Demographics: I am a …

- A. Fellow
- B. Staff (attending nephrologist)
- C. Nurse / Nurse Practicioner
- D. Technician
- E. Dietitian
- F. Administrator
- G. Other

I prescribe high-flux dialysis for…

- None of my patients
- 1-25%
- 25-75%
- All of my patients

The most common dialysate flow rate in my unit is…

- **500 and 500 exclusively**
- **500, but substantial n ≥ 600**
- **≥ 600**
- **≥ 800**

The percent of patients with Td > 4 hrs is…

- 0
- A handful
- > 10%
- ≥ 25%

The best way to describe how initial dialysis prescriptions are written for a new patients is…

- **Cookbook, one size fits all**
- **Highest Qb, longest Td, and biggest dialyzer**
- **Cookbook, modified for patient size**
- **Modeling, to target a specific Kt/V**
- **Other**
- **Not my function to prescribe dialysis**

Objectives
to better understand:

Dialyzer extraction ratio

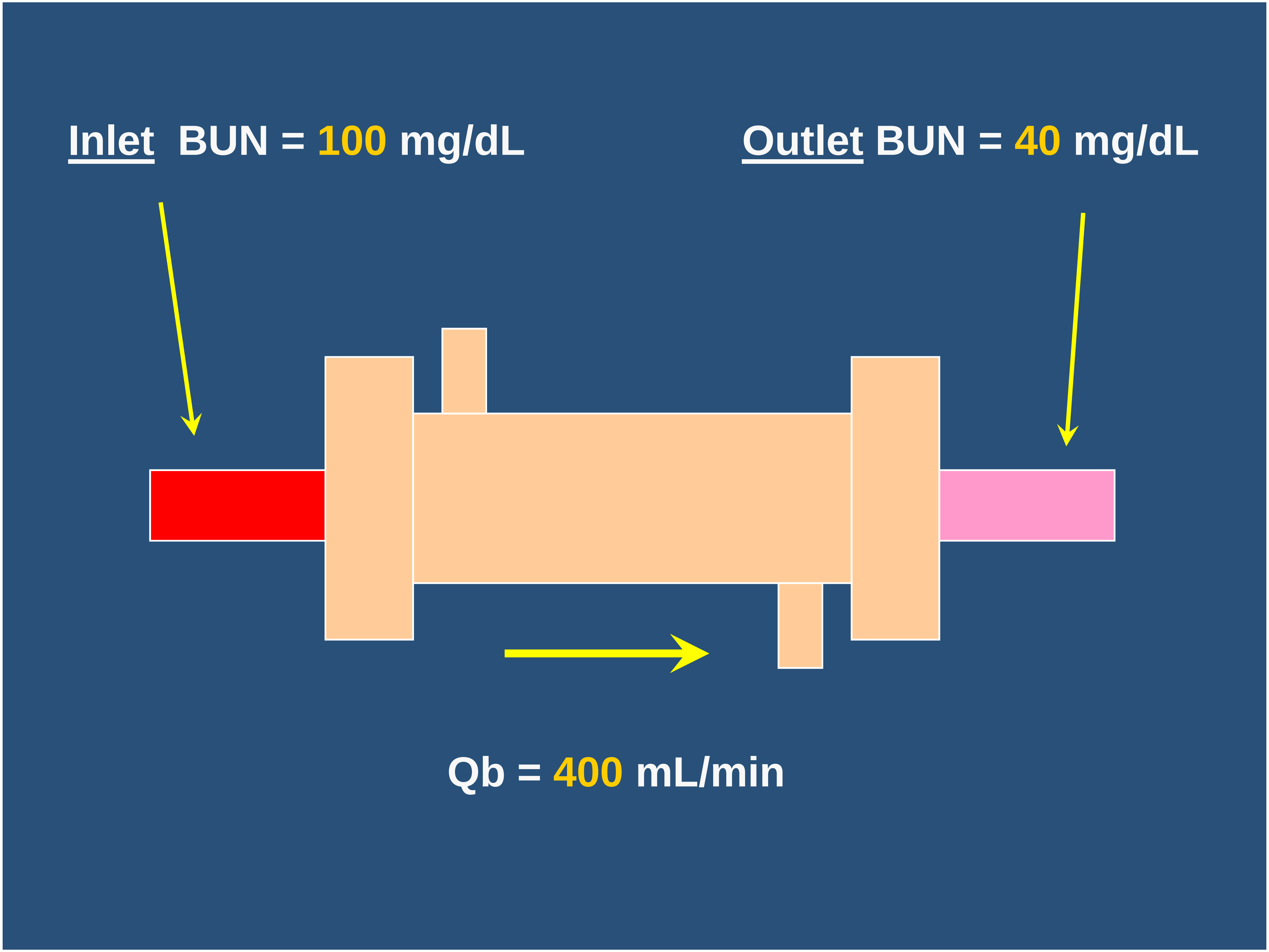
Dialyzer clearance

K_0A

Initial prescription

Adjusting Kt/V

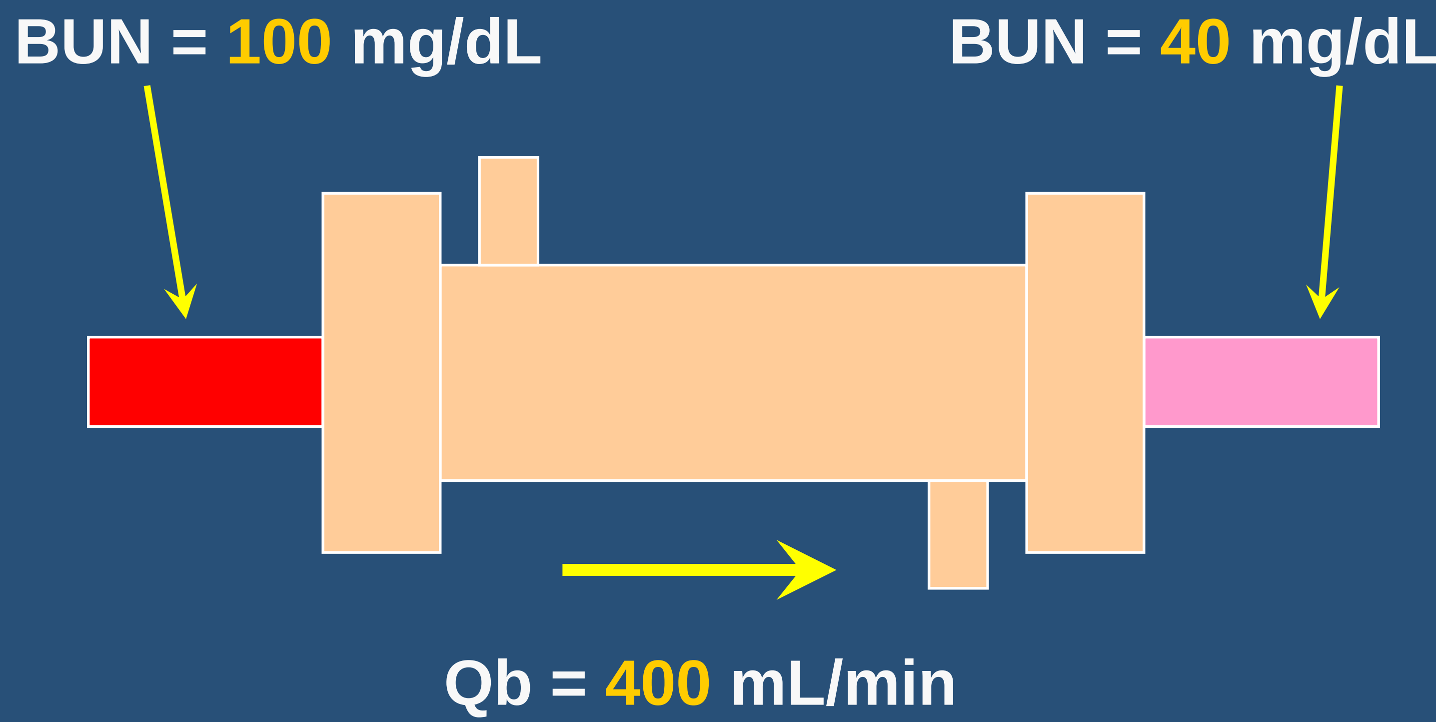
Standard Kt/V


Inlet BUN = 100 mg/dL
Outlet BUN = 40 mg/dL
Qb = 400 mL/min

What is the extraction ratio of this dialyzer?

- 0.40
- 0.60
- 240 ml/min
- 480 ml/min

What is the Extraction Ratio ?



Extraction Ratio = (inlet - outlet) / outlet

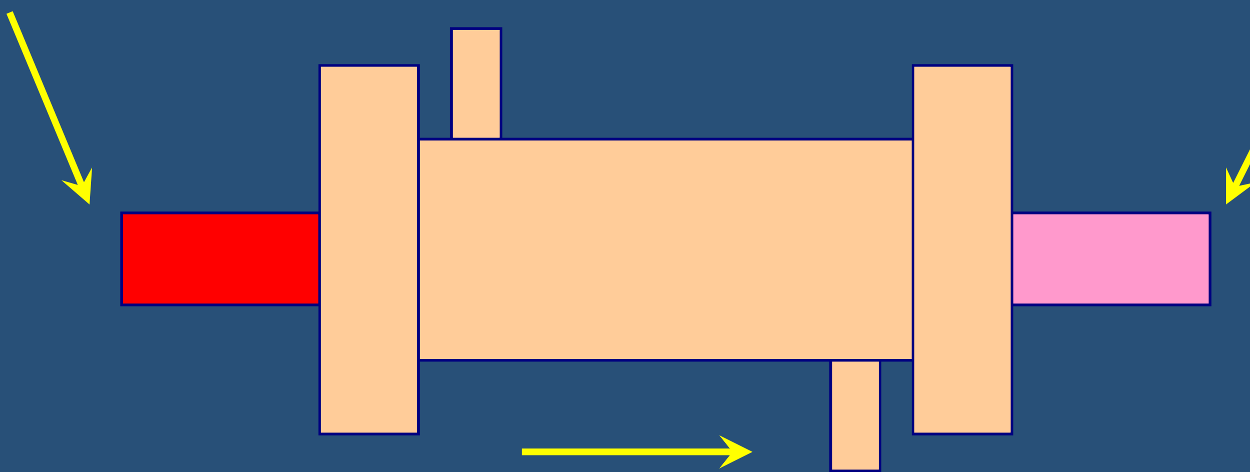
= (100-40)/100 = 60%

If we raise the inlet BUN from 100 to 200, what will happen to the Extraction Ratio?

- increase
- decrease
- stay the same

What is the effect of inlet BUN on ER?

200	ER = 60%	80
BUN = 100 mg/dL	ER = 60%	BUN = 40 mg/dL
10	ER = 60%	4



Qb = 400 mL/min

Inlet BUN has NO effect on extraction ratio (ER)

Suppose we decrease Qb from 400 to 200. What will happen to the extraction ratio?

- Increase
- Decrease
- Stay the same
- Can’t say

Suppose we decrease Qb from 400 to 1 ml/min. What will the outlet BUN be?

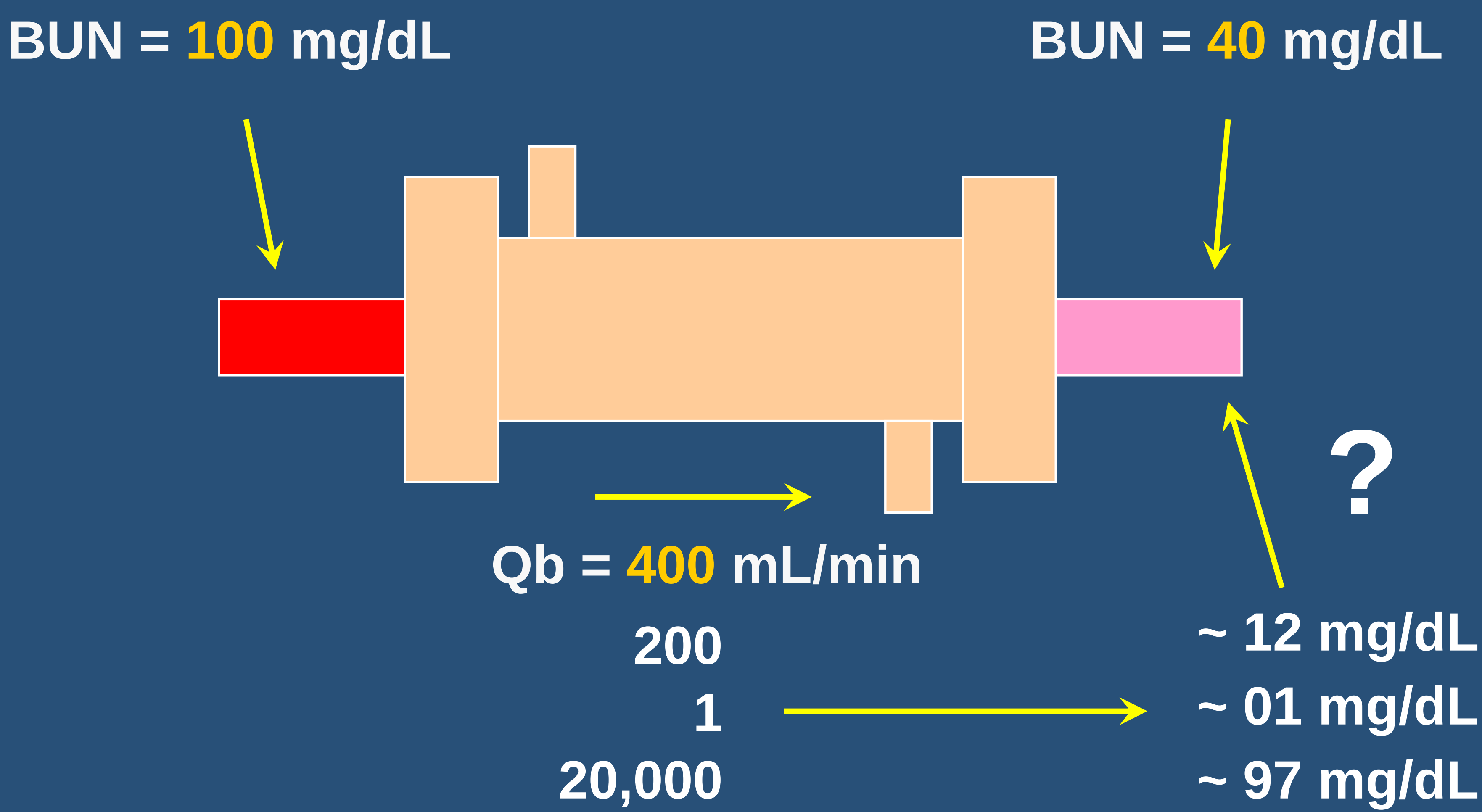
- ~ 97 mg/dL
- ~ 1 mg/dL
- ~ 40 mg/dL (unchanged)
- Can’t say

Suppose we increase Qb from 400 to 20,000 ml/min. What will the outlet BUN be?

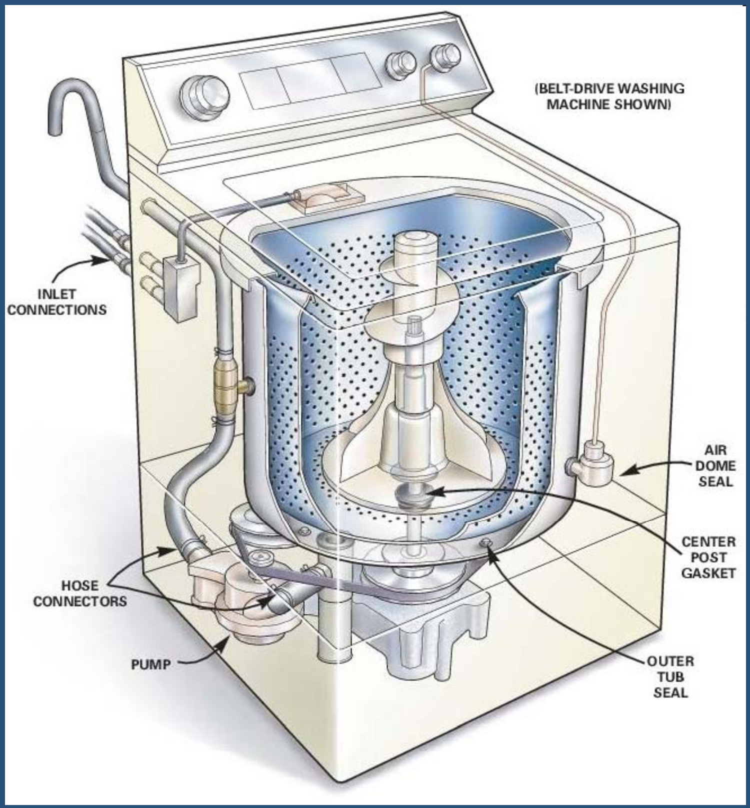
- ~97 mg/dL
- ~ 1 mg/dL
- ~ 40 mg/dL (unchanged)
- Can't say

What is the effect of Qb on ER?

The higher the Qb, the lower the ER.
The lower the Qb, the higher the ER.



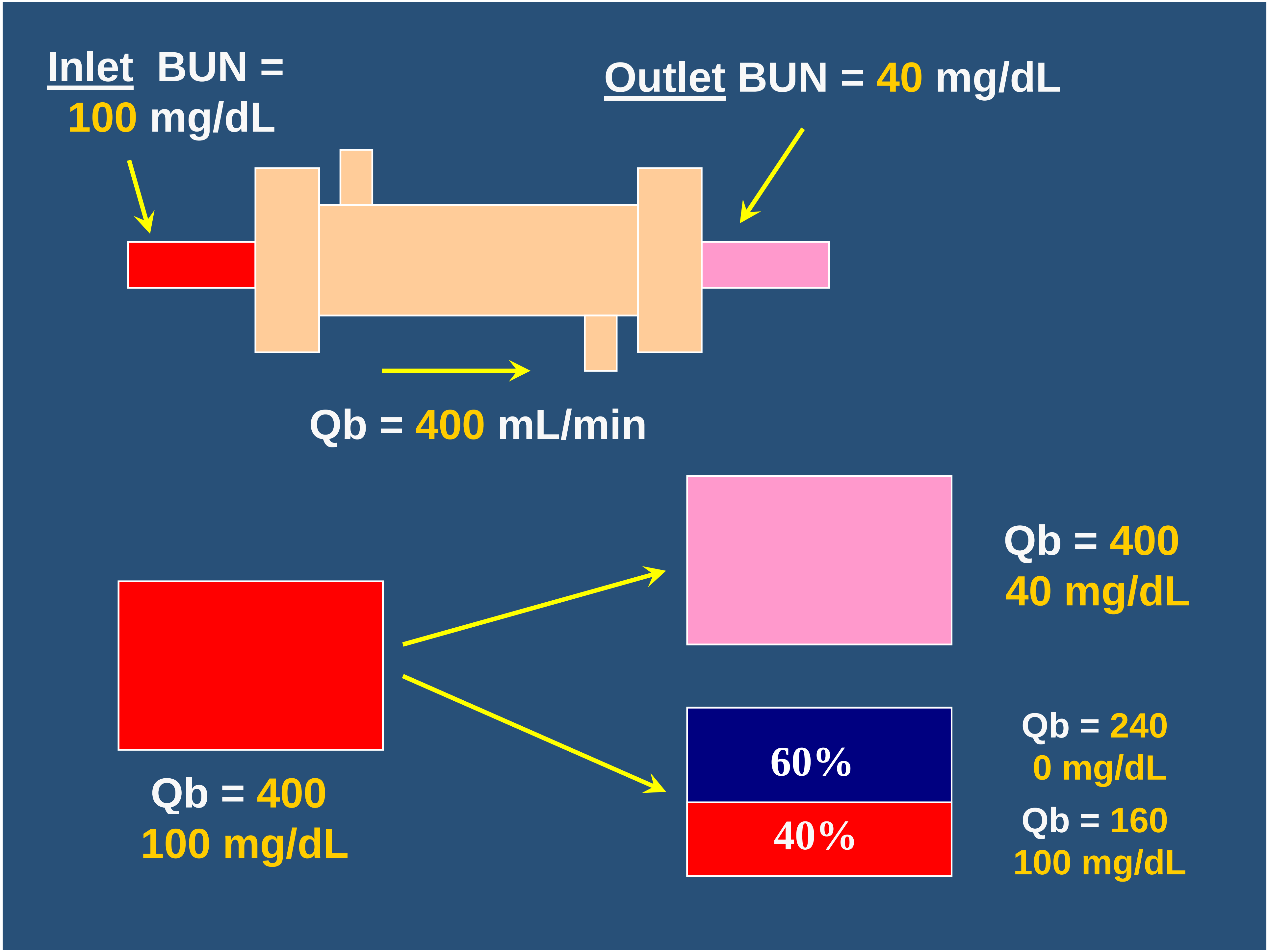
ER = what percent of dirt you remove (transit time)



Dialyzer Clearance (Kd) what is it?

Again, Qb = 400, ER = 60%
What is the clearance?

- **Can’t say, depends on the input BUN**
- **240 ml/min**
- **160 ml/min**



Inlet BUN =
100 mg/dL
Outlet BUN = 40 mg/dL
Qb = 400 mL/min
Qb = 400
40 mg/dL
60%
40%
Qb = 240
0 mg/dL
Qb = 160
100 mg/dL
Qb = 400
100 mg/dL

Clearance

- Qb is 400 ml/min. The Extraction Ratio (ER) is 60%. What is the clearance?
- Clearance (Kd) = ER x Qb

  0.60 x 400

  240 ml/min*

- *Multiply by ~0.87 to correct Qb to blood water flow

Clearance

- **Plasma is 93% water**
- **Why multiply Qb by 0.87 and not by 0.93?**
- **Answer:**
  - **Erythrocyte is 72% water**
  - **87% correction factor is a weighted average of 72% and 93% factored for hematocrit**

Effect of Qb on ER and Kd

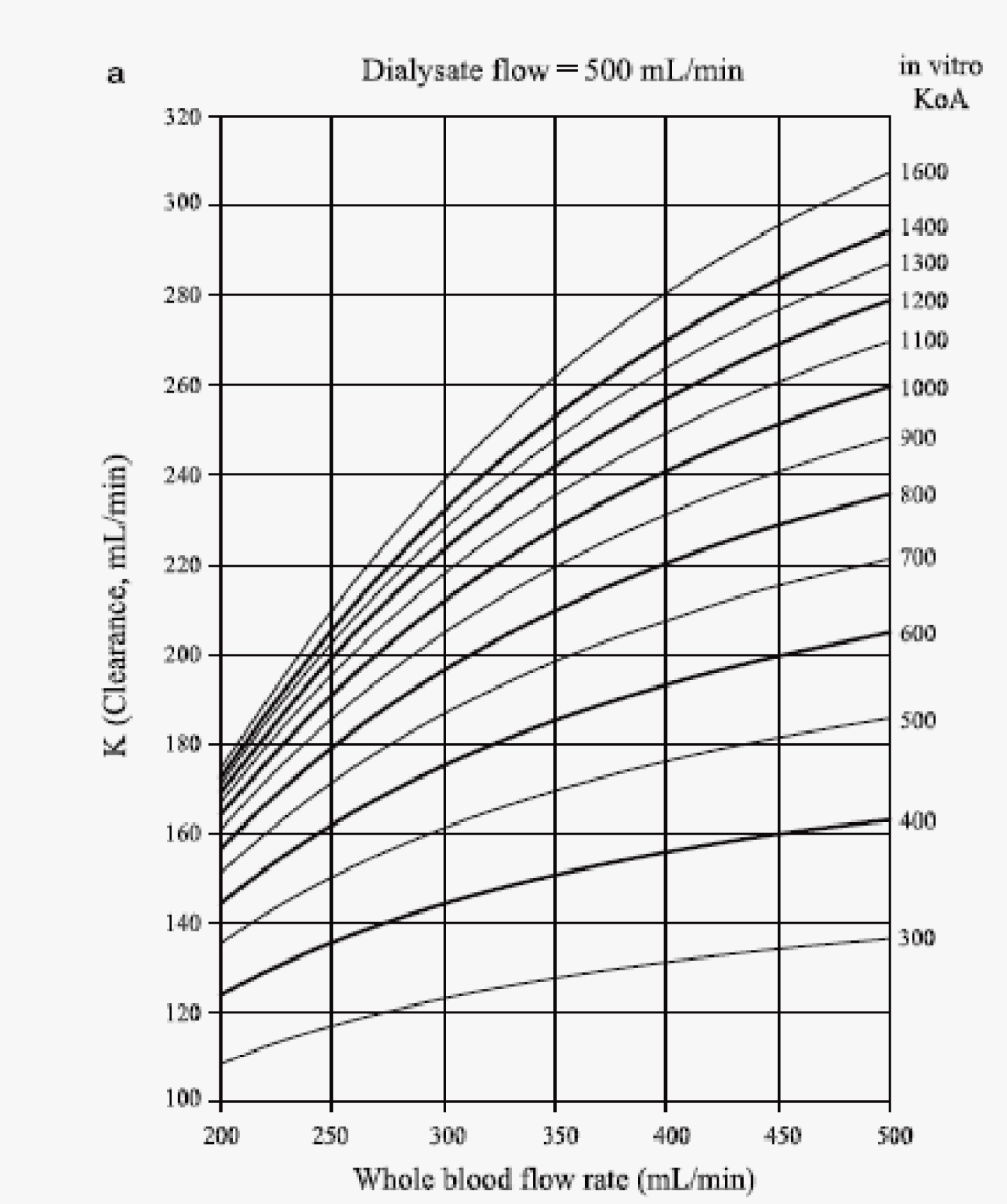
(Inlet BUN = 100)

Qb ***ml/min***	***Outlet BUN***	***ER***	***Kd (Qb x ER)***
400	**40**	**60%**	**240**
500	**48**	**52%**	**260**
200	**12**	**88%**	**176**
50	**1**	**99%**	**50**
20,000	**97**	**3%**	**600**

Effect of Qb on Kd

300 ➲ 600 ml/min

Qb *ml/min*	*Kd* *ml/min*
300	214
600	270
%Δ	%Δ
100%	27%


a
Dialysate flow = 500 mL/min
in vitro
KoA
1600
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
K (Clearance, mL/min)
320
300
280
260
240
220
200
180
160
140
120
100
200
250
300
350
400
450
500
Whole blood flow rate (mL/min)

What is the K_0A

- K_0 = urea permeability coefficient
  A = membrane surface area
  $K_0 \cdot A = K_0A$
- K_0A = Maximum possible clearance at infinite Qb and Qd.
- Units are in ml/min (usually in vitro)
- < 600 ml/min = “Volkswagen”
- > 1200 ml/min = “Porsche”
- In vivo values may be ~30% less, and optimism varies by dialyzer company

  $K_0A = 0.574 \cdot$ manufacturer $K_0A \cdot (1+0.0549 \cdot (Qd - 500)/300)$*

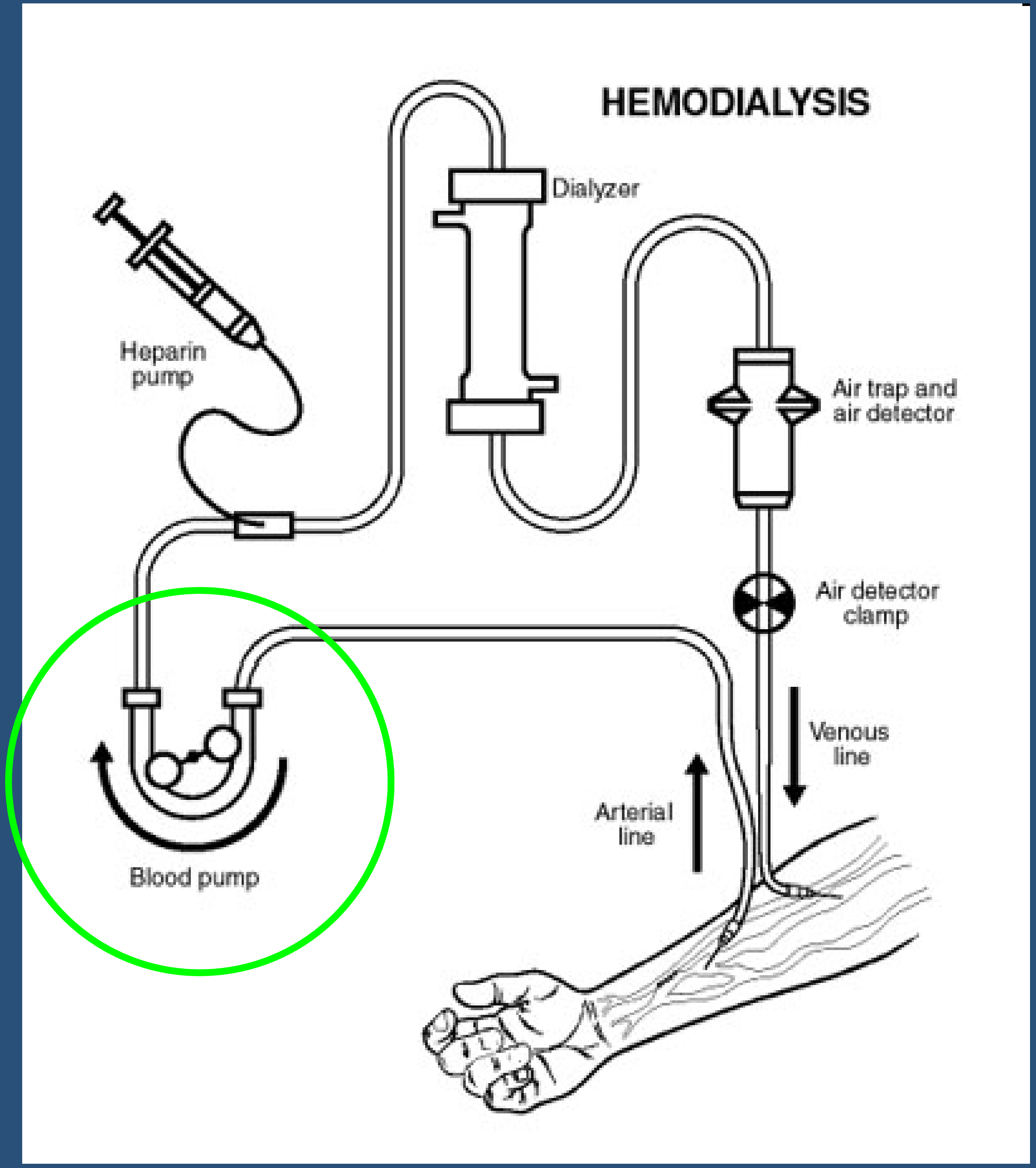
  -(updated from equation in handout. See http://www.ureakinetics.org)

K_0A values (in vitro) of some dialyzers

Dialyzer	K_0A (ml/min)
FX60	955
FX80	1292
EXELTRA-190	1233
TRICEA=110G	783
REVACLEAR	1150
REVACLEAR MAX	1450

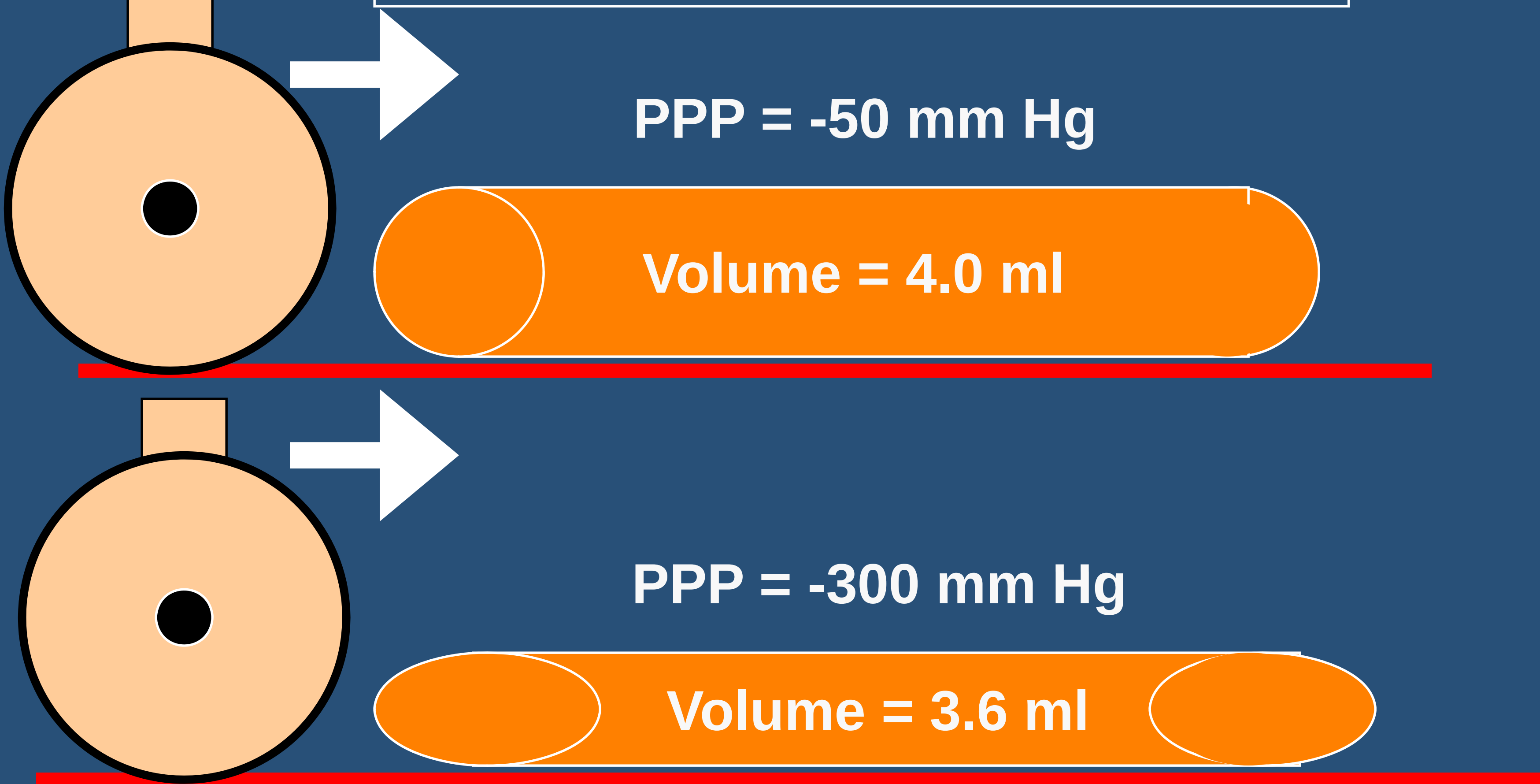
What is the “milkshake effect”

- Sound made by a blood pump that’s ready to blow
- White crud that is sometimes seen at the dialyzer header
- Compression of blood line in the roller pump at high negative pressures


HEMODIALYSIS
Dialyzer
Heparin
pump
Air trap and
air detector
Air detector
clamp
Venous
line
Arterial
line
Blood pump

Why prepump pressure (PPP) reduces blood pump stroke volume

Qb = # revolutions x stroke volume



The milkshake effect!

Effect of Qb on Kd

- Rule of thumb: For every 100 ml/min above 200, reduce Qb by 5%:

- 200 ➲ 200, - 0
- 300 ➲ 285, - 5%
- 400 ➲ 360, - 10%
- 500 ➲ 425 - 15 %

- "No longer a problem" with newer blood lines
- Some machines adjust for Qb based on prepump pressure

Effect of Qd on Clearance

Suppose you are using a dialyzer with K_0A = 1000 and Qb=400. Qd is 500. Increasing Qd to 800 will increase clearance (Kd) by what percent?

- 0%
- 5%
- 10%
- 800/500 = 60%

Effect of Qd on Kd according to the "official equations"

Qb	Qd	K_0A	Kd	
400	500	**800**	214	
400	800	**800**	235	Ratio 235/214 = 1.10
400	500	**1400**	266	
400	800	**1400**	290	Ratio 290/266 = 1.09

NEW: Increasing Qd May have ZERO benefit!

Renal Week 2010 abstract (Ward RA et al: TH-FC038)

- 28 patients, crossover study
- Qd = 600 alternating with 800 BABA ABAB
- Qb averaged 435 mL/min
- Revaclear or Revaclear MAX dialyzers:

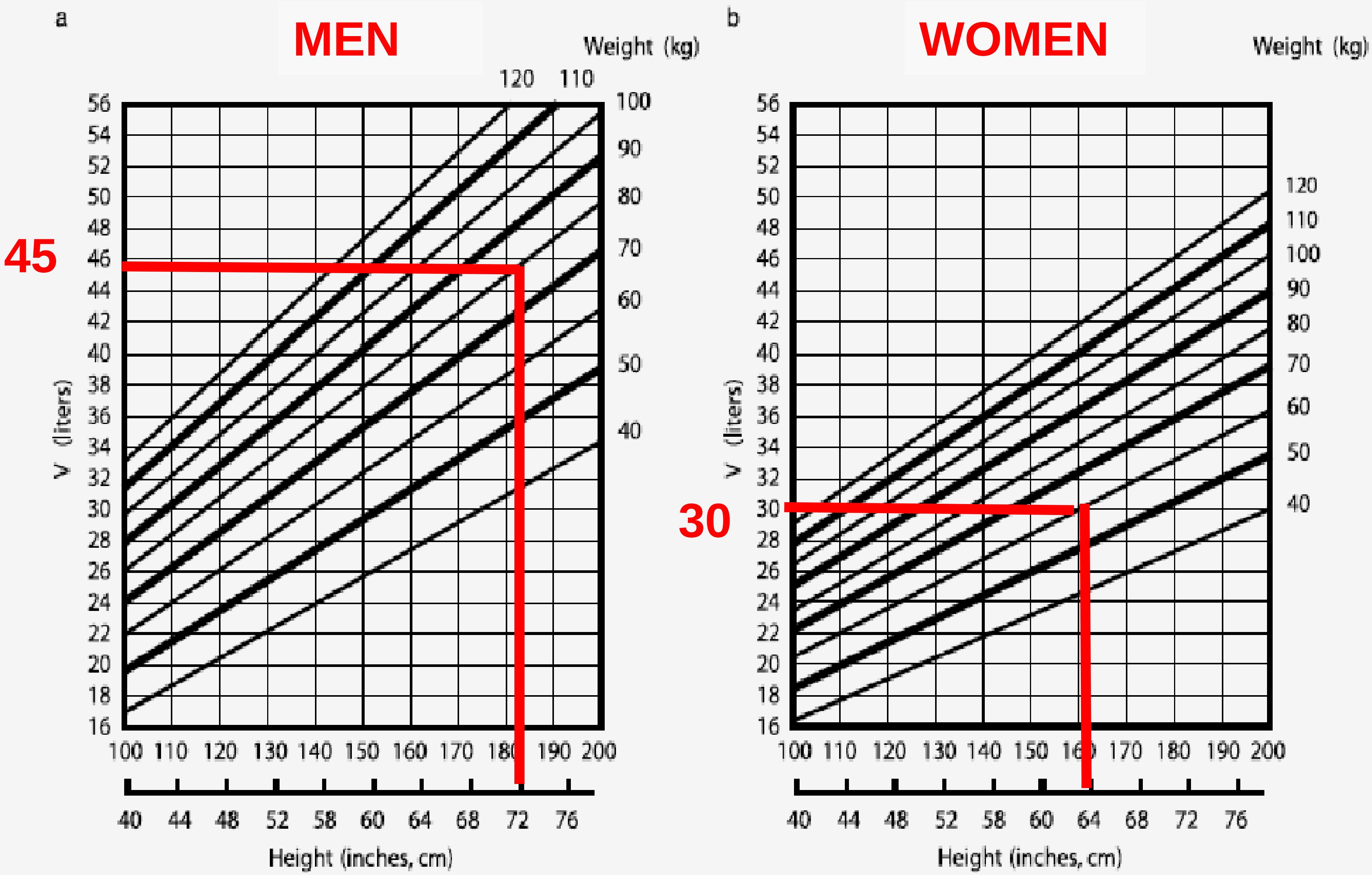
Qd (mL/min)	Kt/V	Ionic Kt/V
600	1.67 ± 0.04	1.44 ± 0.04
800	1..65 ± 0.04	1.48 ± 0.04

So, benefits of Qd USED to be true (e.g., HEMO study), but May NO LONGER be true with certain dialyzers.

What is Kt/V?

- Dimensionless ratio: Kd x t / V
  (ml/min) x (min) / ml
- Example:
  - Kd = 250 ml/min t = 180 min V = 35,000 ml
  - 250 x 180 /3500 = 1.3
- Initial dialysis prescription
  - 1) Estimate V
  - 2) Calculate K • t based on the desired Kt/V
  - 3) Calculate K and t

What is the urea distribution volume (V)?



Initial dialysis Rx - How do you prescribe a Kt/V?

- Estimate V (say it's 36 L)
- Calculate required K • t
  - Multiply the V by desired Kt/V:
    Say Kt/V target is 1.4. Then
    Kd • t = 1.4 x 36 = **50.4 L**
- Divide by K to get the required t.
  - E.g. Kd = 250,
  - t = 50400 / 250 = **202 min**

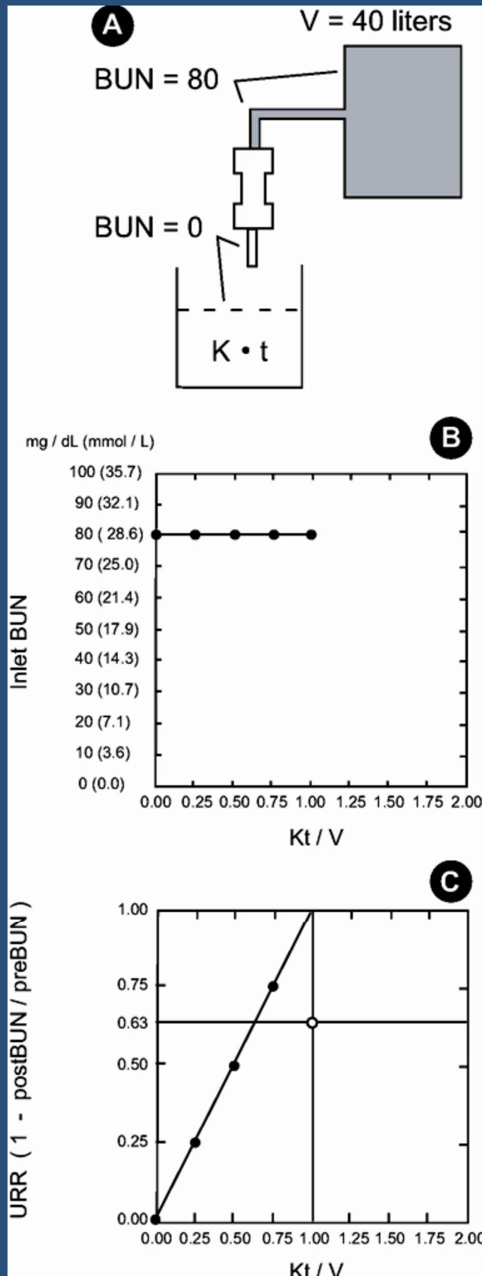
How to adjust Kt/V

- **You want to increase Kt / V by 20%**
- You can’t change V
- (K • t) must increase by 20%
- Increase TIME by 20% (and you’re done)
- Use bigger dialyzer (larger $K_0A \rightarrow \uparrow Kd$)
- Use higher blood flow rate ($\uparrow Qb \rightarrow \uparrow Kd$)
- Do a combination of the above

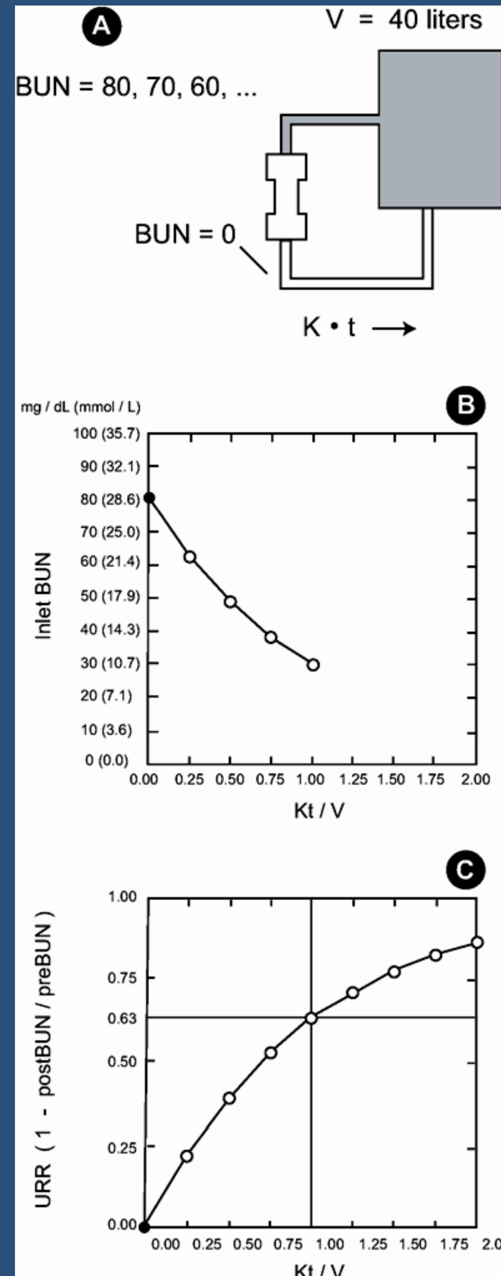
How do we monitor Kt/V ?
How is URR ↔ Kt/V ?

- URR and Kt/V are mathematically related
- This depends on urea generation, time, and UF
- During 3-4 hr. Dialysis, urea generation term is trivial.

Kt/V	URR (UF=0)	URR (UF = 4 kg, 70 kg pt)
1.2	67%	62%
1.4	72%	68%

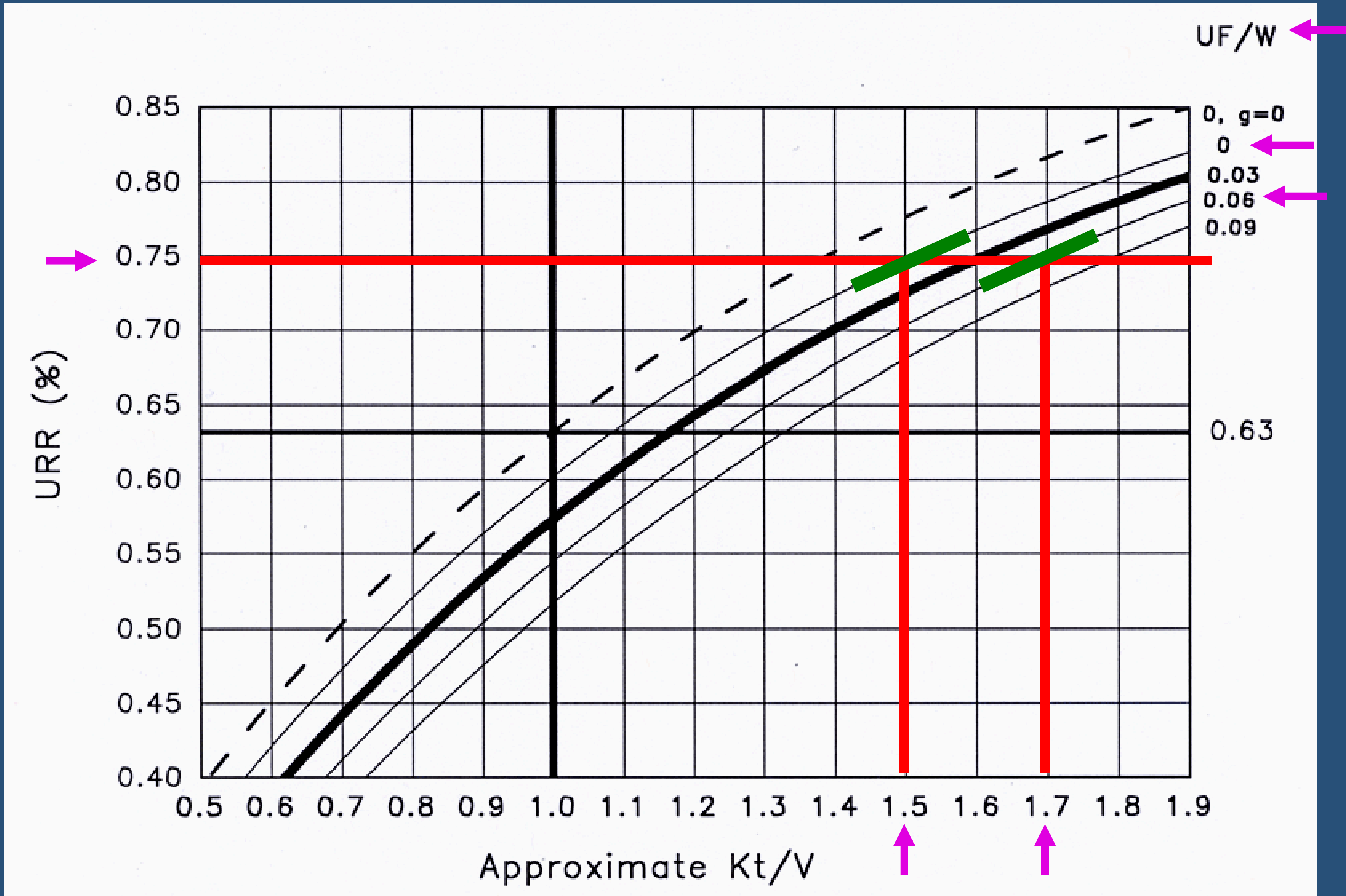


A
V = 40 liters
BUN = 80
BUN = 0
K • t
B
mg / dL (mmol / L)
Inlet BUN
Kt / V
C
URR (1 - postBUN / preBUN)
Kt / V



A
V = 40 liters
BUN = 80, 70, 60, ...
BUN = 0
K • t
B
mg / dL (mmol / L)
Inlet BUN
Kt / V
C
URR (1 - postBUN / preBUN)
Kt / V

Target URR of 75% = Kt/V of 1.5 (no UF) or 1.7 (UF/W = 6% body weight)

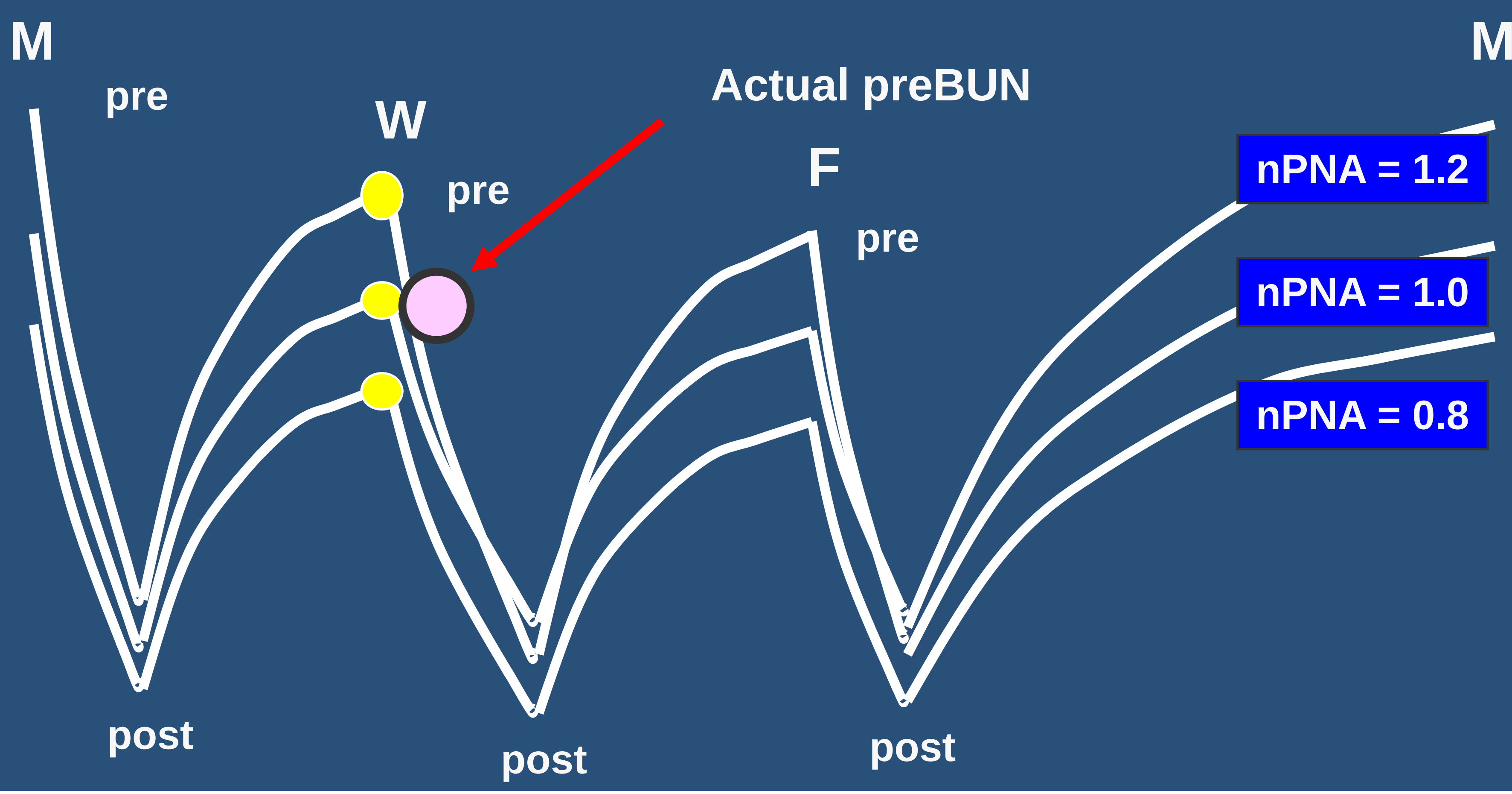


What is nPCR (nPNA) ?

- Based on urea nitrogen generation rate
- Reflects protein intake in stable patients
- Low nPNA reflects poor intake, poor outcome
- High nPNA reflects good intake, good outcome
- Desirable to keep this > 1.0 in HD patients
  (K-DOQI recommends 1.2 for HD and >1.2 for PD)

How is nPNA computed in HD?

- Depends on Pre-BUN
- Computer adjusts sawtooth profile up or down



What is the EKRU? (equivalent urea clearance)

- Think creatinine clearance!

  $K_{Cr} = UV / P$

  UV = Creatinine generation rate

  P = average plasma level

- Now think urea

  UV = G = urea generation

  P = Time-averaged urea concentration

What is the EKRU?
(equivalent urea clearance)

- Think creatinine clearance! (UV/P)
- EKRU = G / TAC
- EKRU = ~11 ml/min

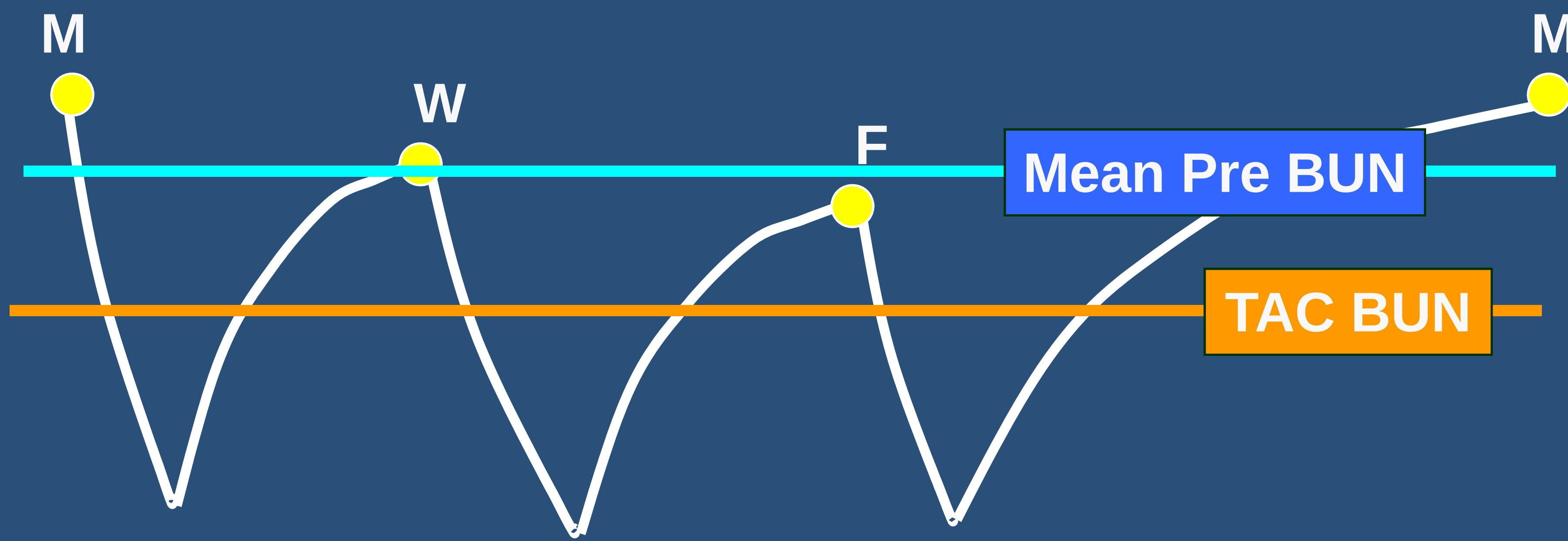
What is weekly EKRU?

- Multiply by minutes in a week (10,080) to get (K x t) per wk.
  Then divide by V
- (11 x 10,080) / 35,000 = 3.2

- 3.2 ? But…. In PD it's 2.0 !

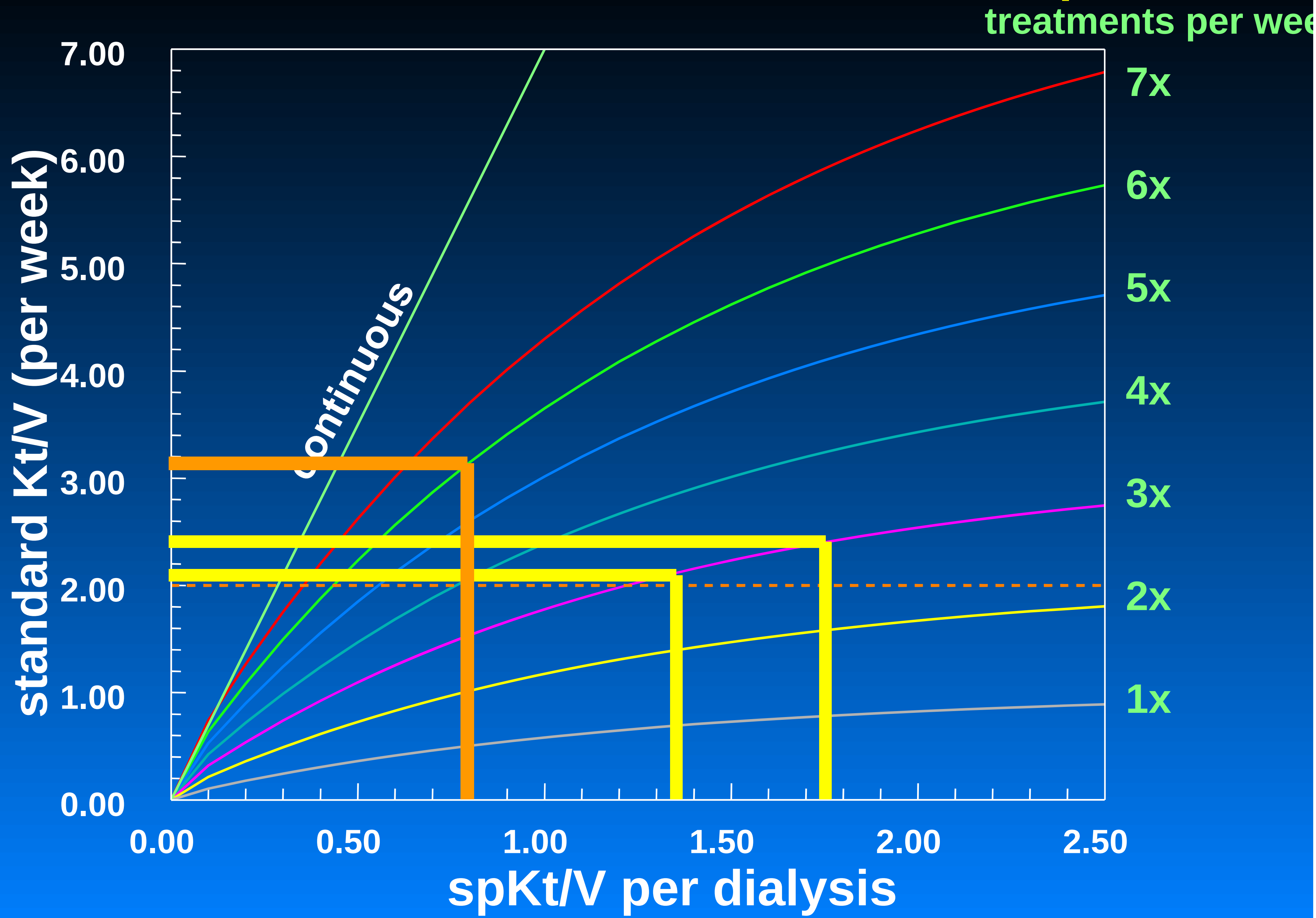
What is “standard” Kt/V ?

- Devised by Gotch to make HD and PD match:

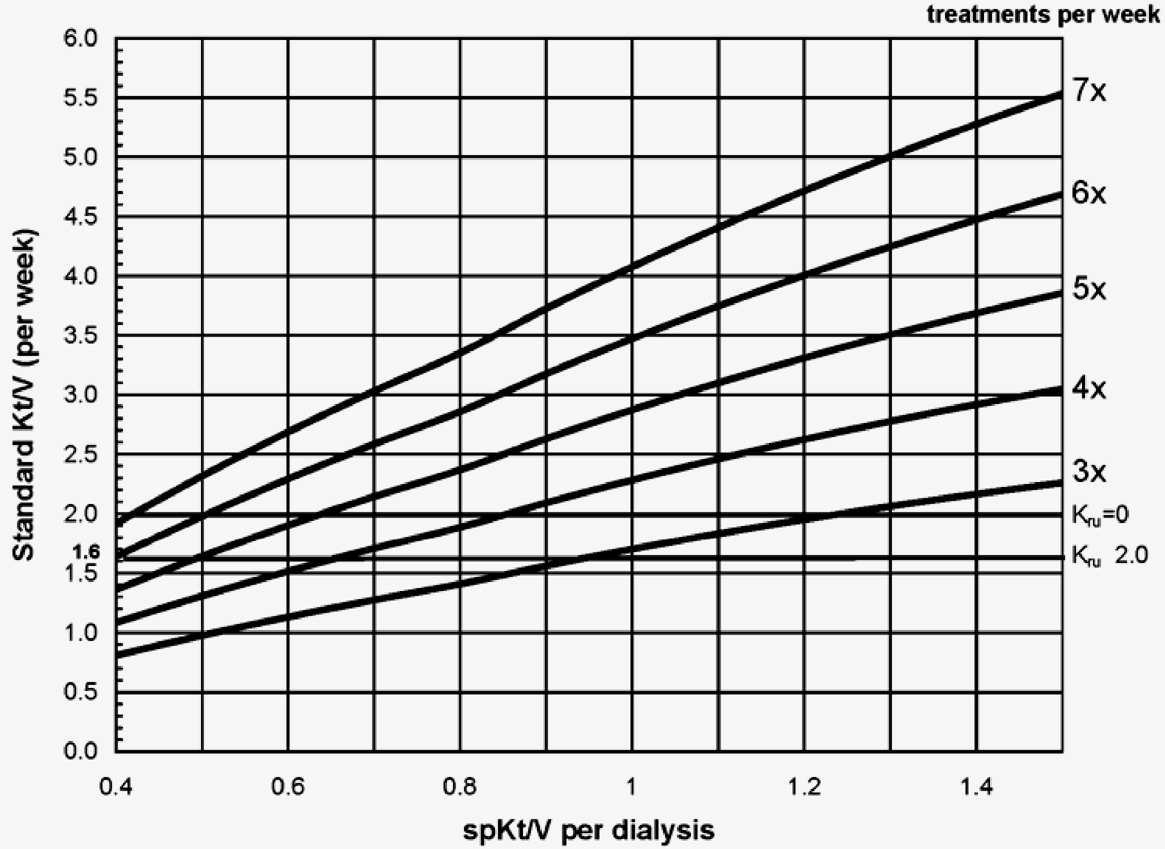


- **Divide g by <u>Mean PreBUN</u> instead of by <u>TAC-BUN</u>**
- **resulting “EKRU” and weekly Kt/V about 1/3 lower**

Standard Kt/V: a continuous clearance equivalent



Standard Kt/V: a continuous clearance equivalent



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HDCN (Hypertension, Dialysis, and Clinical Nephrology, http://www.hdcn.com)

UREAKINETICS.ORG

DIALYSIS ADEQUACY TOOLS AND CALCULATORS

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LATEST DEVELOPMENTS

2009/10/29 Preliminary version of website launched.

Site Login = "solute" and password = "solver"
Note: The calculator and forum are password protected to prevent indexing since we are still modifying many features on the forum and site. Please enter "solute" without the quotation marks for username and "solver" for password to access the calculators. You may need to input these a second time to access the forum.

Calculators

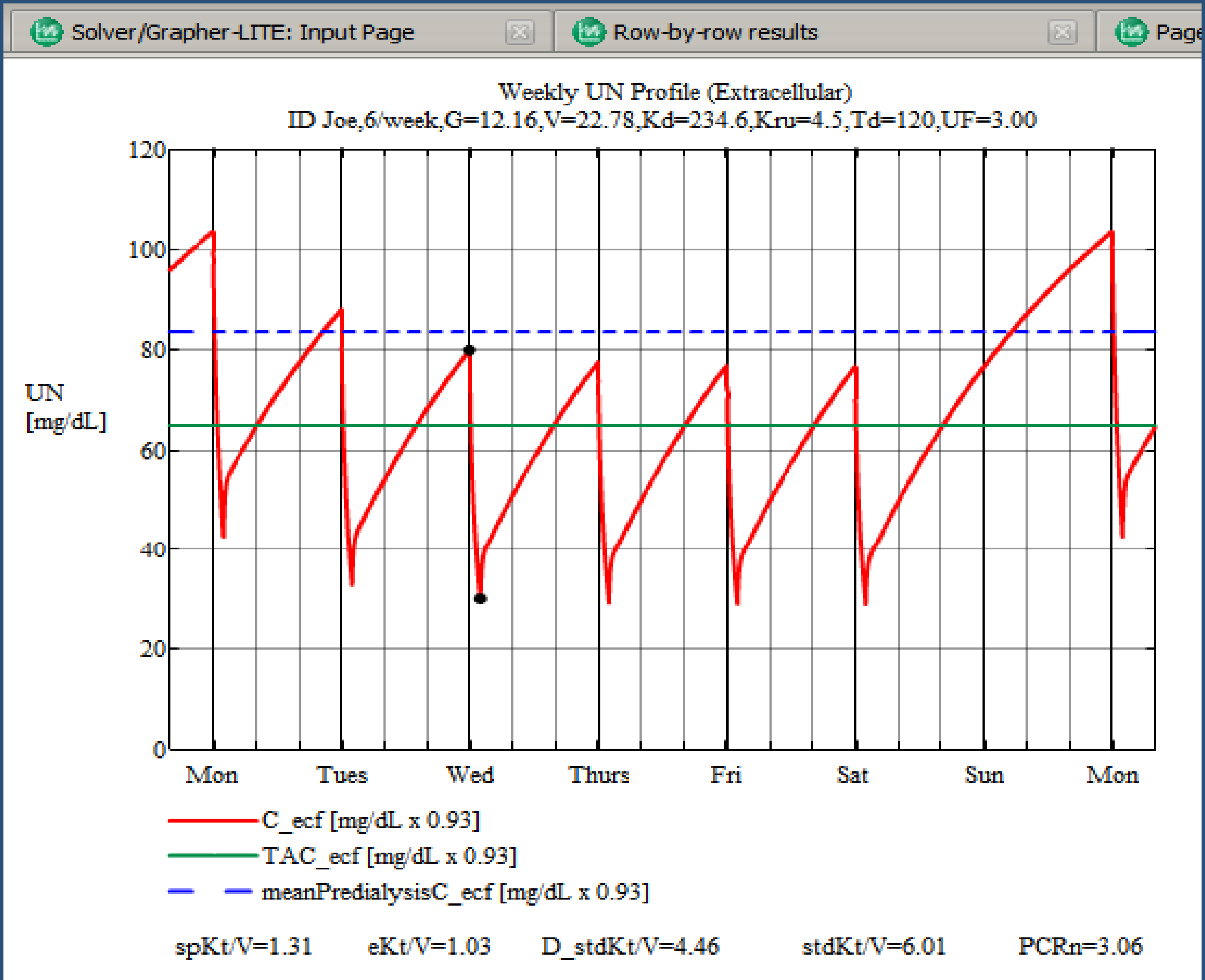
1. Solute-Solver
Input pre and post BUN, solve for V, eKt/V, stdKt/V and SAN-stdKt/V. Program is contained within a single file.

2. Solute-Grapher
Same as solute solver, but graphs the weekly BUN profile. Requires 3 files.

3. Solver-Lite
Good place to start. Only 12 inputs. Uses mg/dL only, no anthropometrics, no hemodiafiltration option nor special modes.

4. What's the K_0A?
Input clearance values from a dialyzer spec sheet and get the K0A.

SoluteSolver output results



What have you learned?

- I hate urea modeling
- I hate dialysis
- What did he say?
- What’s for lunch?