Dialyzers and Dialysis Adequacy

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“The dialyzer is where the tire meets the road”… Peter Lepanto

DIALYZER CHARACTERISTICS

- Membrane Material
  - Biocompatibility
- Solute Removal - Clearance
  - Diffusion
  - Convection
  - Adsorption

Dialyzer Membranes

Cellulose

- Cuprophan
- Cupromonium Rayon
- Hemophan
- Cellulose Acetate
- Cellulose Triacetate

Synthetic

- PAN
- AN 69
- PMMA
- Polysulphone
- Polyflux
- Purema

BIOCOMPATIBILITY

- The choice of membrane material affects how the blood will react when in contact with the membrane

- Reactions to Bioincompatability
- Indicators of Bioincompatability

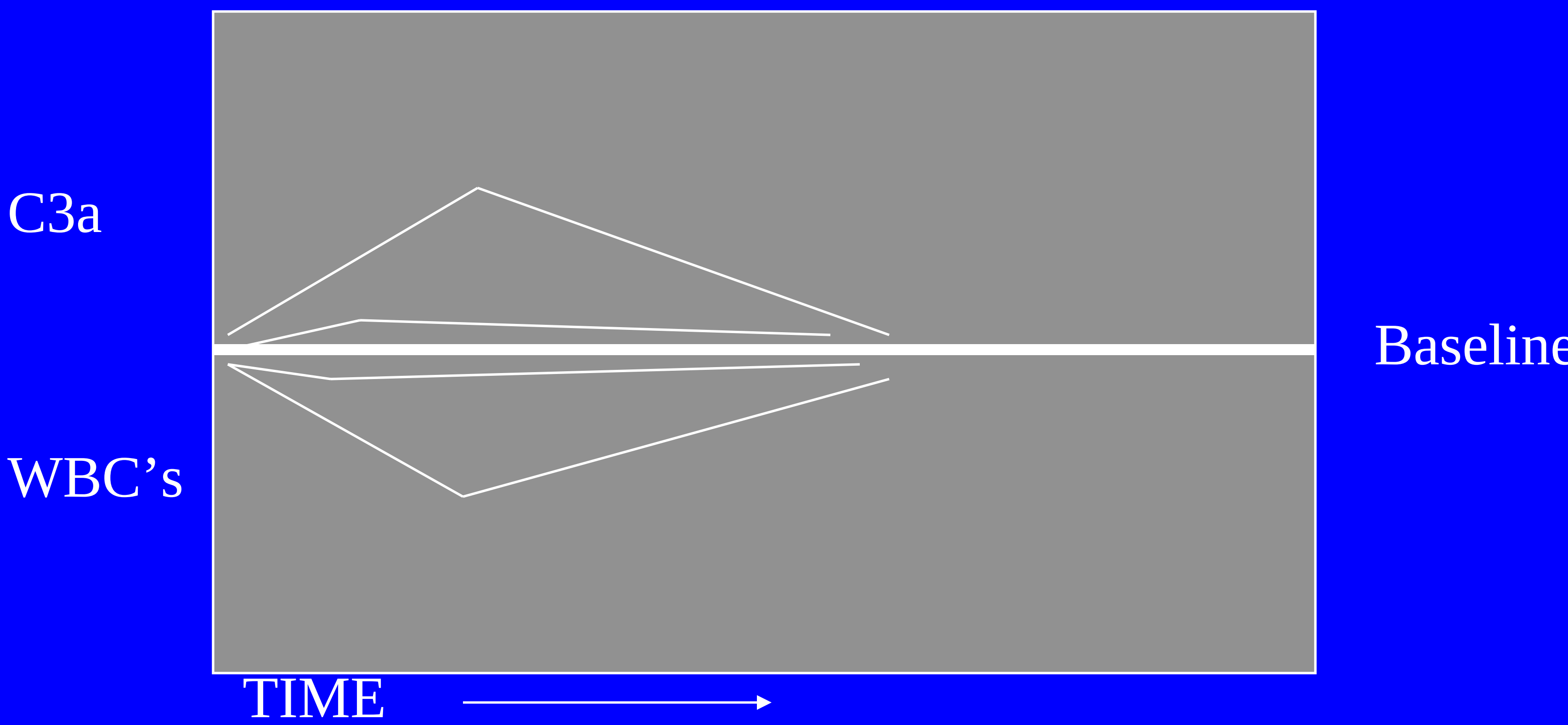
Reactions to Bioincompatability

- Mild / unnoticed
- DAA
- Severe - anaphylactic shock

INDICATORS OF BIOINCOMPATABILITY

- Compliment activation
  - increase in circulating C3a level
  - Decrease in white blood cells
- Hyper coagulation

COMPLIMENT ACTIVATION



SOLUTE REMOVAL

- Diffusion
- Convection
- Adsorption

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

Solute Removal: Diffusion

- In diffusion, molecules move from an area of high concentration to an area of low concentration. The higher the concentration gradient, the more rapid the diffusion

- Diffusive clearances are dependant upon:
  - blood flow rates
  - dialysate flow rates
  - membrane surface area

Solute Removal: Convection

- Also known as “Solute Drag”, molecules move with the fluid as it crossed the membrane.

- Convective clearances are dependant upon:
  - molecular weight cutoff
  - ultrafiltration rate

Solute Removal: Adsorption

- Many molecules, such a proteins, adhere to the wall of the dialyzer membrane. While these substances are removed from the blood, they do not enter the dialysate.

- Removal of solutes by Adsorption is dependant upon:
  - surface area
  - membrane material
  - how much material the membrane has already adsorbed

BACK FILTRATION

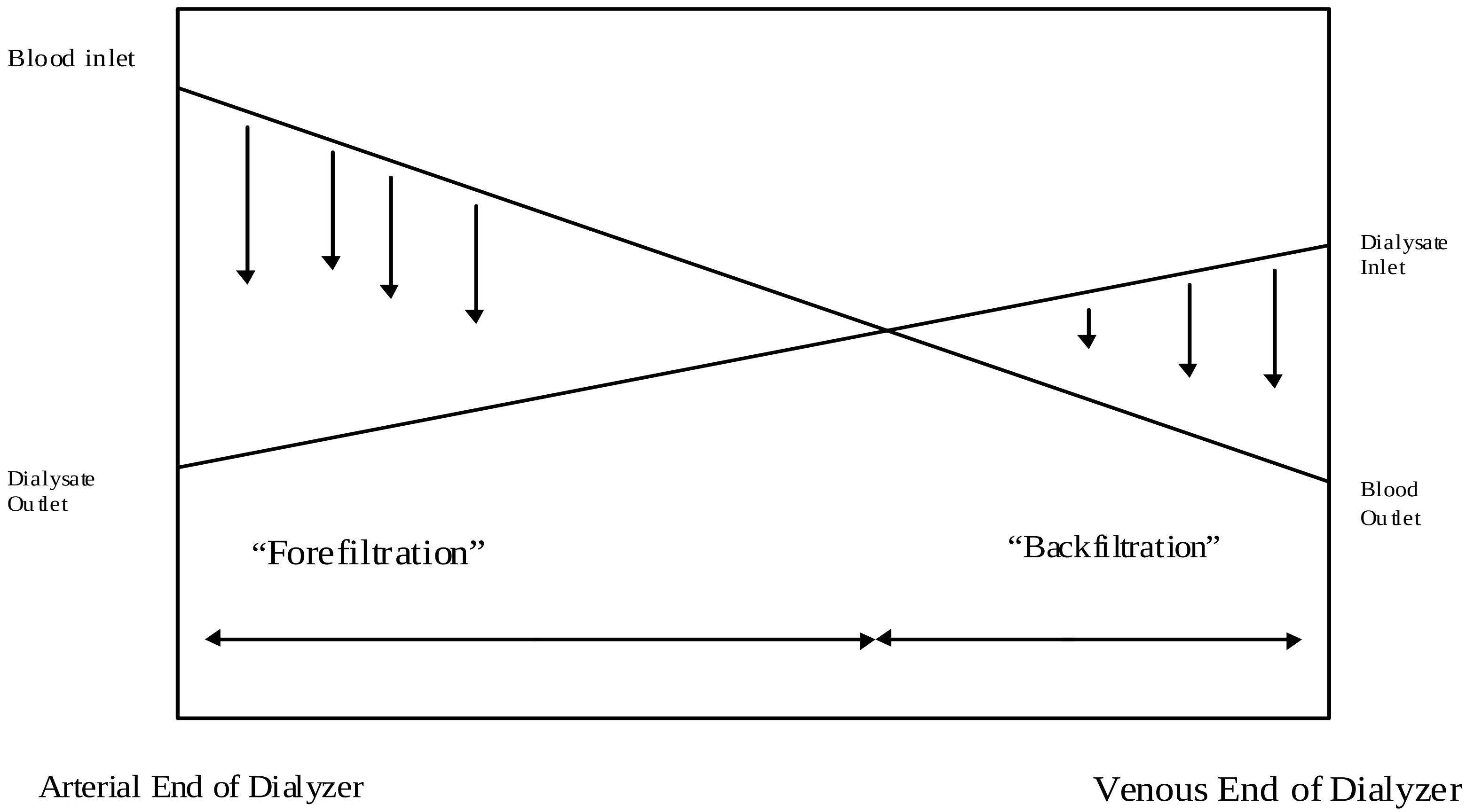
- Backfiltration is the movement of fluid from the dialysate compartment into the blood compartment of the dialyzer.

- Endotoxin transfer
  - This concern is more theoretical than real
- Convective clearances

Backfiltration: Convective Clearances

- Backfiltration is exactly the mechanism in which dialyzers are able to remove large molecular weight substances during a dialysis treatment. The flow of fluid into the blood compartment on the venous end causes the flow of fluid, and solutes, out on the arterial end. Backfiltration makes convection happen.

Backfiltration



CHOOSING YOUR DIALYZER

- The choice of dialyzer affects the dialysis process more than any other single component of the dialysis system.
- Understanding the characterizes of your dialyzer is important to providing adequate dialysis treatment to your patients.

Keys to providing adequate renal replacement therapy

- Measuring dialysis adequacy
  - Urea Reduction Rate
  - Urea Kinetic Modeling
- Other Considerations:
  - Frequency and duration of dialysis
  - Fluid control
  - Phosphorus control

Getting Enough Treatment

How We Measure the Dose of Dialysis

Urea Reduction Rate (URR)

Urea Kinetic Modeling (Kt/V)

Urea Reduction Rate

URR is simply measuring the level of BUN in a patients blood at the beginning of dialysis, and at the end of the treatment, and calculating how much the BUN level was reduced

Factors affecting URR

- Dialyzer Clearance
  - Dialyzer characteristics
  - Blood flow rates
- Time on Dialysis

URR Example

Pre Dialysis BUN is 100

Post Dialysis BUN is 35

The Formula is 100*(1-(Post/Pre))

100*(1-(35/100))

=100*(1-(.35))

=100*.65 = 65% URR

What YOU can do to improve your patients URR

- Turn up blood pump speed quickly at the beginning of the treatment
- Give adequate heparin, and report on excessive clotting in the dialyzer
- Be careful when drawing BUN samples

Urea Kinetic Modeling

Urea Kinetic Modeling is a means of measuring the dose of dialysis by multiplying the dialyzer clearance (K) by the time on dialysis (t), and dividing this product by the patients volume (V)

Factors affecting Kt/V

- Dialyzer Clearance (K), in ml/min
  - Dialyzer characteristics
  - Blood flow rates
- Time on Dialysis (t), in minutes
- The patient’s volume (V), in cc’s

Kt/V Example #1

Dialyzer provides a clearance of 350 ml/min

Patient runs 3 1/2 hours (210 minutes)

Patients volume is 58 liters (58,000 cc's)

Kt/V = 350*210 / 58,000 = 1.27

Kt/V Example #2

Desired Kt/V is 1.2

Dialyzer clearance is 350 ml/min Patient's volume is 55 liters

What is the required time?

Kt/V = 1.2 = 350*X / 55,000

66,000 = 350*X

189 = X   You need to run 3 hours, 9 minutes

What YOU can do to improve your patients Kt/V

- Turn up blood pump speed quickly at the beginning of the treatment
- Give adequate heparin, and report on excessive clotting in the dialyzer
- Be careful when drawing BUN samples

Estimating a Patient's Kt/V

For K, use 3/4's of the blood flow rate)Qb)

For V, use 60% of the patient's weight

For t. use the time on dialysis, in minutes

Example:

A 75 Kilo Patient runs 3.5 Hrs at a 400 Qb

K = 400 X .75 = 300

t = 210

V = 75,000 X .6 =45,000

K(300) X t(210) / V(45,000) = 1.4

Frequency and duration of dialysis

"We hold this truth to be self-evident in dialysis:

*Normal chemistries and physiology are better than abnormal…**a lot** better"*

From the "Unphysiology Hypothesis " Kjellstrand CM, Evans RL, Petersen RJ, Shideman JR, von Hartitzsch B, Buselmeier TJ. The "unphysiology" of dialysis: A major cause of dialysis side effects? Kidney Int 1975; Suppl 2:30-4

THE UN-PHYSIOLOGY HYPOTHESIS

First, the more "unphysiologic" dialysis is, and the more abnormal chemistries and fluid levels are before dialysis, the more violently they will change during dialysis and the more ill-effects that patients will experience.

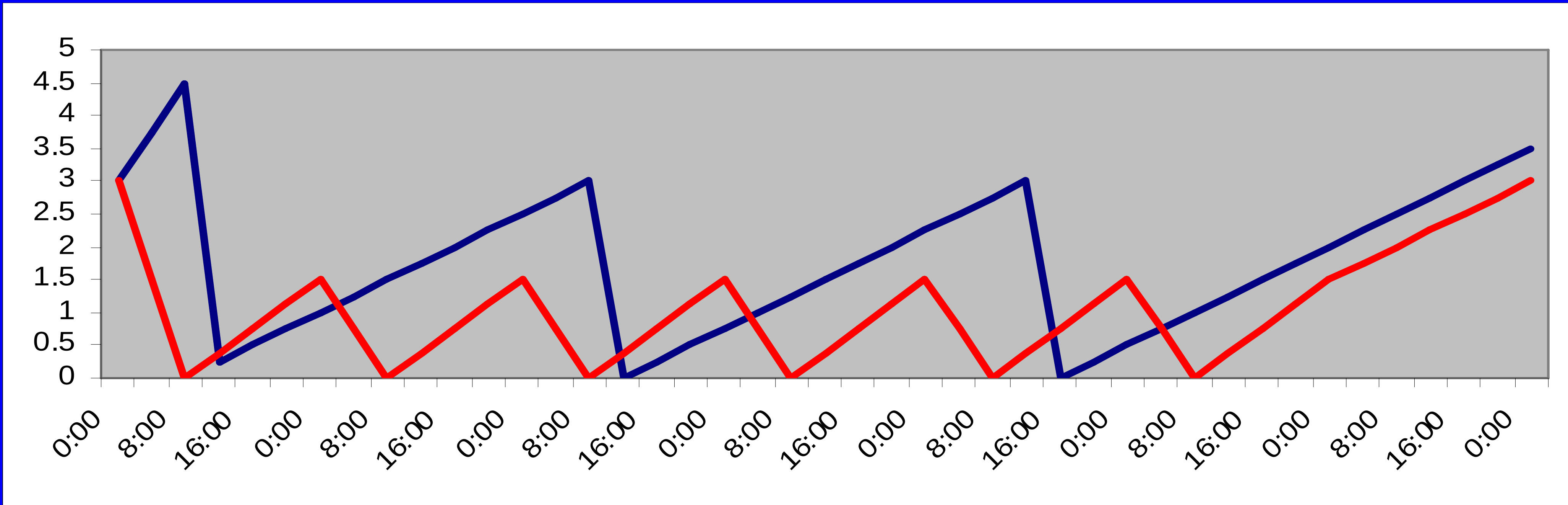
Secondly, when dialysis is over, the patient's serum potassium level is below normal and the patient is alkalotic and short of fluid in the vascular space. The patient's body is never in a normal state; it is in an abnormal state, both before *and* after dialysis.

In-Center Dialysis Patient Survival

- Has remained essentially unchanged in the last decade
- DOQI and KDOQI have had little impact on patient mortality; 23.8% in US before, 23.6% now
- HEMO study of 1846 patients on conventional thrice weekly dialysis randomized to receive kt/V of 1.45 v.S. 1.05 showed ***no improvement*** in survival or hospitalization when dialysis dose was increased.

The most common modalities used for treating kidney failure leave the patient in a state of, well, kidney failure. *– J. Curtis, "Why Home Hemodialysis?" Dialysis and Transplantation Magazine, August, 2008*

Fluid Control



Fluid affects of thrice weekly dialysis treatments on patients

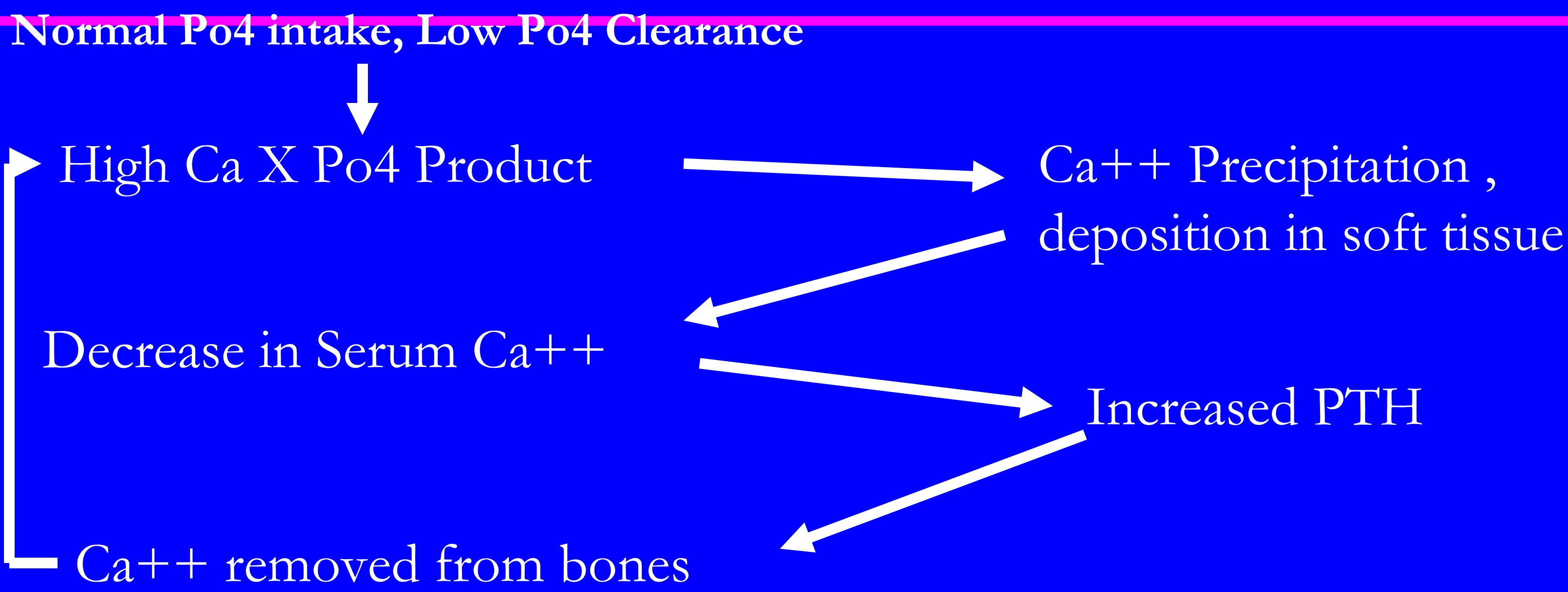
- Blood pressure difficult to control
- Cause considerable stress on heart and cardiovascular system
- Difficulty in determining and maintaining accurate EDW
- Patients have difficulty complying with fluid intake restrictions

Phosphorus

"Trying to remove phosphorus with dialysis is akin to robbing a panhandler outside of a bank rather than the bank itself. You are removing it from where it isn't rather than where it is"

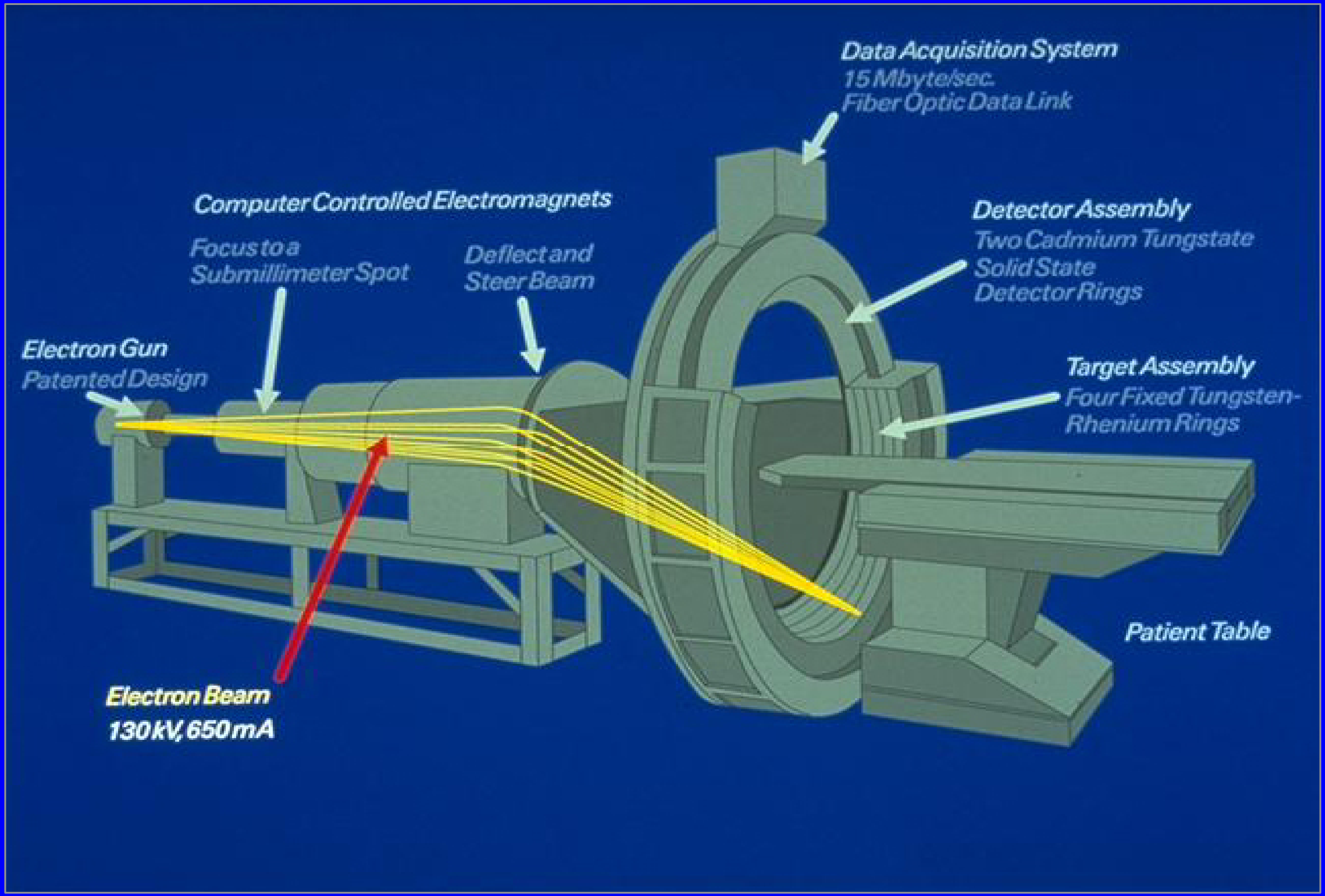
DeSoi CA, Umans JG. Does the dialysis prescription influence phosphate removal? *Semin Dial* 1995; 8(4):201-203.

The Vicious Cycle of Phosphorus



As long as there is too much phosphorus in the blood stream, calcium will be constantly removed from the bones, where it is needed, and deposited in soft tissue, where it is harmful.

Electron Beam Computed Tomography (EBCT)



Slide courtesy of P. Raggi.

EBCT Scores and CV Risk

Mayo Clinic EBCT Guidelines[1]

EBCT Score	Plaque Burden	Implication for CV Risk
<10	Minimal	Low
11-100	Definite, Mild	Moderate
101-400	Definite, Moderate	High
>400	Extensive	Very High

An average dialysis patient's score reaches 2,000 by month three of dialysis!

1. Rumberger JA, et al. *Mayo Clin Proc*. 1999;74:243-252.

There is more to dialysis adequacy than urea removal

- As a healthcare industry, we should strive to help out patients feel as best as they can, and live as normal of a life as possible
- Our focus should be on the patients, and not merely data on a variety of indicative parameters
- As an industry, we care for over 350,000 patients-

ONE PATIENT AT A TIME!

Thank you!

QUESTIONS?

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