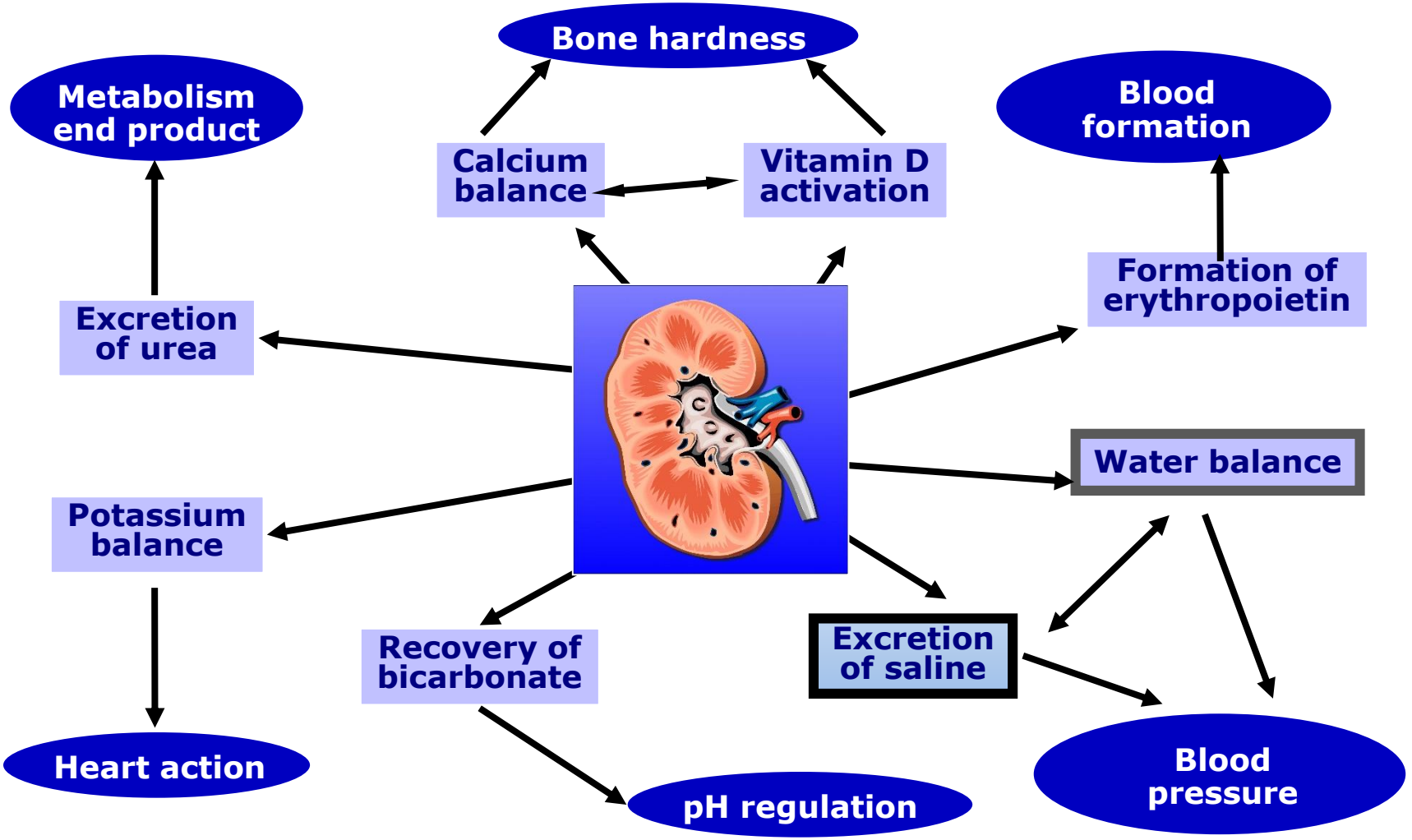
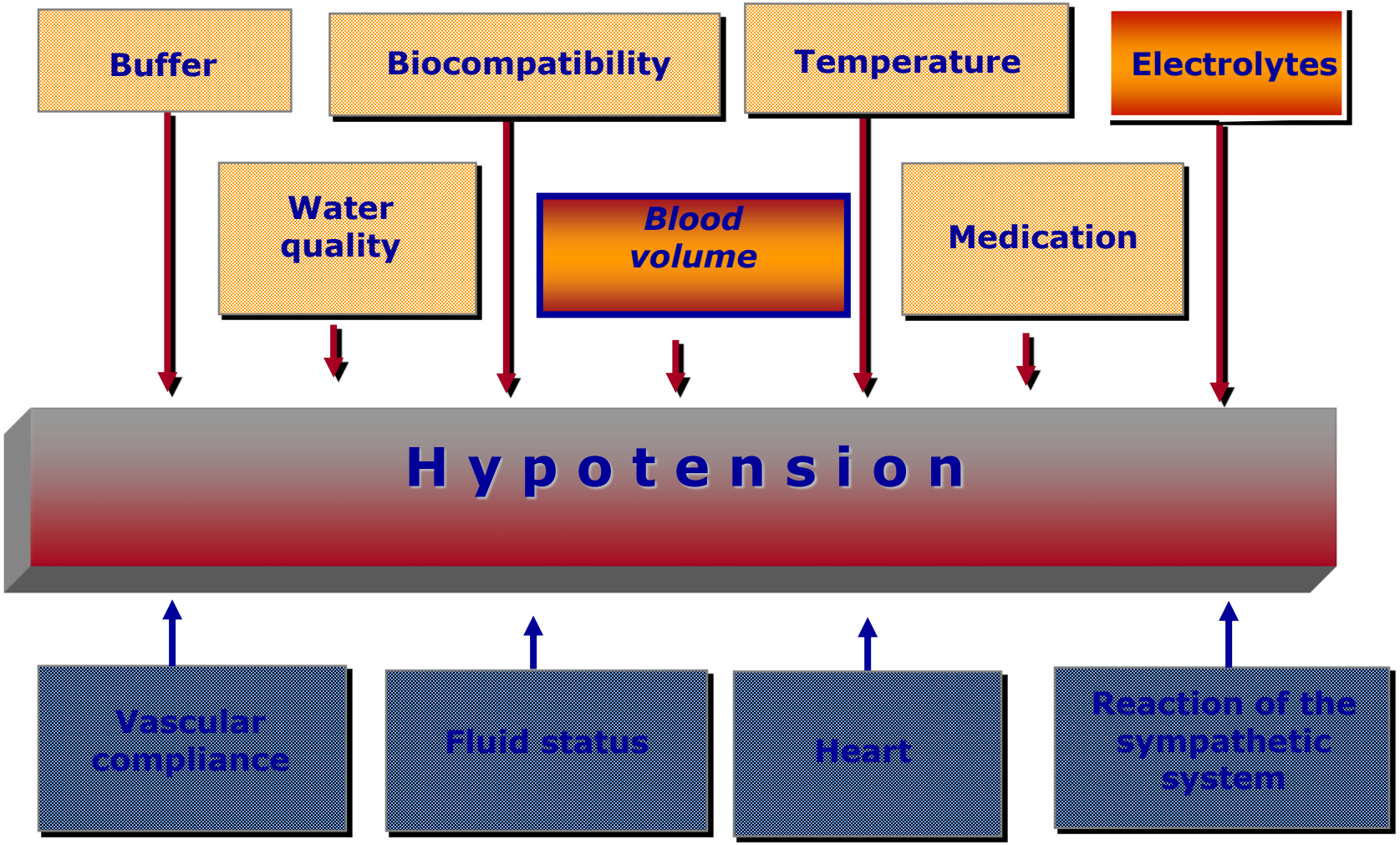
Ultrafiltration and Sodium Profiles

A module in the overall design of "physiological dialysis"

Kidney functions



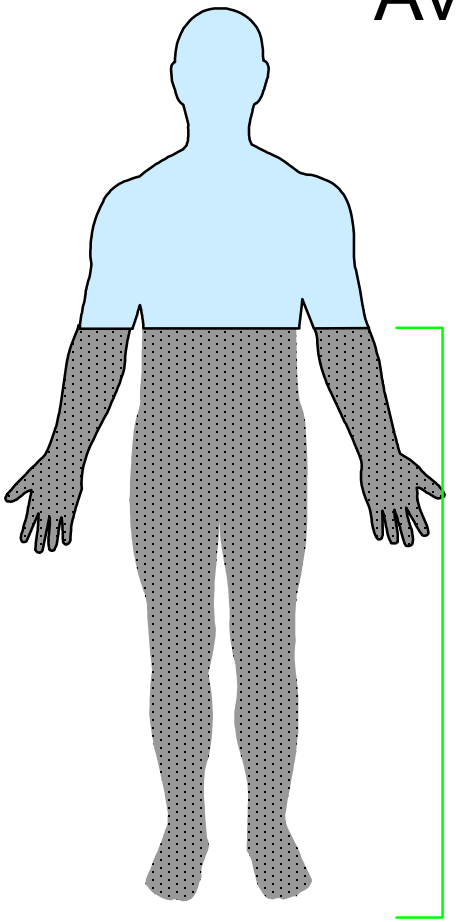
Causes of hypotension



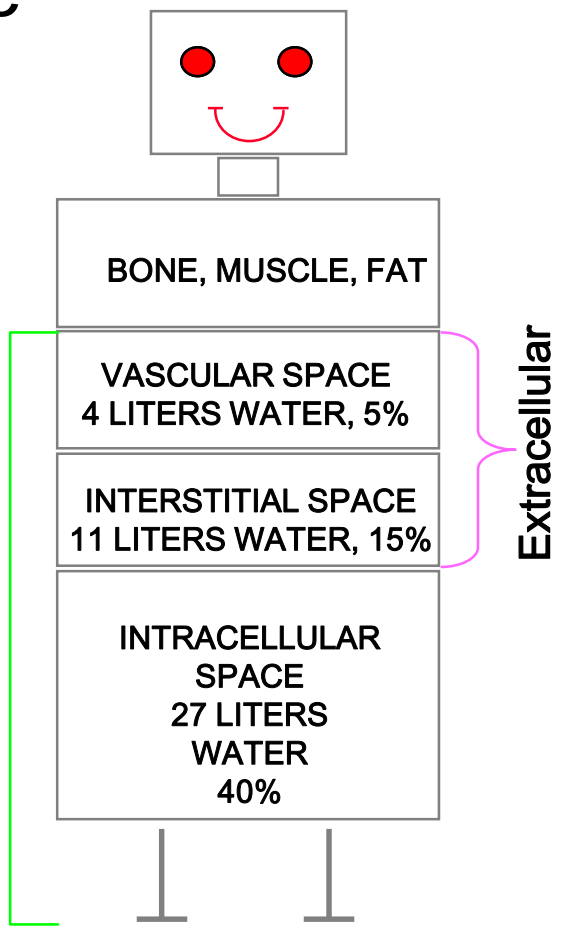
Fluid Spaces in the Body

Average weight Male

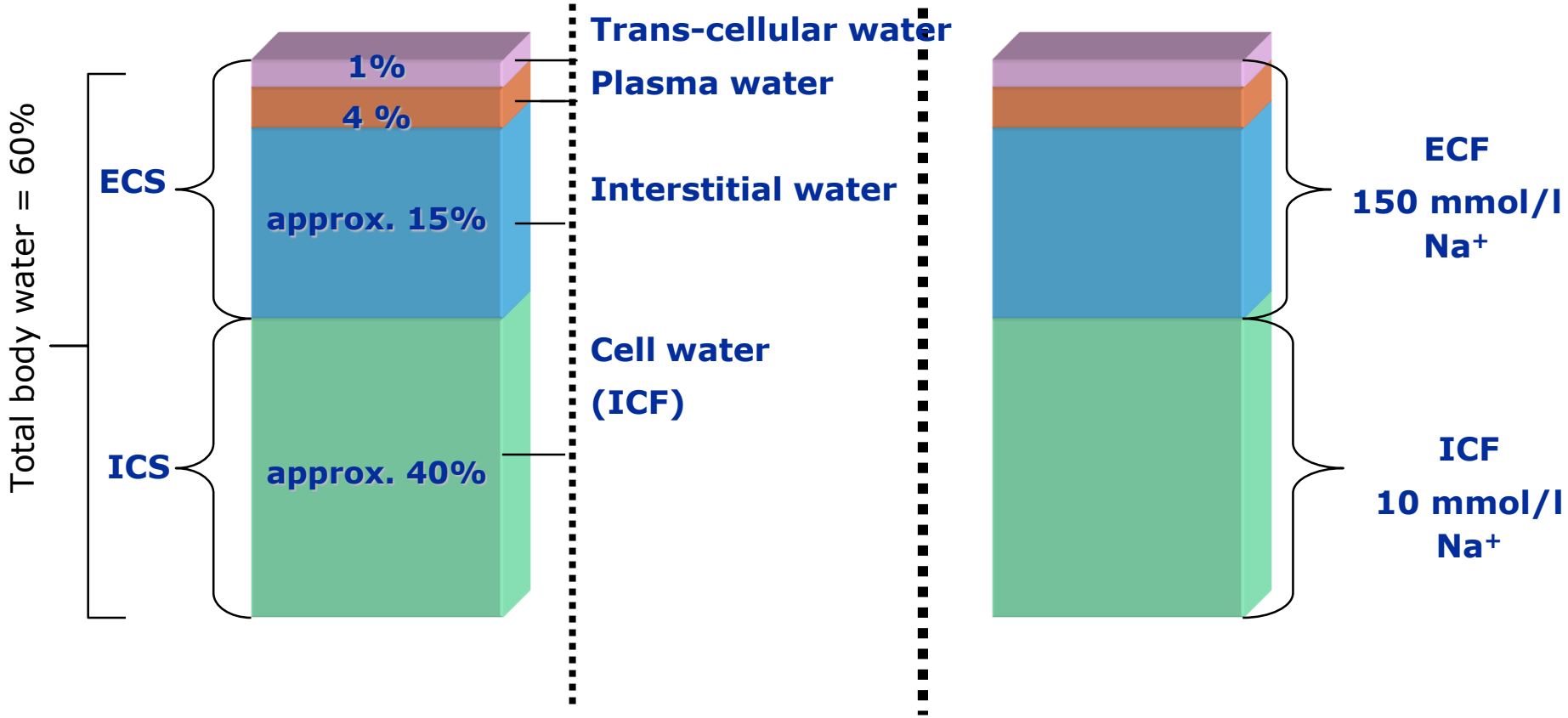
70 kg



60% of Total Body Weight is 42 liters of water



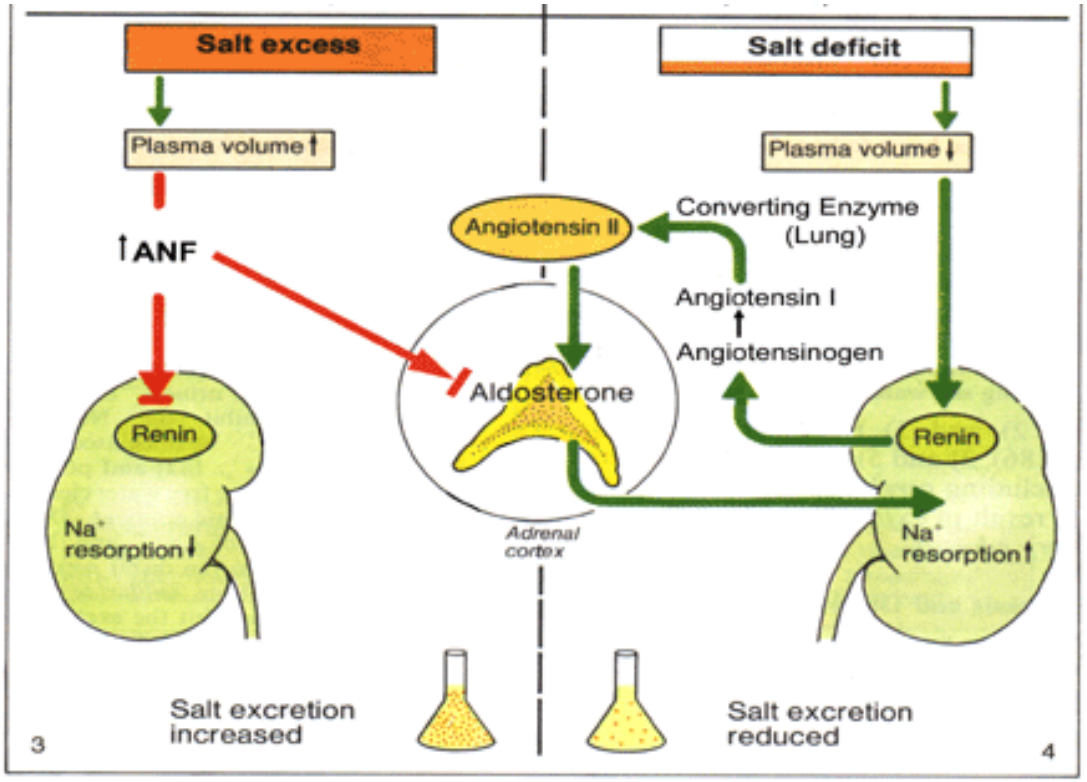
Distribution of water and sodium in the intra- and extracellular spaces



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Sodium balance

- Increased ADH release
- Expansion of heart atria
- Release of ANP
- Vasodilatation at the afferent vessel of the glomeruli
- GFR ↑
- Na+ re-absorption inhibitor
- Increased Na+ excretion

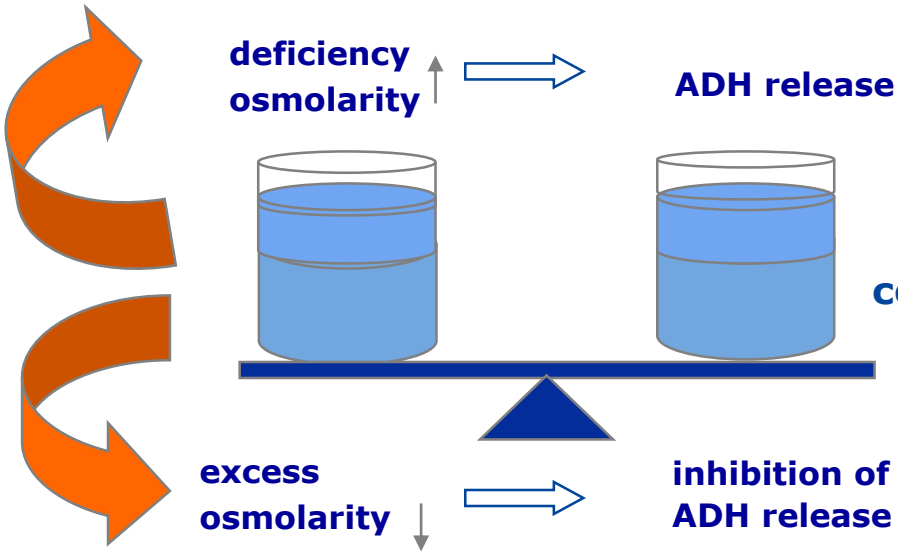


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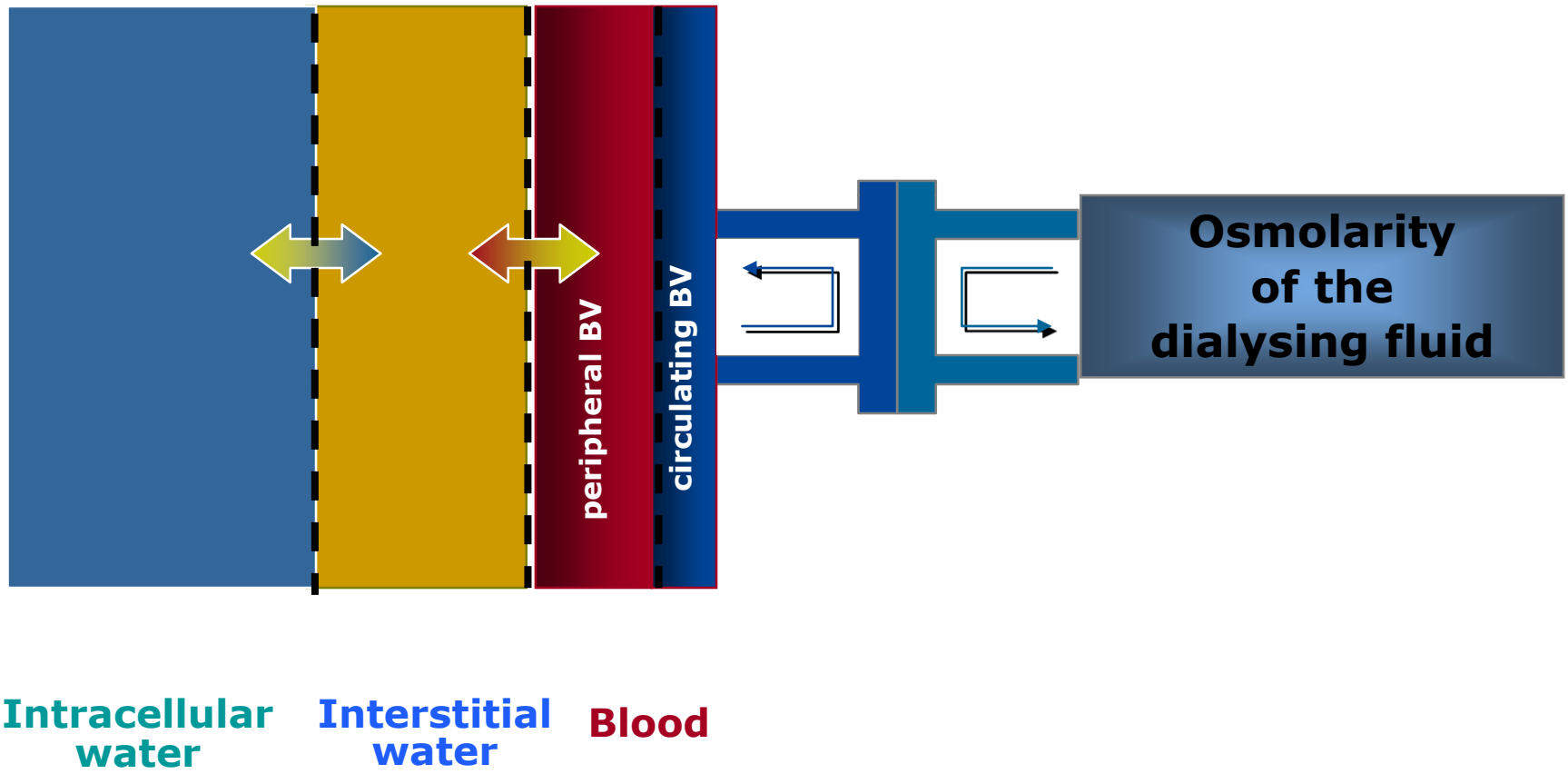
Water balance

INPUT approx. 2.5 L/d
0.3 L oxidation water
0.9 L through nutrition
1.3 L through drinking

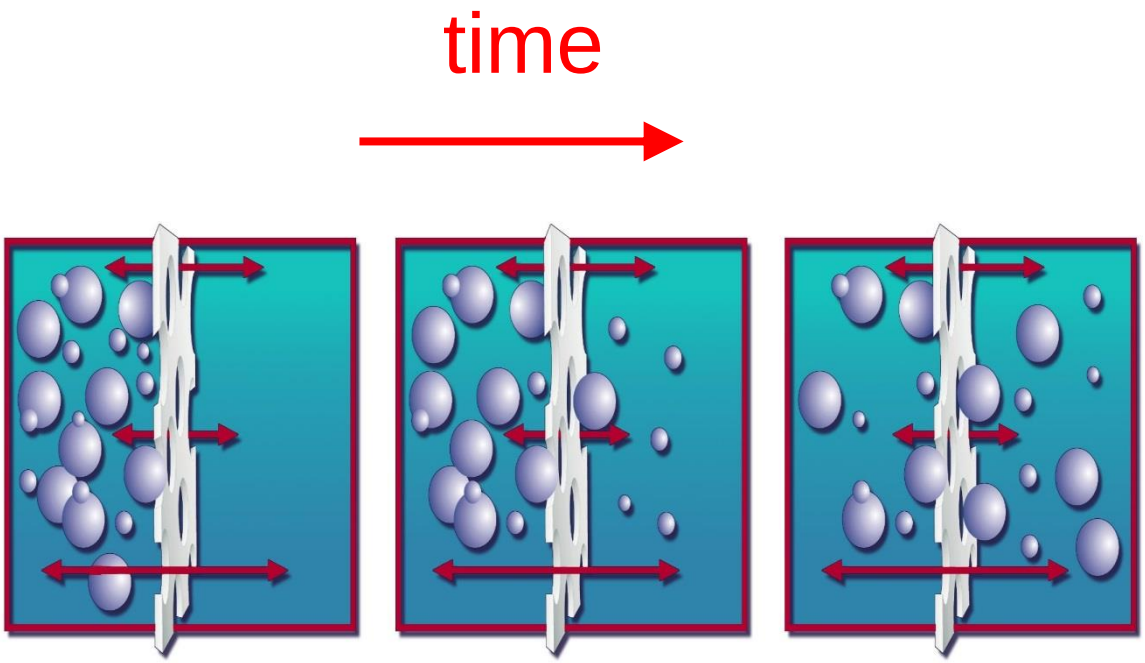
OUTPUT approx. 2.5 L/d
0.1 L through stools
0.9 L through breathing and skin
1.5 L as urine



Electrolyte balance – diffusion



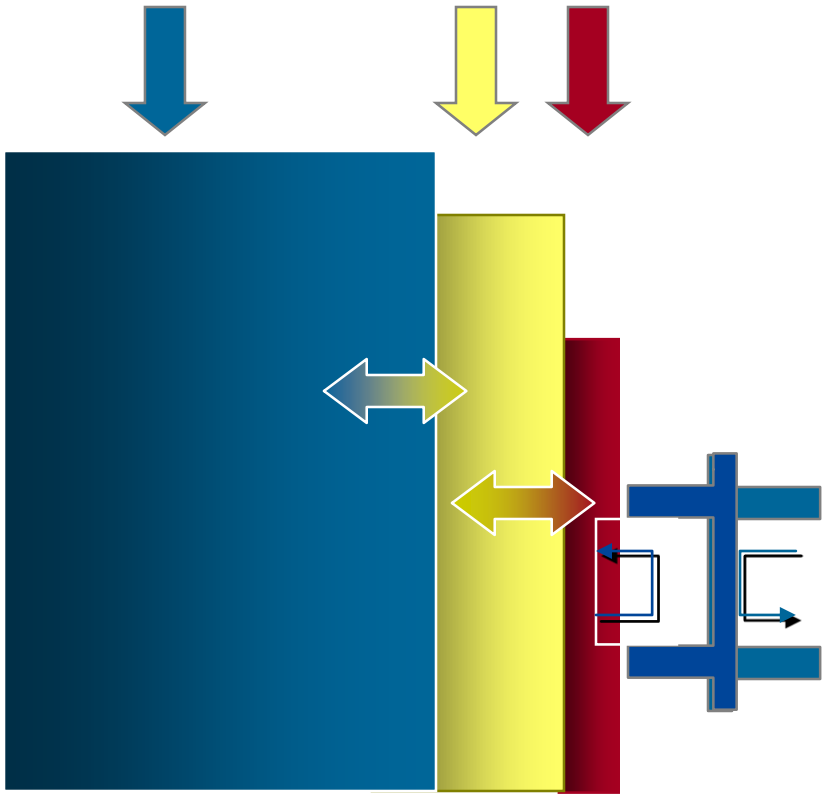
Diffusion



Diffusion: due to the random movement of all molecules Brown‘s molecular movement)

REMARK: Diffusion is faster for smaller molecules!

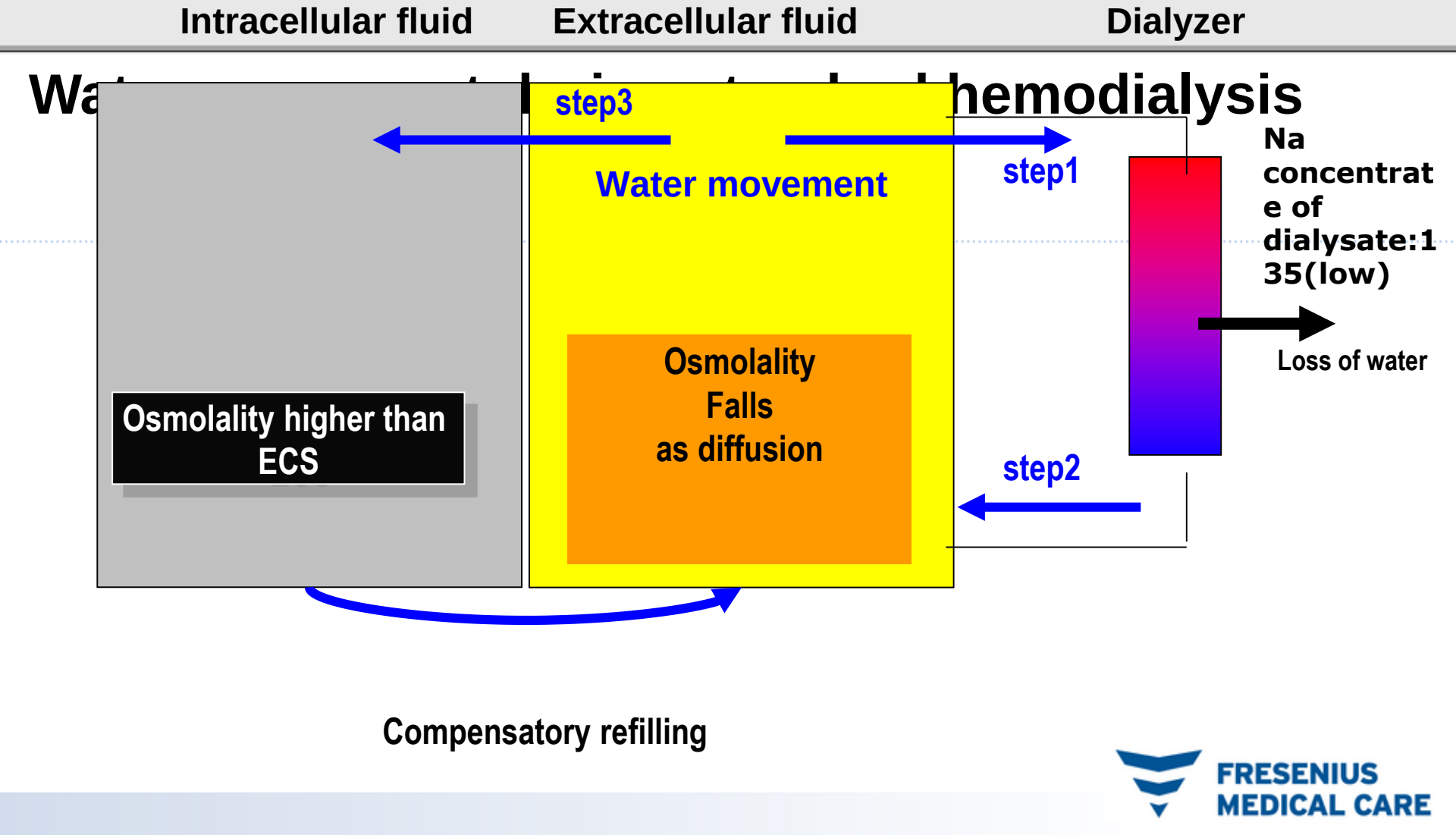
Water balance – ultrafiltration

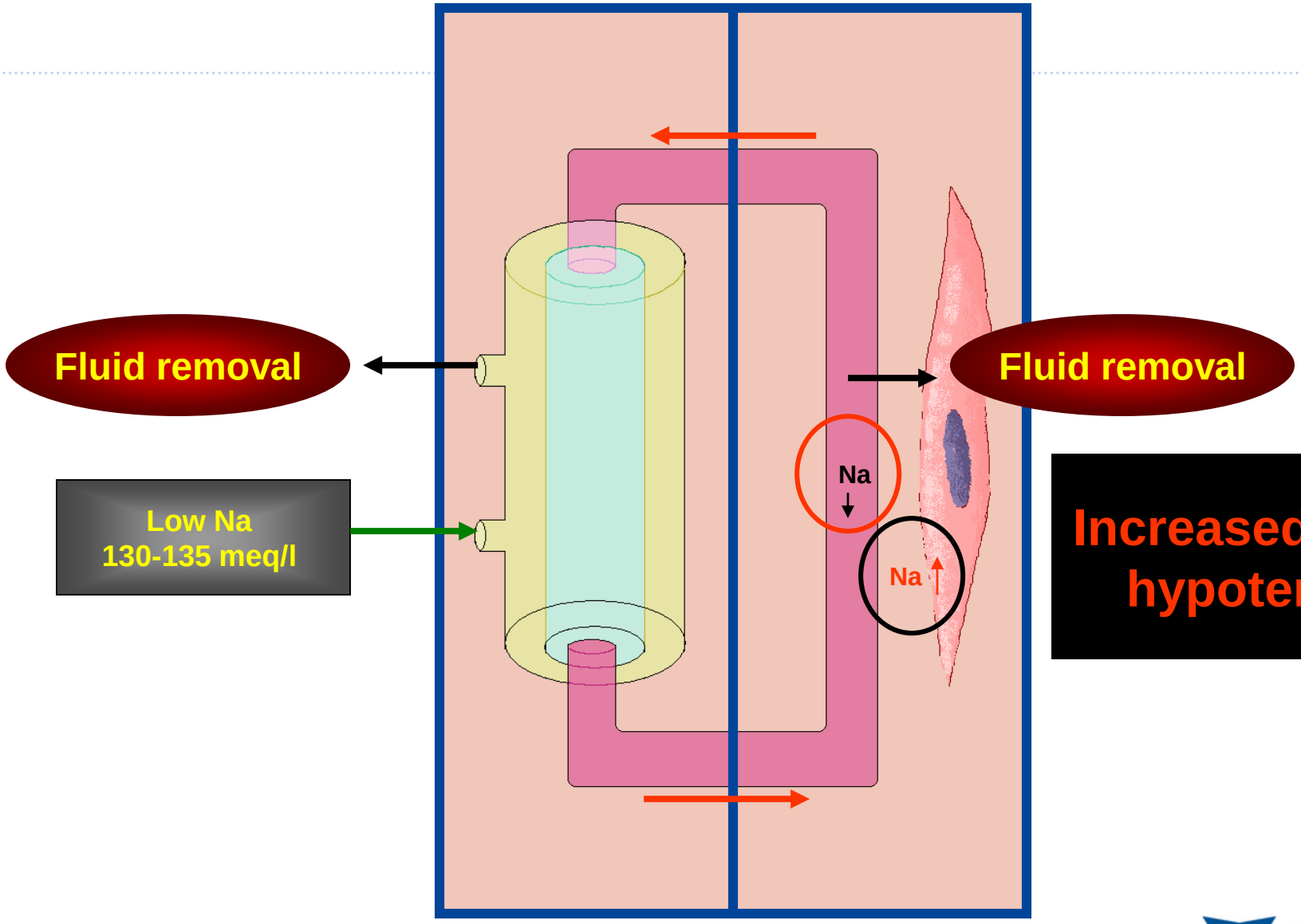


Intracellular water
Interstitial water
Plasma volume



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Intracellular fluid
Extracellular fluid
Dialyzer
hemodialysis
step3
Water movement
step1
Na concentrate of dialysate:135(low)
Loss of water
Osmolality higher than ECS
Osmolality Falls as diffusion
step2
Compensatory refilling



Increased risk of hypotension

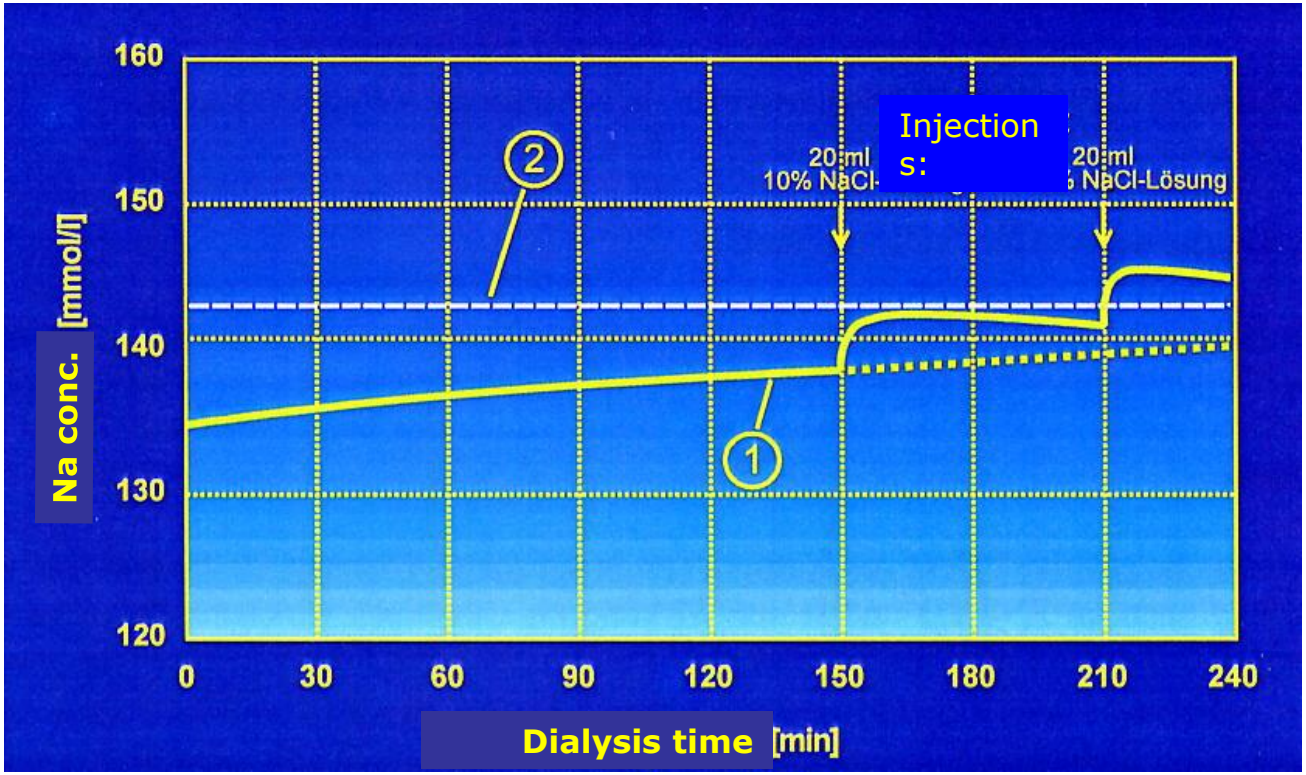
Two Basic Reasons That Patients End up With Dialysis Symptoms During Treatment

- The loss of circulating volume in the vascular space

- The loss of osmolality as the urea is removed during dialysis -

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Result of a saline injection



Patient's pre-dialytic serum concentration (135 mmol/l) (1)
Na concentration in the dialysing fluid (143 mmol/l) (2)

Treatment-induced fluid intake

Step 1: Determining the pre- and postdialytic plasma sodium levels

Step 2: Determining the patient's total body water

Step 3: Calculating the total body water volume (x) required to ensure that, in case of a postdialytic Na+ overload, the Na+ concentration in the total body water is again equal to the predialytic Na+ concentration.

Step 4: Calculating the volume of sodium-free water required for reaching the predialytic Na+ concentration in the total body water.

Calculation example

predialytic Na+: 135 mmol/l
postdialytic Na+: 145 mmol/l
total body water: 40.19 l

males: BW x 0.58
females: BW x 0.53

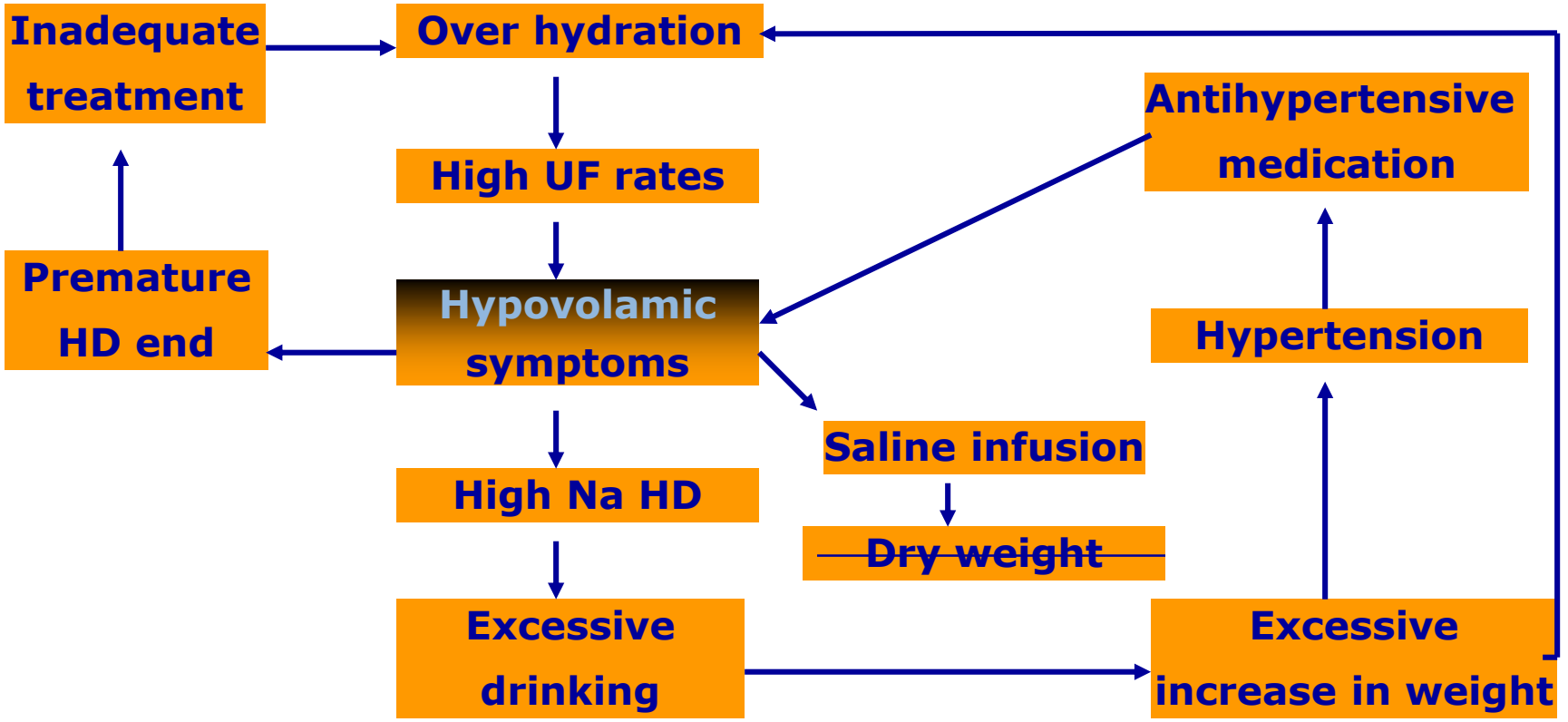
$$\frac{\text{total body water x postdialytic plasma sodium}}{\text{predialytic plasma sodium}}$$

$$X = \frac{42 \times 145}{135} = 45.11 \text{ litres}$$

45.11 – 42 =3.11 Litres
treatment-induced water intake

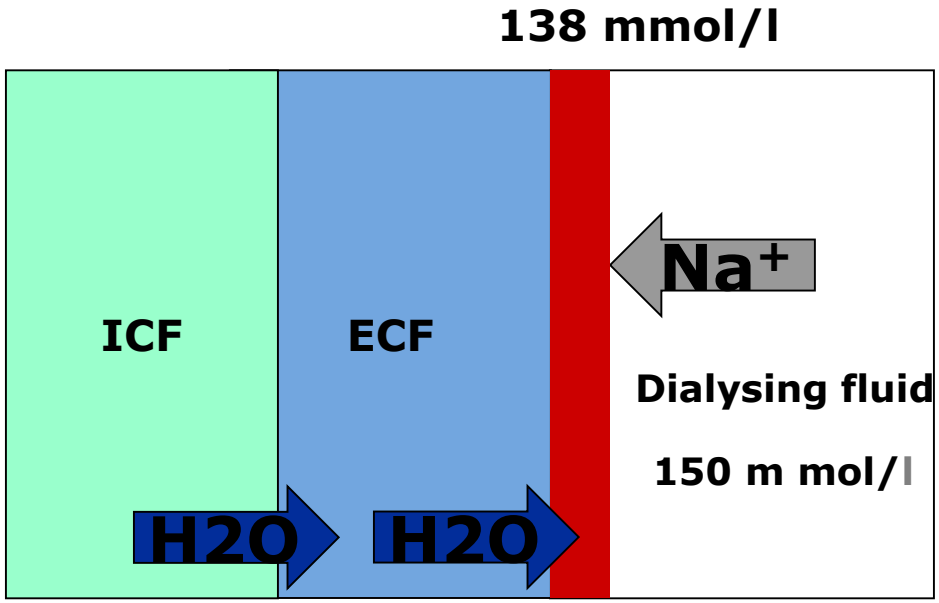
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Consequences of high Na+ HD



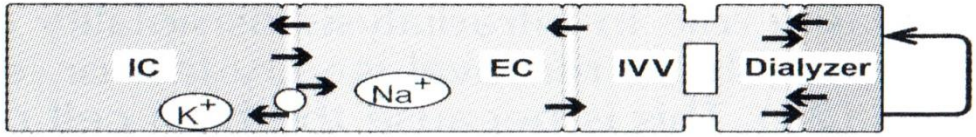
Fluid displacement through osmosis

The increased plasma Na+ level causes the fluid to be displaced from the ICS to the ECS



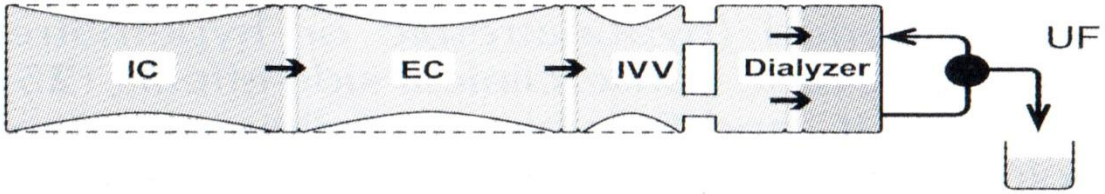
Steady state

a



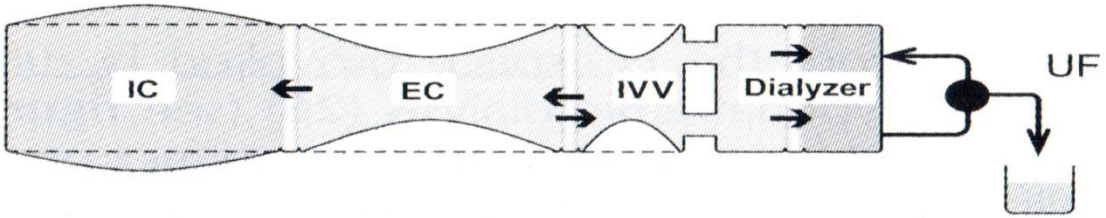
Ultrafiltration (isolated)

b



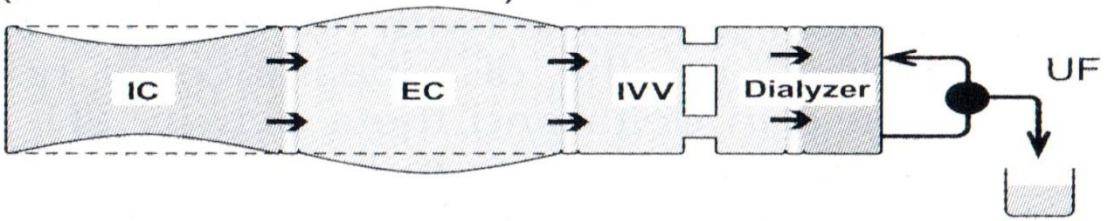
Dialysis (DF: 130 mmol/l Na^+)+Ultrafiltration

c



Dialysis (DF: 150 mmol/l Na^+)+Ultrafiltration

d



Possible solution: profiles

Clinical experience:

An increased plasma sodium level causes the fluid to be displaced from the ICS to the ECS

At the beginning of the treatment, the patients tolerate higher UF rates

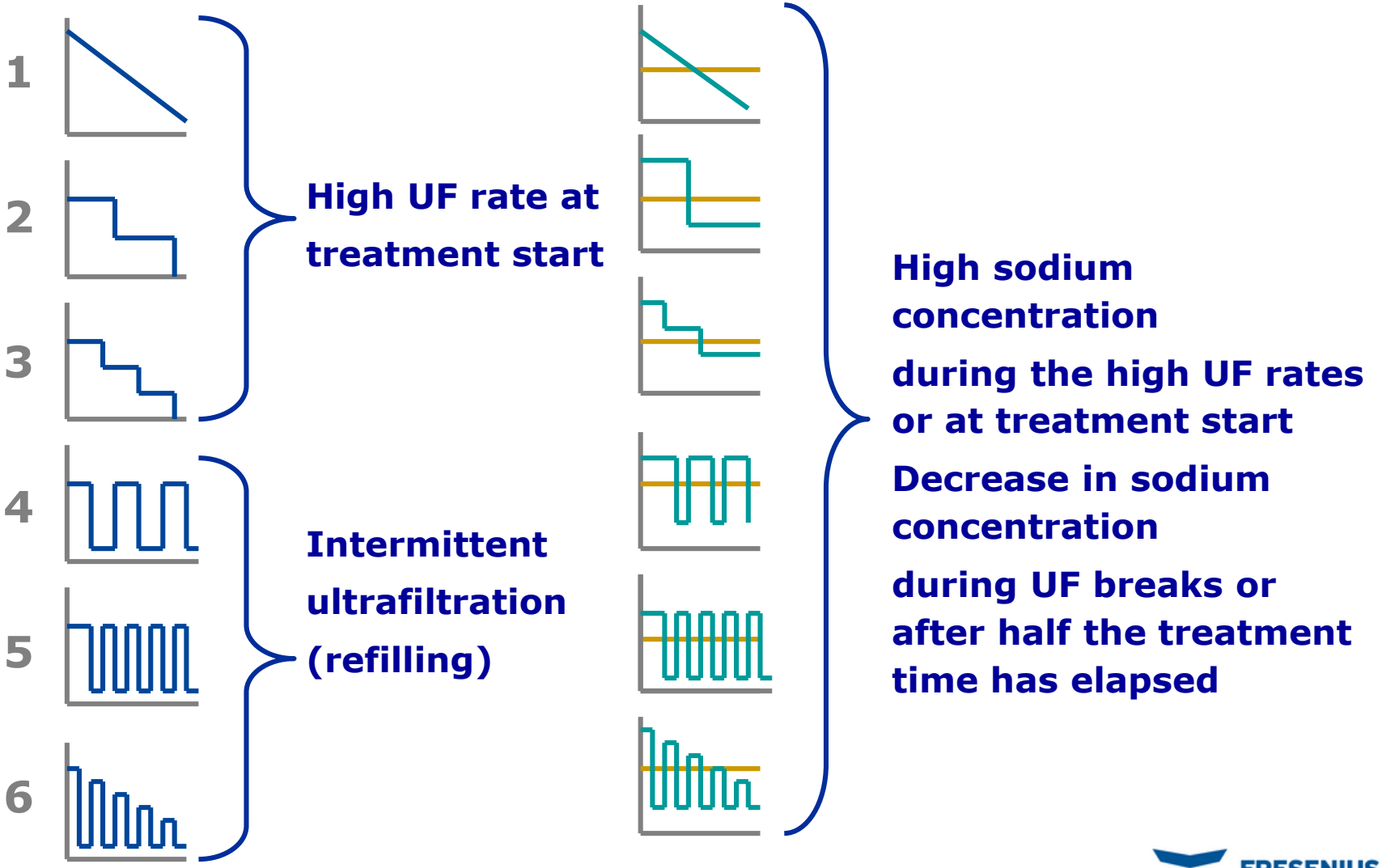
Requirements:

The increase in sodium must not lead to a post dialytic sodium overload.

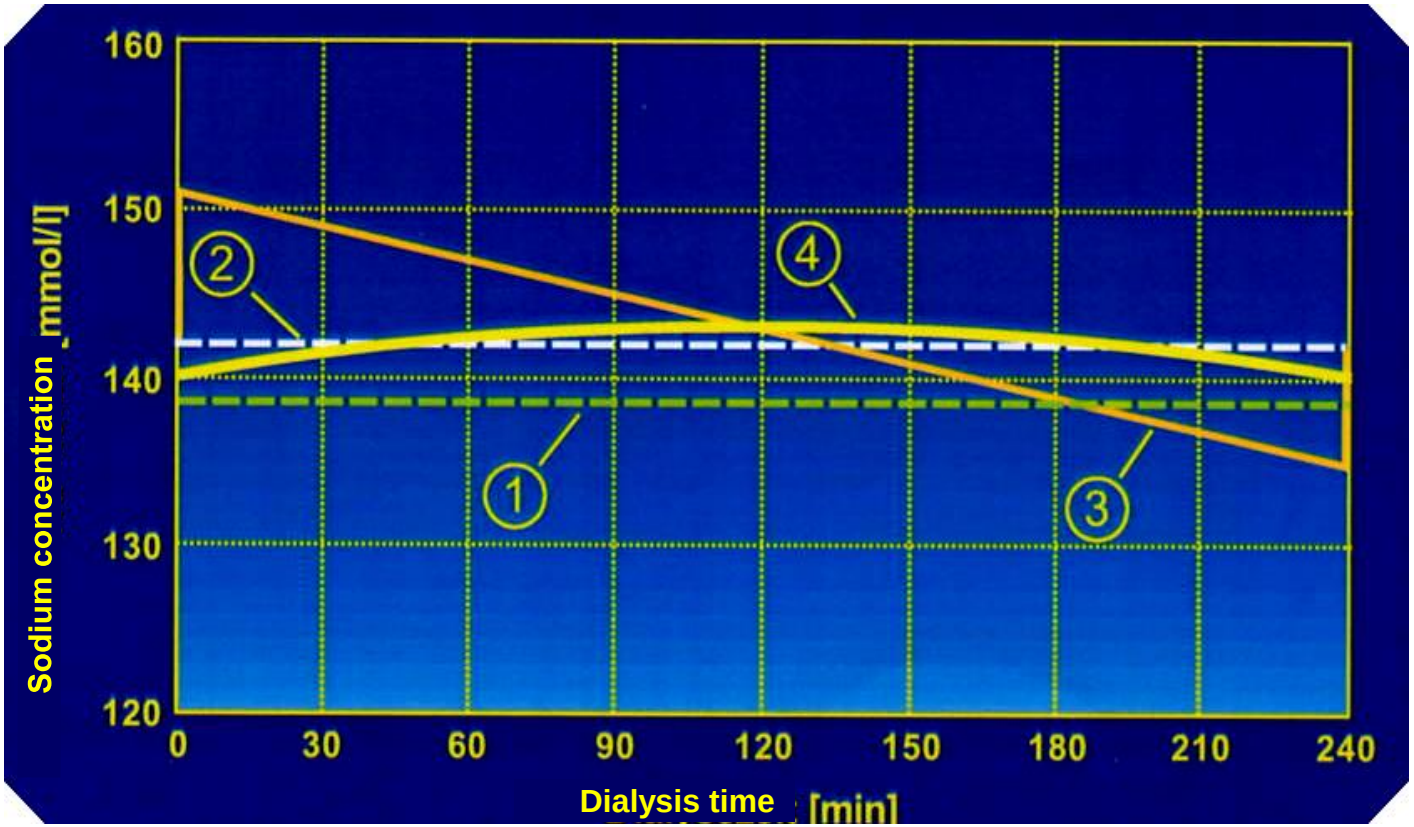
The intradialytic sodium balance must be designed such that the positive (osmotic) effect of sodium is maintained and the drawbacks (post dialytic Na+ overload) are minimized.

High UF rates at treatment start

Neutral Na+ and UF profiles with regard to balance



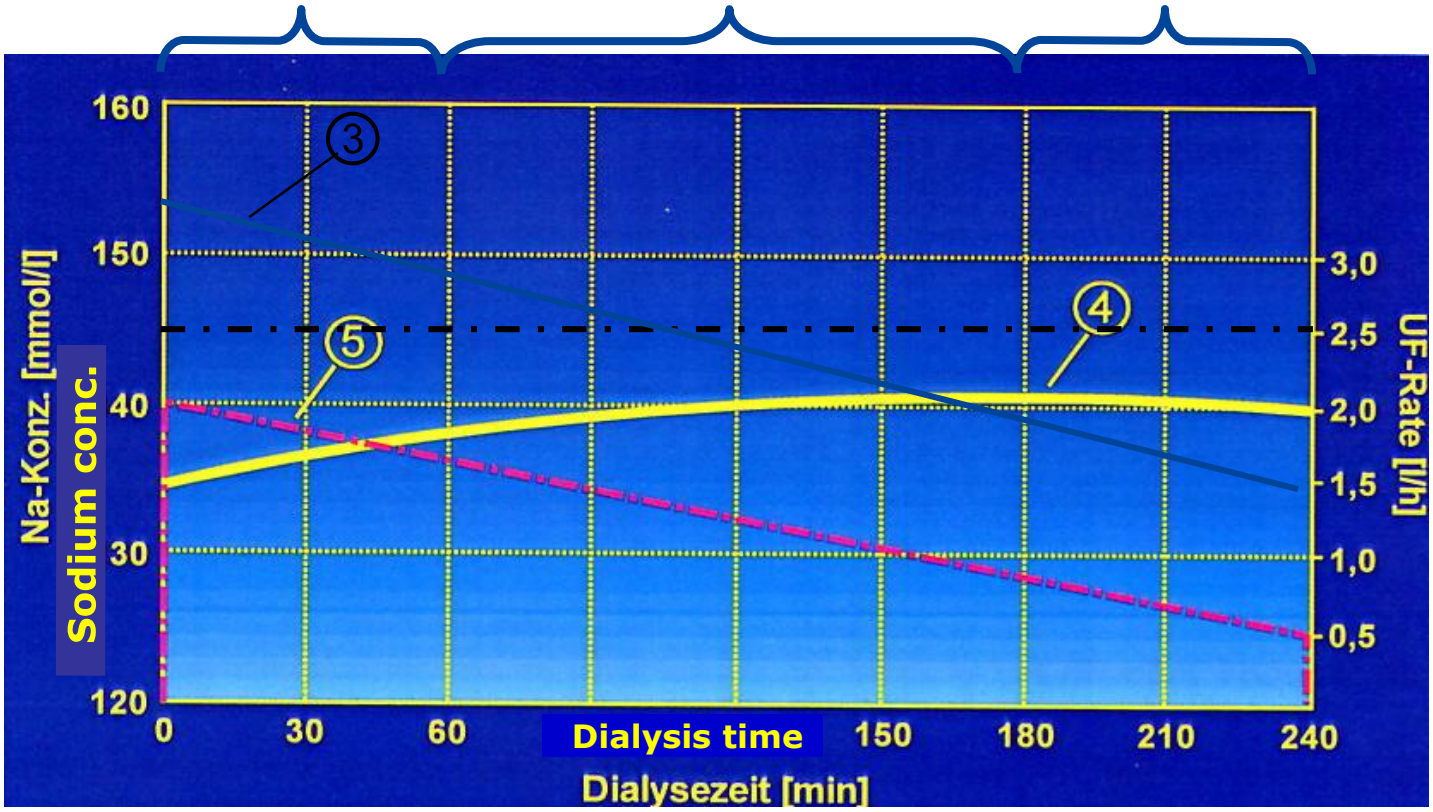
Changing the plasma sodium concentration



Sodium concentration in the dialysing fluid (2) 142 mmol/L
Change in serum sodium concentration without profile (1) 139 mmol/L
Na profile type 1 (3) Initial Na+ 151 mmol/L
Change in serum sodium concentration with Na+ profile (4)

UF profile 1 / Na+ profile 1

Plasma water excess High Na^+ saturation Na^+ at desired level



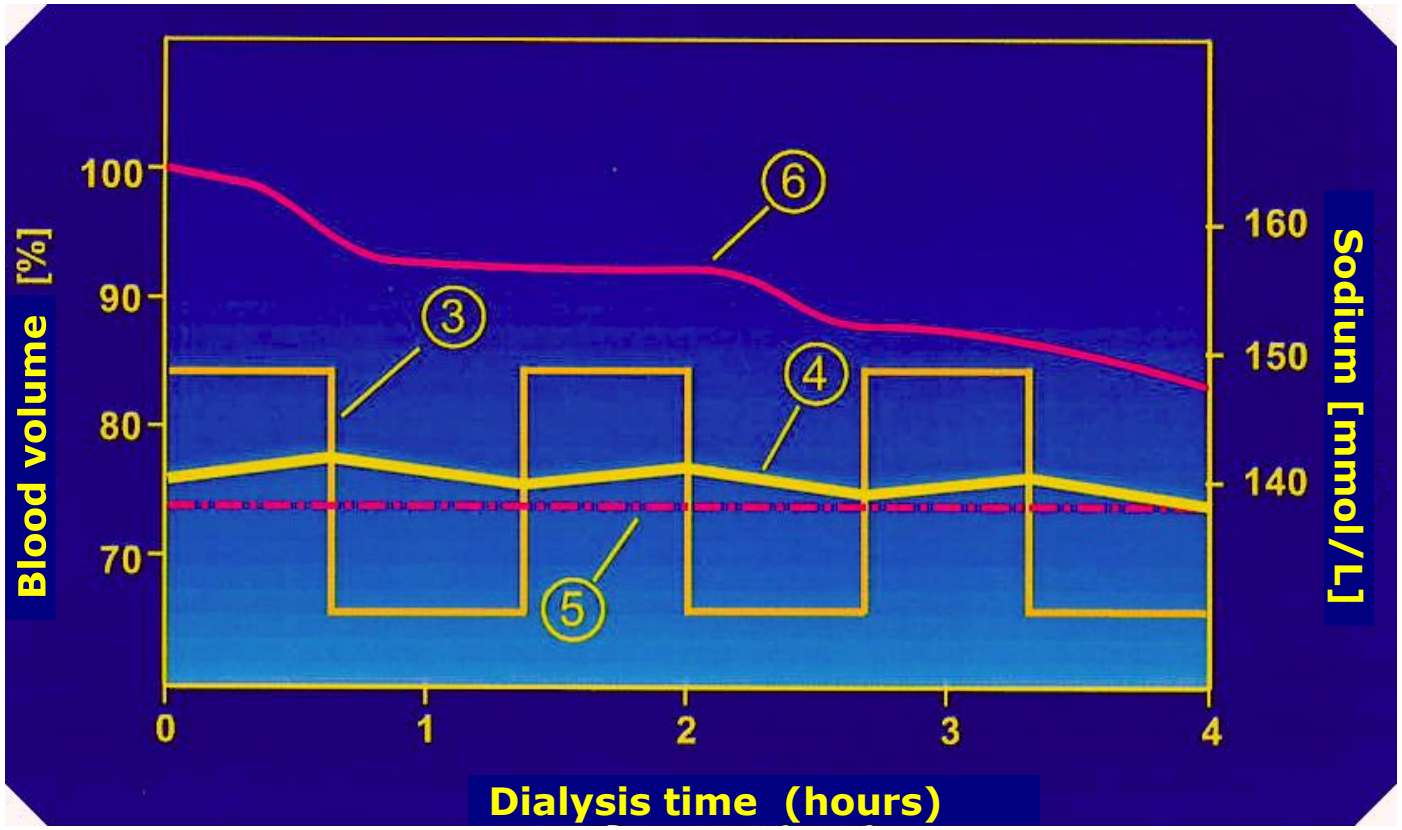
UF profile type 1 (3)
Na profile type 1 (151 mmol/L initial sodium) (5)
Change in plasma Na^+ with Na^+ profile 1 (4)
Desired Na^+ concentration in the dialysing fluid (142 mmol/L)

Volume effects of Na+ profiles

- An increase in sodium in the ECV by 1 mmol/L increases the ECV by 1.3% (ECV 10 L >>> 130 ml).
- Considering the ratio of the interstitial volume to the intravascular volume in the ECV, the blood volume in the intravascular space is increased by 30 ml.
- Mean fluid removal / dialysis = 3000 ml
  As a result, ultrafiltration causes a blood volume reduction of 600 to 1000 ml.
- If the Na^+ concentration changes by 5 mmol/l, the loss in blood volume through ultrafiltration is opposed by a gain in volume of 150 to 200 ml.

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Osmotic effect of Na profiles

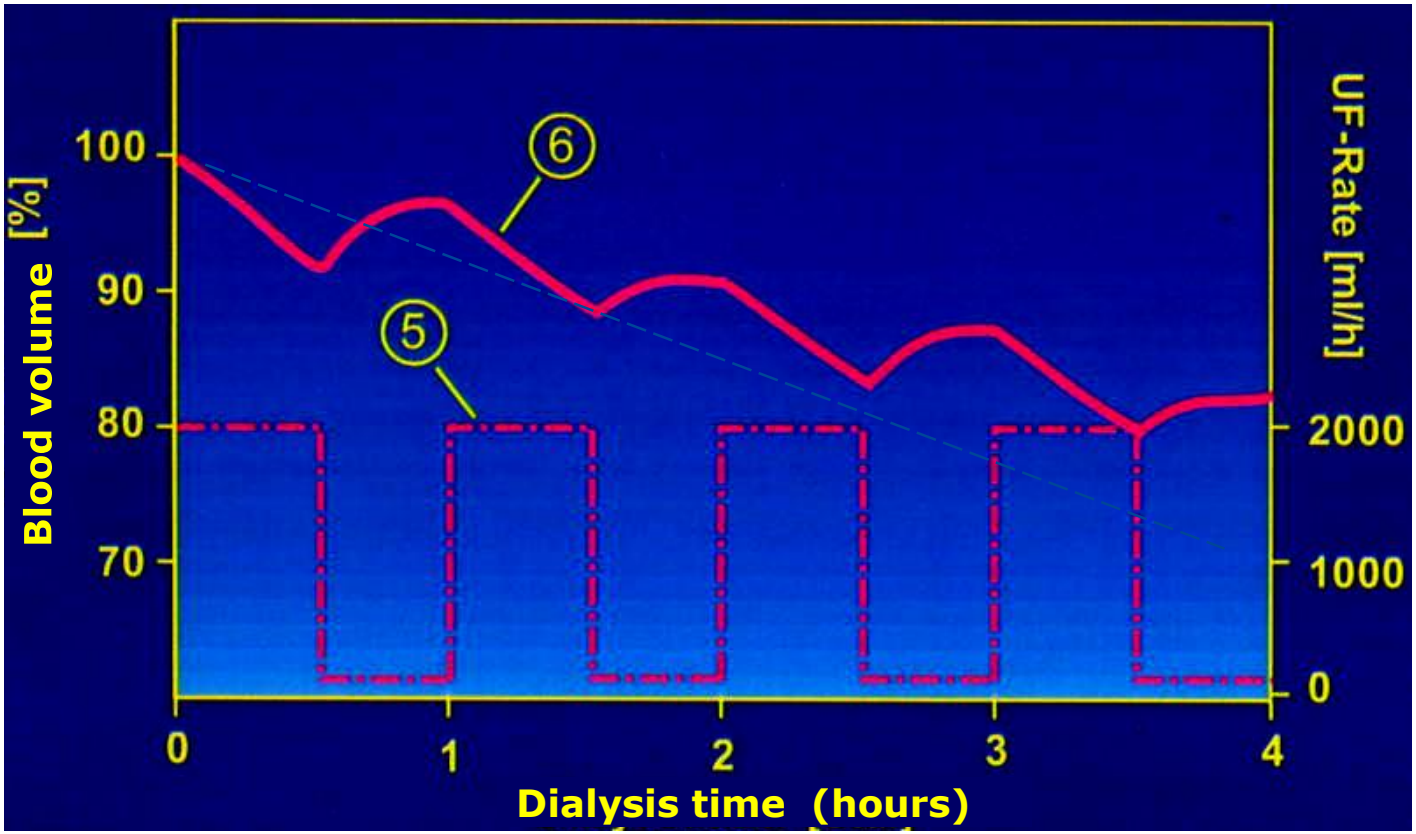


Na profile 4 (3)
Blood volume (6)
Basic concentration of the dialysing fluid (5) 138 mmol/L
Change in plasma sodium concentration (4)

Volume effect of UF profiles

- UF profiles produce a fluid current into the vascular space which is not driven by an osmotic gradient (refilling).
- The increase in volume that can be achieved through refilling usually exceeds that achieved through sodium.

Refilling effect – intermittent UF profiles



UF profile 5 (5)
Change in blood volume (6)

Basic requirements for working with UF and sodium profiles

- Minimum UF time: 2 hours
- Minimum UF rate: 100 ml/min

- First determine the patient's usual predialytic plasma sodium range.
- Determine times of hypotension in the patient and allocate suitable profile so that times of hypotension is contemporary with low UFR.
- Always start with the highest possible initial sodium.
  (Balancing neutrality is ensured at a Kt/V of 1.2!)
- If possible, do not stop the Na profile while the treatment is in progress because, otherwise, balancing neutrality would not be ensured any longer!
- When starting the profile, set the CD limits centrally about the actual value!

Summary

Profiles do not constitute any miracle method but are a reasonable supplement to your therapy options!

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Thank you very much for your attention!

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