

#37Vincenzacourse

Evolution of CRRT Technology



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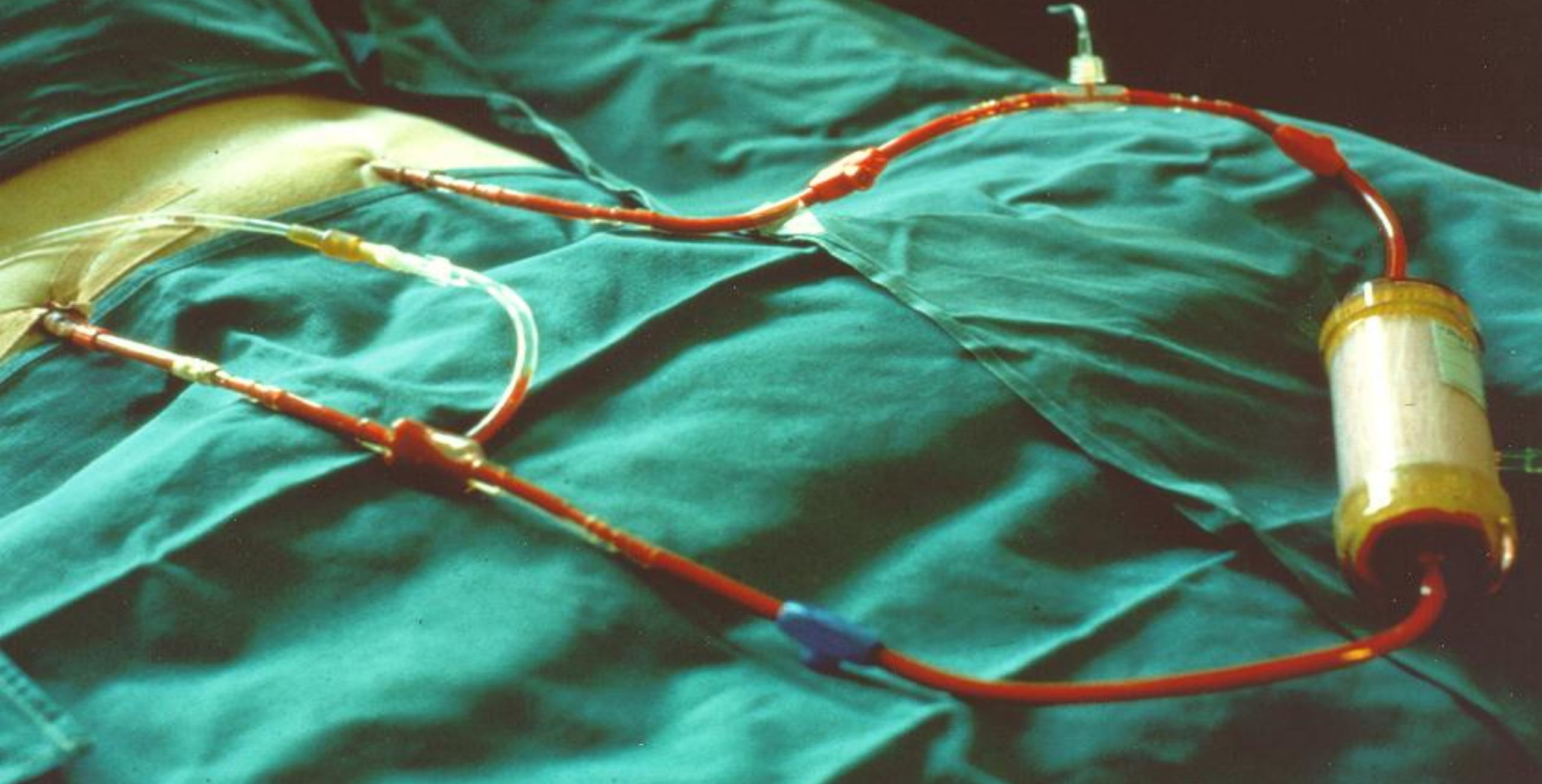
DISCLOSURE

Consultant: Astute, Baxter, OCD, Medtronic, Asahi Medical, Jaffron,

Advisory Board: GE, Kaneka, Cytosorbents, Abbot, Biomerieux

Speaker Bureau: Toray, Estor, FMC, Bellco, Ferrer, Adcock, Otsuka

First CAVH Treatment in Vicenza, 1977



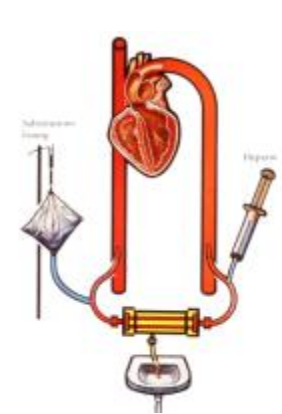


PRESENT

FUTURE

PAST

40 years of CRRT



CAVHD
CAVHDF
Fluid
Balance
systems

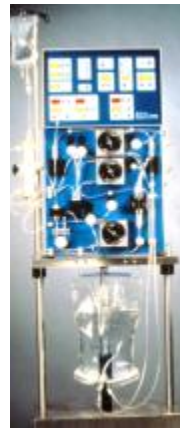
1983



First
generation
CRRT
machines
CVVH
CVVHD
CVVHDF
1990



1995
Second
generation
CRRT
machines
CVVH
CVVHD
CVVHDF
and studies
on Dose &
Adequacy
35 ml/Kg/h



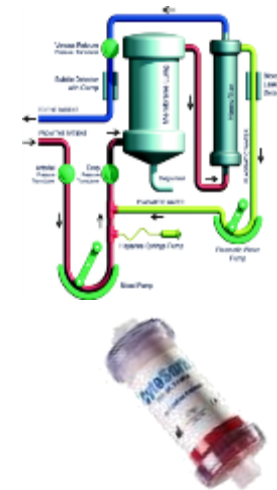
Third
generation
CRRT
machines,
Tr. of Sepsis
HVHF &
HCO Membr.
2002



2005
Liver support
MOST, CPFA



Lung support
ECCO2R
Citrate
anticoagulation
Sorbents
2010



Fourth
generation
CRRT machines
2017



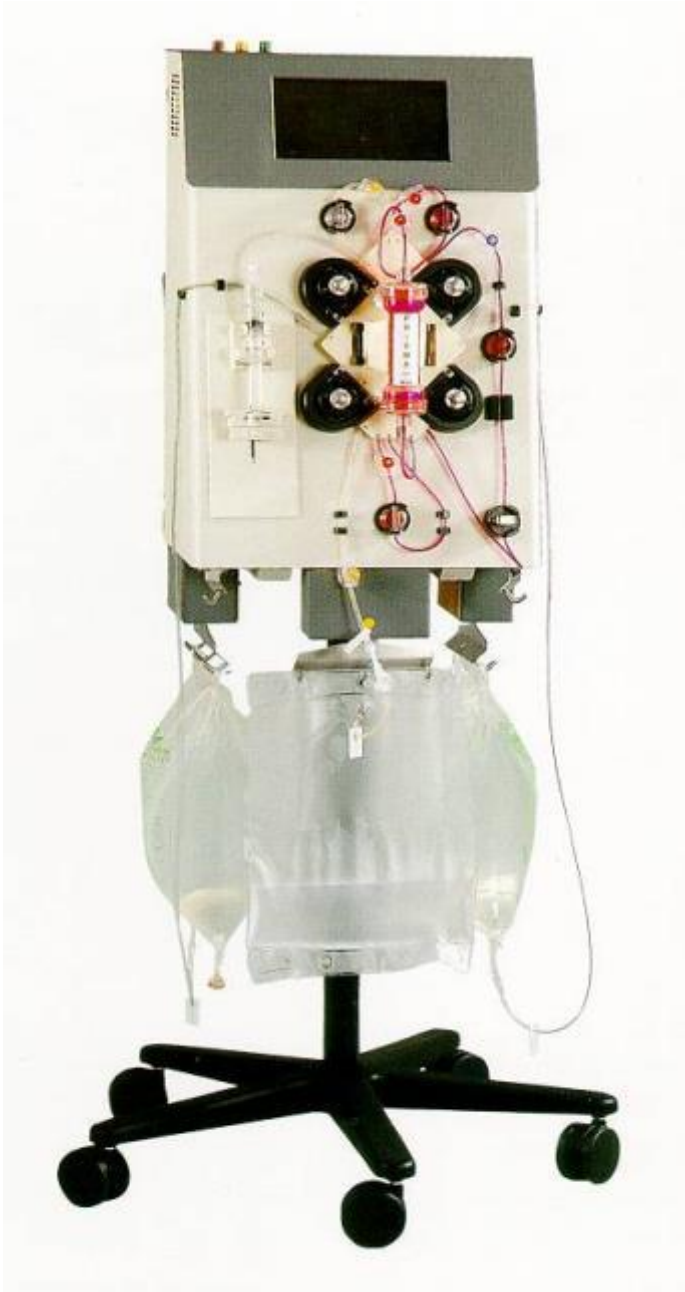
1977
First CAVH
In Gottingen
and
First CAVH
in Vicenza



1986
CVVH
CVVHD
and
Adoptive
Technology



HOSPAL PRISMA



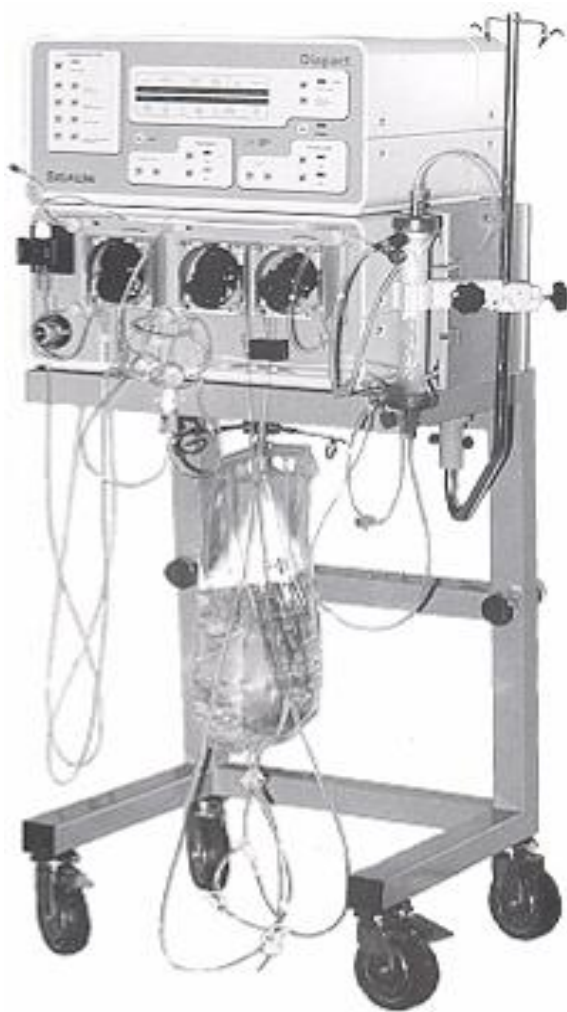
Features:

Self loading of lines and autopriming of the circuit. Treatments performed: CVVH-CVVHD - CVVHDF with large capacity of fluid handling. Large display for operations.

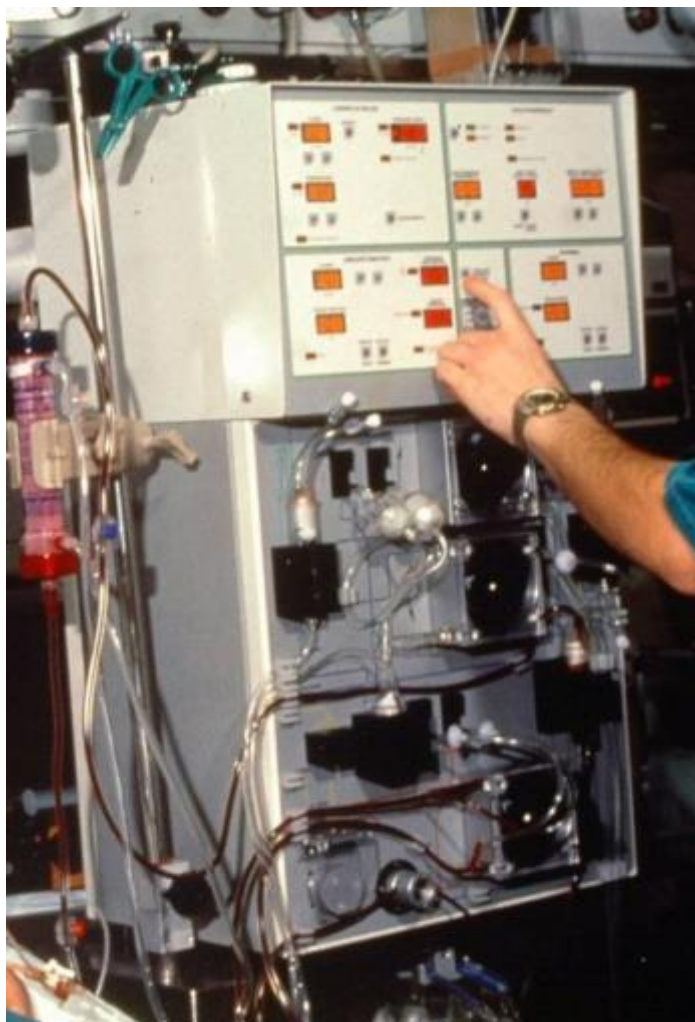




From ECU to Omni: a long way



1988



1991



1994



From ECU to Omni: a long way

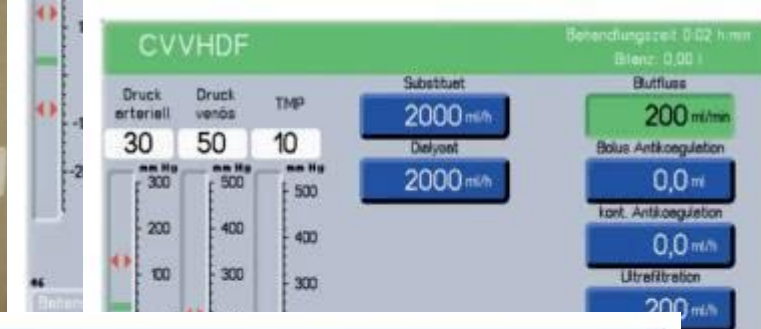


2004



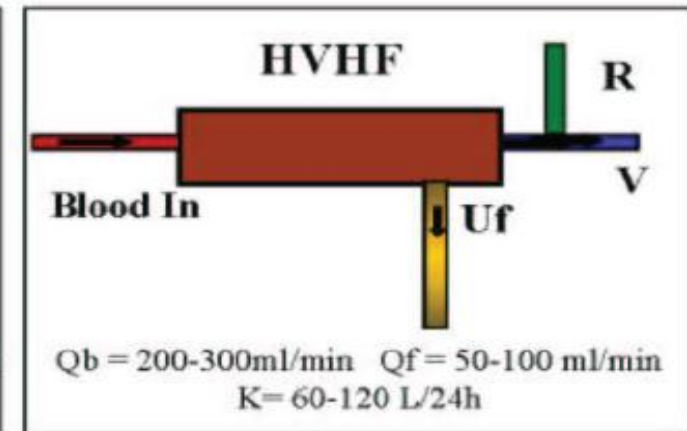
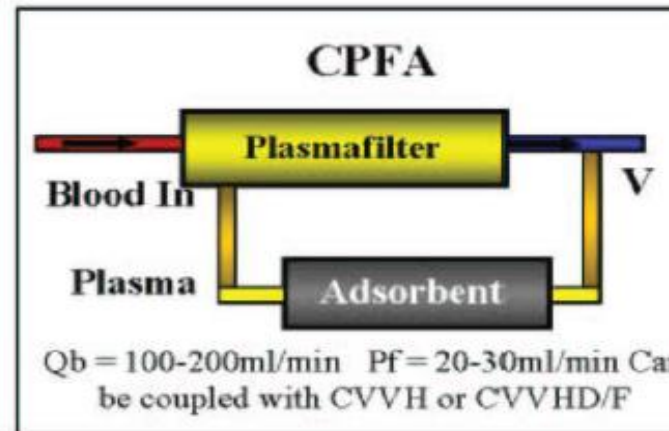
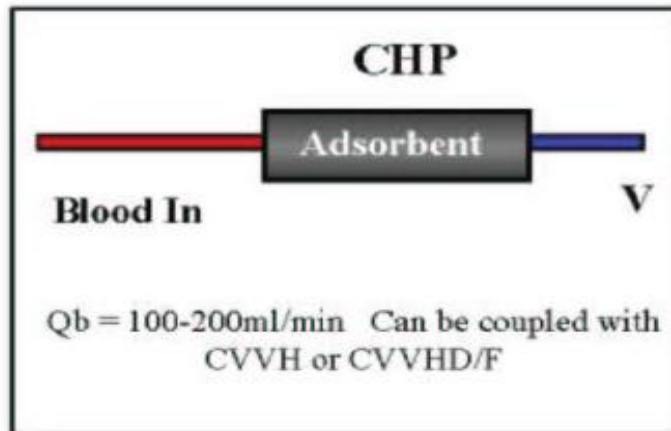
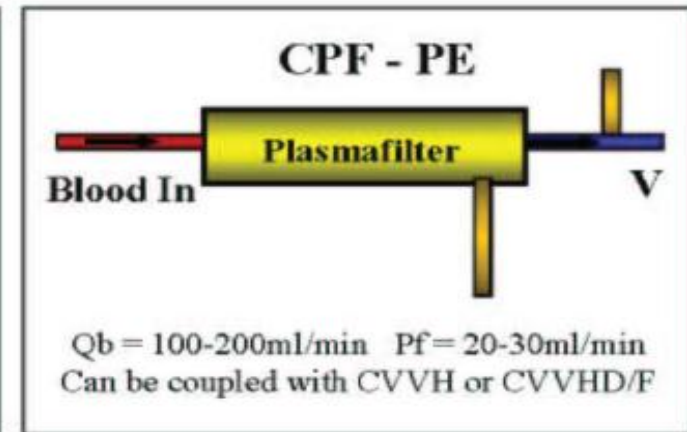
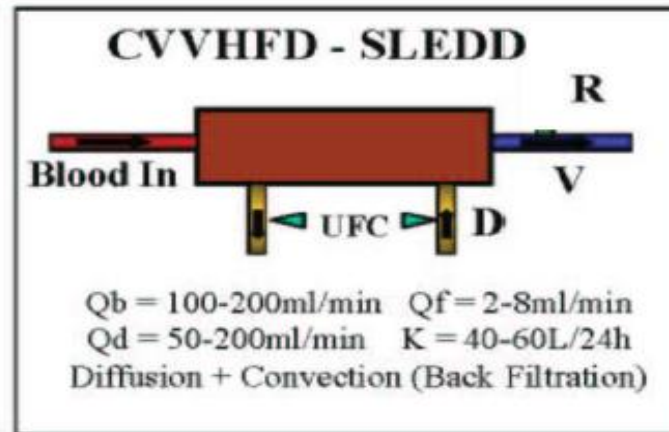
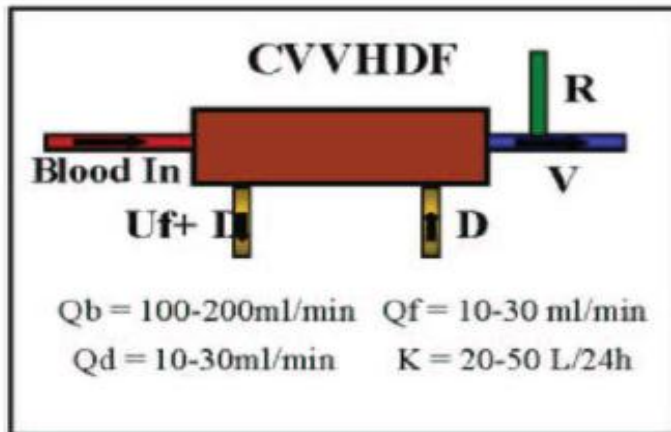
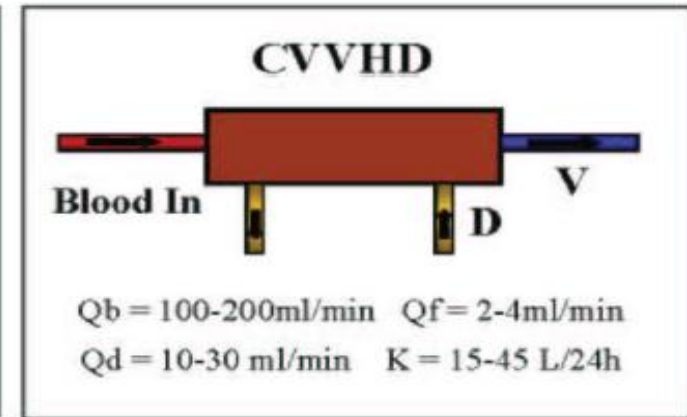
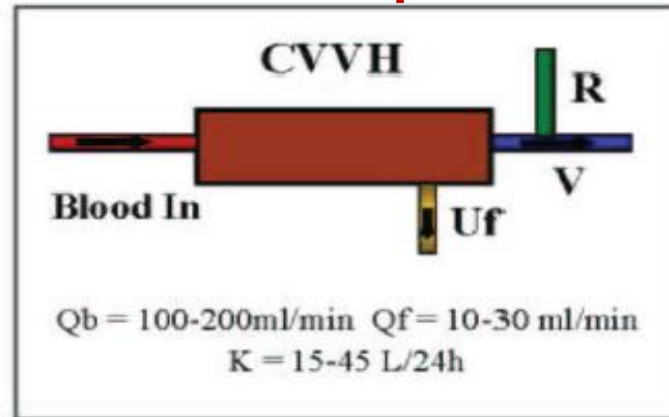
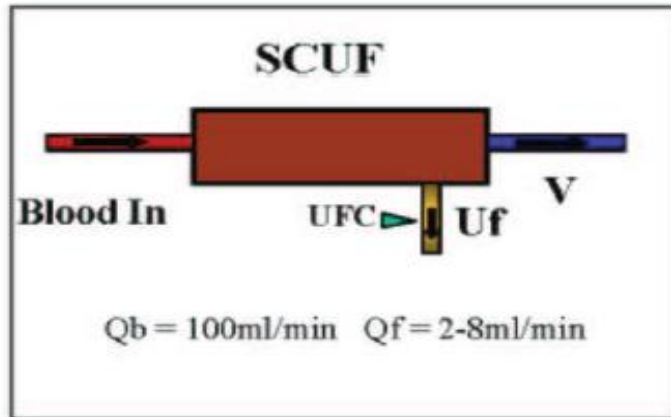
2017



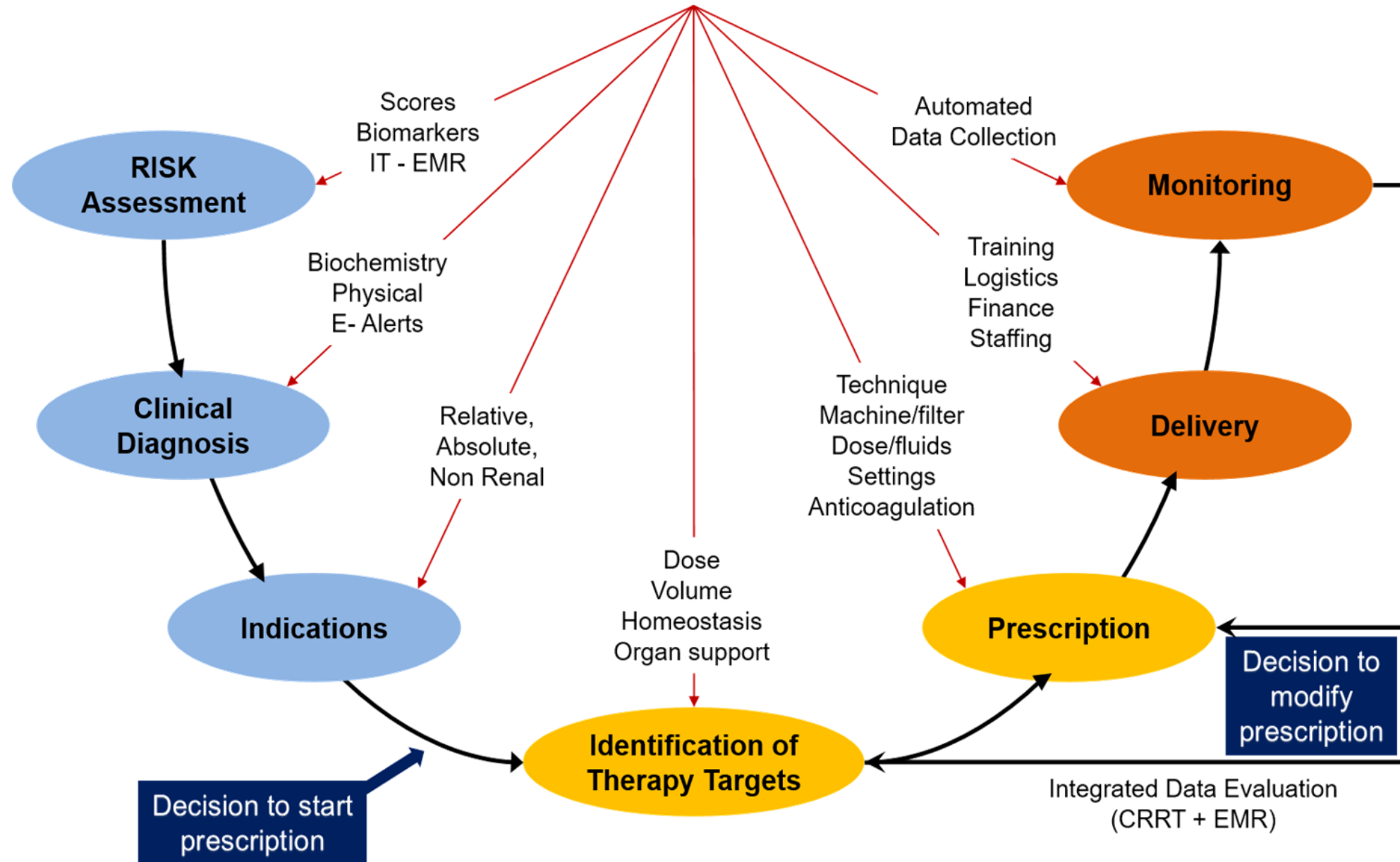


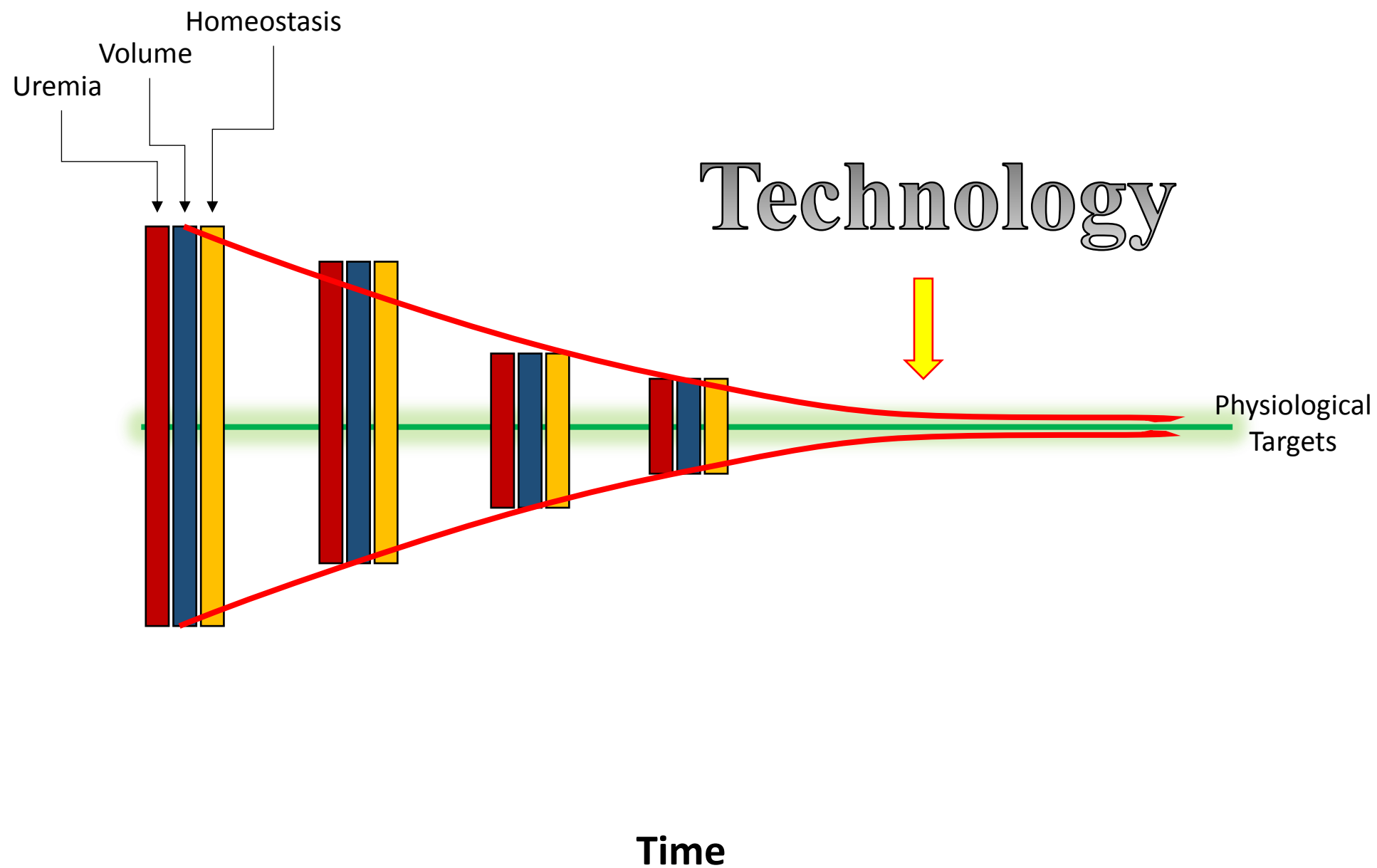


Techniques

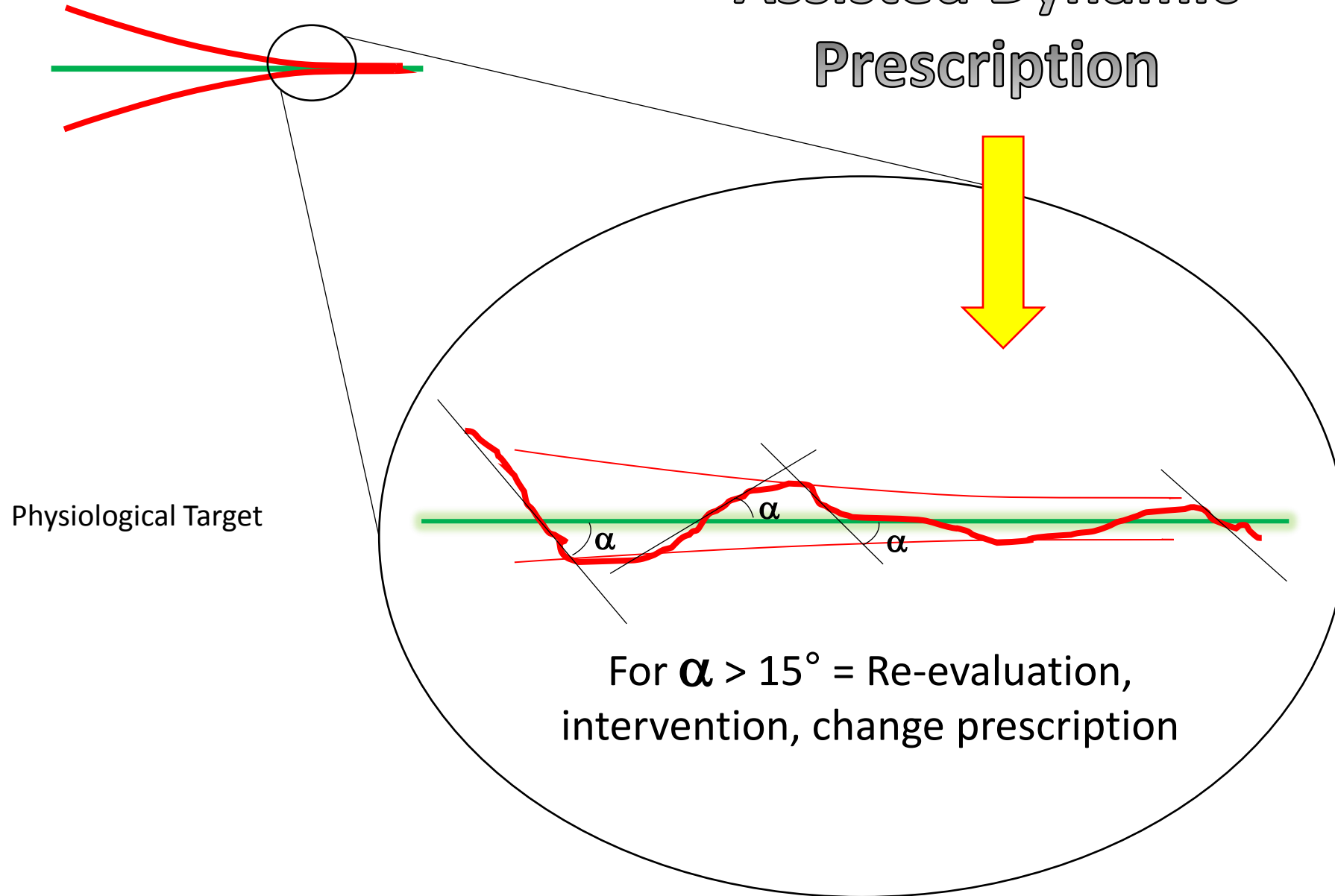


Technology in CRRT



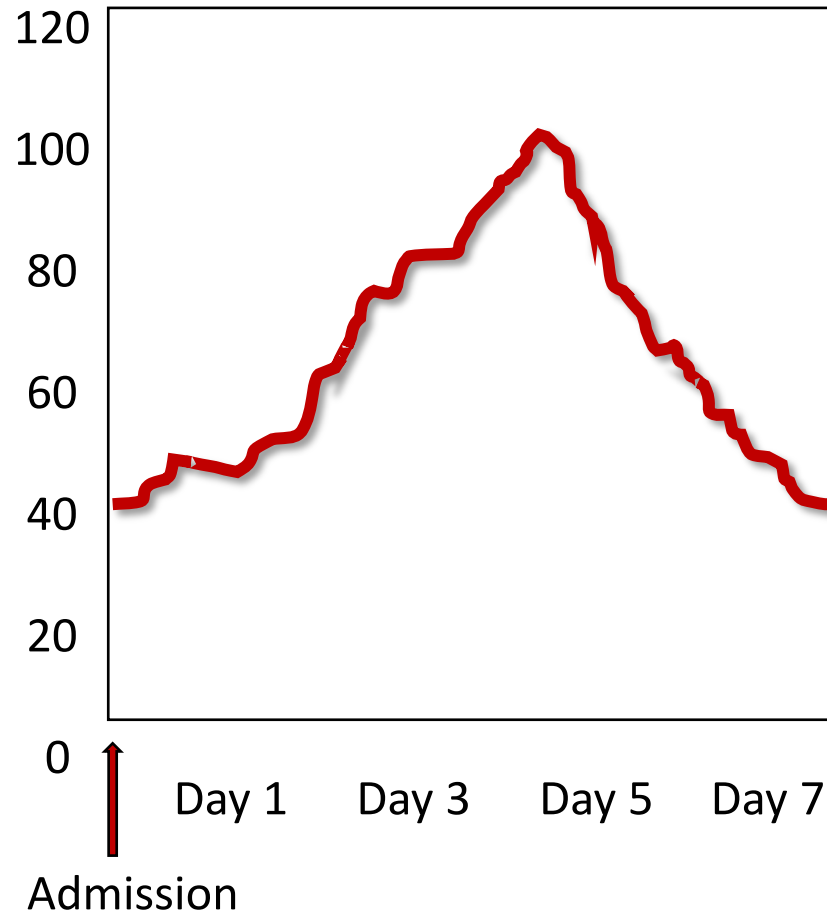


Assisted Dynamic Prescription

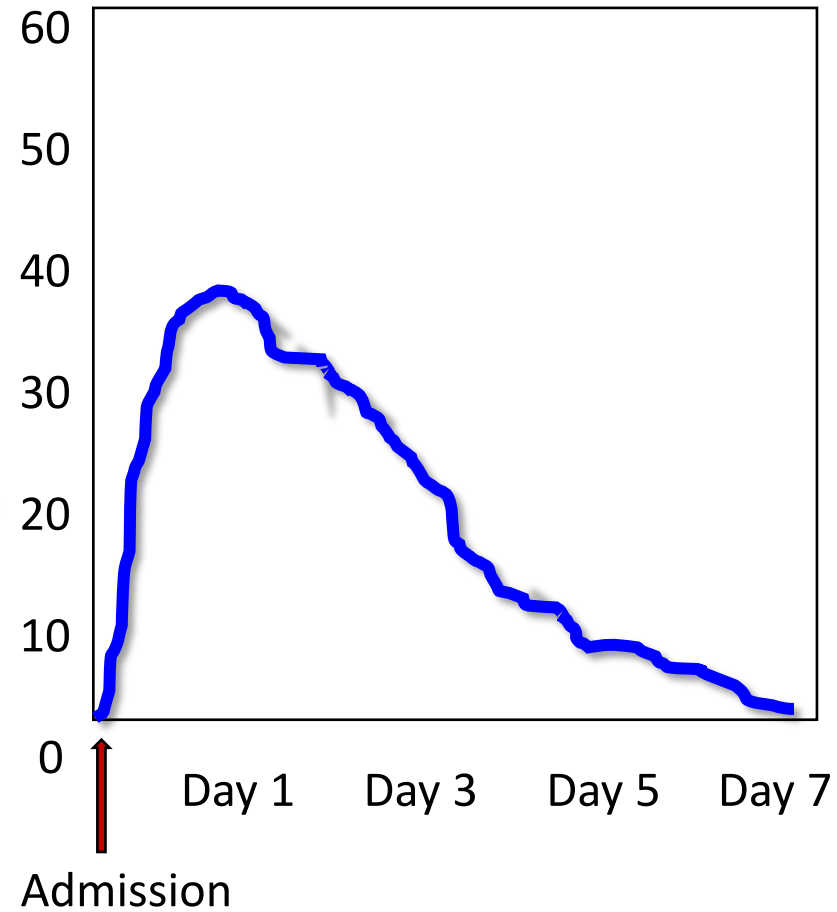


Metabolism and Volume

Azotemia

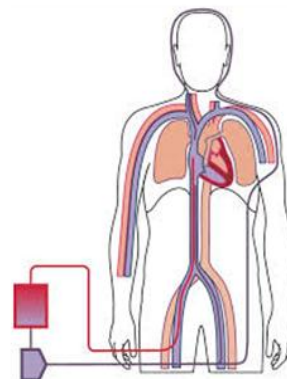


F O %

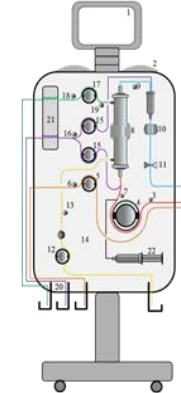




Clinical Chemistry
Laboratory



Patient



CRRT Machine

Data

Signals

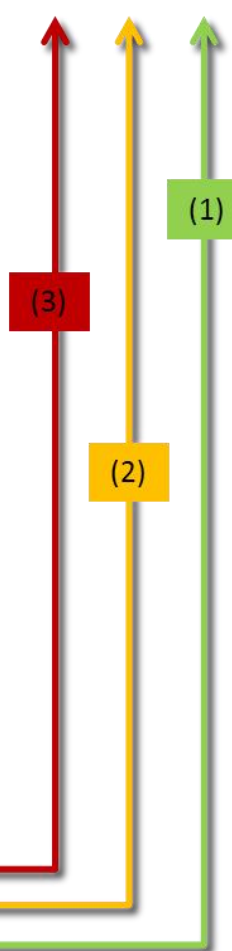


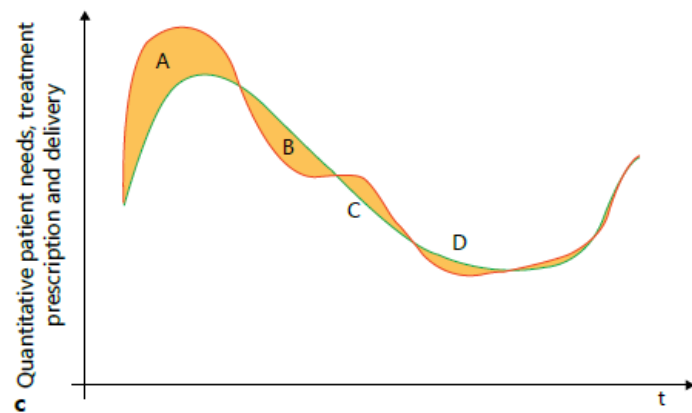
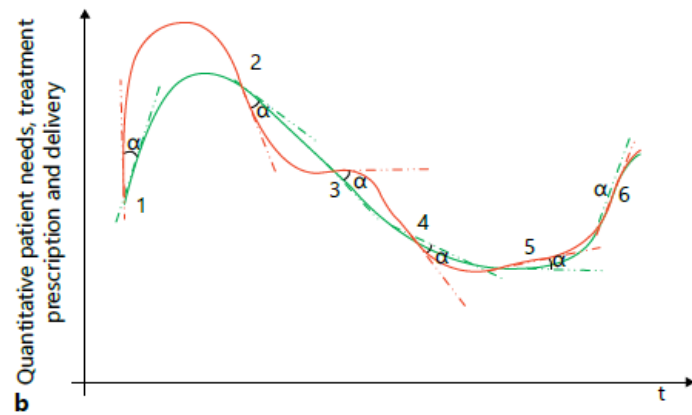
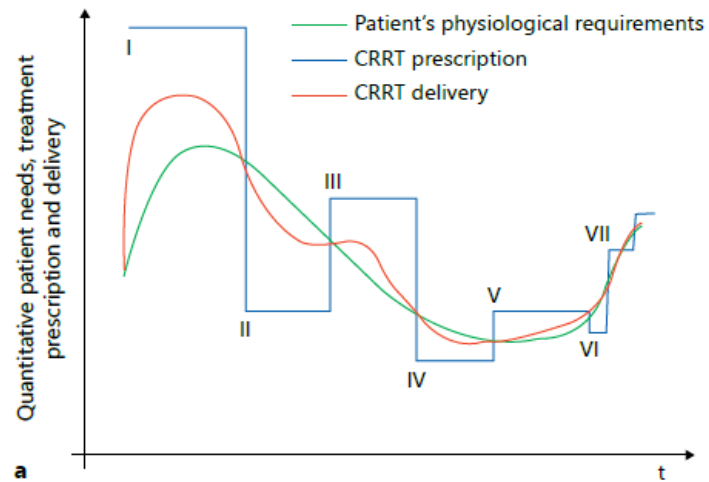
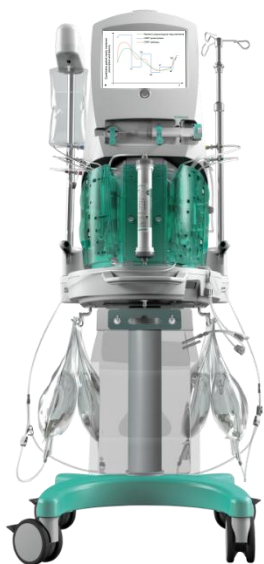
Combined Data/Signal
Expert Analysis

(3) Fully
Automatic
Biofeedback

(1)
Nurse Manual
Biofeedback

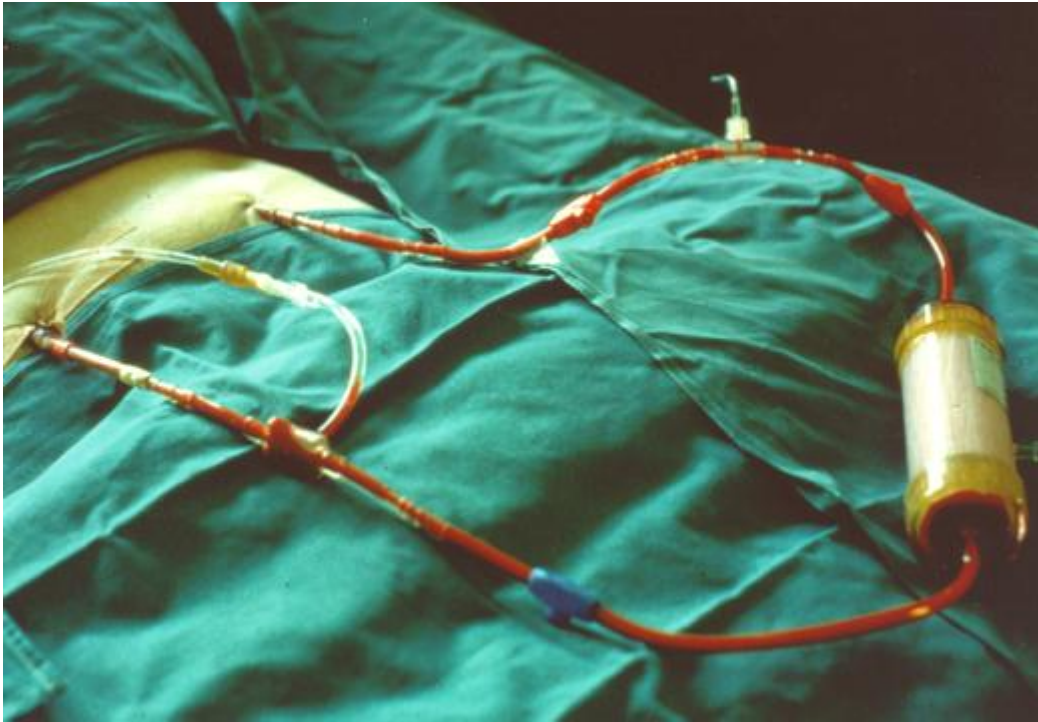
(2) Nurse
Authorized
Biofeedback





Leading Science of CRRT in Vicenza

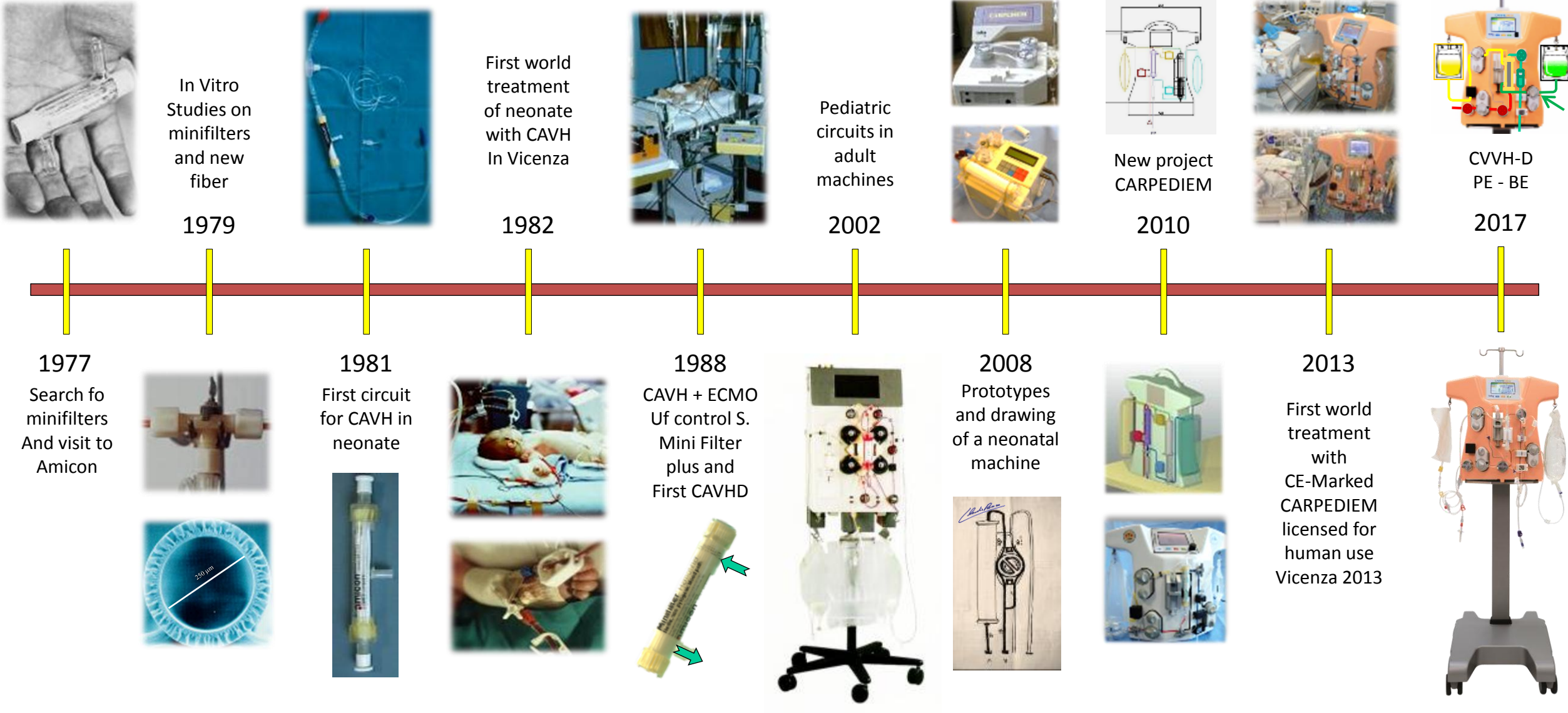
First Adult CAVH in Vicenza 1977



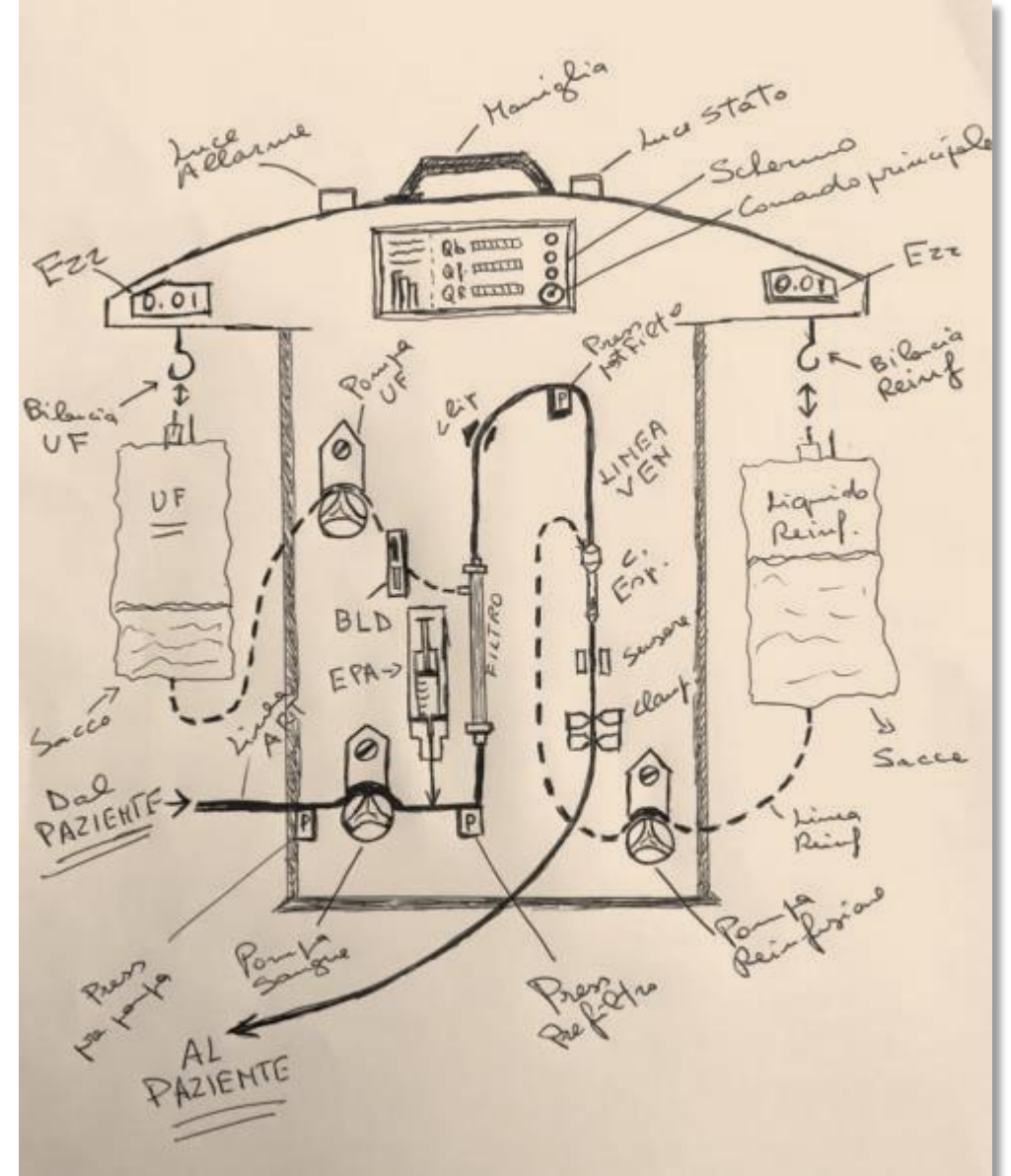
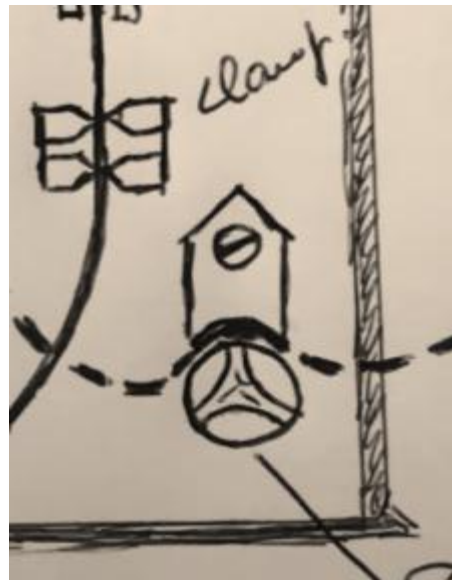
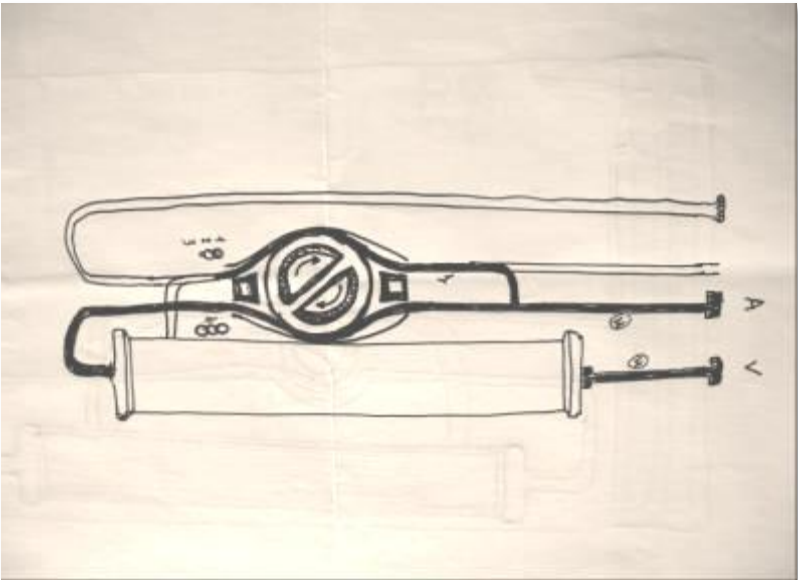
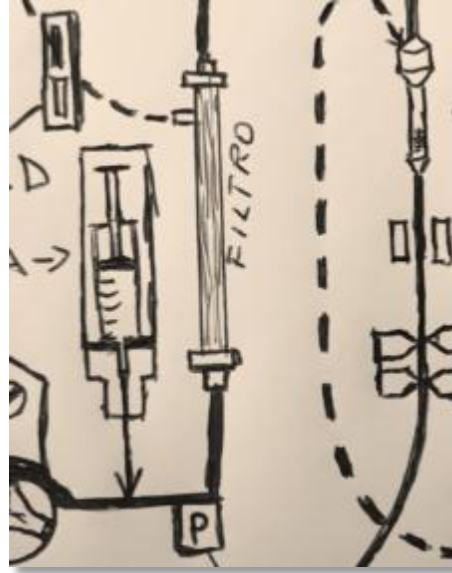
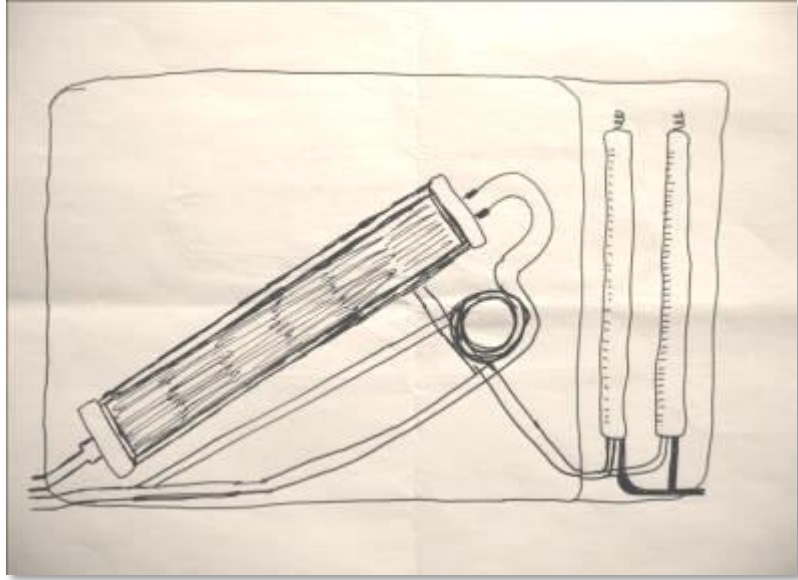
First Neonate CAVH in Vicenza 1982



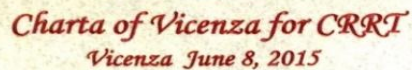
40 years of Pediatric CRRT



From a sketch and project to the Final Machine







The Participants of the Vicenza 2015 Nomenclature Standardisation Initiative (NSI), agree to make any possible effort to standardize the nomenclature of continuous renal replacement therapies and to homogenize its terminology in manuscripts, books, machine software and data collection registries of the future.

The NSI Alliance

[illegible]

**FRESENIUS
MEDICAL CARE**



NIKKISO

MEDICA



B | BRAUN
SHARING EXPERTISE

Baxter
GAMBRO



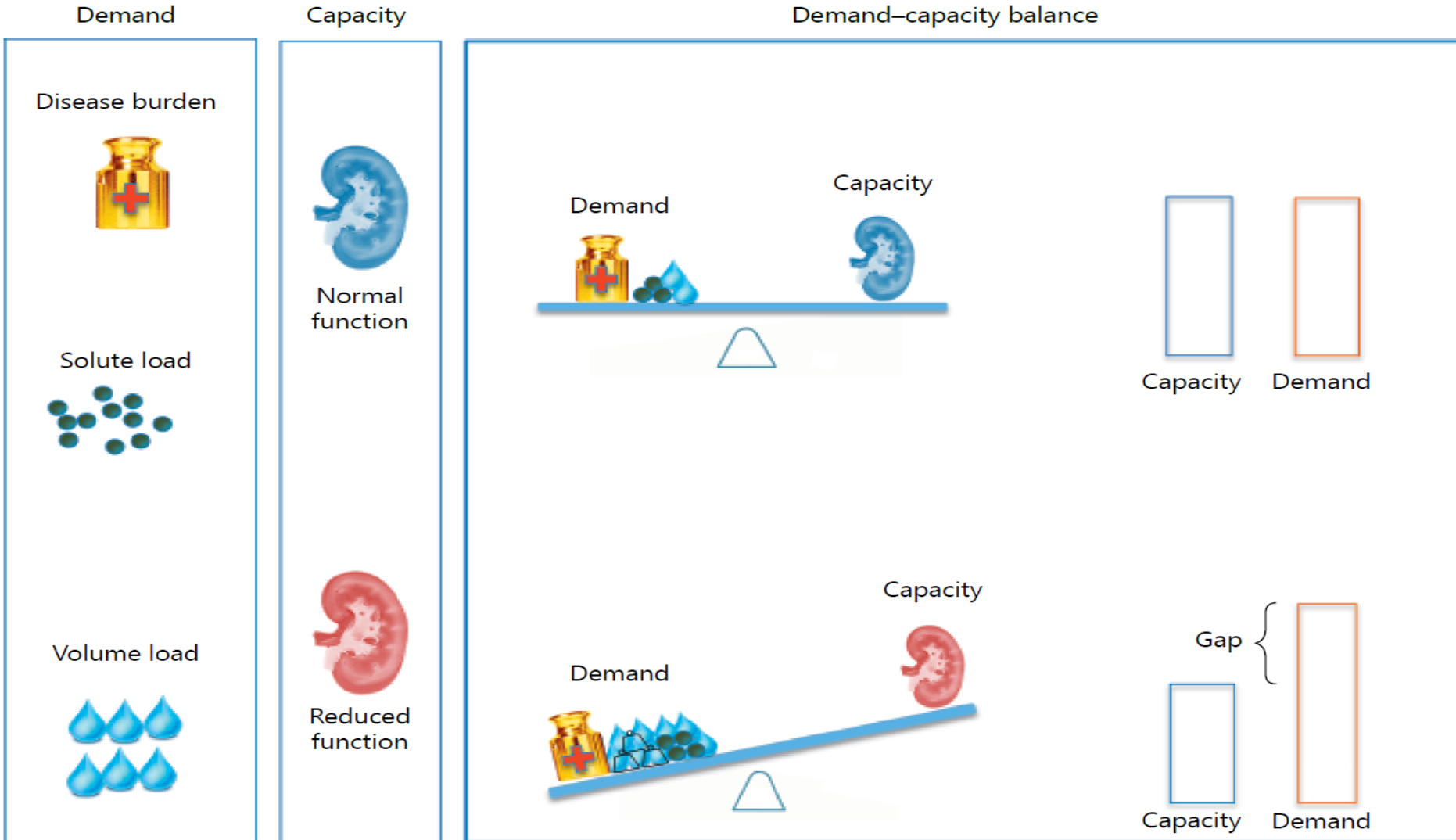
AsahiKASEI
ASAHI KASEI MEDICAL





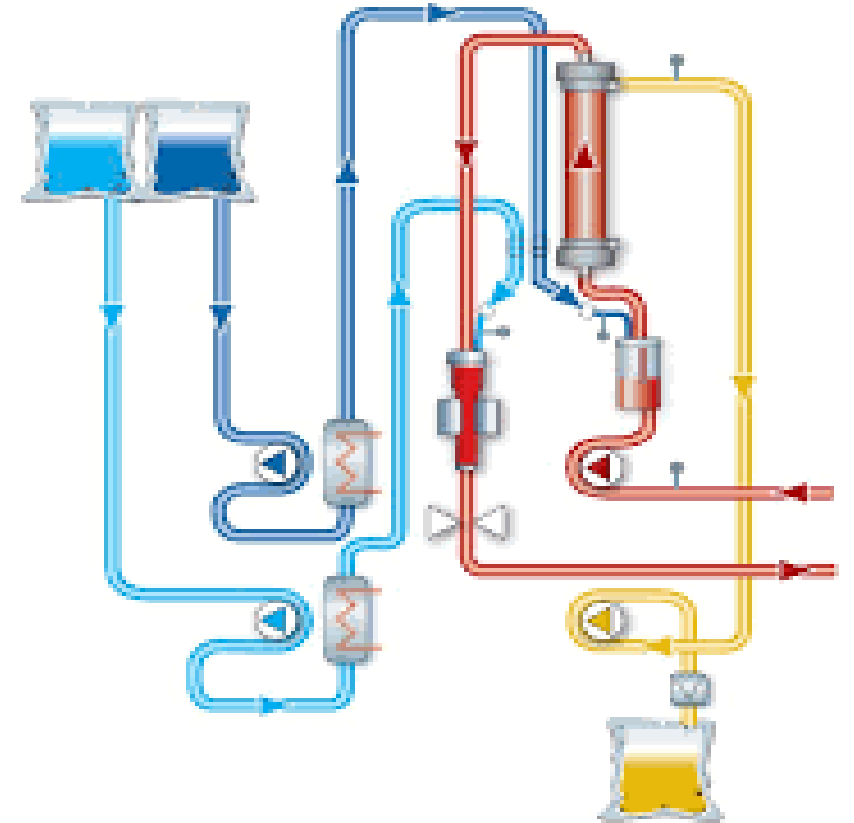
The Future of CRRT

PATIENT IDENTIFICATION



Extracorporeal circuits

- ⊕ Antithrombogenic
- ⊕ Anti microbial properties
- ⊕ Temperature self adjusting
- ⊕ Collapsible (minimum storage volume)
- ⊕ Biodegradable (minimum wasting)



Devices, MOST and ECOS

- ⊕ Fluid Balance control
- ⊕ New Membranes
- ⊕ New sorbent devices
- ⊕ Wearable devices
- ⊕ Population-specific therapies

Multiple Organ Support in Critical Illness and Sepsis



AKI & Sepsis



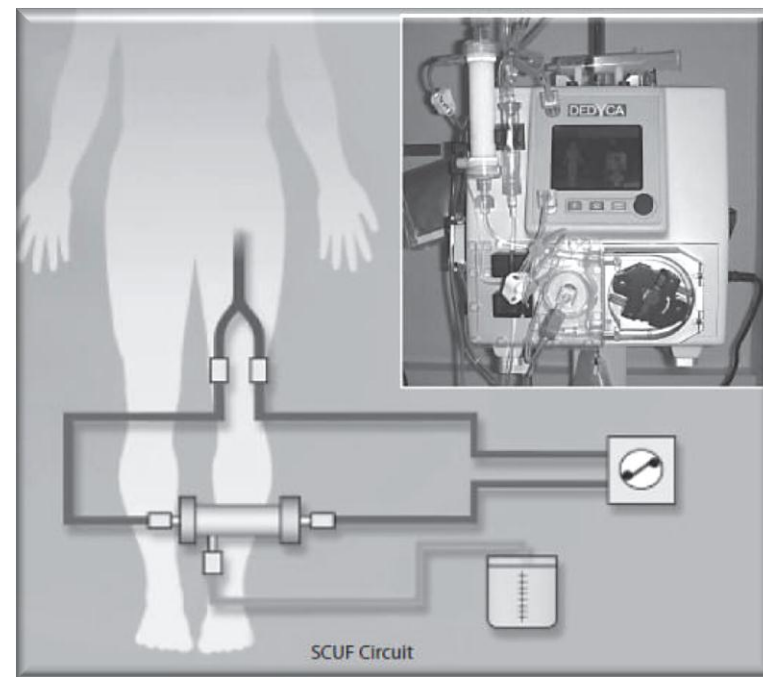
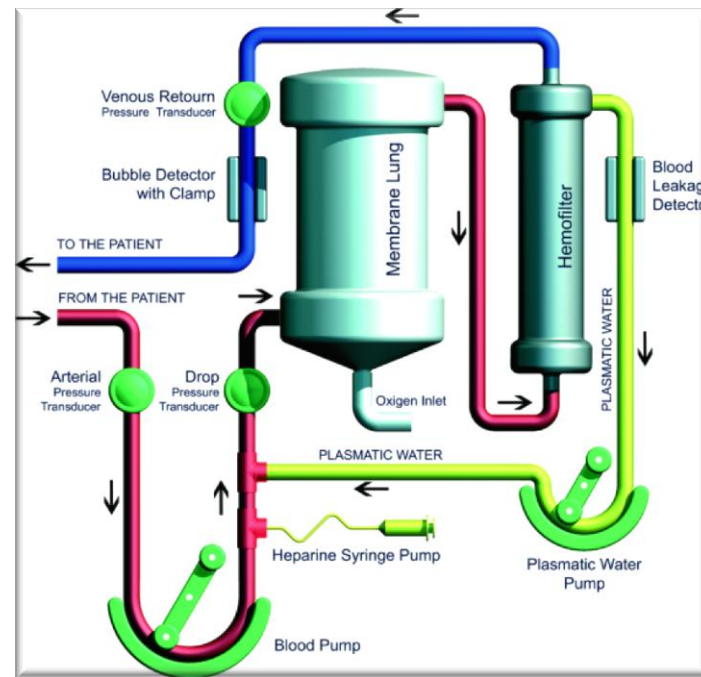
Liver Support

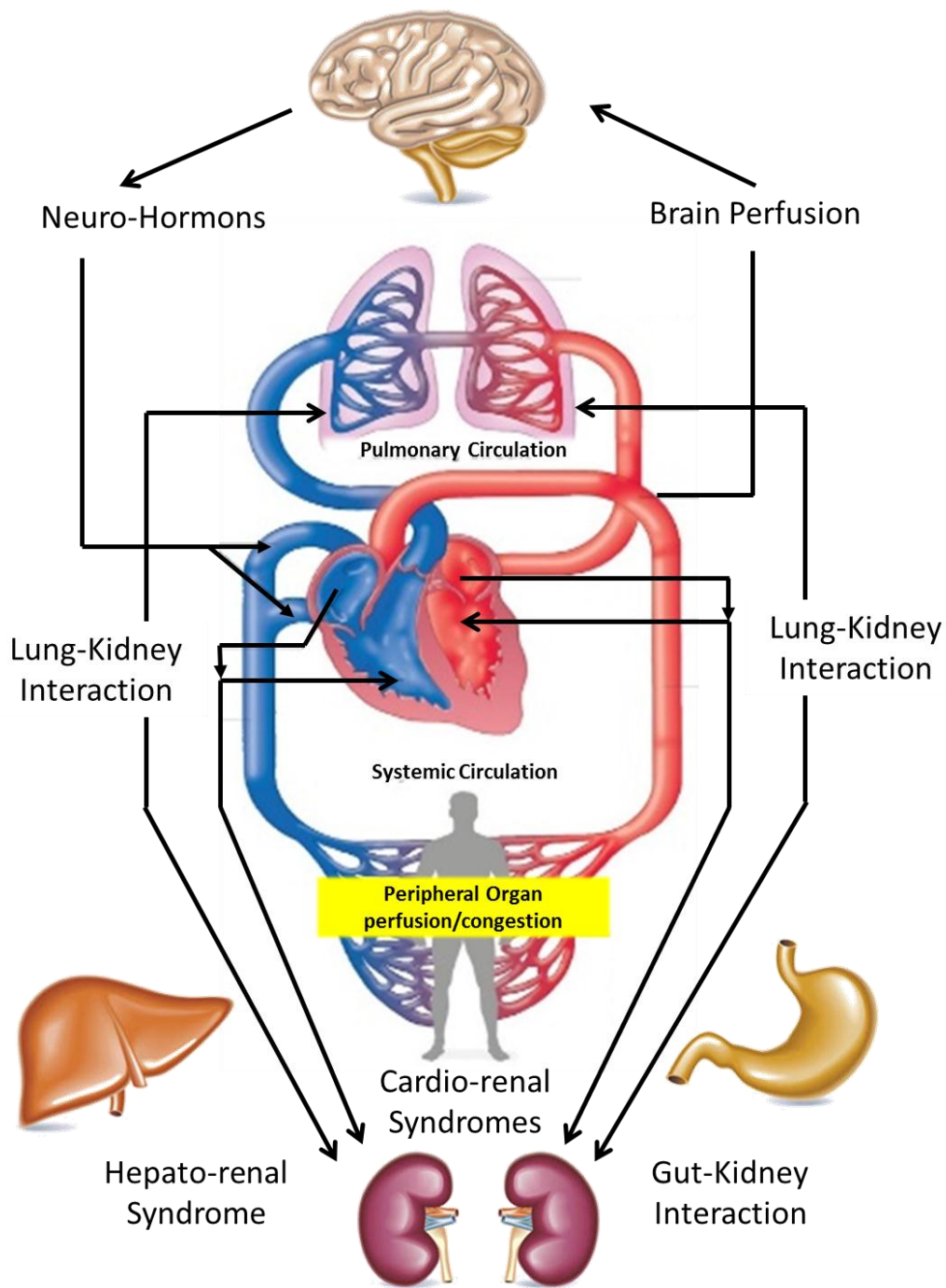


Lung Support ECCO₂R



Heart Failure

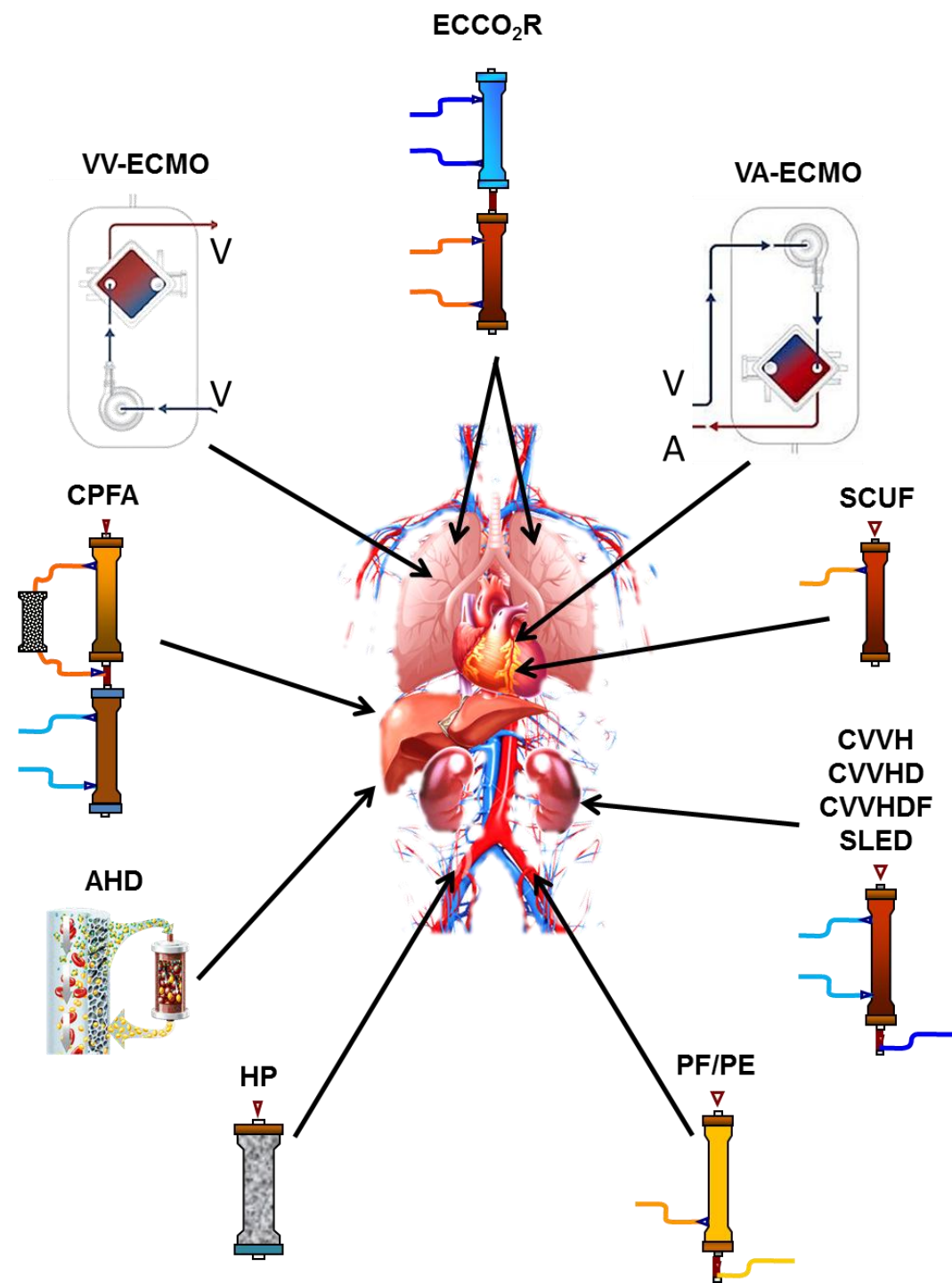


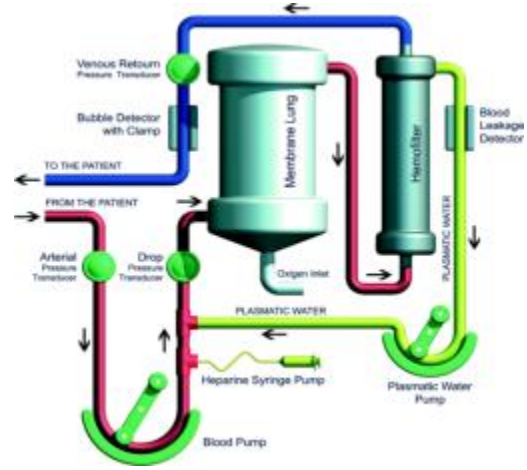


**MOST
and
ECOS**

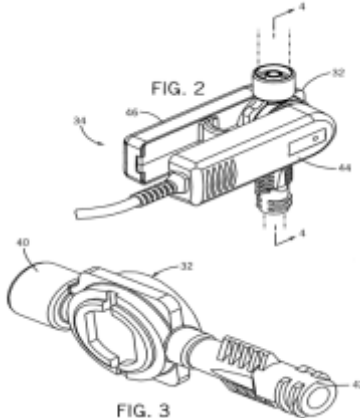
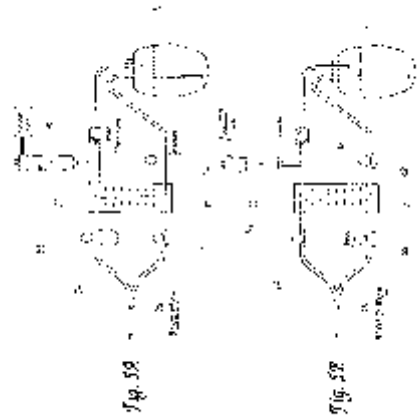


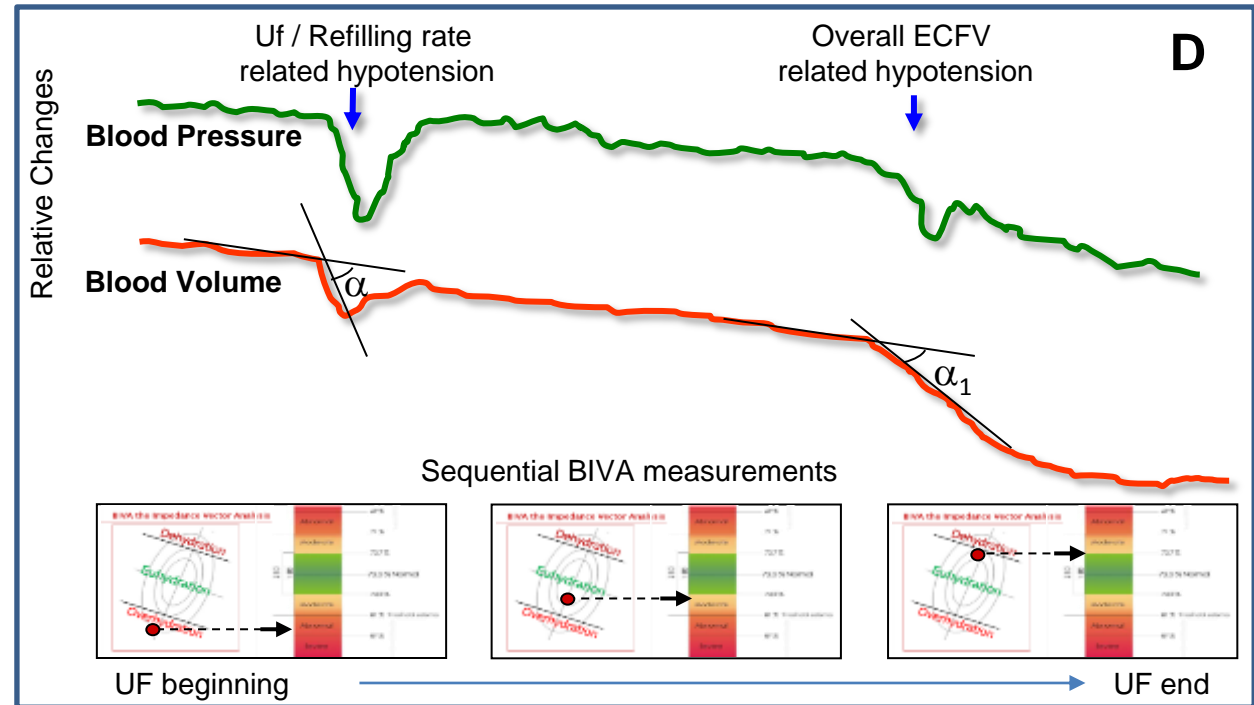
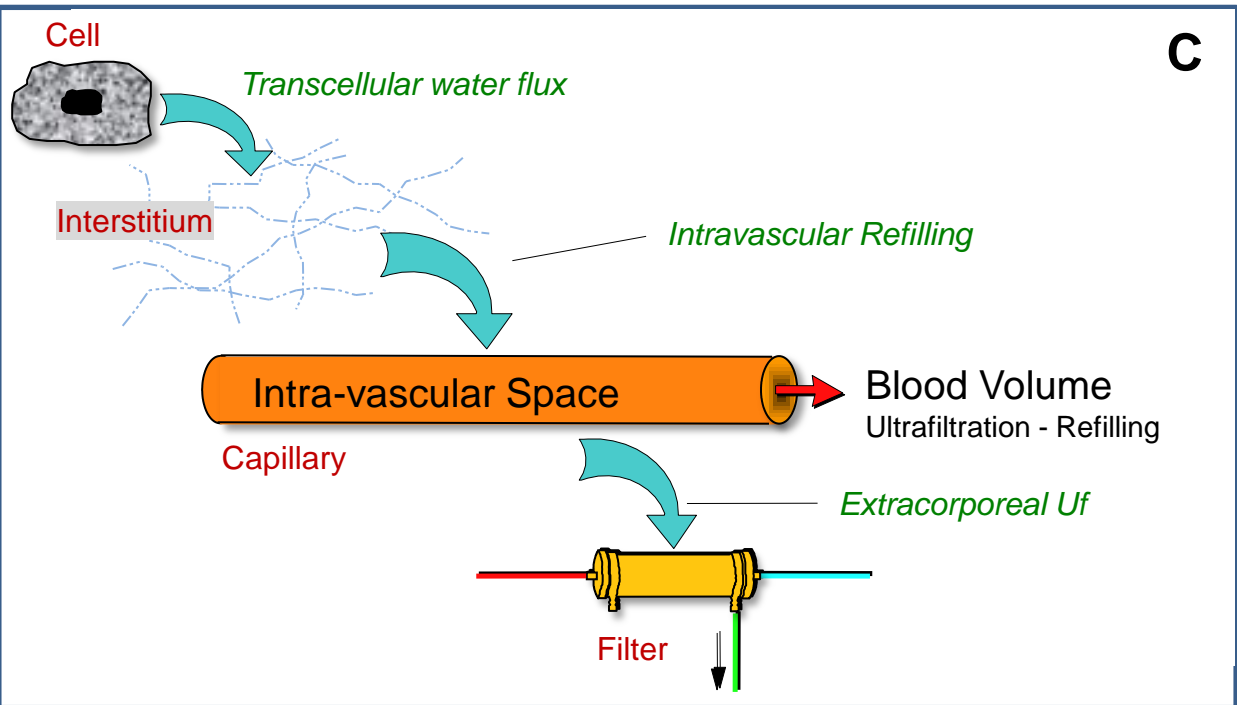
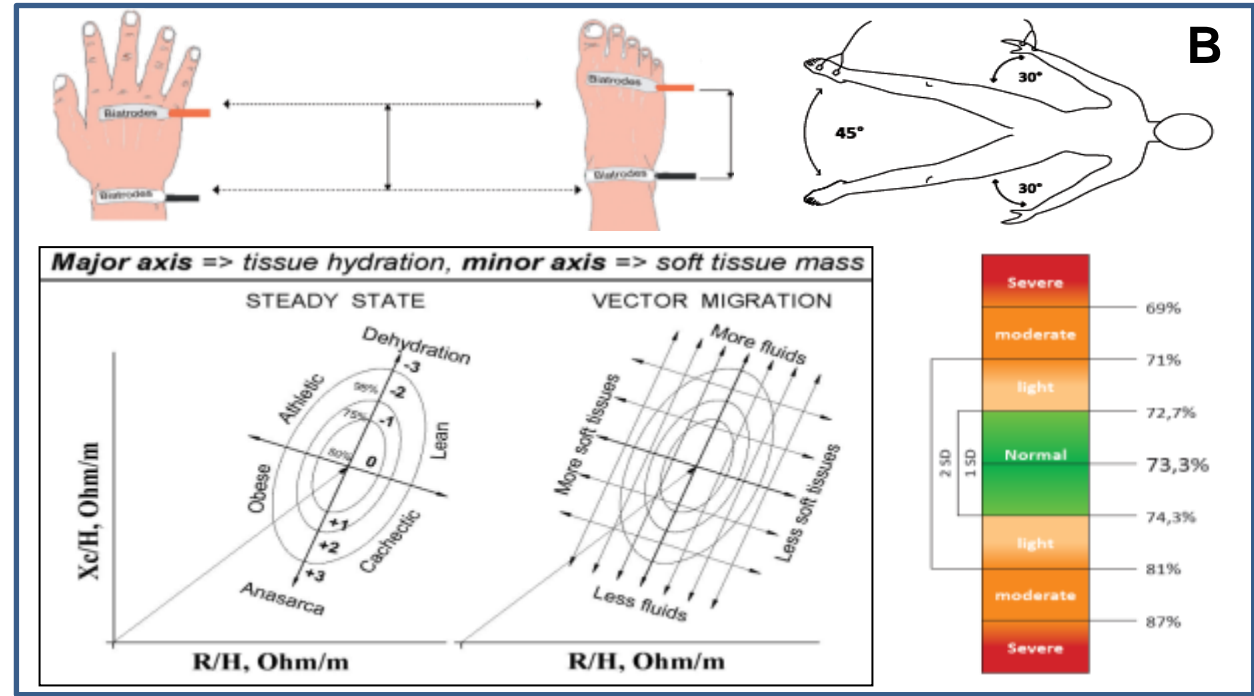
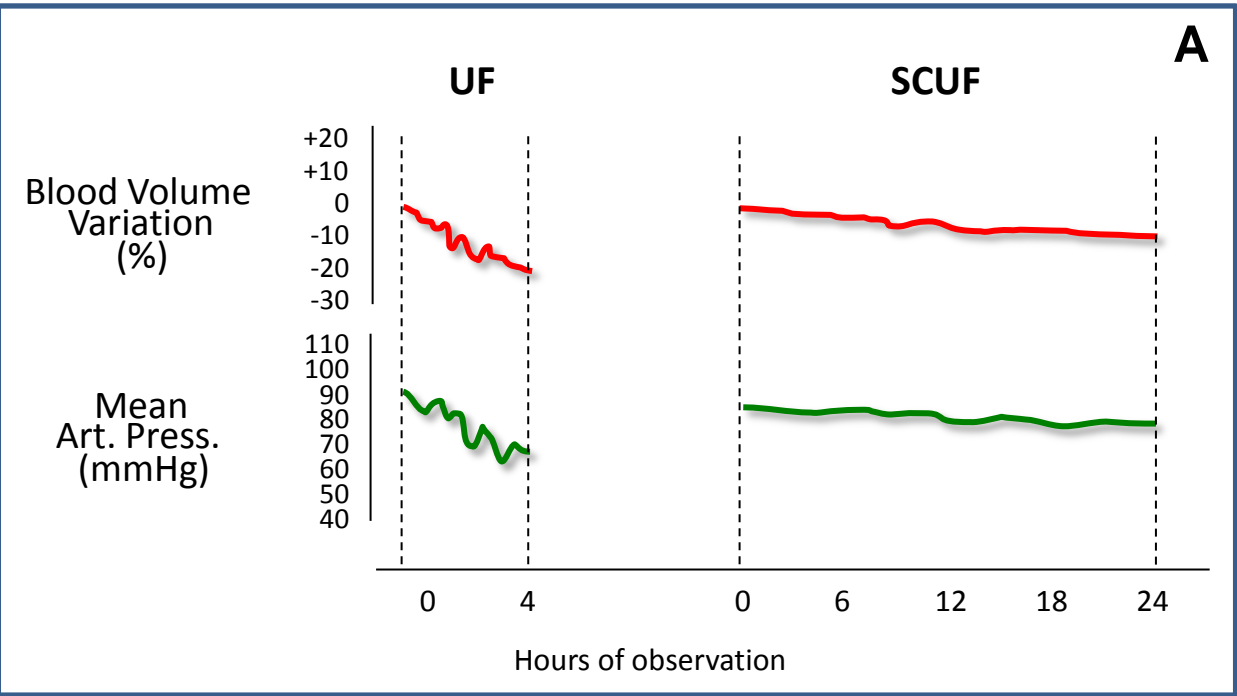
Sepsis



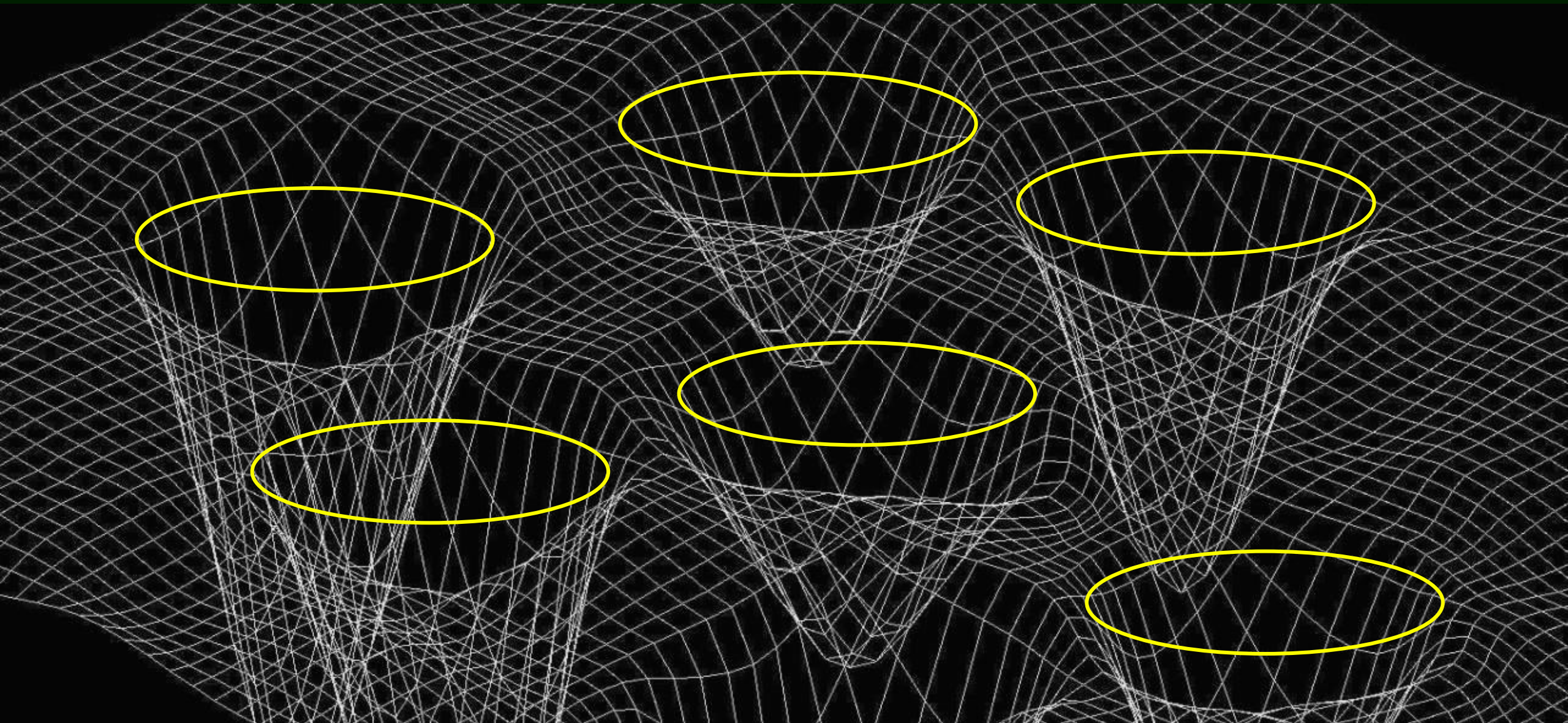


U.S. Patent 5,257,820 BTM



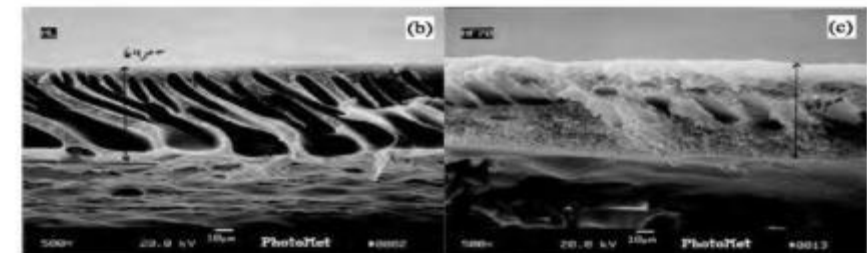
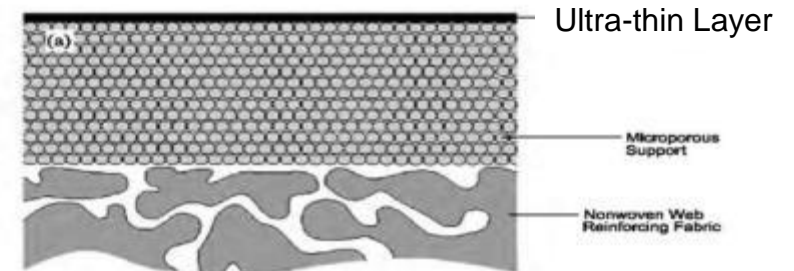
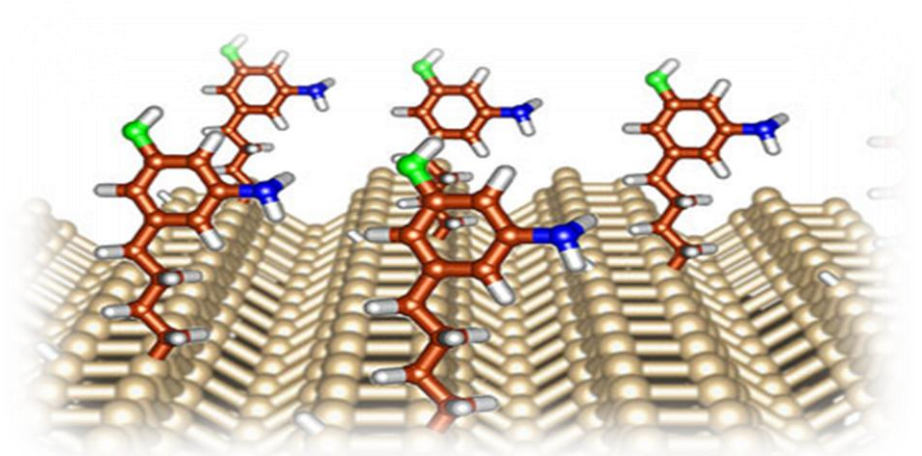
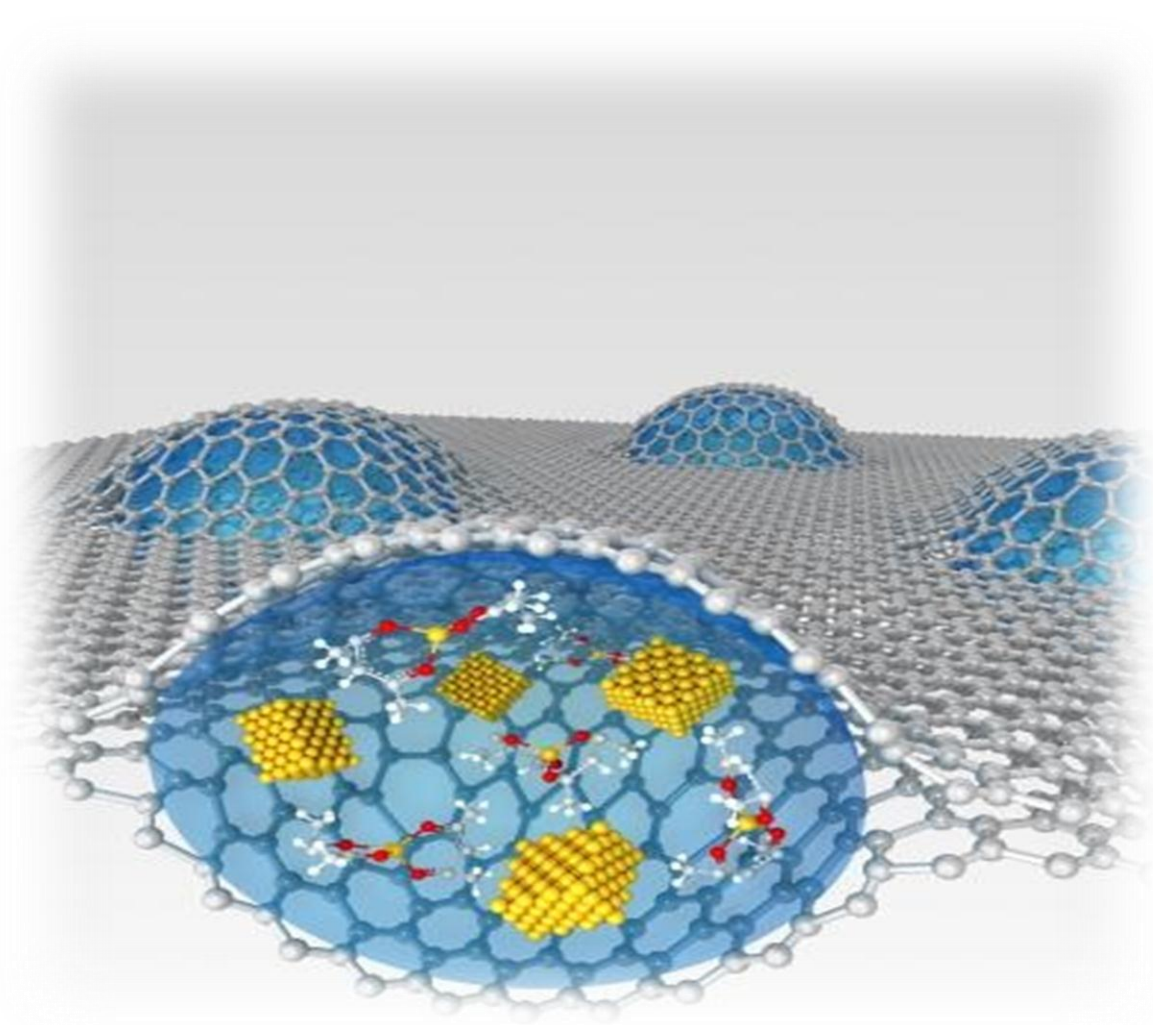


The porosity of the membrane



Effects of Surface Modification

Biocompatibility, Permeability, Non-fouling effect



Water sparing technologies

(Blue Planet Dialysis)

- 1.Regeneration
- 2.Double filtration
- 3.Physical-chemical processes
- 4.Recirculation
- 5.Sorbent technologies



Patient/Machine Card

Cable / Wi-Fi
Computers on wheels



Resident Medical Record

Virtual private Network
With encrypted tunnel



Cloud Connectivity System

Machine Data Only

Filter Life

Treatment Downtime

Prescribed & Delivered Dose

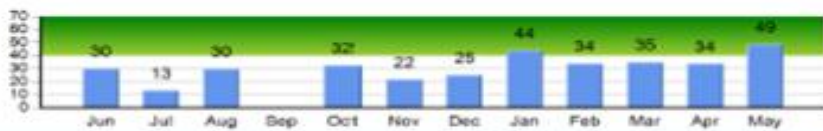
Fluid Removal Parameters

Alarm Management

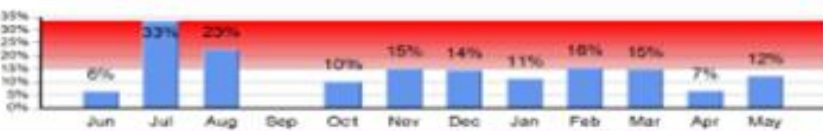
Summary

Prismaflex CRRT Management Report
Sample - Standard - Citrate
as of May 2016

Q. 1) What is our average filter life?



Q. 2) How much treatment time is lost?



Q. 3) How are we tracking toward our dosing target?



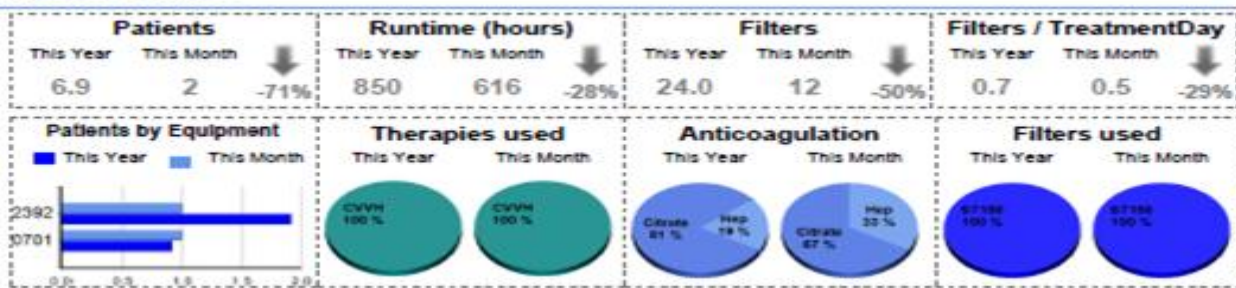
Q. 4) How much fluid was removed per TreatmentDay?



Q. 5) How many access/return (AR) alarms do we have?



May at a Glance



Machine & EMR Data

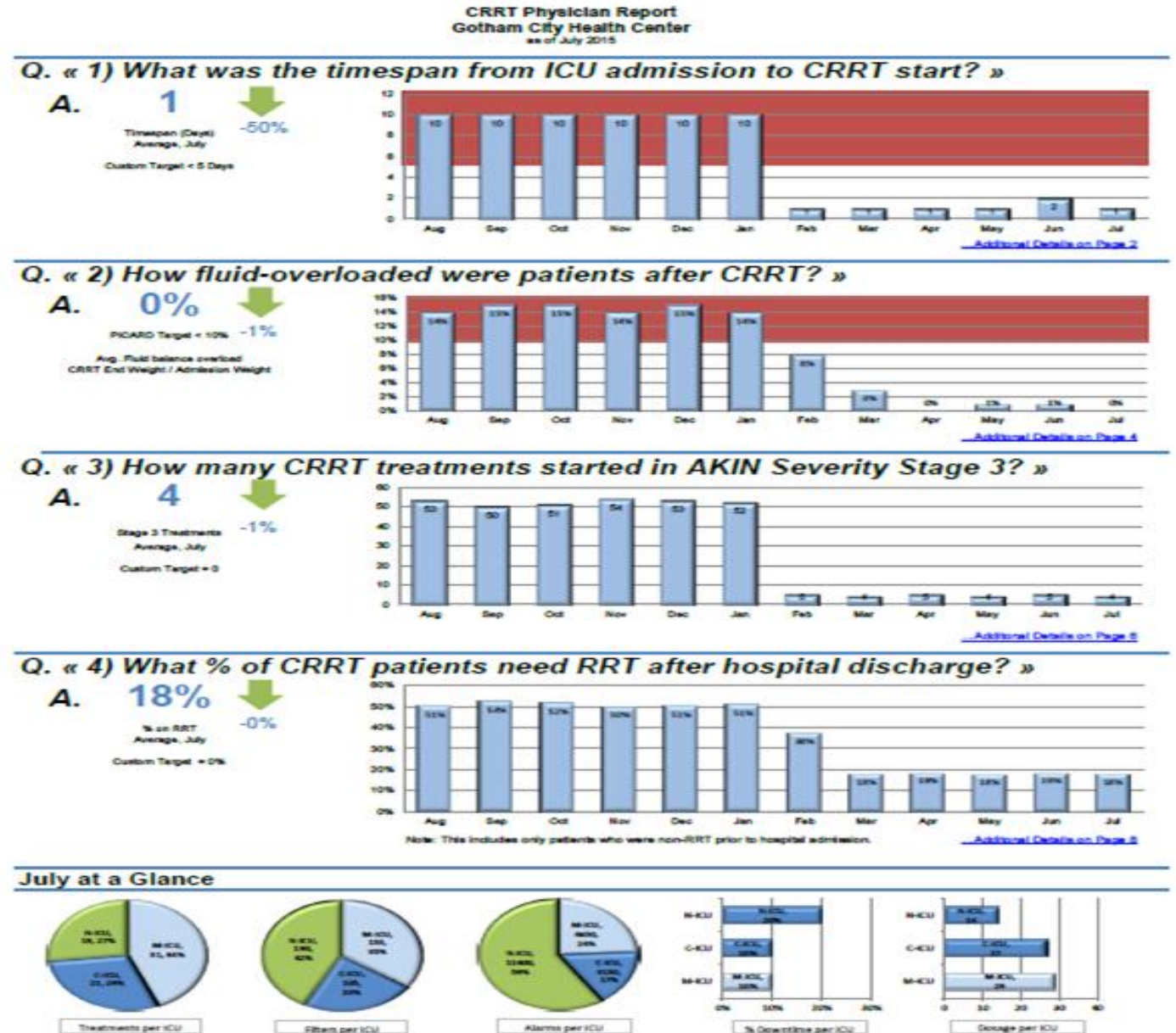
Timing of CRRT Initiation

Fluid Overload and Management, Ventilator and Vasopressor Duration

CRRT Initiation versus KDIGO AKI Stage

Frequency of RRT After CRRT

Summary



The Future of CRRT

An integrated and multidisciplinary approach

There is a multiple organ involvement in critical illness. Specific clinical conditions may begin with impaired function of one organ, but subsequent or immediate dysfunction in other organs can often happen (cardio-renal, heart-lung disorders, hepato-renal and cardio-pulmonary renal syndromes).

The diagnostic as well as therapeutic approach to the patient should be multidisciplinary and complete (holistic?).

The Future of CRRT

An integrated and multidisciplinary approach

Patients who display clear indication for ECMO and are undergoing such a complex therapy, may require further organ support with the addition of renal replacement therapy by dialysis, liver support, hemoperfusion for detoxification and so on.

There is a clear need to explore the organ cross talk and the interactions between different organ systems involved in critical illness.

At the same time, extracorporeal support and organ replacement may become a more complete therapy if different functions are combined in a fully integrated hardware.

The Future of CRRT

An integrated and multidisciplinary approach

Possible errors and negative effects induced by adoptive technology where different organ support systems are utilized in a non-integrated approach make extracorporeal therapies dangerous and inaccurate.

Fluid balance, solute removal, CO₂ removal, aromatic aminoacid removal, electrolyte and acid base equilibration, blood detoxification and oxygenation should be definitely considered a continuum where the artificial organ crosstalk is constant.

Variations in CO₂ must take into account the use of buffers in dialysis or the application of citrate as anticoagulant for a adequate equilibrium of acid-base.

The Future of CRRT

An integrated and multidisciplinary approach

The future will probably lead to a unified hardware with special circuitry that will allow to perform all different organ support therapies on demand, simply escalating or de-escalating the complexity of the system.

From ECMO and CRRT, a patient may be progressively moved to ECCO2R and intermittent dialysis and finally even being discharged with a softer form of organ support including chronic dialysis and respiratory dialysis in case of non recovery or progression towards chronic illness.

The Future of CRRT

An integrated and multidisciplinary approach

Organ crosstalk required a multidisciplinary approach to the critically ill patient. If Multiple Organ support therapy (MOST) is applied, artificial organ crosstalk should also be considered by a task force of experts in different disciplines to avoid negative interactions and unwanted side effects. An integrated monitoring of patients, chemistry and machine parameters will offer the basis for a smart biofeedback leading to correction in prescription and delivery of extracorporeal organ support.



CRS

Altered hemodynamics

↑ Venous congestion
Low output
Decreased perfusion
Fluid overload

Hormonal alterations

Sympathetic activation
ADH release

Immune-mediated damage

Inflammation
Cytokine release
Endothelial activation
Apoptosis & replacement fibrosis

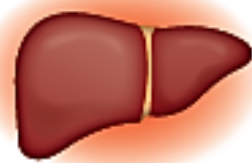


Lung-kidney interactions

PH/RV dysfunction
↑ Venous congestion

Hypoxia
Hypercapnia
Respiratory acidosis

↑ Alveolar-capillary permeability
↑ Circulating mediators
Inflammation & apoptosis



HRS

Splanchnic arterial vasodilation
↑ Abdominal pressure
↓ Effective arterial volume
Inability to increase CO & plasma volume

Dysbiosis
Inflammation
Cytokine release



Sepsis

Inflammation
Cytokine release
Oxidative stress
Altered innate & adaptive response
Endothelial injury & extravasation

Hypoxia
Hypercoagulability

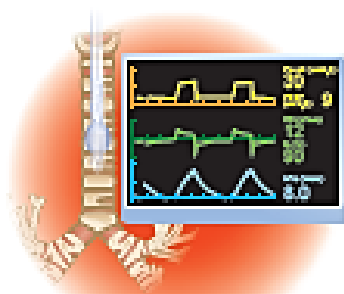
↓ End-organ microcirculation
↑ RVR
Ischemia / reperfusion



AKI

AKI-related alterations

- RAA activation
- H₂O + Na retention
- Vasoconstriction
- Uremic solute retention
- Ca & P abnormalities
- Metabolic acidosis
- Anaemia
- Remote cardiac/lung injury



Mechanical ventilation

Altered hemodynamics

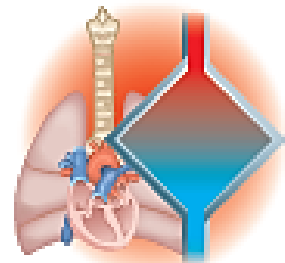
- ↑ Abdominal pressure
- ↑ Intrathoracic pressure
- ↑ Venous congestion
- ↓ CO
- Raised abdominal pressure

Immune-mediated damage

- Biotrauma
- Systemic release of mediators
- Inflammation and apoptosis

Hormonal alterations

- RAA / sympathetic activation
- ADH release



**ECMO /
ECCO₂R**

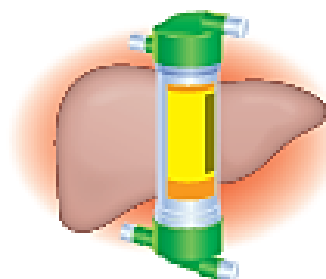
- Ischemia / reperfusion
- Hemodynamic fluctuations
- Fluid overload
- Continuous blood flow during VA-ECMO

Sepsis

- Artificial surfaces
- Catalytic iron
- Hypercoagulability
- Microvascular obstruction

Cannula-related alterations

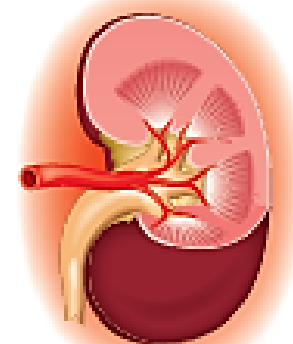
- Venous obstruction
- Occlusive arterial hypoperfusion
- Cholesterol embolism
- Rhabdomyolysis & crush injury



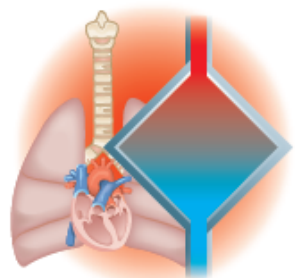
**Extracorporeal
liver support**

- Loss of micronutrients /
antibiotics / catecholamines

- Artificial surfaces
- Hypercoagulability
- Thrombopenia



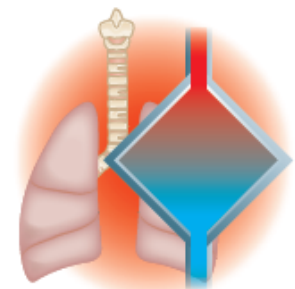
AKI



ECMO

Risk of

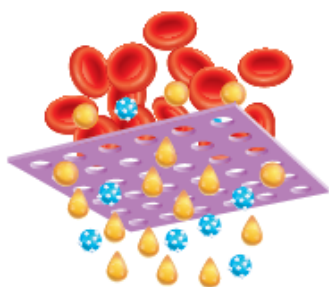
- Oxygenator clotting
- Pulmonary embolism during VV-ECMO
- Arterial embolism during VA-ECMO



ECCO₂R

Risk of

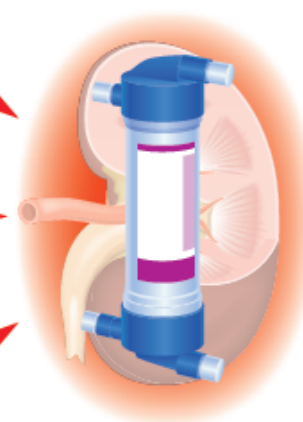
- Oxygenator clotting
- Pulmonary embolism during AV-ECCO₂R



Plasmapheresis

- Loss of micronutrients / antibiotics / catecholamines
- Volume expansion with necessity of UFR adjustment

- Increased coagulability with use of FFP
- Allergic reaction to substitute solution



RRT

RRT-related alterations

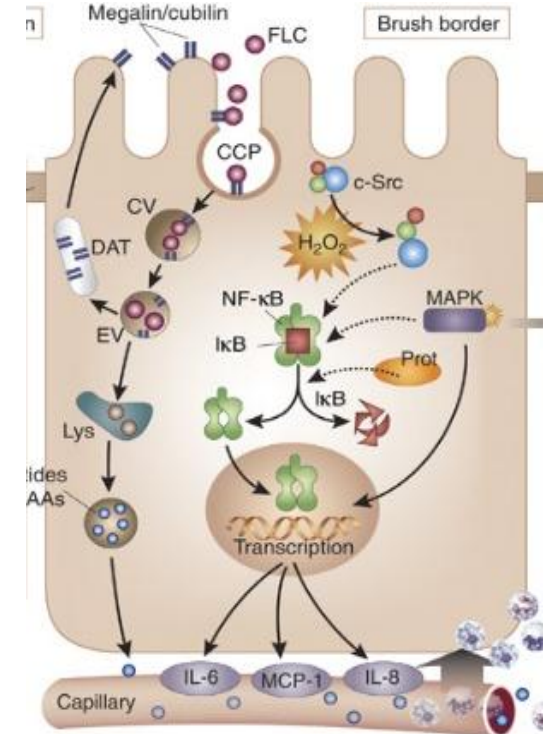
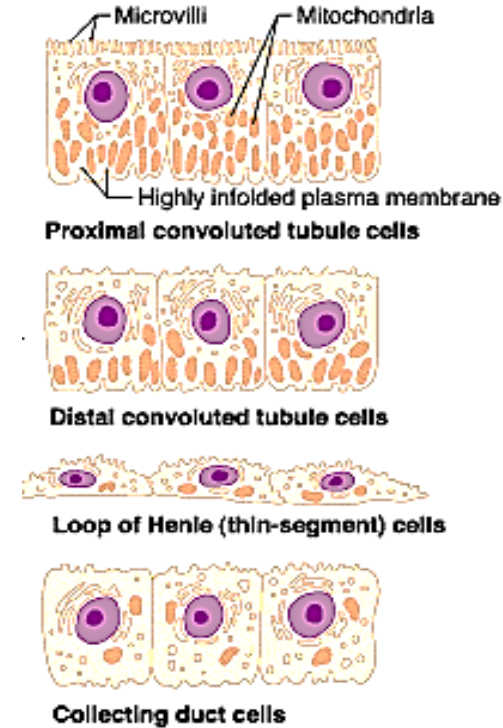
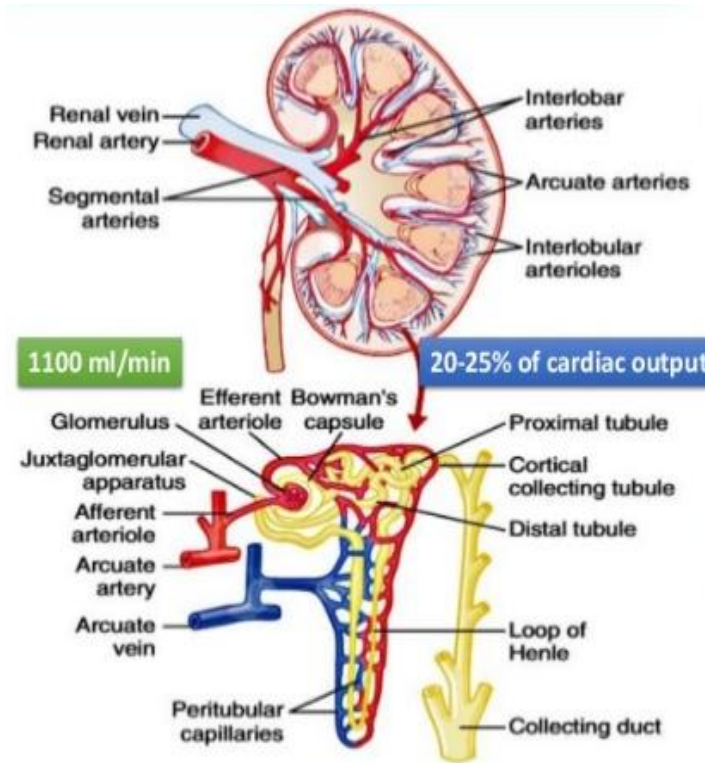
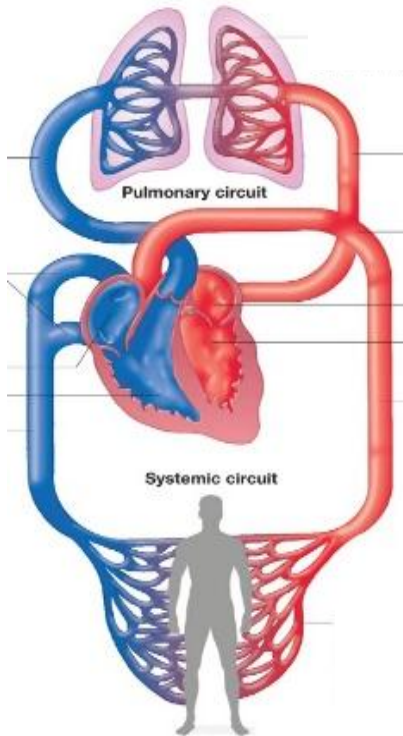
- Loss of micronutrients / antibiotics / catecholamines
- Hypophosphataemia
- Risk of hemolysis, thrombosis and DIC when connected to ECOS circuits
- Risk of Na overload, hypocalcaemia, metabolic alkalosis/acidosis during RCA

Interventions to prevent hemodynamic instability during RRT

- UFR adjustment via monitoring hematocrit changes
- Dialysate Na modeling
- Dialysate cooling

Organ Crosstalk

The case of Heart, Lungs and Kidney



From Native to Artificial Organ Crosstalk

