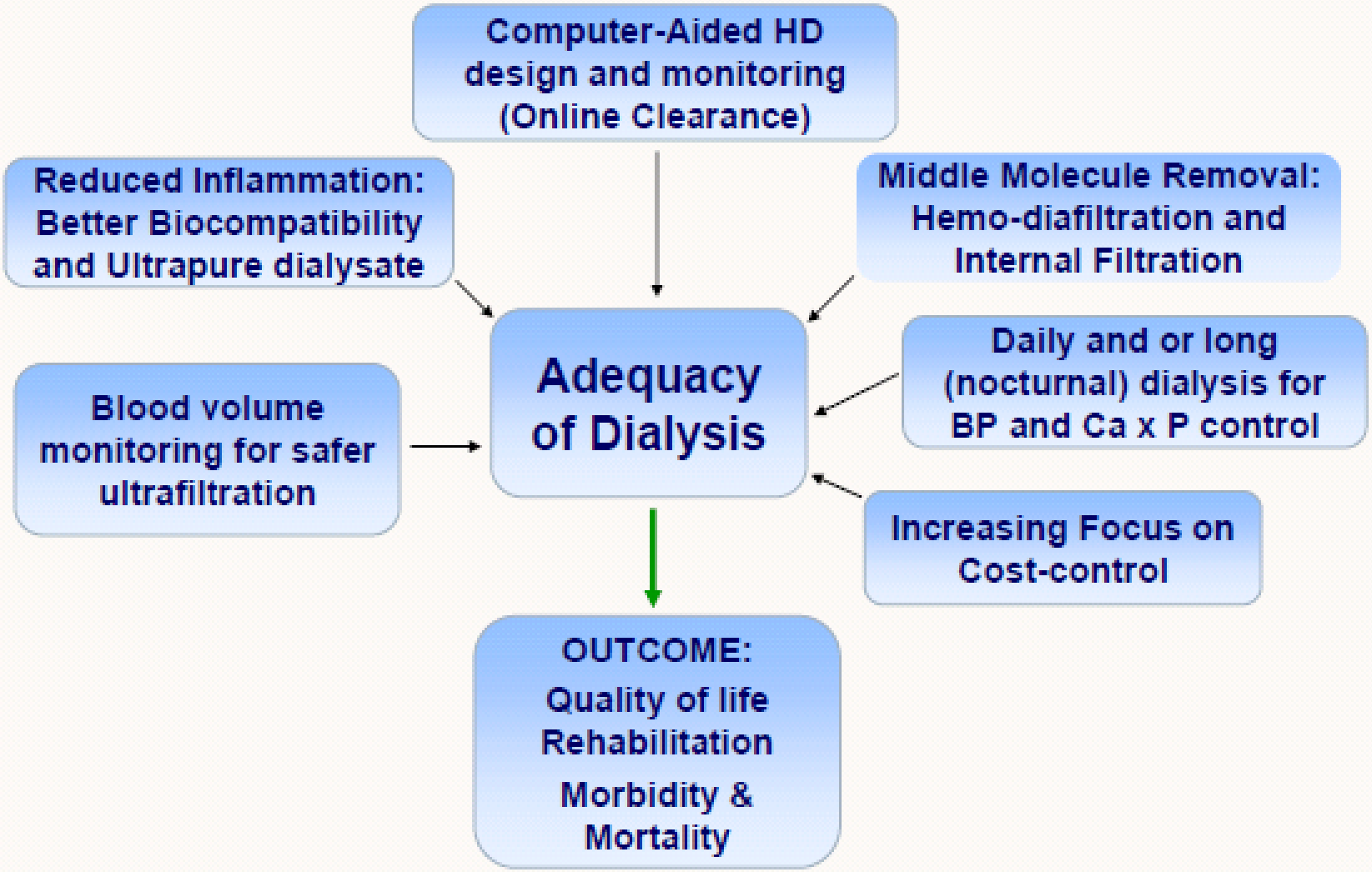
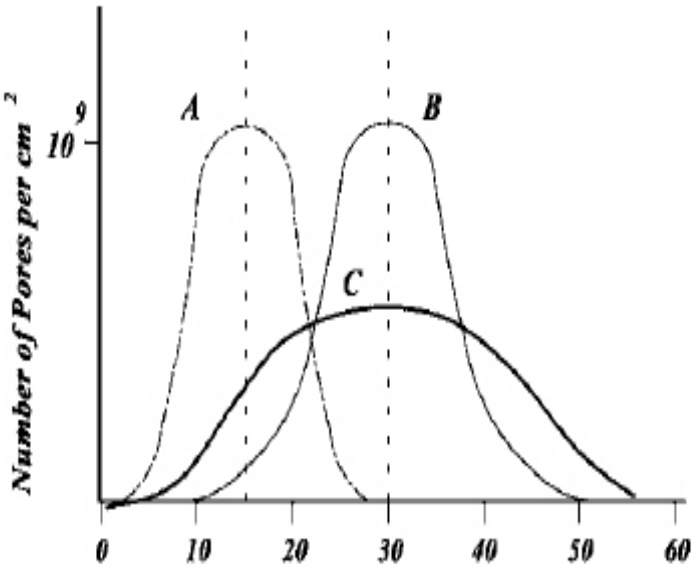

IN
THE
NAME
OF
GOD

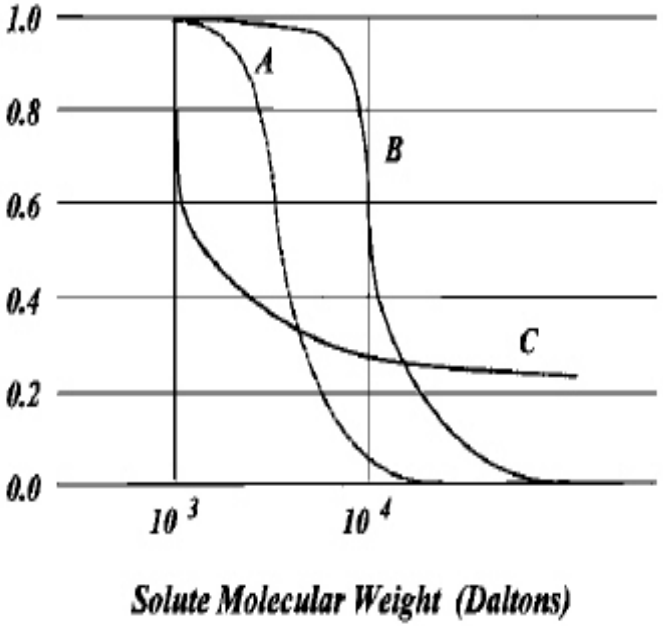
# Adequacy 2000 – into the future



## Curves of Distribution of Pores




## Sieving Coefficients



# Uremic toxins

- I. Small (< 500 D); water soluble
- → Surrogate marker urea or sodium (ionic dialysance)
- → Rapidly produced in intracellular fluid compartment
- → Large variability in intra-patient kinetics (e.g. phosphate)
- II. Middle-molecules (500 – 40,000 D); water soluble
- → B2-microglobulin, PTH, some cytokines (IL-6, TNF)
- → Optimized filter design and convection for removal
- → Complex intra-patient kinetics (generation, compartments)
- III. Small (< 500 D); protein-bound
- → Poorly removed with traditional dialysis
- → Resin adsorption-based therapies are in development


- Vanholder et al:Review on uremic toxins; Kidney International, Vol. 63 (2003), pp. 1934–1943
- Vanholder et al:A bench to bedside view of uremic toxins; J Am Soc Nephrol 19: 863–870, 2008.
- European Uremic Toxin Work Group (Eutox; http://EUTox.info)

# Improving Adequacy of Hemodialysis

## *It's About Life!*

- *It Takes a Team*
- **What is Adequacy of**
- **Hemodialysis ?**
- Adequacy of dialysis refers to how well we remove toxins and waste products from the patient's blood, and has a major impact on their well-being
- When we dialyze a patient, we filter out toxic particles that can affect every organ of their body

# How Do We Know if a Patient is Adequately Dialyzed?

- Blood samples are drawn before and after the treatment. The results are compared….this is called the pre and post BUN.
- The lab analyzes the BUN results and performs calculations.

These calculations are known as the KT/V and URR.

## How Do We Know if a Patient is Adequately Dialyzed?

- ***K/DOQI Guidelines***
- **Define Adequate**
- **Dialysis as:**
- **KT/V = 1.2 or greater**
- **URR = 65%**
- **or greater**
- **What Does This Mean?**
- URR% - Urea Reduction Ratio tells us the percentage of urea removed during the treatment
- KT/V - Formula utilizing dialyzer urea clearance, treatment time and total body fluid

# What are the Symptoms of Inadequate Treatment?

- Weakness, Tiredness
- Loss of Body Weight
- Poor Appetite
- Nausea / Vomiting
- Feeling Better after Treatment
- Yellowish Skin Color
- More Infections
- Prolonged Bleeding
- Premature Death
- Under-Dialyzed Patients May Experi

# Hemodialysis Prescription Determines Adequacy

- Hemodialysis Prescription Components:
- Duration of Treatment
- Dialyzer Urea Clearance (KOA)
- Blood Pump Speed
- Dialysate Flow Rate
- Heparinization
- Access

# Duration of Treatment

- The longer a patient dialyzes, the more blood flows through the dialyzer, allowing for more cleaning to take place…
- *Every Minute Counts!*
- *Encourage Your Patients to Complete the Entire Treatment Time!*

# Dialyzer Urea Clearance (KOA)

- KOA is a measurement of the dialyzer's ability to remove urea through the pores in the membrane.

Urea clearance is determined by the size of the dialyzer membrane and the size and number of pores located in the membrane.

- *The Larger the Dialyzer, the More Urea Clearance…*
- *Verify You Are Using the Correct Dialyzer Ordered!*

# Blood Pump Speed

- Also known as Blood Flow Rate…Speed of the blood going through the dialyzer membrane for urea

removal.

- The more blood passing through the dialyzer during the treatment…the *More Urea Removed*.
- *Verify the Blood Pump Speed*
- *Matches the Dialysis Prescription!*
- *Patient Should Maintain Prescribe*
- *Blood Flow Rate Throughout*
- *Dialysis Treatment!*

# Dialysate Flow Rate

- The Speed which the Dialysate Flows through the Dialyzer.
- The Faster the Dialysate Flows through the Dialyzer ….the *More Urea is Removed.*
- *Verify Correct Dialysate Flow Setting!*

# Heparinization

- Keeps the blood from clotting, and blocking the fibers. This allows the blood to flow freely through the fibers of the membrane, and ure can be removed.
- Adequate Heparinization will Prevent Fiber Clotting and… *More Urea is Removed!*
- *Ensure Correct Heparin Dose is Administered!*
- *Monitor Lines and Dialyzer for Clotting Throughout Treatment!*

# •Vascular Access

**What Can You Do To Improve Vascular Access Function?**

- AV Fistula is the Preferred Access

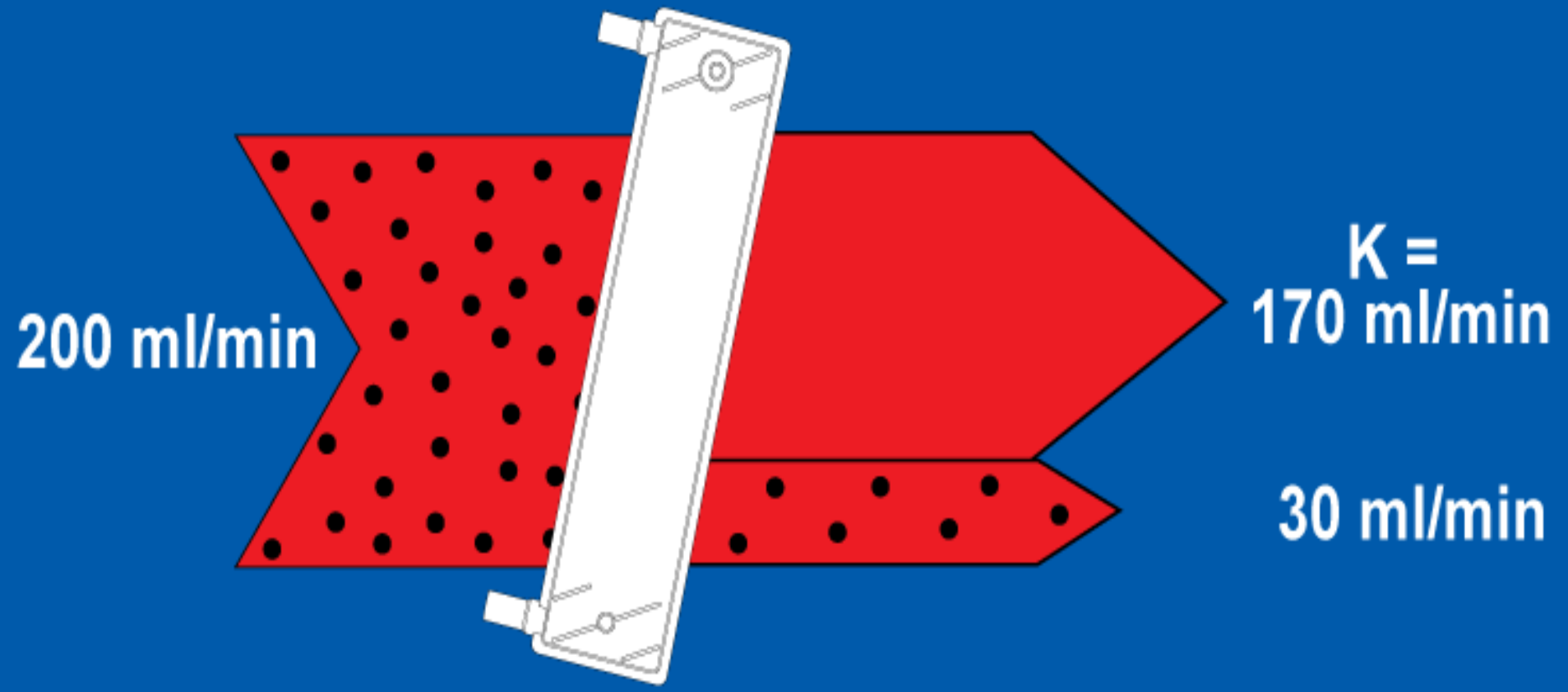
Adequate dialysis depends on having a vascular access that works well

- Poorly functioning access causes inadequate dialysis and can lead to *premature death*
- *Become Proficient in Proper Access Cannulation*
- *Notify Physician if Access has Poor Flow and Request Surgical Evaluation of Access*
- *Thorough Access Assessment Every Treatment*
- *Monitor Arterial Pressure for Signs of Inadequate Flow (Negative pressure > -250)*
- *Monitor Venous Pressure for Signs of Excessive Pressure (Venous Pressure > ½ of Blood Flow Rate)*
- *Prompt Physician Notification of Access Problems*

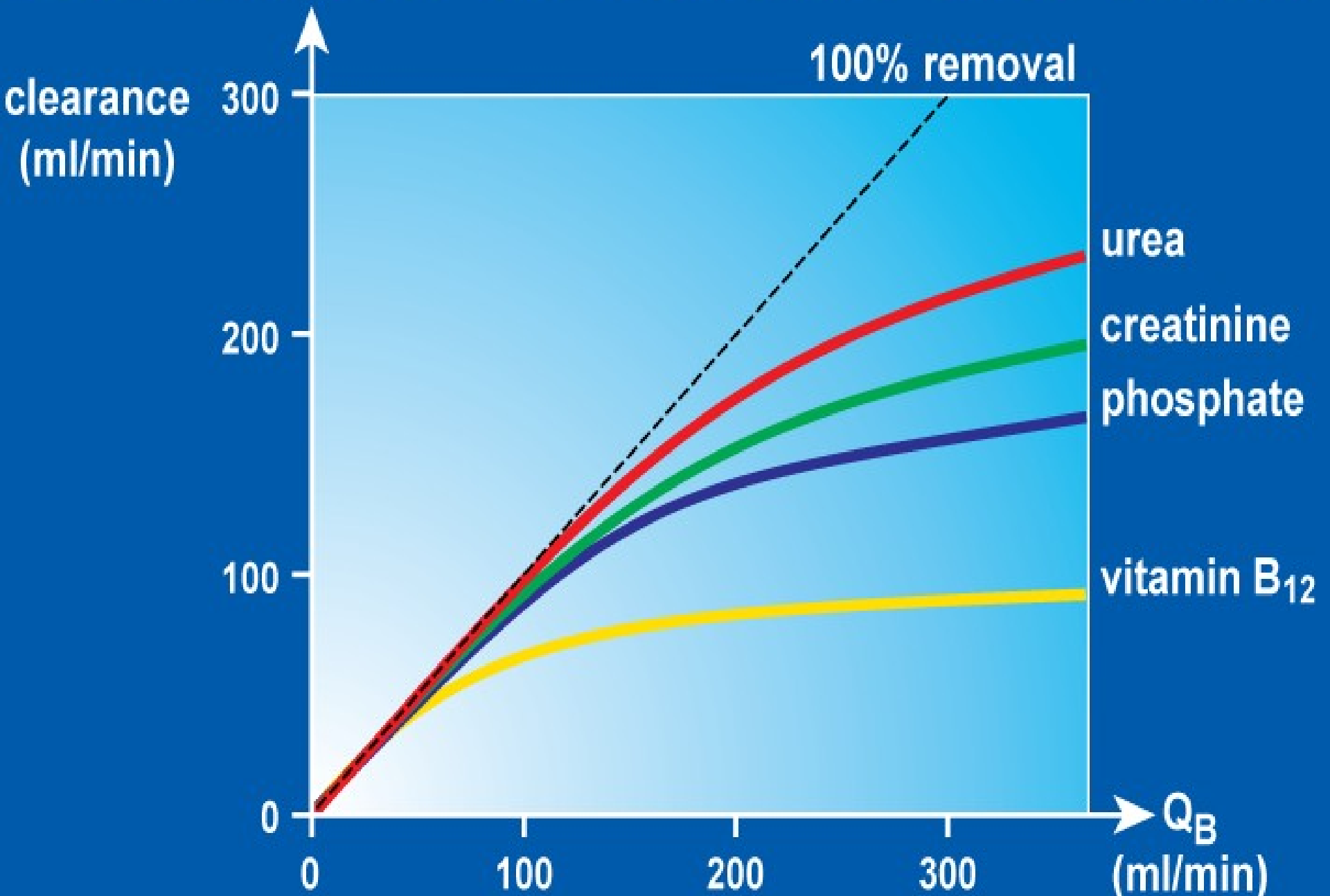
# Dialyzer Clearance

- Clearance (K) specifications for dialyzers indicate the amount of a specific Solute will be "cleared" from the patients blood in a given amount of time
- For example, if the specs say a dialyzer has a clearance of 350 ml/min at a Qb of 400 ml/min, it means that in one minute 350 ml's of blood will be cleared of urea, and the remaining 50 ml/min will have the same amount of urea that it started with

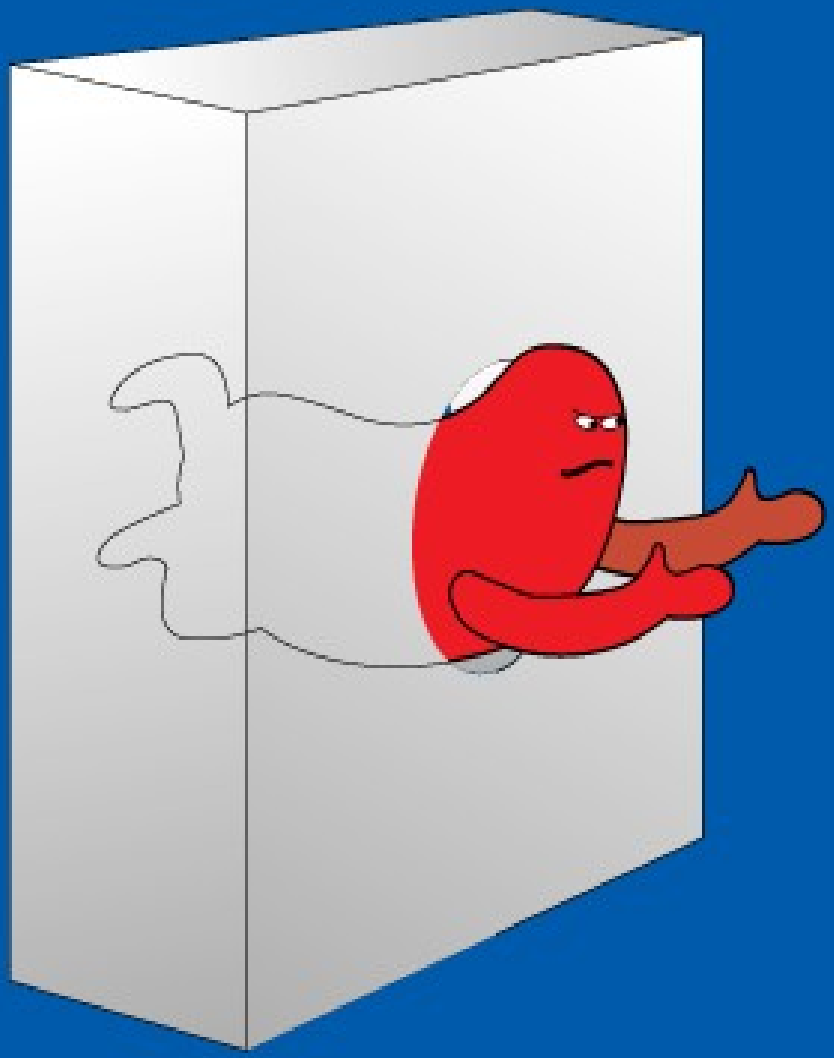
# Dialyzer Clearance

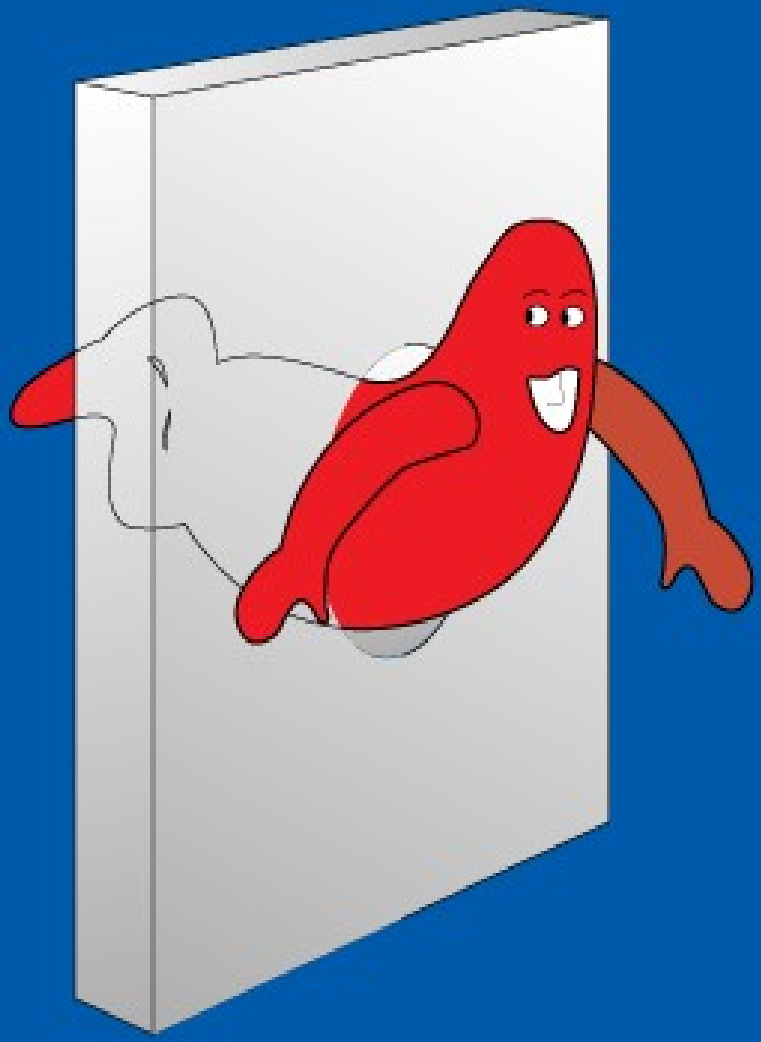


# Clearance vs Blood Flow Rate



# Membrane Thickness





# Clearance Calculation


$$K = \frac{Q_{B_{in}} \times C_{B_{in}} - Q_{B_{out}} \times C_{B_{out}}}{C_{B_{in}}} \text{ (ml/min)}$$

# Mass Transfer coefficient

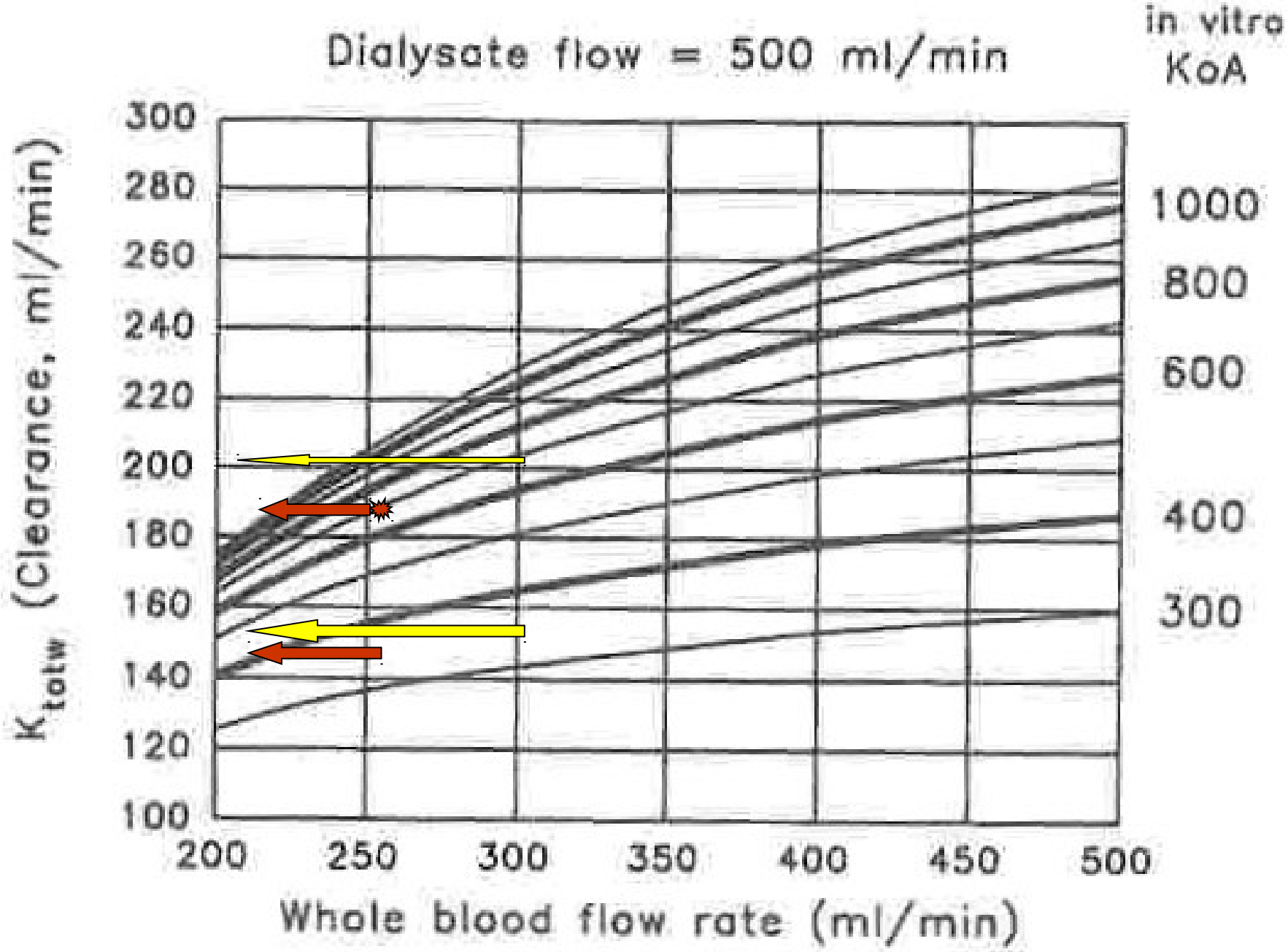
مقداری کمّی صافی خاصی ( )KOA Mass Transfer coefficient
استکه از طریق نفوذ پذیری ضخامت غشاء ، اندازه
. مواد ، میزان جریان خون و مایع دیالیز مشخص می شود

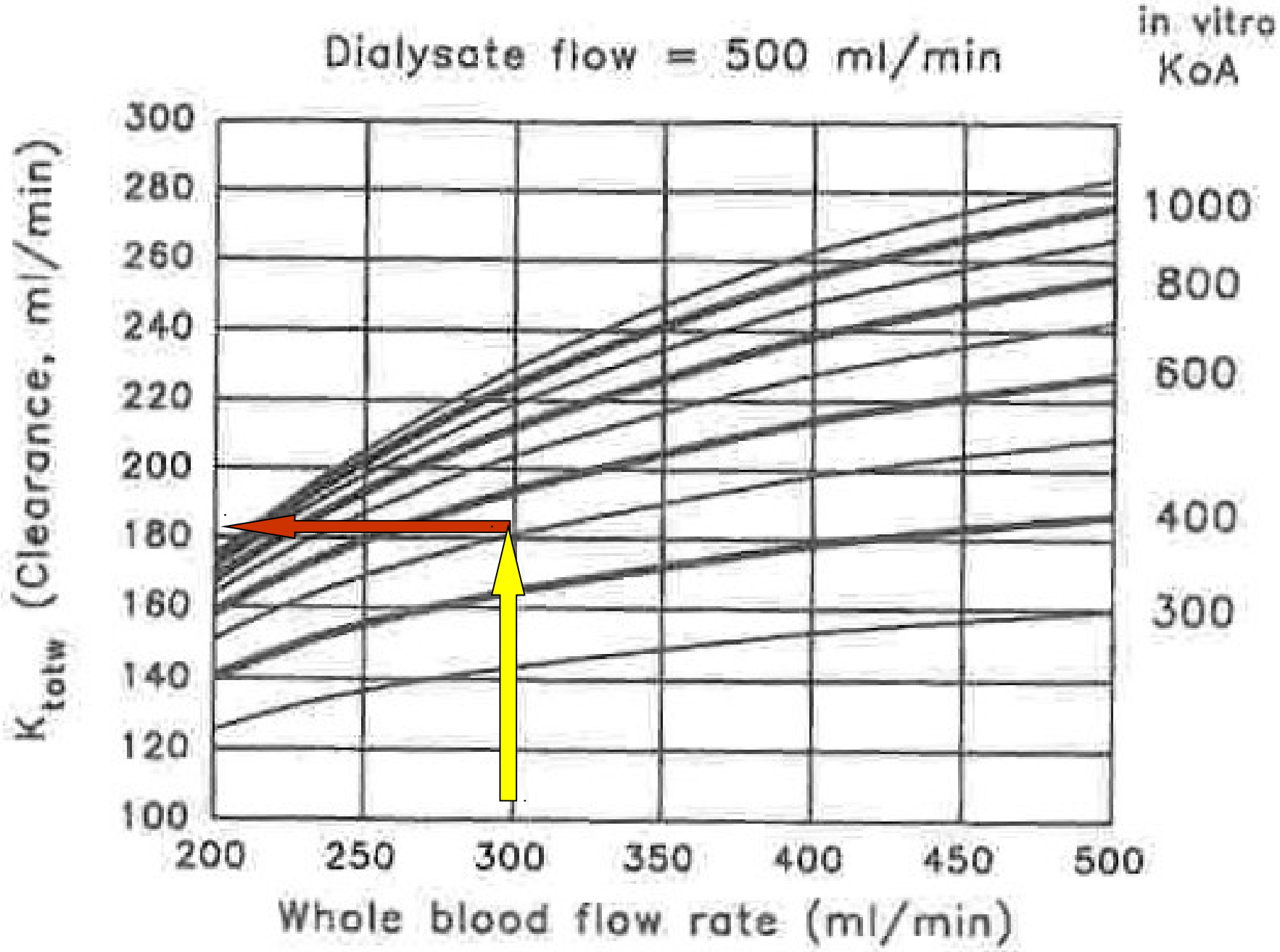
quantity amount of special filter that through permeability, membrane thickness, size, material, amount of blood flow and .dialysis fluid is identified

KOA each filter is equal to multiplication of its ability to filter the .clearance of a substance on its surface smoothness

The KoA is the maximum theoretical clearance of the dialyzer per minute for a given solute at infinite blood and dialysis solution flow .rates

.KOA for different filter urea usually between 200 to 1100 can vary


Dialysate flow = 500 ml/min
in vitro KoA
1000
800
600
400
300
$K_{totw}$ (Clearance, ml/min)
300
280
260
240
220
200
180
160
140
120
100
200
250
300
350
400
450
500
Whole blood flow rate (ml/min)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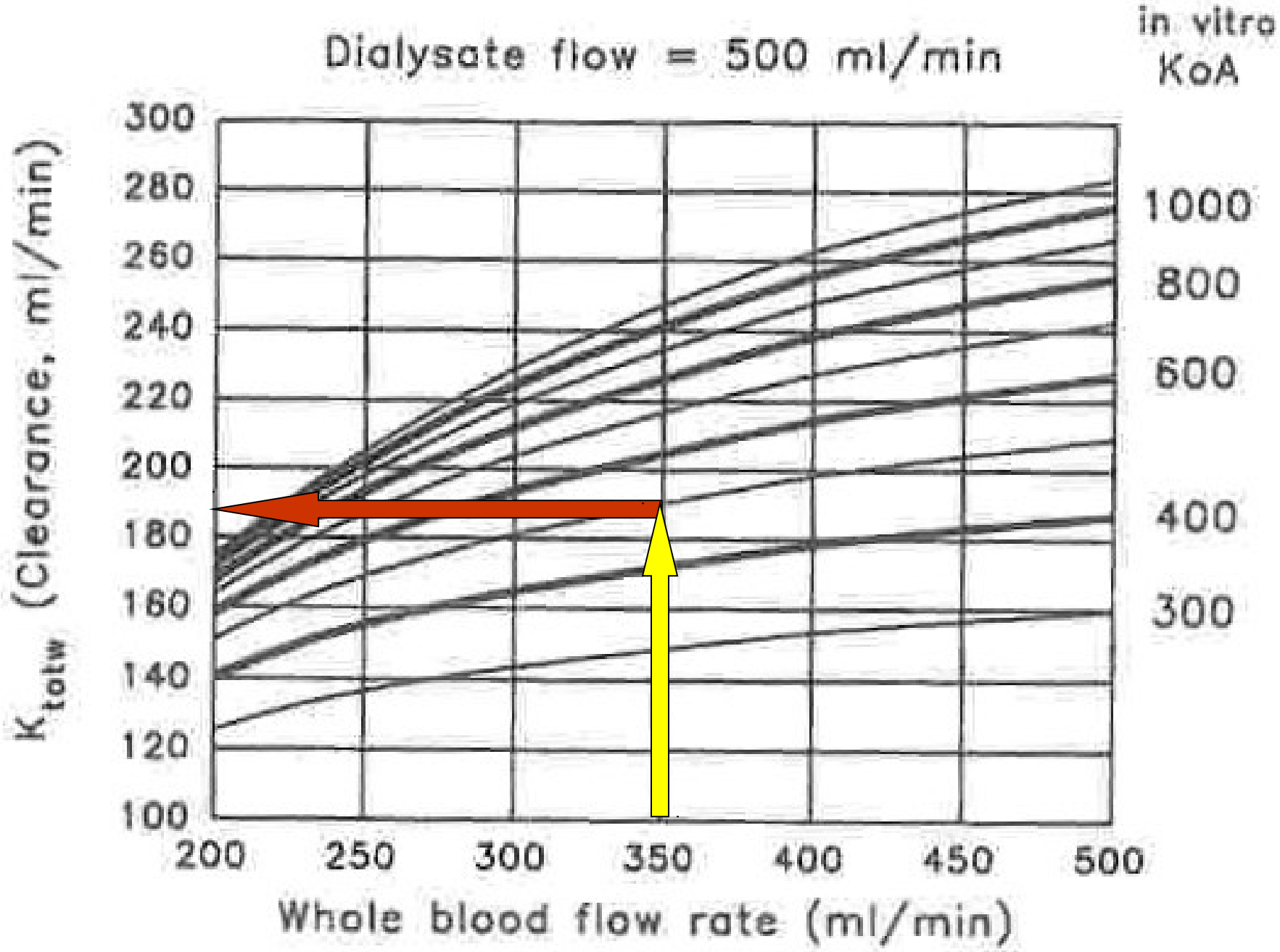
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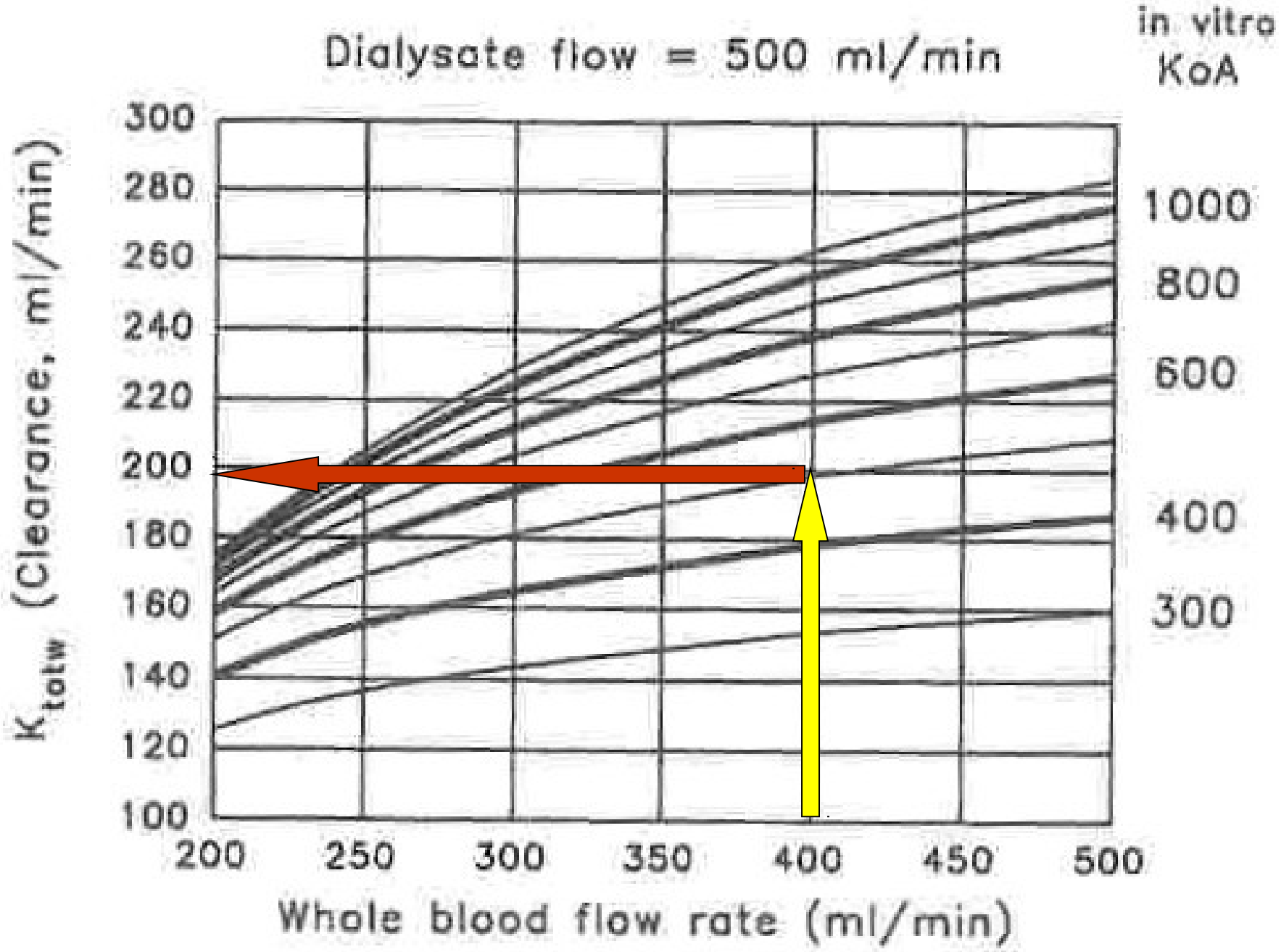
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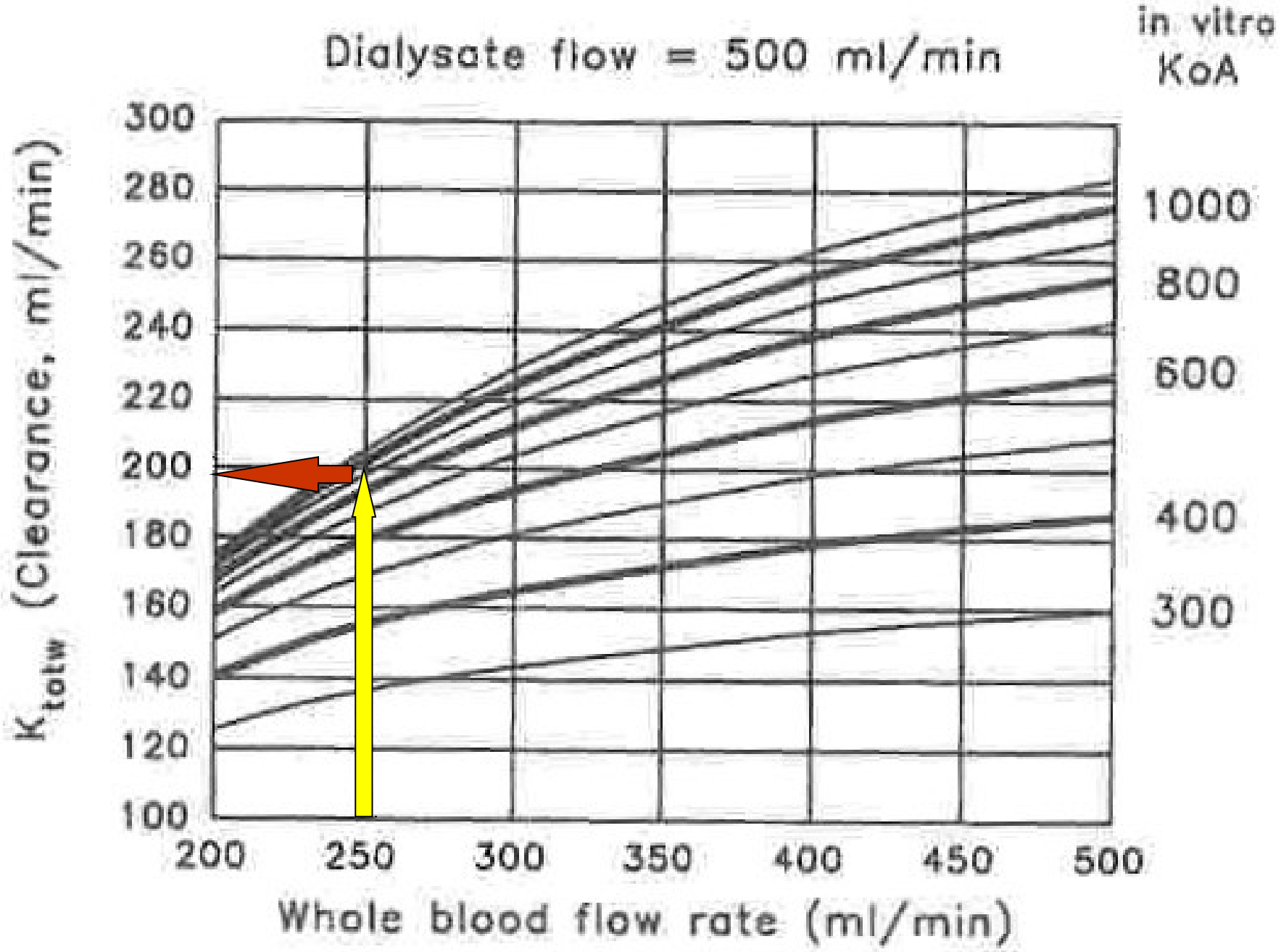
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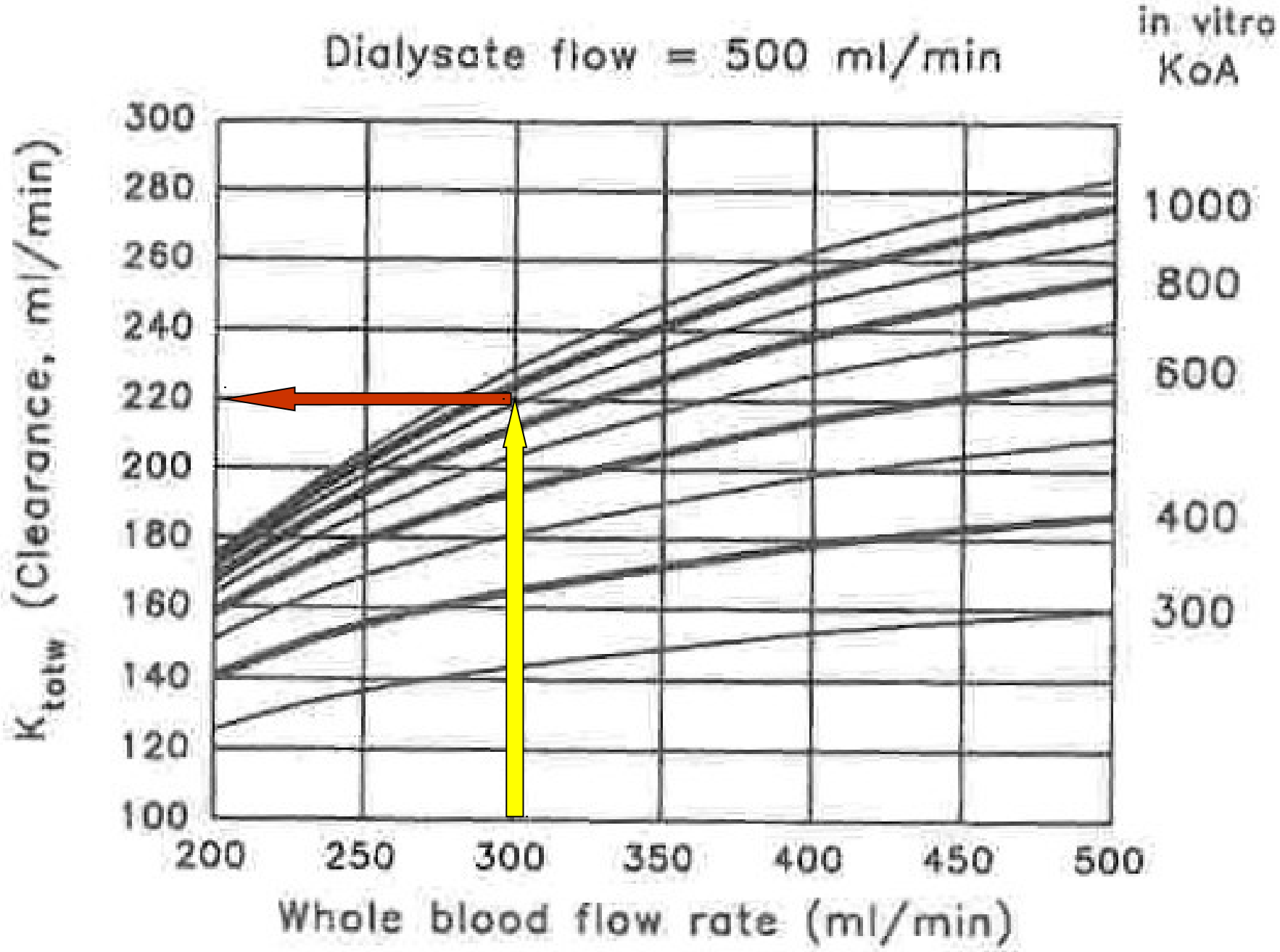
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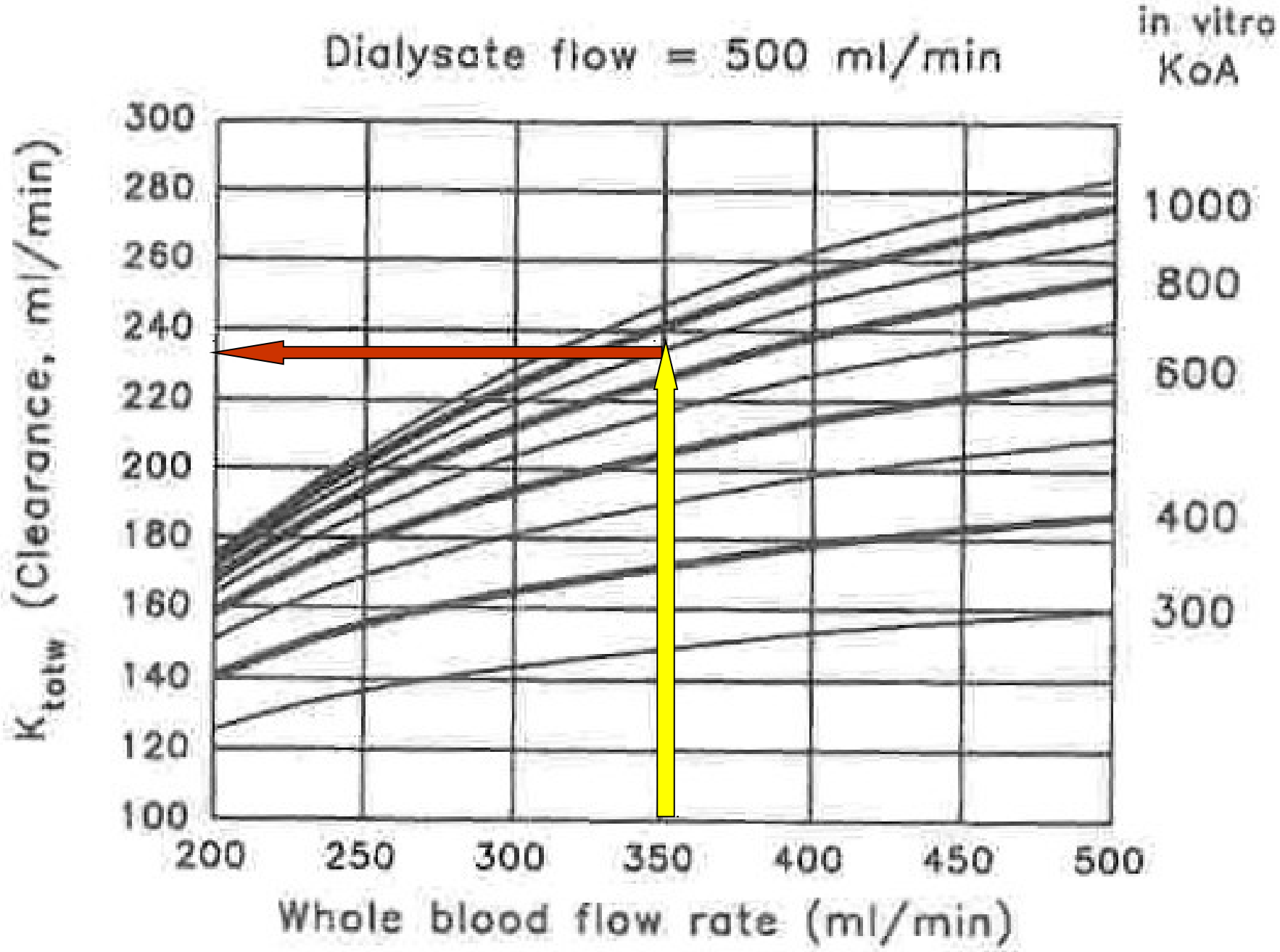
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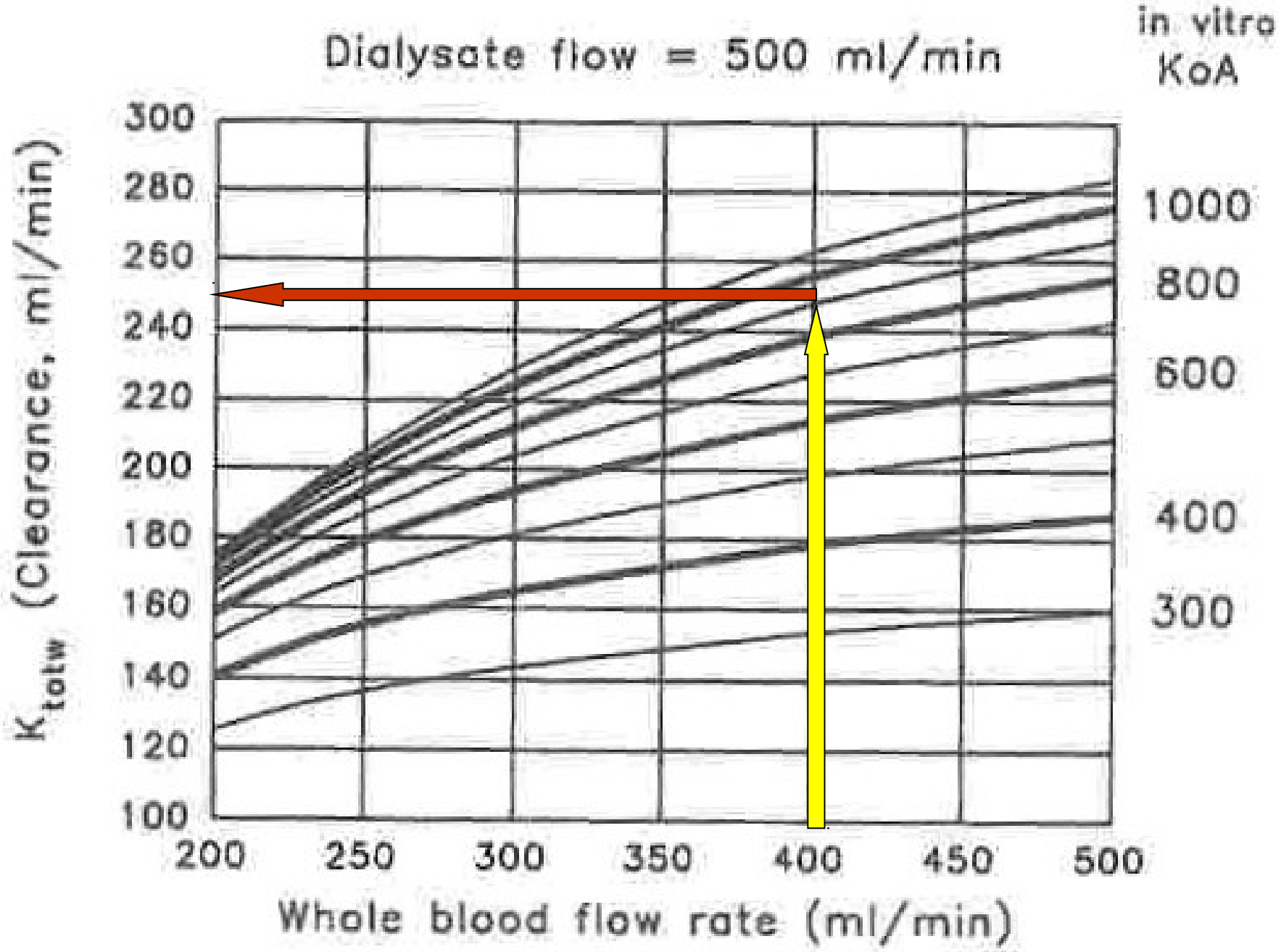
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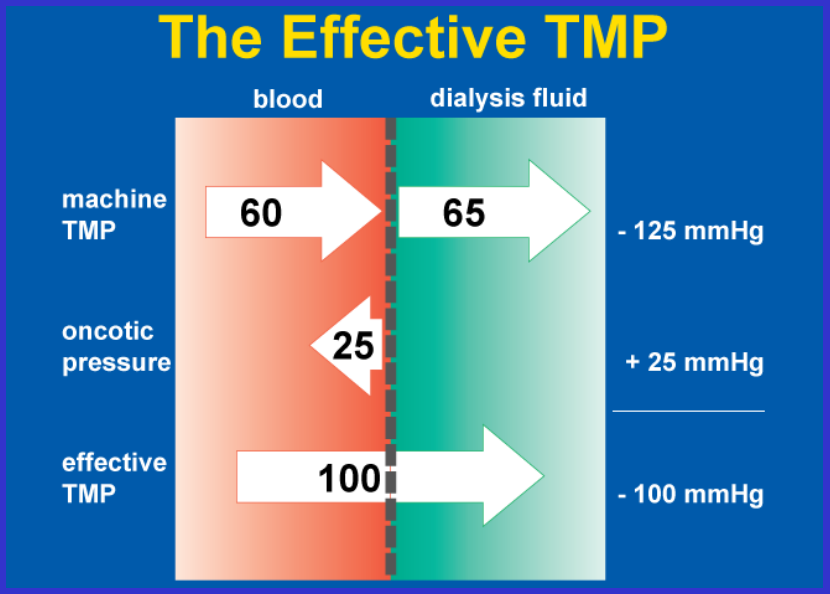
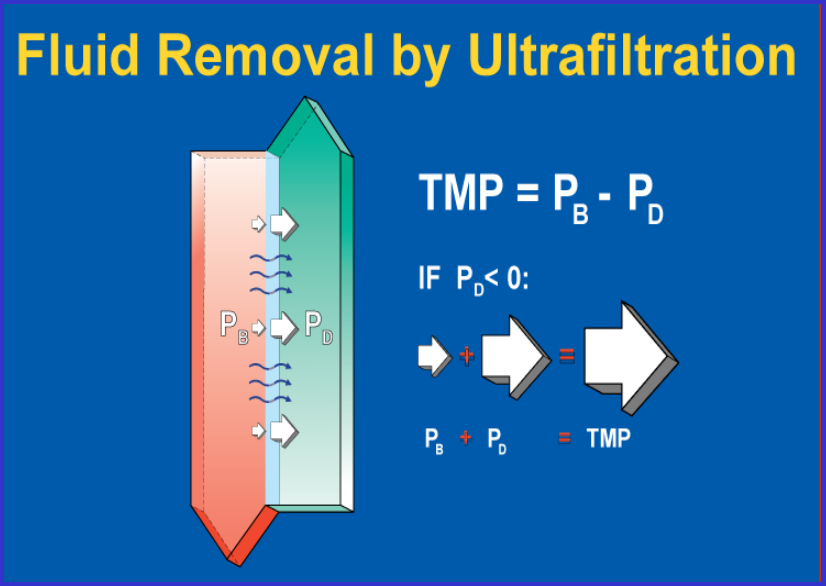
Whole blood flow rate (ml/min)

# Fluid Removal




;That is independent to

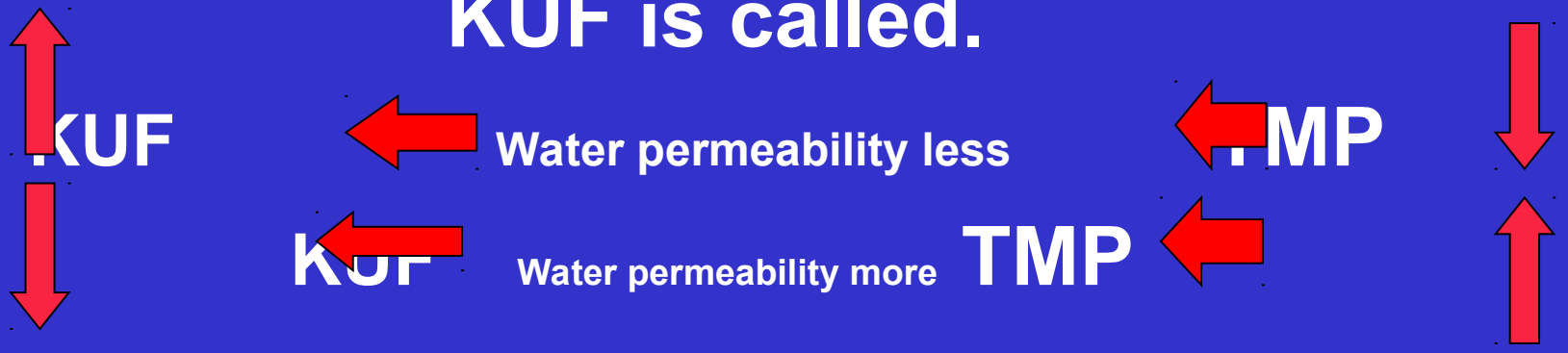
.The function of membrane of dialyzer- 1

.The size of ports of fibers- 2

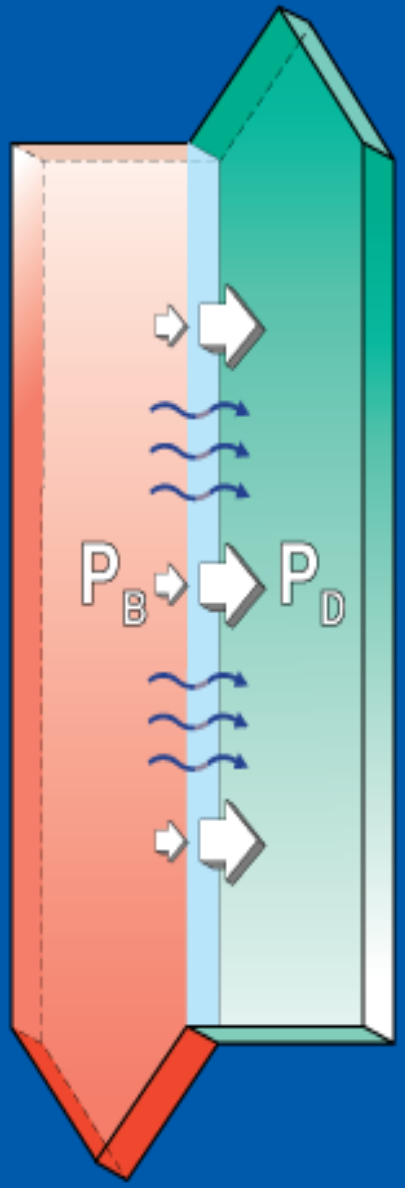
# KUF

**Permeability dialyzer to water**

**Volume in ml of liquid taken from the patient over time Is taken to per (MM Hg) mm Hg pressure**
**KUF is called.**

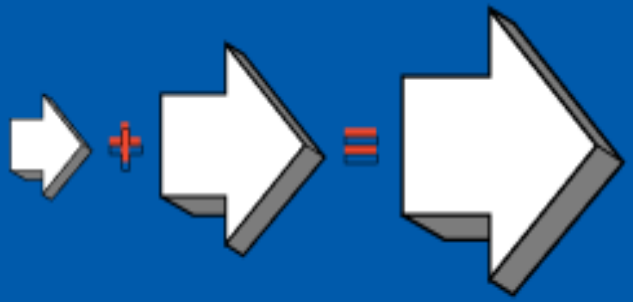


# Fluid Removal by Ultrafiltration




$$TMP = P_B - P_D$$

IF $P_D < 0$:



$P_B + P_D = TMP$

# High-Efficiency

# and

# High-Flux Hemodialysis

# Definitions of flux, Permeability, and efficiency

## Flux

- Measure of ultrafiltration capacity
- Low and high flux are based on the ultrafiltration coefficient(Kuf)
  - Low flux; Kuf <10 ml/h/mmHg
  - High flux; Kuf >20 ml/h/mmHg

## Permeability

- Measure of the clearance of the middle molecular weight molecule (eg, β2-microglobolin)
- General correlation between flux and Permeability
  - Low Permeability; β2-microglobolin clearance<10ml/h/mmHg
  - High Permeability; β2-microglobolin clearance<20ml/h/mmHg

## Efficiency

- Measure of urea clearance
- Low and high efficiency are based on the urea KoA value
  - Low efficiency; KoA <500 ml/min
  - High efficiency; KoA >800 ml/min

# Classification of High-Performance Dialysis

- High-Efficiency Low-flux hemodialysis
- High-Efficiency High-flux hemodialysis
- Low-Efficiency High-flux hemodialysis

# Characteristics of High-Efficiency Dialysis

- Urea clearance rate is usually >210 ml/min
- Urea KoA of the dialyser is usually >600 ml/min
- Ultrafiltration coefficient of the dialyser(Kuf) maybe high or low
- Clearance of middle molecular weight molecules maybe high or low

---

Ko- mass transfer coefficient; A- surface area

# Differences between High and Low-Efficiency Hemodialysis

| | High Efficiency, ml/min | Low Efficiency, ml/min |
|---|---|---|
| Dialyzer KoA | ≥600 | <500 |
| Blood flow | ≥350 | <350 |
| Dialysate flow | ≥500 | <500 |
| Bicarbonate dialysate | Necessary | optimal |

Ko- mass transfer coefficient; A- surface area

# Causes of High-Efficiency Dialysis Failure

## Access-related

- Low blood flow rate
- High recirculation rate

## Time-related

- Patient not adherent to prescribed time
- Staff not adherent to prescribed time
- Failure to adjust time for conditions such as alarm, dialysate bypass, and hypotention

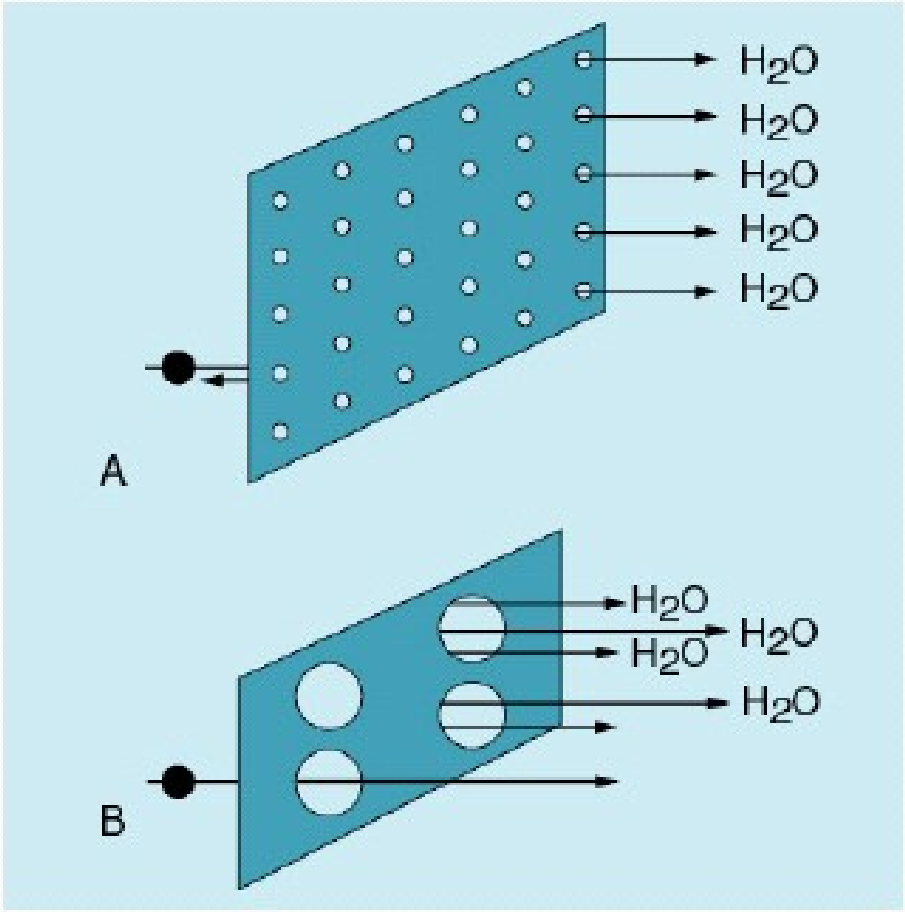
# Benefits High-Efficiency Dialysis

- Higher clearance of small solutes, such as urea, compared with conventional dialysis without increase in treatment time
- Better control of chimistery
- Potentially reduced morbidity
- Potentially higher patient survival rates

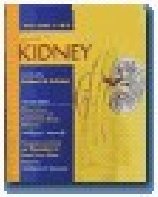
# Characteristics of High-Flux dialysis

- Dialyzer membranes are characterized by a high ultrafiltration coefficient(Kuf>20 ml/h/mmHg
- High clearance of middle molecular weight molecules occurs (eg, $\beta_2$-microglobolin)
- Urea clearance can be high or low, depending on the urea KoA of the dialyzer
- High-flux dialysis requires an automated ultrafiltration control system

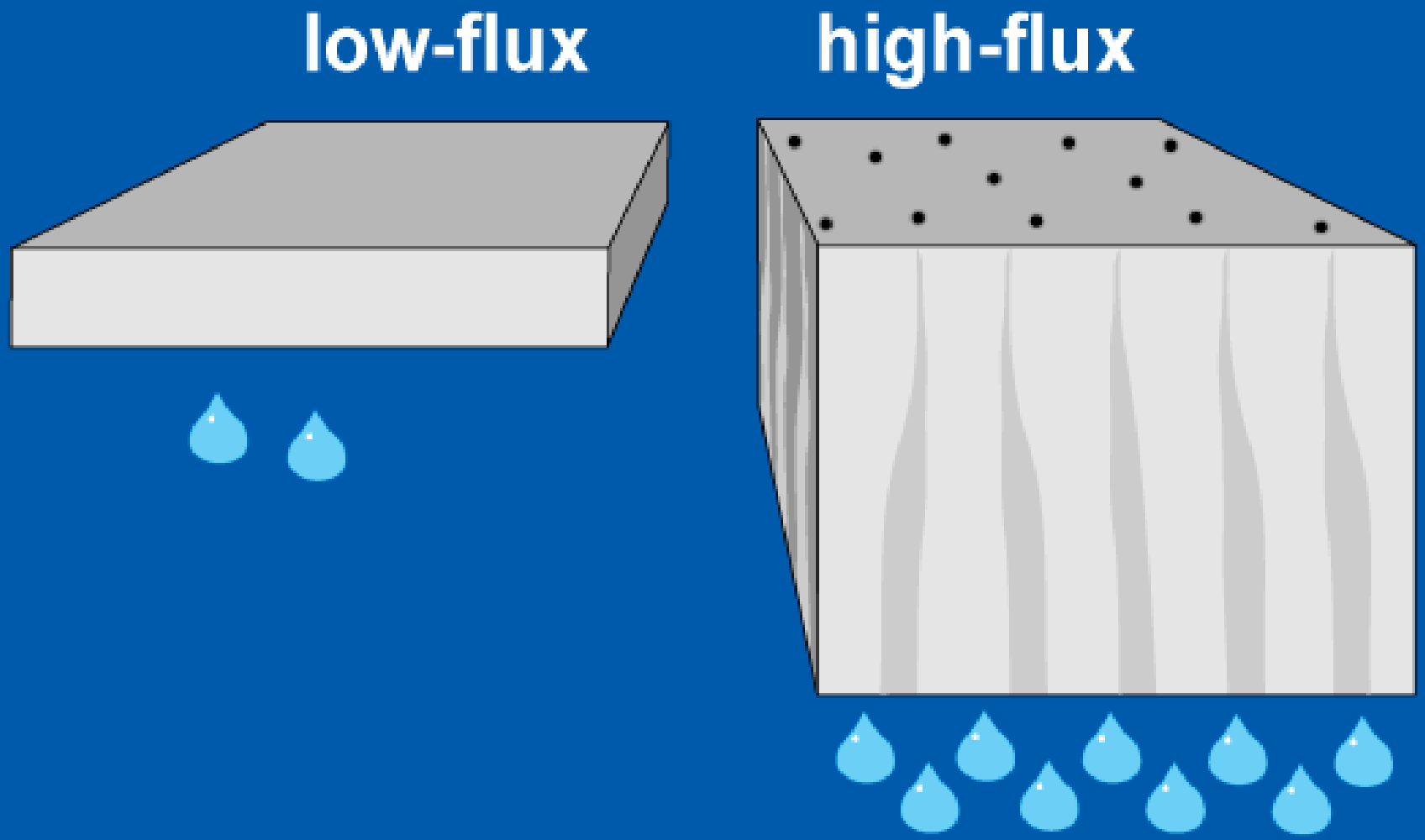
# Membrane Flux and Pore Size 1



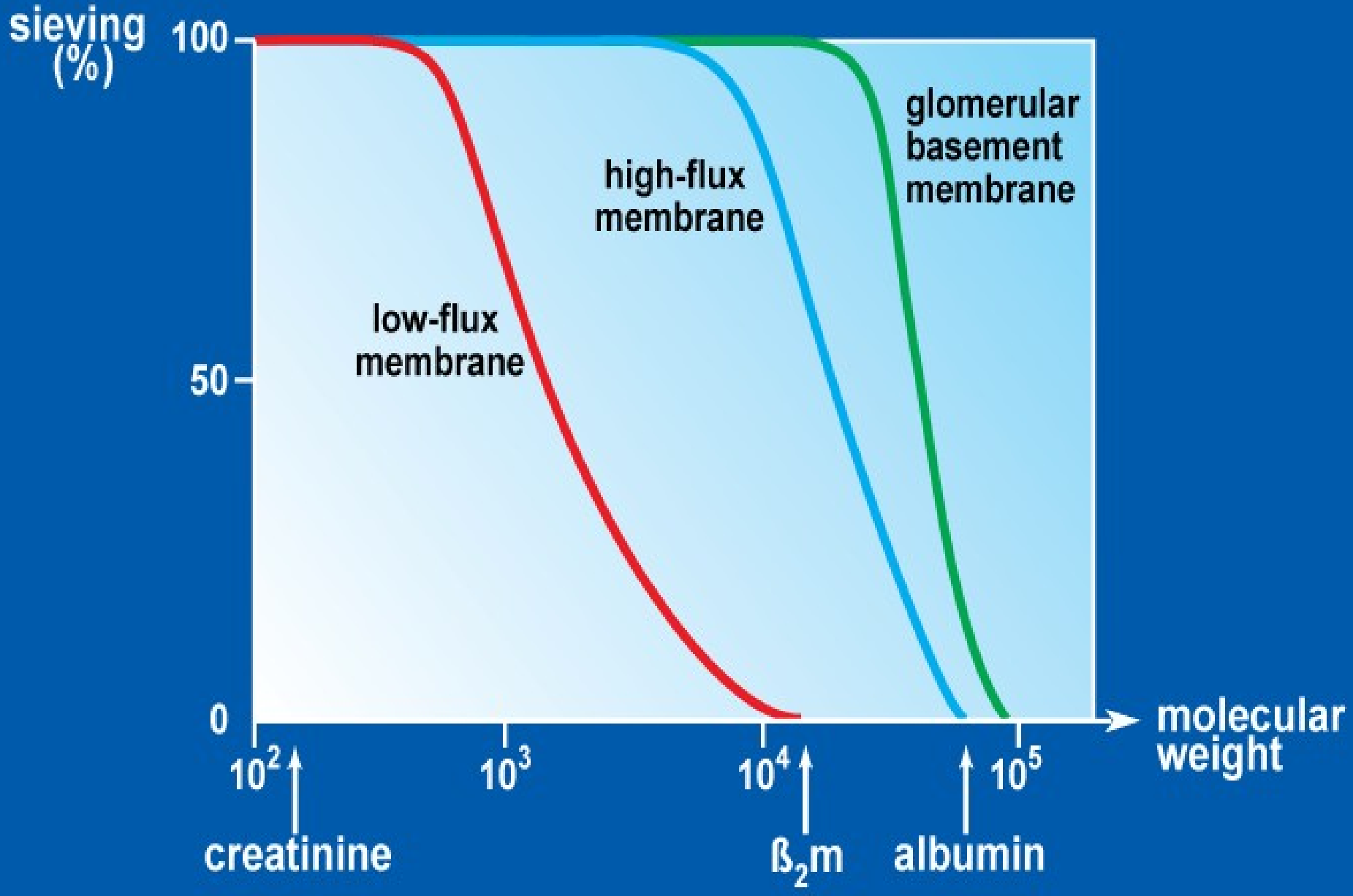

Sivasankaran Ambalavanan, Gary Rabetoy & Alfred K. Cheung; www.kidneyatlas.org



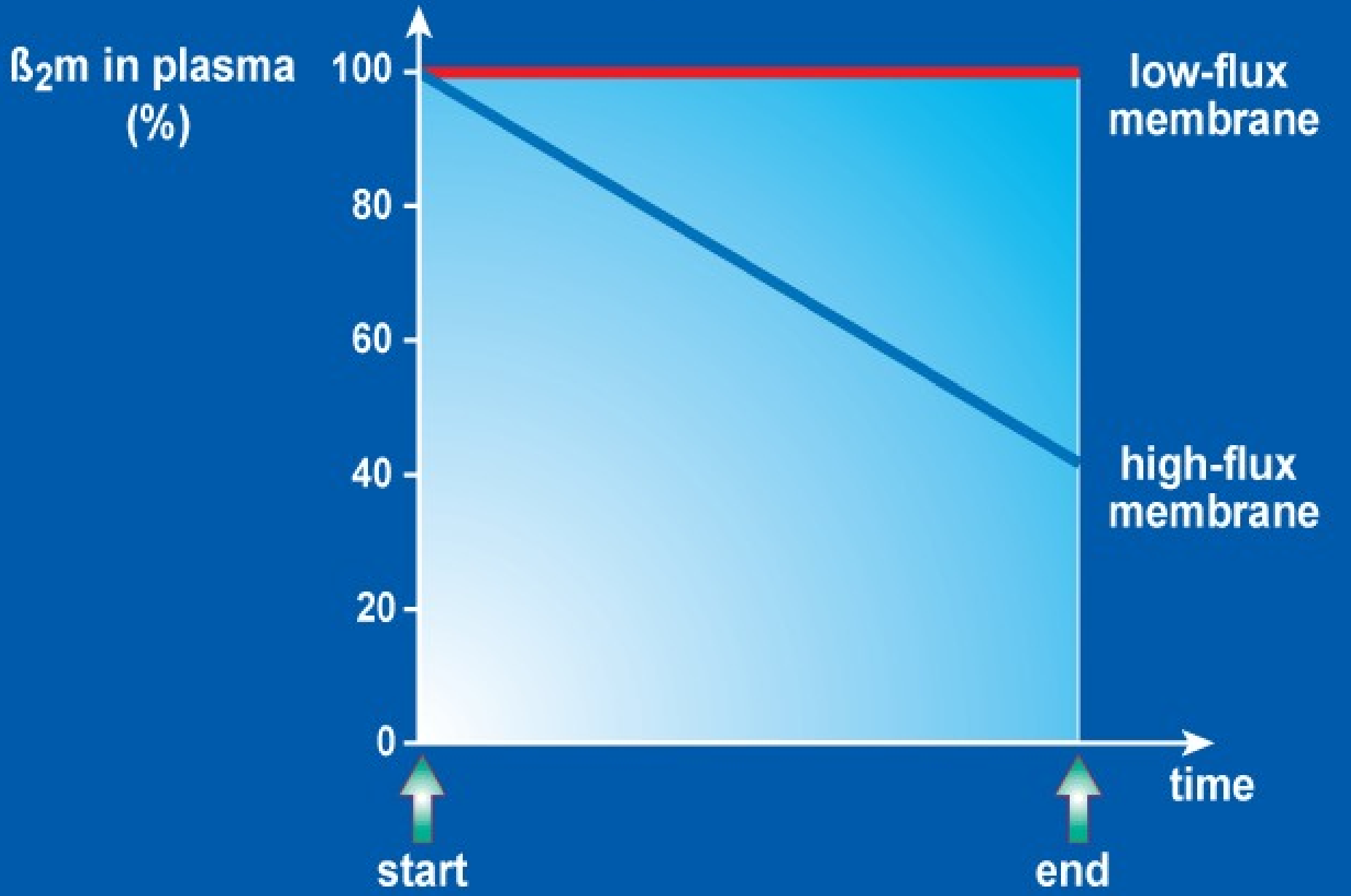
# Membrane Structure



# Membrane Permeability



# Removal of $ß_2m$ during HD



# Technical requirements for High-Flux dialysis

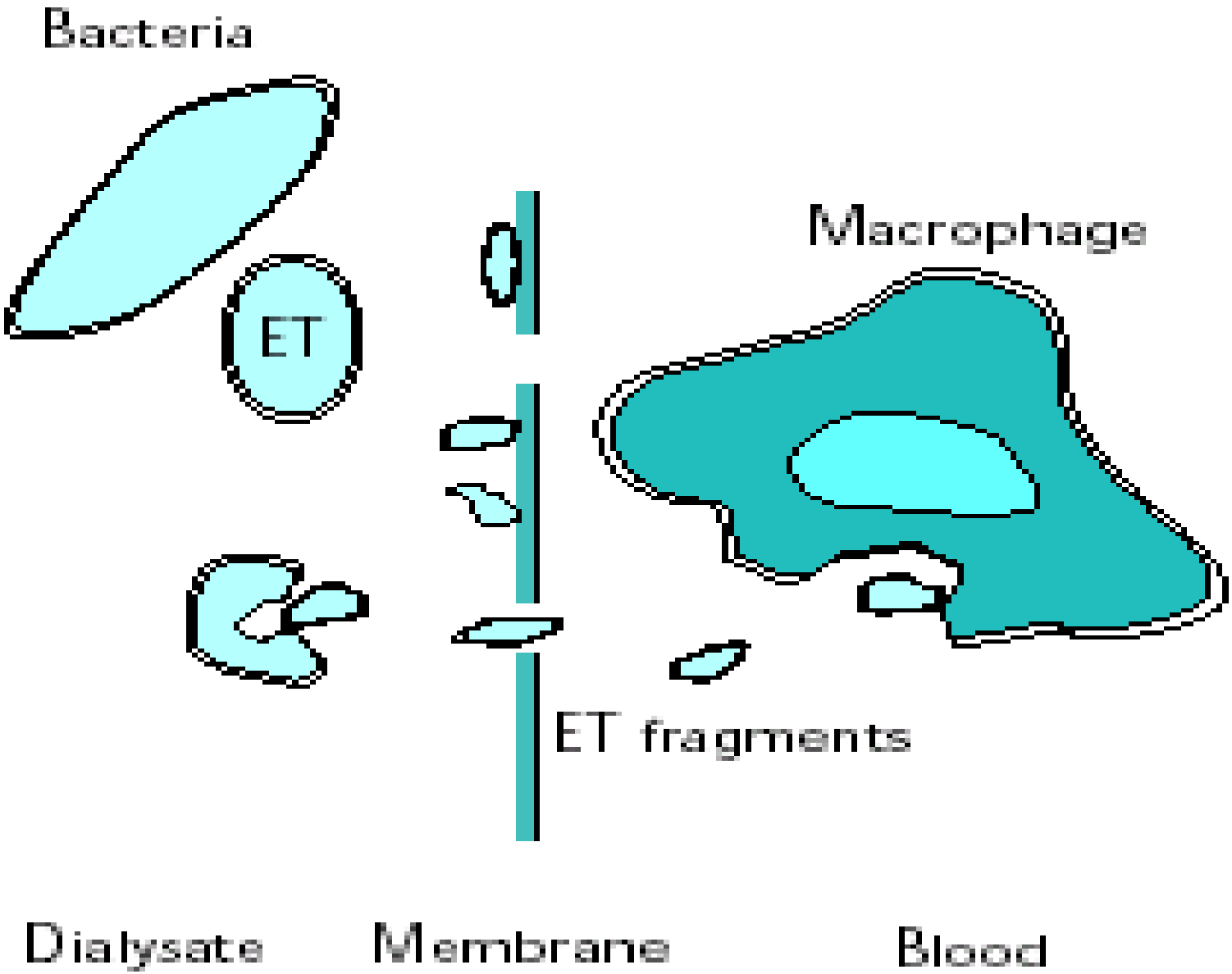
- ✓ High-Flux dialyzers
- ✓ Automated ultrafiltration control system

# Potential Benefits of High-Flux Dialysis

- Delayed onset and risk of dialysis-related amyloidosis because of enhanced β2-microglobolin clearance
- Increased patient survival resulting from higher clearance of middle molecular weight molecules
- Reduced morbidity and hospital admissions
- Improved lipid profile
- Higher clearance of aluminum
- Improved nutritional status
- Reduced risk of infection
- preserved residual renal function

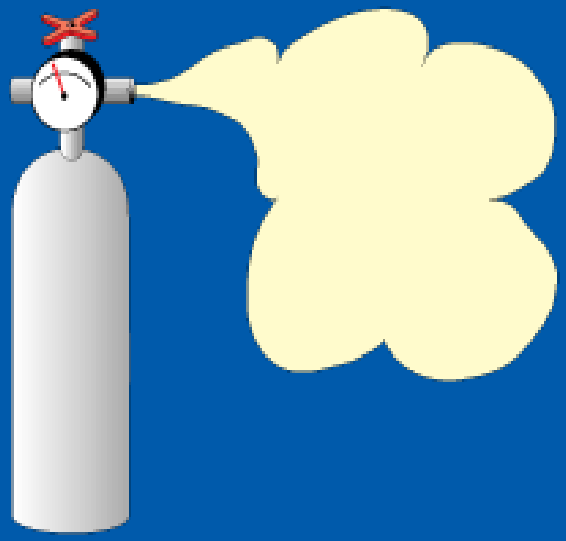
# Limitation of High-Flux Dialysis

- ✓ Enhanced drug clearance, requiring supplemental dose after dialysis
- ✓ High cost of dialyzers

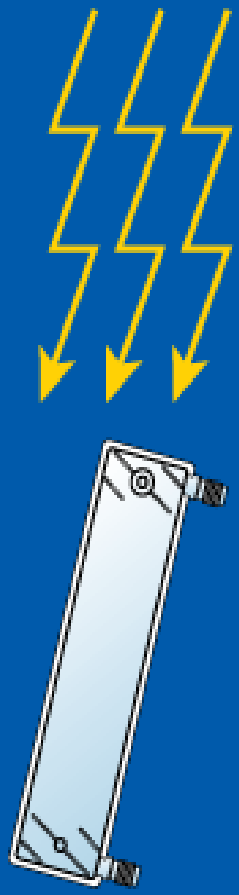

Bacteria
ET
Macrophage
ET fragments
Dialysate
Membrane
Blood

# Sterilization Methods

ethylene oxide



radiation



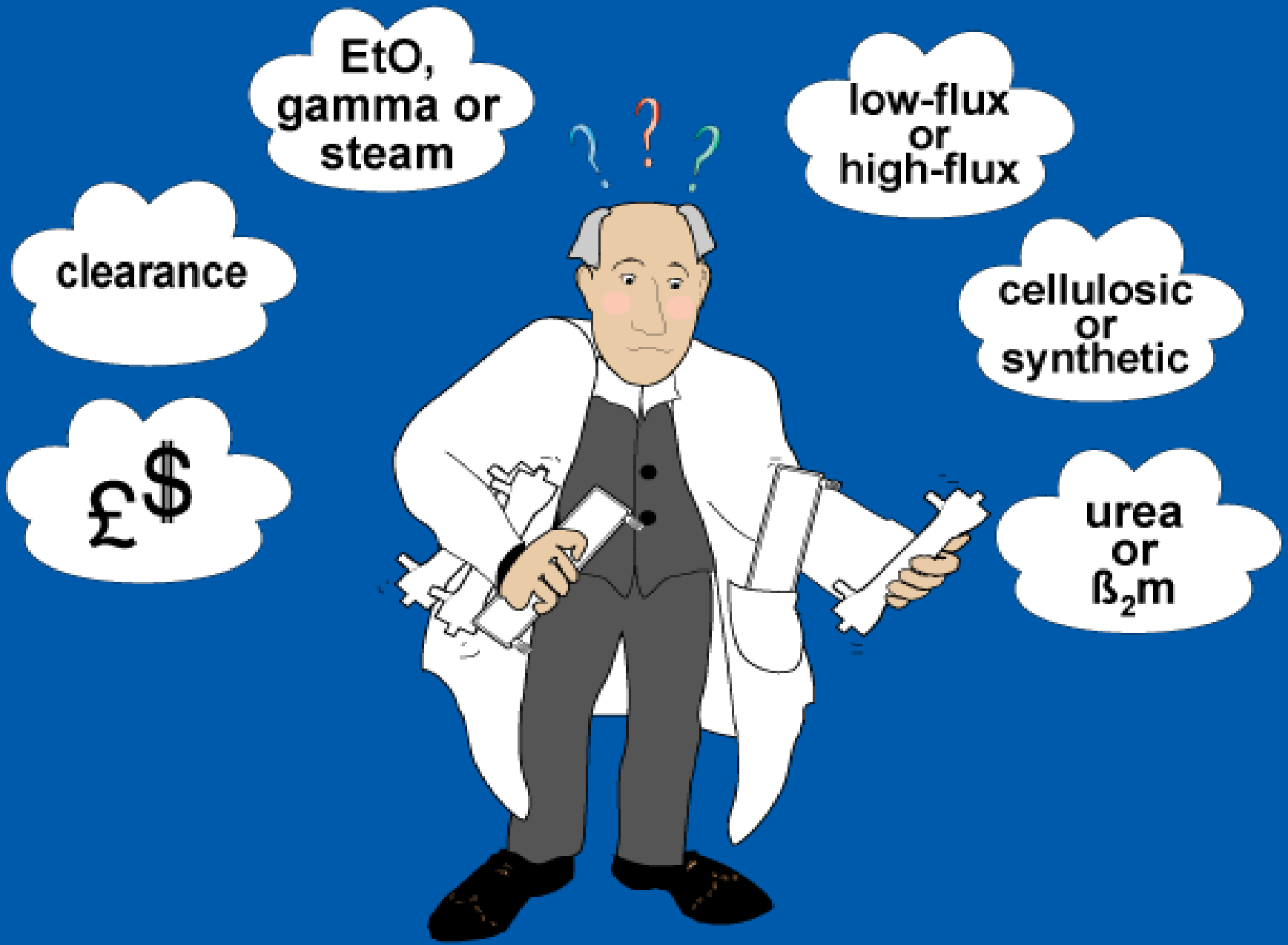
steam

Select the appropriate filter for a patient usually Clearance by doctors to determine the definition

The result is that to achieve dialysis adequacy

Is considered desirable.

# The Important Choice



# *Example of use:*

**The patient was a 60kg with height is 160cm.**

1- Calculate volume (v) = 32L(32000ML)

Calculate time (t) = 4h(240 min)- 2

Determination goal K.T/V, K.T/V in a suitable dialysis- 3 session = 1/3

- **K.T/V= 1/3**
- **( K . 240) / 32000= 1/3**
- **K= ( 1/3 . 32000) / 240=173**
- **K= 173**

**R5 with inspiratory flow filter urea clearance 200 ml of blood per minute is about 170 ml of this filter can be selected and to determine blood flow higher than 200 means about 250 ml per minute to reach the desired clearance.**