IN THE NAME OF GOD

Acute Hemodialysis Prescription

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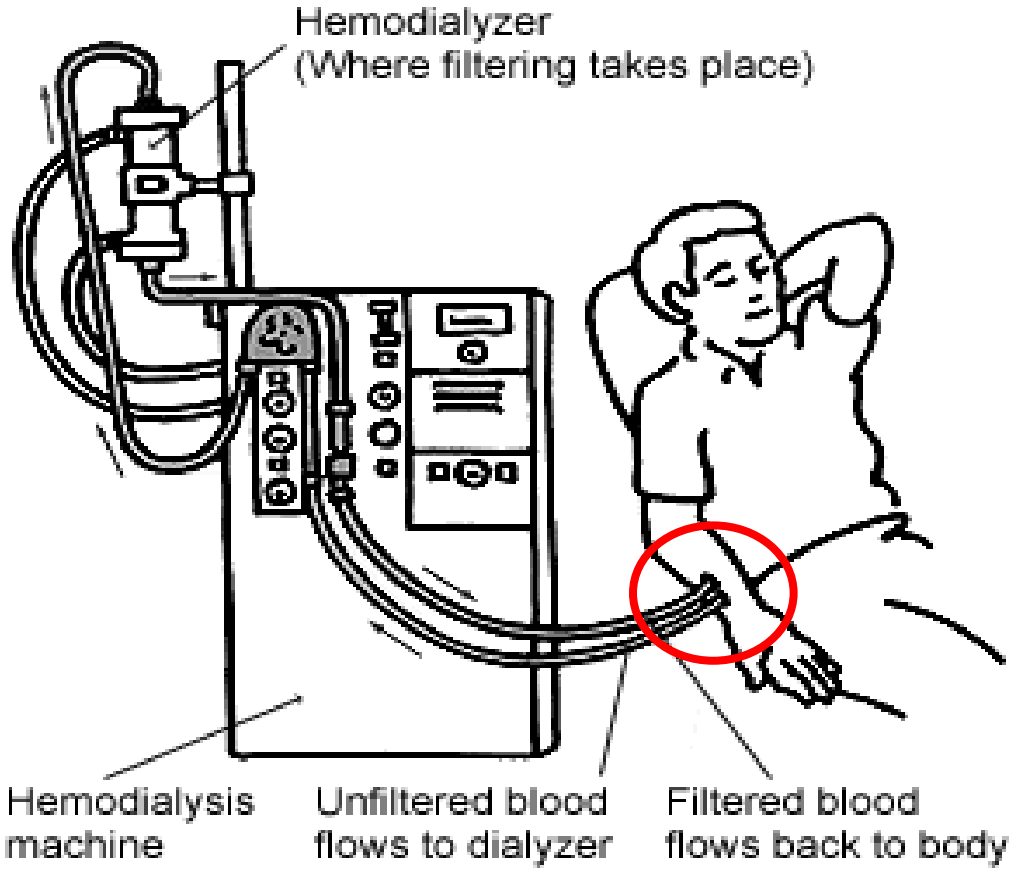
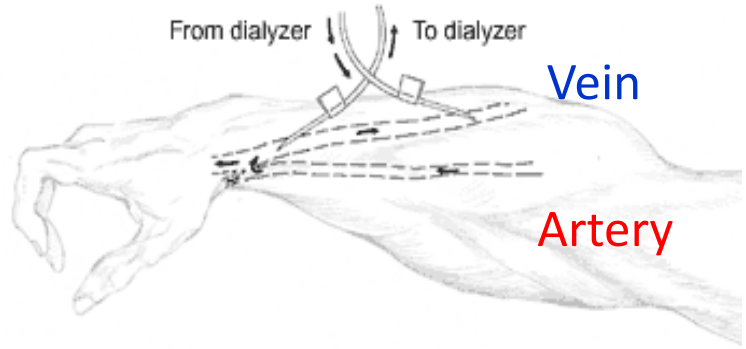
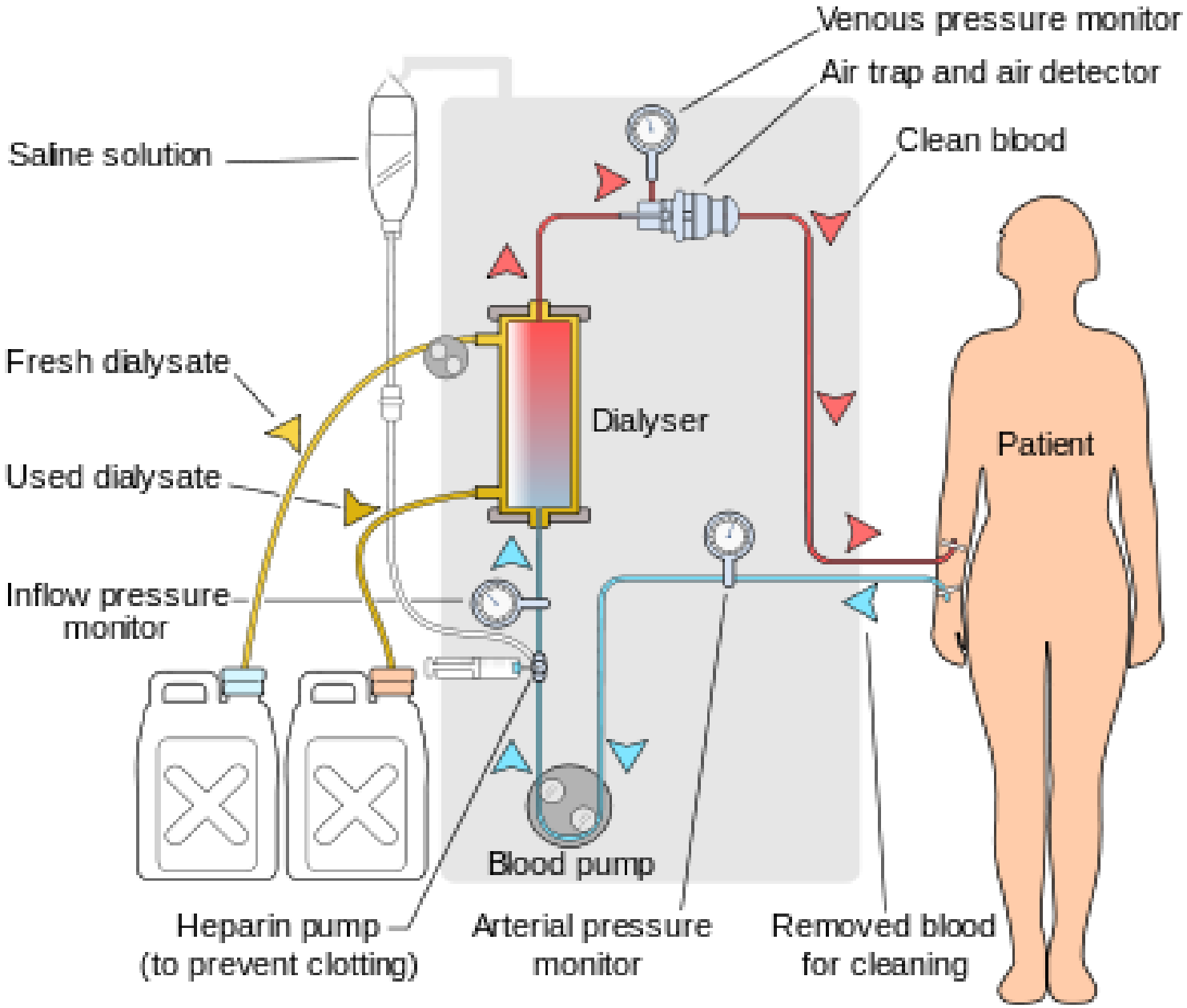
IUMS

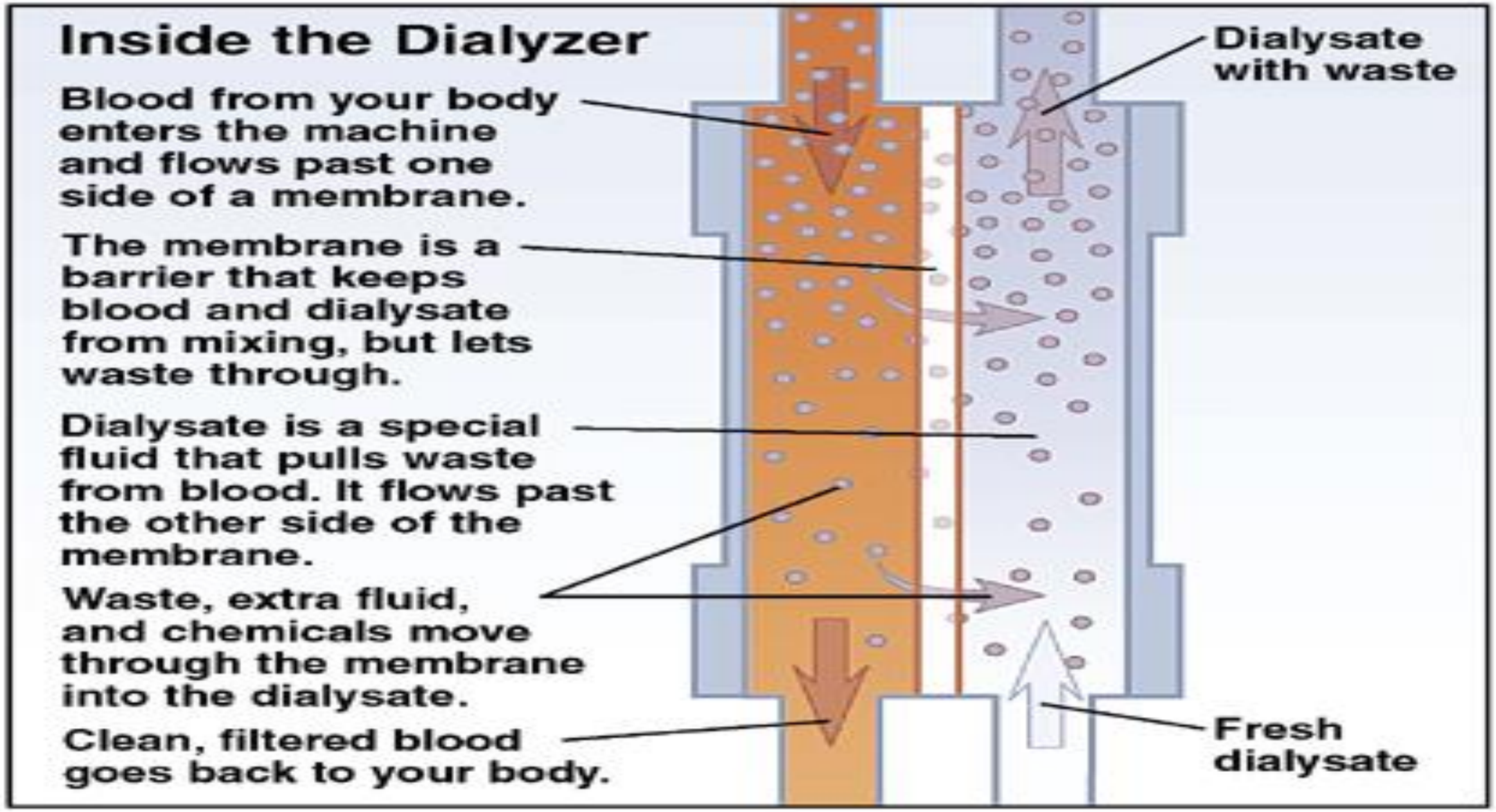
Principle of Hemodialysis





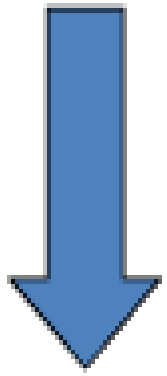

Venous pressure monitor
Air trap and air detector
Saline solution
Clean blood
Fresh dialysate
Dialyser
Patient
Used dialysate
Inflow pressure monitor
Blood pump
Heparin pump (to prevent clotting)
Arterial pressure monitor
Removed blood for cleaning

Hemodialysis Filter (Dialyzer)



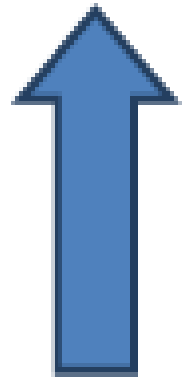
Blood

- Na = 140 mEq/L
- K = 4.5 mEq/L
- Cl =100 mEq/L
- CO2 = 24 mEq/L
- BUN = 30 mg/dL
- Cr = 5 mg/dL
- Glucose = 100 mg/dL
- Calcium=1.2 mmole/L
- Phosphorus=4 mg/dL
- Magnesium=2 mg/dL
- Vit B12 = 500 pg/mL
- Albumin = 4 g/dL



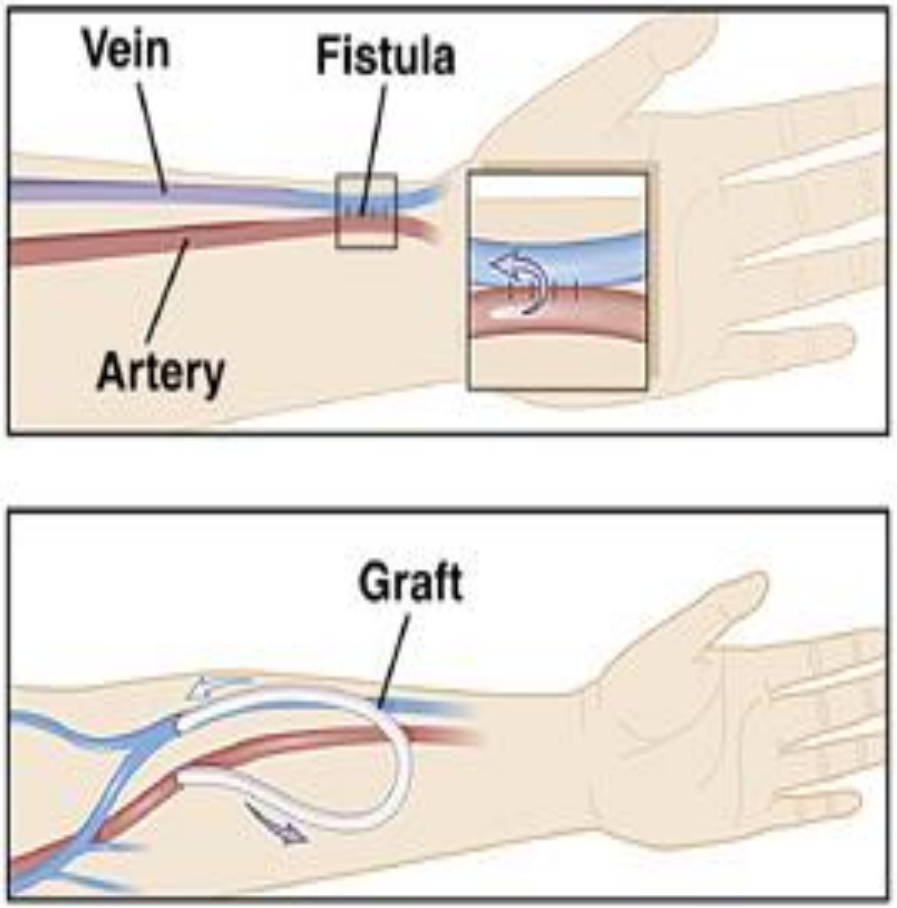
Dialysate

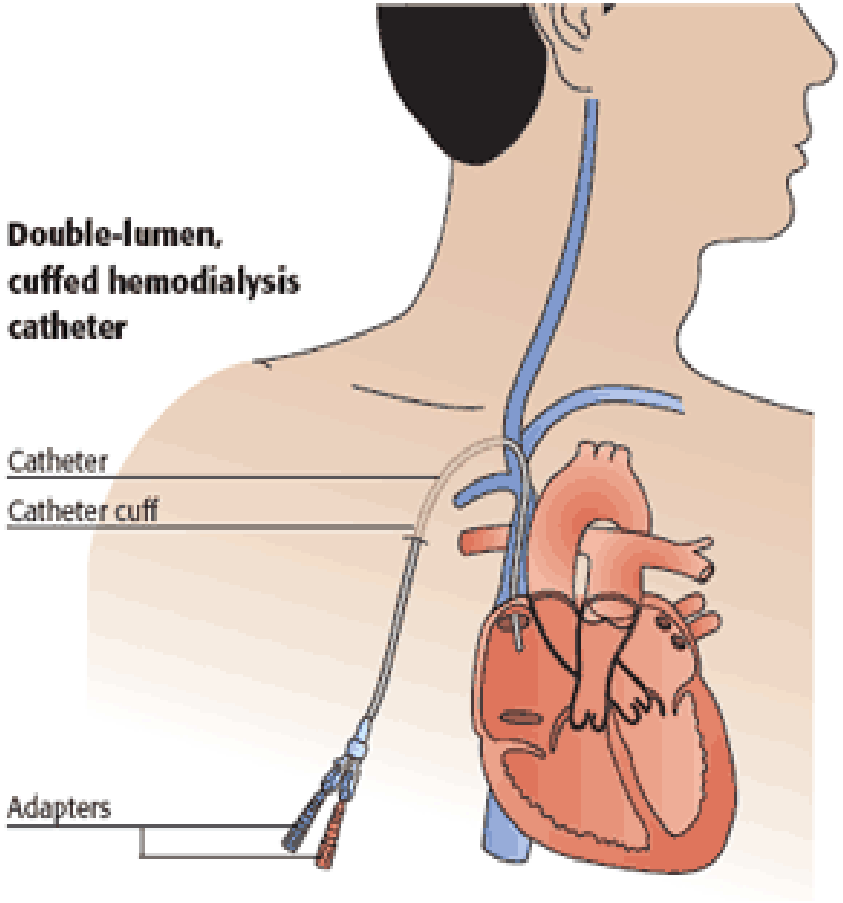
- Na= 140 mEq/L
- K= 2 mEq/L
- Cl= 100 mEq/L
- HCO3=35 mEq/L
- Urea=0 mg/dL
- Cr=0 mg/dL
- Dextrose= 200 mg/dL
- Calcium=2.5 mEq/L
- Phosphorus = 0 mg/dL
- Magnesium=1.2 mg/dL
- Vit B12= 0
- Albumin =0



Hemodialysis Filter (Dialyzer)

Hemodialysis Vascular Access





Acute hemodialysis

All patients are different, and the circumstances eventuating in the need for acute hemodialysis vary widely

"typical" prescription for an acute hemodialysis in a 70-kg adult

Rx: Acute hemodialysis (not for initial treatment)
Session length: Perform hemodialysis for 4 hours
Blood flow rate: 300-350 mL/min
Dialyzer:

- ✓ Dialyzer membrane: your choice
- ✓ Dialyzer K_{UF}: your choice
- ✓ Dialyzer efficiency: usually a dialyzer with a **K_0A of 800-1200** is used

Handbook of Dialysis 2015

Dialysis solution composition

Base: bicarbonate 25 mM
Sodium: 145 mM
Potassium: 3.5 mM
Calcium: 1.5 mM (3.0 mEq/L)
Magnesium: 0.375 mM (0.75 mEq/L)
Dextrose: 5.5 mM (100 mg/dL)
Phosphate: none

Dialysis solution flow rate: 500 mL/min
Dialysis solution temperature: 35°C-36°C

Composition

Formula	Concentrated solution (g/l)		Diluted solution (35 times)(g/l)	
Sodium chloride	216.812		6.194	
Potassium chloride	5.218		0.149	
Calcium chloride,$2H_2O$	6.431		0.183	
Magnesium chloride,$6H_2O$	3.557		0.101	
Acetic acid (glacial)	7.356		0.210	
Dextrose,H_2O	70.000		2.000	
Electrolytes	mmol/l	mEq/l	mmol/l	mEq/l
Na+	3710	3710	106.00	106.00
K+	70	70	2.00	2.00
Ca++	43.75	87.50	1.25	2.50
Mg++	17.50	35	0.50	1.00
$CH3COO^-$	122.50	122.50	3.50	3.50
Cl^-	3902.50	3902.50	111.50	111.50

غلظت نهایی مایع دیالیزبیکربنات

- Na :135meq/l
- K:1 & 2 meq/l
- Mg:1 meq/l
- Ca:2.5 meq/l
- Cl:104 meq/l
- Acetate :35 meq/l
- Glucose : 200mg/dl

- Na :106 + **32** meq/l
- K:1 & 2 meq/l
- Mg:1 meq/l
- Ca:2.5 meq/l
- Cl:111.5 meq/l
- Acetate :3.5 meq/l
- Glucose : 200mg/dl
- **Bicarbonate :32 meq**

5.1 Composition of a Standard Hemodialysis Solution

Component	Concentration (mM)
Sodium	135–145
Potassium	2–3
Calcium	1.25–1.75
	(2.5–3.5 mEq/L)
Magnesium	0.25–0.375
	(0.5–0.75 mEq/L)
Chloride	98–124
Acetate[a]	3–8
Citrate[a]	0.8–1.0 (2.4–3.0 mEq/L)
Bicarbonate	25–35
Glucose	0–11
pCO_2	40–110 (mm Hg)
pH	7.1–7.3 (units)

Acute hemodialysis Prescription

A.. dialysis session length
B. blood flow rate
C. Choosing a dialyzer
D. Choosing the dialysis solution

Reduce the amount of dialysis for the initial one or two sessions

- ❖ predialysis serum urea nitrogen (SUN) level>125 mg/dL ⇨
- ❑ dialysis session length **2-hour**
- ❑ blood flow rate of only **200 mL/min** (150 mL/min in small patients)
- ❑ **relatively low-efficiency hemofilter**
- ❑ A urea reduction ratio of **<40%**

A **longer initial dialysis session** or use of **excessively high blood flow rates** in the acute setting ⇨ **disequilibrium syndrome**

second dialysis session

- Second dialysis session can usually be increased to 3 hours, provided that the predialysis SUN level is <100 mg/dL.
- Subsequent dialysis sessions can be as long as needed.
- The length of a single dialysis treatment **rarely exceeds 6 hours** unless the purpose of dialysis is treatment of drug overdose.
- Slow low-efficiency hemodialysis (SLED) uses **low blood and dialysis solution flow rates** and **longer treatment sessions** in order to more **safely remove fluid**.

dialysis adequacy

- Most ICU patients are fluid overloaded, and urea distribution volume is often much greater than 50%-60% of body weight.

- A typical 3- to 4-hour acute-dialysis session will deliver a **single-pool *Kt/ V* of only 0.9**, with an **equilibrated *Kt/ V* of 0.7**.

- This low level of *Kt/ V*, if given three times per week, is associated with a high mortality in chronic, stable patients. One option is to dialyze sick patients with acute renal failure on a daily (**six or seven times per week**) basis.

- If **every-other-day dialysis** is to be given, the treatment length should probably be set **at 4-6 hours,** to deliver **a single-pool *Kt/ V* of at least 1.2-1.3**, as recommended for chronic therapy.

- **KDIGO** workgroup on acute kidney injury (2012) recommends that when attempting to maintain acute patients on a **3-times-per-week schedule**, each treatment should have **a *Kt/ V* of ≥1.3.**

amount of dialysis….

- The amount of dialysis may need to be adjusted upward in hypercatabolic patients.

- A low predialysis SUN level should not be used as a justification to reduce the amount of dialysis unless substantial residual renal urea clearance is documented

- Many acute renal failure patients tend to have decreased urea generation rates due to lack of protein ingestion and/or to impairment of urea synthesis by the liver.

- **Therefore, a low SUN does not necessarily reflect low levels of other uremic toxins.**

Choosing a dialyzer

❑ Membrane material

No recommendation favoring use of high-flux membranes .

Membrane flux has not been studied as a separate factor in any randomized study of acute dialysis.

❑ Ultrafiltration coefficient (*K*UF)

Use dialyzers of high water permeability (e.g., *K*UF > 6.0) and may lose accuracy if a high fluid removal rate is attempted using a dialyzer that is relatively impermeable to water.

❑ Dialyzer urea clearance

For **the first couple of dialysis sessions**, it is best to **avoid using very high-efficiency** dialyzers

A dialyzer with an in vitro **K_0A urea of about 500-600 mL/min** is recommended for the **initial session** to minimize the risk of inadvertent overdialysis and of developing the disequilibrium syndrome.

Choosing the dialysis solution

- Dialysis solution bicarbonate concentration
- Dialysis solution sodium level
- Dialysis solution potassium level
- Dialysis solution calcium levels
- Dialysis solution magnesium levels
- Dialysis solution dextrose level
- Dialysis solution phosphate levels

Dialysis solution bicarbonate concentration

- Icu patients are often relatively alkalotic, and so prescriptions for “standard” bicarbonate dialysis solution, containing 35-38 mM, should not be used without first carefully evaluating the patient’s acid-base status.

- If the predialysis plasma **bicarbonate level is 28 mM or higher**, or if the patient has respiratory alkalosis, a custom dialysis bicarbonate level (e.g., 20-28 mM, depending on the degree of alkalosis) should be used.

- In dialysis patients, the most common causes of metabolic alkalosis are a reduced intake of protein, intensive dialysis for any reason (e.g., daily dialysis), and vomiting or nasogastric suction, administered lactate or acetate with (TPN) solutions, or citrate due to citrate anticoagulation.

Patients with severe metabolic acidosis

- ❑ Severe metabolic acidosis (**Bicarbonate level <10 mmol/L**)
  - ✓ lowering of the ionized calcium level
  - ✓ paradoxical acidification of the cerebrospinal fluid
  - ✓ increase in the tissue production rate of lactic acid.

- ❑ Initial therapy should aim for a **target postdialysis plasma bicarbonate value of 15-20 mmol/L** is generally appropriate.

A dialysis solution bicarbonate level of **20-25 mM** is normally used.

Dialysis solution sodium level

- The dialysis solution sodium level in the sample prescription is **145** mM.

- This level is generally acceptable for patients who have normal or slightly reduced predialysis serum sodium concentrations

❖ **Patients with normal serum sodium**

For patients with normal or near-normal serum sodium levels, we use a dialysate sodium concentration of 137 mEq/L.

Hyponatremia

- Predialysis serum sodium level >130 mmol/L
- Predialysis serum sodium level <130 mmol/L

Predialysis serum sodium level >130 mmol/L

- The goal should be to keep serum sodium at or above 140 mmol/L, and dialysis solution sodium should be in the range of 140-145 mM.

- The potential benefits of keeping **dialysis solution sodium <10 mM above the serum level** in patients with possible **brain edema and/or hypotension**

Predialysis serum sodium level <130 mmol/L

- Rapid correction of hyponatremia has been linked to osmotic demyelination syndrome.

- The **maximum safe rate of correction** of the serum sodium concentration in severely hyponatremic patients is in the **range of 6-8 mmol/L per 24 hours.**

- **In patients with severe hyponatremia :**

✓ Set the **dialysis solution sodium level** as low as possible (with **most machines** one can go **no lower than 130 mM**, with the Dialog Plus machine from **B.Braun** one can get **down to a dialysate sodium of ˜123 mM**).

✓ **Dialyze at a slow** (**50-100 mL/min**) **blood flow rate.** For **not longer than 1 hour** at a time.

✓ Alternating with **isolated ultrafiltration** as needed for volume control.

Predialysis serum sodium level <130 mmol/L…

- **Another approach** : To delay dialysis for a few days **if possible** and to treat hyponatremia with hypertonic saline, removing excess fluid by isolated ultrafiltration as needed.

- If continuous hemodialysis or hemofiltration is available, use of one of these modalities with an appropriate sodium-reduced dialysis solution/replacement fluid is another good option and allows for the greatest control of the rate of serum sodium increase.

Chronic hyponatremia

- Set the dialysate sodium to the **lowest commercially available setting (130 mEq/L), reduce the blood flow rate to 2 mL/kg/min, and reduce the dialysis time**

- **hourly measurements** of the serum sodium concentration during the course of dialysis are **mandatory,** and **administration of small amounts of 5 percent dextrose in water (D5W)** may still be required to assure that correction **does not exceed 6 mEq/L during the dialysis treatment.**

- **The goal is to correct the hyponatremia over the course of multiple hemodialysis sessions that are performed over a period of several days.**

Up to date 2022

Hypernatremia

Whenever the dialysis solution sodium level is **more than 3-5 mM lower** than the plasma value, **three complications** of dialysis occur :

1. **Hypotension**.
2. **Muscle cramps.**
3. **Cerebral edema and exacerbating the disequilibrium syndrome**.

The risk of disequilibrium syndrome is the most important one

- **Use of low-sodium dialysis solution should certainly be avoided in predialysis SUN level >100 mg/dL.**

- **The safest approach is to first dialyze a patient with a dialysis solution sodium level close to that of plasma and then correct the hypernatremia by slow administration of slightly hyponatric fluids.**

Chronic hypernatremia

- If the serum sodium concentration is only mildly elevated, use a dialysate sodium concentration that is **within 2 mEq/L of the plasma sodium concentration for the first dialysis session**.

- Patients with extremely high serum sodium concentrations are best treated with **CRRT .**

Acute hypo- or hypernatremia

- Patients with hyperacute salt poisoning or hyperacute water intoxication should undergo aggressive correction of their serum sodium concentration.

- Rapid correction is well tolerated in hyperacute disturbances.

- **Conventional** hemodialysis with a **standard sodium concentration** can be used to correct the electrolyte disturbance rapidly.

Dialysis solution potassium level

- **Ranges from 2.0 to 4.5 mM.**

- **predialysis serum potassium level <4.5 mmol/L:**

The dialysis solution **potassium level can be ≥4.0 mM** with special caution needed in cardiac patients prone to arrhythmias.

- **predialysis plasma potassium level >5.5 mmol/L:**

A dialysis solution **potassium level of 2.0** is usually appropriate in stable patients.

- **Dialysis solution potassium concentration should be raised to 2.5 to 3.5 in patients at risk for arrhythmia or in those receiving digitalis**

❖ **There is a marked rebound increase in the serum potassium level within 1–2 hours after dialysis**

Dialysis solution calcium levels

- Generally recommended level for acute dialysis is 1.5–1.75 mM (3.0–3.5 mEq/L).

- There is some evidence that dialysis solution calcium levels **<1.5 mM** (3.0 mEq/L) **predispose to hypotension during Dialysis**.

- In patients with predialysis hypocalcemia, correction of acidosis can result lowering of the ionized plasma calcium level (with possible precipitation of seizures).

Dialytic treatment of acute hypercalcemia

- ✓ Hemodialysis can be effective in lowering the serum calcium concentration.

- ✓ Under most circumstances prefer to add at least 1.25 mM (2.5 mEq/L) calcium to the hemodialysis solution to minimize the possibility of an overly rapid decrease in the serum ionized calcium.

Dialytic treatment of acute hypercalcemia

- For patients with mild hypocalcemia, normocalcemia, or mild hypercalcemia , use a dialysate calcium concentration of 2.5 mEq/L.

- For patients with significant hypocalcemia (total plasma calcium level <8 mg/dL , particularly if the patient is symptomatic, use a dialysate calcium concentration of 3 to 3.5 mEq/L.

- For patients with severe hypercalcemia (total plasma calcium level >12 mg/dL, use a dialysate calcium concentration of 2 to 2.5 mEq/L.

Dialysis solution magnesium levels

- The usual dialysis solution magnesium level ranges from 0.25 to 0.75 mM(0.5–1.5 mEq/L).
- The best dialysis solution magnesium level to use for acute dialysis in terms of blood pressure maintenance remains unknown.
- Hypomagnesemia occurs in malnourished dialysis patients and in dialysis patients receiving TPN.

Dialysis solution dextrose level

- Dialysis solution for acute dialysis should always contain dextrose (100–200 mg/dL)

- Septic patients, diabetics, and patients receiving beta-blockers are at risk of developing severe hypoglycemia during dialysis.

Dialysis solution phosphate levels

- Phosphate is normally absent from the dialysis solution.

- Use of a **large-surface-area dialyzer and provision of a longer dialysis session** increase the **amount of phosphate removed** during dialysis

- Malnourished patients and patients receiving hyperalimentation or in patients being intensively dialyzed for any purpose may have **low or low-normal predialysis serum phosphate** levels.

- Severe hypophosphatemia can cause respiratory muscle weakness and alterations in hemoglobin oxygen affinity.

This can lead to respiratory arrest during dialysis.

Dialysis solution phosphate levels…

- For prevention of hypophosphatemia, the phosphorus concentration in the final dialysis solution should be about 4 mg/dL.

- For patients at risk, phosphate can be added to the dialysis solution this practice is not FDA-approved.

- Phosphate can be given intravenously, although this must be done carefully to avoid overcorrection and hypocalcemia& acute kidney injury.

Ultrafiltration orders

- Fluid removal needs can range from 0 to 5 kg per dialysis session.

- Fluid removal rates of **10 mL/kg per hour** are usually well tolerated in volume overloaded patients.

- If the patient does not have pedal edema or anasarca, in the absence of pulmonary congestion, it is unusual to need to remove greater than 2–3 L over the dialysis session.

Ultrafiltration orders…

- If a large amount of fluid (e.g., **4.0 L**) must be removed **over a 2-hour period** , it is impractical and dangerous.

- The **dialysis solution flow** can initially be **shut off,** and isolated ultrafiltration can be performed **for 1–2 hours, removing 2–3 kg of fluid.**

- **Immediately** thereafter, dialysis can be performed **for 2 hours**, removing the remainder of the desired fluid volume.

❖ **If severe electrolyte abnormalities, such as hyperkalemia are present, dialysis may have to be performed prior to isolated ultrafiltration.**

Impact of dialysis frequency on ultrafiltration needs

Use of a **frequent** (**4-7 times per week**) dialysis schedule **reduces the amount of fluid that needs to be removed with each dialysis :**

- ✓ lowering the risk of intradialytic hypotension
- ✓ Ischemic damage to an already impaired set of kidneys.

An alternative way to remove fluid relatively asymptomatically is to use SLED

Patient monitoring and complications

The patient’s blood pressure should be monitored as often as necessary , but **at least every 15 minutes** for an **acute dialysis in an unstable patient**.

Postdialysis evaluation

1. Weight loss
2. Postdialysis blood values

Postdialysis blood values

❖ For **urea nitrogen, sodium, and calcium**, the postdialysis specimen can be drawn **20–30 seconds to 2 minutes after dialysis.**

❖ A postdialysis increase in the **plasma urea level of 10%–20% usually occurs within 30 minutes** due to reequilibration of urea between various body compartments.

❖ because of concomitant shifting of potassium into cells due to correction of acidosis or to cellular uptake of glucose ⇨ it is best to sample blood for potassium **at least 1 hour after the end of dialysis**.

SUMMARY AND RECOMMENDATIONS

- The components of the **acute dialysis** prescription include the choice of hemodialysis **membrane, dialysate composition** and **temperature**, **blood flow rate**, **amount and rate of ultrafiltration (UF)**, choice of **anticoagulation**, and **total dialysis dose.**

- Biocompatible high-flux membranes for acute hemodialysis can use.

- For the first dialysis treatment, the blood flow rate depends on the degree of azotemia. BUN >100 mg/dL, use a blood flow rate of ≤200 mL/min for the first treatment or two (of 2 to 2.5 hours each).

- Use a **dialysis blood flow rate of 400ml/min.**

SUMMARY AND RECOMMENDATIONS…

- Most patients who survive AKI recover renal function.
- Dialysis should not be continued for longer than is necessary.
- For patients who are still acutely ill, the decision to discontinue dialysis should be determined by the degree of recovery of renal function and by the patient's overall condition.


Thank
you