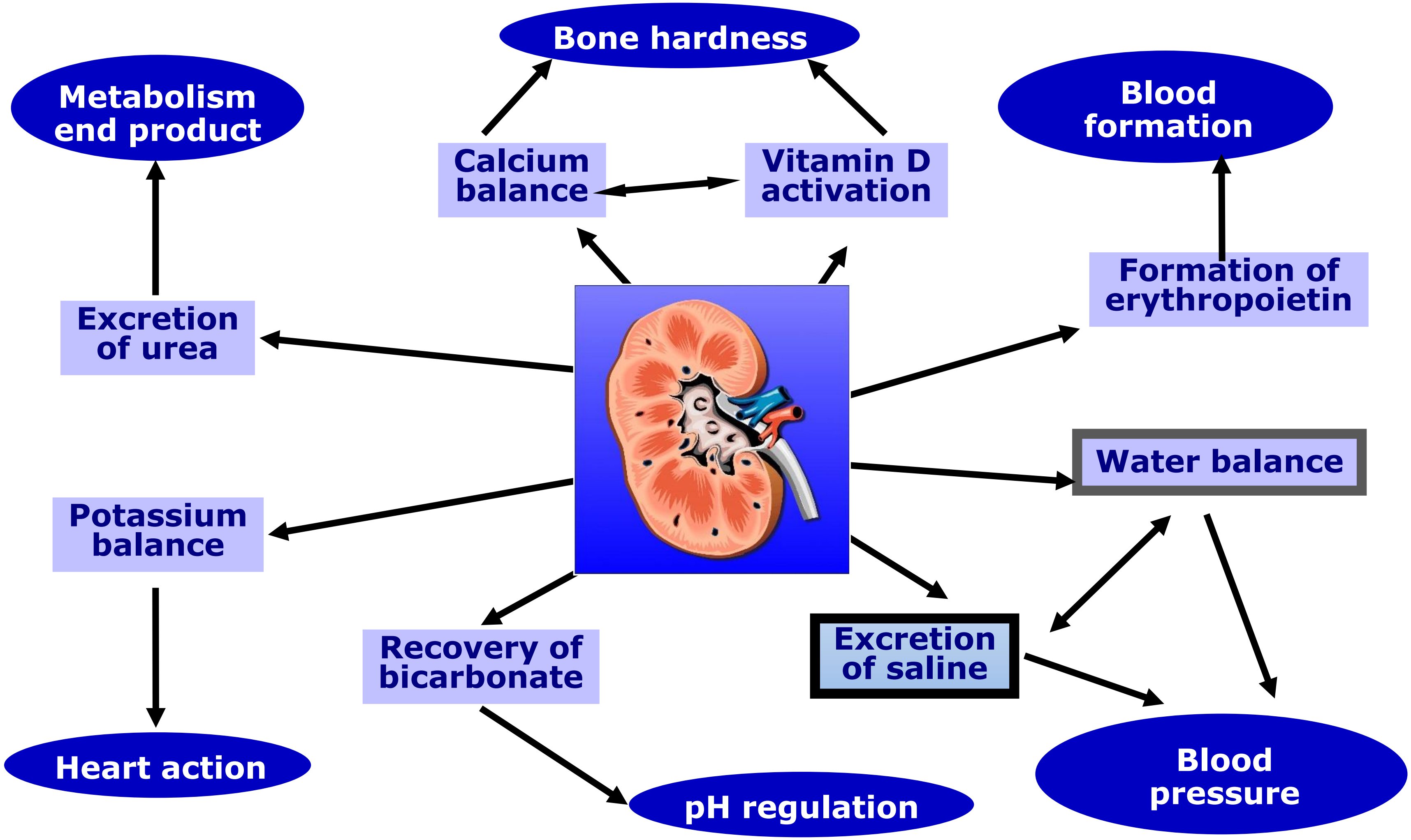
Ultrafiltration and Sodium Profiles

A module in the overall design of "physiological dialysis"

Kidney functions



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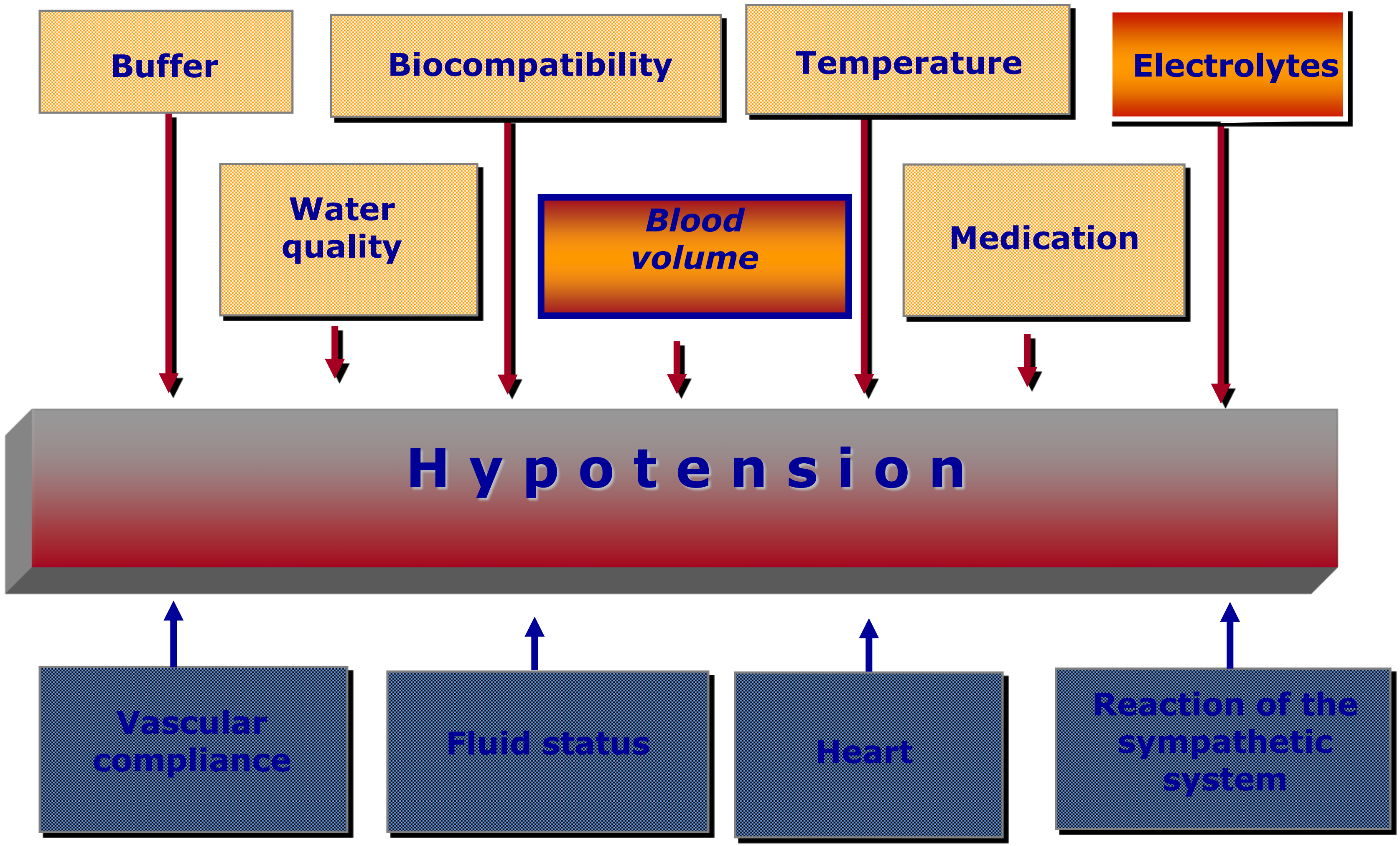
Causes of hypotension



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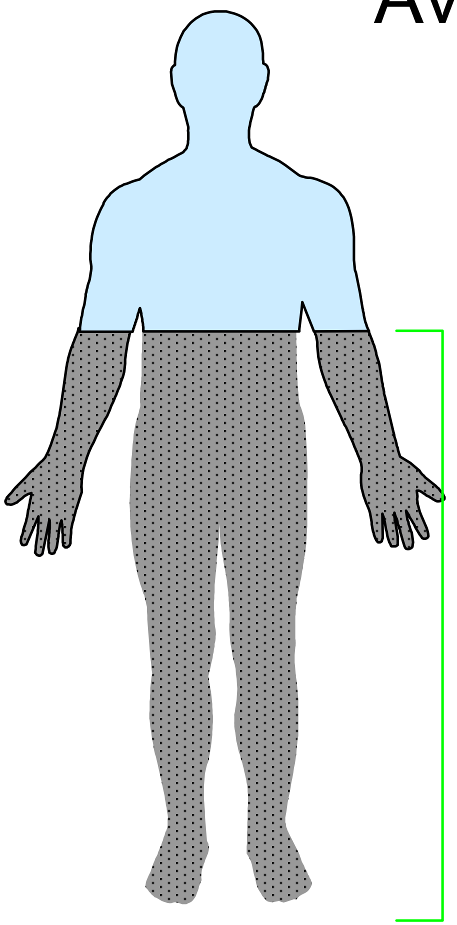
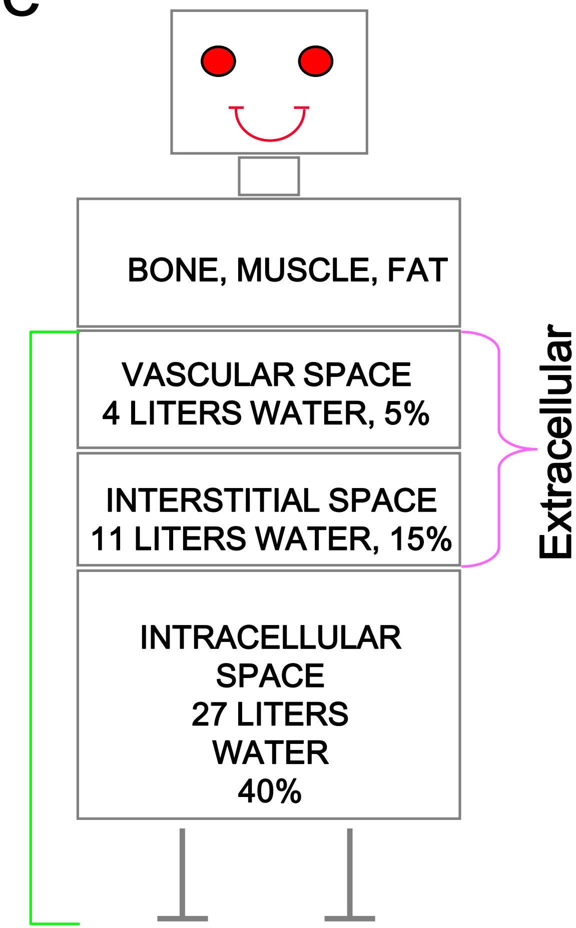
Fluid Spaces in the Body

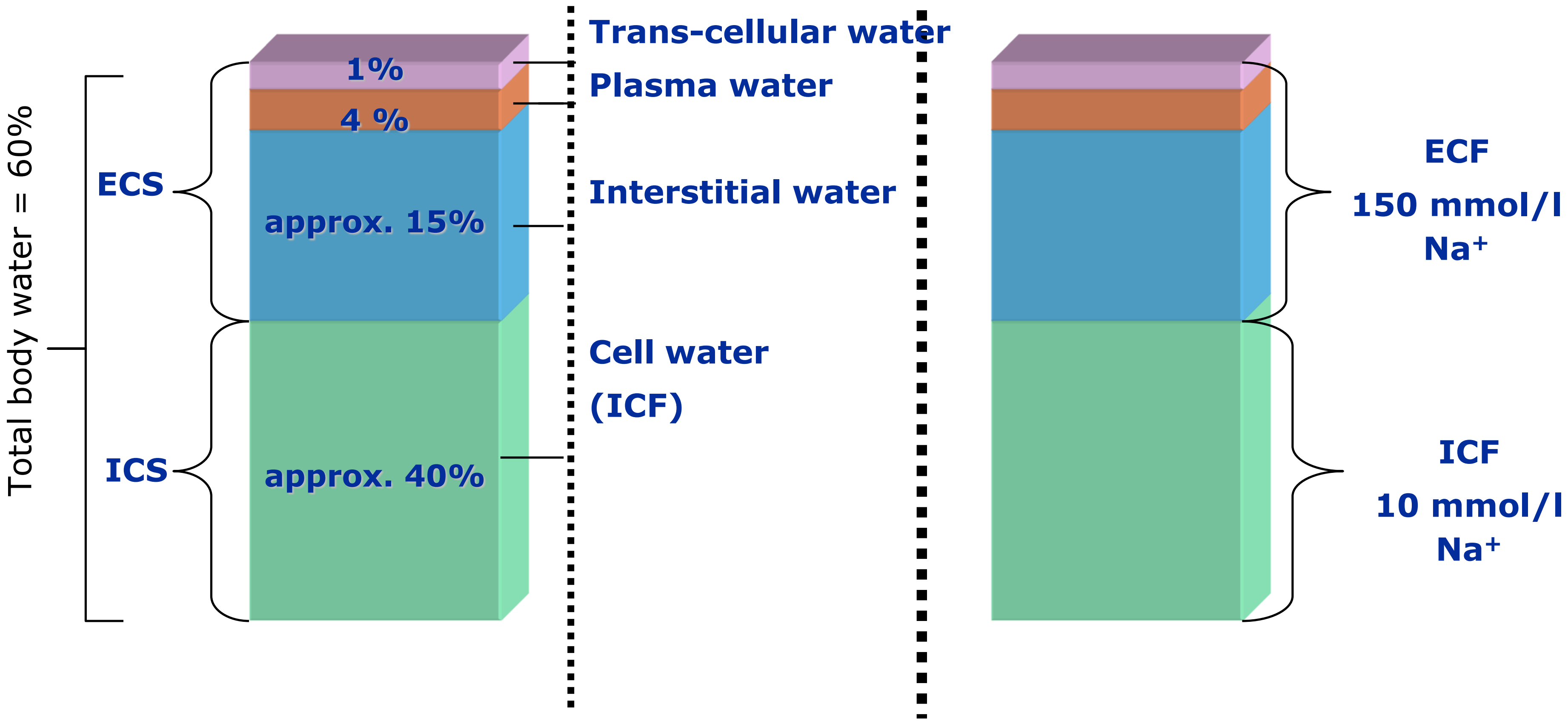
Average weight Male
70 kg



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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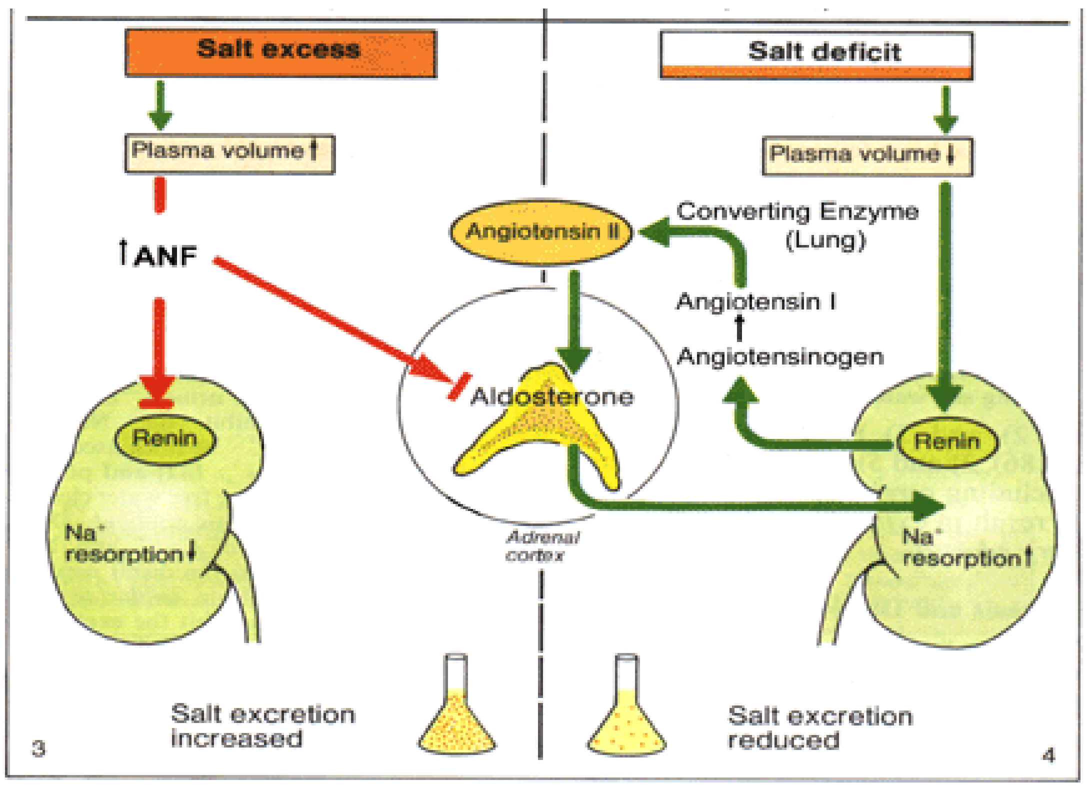
Sodium balance

- 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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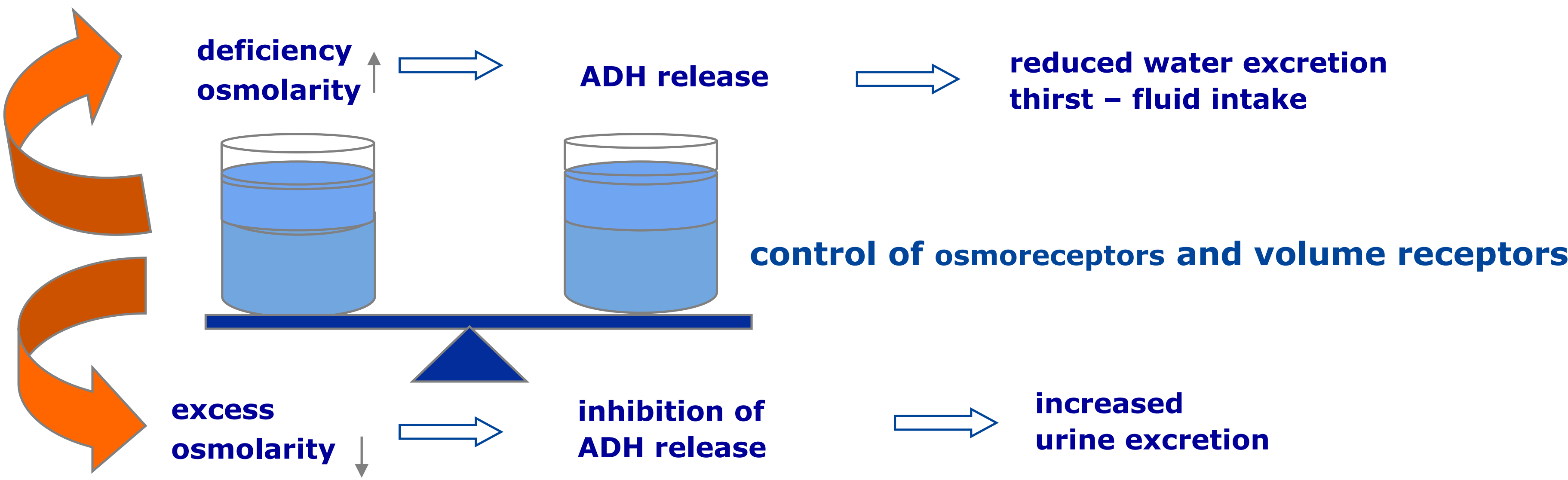
Water balance

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



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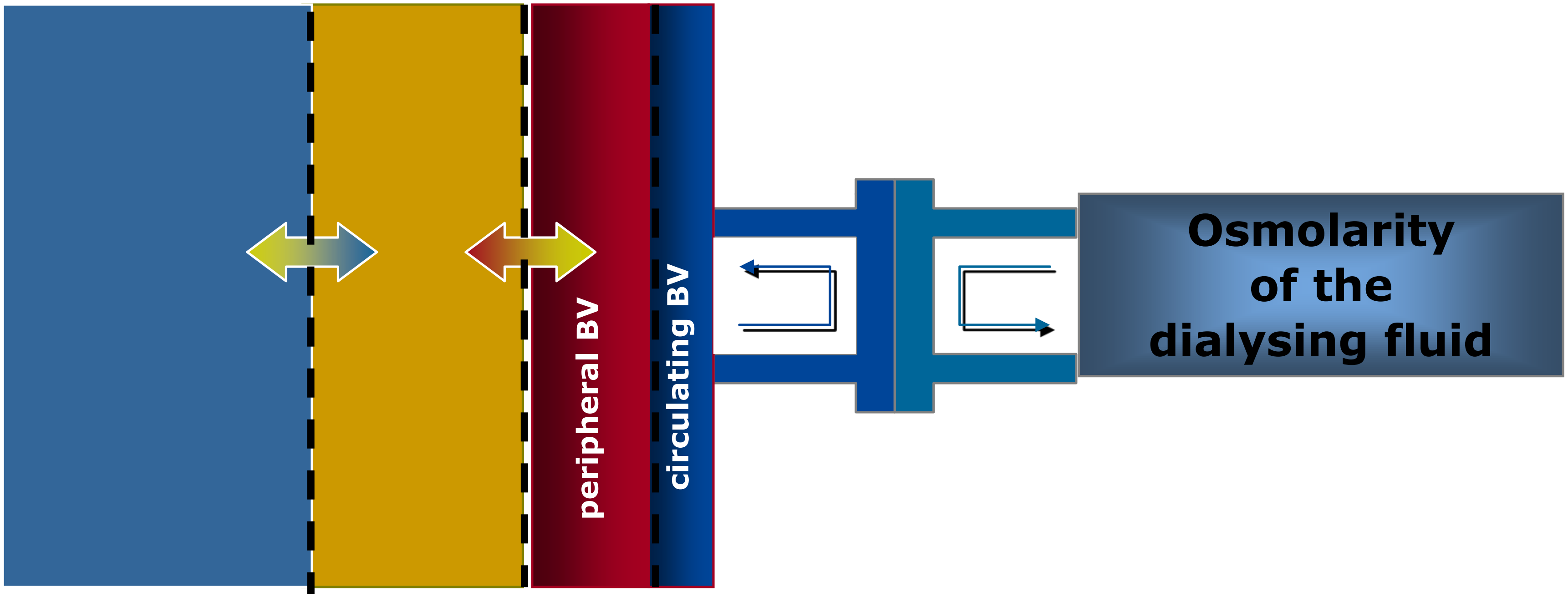
Electrolyte balance – diffusion

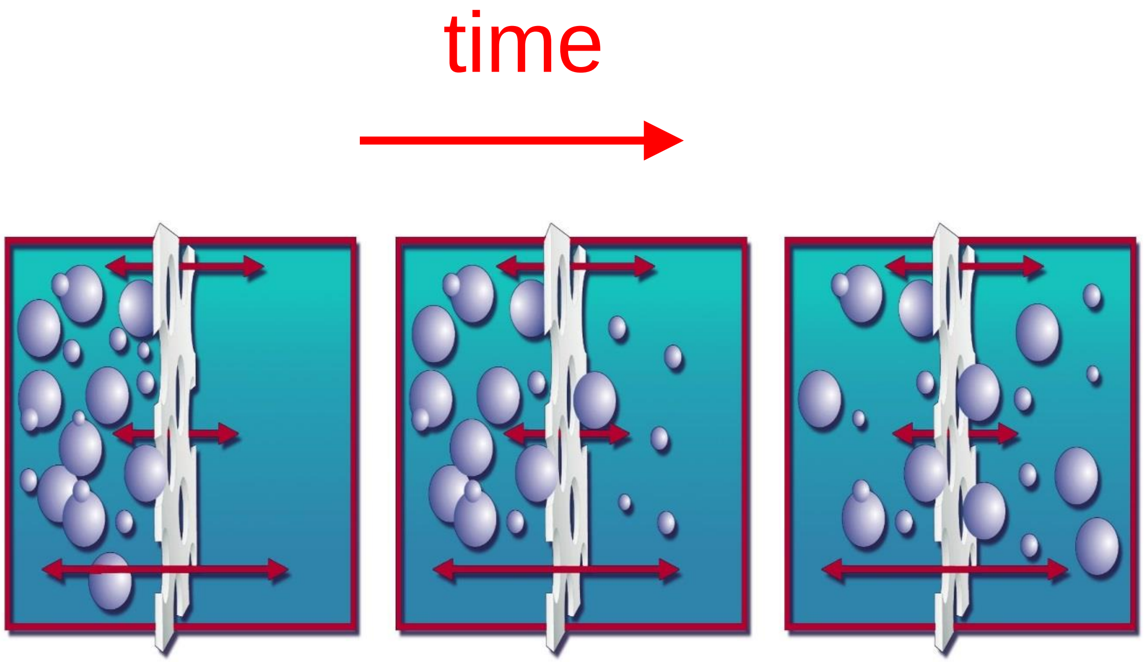


Intracellular water

Interstitial water

Blood

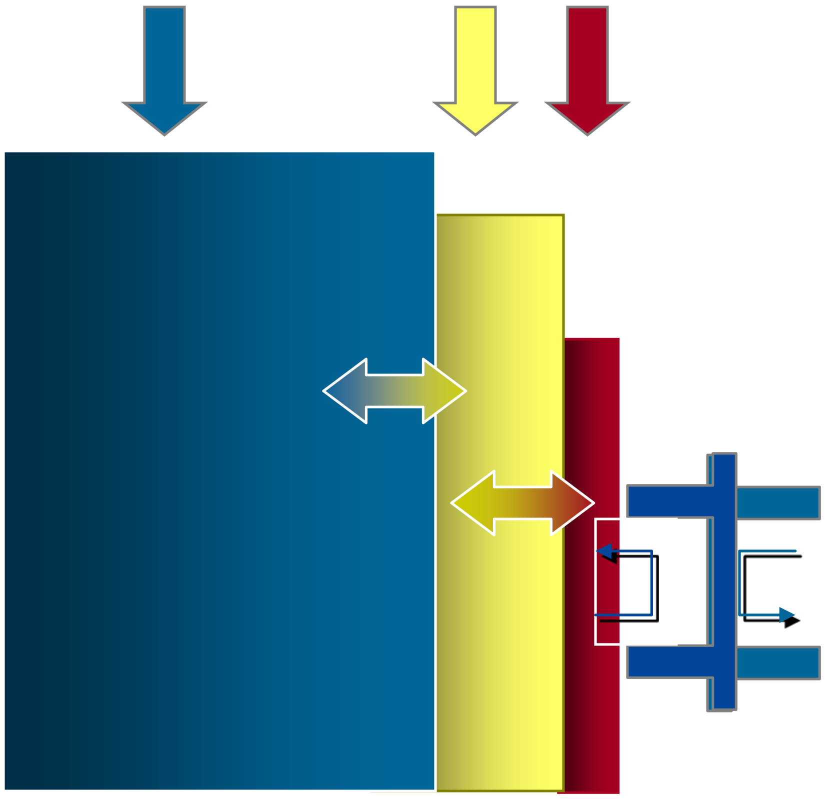
Diffusion



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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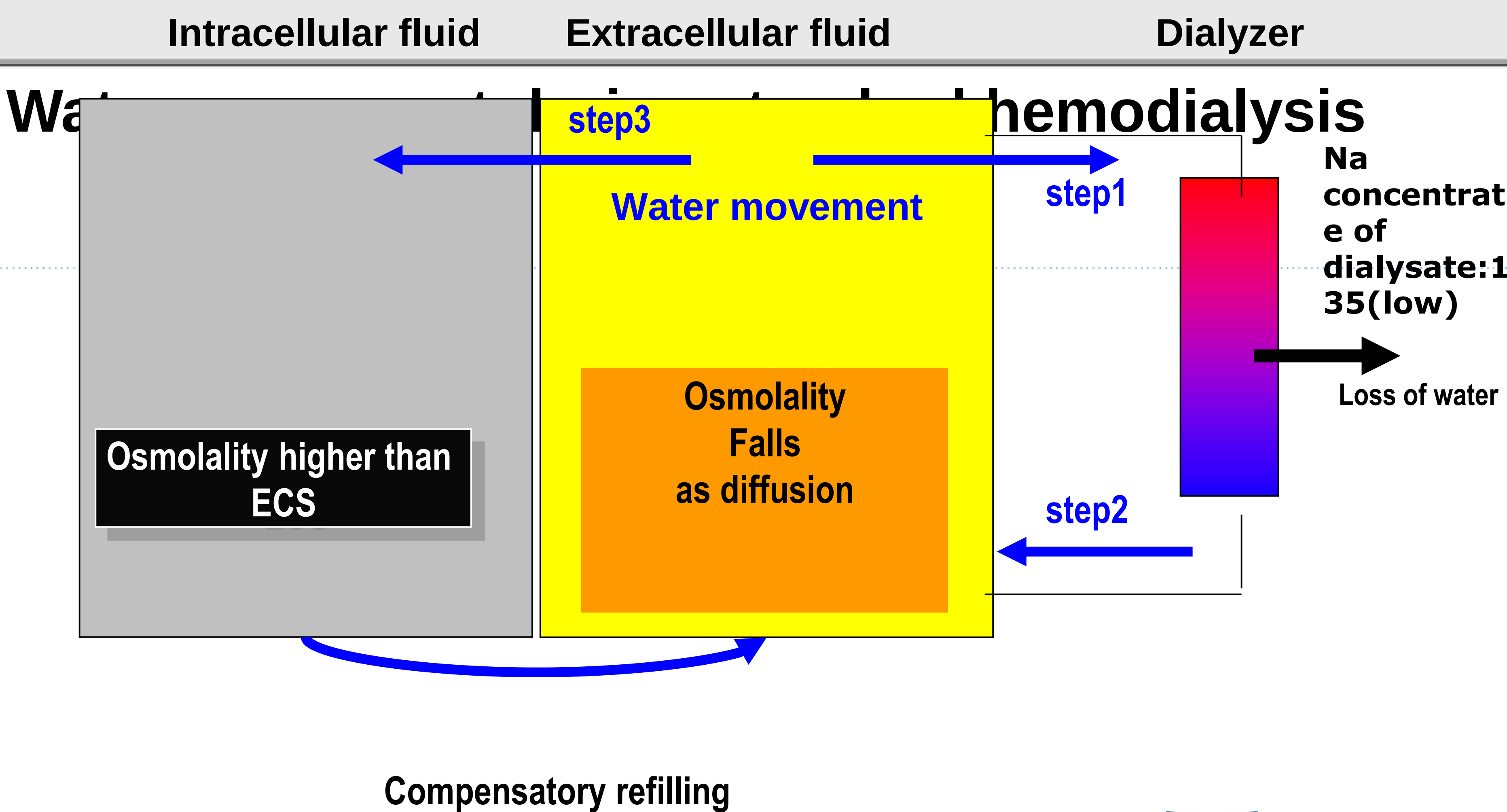

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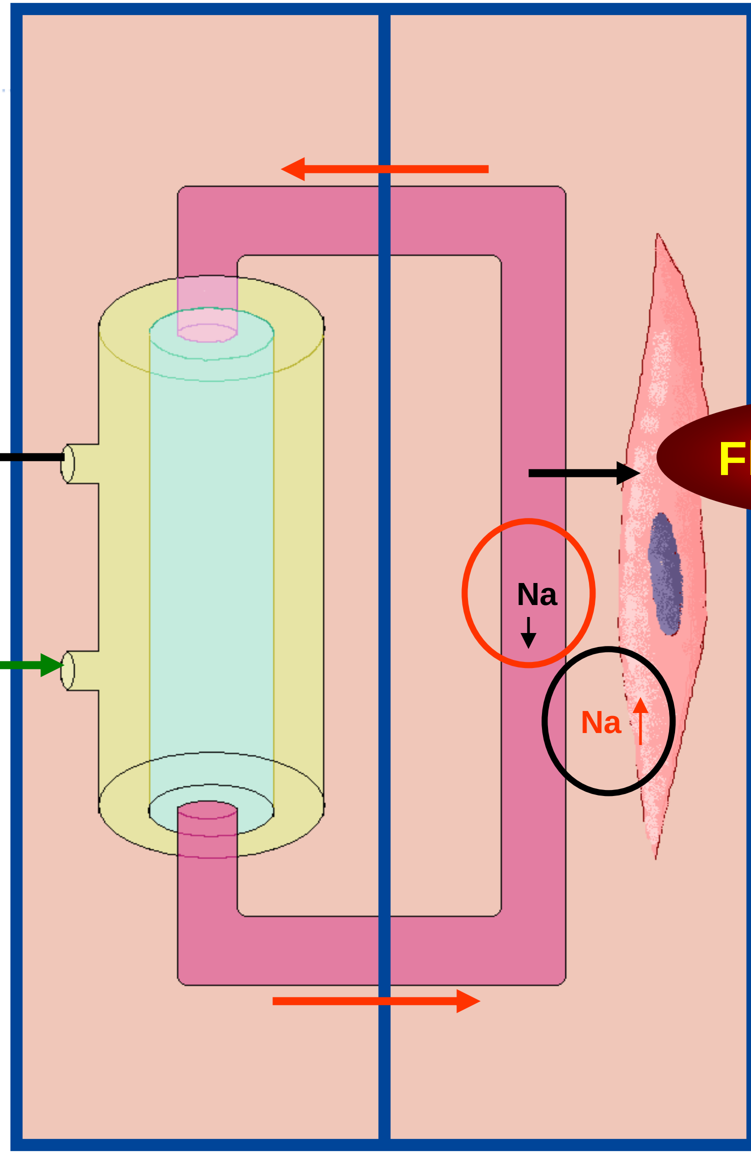
Fluid removal

Low Na
130-135 meq/l



Fluid removal

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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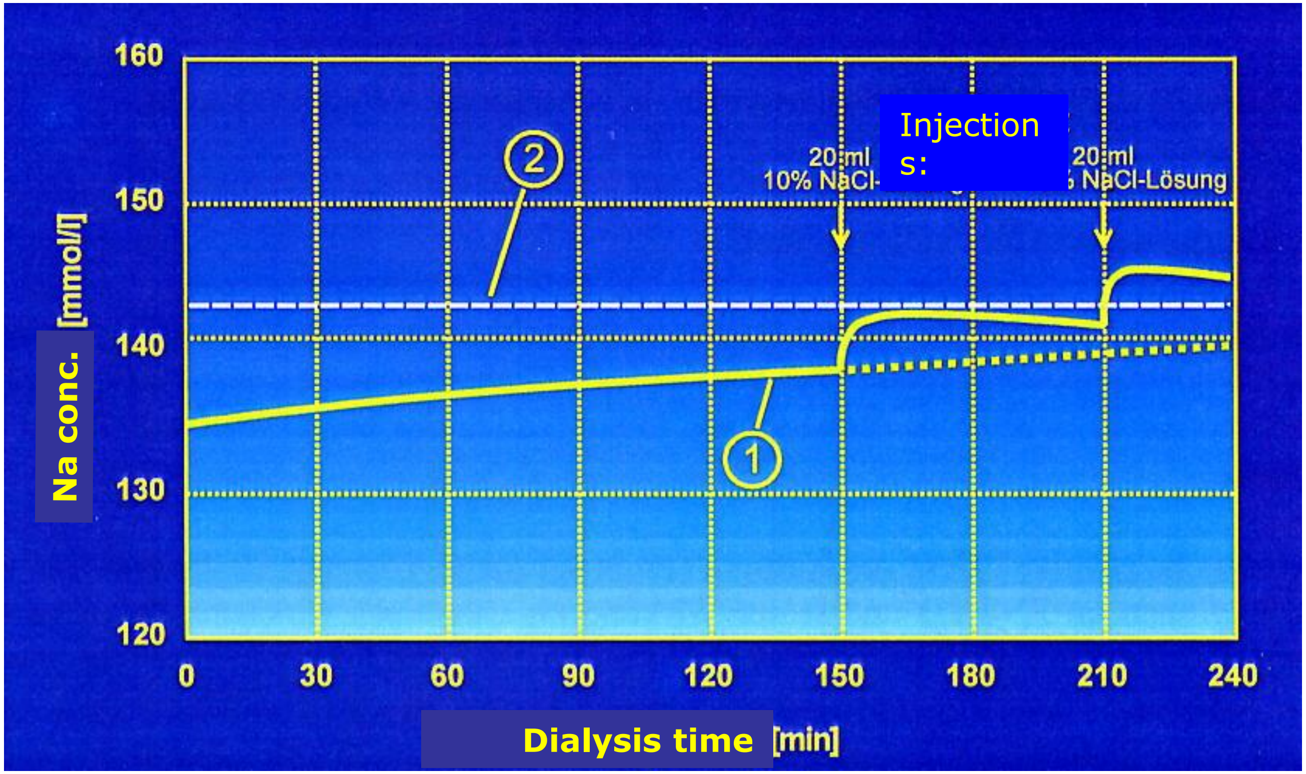
Result of a saline injection



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

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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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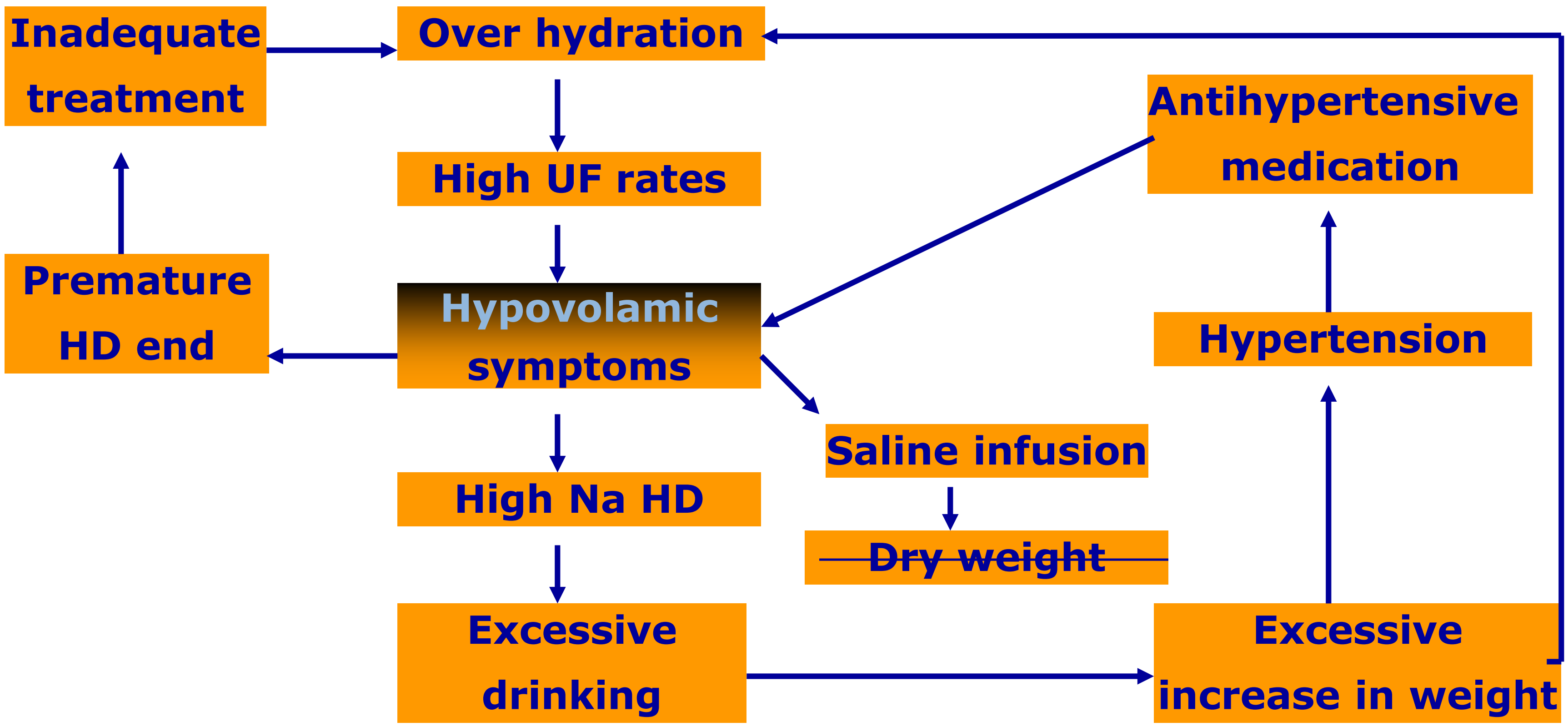
Consequences of high Na+ HD



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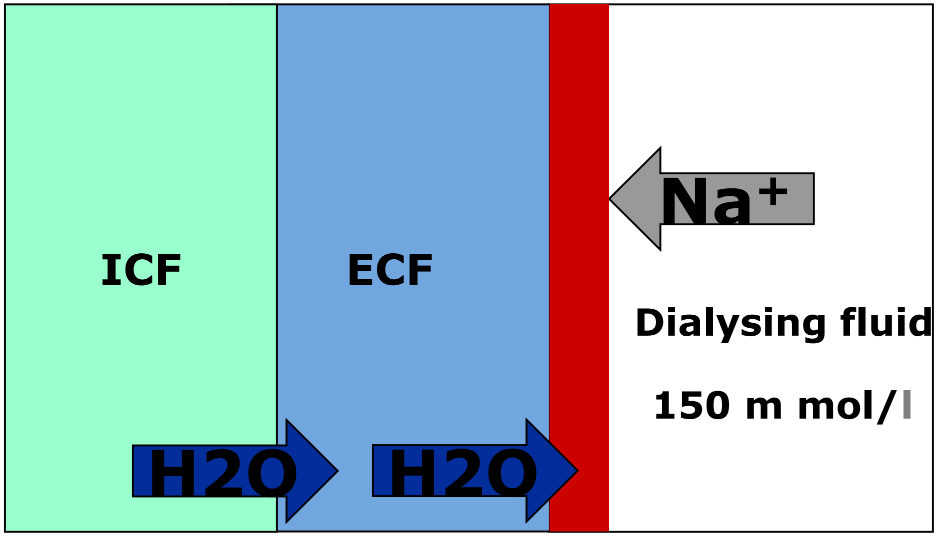
Fluid displacement through osmosis

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

138 mmol/l



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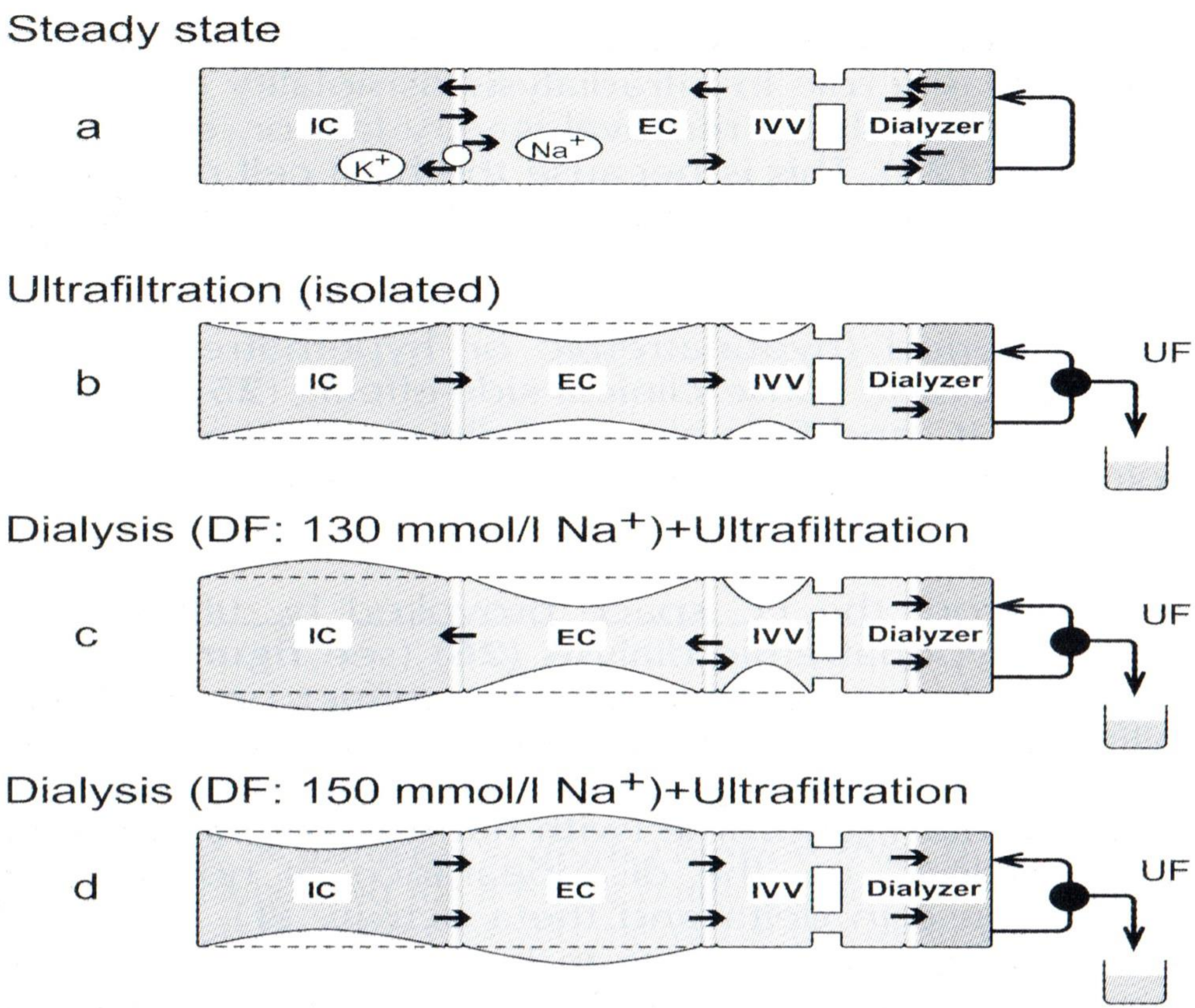

Steady state
a
IC
K+
Na+
EC
IVV
Dialyzer
Ultrafiltration (isolated)
b
IC
EC
IVV
Dialyzer
UF
Dialysis (DF: 130 mmol/l Na+)+Ultrafiltration
c
IC
EC
IVV
Dialyzer
UF
Dialysis (DF: 150 mmol/l Na+)+Ultrafiltration
d
IC
EC
IVV
Dialyzer
UF

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:

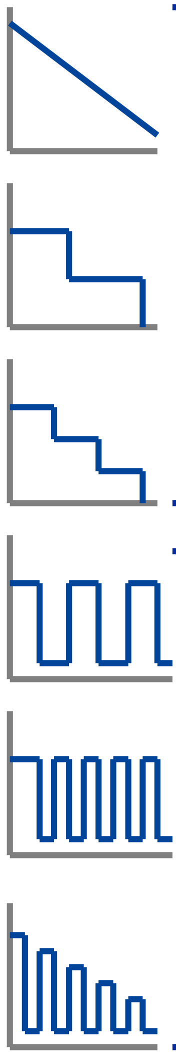
The increase in sodium must not lead to a post dialytic sodium overload.

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

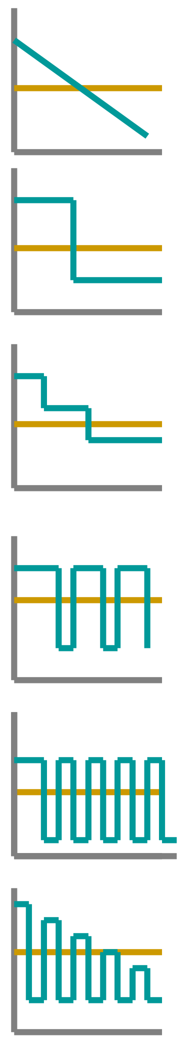
Neutral Na+ and UF profiles with regard to balance

1
2
3
4
5
6



High UF rate at treatment start

Intermittent ultrafiltration (refilling)



High sodium concentration

during the high UF rates or at treatment start

Decrease in sodium concentration

during UF breaks or after half the treatment time has elapsed

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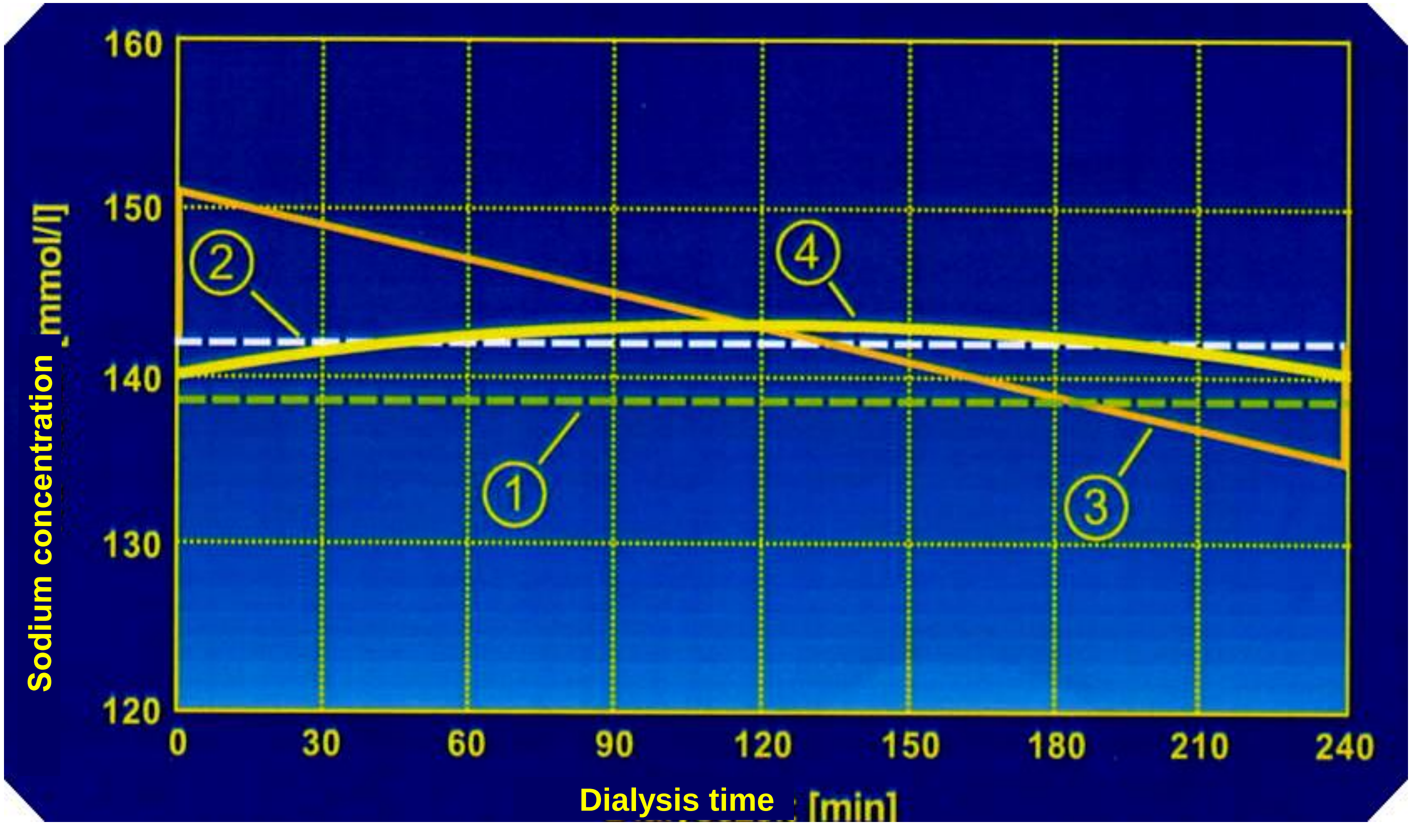
Changing the plasma sodium concentration



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)

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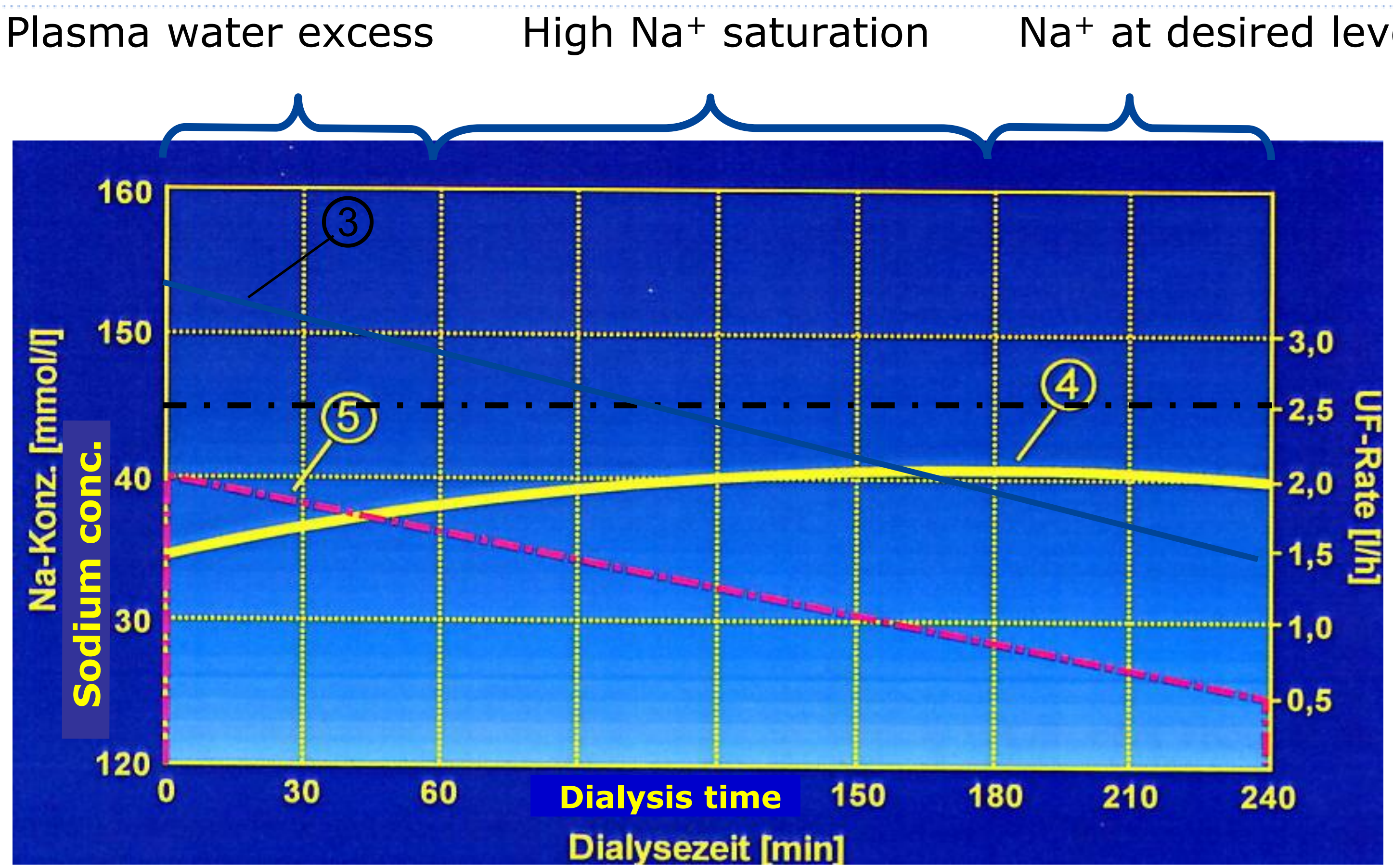
UF profile 1 / Na+ profile 1



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)

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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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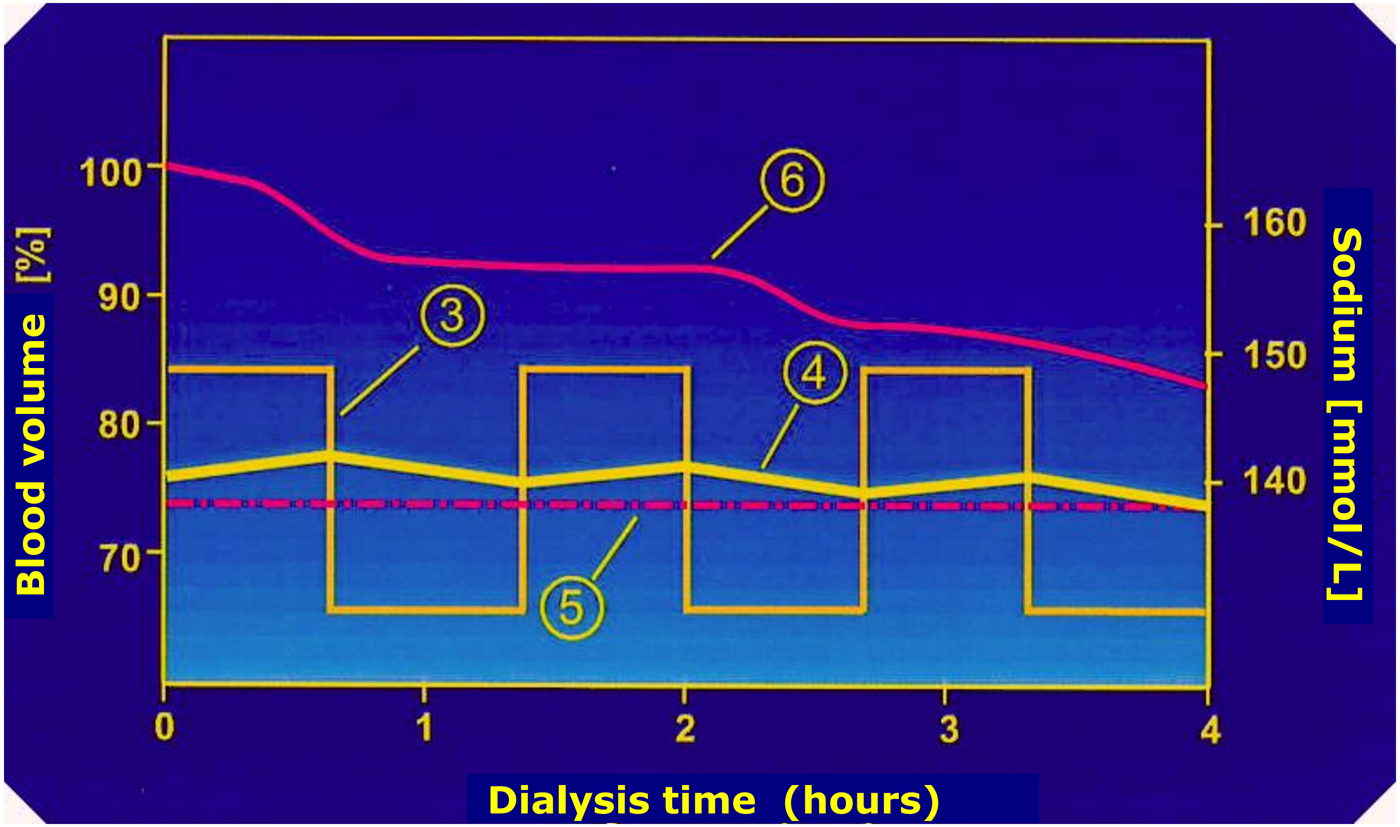
Osmotic effect of Na profiles



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.

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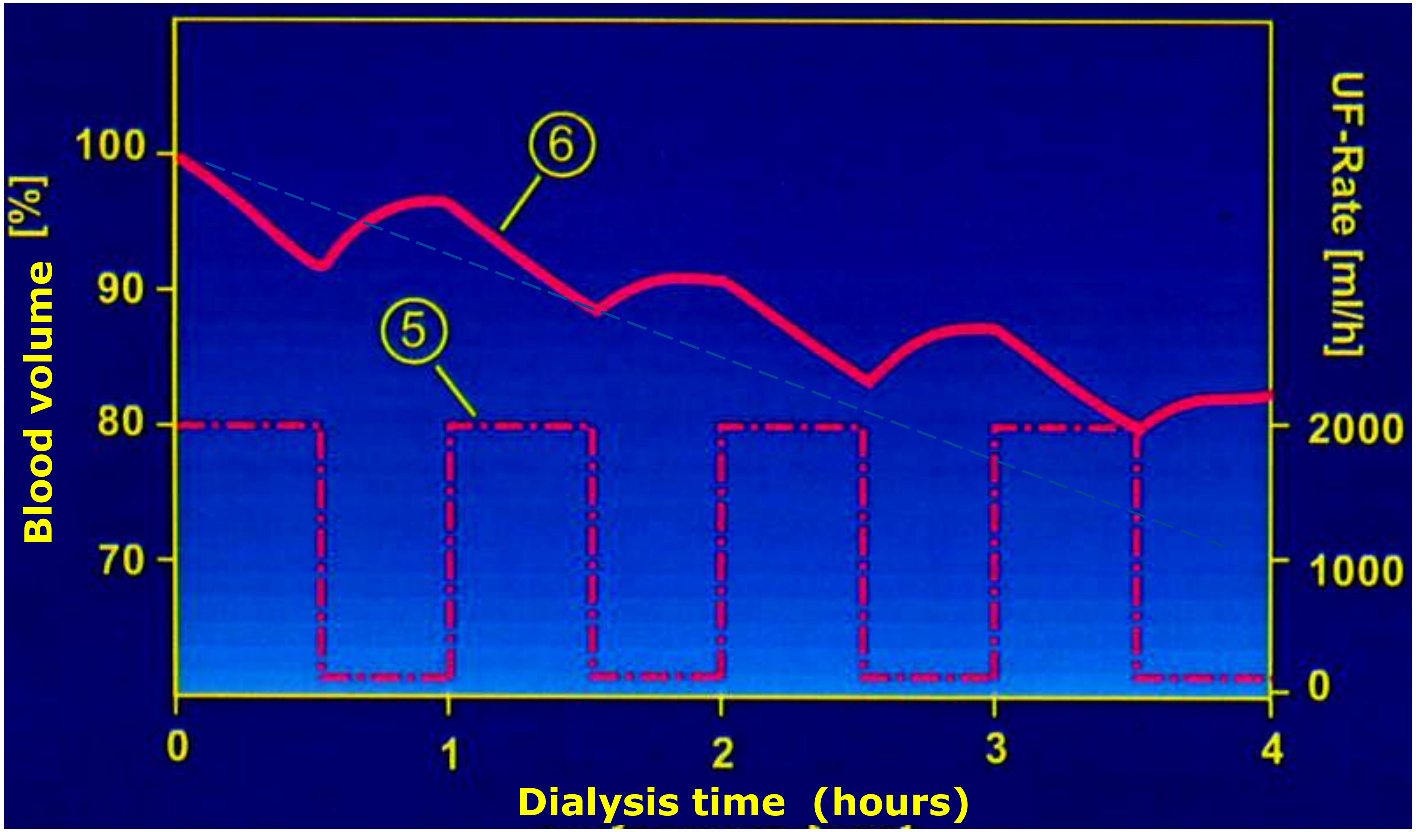
Refilling effect – intermittent UF profiles



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

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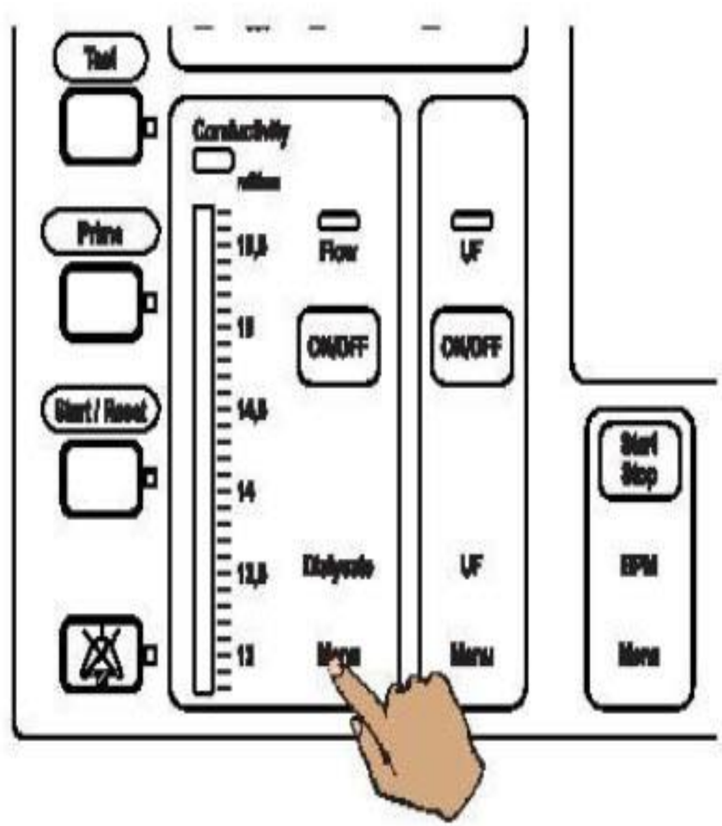
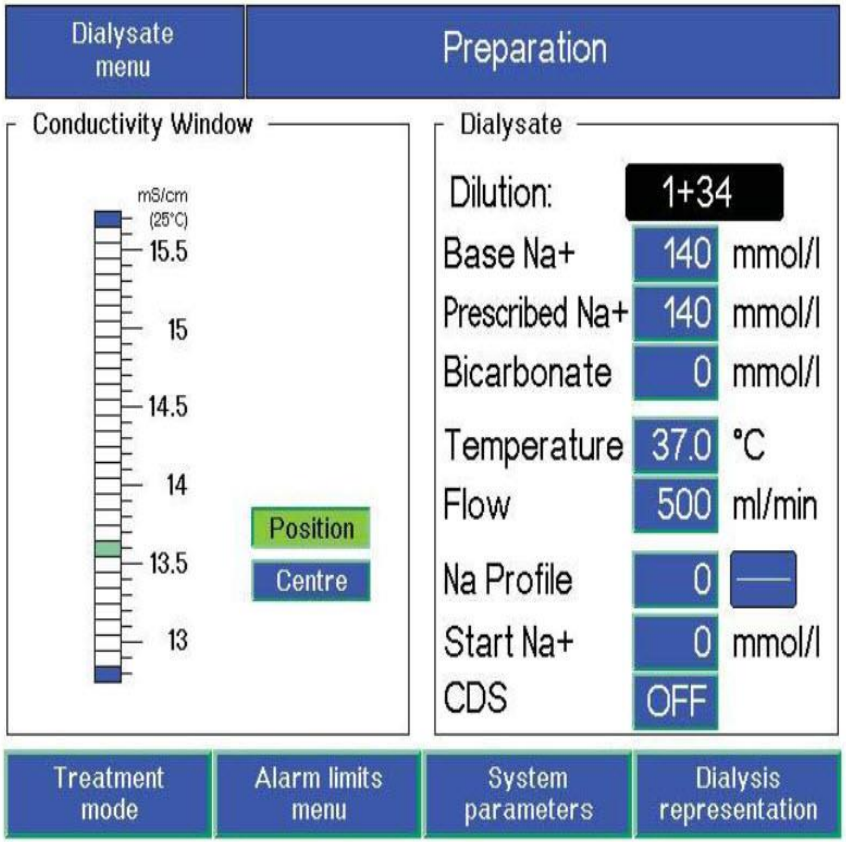
Basic requirements for working with UF and sodium profiles

- 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!


Prime
Flow
ON/OFF
UF
ON/OFF
Dialysate
UF
BPM
Menu
Menu



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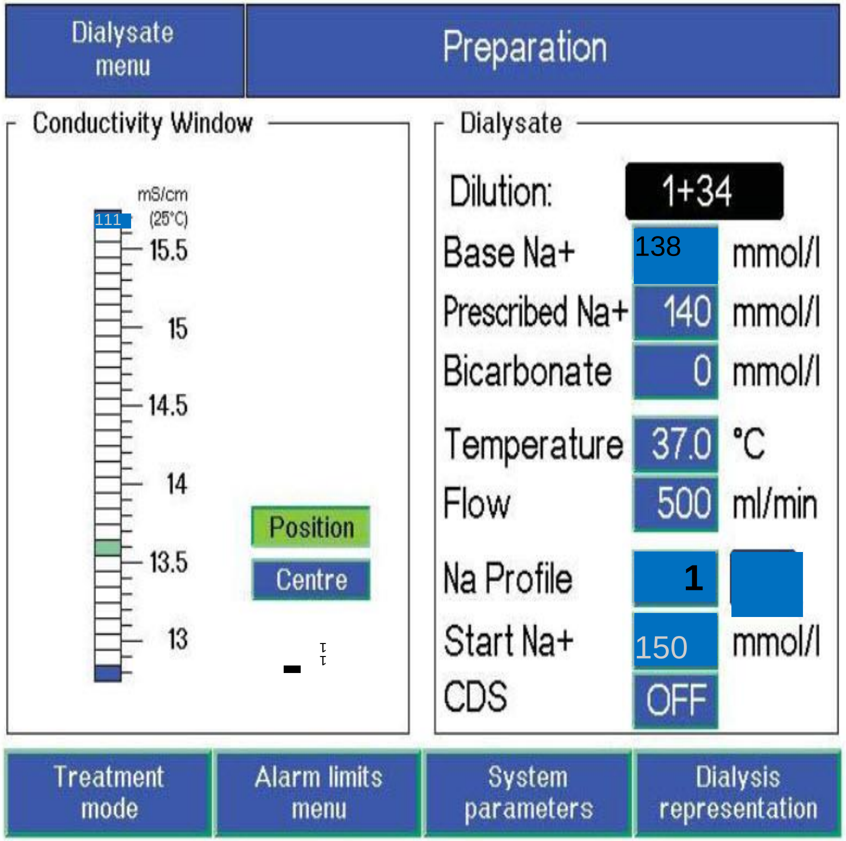

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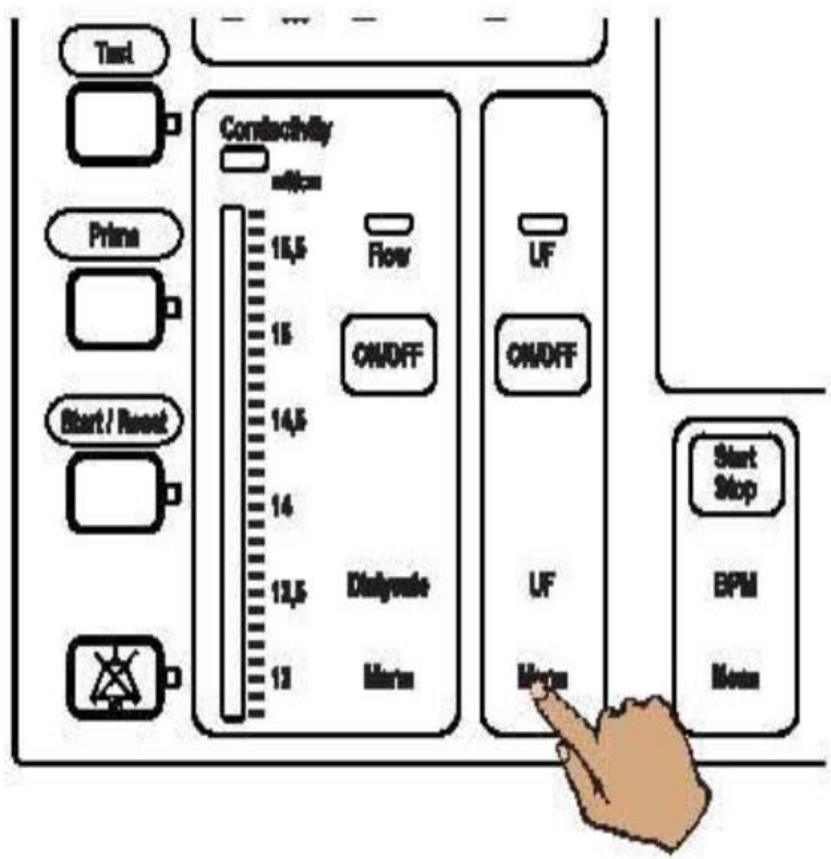

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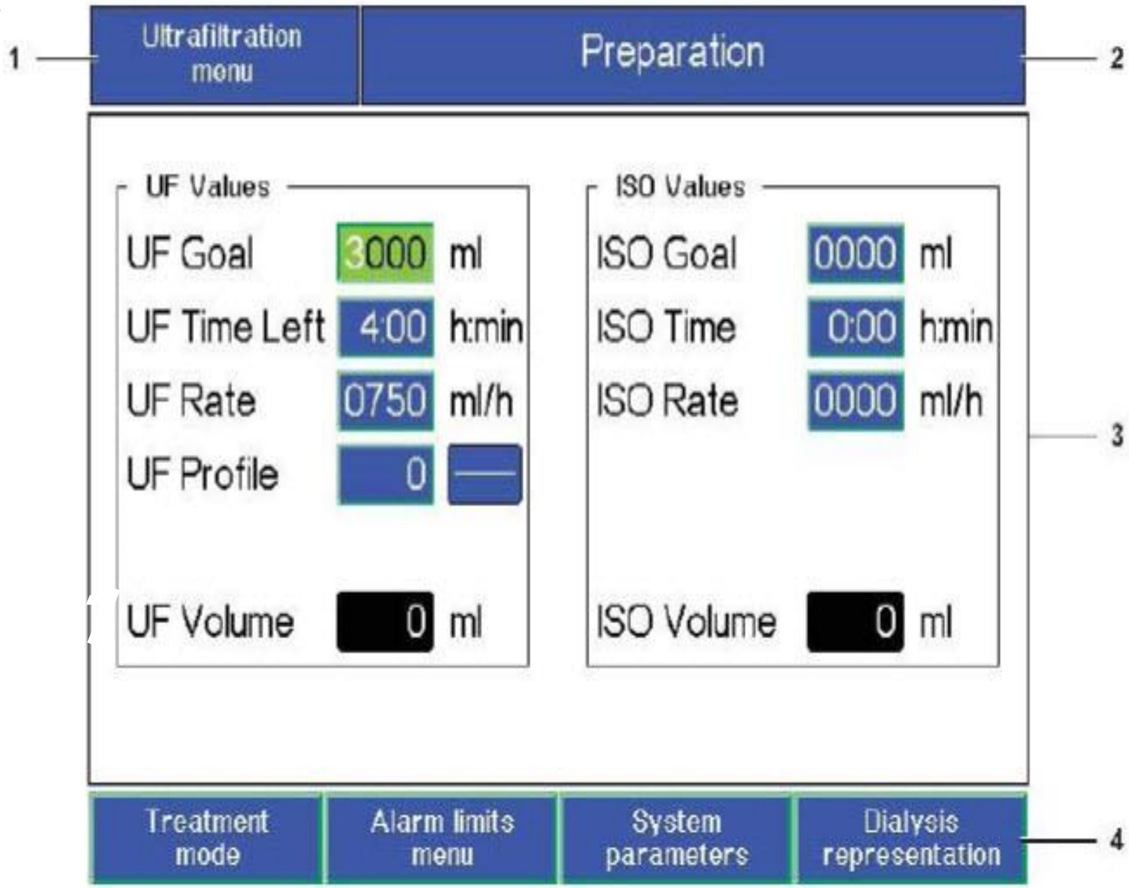
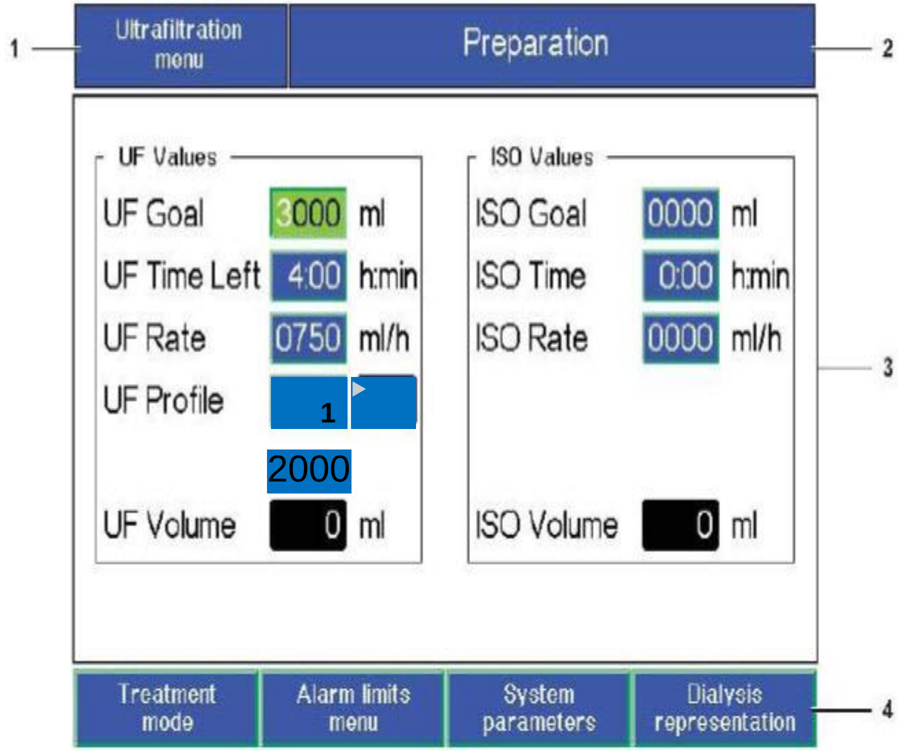

1
Ultrafiltration menu
Preparation
2
UF Values
UF Goal
3000 ml
UF Time Left
4:00 h:min
UF Rate
0750 ml/h
UF Profile
0
UF Volume
0 ml
ISO Values
ISO Goal
0000 ml
ISO Time
0:00 h:min
ISO Rate
0000 ml/h
ISO Volume
0 ml
3
Treatment mode
Alarm limits menu
System parameters
Dialysis representation
4


1
Ultrafiltration menu
Preparation
2
UF Values
UF Goal
3000
ml
UF Time Left
4:00
h:min
UF Rate
0750
ml/h
UF Profile
1
2000
UF Volume
0
ml
ISO Values
ISO Goal
0000
ml
ISO Time
0:00
h:min
ISO Rate
0000
ml/h
3
ISO Volume
0
ml
Treatment mode
Alarm limits menu
System parameters
Dialysis representation
4

Procedural instructions

- The UFC of the dialyzer must correspond to the UF rate.
- If UF profiles are used in SN dialysis mode, high UF rates result in a increase in haemoconcentration. Select high values for the mean blood flow!
- If, up to now, you supported high Na+ therapy and no longer wish to do so, please proceed moderately and gradually.

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Note regarding the dialyzer

The UFC of the dialyzer must correspond to the UF rate.
Example:

- **Mean UF rate: 750 ml/h**
- **Initial UF rate: 2000 ml/h**
-

- **The following is applicable: UF factor x mean TMP = weight loss / h**
- **This means: UF factor = 2000 ml/h / 200 mmHg**
- **UF factor = 10 ml/h x mmHg**

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Summary

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

Thank you very much for your attention!

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