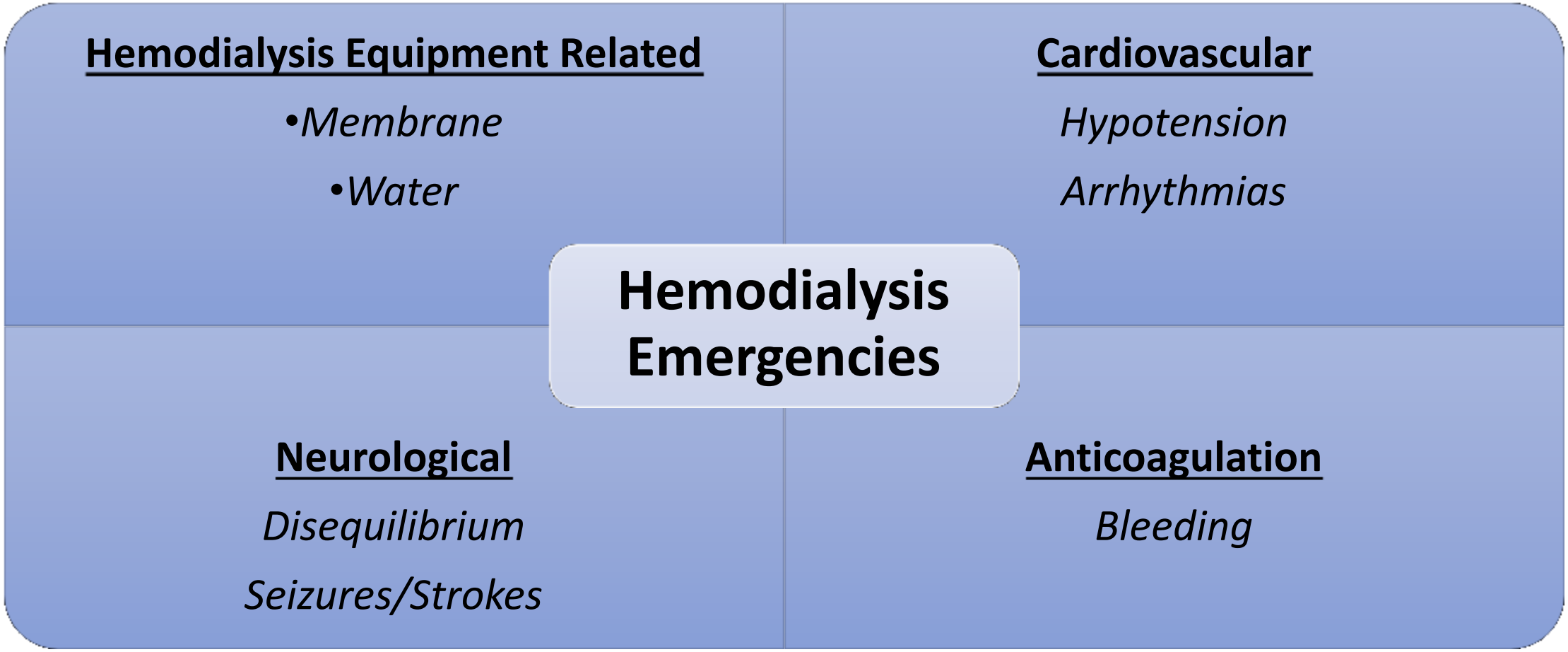

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How common are these?

Type of Emergency	Estimated frequency (per million HD sessions)	References
Dialysis Disequilibrium		
Air embolism	8.5 - 33	Tennankore et al, Wong et al
Haemolysis		
Vascular access haemorrhage		
Venous needle dislodgement	14 – 91	Tennankore et al, Wong et al, VA study, Pennsylvania Patient Safety Study
Allergic reaction	21 - 170	Villarroel and Ciarkowski, Daugirdas et al, Simon et al
Cardiac arrest	70	Karnik et al
Errors in following HD prescription		

Saha and Allon, CJASN 2017;12:357-369

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Intradialytic Hypotension

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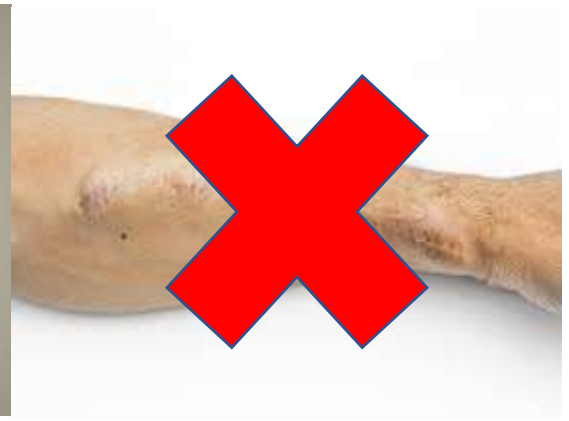
Intradialytic Hypotension – Definition

Term	Definition
Nadir90	Minimum intradialytic SBP < 90mmHg
Nadir100	Minimum intradialytic SBP <100mmHg
Fall20	(Pre-HD SBP – minimum intradialytic SBP) ≥ 20mmHg
Fall30	(Pre-HD SBP – minimum intradialytic SBP) ≥ 30mmHg
Fall20Nadir90	(Pre-HD SBP – minimum intradialytic SBP) ≥ 20mmHg AND minimum intradialytic SBP < 90mmHg
Fall30Nadir90	(Pre-HD SBP – minimum intradialytic SBP) ≥ 30mmHg AND minimum intradialytic SBP <90mmHg
KDOQI	(Pre-HD SBP – minimum intradialytic SBP) ≥ 20mmHg AND symptoms of cramping, headache, light-headedness, vomiting or chest pain during HD
HEMO	Fall in SBP resulting in intervention of UF reduction, blood flow reduction, or saline administration

Flythe, JASN March 2015;26(3):724-734

Intradialytic Hypotension -- Implications

- Patient reported symptoms (cramps, dizziness)
- Inadequate dialysis dose (reduction of dialysis time, pump speed)
- Vascular access dysfunction/loss
- End-organ ischaemia (cardiac/cerebral/mesenteric)



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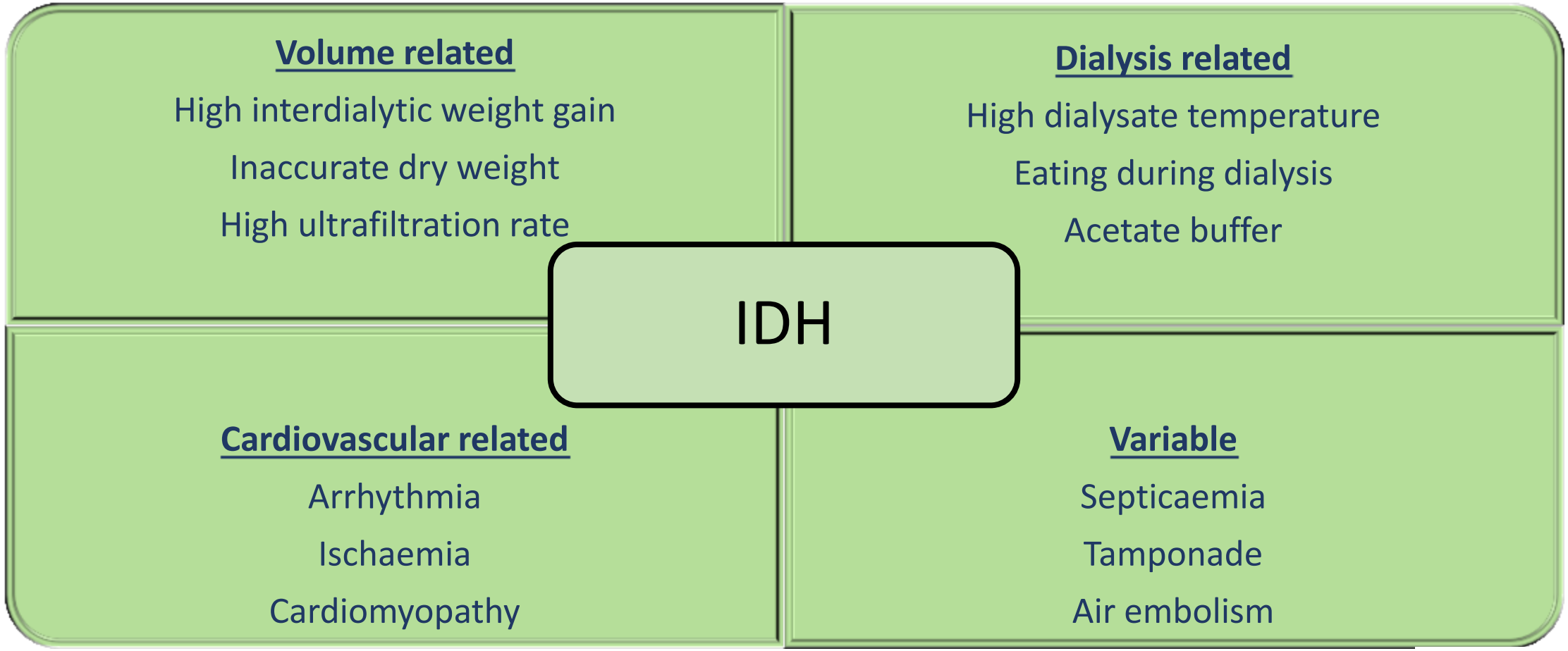
Intradialytic Hypotension – Who?

Risk Factors for Intradialytic Hypotension
Diabetes Mellitus
Cardiovascular Disease e.g. congestive cardiac failure, left ventricular systolic dysfunction
Malnutrition/hypoalbuminemia
Autonomic dysfunction
Severe anaemia
Female gender
Age > 65
High ultrafiltration rate
High ultrafiltration volume/high interdialytic weight gain

Causes of Intradialytic Hypotension (IDH)



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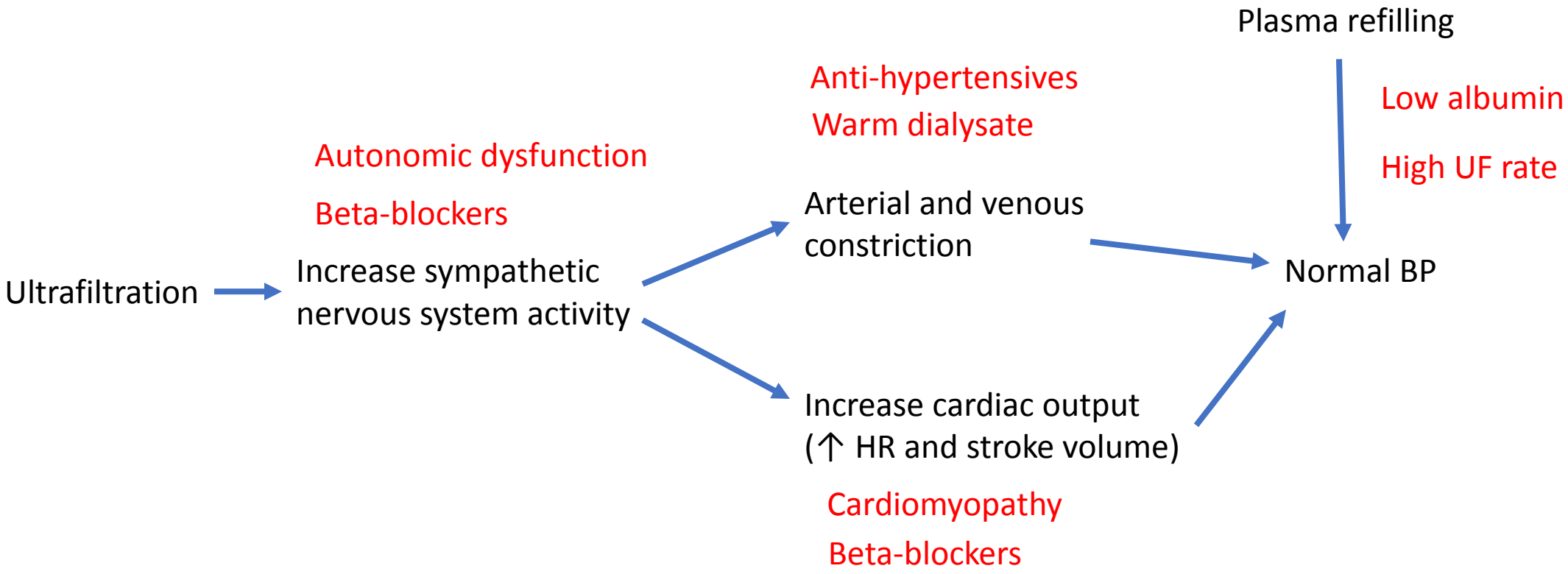
Pathophysiology



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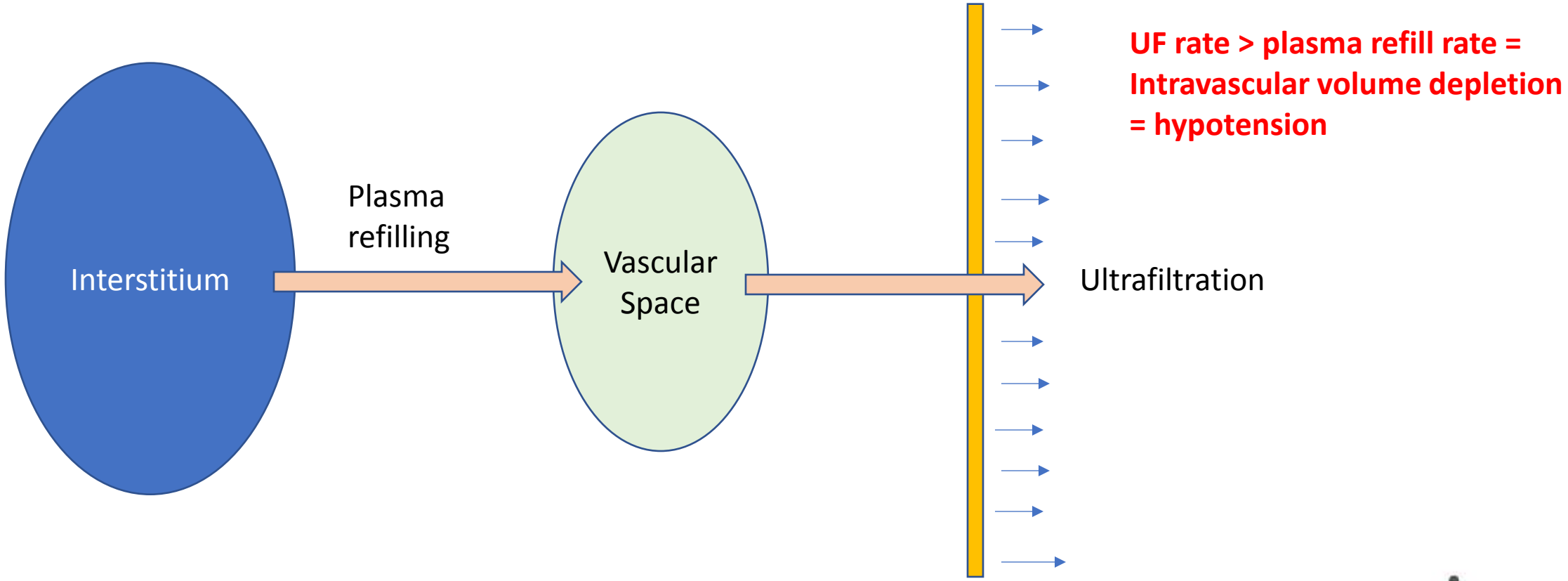
Ultrafiltration and plasma refilling

UF rate determined by UF volume and UF time



UF rate > plasma refill rate = Intravascular volume depletion = hypotension

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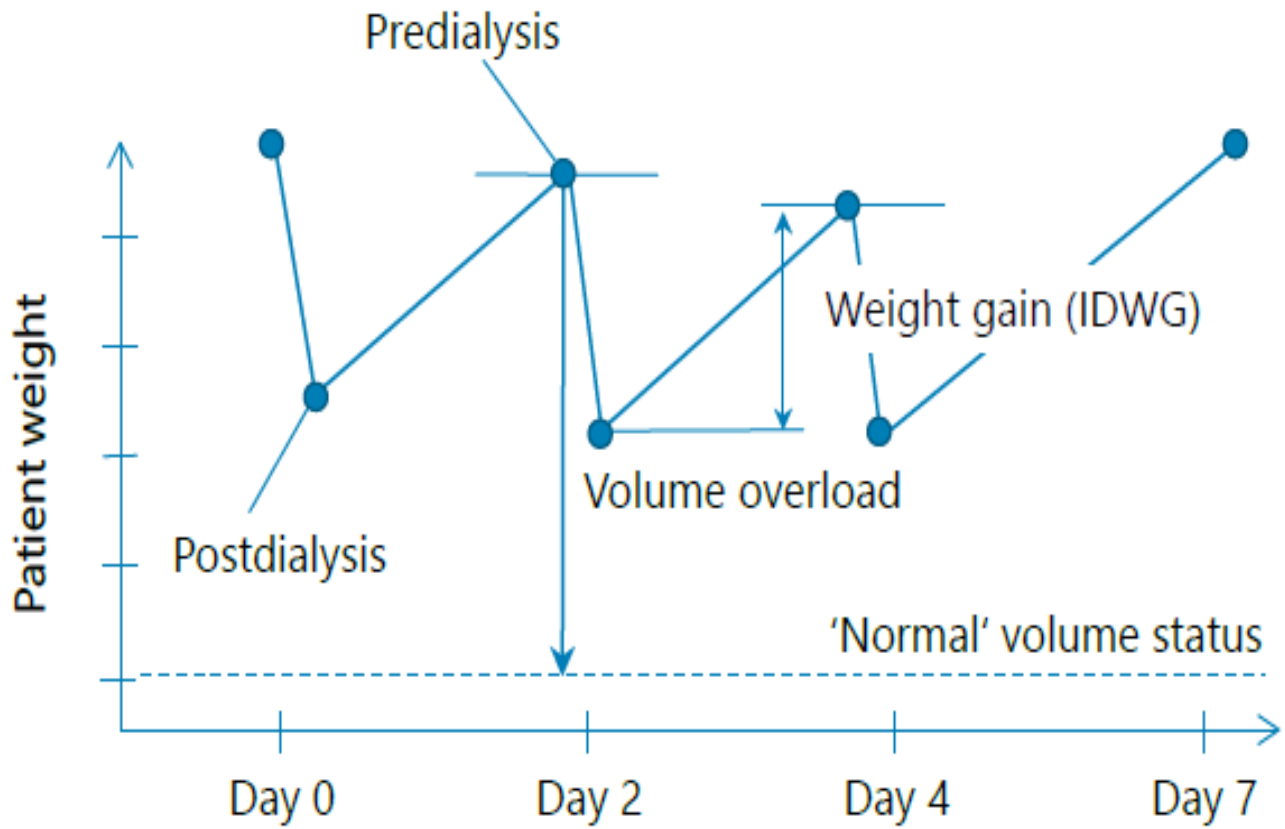
Interdialytic Weight Gain



Hecking et al, Am J Nephrol 2013;38:78-90

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Ultrafiltration rate and cardiovascular mortality

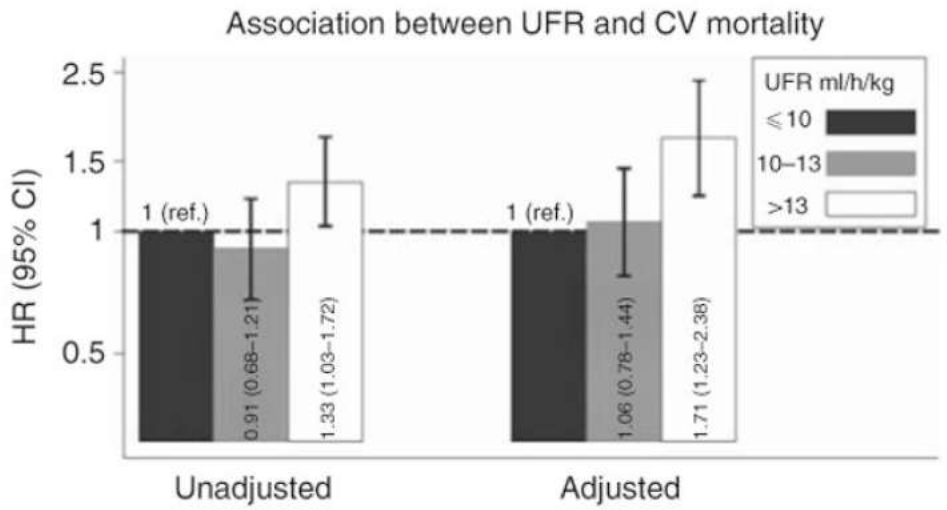

Figure 2. Unadjusted and adjusted associations between ultrafiltration rate (UFR) and cardiovascular (CV)-related mortality based on Cox regression models
Multivariable models were adjusted for age, sex, interdialytic weight gain, race (black, non-black), smoking status (never, past, current), vintage (< 1, 1–2, 2–4, ≥4 years), access type (graft, fistula, catheter), systolic blood pressure (< 120, 120–140, 140–160, 160–180, ≥ 180 mm Hg), residual urine output (≤ versus > 200 ml/day), diabetes, congestive heart failure, peripheral vascular disease, ischemic heart disease, cerebrovascular disease, serum albumin, creatinine, hematocrit (< 30, 30–33, 33–36, ≥ 36%), and phosphorus, and use of α-adrenergic blocker, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, β-blocker, calcium channel blocker, nitrates, and other antihypertensives. A two-way cross-product term with time was included for albumin due to non-proportional hazards.
Abbreviations: ref., reference; CI, confidence interval; HR, hazard ratio.

Flythe et al, Kidney Int 2011;79(2):250-257

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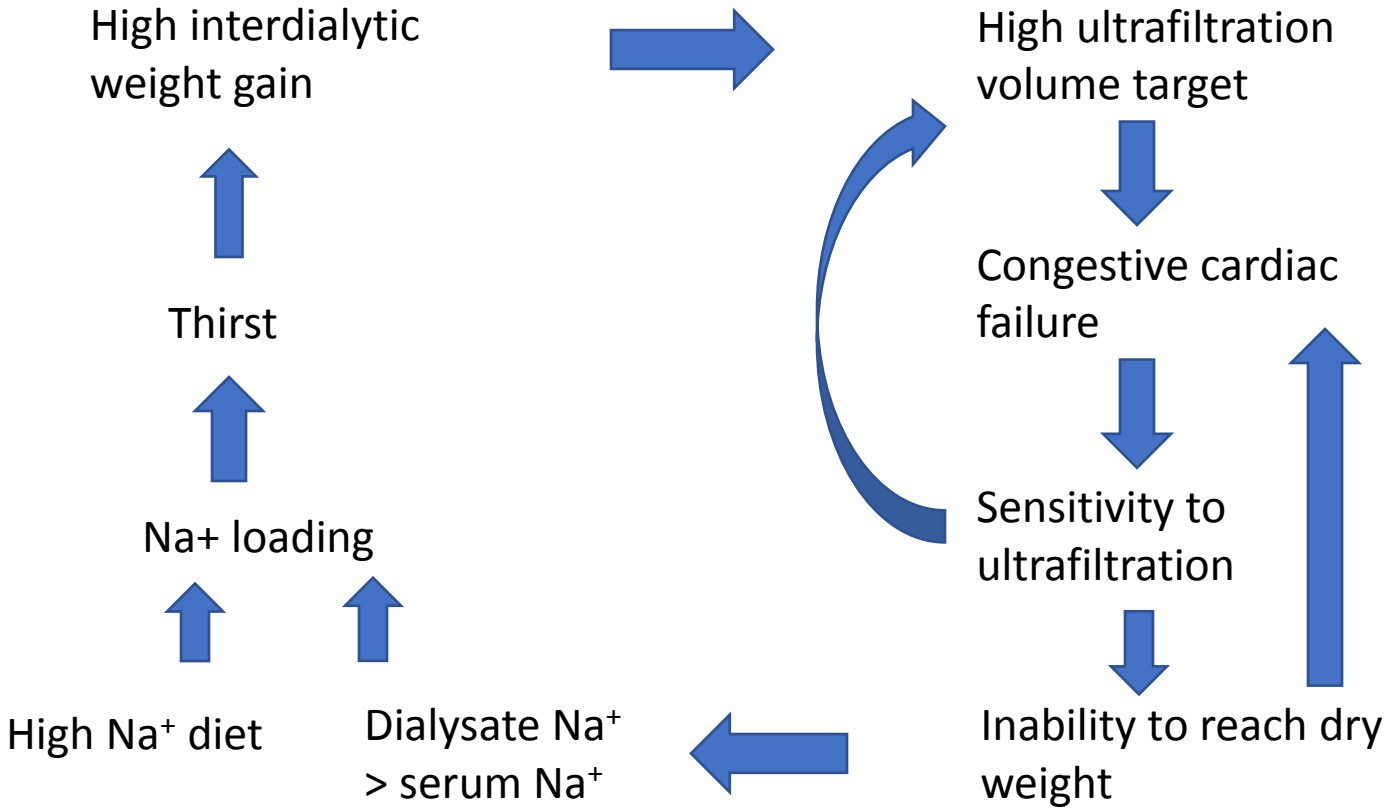
A Vicious Cycle……



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Dry Weight – What does it mean?

Weight obtained at the conclusion of a regular dialysis treatment below which the patient more often than not will become symptomatic and go into shock (Henderson)

Weight at the end of dialysis at which patient can remain normotensive until the next dialysis despite the retention of saline and ideally without the use of anti-hypertensive medication (Charra, 1996)

Lowest tolerated post-dialysis weight achieved via a gradual change in post-dialysis weight at which there are minimal signs or symptoms of hypovolaemia or hypervolemia (Sinha and Agarwal, 2009)

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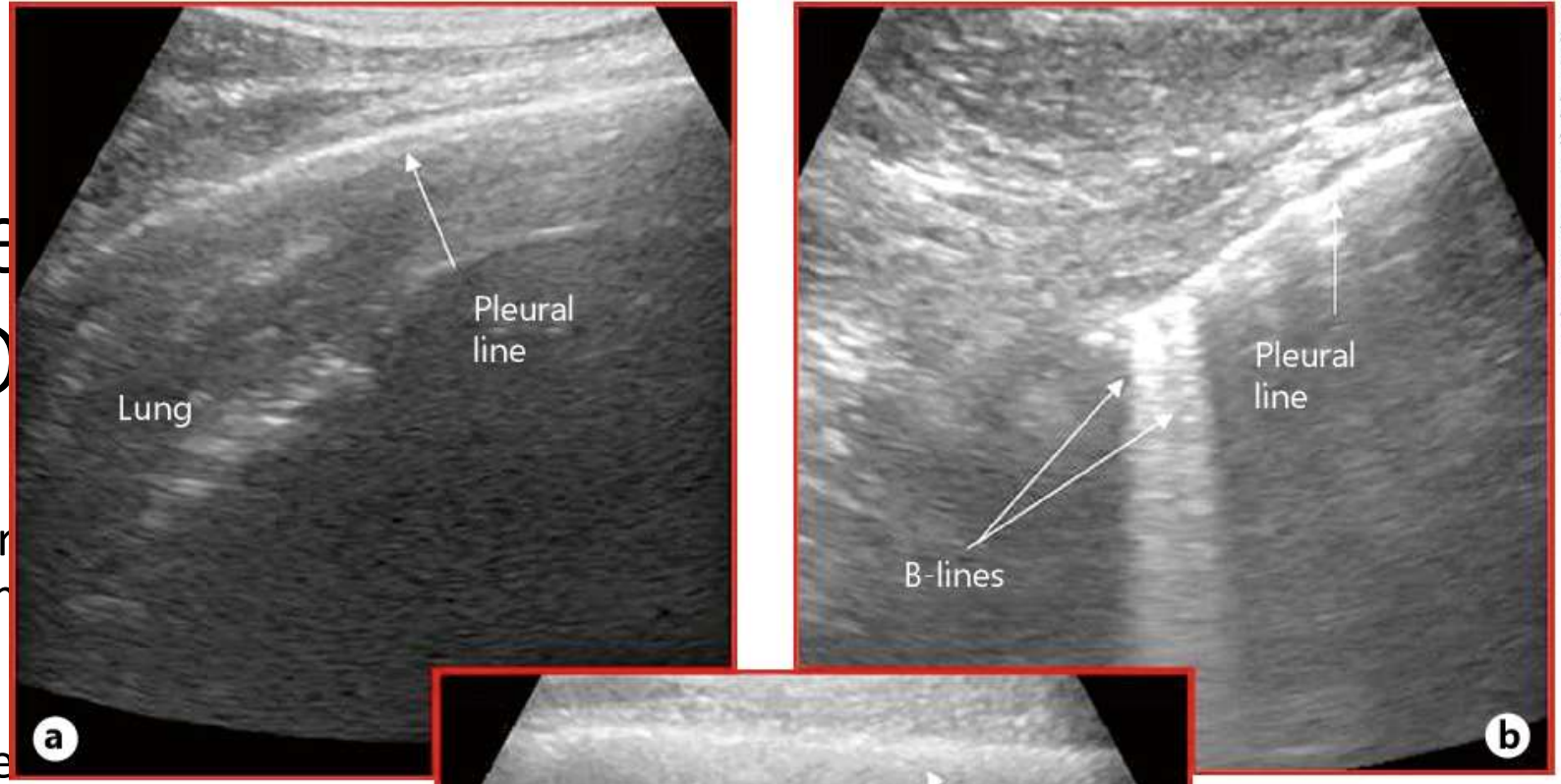
Dry We
Tools D

- Echocardiogr
  measuremer
- Biomarkers e
  (BNP) and its
  proBNP)
- Bioimpedanc
- Ultrasonogra



Color version available online

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Bioimpedance analysis

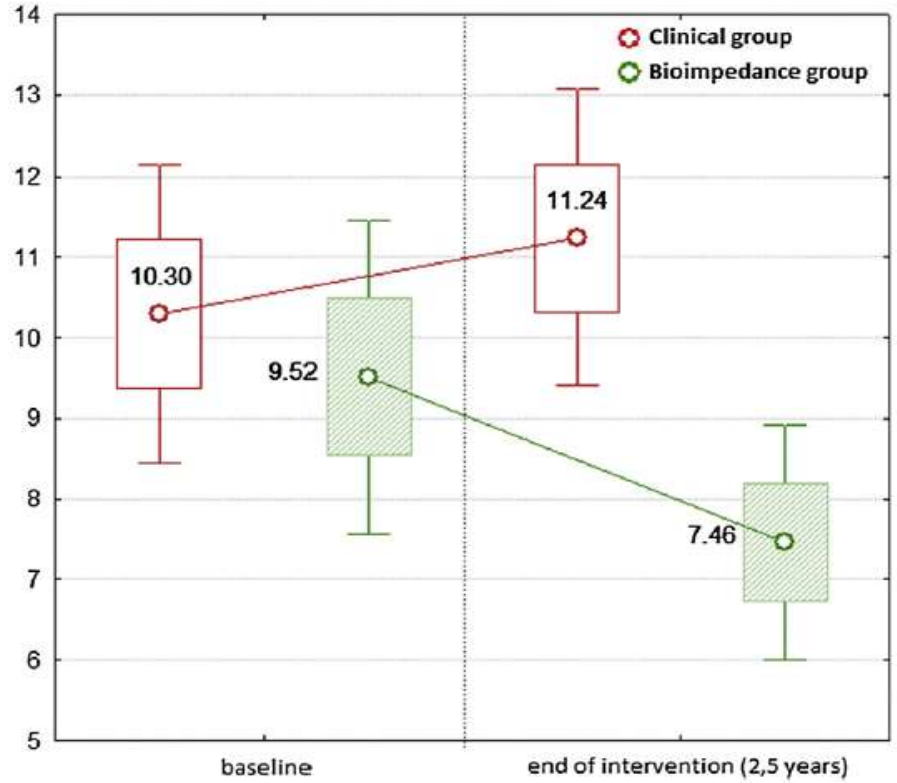

Figure 2. Mean relative fluid overload at baseline and at the end of intervention (box, mean ± standard error; whiskers, 95% confidence interval).

Onofriescu et al, AJKD 2014

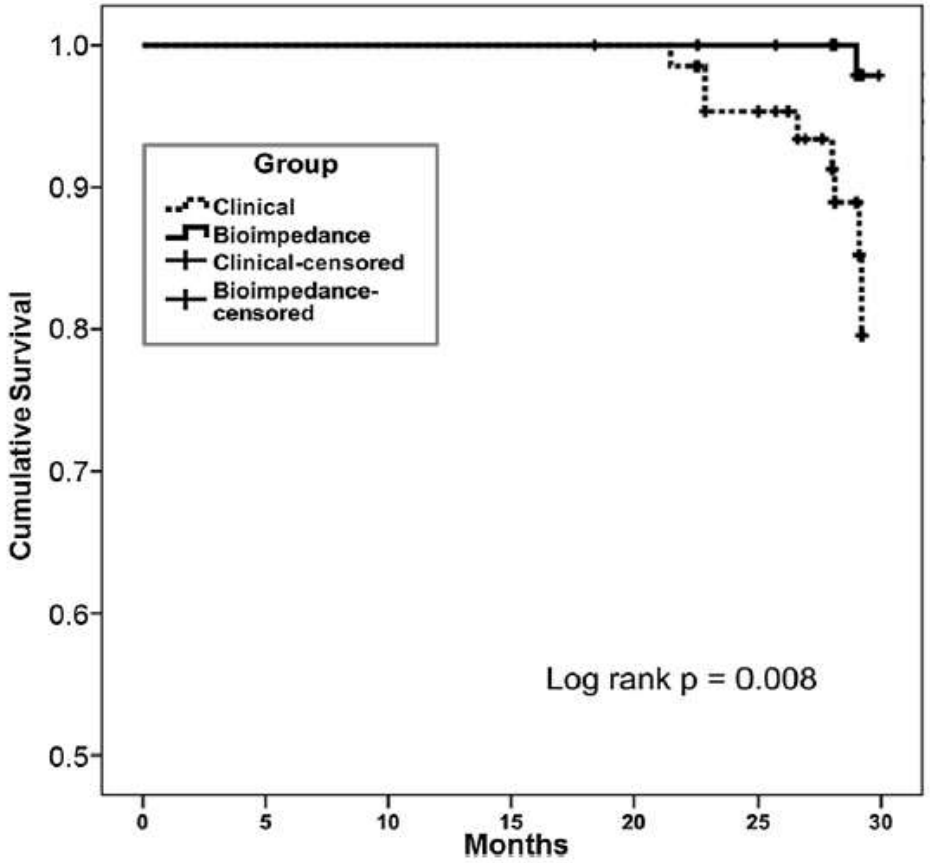

Figure 4. Kaplan-Meier survival analysis.

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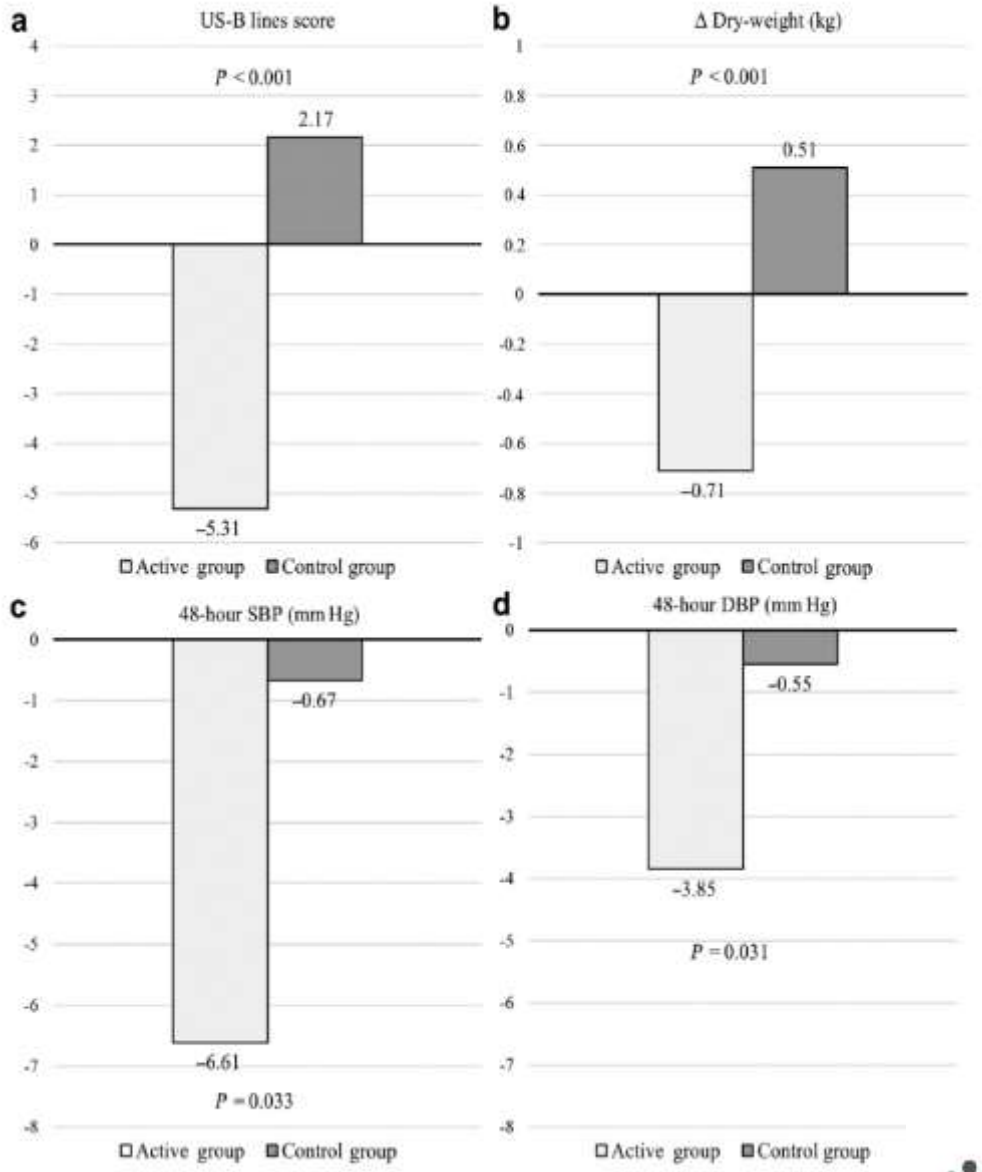
Lungs Ultrasound guided dry weight reduction



Loutradis et al, Kidney International 2019

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IDH – Acute management

- Reduction/cessation of ultrafiltration
- Trendelenburg position
- Saline boluses
- ? Reducing blood pump speed
- Consideration of acute causes

Prevention and Management

- ✓ Limit fluid and salt intake
- ✓ Discourage eating before /during dialysis
- ✓ Maximize diuretic use for patients with residual renal function
- ✓ Minimize use of anti-hypertensive medication prior to dialysis
- ✓Setting an accurate dry weight
- ✓ Lower dialysate temperature
- ✓Increase dialysate calcium
- ✓Ultrafiltration/sodium profiling
- ✓Increase dialysis time and/or frequency

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Dialysis Disequilibrium

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Dialysis Disequilibrium – What Is It?

Symptoms involve the neurological system, and include:

- Restlessness
- Headache
- Mental confusion
- Coma
- Seizures

Other conditions may mimic:

- Acute cerebrovascular event
- Intracranial bleed
- Hypoglycemia
- Hyponatraemia
- Uraemia

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Dialysis Disequilibrium

- Predisposing factors:
  - High blood urea nitrogen (> 175mg/dL or 62.5mmol/L)
  - Rapid decline
  - Pre-existing neurological conditions
  - First session of haemodialysis
  - Hyponatraemia
  - Pre-existing liver disease

Dialysis Disequilibrium

- Potential strategies to prevent dialysis disequilibrium syndrome in high-risk patients
  1. Limit the first haemodialysis session to 2-2.5 hours
  2. Limit the blood flow to 150-200mls/min
  3. Small surface area dialyser (0.9-1.2m^2)
  4. Sodium modelling or a high-sodium dialysate
  5. Consideration of intravenous mannitol (1g/kg)
  6. Consider CRRT in high-risk patients (traumatic brain injury, intracranial haemorrhage, intracranial mass)

Venous Air Embolism

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Venous Air Embolism

Rare in occurrence

High index of suspicion necessary, as may mimic other more common complications

Results in

- Local ischaemia
- Circulatory arrest
- Activation of complement and coagulation cascade
- Localized inflammation
- Vascular endothelial cell damage

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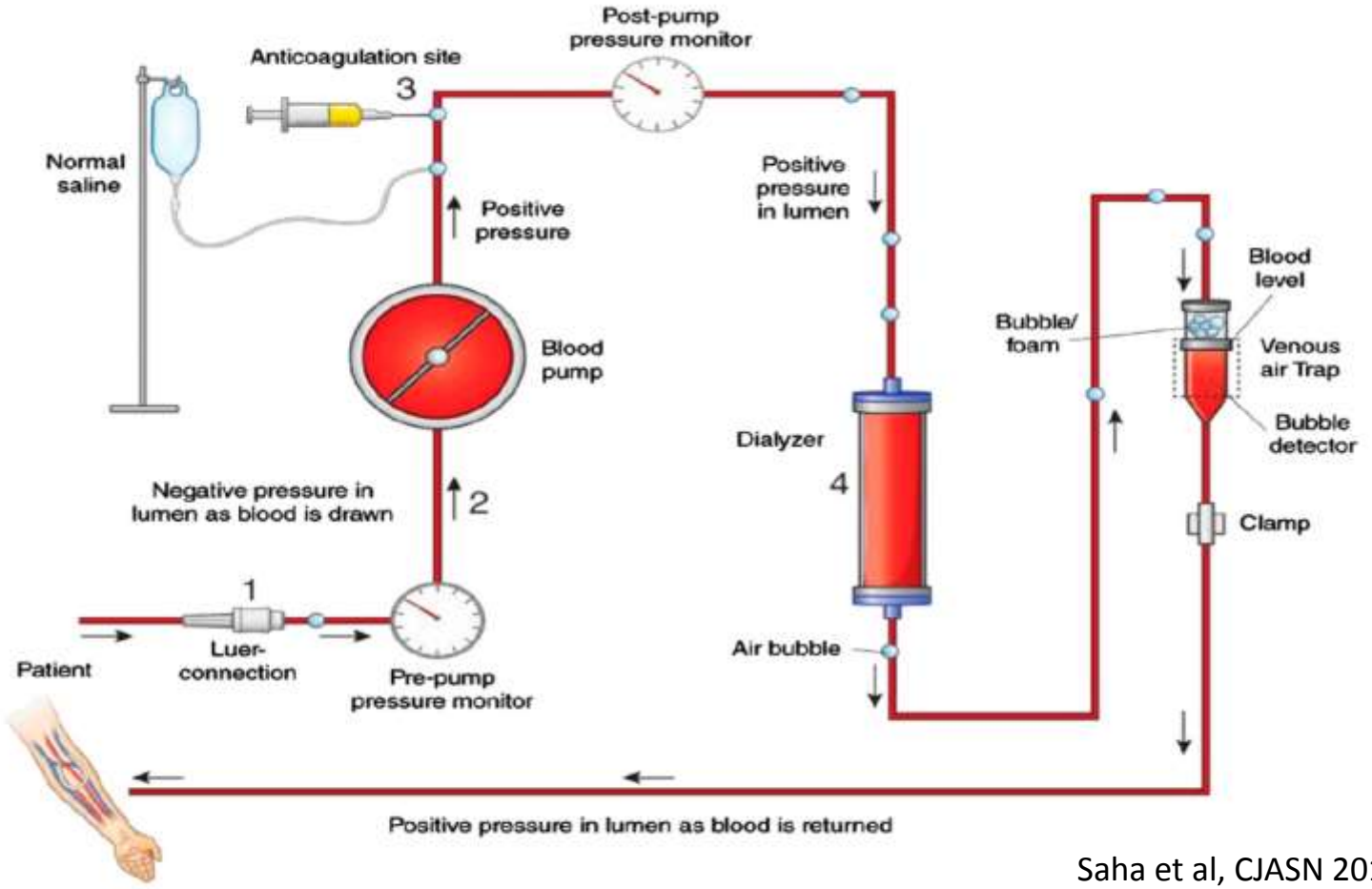
Possible sites of air entry into circuit



Saha et al, CJASN 2017, 12:357-369

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Clinical Presentation

Cerebral air embolism

- Blurring of vision
- Altered mental status
- Seizures
- Ischaemic stroke

Pulmonary air embolism

- Hypotension
- Tachycardia

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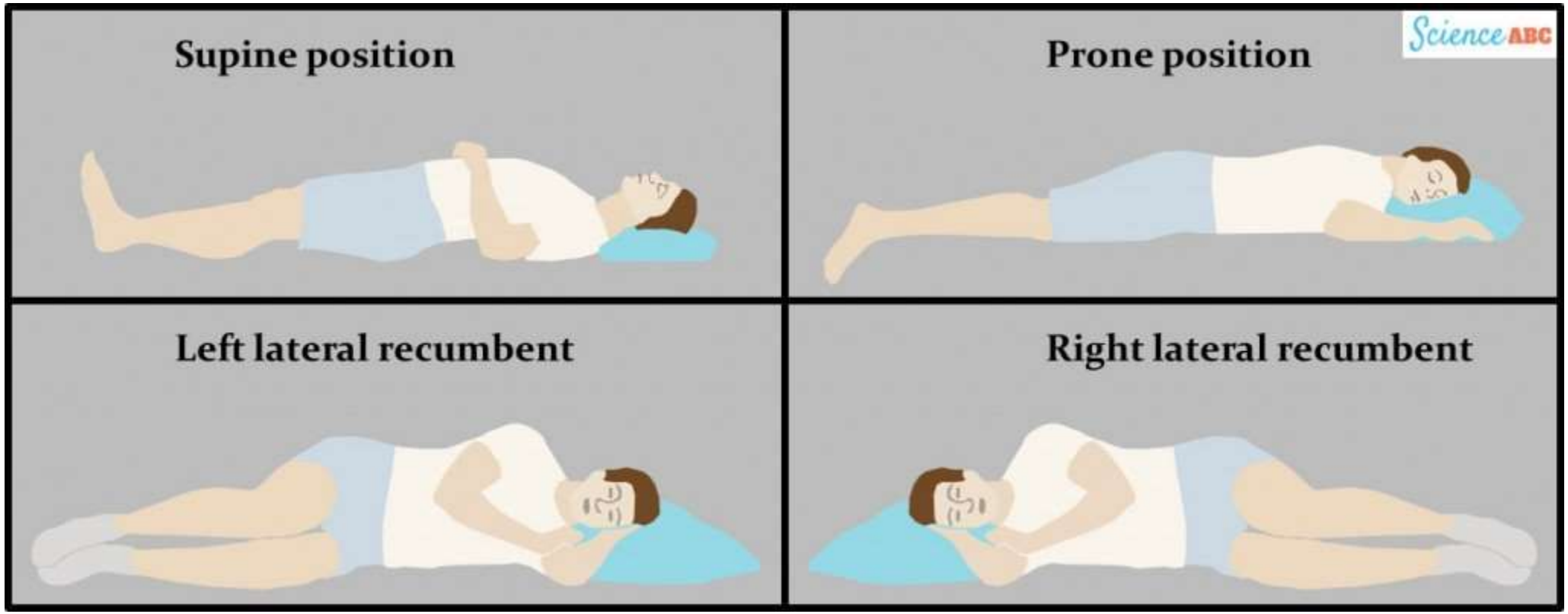
Clinical Presentation

- Degree of end-organ damage depends on:
  - Rate of air entry
  - Volume of air
  - Patient's position (erect position typically leads to obstruction of cerebral blood vessels, while as recumbent position leads to obstruction of coronary vessels)
  - Cardiac status

Management

- Acute management includes
  - Provision of 100% oxygen
  - Aspiration of air if catheter still in place
  - Left lateral recumbent vs supine position
  - May require mechanical ventilation if unable to maintain adequate saturations

Left lateral recumbent vs. supine



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Haemolysis

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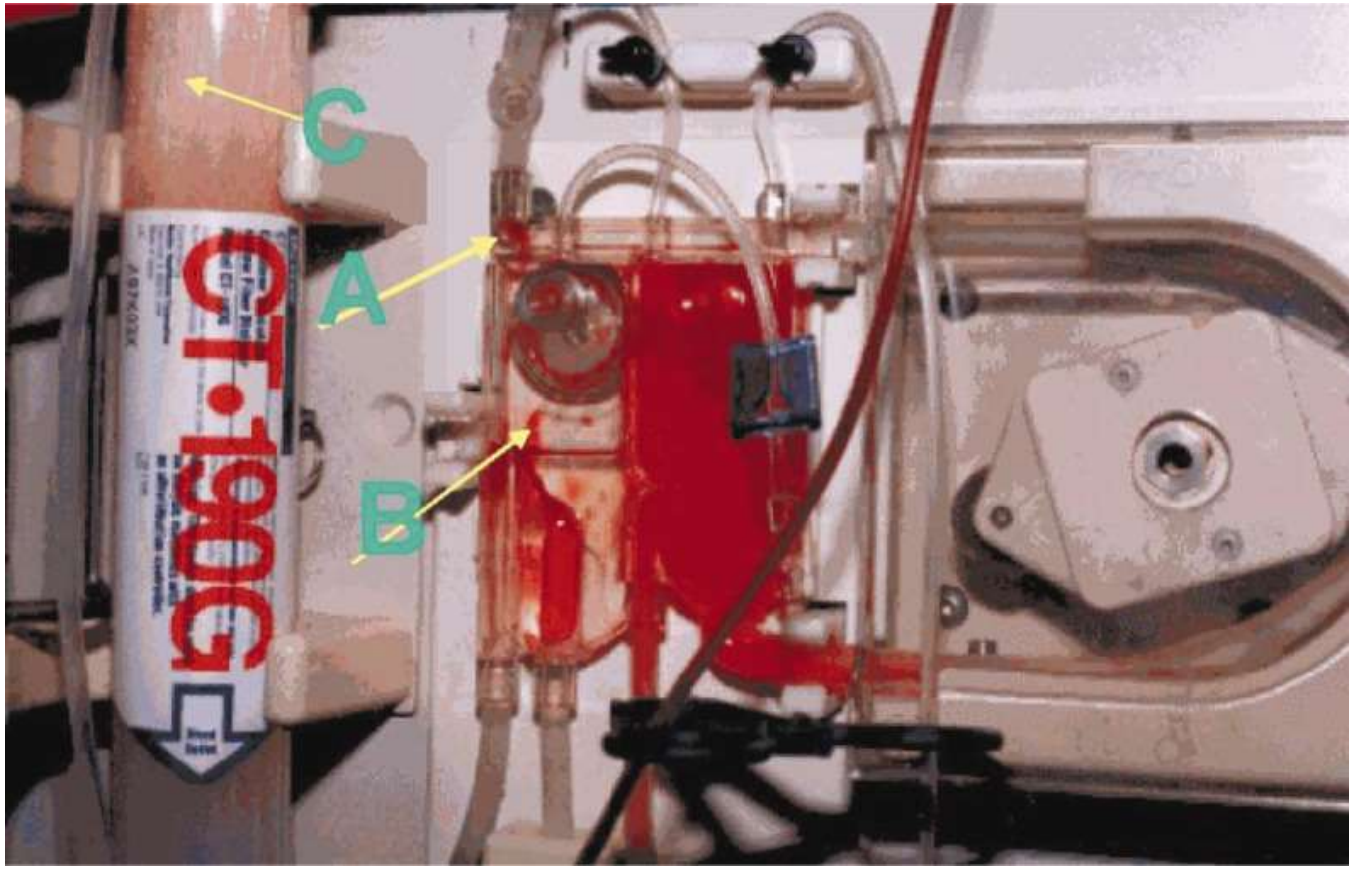

Duffy et al, Kidney Int 2000;57(4):1668-1674

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Clinical Presentation

- Patients with severe haemolysis can present with the following:
  - Nausea
  - Shortness of breath
  - Abdominal/back pain
  - Chills
  - Hypertension (initial stages)

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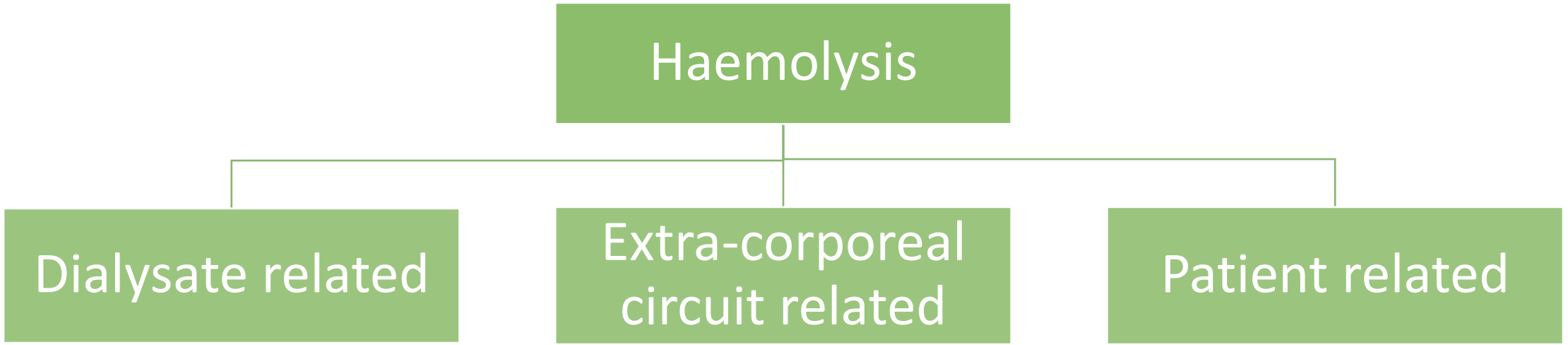
What causes haemolysis?



- Contamination with copper, zinc, chloramine
- Hypo-osmolar dialysate
- Hyperthermia

- Blood pump malocclusion
- Single-needle high-flow dialysis
- Partial occlusion of dialysis catheter
- Kink of tubing

- Autoimmune haemolysis
- Sickle cell anaemia

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Investigations

- Serum haptoglobin
- Lactate dehydrogenase
- Haematocrit/haemoglobin
- Pink serum
- Peripheral blood film

Management

It is imperative to recognise severe haemolysis

Immediate management includes:

- Stopping dialysis
- Blood should **not** be returned from the extracorporeal circulation to the bloodstream (risk of precipitating severe hyperkalaemia due to infusion of potassium released from haemolyzed cells)
- Blood tubing and needle system should be saved for further investigations
- Examining patient to ensure stability, including supplemental oxygen
- Dialysis machine should be sequestered until cleared

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Subsequent management

- Further root cause analysis includes
  - Documenting the following:
    - Arterial/venous access pressures
    - Evidence of kinks in tubing
    - Needle infiltration
    - Blood pump malocclusion
  - Checking the dialysate
    - Temperature
    - Conductivity
    - Osmolality
    - Biochemistry

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Diagnosis, RCA and Prevention

- Diagnosis of the underlying cause and further actions to prevent similar episodes are essential
- Monitoring for cluster of similar events in dialysis unit
- Dialysis machines should be reused only after cleared by biomedical department/engineers

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Dialyzer Reactions

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Allergic Reactions in Haemodialysis

- Potential causes include:
  - Dialyzer
  - Sterilant
  - Heparin
  - Other medications administered during dialysis

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Type A reaction ("Anaphylactic")

- Estimated to occur in approximately 4 of every 100 000 treatments
- Rapid onset (typically within 5-20 minutes) of initiation
- Presentation similar to anaphylaxis:
  - Pruritus
  - Urticaria
  - Bronchospasm
  - Laryngeal oedema
  - Anaphylactic shock
- Mediated by IgE antibodies to sterilant or compounds in dialyzer header
- Contamination by bacterial peptides

Case Report

SAGE Open Medical Case Reports

Anaphylactic reaction to ethylene oxide in a hemodialysis patient

SAGE Open Medical Case Reports
Volume 7: 1–3

DOI: 10.1177/2050313X19838744
journals.sagepub.com/home/sco
SAGE

Bobak J Akhavan[1], Ugochi A Osborn[2] and Reeba Mathew[3]

Abstract

We present the case of a patient who developed a severe systemic allergic reaction during initiation of hemodialysis. The reaction completely resolved by switching the dialysis filter sterilized by ethylene oxide to a steam sterilized filter. Ethylene oxide is used to sterilize heat sensitive medical devices, and although allergic reactions related to ethylene oxide have been reported before, awareness is lacking among providers in the inpatient setting, specifically in the intensive care unit setting.

Keywords

Ethylene oxide, anaphylaxis, systemic allergy, hemodialysis filter, dialyzer

Date received: 11 October 2018; accepted: 27 February 2019

Type A Reaction --- Management

Stop the dialysis immediately!

Do **NOT** return blood (clamp off dialysis tubing to prevent further return blood from extracorporeal circuit from returning to body)

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Type B Reaction (“Boring”)

Occurs later in the dialysis session (30 minutes)

More common (3-5% of treatments)

Symptoms less intense:

- Back pain
- Chest pain
- Nausea/vomiting
- Mild hypotension

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Prevention/minimization of dialyzer reaction

- Prime the dialyzer well
- Switch from ethylene-oxide sterilization to gamma or steam sterilization
- Treat with anti-histamines, corticosteroids, epinephrine for a hypersensitivity reaction
- Exclude other conditions that may mimic a dialyzer reaction e.g. air embolism

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A Familiar Scenario

- 60 year old man on regular haemodialysis experiences chest pain and breathlessness 20 minutes into haemodialysis. His blood pressure has dropped to 90/50mmHg.

- What are the possible causes?
- (Acute coronary syndrome? Air embolism? Haemolysis? Dialyzer reaction?)
- Do we return the blood ?

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In Summary

- Dialysis emergencies are generally uncommon, however prompt recognition is essential
- Presentations may overlap, and recognition of red flags is important as these have an impact on subsequent management
- A system of root cause analysis after an occurrence is essential to prevent future recurrence

Questions?

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