Intensive Care Unit Renal Support: In Search of New Directions

Balazs Szamosfalvi, MD

Monday, 08/30/2011 11:45-12:15

Presenter Disclosure Information

I will discuss off label (US/FDA) use and/or investigational use of citrate solutions for regional anticoagulation during renal replacement therapy in my presentation.

I have financial relationships to disclose:

Employee of: Henry Ford Health System, Detroit, MI

Consultant for: Baxter, Inc

Stockholder in:

Research support from: Fresenius-NA, Cytopherx, Inc (formerly Nephrion)

Honoraria from:

Patent: Automated RCA Systems

Objectives

1. Introduce ICU continuous renal replacement therapy (CRRT) equipment and terminology

2. Summarize current recommendations and future directions after the ATN and RENAL trials

3. Present our novel CRRT program integrating regional citrate anticoagulation (RCA) and 24-hour sustained low efficiency dialysis (SLED) with computerized prescription generation and internet-based telemetry

Select CRRT Machines in the USA

Scale-based effluent balancing

1. Gambro Prismaflex

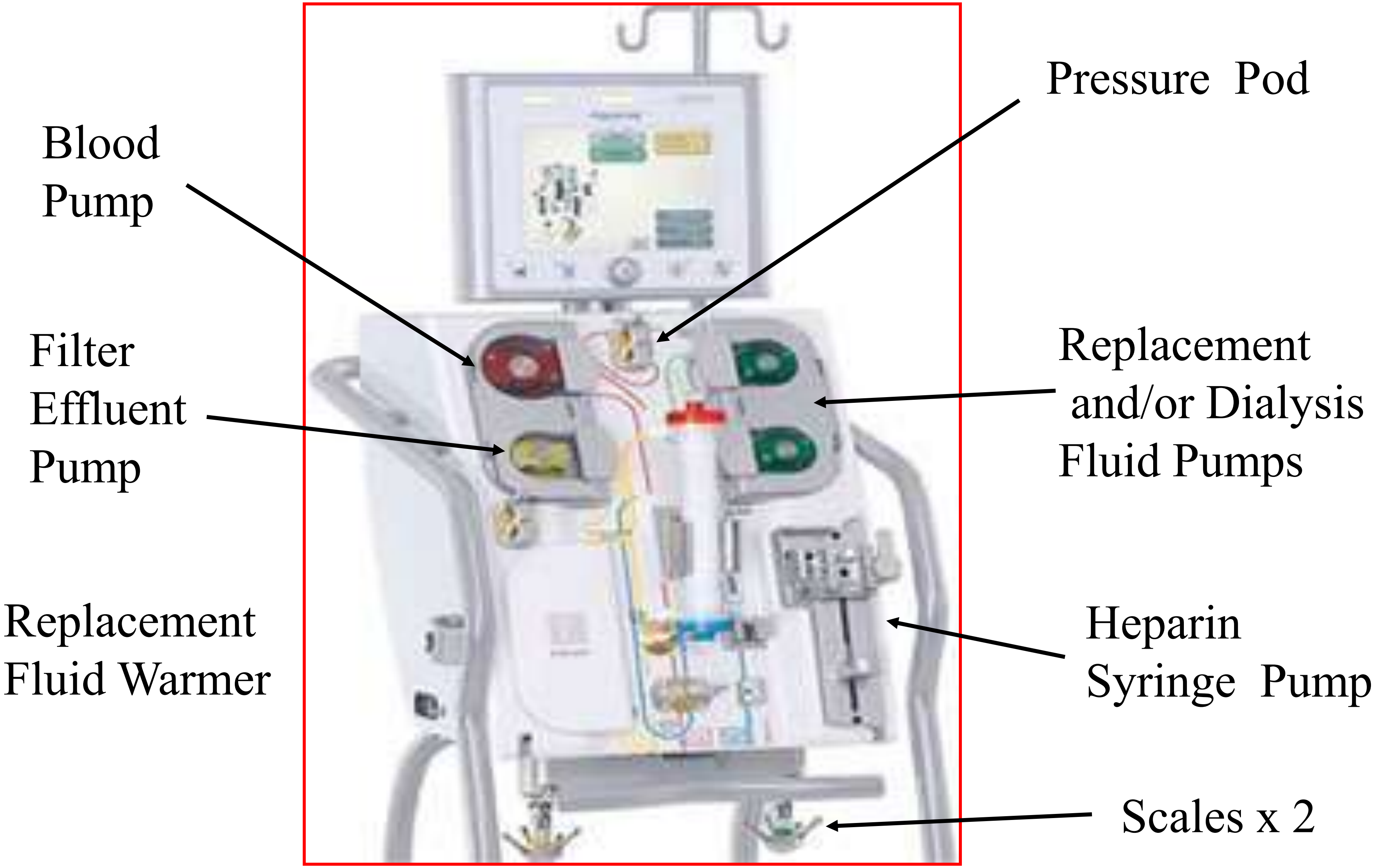
Scale-based effluent balancing

2. Braun Diapact

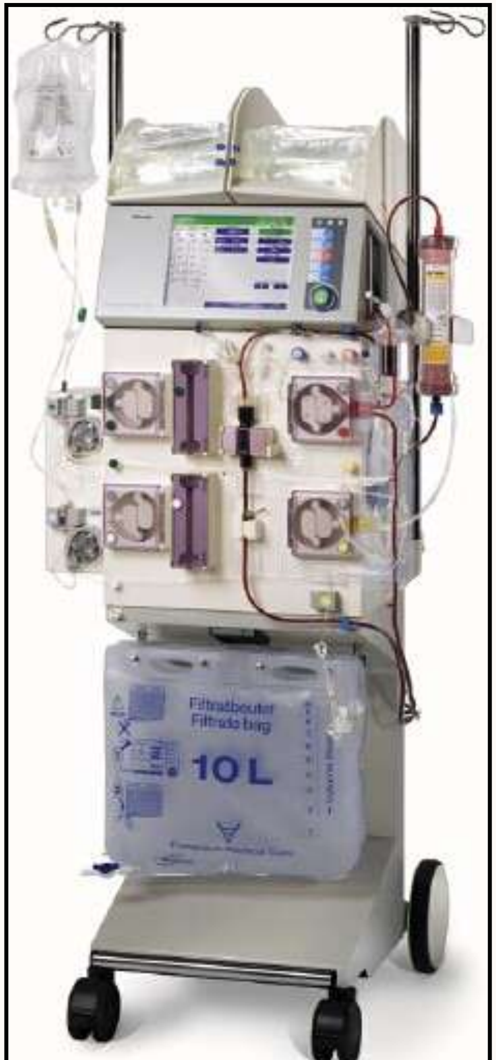
Sterile effluent balancing chamber

3. NxStage System One

CRRT Machine: Basic Layout



CRRT Device in Europe



Fresenius Multifiltrate™ CRRT System —
Integrated Citrate & Calcium Pumps

Continuous Renal Replacement Therapy (CRRT): Modalities

1. Continuous Arterio-Venous Hemofiltration: CAVH

   The earliest form of CRRT, it used arterial blood pressure to drive blood flow and ultrafiltration in the circuit

2. Continuous Veno-Venous Hemofiltration: CVVH

   It replaced CAVH with a blood pump added to the circuit;

   Pre-dilution CVVH: Replacement fluid infused pre-filter

   Post-dilution CVVH: Replacement fluid infused post-filter

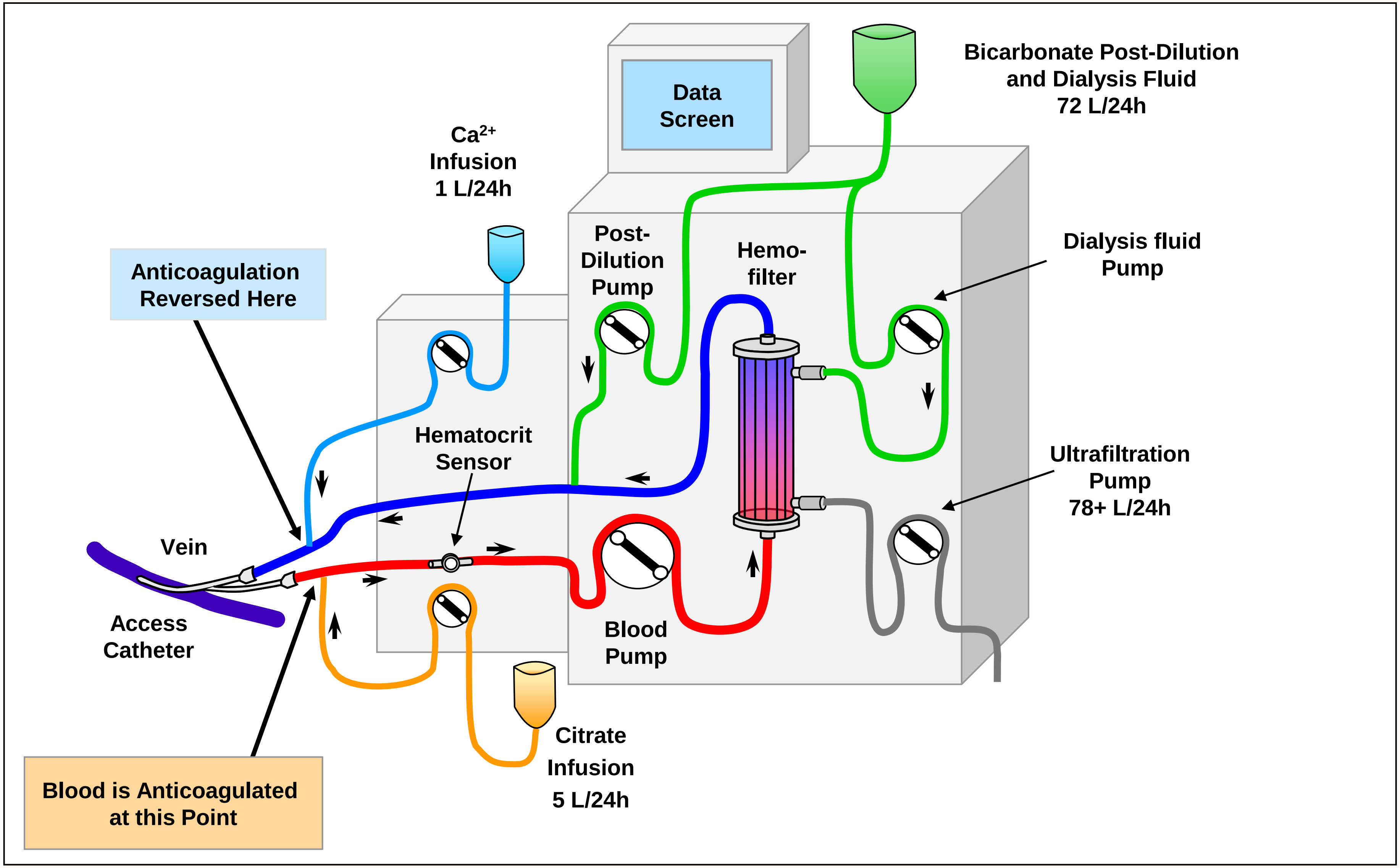
3. Continuous Veno-Venous Hemodialysis: CVVHD

   Uses counter-current dialysis for solute removal; it is being replaced by less expensive sustained low efficiency dialysis (SLED) using online generated dialysis fluid

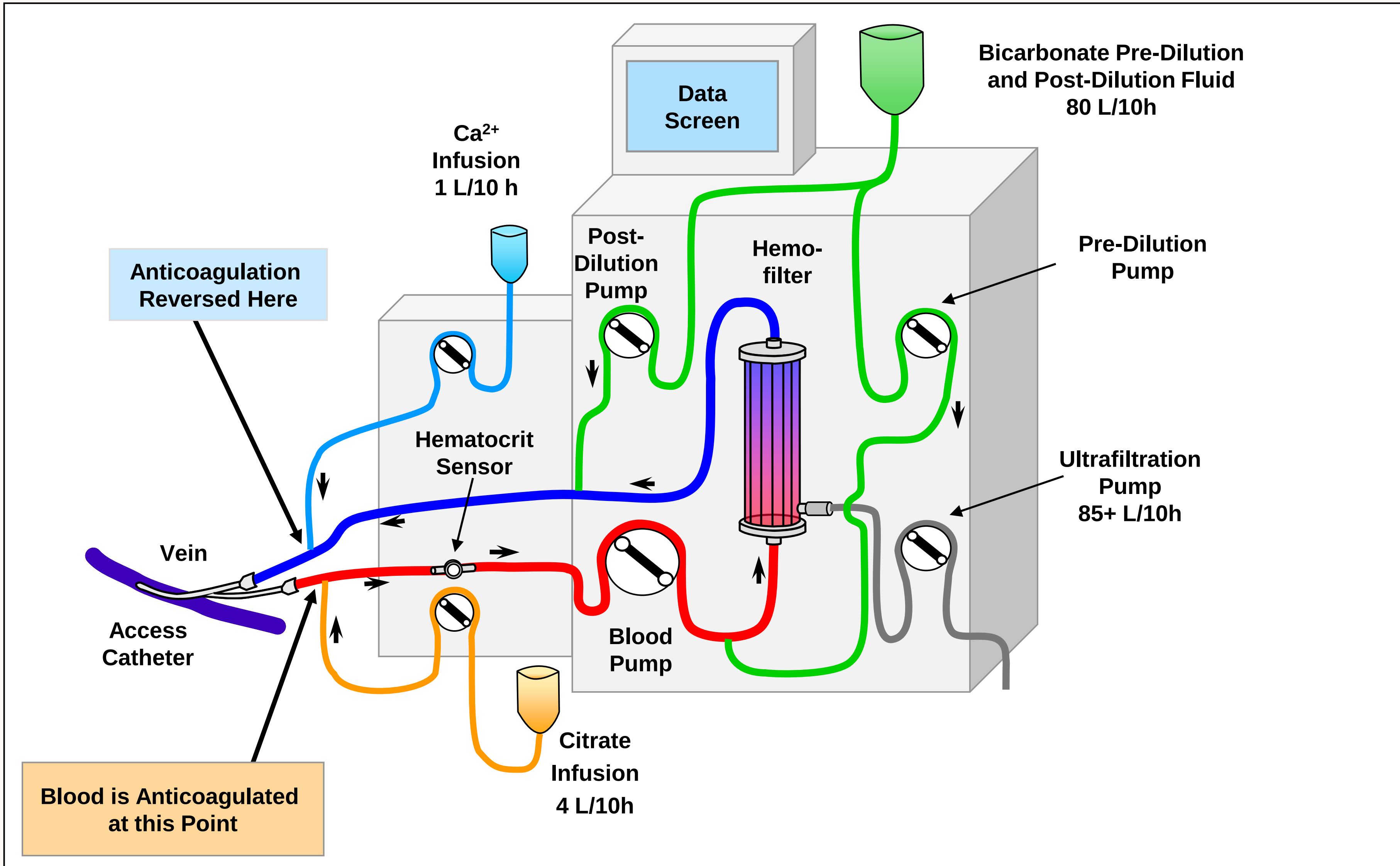
4. Continuous Veno-Venous Hemodiafiltration: CVVHDF

   The combination of CVVH and CVVHD on a single filter

RCA for 24-hour Post-Dilution CVVHDF



RCA for Simultaneous Pre-and Post-Dilution High Volume Hemofiltration for SIRS



The ATN Study (2008)

1. Significance
   - Large, randomized clinical outcomes study for intensity of CRTT and intermittent HD in acute renal failure
   - Compared CRRT with 20 ml/kg/h versus 35 ml/kg/h filter effluent flow rate
   - Compared intermittent HD 1.2-1.4 single-pool urea Kt/V per session 3x/week versus 6x/week
2. Conclusions[1]
   - “Intensive renal support in critically ill patients with acute kidney injury did not decrease mortality, improve recovery of kidney function, or reduce the rate of non-renal organ failure as compared with less-intensive therapy involving a defined dose of intermittent hemodialysis three times per week and continuous renal-replacement therapy at 20 ml per kilogram per hour.”

1. Palevsky P et al: Intensity of Renal Support in Critically Ill Patients with Acute Kidney Injury; N Engl J Med 2008;359:7-20.

The RENAL Study (2009)

1. Significance
   - Large, multicenter, randomized clinical study of the intensity of CRRT in acute kidney injury for 90-day mortality endpoint
   - Compared CRRT with 25 ml/kg/hour versus 40 ml/kg/hour filter effluent flow rate

2. Conclusions[1]
   - "In critically ill patients with acute kidney injury, treatment with higher-intensity continuous renal-replacement therapy did not reduce mortality at 90 days."

1. Bellomo R et al: Intensity of Continuous Renal-Replacement Therapy in Critically Ill Patients; N Engl J Med 2009;361:1627-38.

ICU Renal Support 2011

- Prescribe 25-30 ml/kg/h filter effluent rate
- 24-hour continuous therapy with early start
- Regional citrate anticoagulation[1,2]
- (?) Plasma adsorption: protein-bound toxin, cytokine and endotoxin removal; liver support[3,4]
- (?) Selective cytopheretic device: ameliorate severe inflammatory response syndrome[5]
- (?)Online measured small solute clearance: for dosing of dialysis and medications

1. Davenport A et al, Citrate anticoagulation…; NDT Plus (2009) 2: 439–447
2. Oudemans-van Straaten HM, Citrate Anticoagulation…; Blood Purif 2010;29:191-196
3. Cruz DN et al, Early Use of Polymyxin B Hemoperfusion…; JAMA. 2009;301(23):2445-2452
4. Intermittent Modular Plasma Adsorption of Cytokines and Toxins (IMPACT); Minntech Corp.
5. Humes HD et al, A Selective Cytopheretic Inhibitory Device… Blood Purif 2010;29:183-190

What is the biggest disadvantage of traditional CRRT?

Problems with traditional CRRT

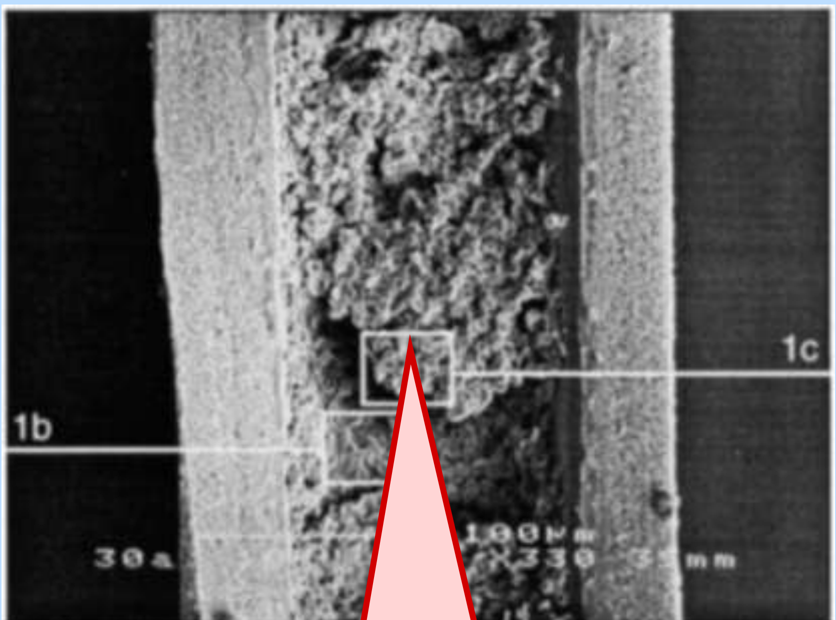
1. Cumbersome despite improved machines:
   - Scale-based balancing of > 50 liters effluent
   - Frequent clotting complications
   - Cannot use fistula or graft access
2. Very expensive compared to dialysis:
   - Custom blood circuits and filters
   - Pre-packaged replacement fluid
   - Nurse time if 1:1 nurse: patient ratio is needed
3. Lack of consensus on best approach:
   - CVVH versus CVVHDF versus CVVHD
   - Optimal replacement fluid compositions
   - Optimal anticoagulation strategy

Principles of Our Near-Automated 24-hour SLED-RCA Protocol

Heparin versus Citrate

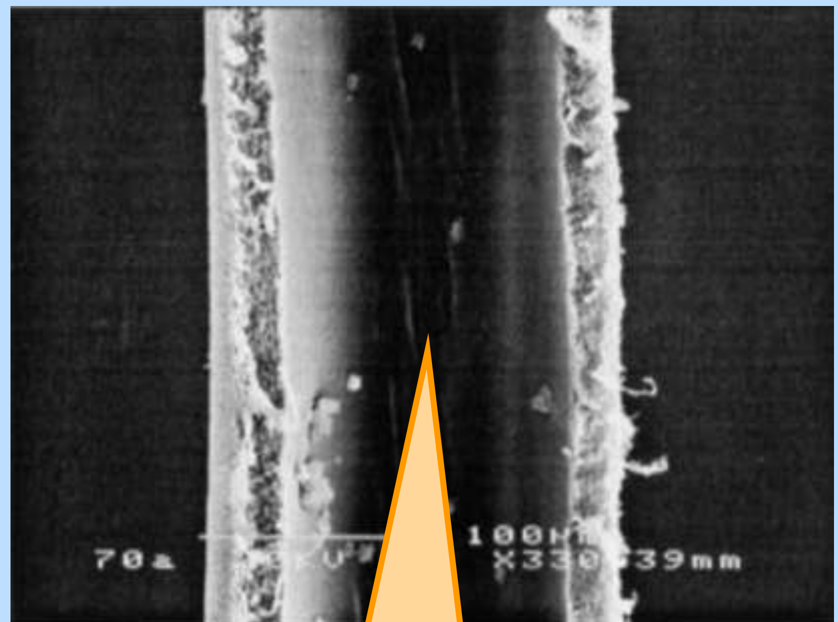
Scanning Electron Micrograph
Polysulfone Dialyzer Hollow Fiber

Heparin



Clotted Fiber

Citrate



Clean Fiber

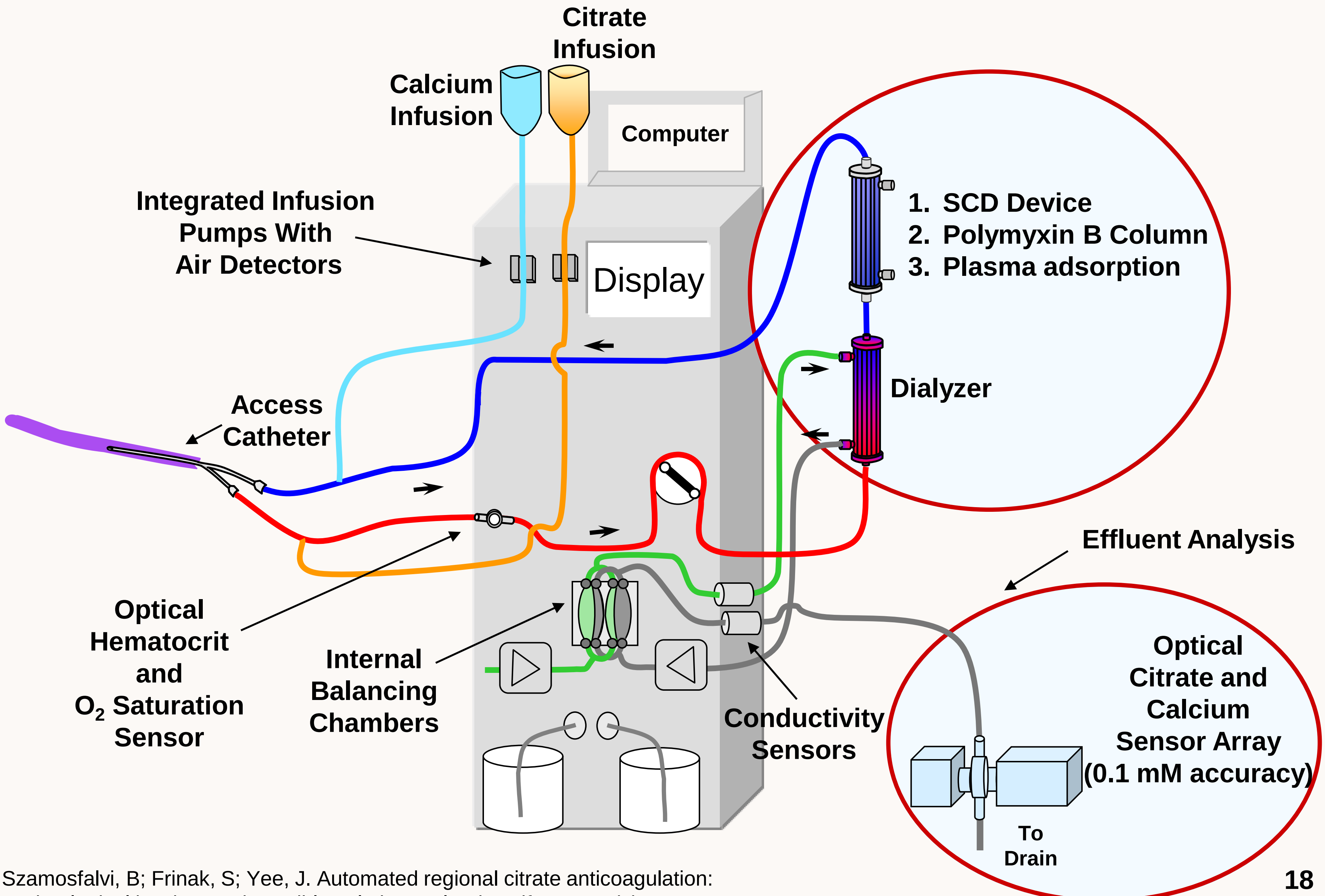
Hofbauer et al: Effect of anticoagulation on blood membrane interactions during dialysis; Kidney Int, Vol 56 (1999): pp 1578-1583

HFH Cost of 72 hours of CRRT ($)

	Traditional CRRT	24-hour SLED-RCA
Filter & Tubing	$300 (2 x $150)	$45 (1.5 x $30)
Fluid/Dialysate	$1000 (200L x $5)	$50
Citrate/Ca +Lab	$0	$150 (3 x $50)
Total Cost 72 h	$1300	$245
Daily Savings	NA	≈ $350/day/pt

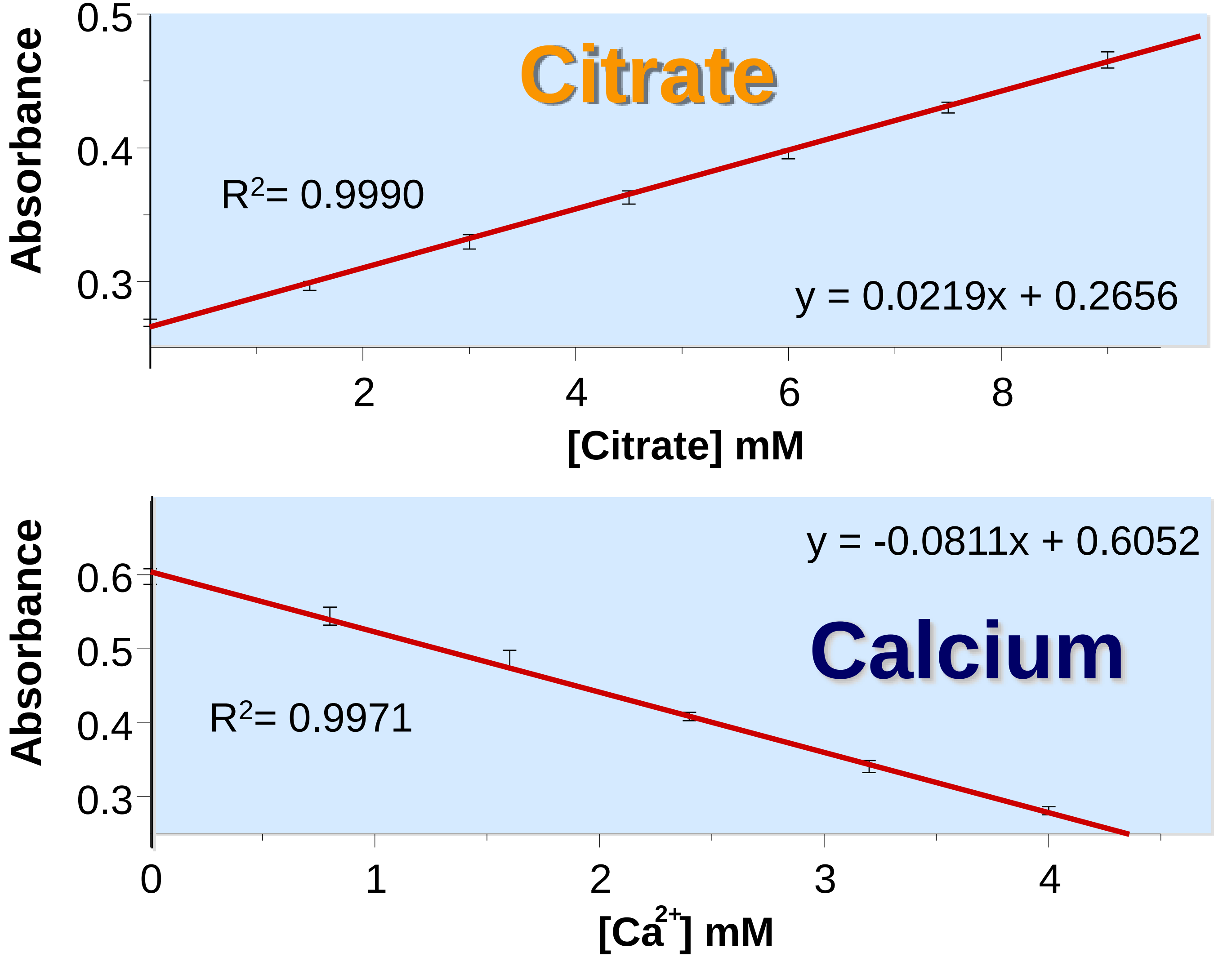
Savings due to alarm-free SLED-RCA with reduced CRRT technician and ICU nurse staffing costs are not considered

Dialysis with Automated RCA: QB 20-300 ml/min



Szamosfalvi, B; Frinak, S; Yee, J. Automated regional citrate anticoagulation: technological barriers and possible solutions. Blood Purif 2010;29(2): 204-9

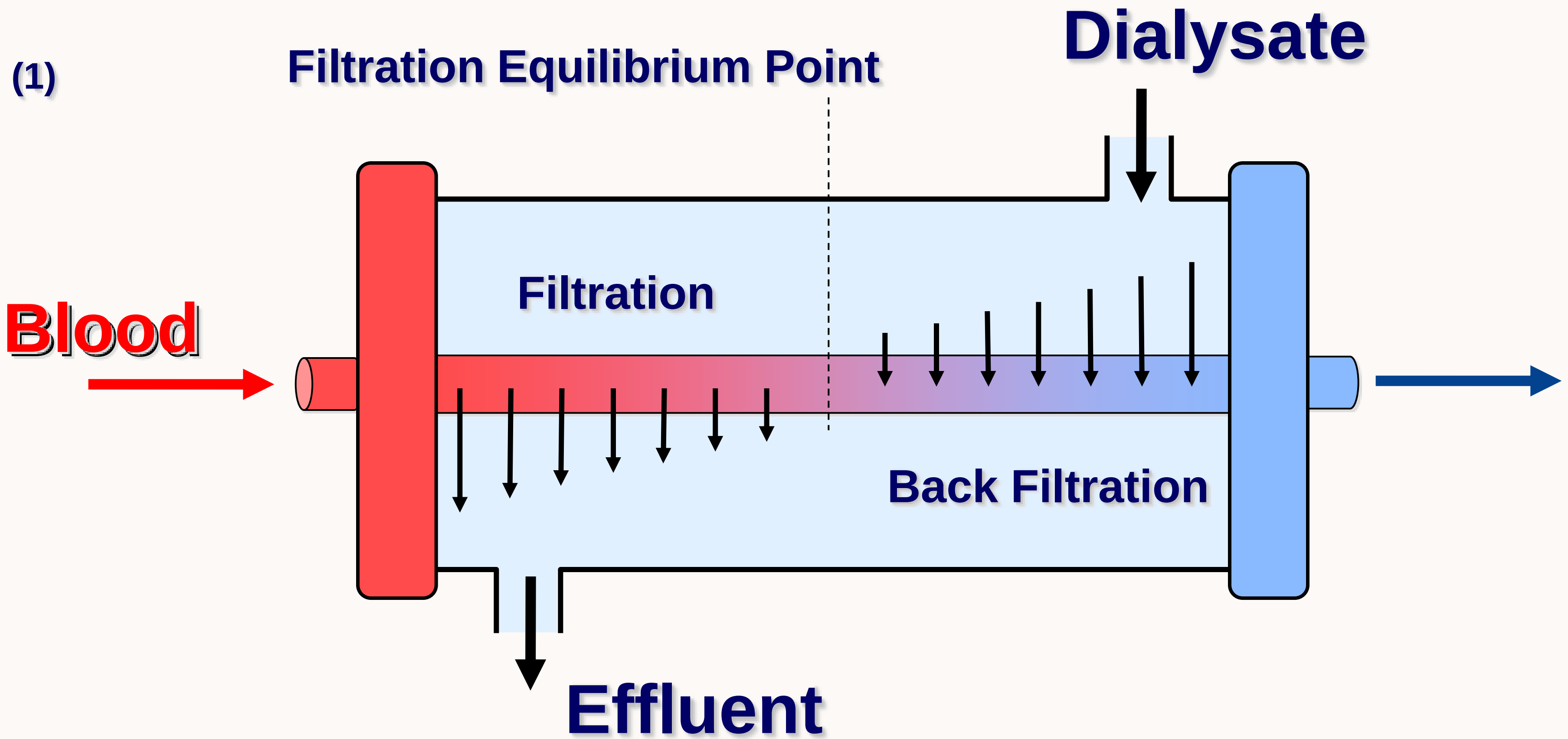
Online Effluent Citrate- and Calcium Sensor



Adapted from Yang, Y. J., B. Szamosfalvi, J. Yee, S. Frinak and E. V. Anslyn (2011). "Development of an online citrate/Ca2+ sensing system for dialysis." Analyst 136(2): 317-320

New Dialyzer Designs Provide 24-hour SLED with the Middle-Molecule Transport Properties of CVVHDF

2011: Internal Convection, Large Filters



Middle-molecule clearance equal or greater in CVVHD than CVVH[2]

1. Adapted from Depner T and Garred L: Solute transport mechanisms in dialysis; in Replacement of Renal Function by Dialysis, 5th edition; p85
2. Messer, J et al. Middle-Molecule Clearance in CRRT: In Vitro Convection, Diffusion and Dialyzer Area. ASAIO Journal 2009; 55:224-226

ICU Extracorporeal Support 2011 → Future

Near-automated RCA, reduced WBC, PLT and complement activation

Computerized SLED prescribing & telemetry monitoring

Ultrafiltration: blood volume and central venous O_2 saturation monitoring

Antibiotic dosing: according to online measured clearance

Biocompatibility: lower blood flow, ultrapure dialysate, no glucose degradation products

Columns for removal of endotoxin, cytokines, inflammatory cells, protein-bound toxins

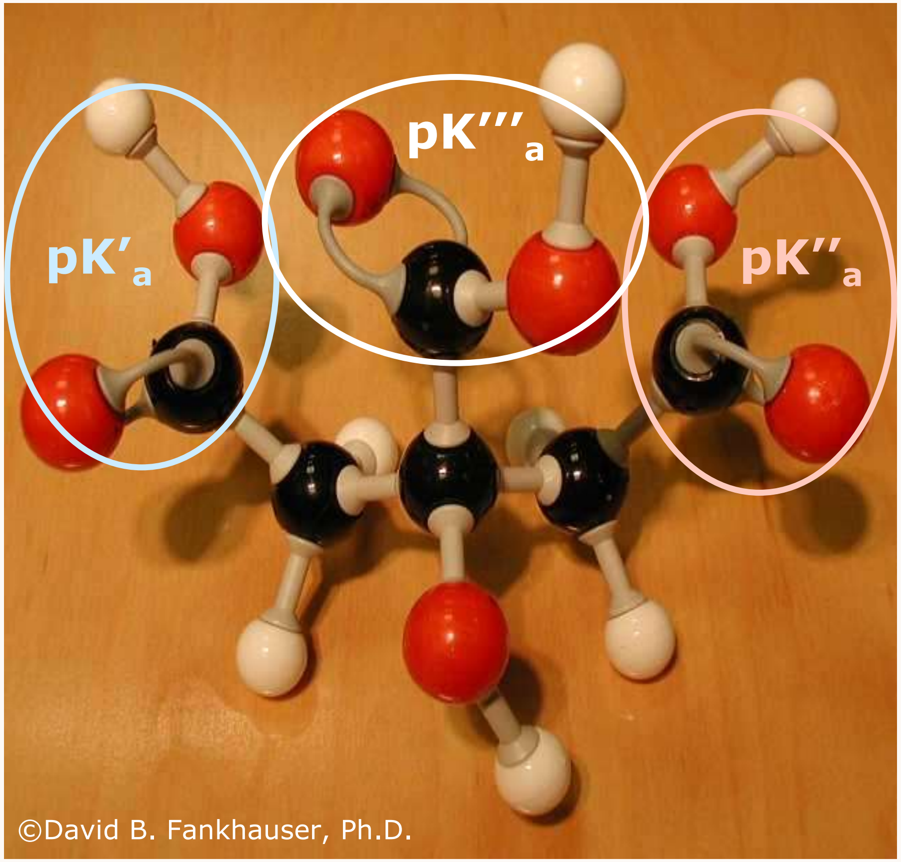
FOCUS: EASE OF USE + <u>LOW COST</u> FOR EARLY START CRRT

OUTCOME:

? Improved Survival & Renal Recovery

<u>Reduced Complications & Cost</u>

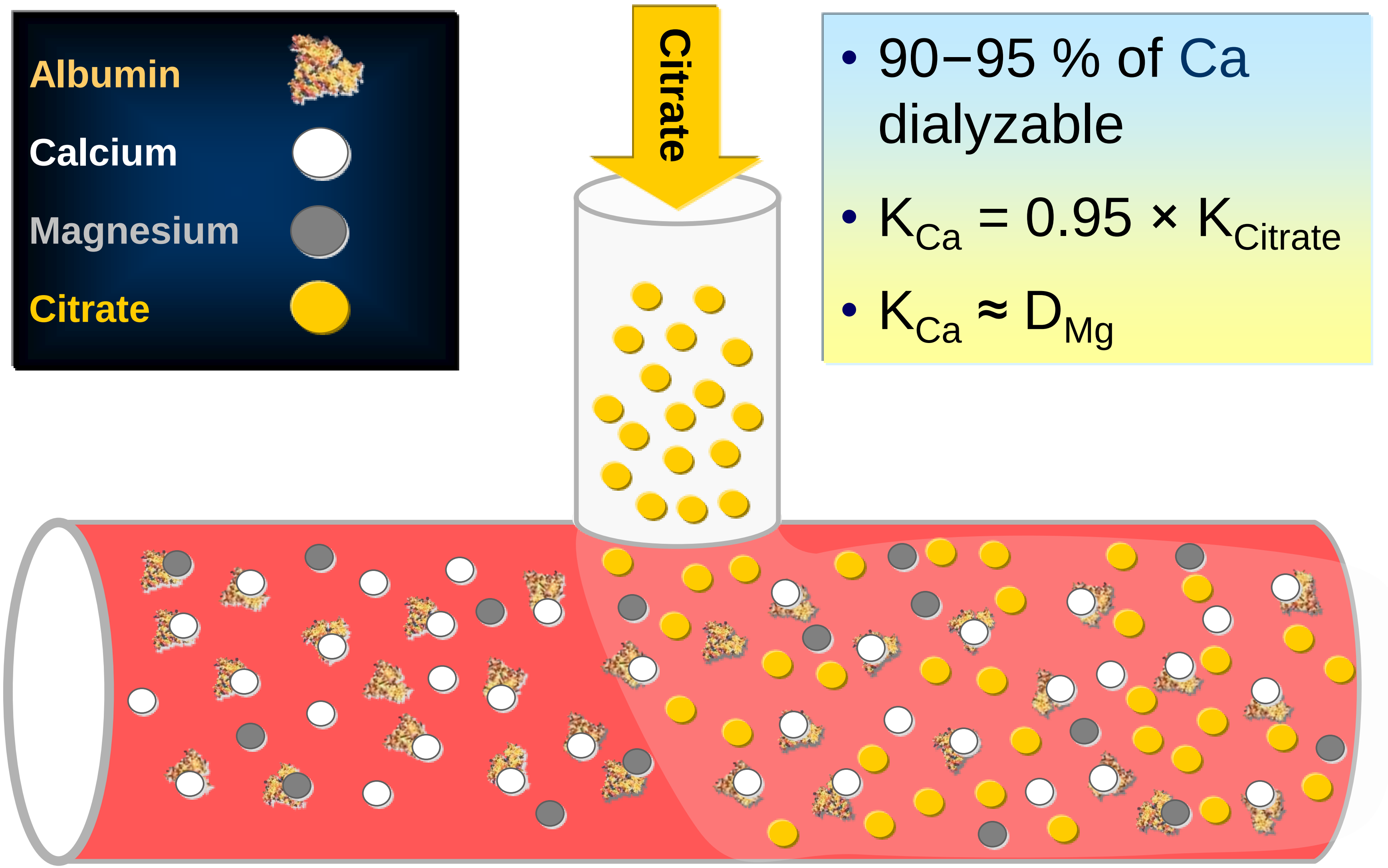
Citric Acid / Citrate
Fundamental Properties



- Only citrate^{3-} in plasma
- Molecular weights:
  - Citrate^{3-} 189 Da
  - Ca-Citrate^{-} 229 Da
- No RBC entry
- Metabolized to HCO_3^-
- Anti-inflammatory: blocks WBC, PLT and complement activation

Walser M, J Clin Invest. 1961 April; 40(4): 723–730
Whitfield LR et al, Thrombosis Research 1981; 21: 681-684
Crismon et al, J Appl Physiol 1961; 16(6):1103-1108
Janssen et al, Blood Purif 1994; 12:308-316

Citrate Effects on Plasma



- 90–95 % of Ca dialyzable
- $K_{Ca} = 0.95 \times K_{Citrate}$
- $K_{Ca} \approx D_{Mg}$

Commercial Citrate Solutions

ACD-A Solution

Na^+	225 mM
$Citrate^{3-}$	75 mM
Citric acid	38 mM
Dextrose	124 mM

4%-TSC Solution

Na^+	408 mM
$Citrate^{3-}$	136 mM
Citric acid	0 mM
Dextrose	0 mM

ACD-A — Acid

- **Used most often**
- **Provides acidic circuit pH**
- **Plasma $\Delta Na^+ \approx +3$ mEq**
- **Plasma $\Delta HCO3^- \approx -3$ mEq**

4%-TSC — Basic

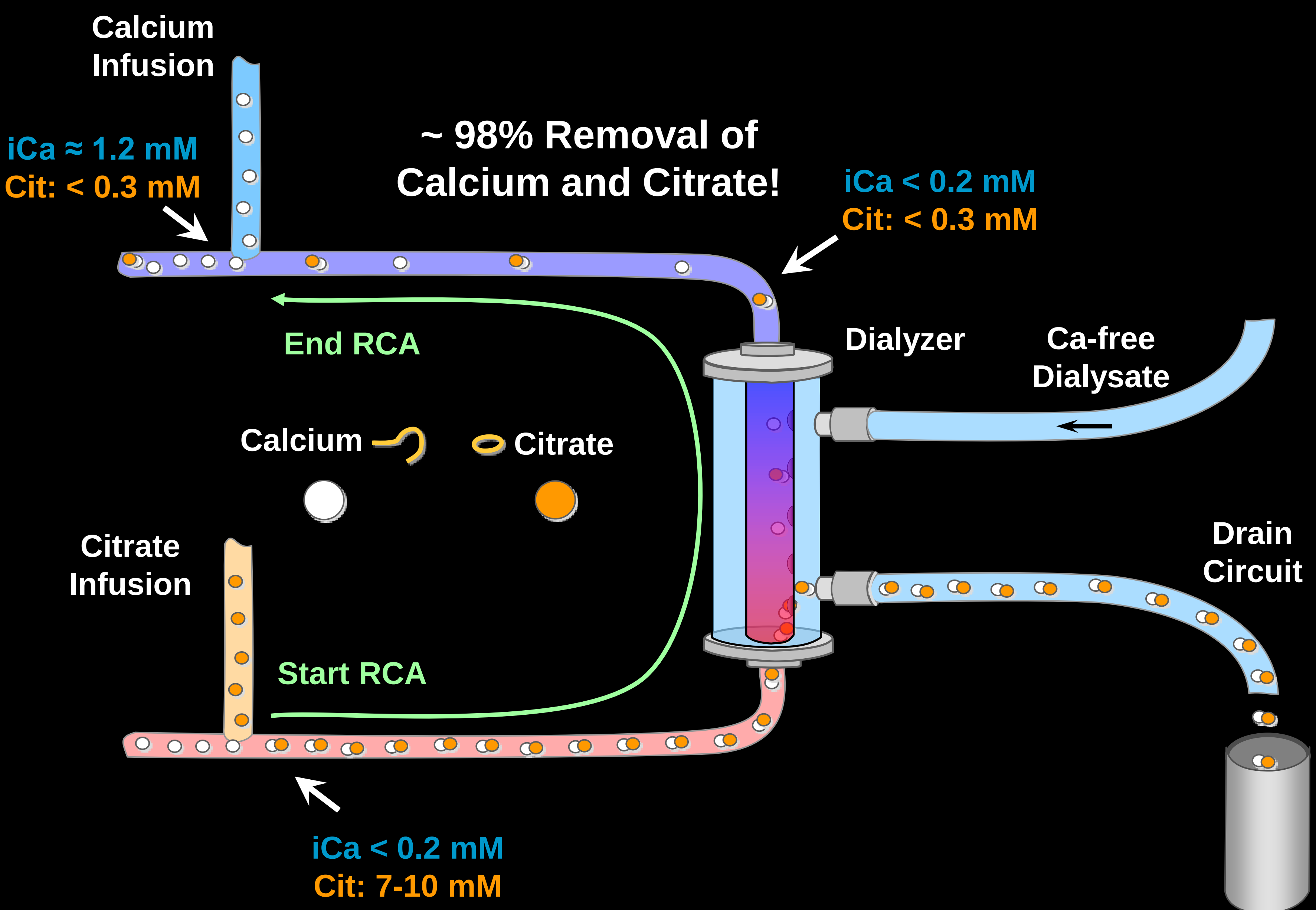
- **Used rarely, briefly**
- **Acidemic patients (pH <7.1 or HCO_3^- <10)**
- **Plasma $\Delta Na^+ \approx +9$ mEq**
- **Plasma $\Delta HCO3^- \approx 0$ mEq**

Qcit (ml/h) = 2 x QB (ml/min) for 4%-TSC

Qcit (ml/h) = 2.5 x QB (ml/min) for ACD-A

(Ex: Q_B 100 ml/min $\longrightarrow$ Q_{cit} 200 ml/h if 4%-TSC is used)

"Truly Regional" Citrate Anticoagulation

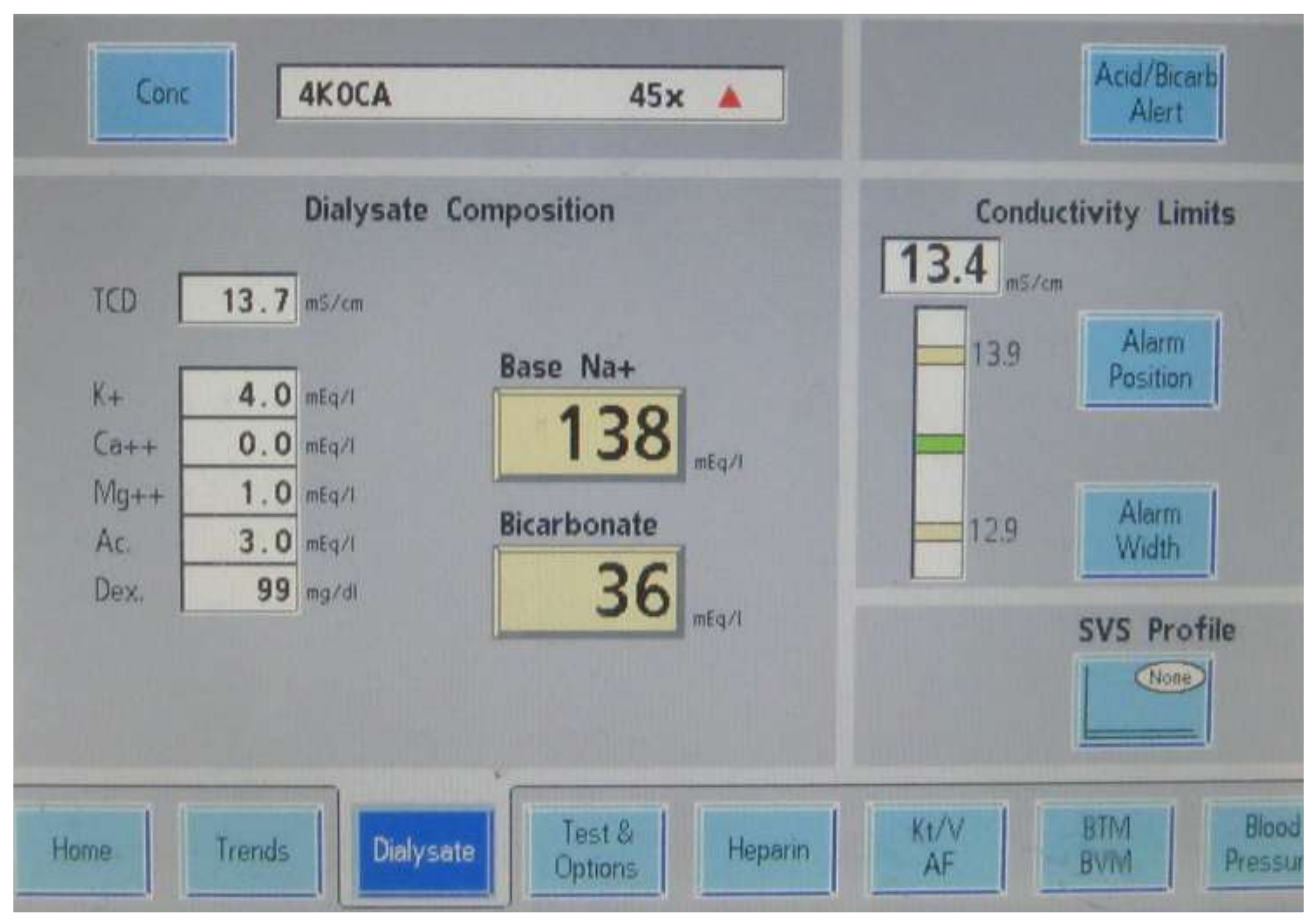


Online-Generated Dialysate

Na^+	**140 (130-150)**	**mM**
K^+	1, 2, 3 or **4**	mM
HCO_3^-	**32 (20-40)**	**mM**
Mg^{2+}	0.5	mM
Cl^-	108	mM
Phosphate	**1.0**	**mM**
Acetate	4	mM
Dextrose	5.5	mM

- High Mg^{2+}; IV Mg^{2+} supplementation not required
- Contains P; IV phosphate supplementation not required

Flexible Dialysate $Na^+/HCO3^-$ Selection

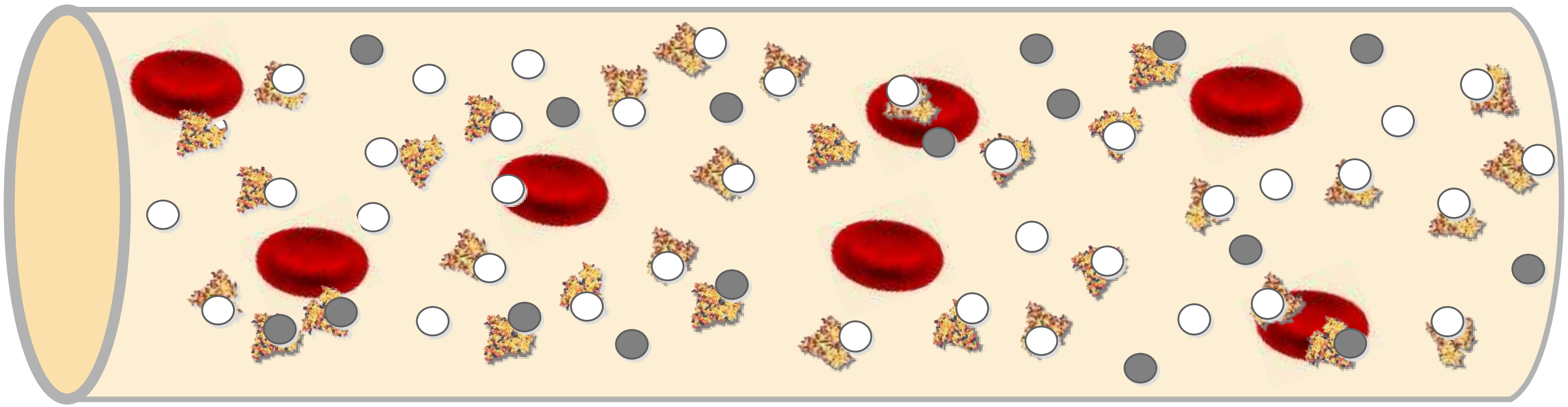


136 mM Calcium Solution

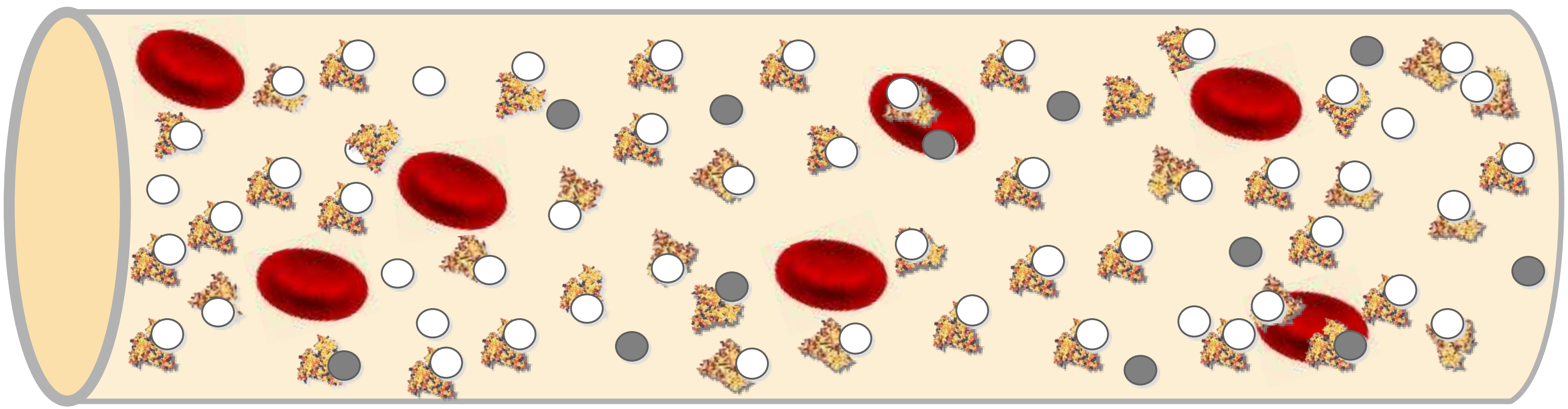
For **ACD-A or 4%-TSC**		
Ca^{2+}	136	mM
Mg^{2+}	20	mM
Na^{+}	140	mM
Cl^{-}	452	mM

- Ca^{2+} infusion restores Ca^{2+} mass balance
- Na^{+} mass balance is restored by the dialysis fluid
- Dextrose mass balance set by dialysis fluid dextrose
- At QB of 200 ml/min, QCa = 100−140 (120) ml/hour

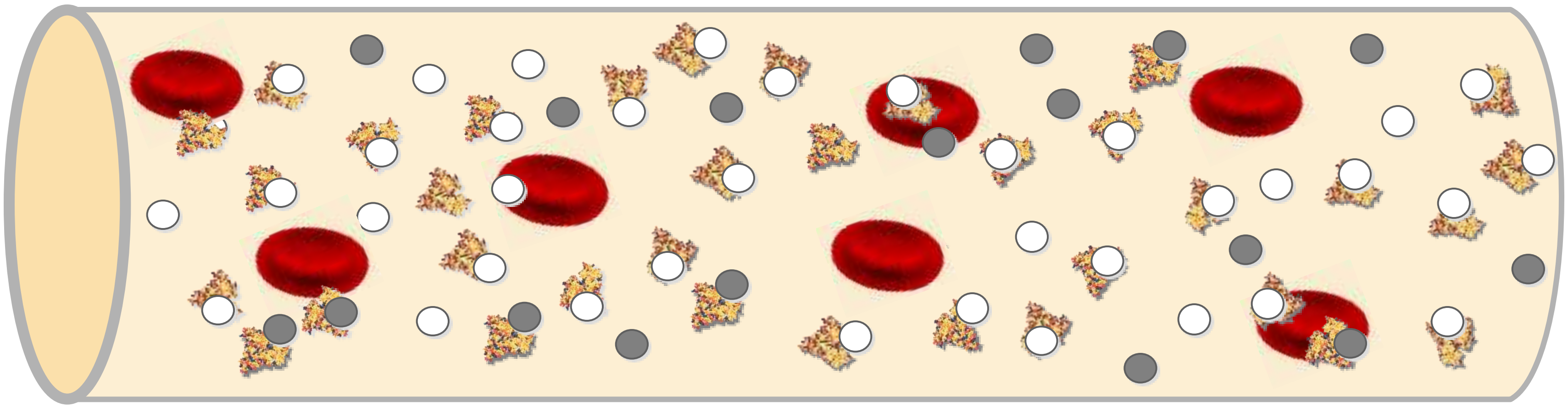
Albumin Defines Plasma Total Calcium Goal



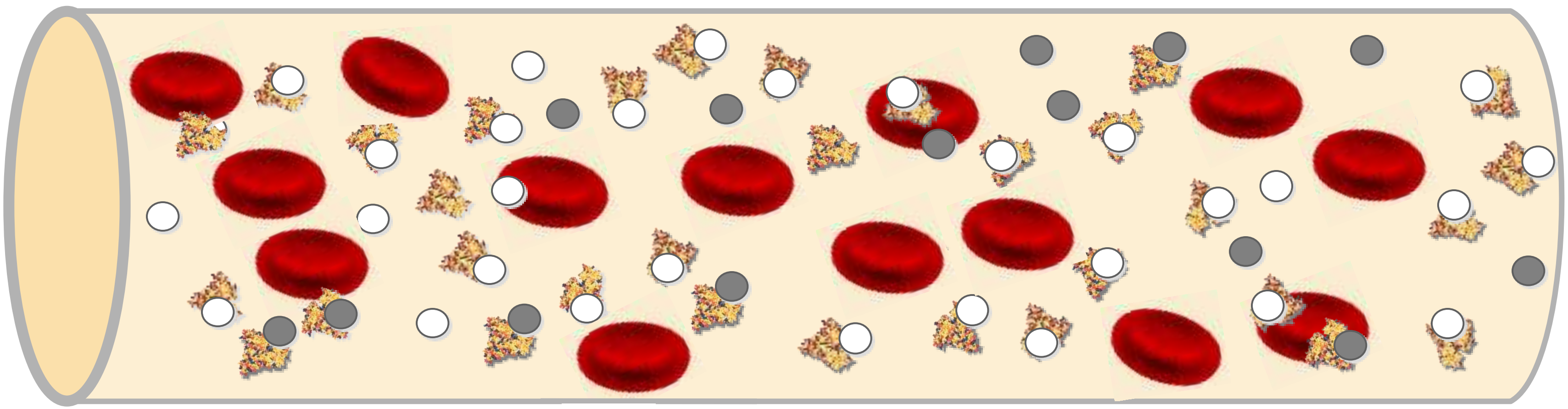
More Albumin ⇒ More Bound Ca ⇒ More Ca Needed



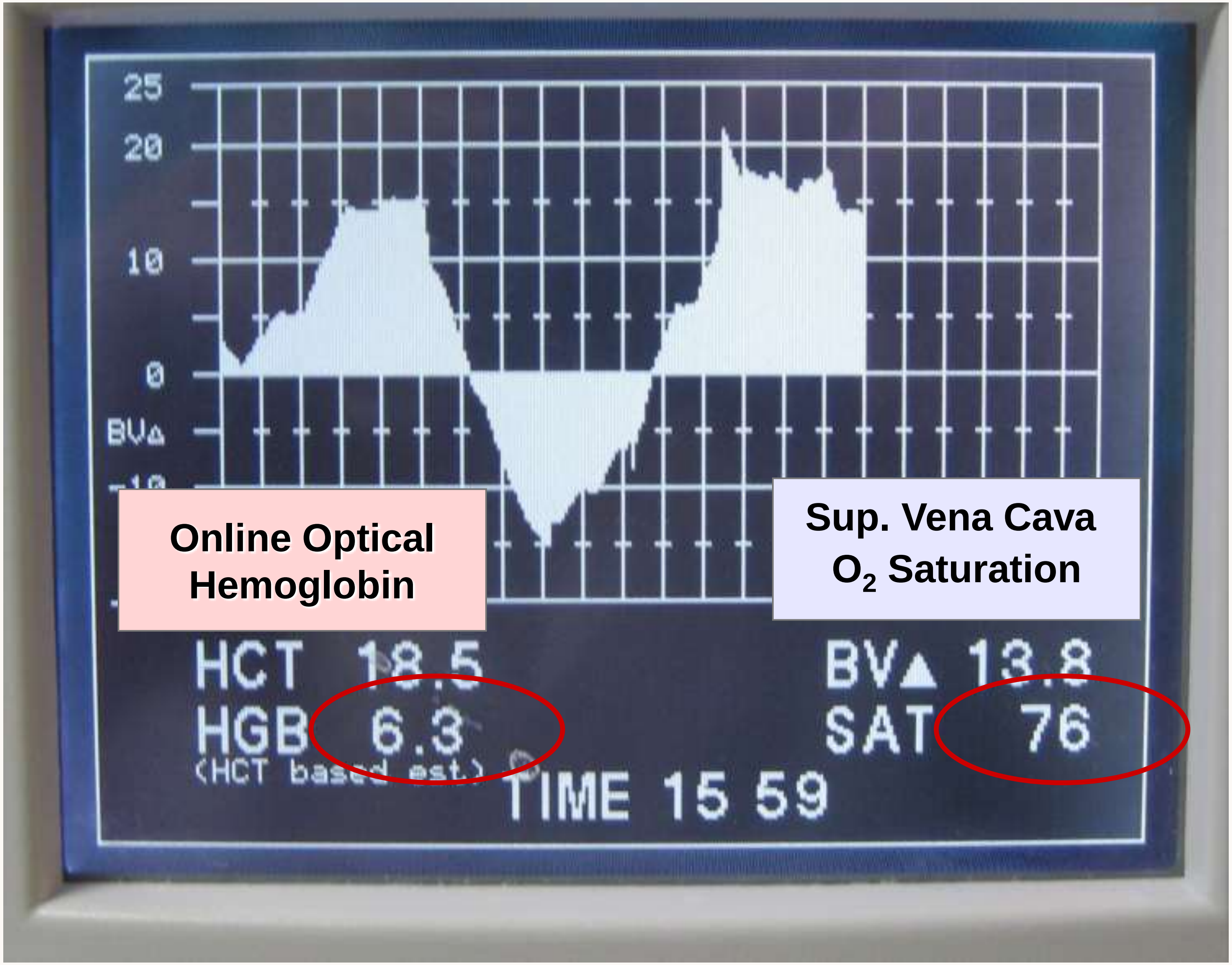
Hematocrit Defines Circuit Plasma Flow



More red cells ⇒ Less plasma ⇒ Less Ca Needed



Optical Hematocrit Monitor



Ca-Infusion Rate for 24-h SLED (ml/hr)

Ca/Mg solution (10 gm $CaCl_2$ + 2 gm $MgCl_2$ in 0.5 L 0.9% saline)

Hgb g/dL ALB g/dL	6-6.9	7-7.9	8-8.9	9-9.9	10-10.9	11-11.9	12-12.9	13-13.9	14-14.9	15-15.9
0.3-0.7	34	33	32	30	29	28	26	25	24	22
0.8-1.2	36	35	33	32	31	29	28	26	25	24
1.3-1.7	38	37	35	34	32	31	29	28	26	25
1.8-2.2	40					32	31	29	28	26
2.3-2.7	42		39		36	34	32	31	29	27
2.8-3.2	44					36	34	32	30	29
3.3-3.7	46					37	36	34	32	30
3.8-4.2	48	47	45	43	41	39	37	35	33	31
4.3-4.7	50	48	47	45	43	41	39	37	35	33
4.8-5.2	52	50	48	46	44	42	40	38	36	34
5.3-5.7	54	52	50	48	46	44	42	40	37	35

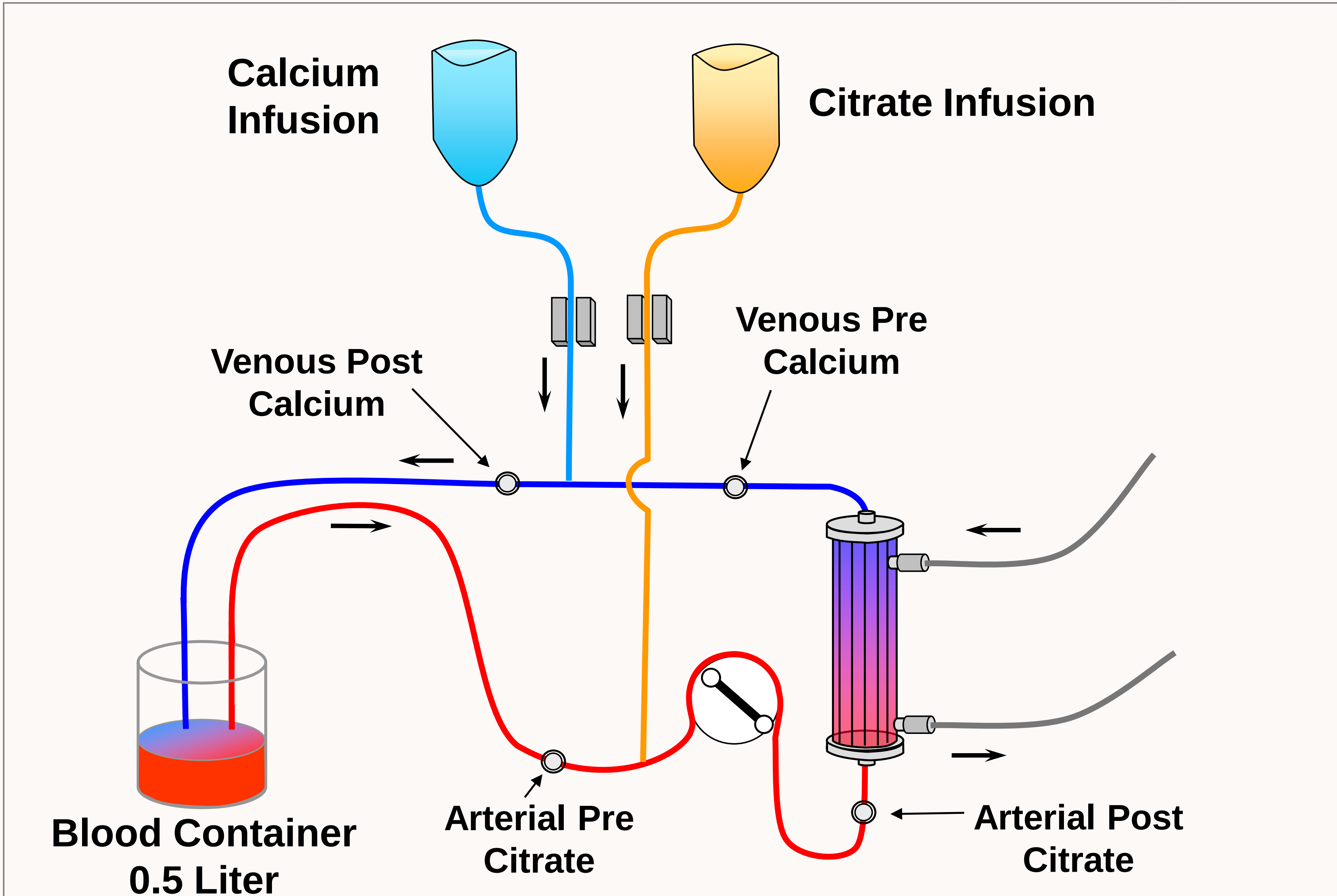
Starting Value

New Value

Simple, Predictive Ca-Infusion Dosing

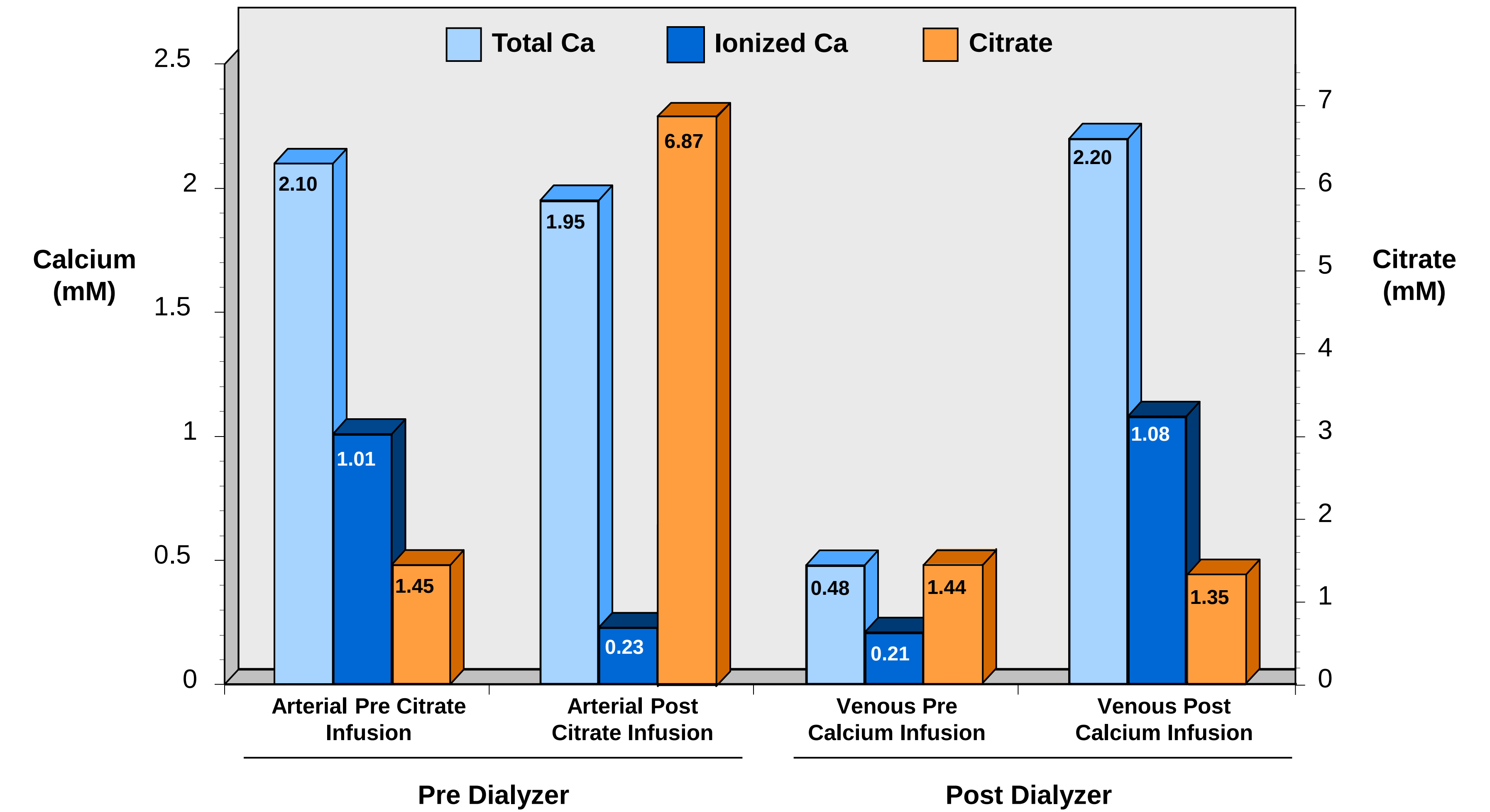
- **The blood flow rate is fixed**
- **Hematocrit sensor determines plasma flow rate**
- **The systemic albumin level is known**
- **The Ca-infusion rate is easily calculated**

SLED-RCA *in vitro* Testing



Szamosfalvi B et al: Automated Regional Citrate Anticoagulation…; Blood Purif 2010;29:204-209

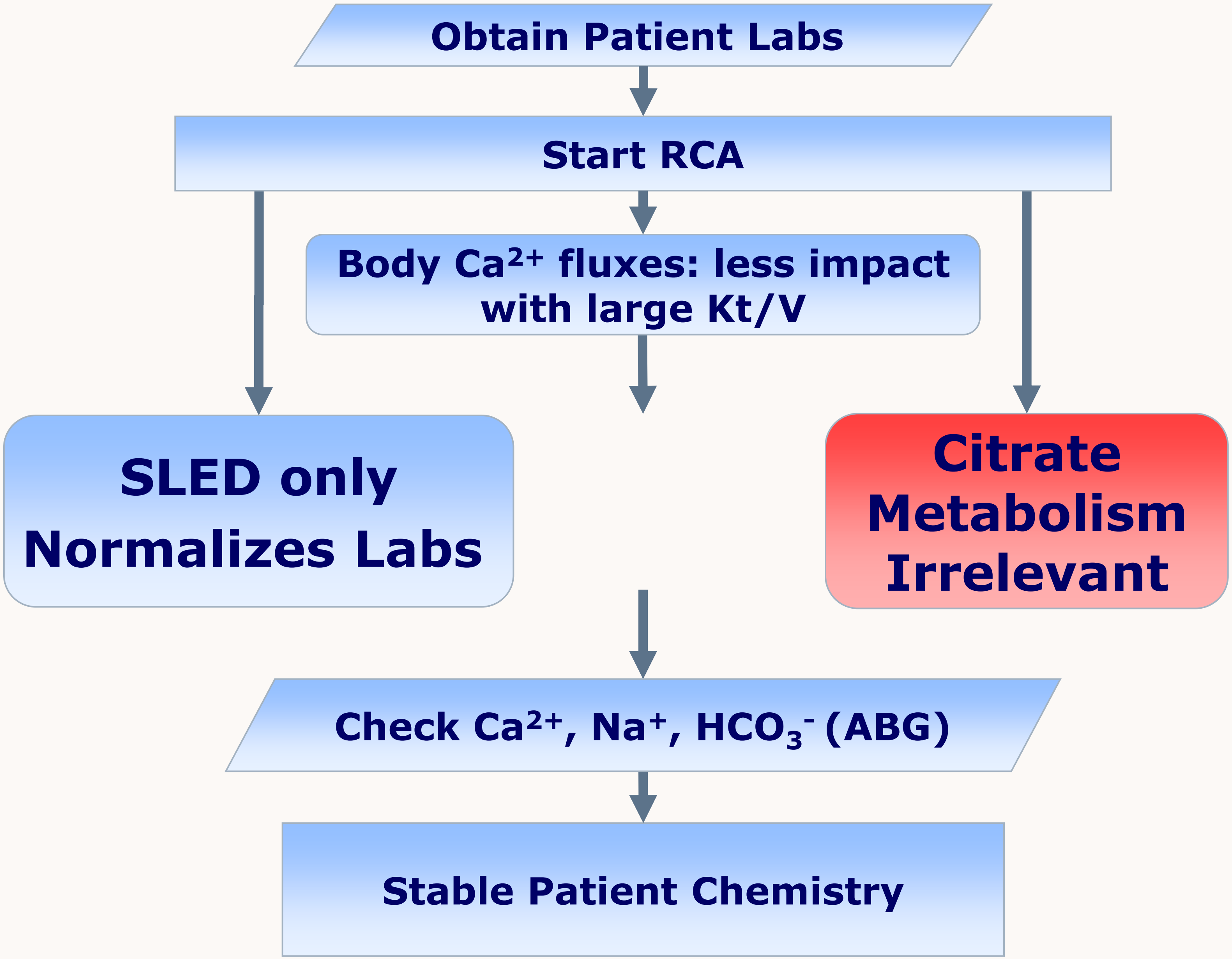
RCA Circuit Chemistry Data [n=6] Anhepatic Sham Dialysis



Hct 30% (repeated at Hct = 21-45%)

Szamosfalvi B et al: Automated Regional Citrate Anticoagulation…; Blood Purif 2010;29:204-209

Safe SLED-RCA Operation



24-hour SLED-RCA Program Clinical Performance

Uniform 24-hour SLED-RCA Prescription

1. **SLED Prescription with high-flux filter**
   - **QB = 60 ml/min**
   - QD = 400 ml/min (Ca-free)
   - <u>QCit = 150 ml/h (ACD-A) (fixed)</u>
   - QCa = 30-50 ml/h (from table)
   - QNetUF = 0-500 ml/h
   - 24-hour (continuous)
2. **Other Features w iHD mode 9h 59m**
   - Online measured delivered dose of dialysis
   - Continuous online display of the hematocrit and central venous O_2 saturation

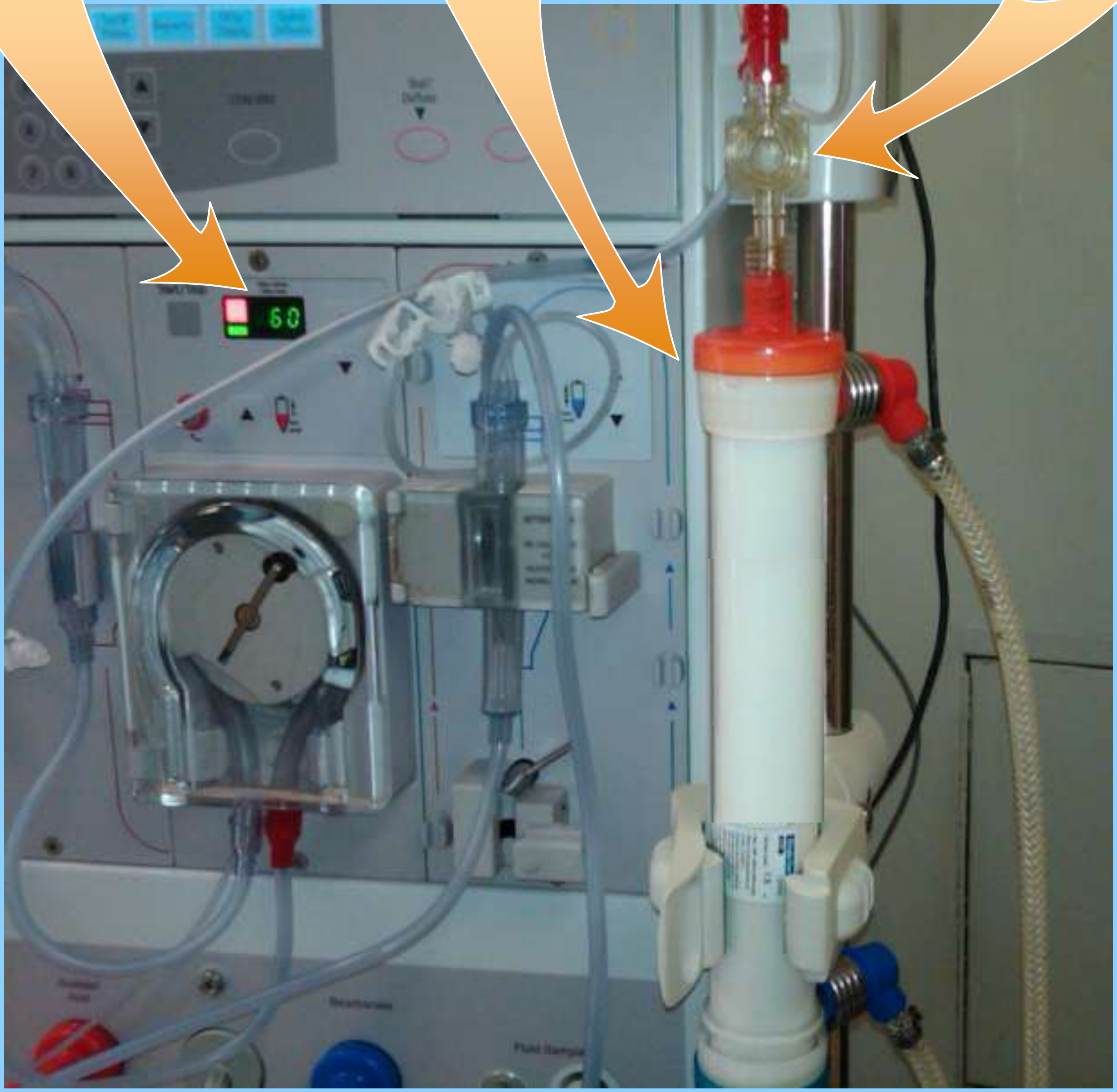
Blood Flow = 60 ml/min

High Flux Dialyzer

Hematocrit Chamber
on Arterial Blood Line

S
L
E
D

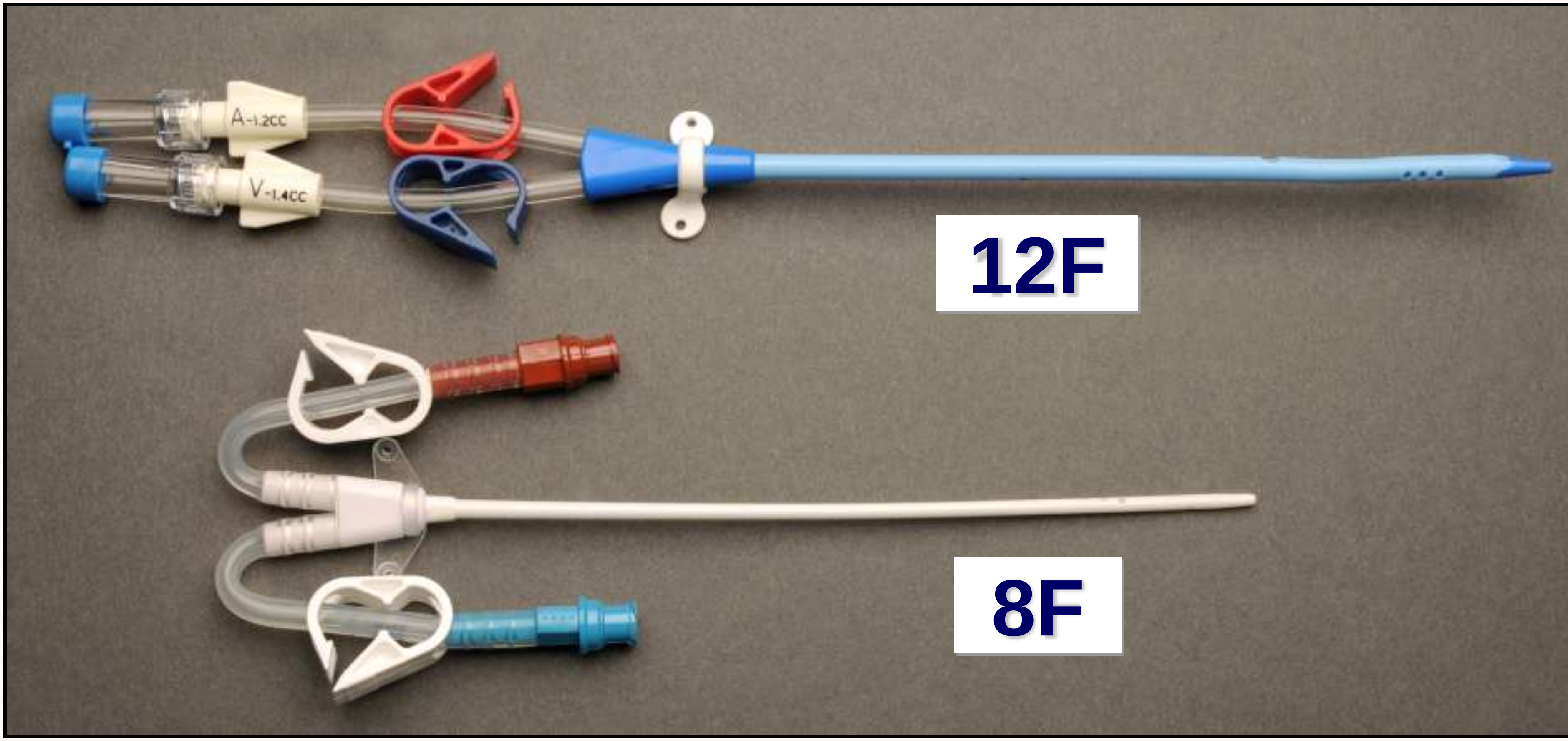
24
hr.



Dialyzer after 43 hours

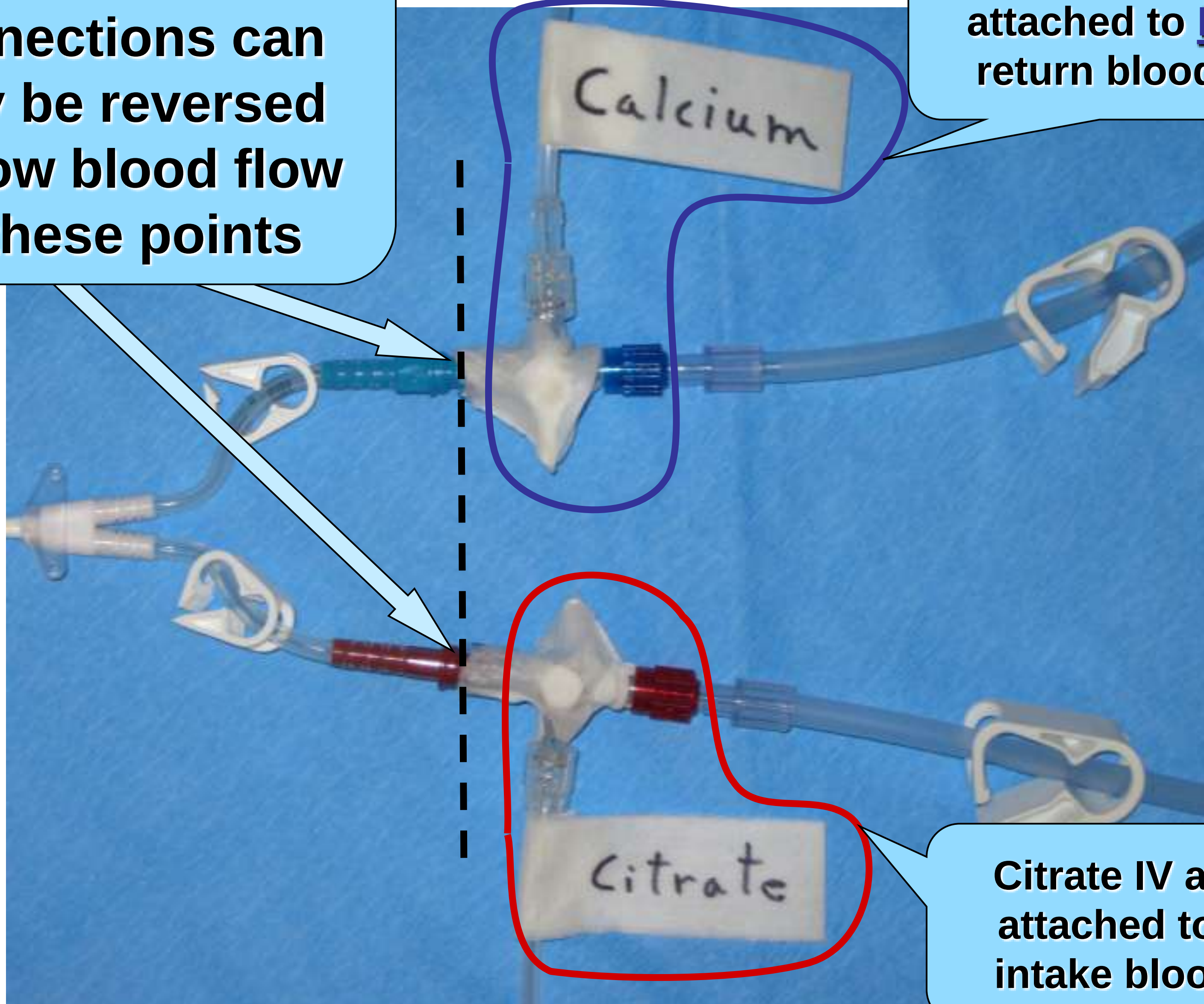
Dialyzer New

Low blood flow (60ml/min) allows the use of smaller access catheters



Catheter connections can only be reversed for low blood flow at these points

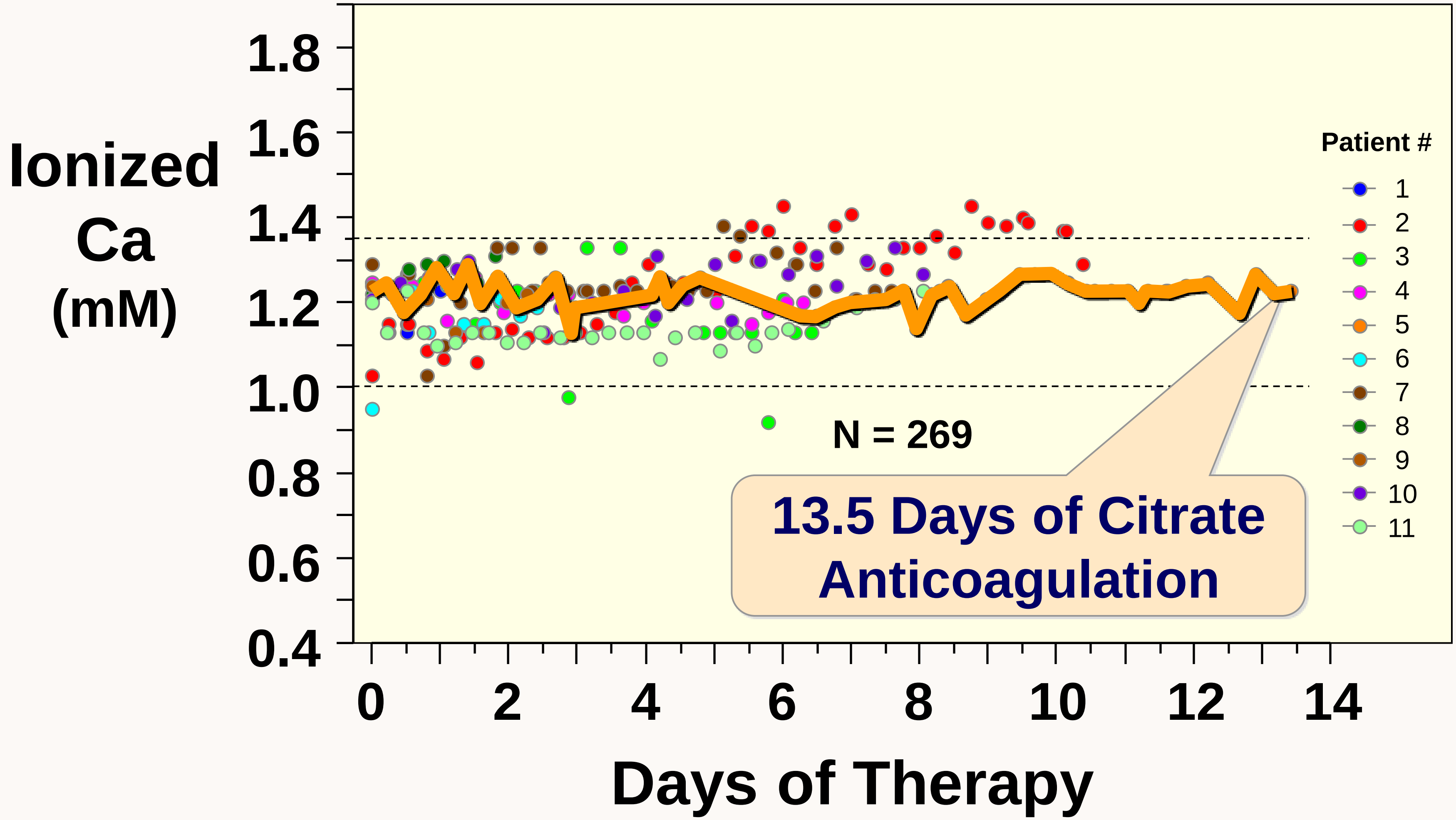
Calcium IV always attached to BLUE return blood line



Citrate IV always attached to RED intake blood line

Systemic Ionized Calcium

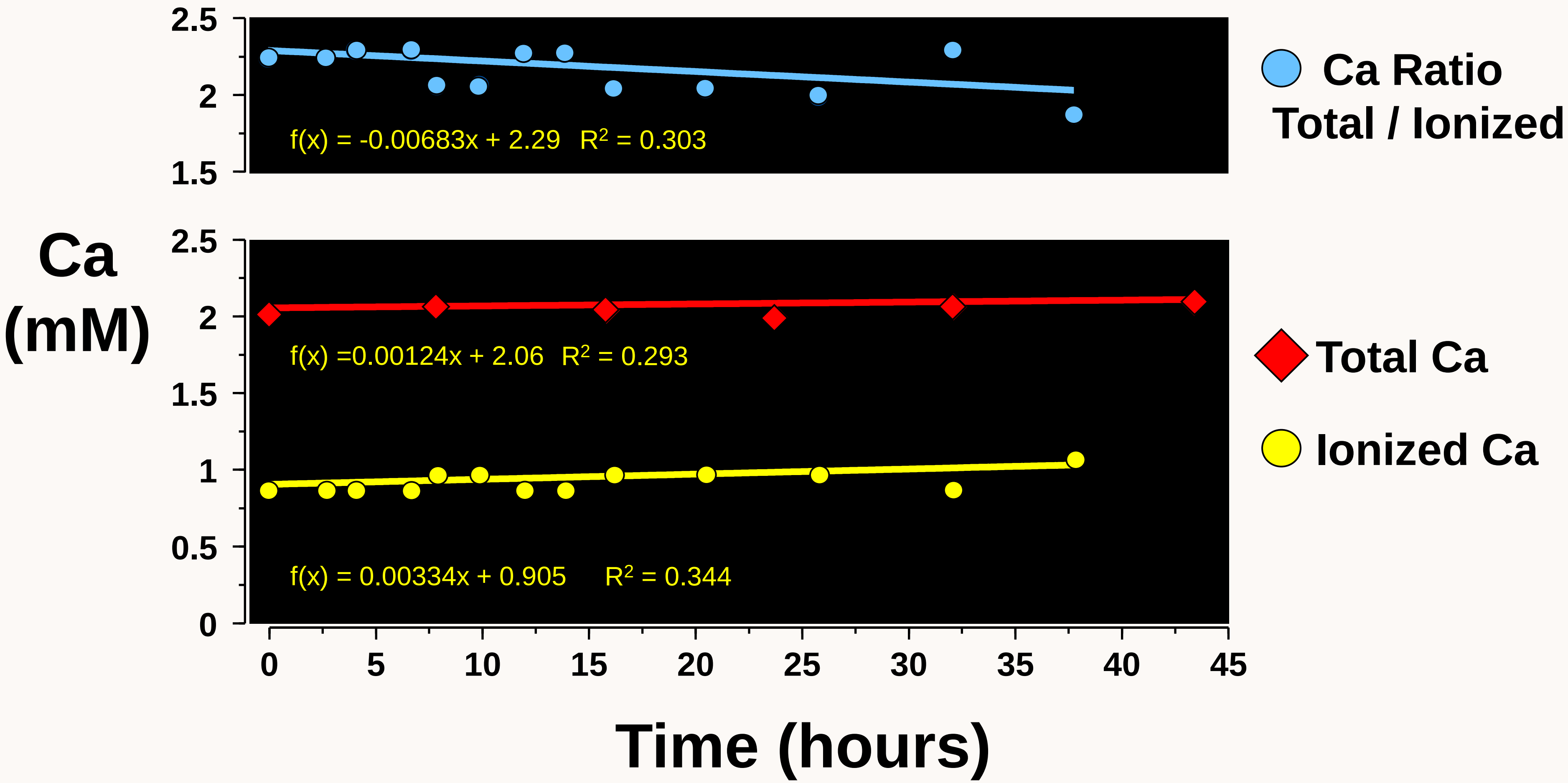
Individual patients during 24-h SLED-RCA



Severe Liver Failure Patient

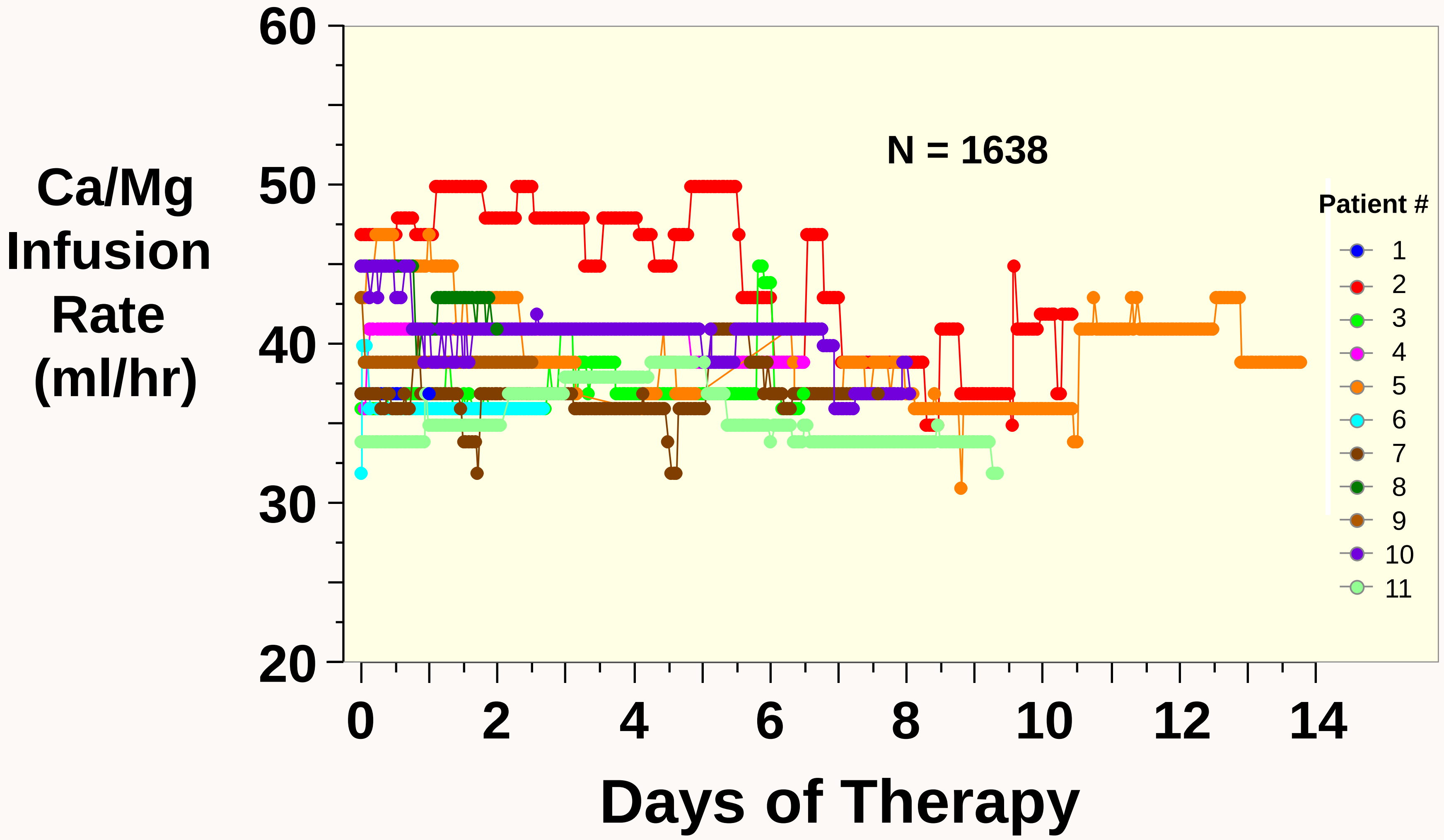
Treated with 24-hour SLED-RCA

INR 3-4 on FFP | **Lactate 15-20 mM** | **Total Bilirubin 29 mg/dL**

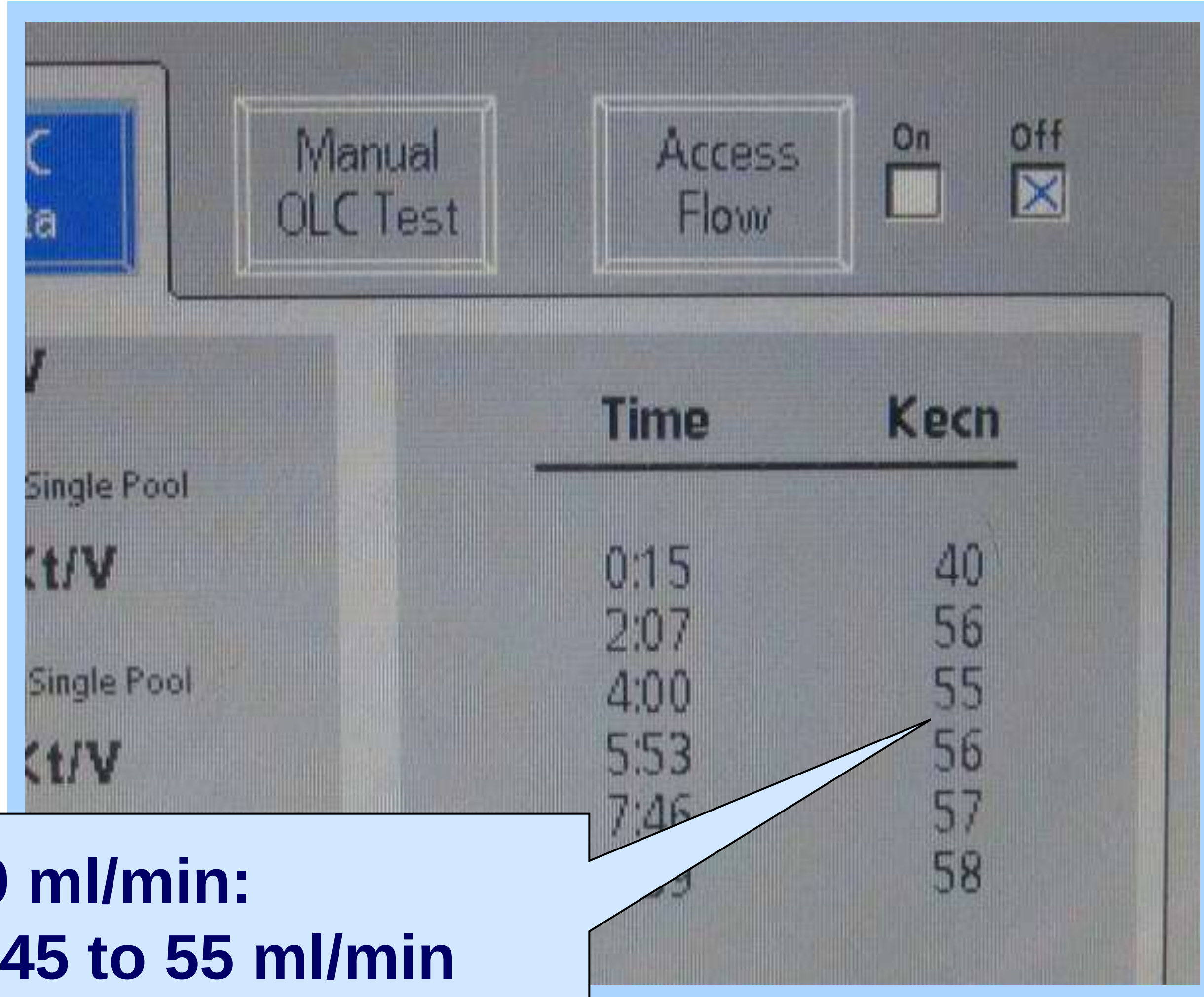


Calcium infusion rate

Individual patients during 24-h SLED-RCA



Online Dialyzer Clearance

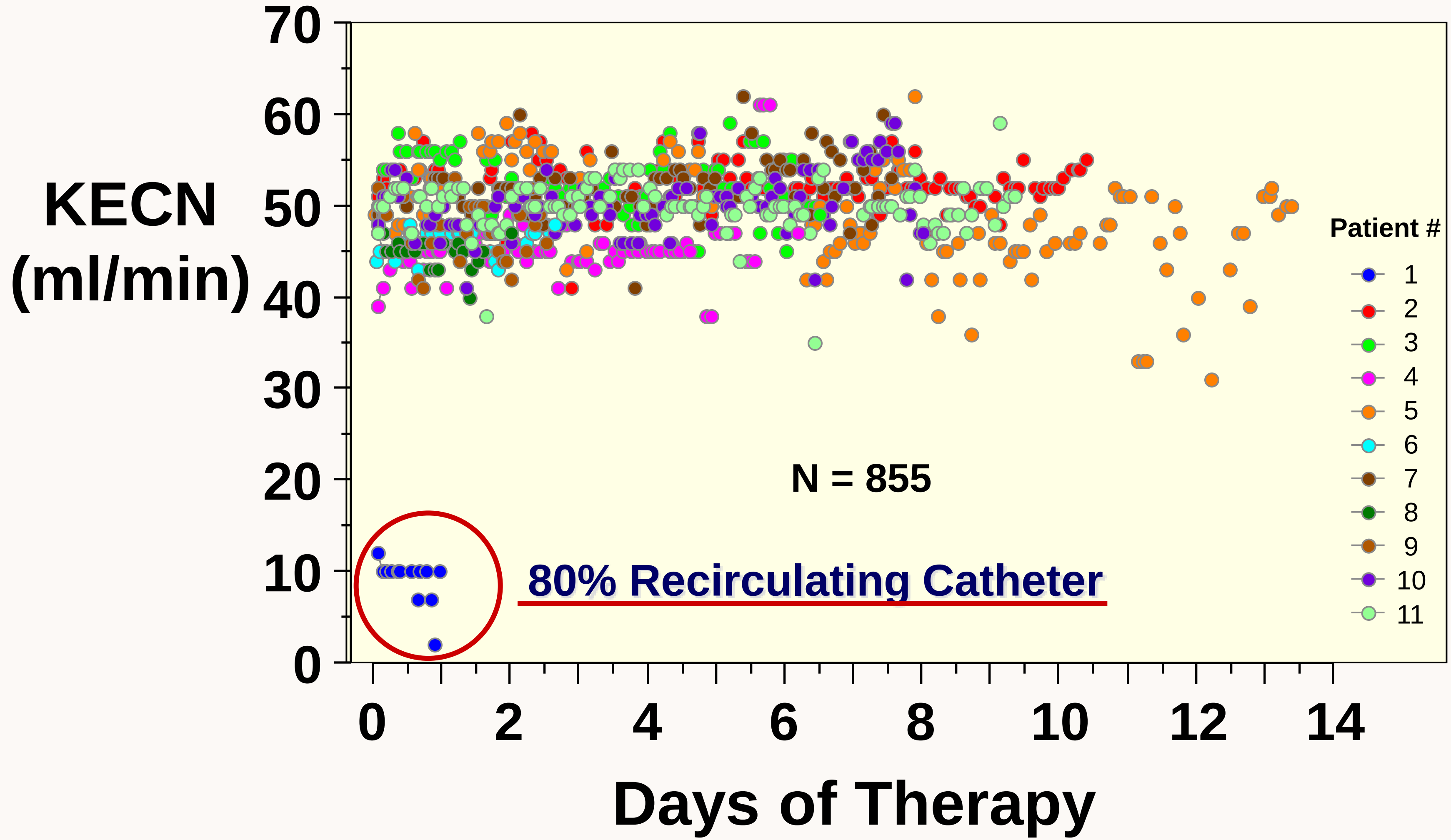


QB = 60 ml/min:
Kecn = 45 to 55 ml/min
(≈effective urea clearance)

Gotch, FA; Panlilio, FM; Buyaki, RA; Wang, EX; Folden TI; Levin, NW. Mechanisms determining the ratio of conductivity clearance to urea clearance. Kidney International (2004) 66, SS3–SS24

Online Ionic Dialysance (Kecn)

Individual patients during 24-h SLED-RCA



Individual patient mean data and overall mean of treatment data recorded every hour during 24-hr SLED-RCA

Patient #	Total Dialysis Time (hrs)	Total Dialysis Time (Days)	Hb (g/dL)	O2 Saturation (%)	Ca/Mg Infusion (ml/hour)	Hourly Net Fluid Removal (ml/hour)	Total Fluid Removed (Liters)	KECN (ml/min)	ICA (mM/L)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
Mean									
SD									
Minimum									
Maximum									
N									
Total Hrs/Days	1638 /	68.3							

Mean

6.2 TX days

24.5L Removed

Summary 24-h SLED-RCA

1. Main Performance Features

- SLED-RCA is easy to perform & <u>safe</u>
- Online clearance measurement
- Costs are very low

2. Additional Benefits

- Hct and central venous O_2 saturation sensing
- Small dialysis catheter with blood flow 60 ml/min
- Ready to integrate second cartridge

Scaling Up SLED-RCA: “In The Cloud” Electronic Prescription Generation and Database Archival

Inpatient Rounding List

TEAM A | TEAM B | TEAM 1 | TEAM 2 | TEAM i2 | TEAM Tp | TEAM Master | Report Menu

DOWNLOAD MASTER

Search: Nephrology Rounding Results

ADD PATIENT

Search Arguments: Prepared for: , 5/5/10 Sort: team ascending Displaying most recent 1 thru 4 of 4 records found.

Name	Mrn	Date of Entry	Pri Res.	Room	Round Active	Reason		
Test1, Patient	11111111	07/02/2009	-	H201	Y	SLED-R... e...		
Test, Patient 2	22345678	01/27/2009	-	H2000	Y	ARF: Order...	N...	04/23/2010 14:53:31
Patient Test	15184704	02/02/2009	-	H1000	Y	DAILY TEST...	**NEW**	04/08/2010 14:32:31
Test, Patient 3	33345678	02/02/2009	-	H2100	Y	Order Form...	NEW	04/09/2010 10:03:04

Click Here to Order a Dialysis Treatment

ADD PATIENT

Update Status

 ☑ Signed SALINE HEMO CCVHDF CITRATE

24•hr SLED WITH CITRATE ANTICOAGULATION ORDER/NOTE

ADD IPD DIALYSIS ORDER Entry Date: 10/27/2010 02:26:24 PM User Log: bszamos1: Add 10/27/10

Name : (L, F) Patient Test MRN: 15184704 Room Number: 1000c

Treatment Type:24 HOUR SLED WITH CITRATE

☑ Set machine in Hemodialysis Mode for 9 hours 59 minutes (Re-setup every 10 hours for continuous treatment)

Contact Isolation: ◉ NO ○ YES Cause:

(required values to calculate infusion rates)

ALB: 2.6 g/dL HGB: 9.1 g/dL HCO_3: 18 mEq/L

☑ Citrate Dextrose (ACD-A) at 150 ml/hr

☑ **37** mL/Hr

136 mM Ca in 0.9% saline (10 gm $CaCl_2$ + 2 gm $MgCl_2$/500 mL)

Calculate Infusion

(Select initial Calcium infusion rate from the 24-hour SLED-RCA Table.

Adjust the Ca/Mg infusion rate per 24-hour SLED-RCA protocol.)

Ultrafiltration CALCULATOR

Desired NET UltraFiltration Goal 200 ml/hr as tolerated

Effective NET UltraFiltration Goal 200 ml/hr

TOTAL goal in 10 hours **3870** (ml) (Net goal + remove Citrate 1200 or 1500 + Ca/Mg ~400 ml infused in 10 hours)

Dialysate temperature 36.5 C Sodium Program: No

TESTS & MEDICATIONS

1.

Fluid Flow Rates & Dialyzer

☑ Rexeed 15-SX FILTER

☑ 60 Blood FLow (ml/min)

☑ 400 Dialysate Flow (ml/min)

Dialysate Bath

Potassium	Calcium	Phosphorus
○ 2 mEq/L	☑ 0 mEq/L	○ 0 mg/dL
○ 3 mEq/L		◉ 3.2 mg/dL
◉ 4 mEq/L		

Sodium: 142 mEq/L

Bicarbonate: 32 mEq/L

Special Orders

Age: 69 Sex: ◉ Male ○ Female Height: 180 (cm)

Weight: 90 kg

Calculate Volume Vol.: 45 (L)

1. ☑ Document DELIVERED Kt/V
2. ☑ Document Average QB/Kecn (Ionic dialysance)
3. ☑ Measure Access Recirculation

Labs Date: 10/26/2010

Calcium:	8.6	mg/dL	Ionized Calcium:	1.12	mmo/L
Magnesium:	2.1	mg/dL	Phosphorus:	3.6	mg/dL
Na:	137	mEq/L	PROTEIN:	6.2	mg/dL
K:	4.3	mEq/L	BUN:	57	mg/dL
Cl:	105	mEq/L	Cret:	3	mg/dL

Henry Ford Health System (24-hr)

SUSTAINED LOW EFFICIENCY DIALYSIS (SLED) WITH REGIONAL CITRATE ANTICOAGULATION (RCA) ORDER/NOTE

Room Number: **1000c**

DATE: **10/27/2010 14:26:24**

NAME: **Patient Test**

MRN: **15184704**

Treatment Type: 24 HOUR SLED WITH CITRATE

☑ Set machine in Hemodialysis Mode for 9 hours 59 minutes (Re-setup every 10 hours for continuous treatment)

Isolation: ☑ NO ☐ YES Cause:

Citrate and Calcium infusion rates during RCA

☑ **Citrate Dextrose (ACD-A) at 150 ml/hr**

☑ **Calcium/Magnesium (Ca/Mg) in 0.9% saline (10 gm $CaCl_2$ + 2 gm $MgCl_2$ /500 mL)**

Ca/Mg Infusion RATE: 37 **mL/Hour**

(Select initial Ca/Mg infusion rate from 24-hour SLED-RCA Table 1. Adjust the Ca/Mg infusion rate per 24-hour RCA protocol.)

Ultrafiltration CALCULATION: UF RATE 387 ml/hr

Patient NET Goal PER HOUR 200 ml/hr (as tolerated)

TOTAL goal in 10 hours 3870 (ml) (Net goal + remove Citrate 1200 or 1500 ml + Ca/Mg ~400 ml infused in 10 hours)

Dialysate temperature 36.5 C Sodium Program: No

TESTS & MEDICATIONS

1.
2.
3.

Fluid Flow Rates & Dialyzer

FILTER: **REXEED15-SX**

BLOOD FLOW: **60** ml/min

DIALYSATE FLOW: **400** ml/min

Dialysate Bath

Potassium	Calcium	Phosphorus
☐ 2 mEq/L	☑ 0 mEq/L	☐ 0 mg/dL
☐ 3 mEq/L		☑ 3.2 mg/dL
☑ 4 mEq/L	Sodium: 142 mEq/L	Bicarb: 32 mEq/L

Special Orders

Volume: 45 Liters

☑ 1. Document DELIVERED Kt/V

☑ 2. Document Average Kecn (Ionic dialysance)

Lab Date: 10/26/2010

Albumin: **2.6** g/dL	Protein: **6.2** g/dL
Calcium: 8.6 mg/dL	Ionized Calcium: 1.12 mmol/L
Magnesium: 2.1 mg/dL	Hemoglobin: **9.1** g/dL
Phosphorus: 3.6 mg/dL	
Na: 137 mEq/L	HCO3: **18** mEq/L
K: 4.3 mEq/L	BUN: 57 mg/dL
Cl: 105 mEq/L	Creatinine: 3 mg/dL
Hepatitis BsAg : 10/25/2010	**NEGATIVE**
C.difficile toxin : 10/22/2010	**NEGATIVE**

Patient Evaluation: History:

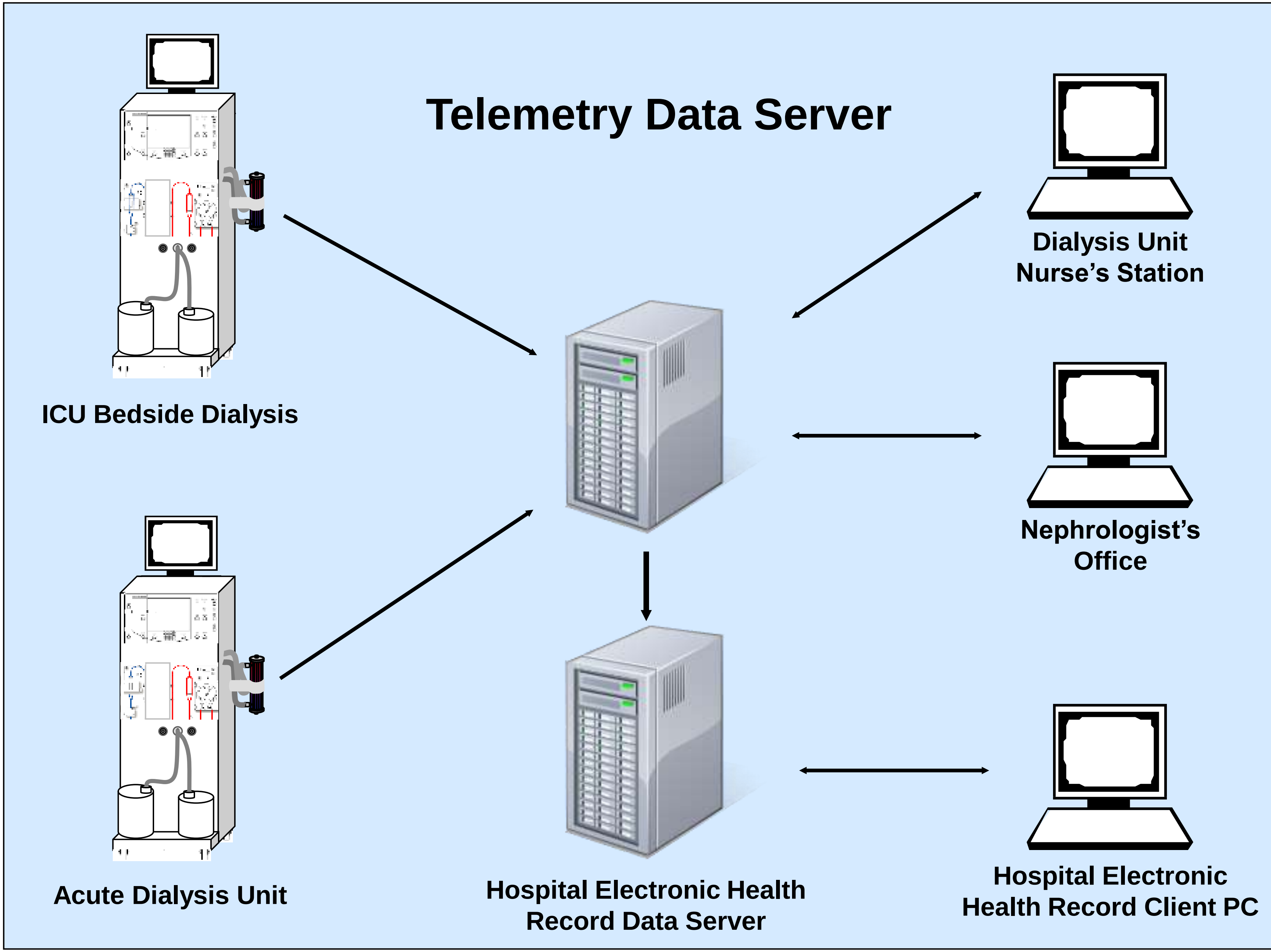
60 y.o male status post CABG 10/12/2010; course complicated by HAP, VDRF and anuric AKI. CRRT was started 10/20/2010.

Exam: T : **36.5** BP: **100** / **50** HR: **110** RR: **18** W: **90** kg

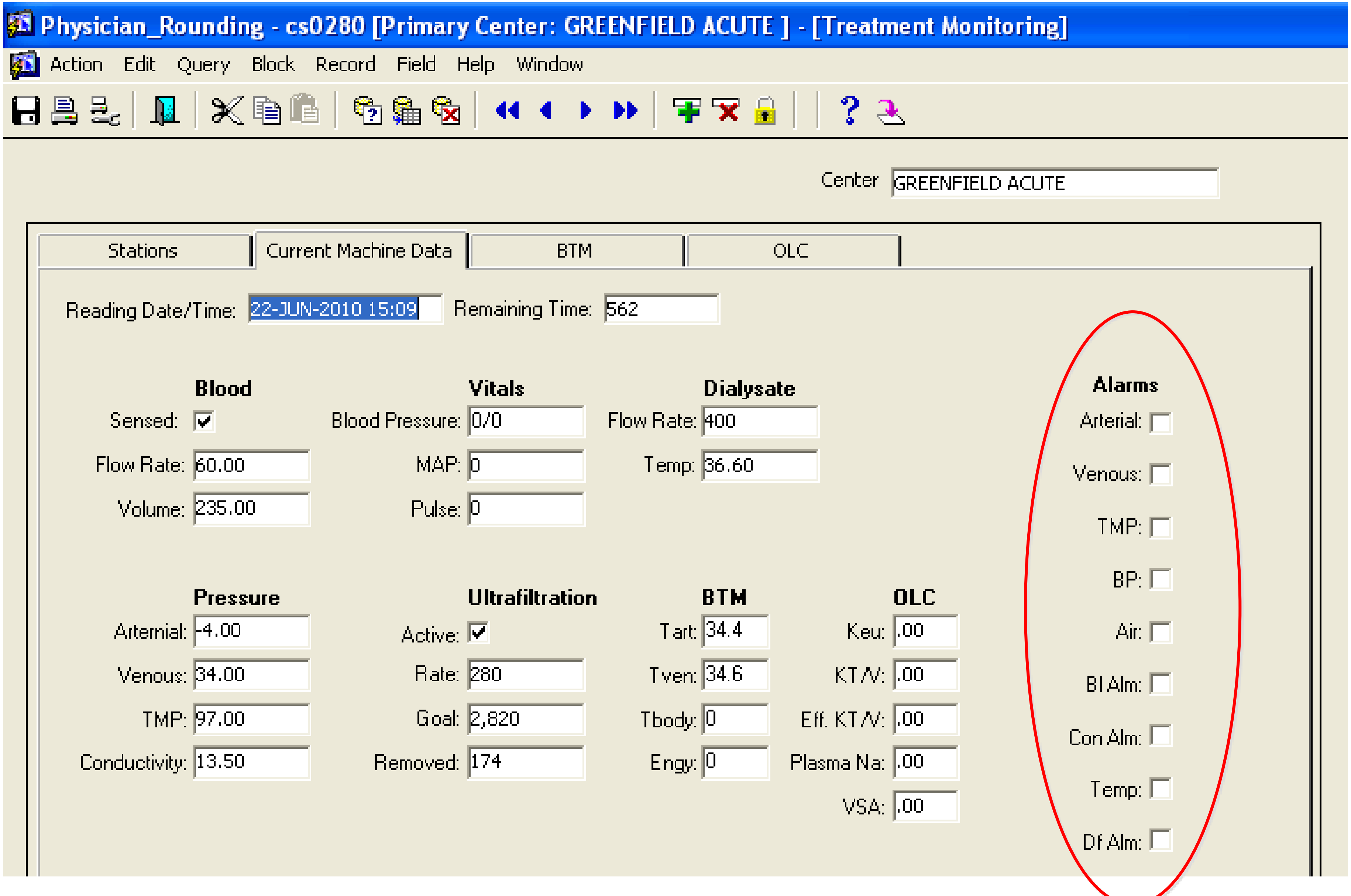
Attending Physician Attestation:

1. Patient Seen on Dialysis Init: ____ hr: ____ min: ____

Scaling Up SLED-RCA: Treatment Telemetry and Database Archival


Telemetry Data Server
ICU Bedside Dialysis
Acute Dialysis Unit
Dialysis Unit
Nurse's Station
Nephrologist's
Office
Hospital Electronic Health
Record Data Server
Hospital Electronic
Health Record Client PC

Telemetry: Machine Status



Telemetry: Flowsheet Data

Runsheet - cs0100 [Primary Center: GREENFIELD ACUTE] - [Run Sheet]

Action Edit Query Block Record Field Help Window

Time	Sys/Dia	MAP	Pls	BFL	Art	Ven	UFR	Cond	Tart	Tven	Tbody	Init
18:00	0/0	0	0	0	52.00	247.00	0	14.00	31.3	30.9	.0	
17:58	0/0	0	0	185	1.00	388.00	280	14.00	31.3	31.0	.0	
17:28	0/0	0	0	60	-121.0	330.00	280	14.00	31.2	30.8	.0	
17:12	0/0	0	0	60	-35.00	338.00	280	14.00	31.3	30.9	.0	
17:11	Keu=44 Proj. S-P Kt/V=0.14 Eff. Kt/V=0.11 Plasma NA=137.2 VSA=43.0											
17:11	0/0	0	0	60	-52.00	325.00	280	13.60	31.3	31.0	.0	
16:58	0/0	0	0	60	-37.00	201.00	280	14.00	31.3	30.9	.0	
16:43	0/0	0	0	60	-36.00	123.00	280	14.00	31.2	30.6	.0	
16:33	0/0	0	0	60	-23.00	40.00	280	14.10	31.3	30.8	.0	
16:30	0/0	0	0	60	3.00	59.00	280	14.10	31.3	30.8	.0	
16:29	0/0	0	0	60	-22.00	63.00	280	14.00	31.2	30.6	.0	
16:28	0/0	0	0	60	-43.00	41.00	280	14.00	31.3	30.6	.0	
16:27	0/0	0	0	60	-24.00	38.00	280	14.00	31.3	30.6	.0	
16:27	NAME ON DIALYZER (Y / N)=n											
16:27	VERIFY DISINFECTION (Y / N)=y											
16:27	STRILANT NEG. (Y / N)=y											
16:27	VEN.LINE DETECTOR ARMED (Y / N)=y											

PATIENT, TEST 1(UNIT) / 1

Exit

21-JUN-2010 18:26:

24-hr SLED-RCA is CRRT and More!

	24-hr SLED-RCA	Traditional CRRT
Continuous	Yes; QB = 60 ml/min	Yes; QB ≥ 100 ml/min
Clearance	3 L/hr (fixed)	1-4 L/hr
Convection	≈ 10-30% (hidden)	0-100%
Automated RCA	Coming soon!	Not Implemented
Online Clearance	Standard	Not Available
Telemetry	Available	Available Soon?
Diagnostic Use Of CRRT	Hct sensing; VO_2 saturation	Not Implemented

HFH "Citrate Group"

- Balazs Szamosfalvi, MD
- Stanley Frinak, MSEE
- Jerry Yee, MD
- Tom Lubkowski
- Gary Zasuwa
- CRRT Technician Team
- ICU Teams
- Greenfield Health System