CRRT nursing

X Edizione

Corso Teorico Pratico

CORSO CRRT

CRRT e Anticoagulazione

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SITI ISIC
Società Italiana di Terapia Intensiva
Italian Society of Intensive Care
FONDATA NEL 1975

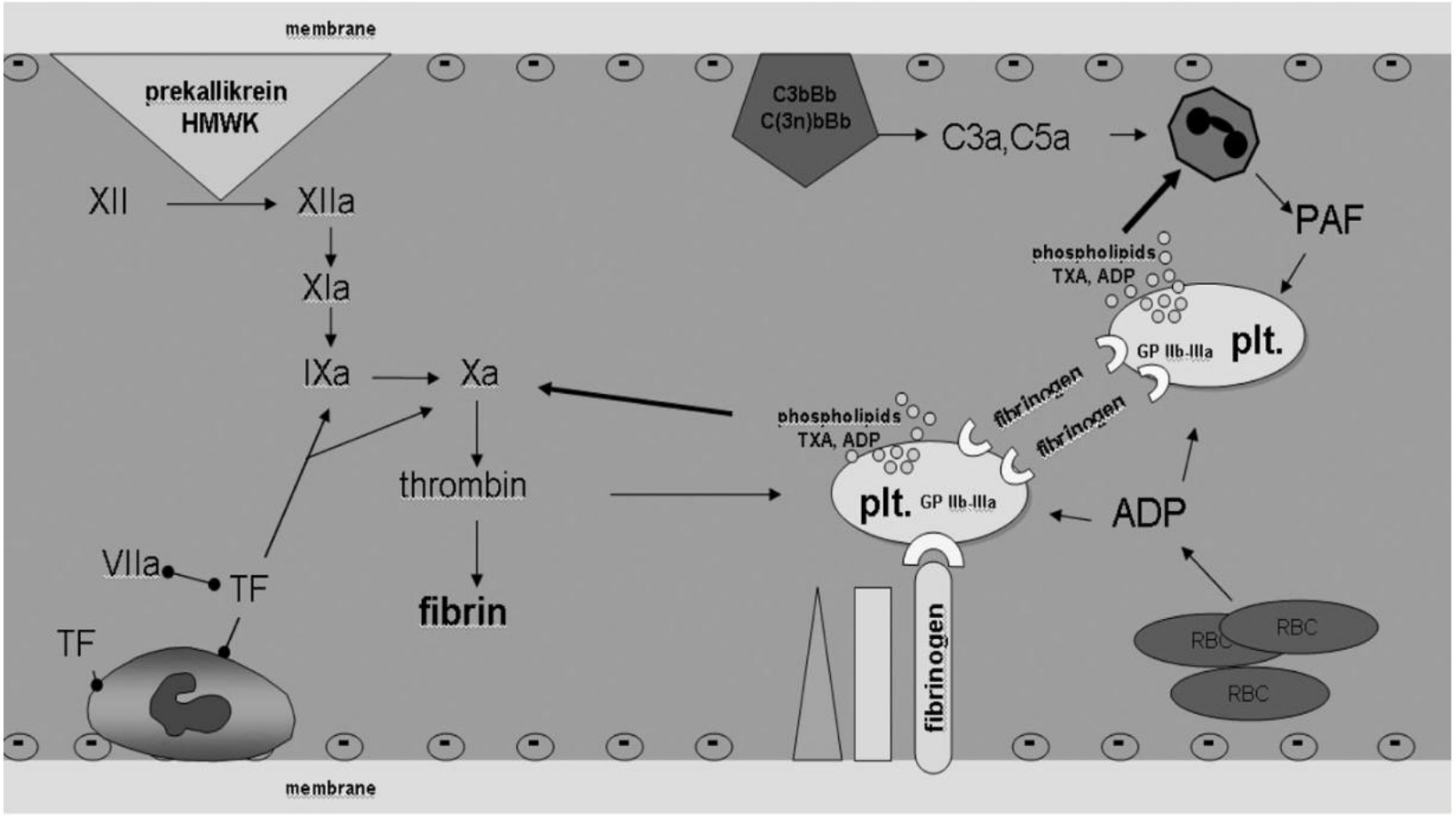
Dip. di Anestesia e Rianimazione
AOU Careggi - Firenze

Agenda

- **Come mantenere la pervietà e il perfetto funzionamento del circuito.**
- **Diversi regimi di anticoagulazione.**
- **Monitoraggio del paziente con equilibrio fra sanguinamento e coagulazione.**

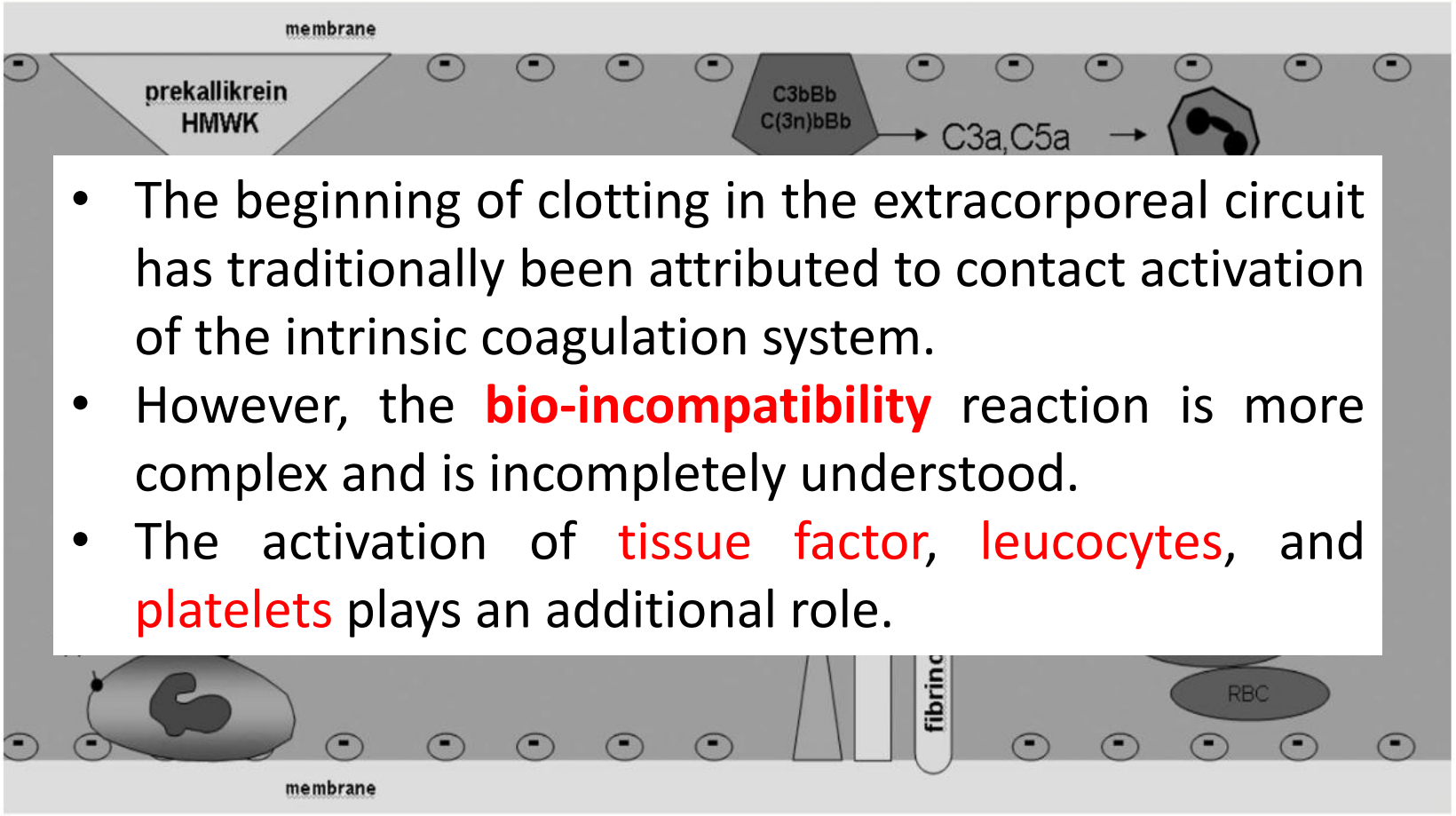
Review

Clinical review: Patency of the circuit in continuous renal replacement therapy



Review

Clinical review: Patency of the circuit in continuous renal replacement therapy

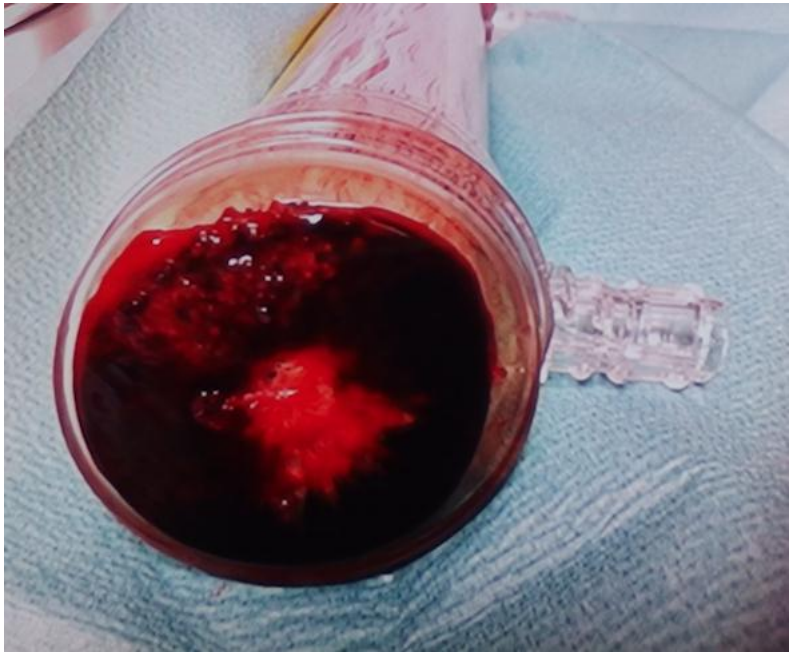


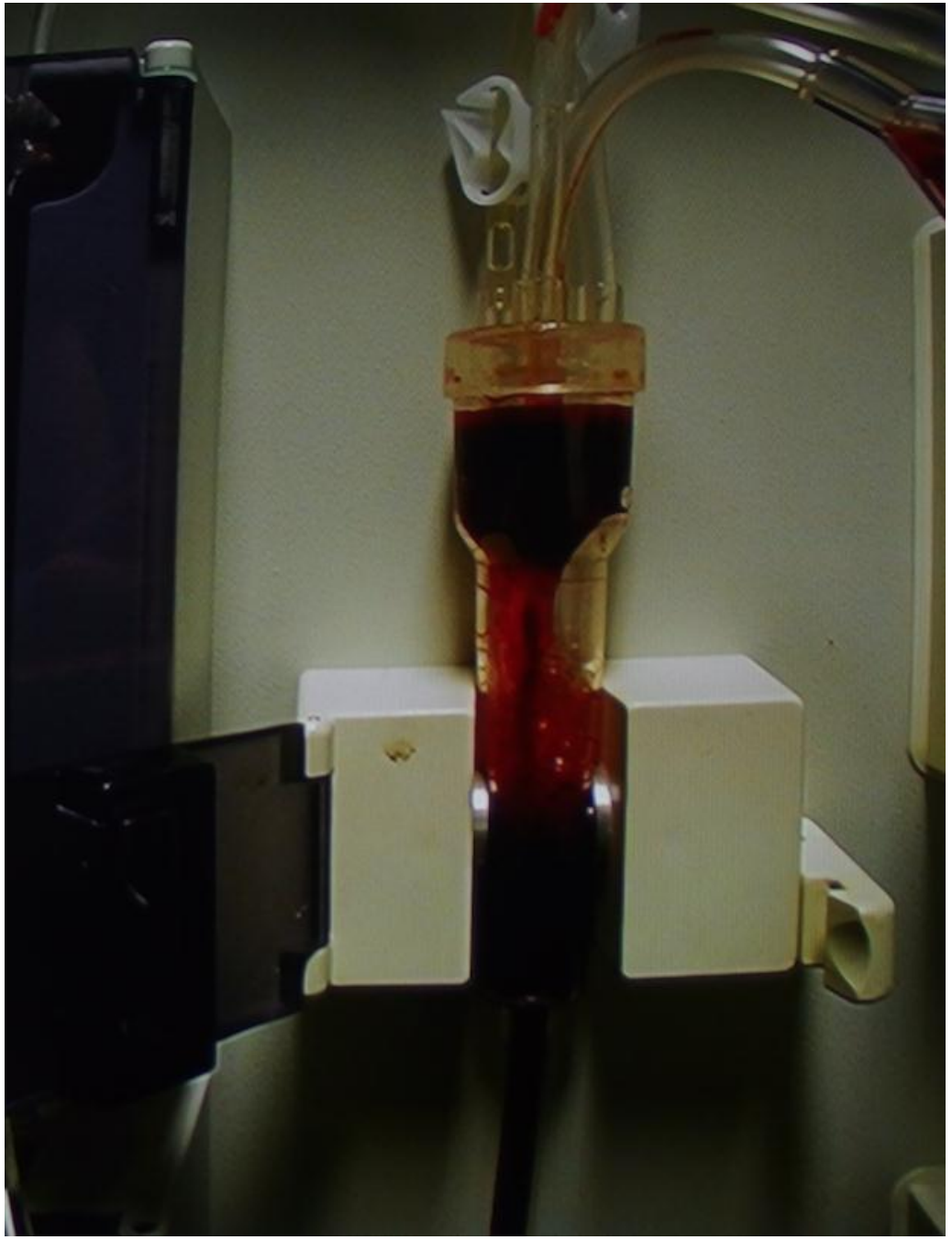
- The beginning of clotting in the extracorporeal circuit has traditionally been attributed to contact activation of the intrinsic coagulation system.
- However, the **bio-incompatibility** reaction is more complex and is incompletely understood.
- The activation of tissue factor, leucocytes, and platelets plays an additional role.

Ricci D et al. Contrib Nephrol (2017) 190:19–30

Joannidis M et al. Critical Care (2007) 11:218

- Delivery failure
- Blood loss
- Increased workload
- Increased costs





Kidney Disease: Improving Global Outcomes (2012)

Chapter 5.3: Anticoagulation

In patients with AKI requiring RRT, the contact of blood with the foreign surface of the extracorporeal circuit results in activation of both the intrinsic and the extrinsic pathway of plasmatic coagulation and activation of platelets.[571] Prevention of dialyzer/hemofilter clotting often requires some form of anticoagulation, which may represent a particular challenge in patients with AKI. The need for continuous anticoagulation represents a potential drawback of CRRT.

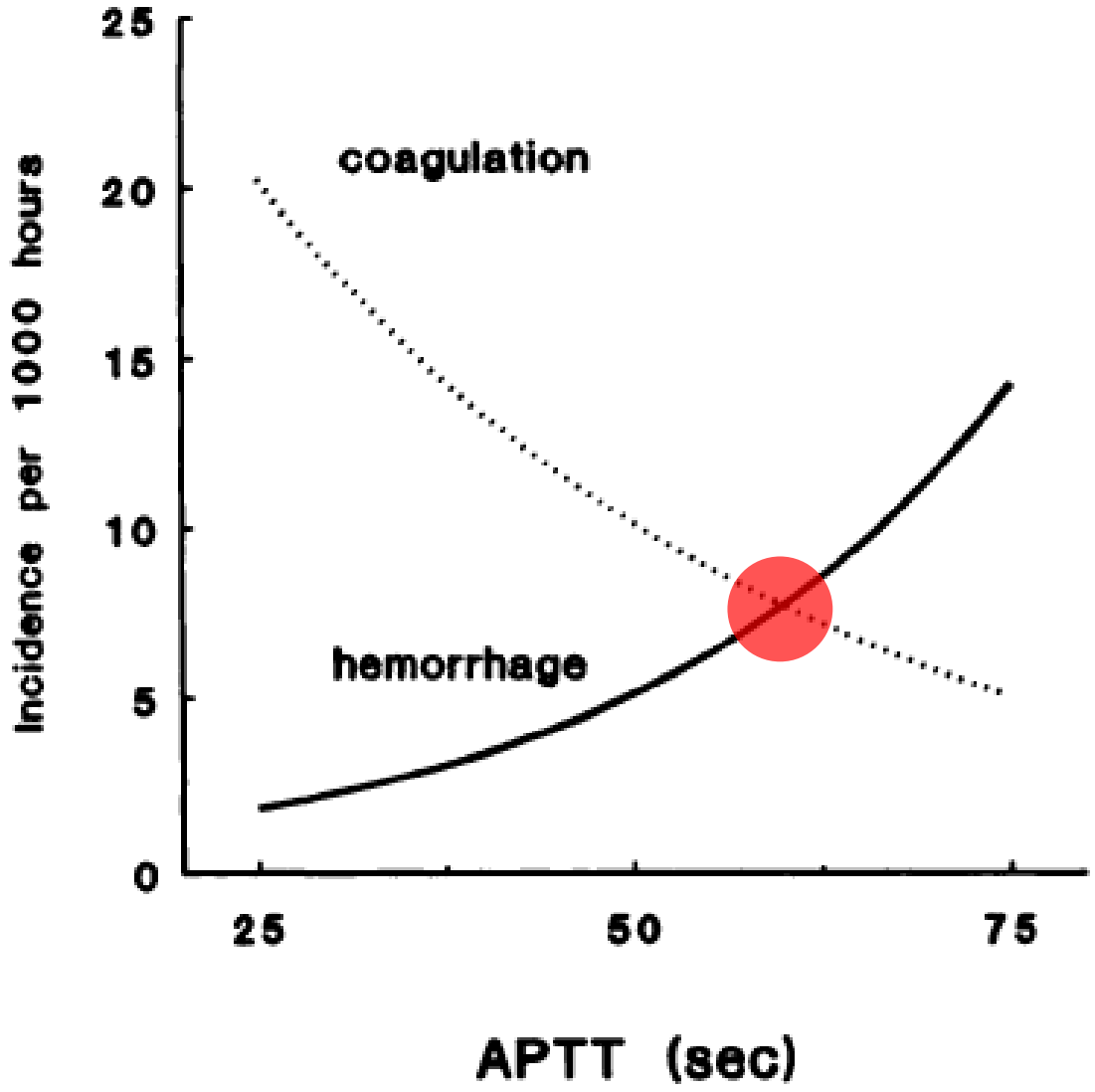
http://kdigo.org/home/guidelines/acute-kidney-injury/.

Kidney Disease: Improving Global Outcomes (2012)

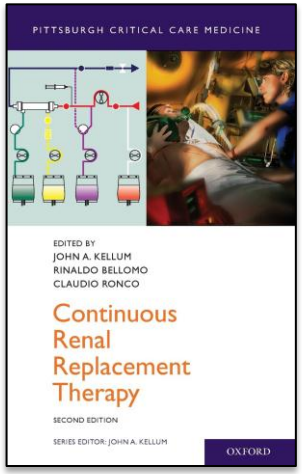
- In a patient with **AKI requiring RRT**, base the decision to use anticoagulation for RRT on assessment of the patient's **potential risks and benefits** from anticoagulation (Not Graded)

  - We recommend **using anticoagulation** during RRT in AKI if a patient does not have an increased bleeding risk or impaired coagulation and is not already receiving systemic anticoagulation. (1B)

Heparin Use in Continuous Renal Replacement Procedures: The Struggle Between Filter Coagulation and Patient Hemorrhage[1]



van de Wetering J et al. J Am Soc Nephrol (1996);7:145-50



- Develop a bedside protocol for anticoagulant use
- Develop your own expertise with this protocol
- If the circuit clots, it can be replaced. If the patient bleeds, a more serious and adverse outcome may occur.

- To loose a filter to protect a patient is entirely acceptable.
- To loose a patient to protect a filter is NOT.
- Often, the circuit clots NOT because anticoagulation is suboptimal or inadequate, but rather because of poor-quality vascular access and/or poor attention to optimal machine operation.

Kellum JA, Bellomo R, Ronco C - 2015

Anticoagulation for CRRT

- Unfractioned heparin
- Low molecular weight heparins
- Heparinoids
  - Danaparoid (Orgaran®)
- Direct thrombin inhibitors
  - Hirudin / Argatroban
- Prostacycline
- Nafamostat
- NO anticoagulation
- Regional citrate-anticoagulation

Anticoagulation for CRRT

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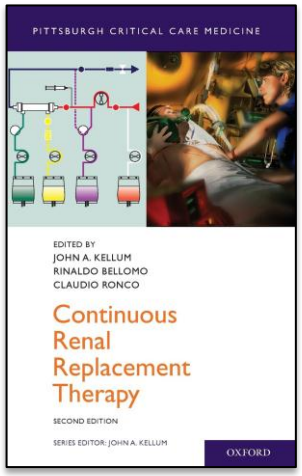
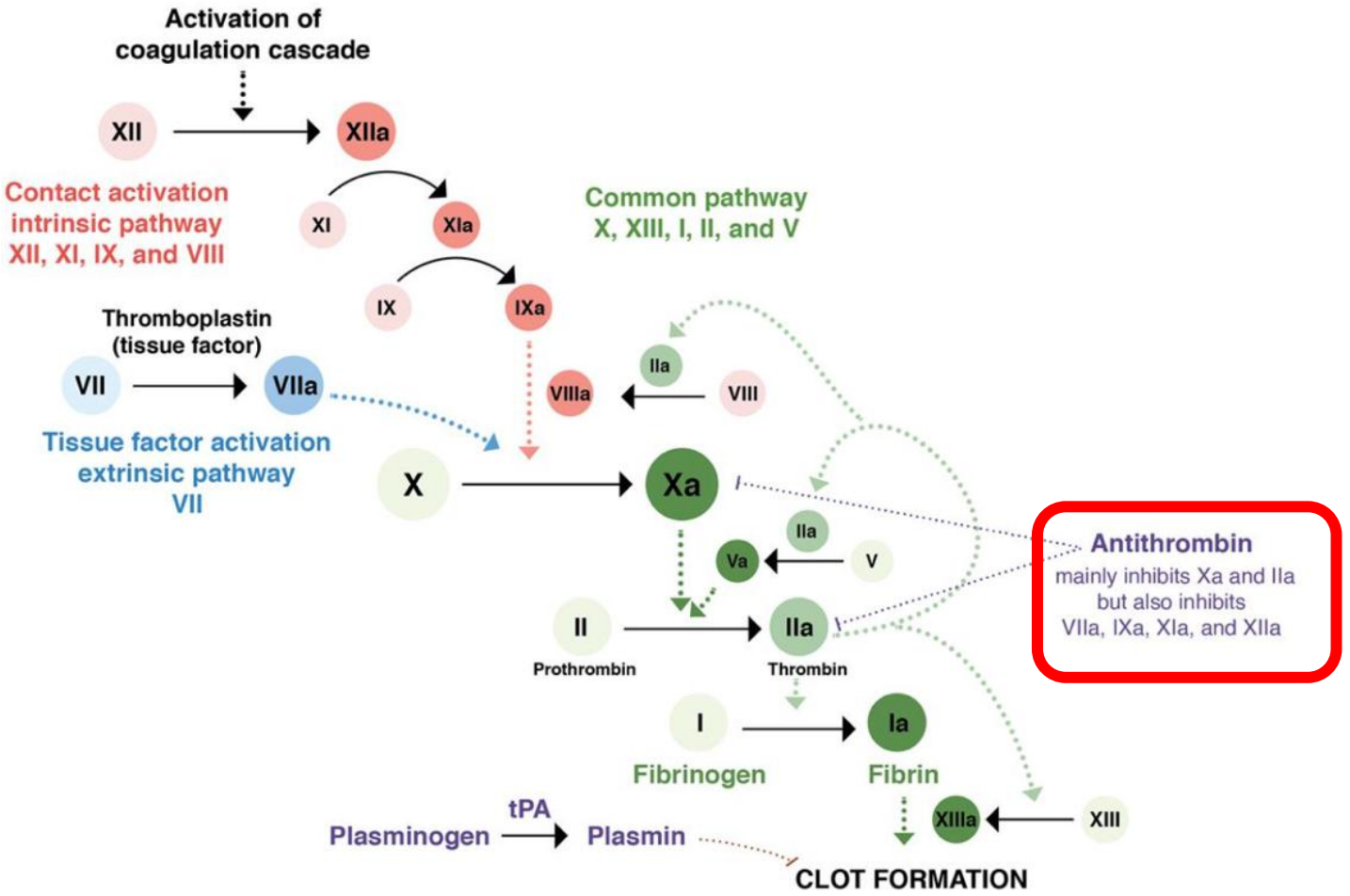
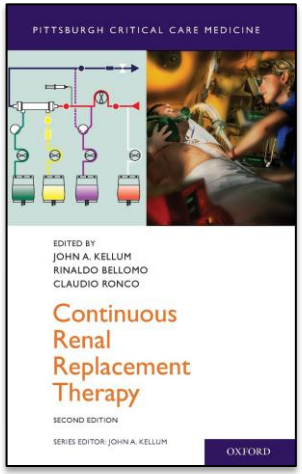


Heparin is used most commonly as anticoagulant for RRT by blocking factor Xa and thrombin



Kellum JA, Bellomo R, Ronco C - 2015

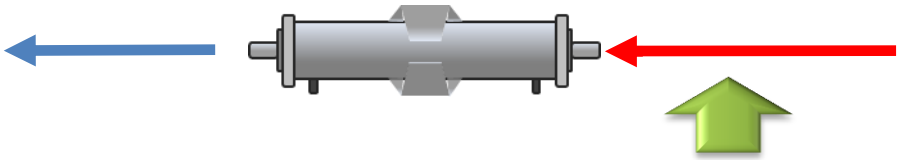


HEPARIN ANTICOAGULATION

A possible scheme for UFH consists of a bolus of 30 IU/kg followed by an initial rate of 5 to 10 IU/kg per hour in patients with normal coagulation.

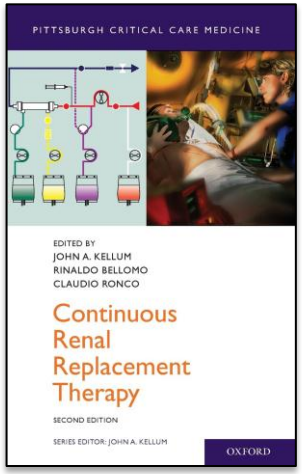
HEPARIN DOSING GUIDE			
Heparin infusion rate	INR	aPTT	Platelets
10 IU/Kg/h	< 1.5	< 40 s	> 150,000 / mL
5 IU/Kg/h	>1.5 but < 2.5	> 40 s but < 60 s	< 150,000 / mL > 75,000 / mL
No anticoagulation	> 2.5	> 60 s	< 75,000 mL

- Administer heparin into the circuit before blood enters the membrane in the "**pre-filter**"



- Check and assess the patient for evidence of spontaneous bleeding (urine, feces, wounds, puncture sites, mucus membranes).

Kellum JA, Bellomo R, Ronco C - 2015



HEPARIN ANTICOAGULATION

- It is not necessary to use full heparin anticoagulation (many pts have low PLT count and altered clotting)

- After major surgery and/or epidural cath → **no anticoagulation** for the firs 24-48 hours (or citrate) maybe a safer option

- A filter life 20-24 hours is common using heparin correctly

Kellum JA, Bellomo R, Ronco C - 2015

Ronco *et al. Critical Care* (2015) 19:146
DOI 10.1186/s13054-015-0850-8

CRITICAL CARE

REVIEW Open Access

Renal replacement therapy in acute kidney injury: controversy and consensus

Claudio Ronco[1], Zaccaria Ricci[2*], Daniel De Backer[3], John A Kellum[4], Fabio S Taccone[3], Michael Joannidis[5], Peter Pickkers[6], Vincenzo Cantaluppi[7], Franco Turani[8], Patrick Saudan[9], Rinaldo Bellomo[10], Olivier Joannes-Boyau[11], Massimo Antonelli[12], Didier Payen[13], John R Prowle[14] and Jean-Louis Vincent[3]

Unfractionated heparin (UFH) is still the most widely used anticoagulant

(Hirsh J, et al. Chest. 2001;119:64S–94S)

Major advantages of UFH:

- Low costs,
- Ease of administration
- Simple monitoring
- Reversibility with protamine
- Half-life of UFH is about 90 minutes

- **aPTT** is still the best option for monitoring
- Levels of greater than **45 to 50** seconds have been associated with an increased risk of bleeding

Ronco C, Ricci Z, De Backer D et al. et al. Critical Care (2015) 19:146

Attention:

- heparin-induced thrombocytopenia (HIT)
- Antithrombin levels

Heparin-Induced Thrombocytopenia

KEY CLINICAL POINTS

HEPARIN-INDUCED THROMBOCYTOPENIA

- Heparin-induced thrombocytopenia (HIT) is characterized by a decrease in the platelet count of more than 50% from the highest platelet count value after the start of heparin, an onset 5 to 10 days after the start of heparin, hypercoagulability, and the presence of heparin-dependent, platelet-activating IgG antibodies.
- Use of a scoring system that takes into account the timing and magnitude of the platelet count fall, new thrombosis, and the likelihood of other reasons for thrombocytopenia is helpful in assessing the pretest probability of HIT.
- Delayed-onset HIT develops after the cessation of heparin, and spontaneous or autoimmune HIT develops in the absence of heparin exposure.
- Platelet factor 4–heparin antibody tests should be ordered only if clinical features reasonably suggest HIT. These tests have a high negative predictive value but a low positive predictive value.
- Treatment of acute HIT requires the cessation of heparin and the initiation of therapeutic-dose anti-coagulation with an alternative agent (argatroban, danaparoid, fondaparinux, or bivalirudin).
- Warfarin should be avoided in patients with acute HIT.

N ENGL J MED 373;3 NEJM.ORG JULY 16, 2015

Ronco C et al. Critical Care (2015) 19:146

Renal replacement therapy (RRT)

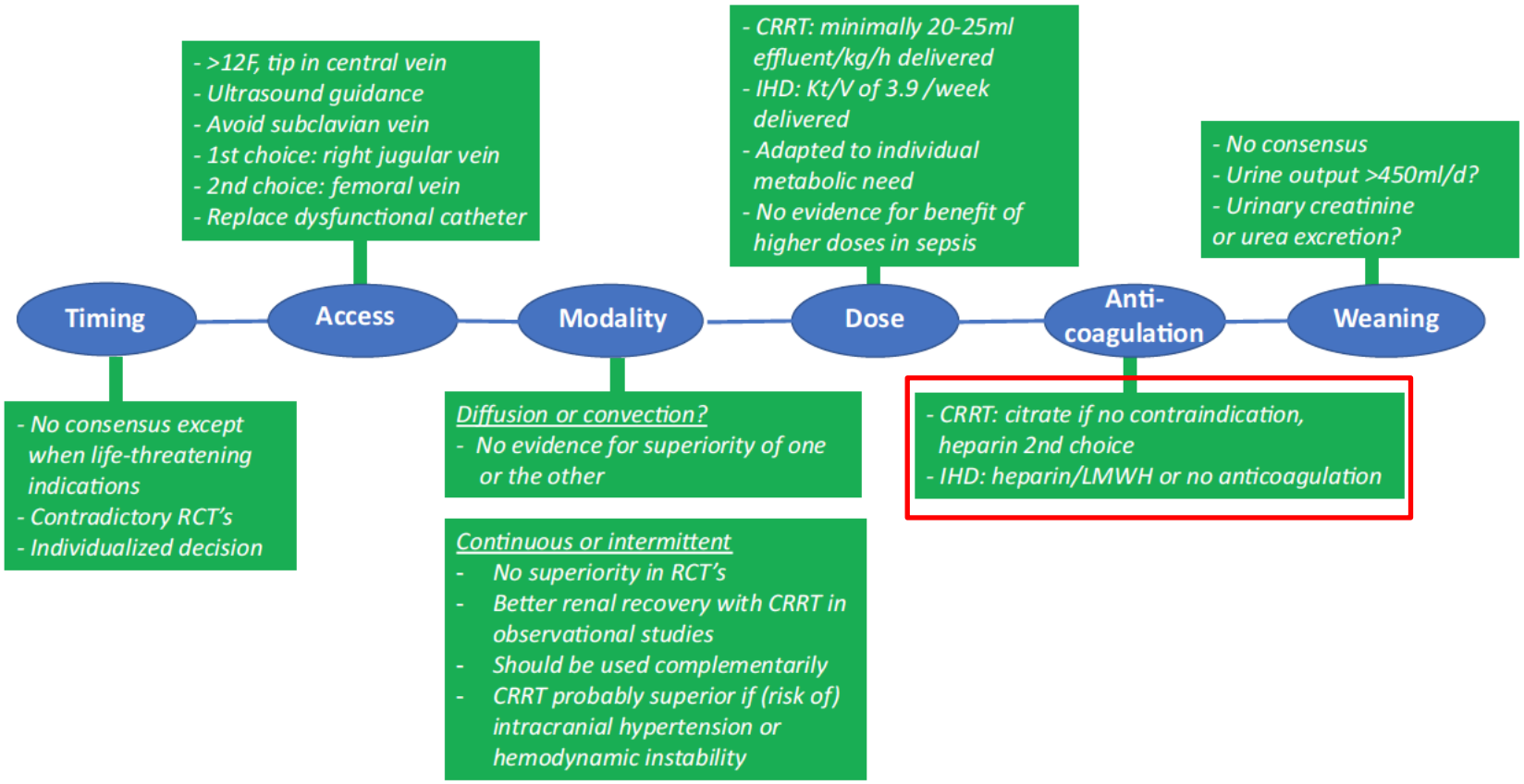
Anticoagulation

To maintain filter and circuit patency, anticoagulation is required. As the application of heparin is associated with several complications [mainly bleeding and heparin-induced thrombocytopenia (HIT)], the interest in RCA has increased [36, 37]. It has now become clear that compared with systemic heparin, RCA is associated with increased filter lifespan, reduced bleeding and transfusion rates and a lower incidence of HIT, however, without effect on mortality [38]. On the basis of these data, the KDIGO guidelines suggest using RCA as a first-line anticoagulant for CRRT when no contraindications are present.

Pickkers P et al. Intensive Care Med (2017) Jan 30

RESEARCH AGENDA

The intensive care medicine agenda on acute kidney injury



Pickkers P et al. Intensive Care Med (2017) Jan 30

RESEARCH AGENDA

The intensive care medicine agenda on acute kidney injury

- CRRT: minimally 20-25ml

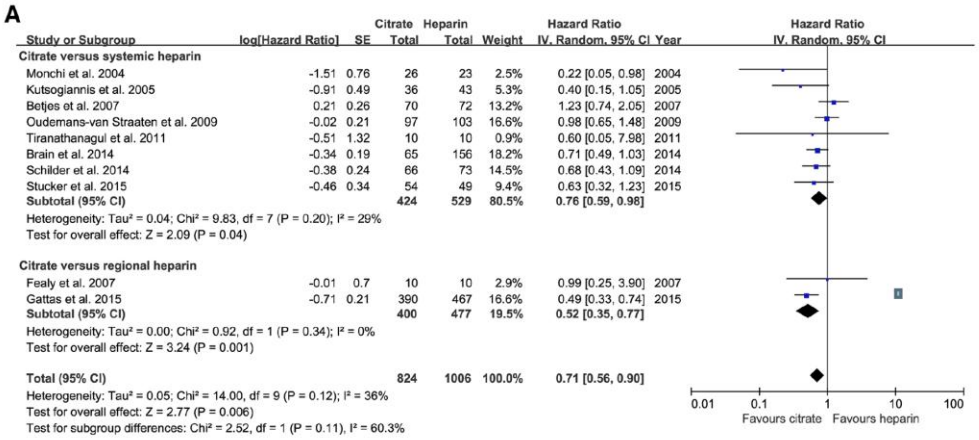
- CRRT: citrate if no contraindication, heparin 2nd choice
- IHD: heparin/LMWH or no anticoagulation

- Better renal recovery with CRRT in observational studies
- Should be used complementarily
- CRRT probably superior if (risk of) intracranial hypertension or hemodynamic instability

Pickkers P et al. Intensive Care Med (2017) Jan 30

Citrate versus heparin anticoagulation for continuous renal replacement therapy: an updated meta-analysis of RCTs

Ming Bai
Meilan Zhou
Lijie He
Feng Ma
Yangping Li
Yan Yu
Pengbo Wang
Li Li
Rui Jing
Lijuan Zhao
Shiren Sun



- 11 RCTs with 992 patients and 1998 circuits.
- **Citrate for CRRT significantly reduced the risk of circuit loss** compared to regional (P = 0.001) or systemic (P = 0.04) heparin.
- Citrate also reduced the incidence of filter failure (P = 0.04).
- The citrate group had **a significantly lower bleeding risk** than the systemic heparin group (P_0.001) and similar bleeding risk to the regional heparin group (P = 0.51).
- The incidences of HIT and hypocalcemia were increased in the heparin and citrate groups, respectively.

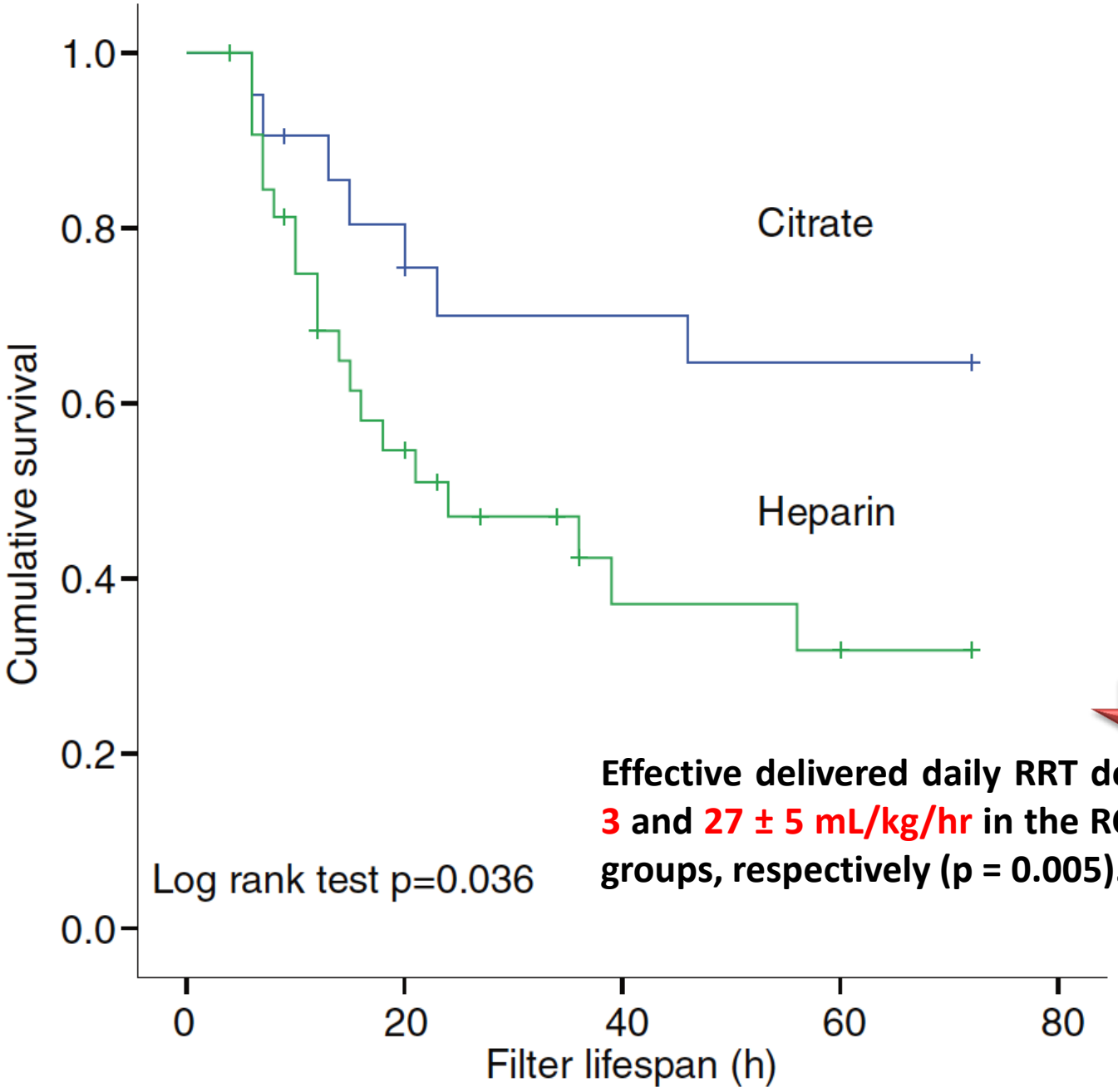
Bai M et al. Intensive Care Med (2015) 41:2098-110.

Citrate versus heparin anticoagulation for continuous renal replacement therapy: an updated meta-analysis of RCTs

Conclusions:

- Given the lower risk of circuit loss, filter failure, bleeding, and HIT, **regional citrate should be considered a better anticoagulation method** than heparin for CRRT in critically ill patients **without any contraindication**.

Bai M et al. Intensive Care Med (2015) 41:2098-110.



Effective delivered daily RRT doses were 29 ± 3 and 27 ± 5 mL/kg/hr in the RCA and heparin groups, respectively (p = 0.005).

Stucker et al. Critical Care (2015) 19:91

- For patients without an increased bleeding risk or impaired coagulation and not already receiving effective systemic anticoagulation, we suggest the following:

    - For anticoagulation in CRRT, we suggest using **regional citrate anticoagulation** rather than heparin in patients who do not have contraindications for citrate. (2B)

    - For anticoagulation during CRRT in patients who have **contraindications for citrate**, we suggest using either unfractionated or low-molecular-weight **heparin**, rather than other anticoagulants. (2C)

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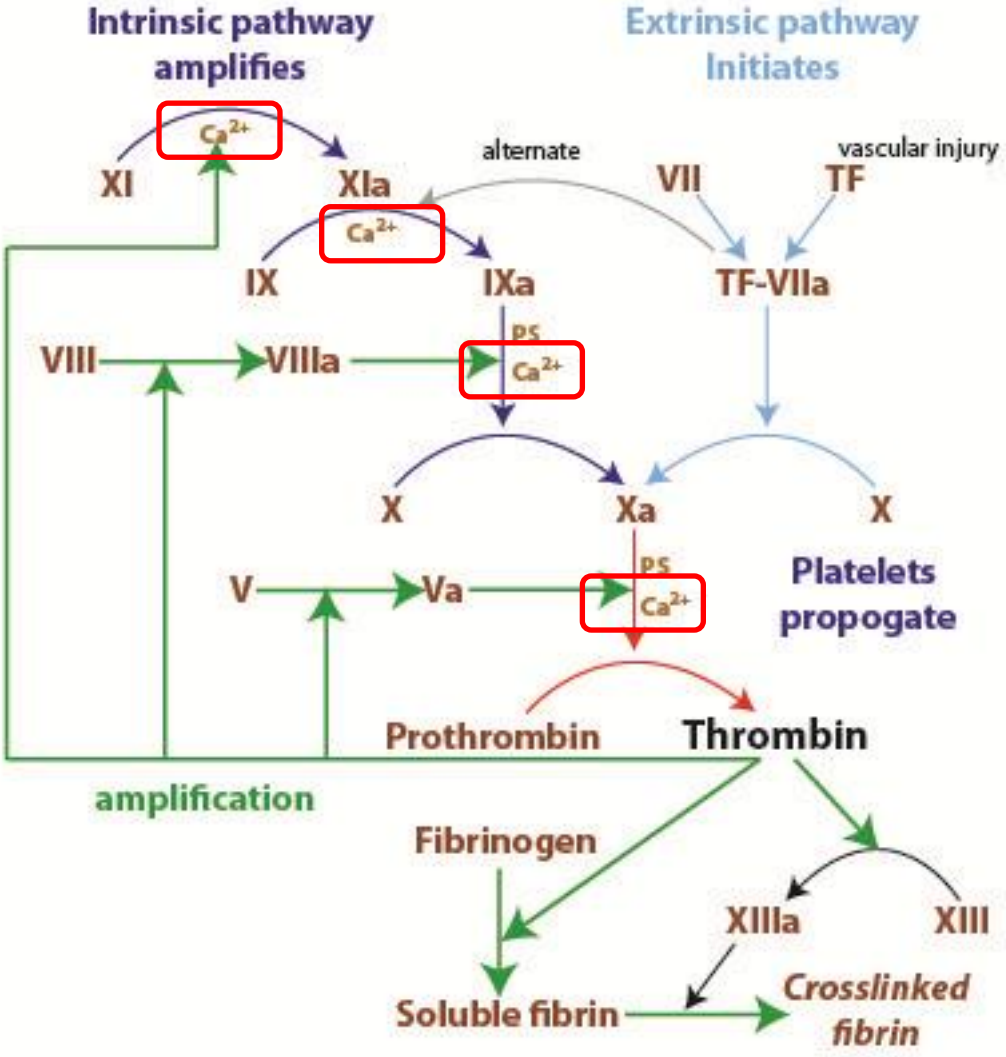
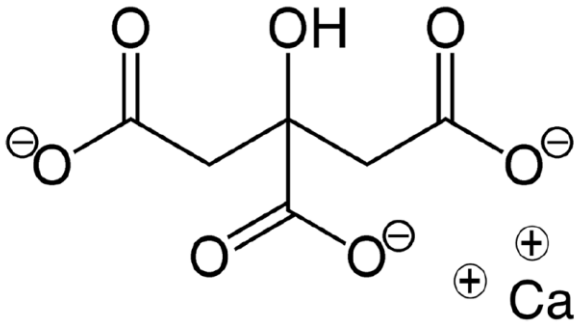
http://kdigo.org/home/guidelines/acute-kidney-injury/.

The anticoagulant effect of sodium **citrate** relies on forming a complex with **ionized calcium**, thus removing an essential component of the coagulation cascade.





Citrate forms a complex with the Ca++ ions, making them unavailable as co-factor within the clotting cascade

- Citrate has been used for many years across a variety of medical applications, for example, it is widely used for the storage of red blood cells.

- As early as 1990, clinicians began to see the possibilities for utilising citrate as regional anticoagulant in CRRT

Blood is removed via the A line and citrate is added

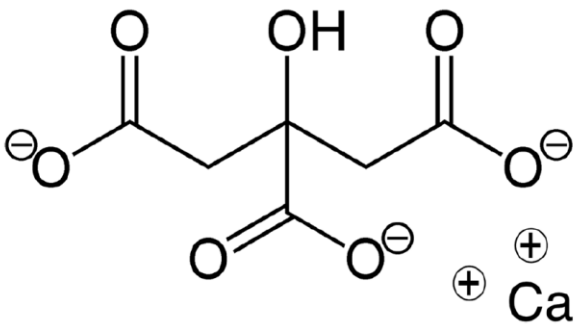
Citrate complexes with calcium and prevent clotting

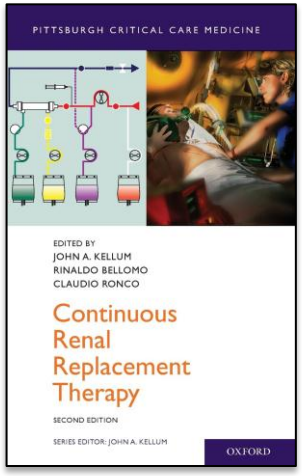
30-60% of the citrate-calcium complexes are removed by the filter

298 Da
High hydosolubility
Sc = 1

Calcium is replaced in the V line

Remaining citrate-calcium compl. are metabolized to bicarbonate and Ca^{++} Is released

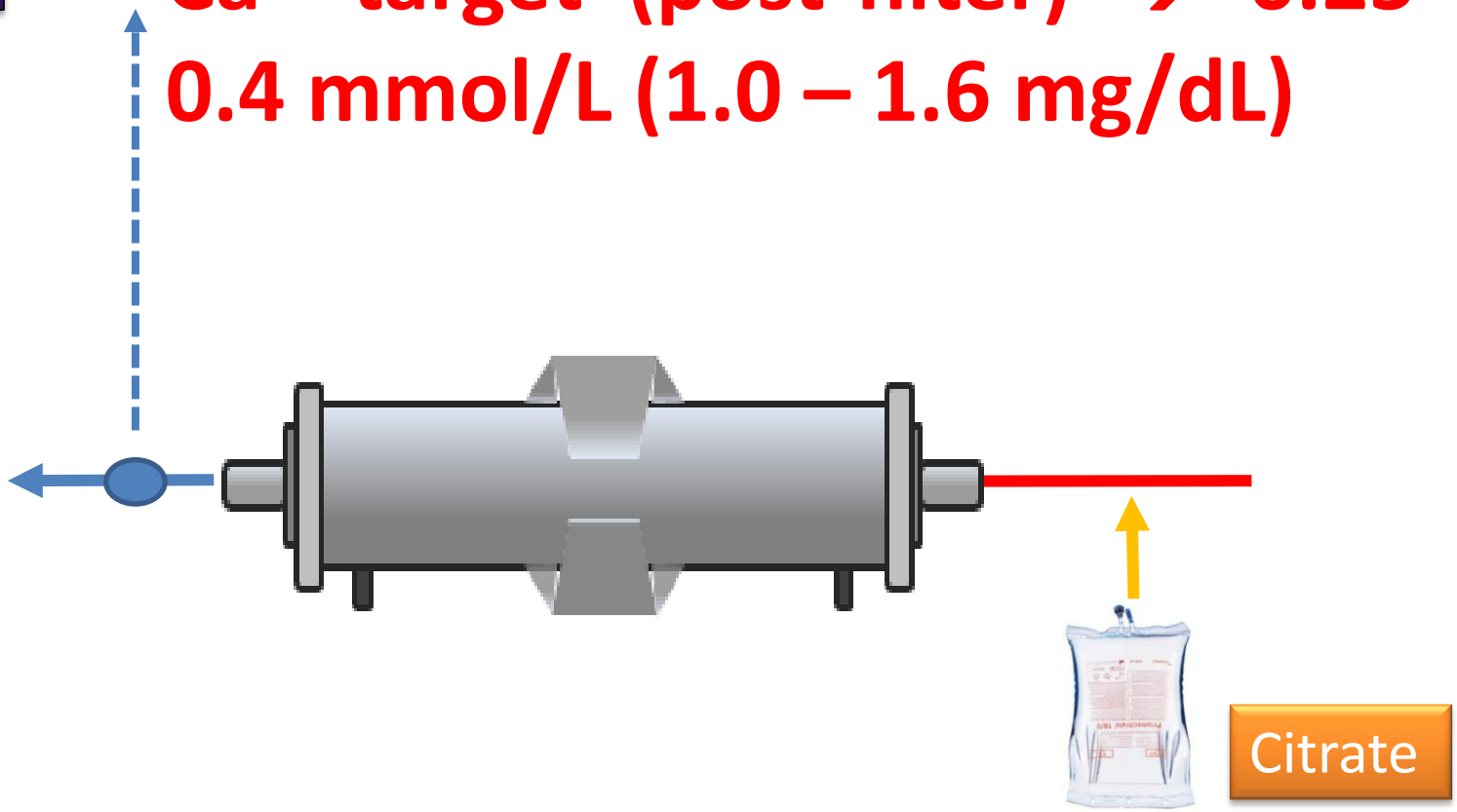




REGIONAL CITRATE

- When citrate is infused into the circuit → combines with Ca^{++} → citrate-Calcium complexes

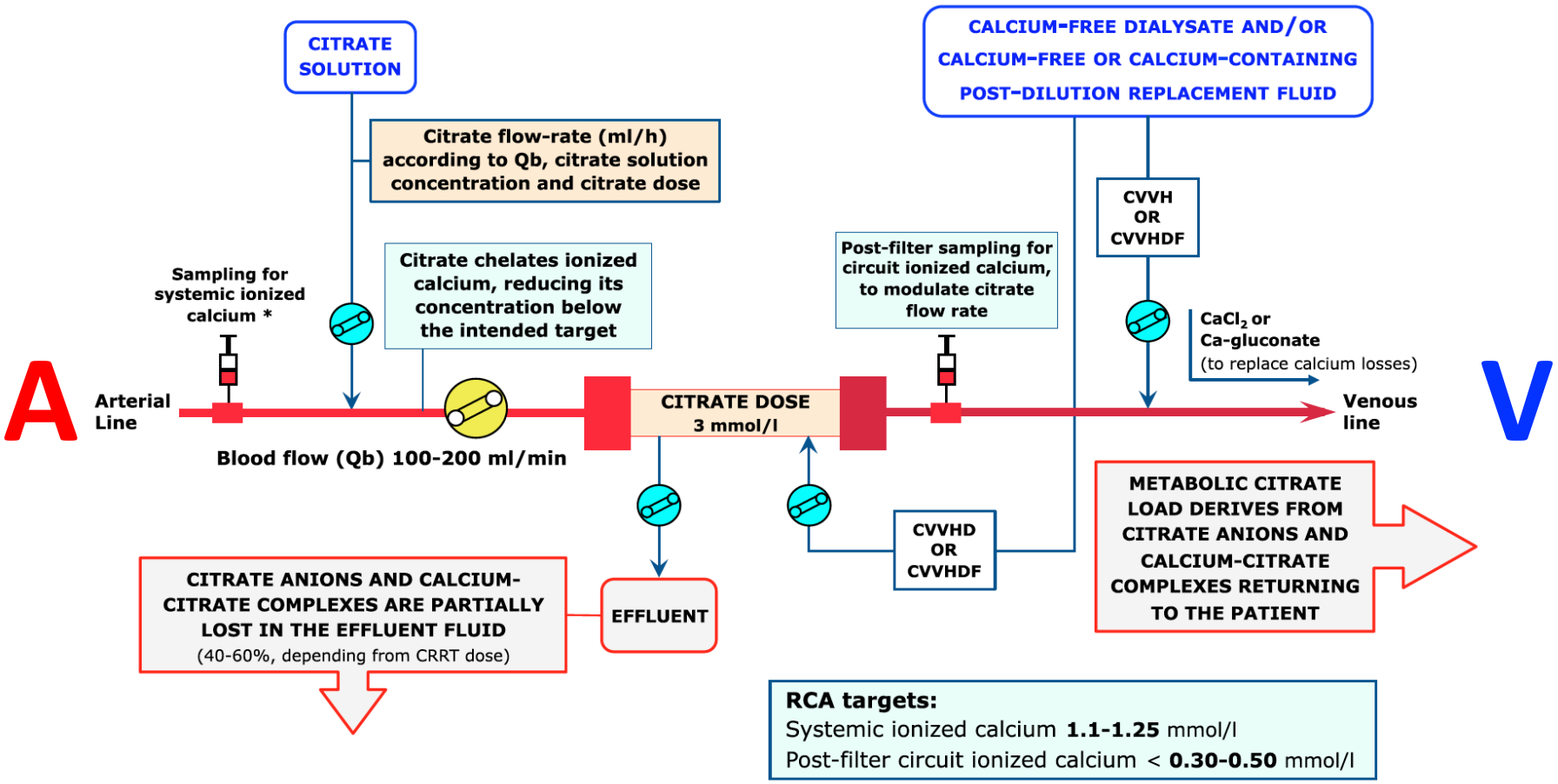
- **Ca^{++} target (post-filter) → 0.25 - 0.4 mmol/L (1.0 – 1.6 mg/dL)**



Kellum JA, Bellomo R, Ronco C - 2015

Regional Citrate Anticoagulation for RRTs in Critically Ill Patients with AKI

Santo Morabito, Valentina Pistolesi,* Luigi Tritapepe,† and Enrico Fiaccadori‡*

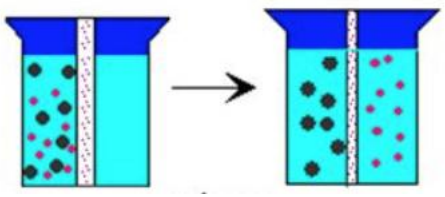


Morabito S et al. Clin J Am Soc Nephrol (2014) 9:2173-88

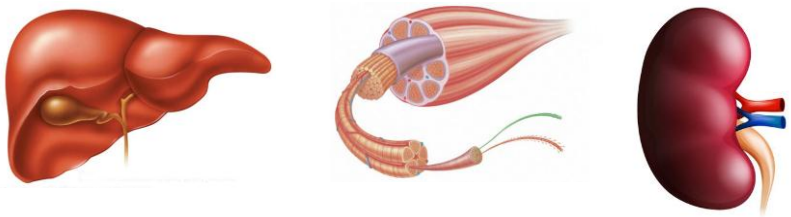
Citrate

Citrate is partially removed by filtration or dialysis.

(Mariano F, et al. Nephrol Dial Transplant 2011; 26: 3882–3888)



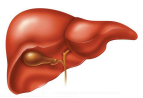
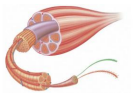
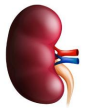
The remaining amount, infused into the patient, is rapidly metabolized in the citric acid (Krebs) cycle, especially in the liver, muscle, and renal cortex



The ensuing regional hypocalcemia in the filter inhibits thrombin generation.

Ricci D et al. Contrib Nephrol (2017) 190:19–30

REGIONAL CITRATE

- There is no systemic anticoagulation as a result of:
  - Any citrate-calcium complex → patient's blood →    → **1 cit = 3 bicarbonate** ions
  - During this metabolism, **Calcium is released** contributing to normalizing of the coagulation
  - 1 mmol citrate → 2.48 kJ (593 cal/mmol citrate)

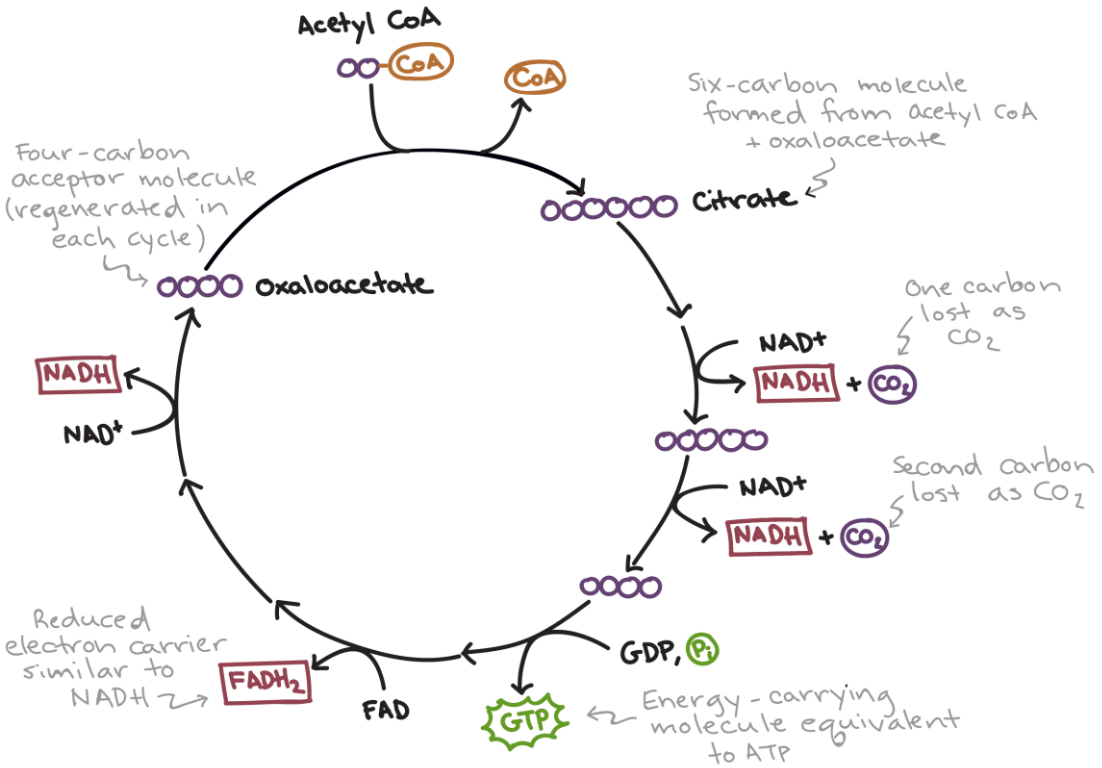
Am J Clin Nutr 2017; 105:1559-63

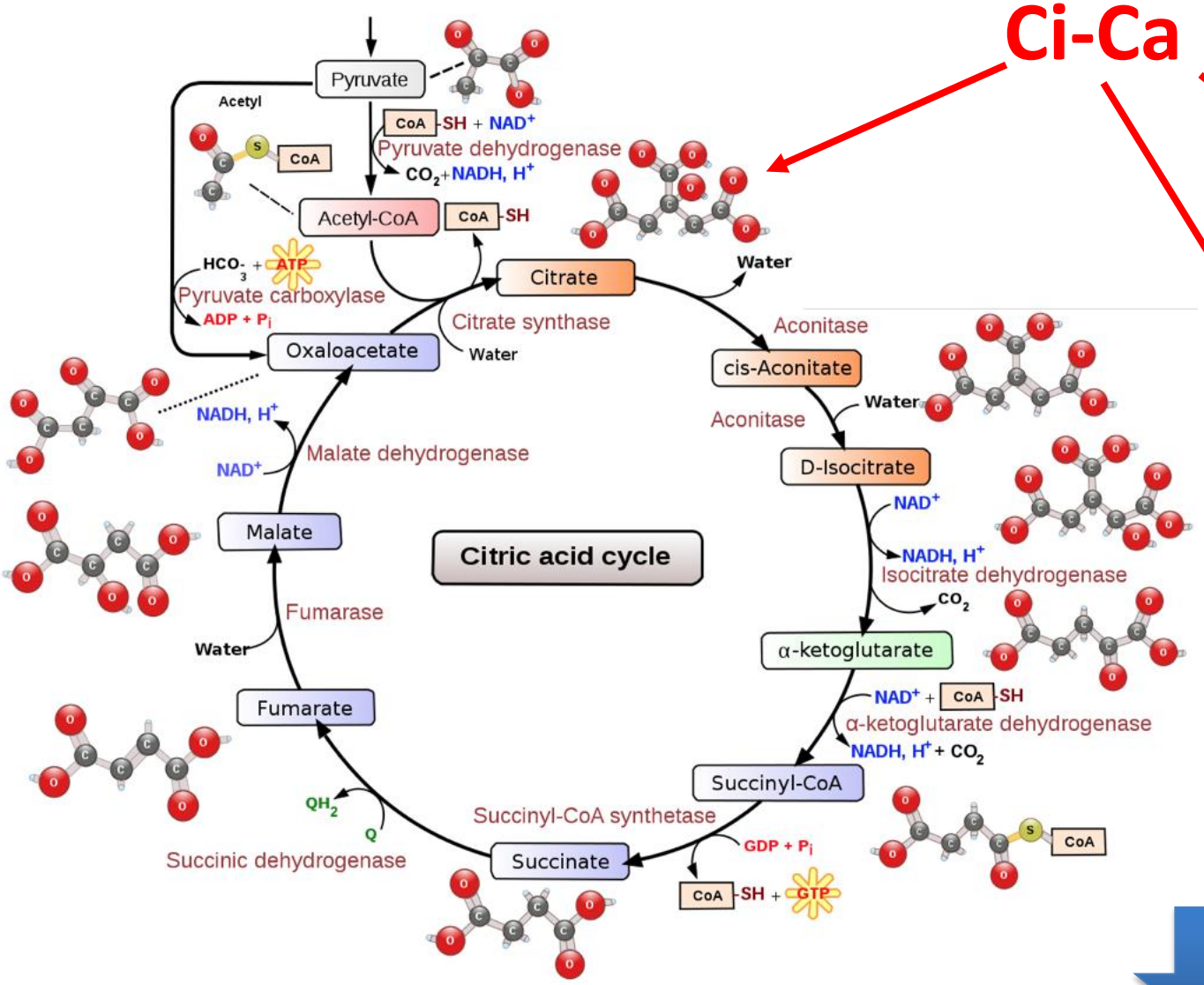
Kellum JA, Bellomo R, Ronco C - 2015

The citrate **metabolic load** to the patient is:

$$[\text{Citrate}]_{pre} - [\text{Citrate}]_{eff}$$

With the more commonly reported citrate protocols, the citrate load is approximately **10–20 mmol/h**.





Ci-Ca

Ca^{++}

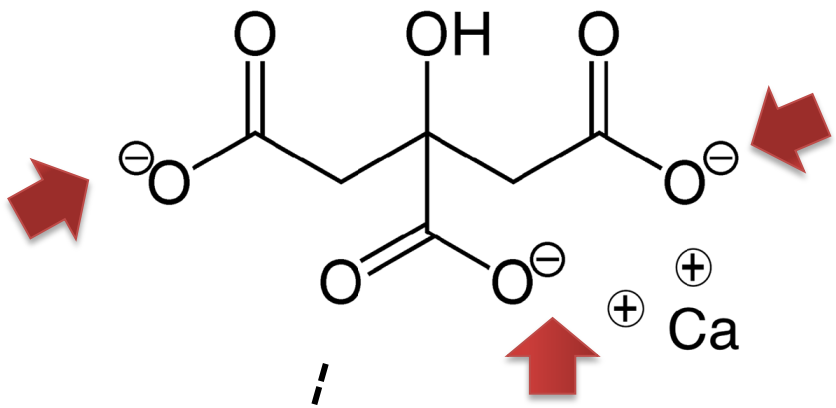
Na^{+}

Half life 5’

2.48kJ – 593 cal/mmol citrate

O_2 dependent

Acid-base effects



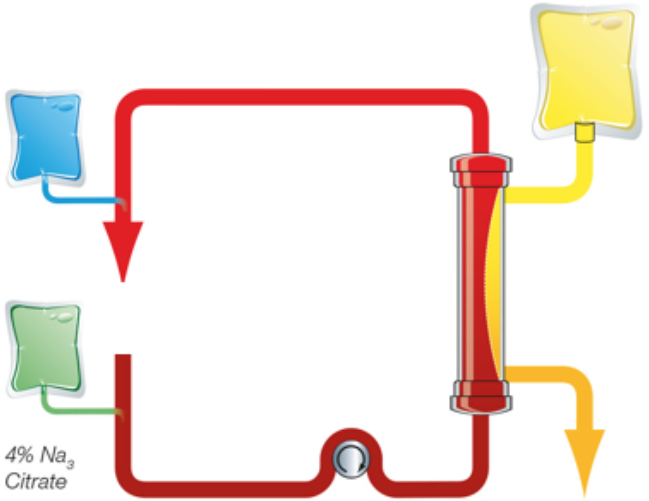
pH

- $PaCO_2$
- SID
- Weak acids

Stewart approach

$$\text{SID} = \left(\text{Na}^+ + \text{K}^+ + \text{Ca}^{2+} + \text{Mg}^{2+}\right) - \left(\text{Cl}^- + \text{lactate}-\right)$$

Acid-base effects



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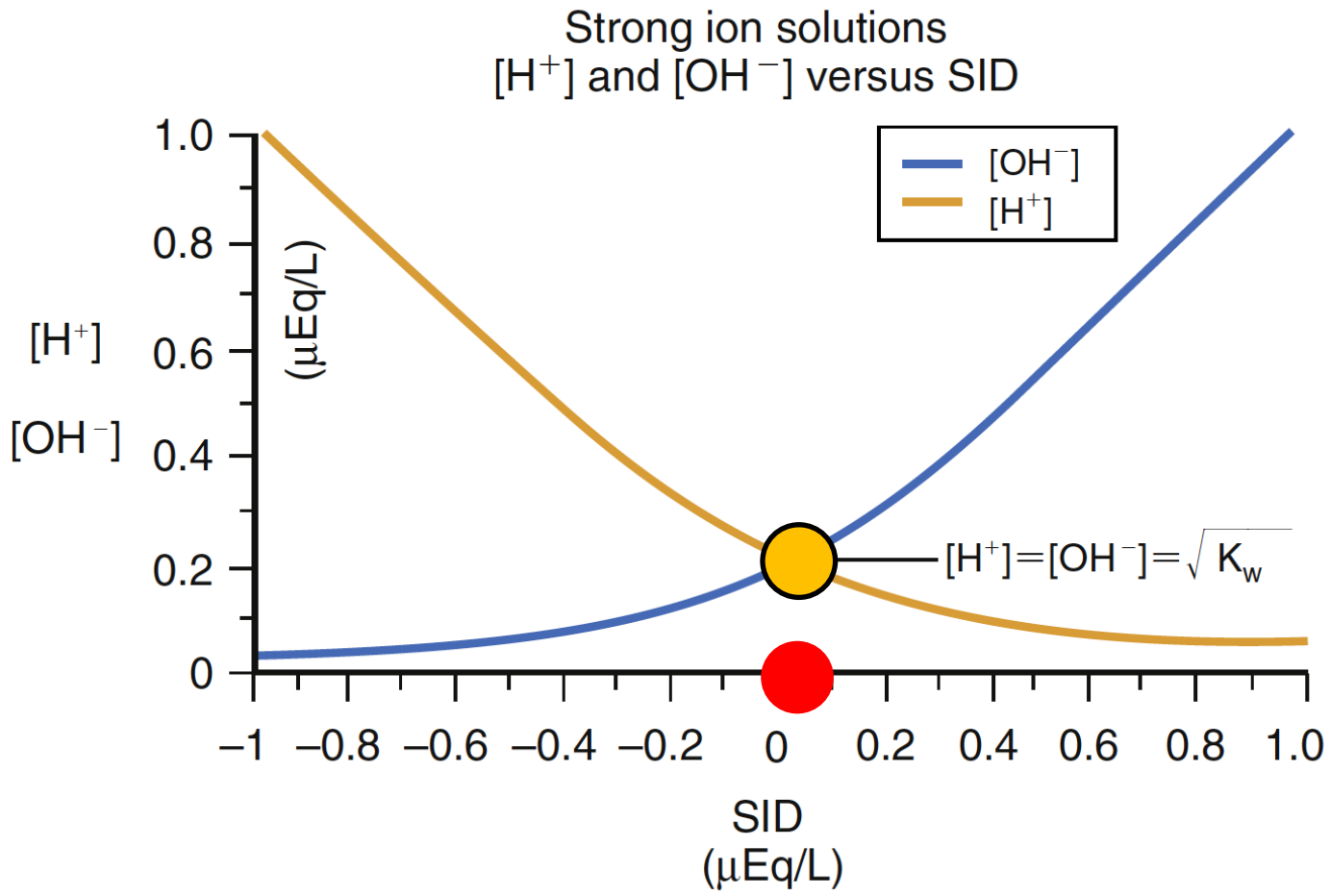
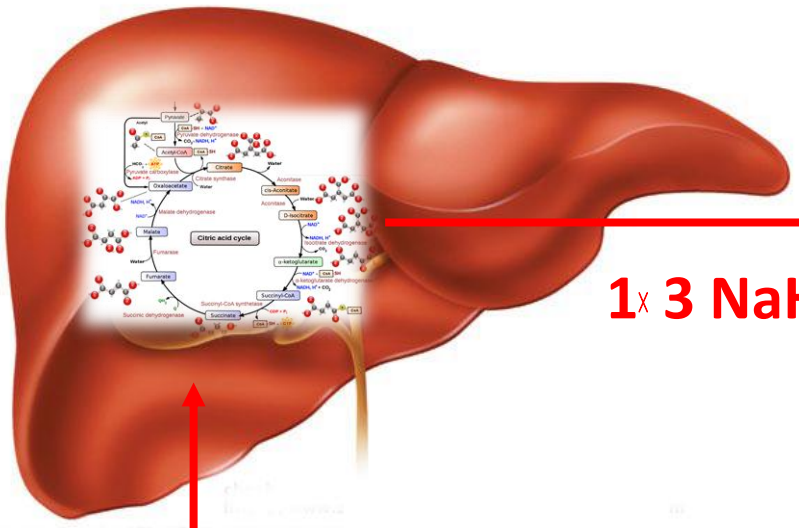
Any change in SID will change both [H+] and [OH−] concentrations.

Because of the Kw, this relationship is inverse:
as [H+] increases, [OH−] decreases



Acid-base effects



Metabolic Alkalosis

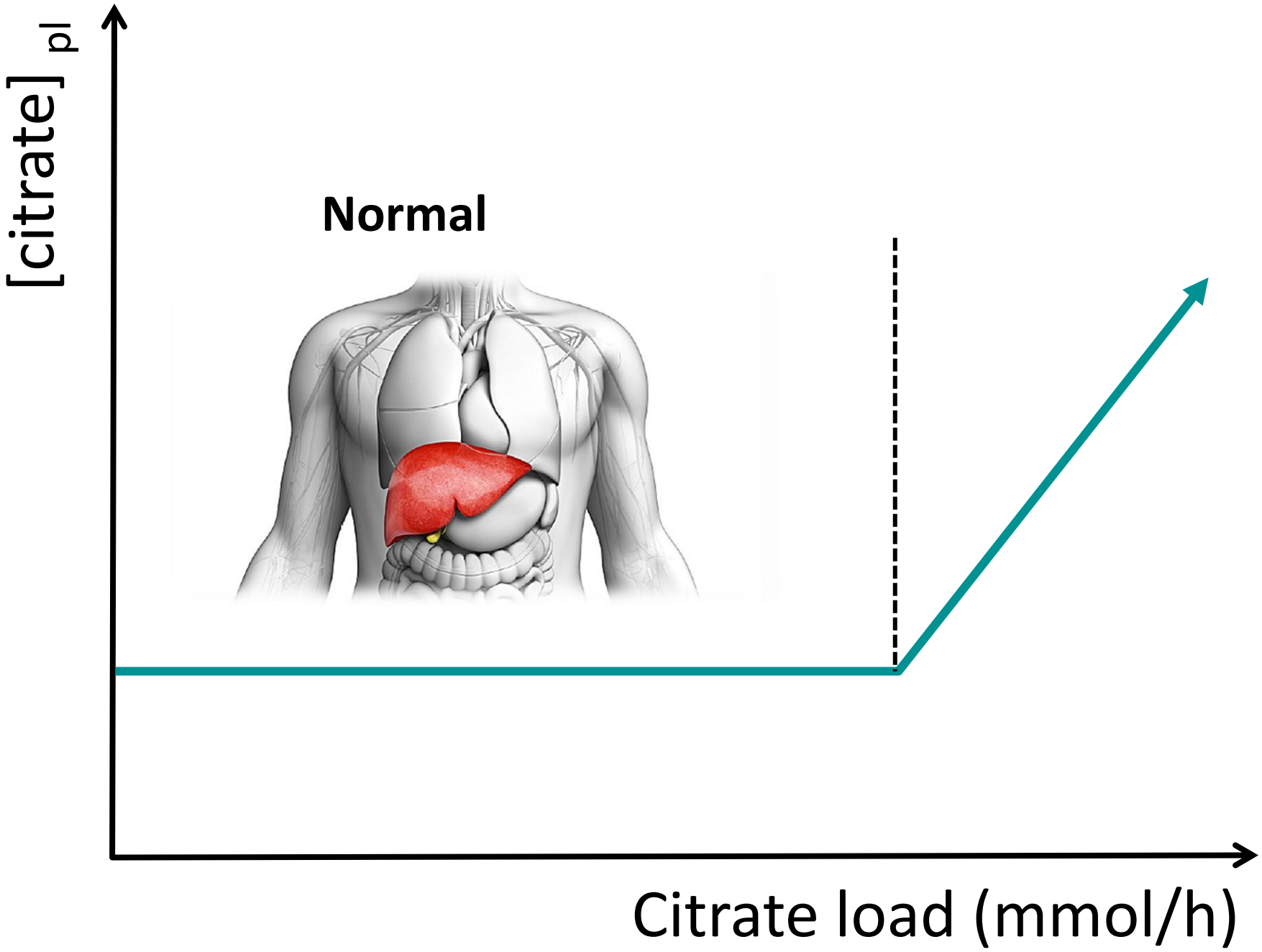
1χ 3 $NaHCO_3^-$

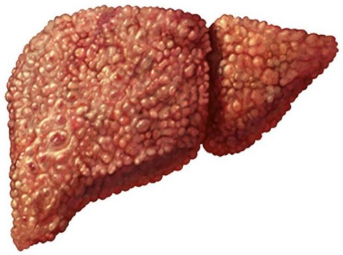
⇑ SID

Ci-Ca

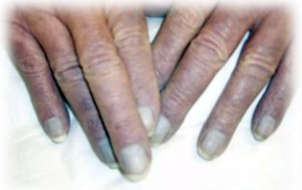
4% Na_3 Citrate

Ci-Ca accumulation ⟶ Metabolic Acidosis


[citrate] pl
Normal
Citrate load (mmol/h)



Liver failure



Hypoxemia

Shock

[citrate]$_{pl}$

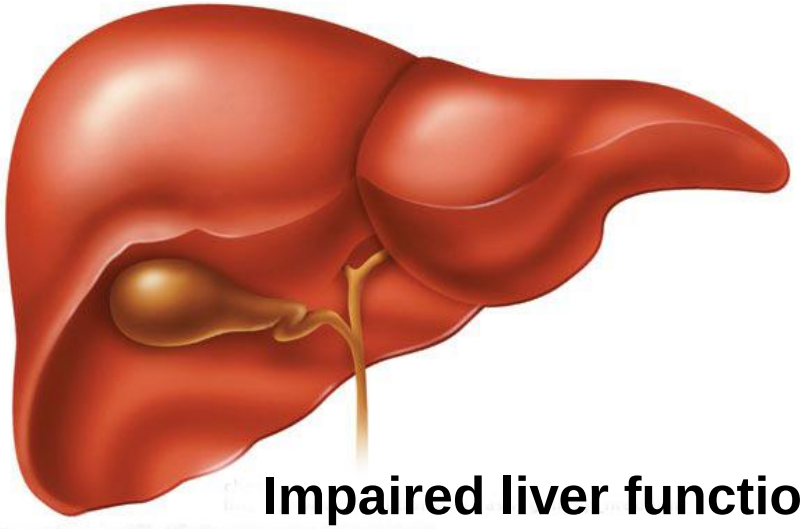
Citrate load (mmol/h)

The ratio of total to ionized calcium appears to be the best parameter to detect citrate accumulation with an optimal cutoff at 2.1.

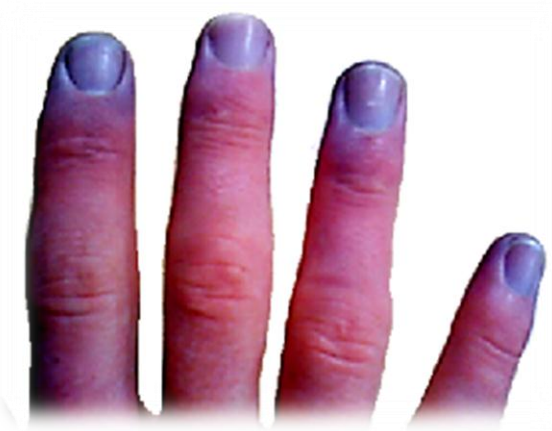
$Ca/Ca^{++} < 2.5$!!!

…accurately predict the citrate accumulation (systemic citrate concentration **1 mmol/L**) with high sensitivity and specificity (89 and 100%, respectively)

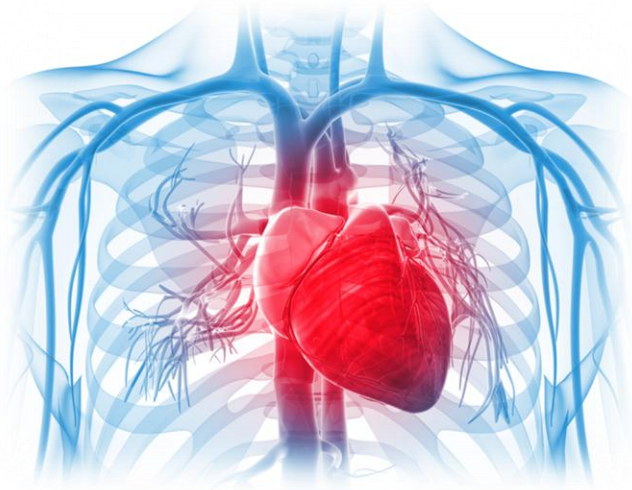
(Bakker AJ, et al. Clin Chem Lab Med (2006) 44: 962–966)



Impaired liver function



Hypoxemia



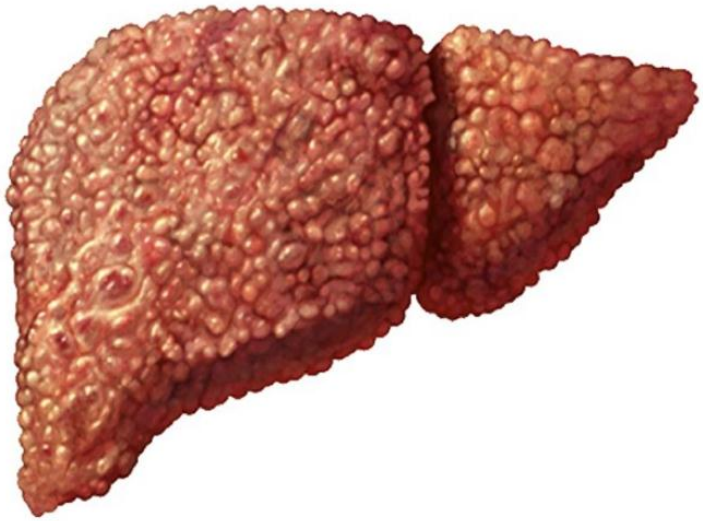
Shock

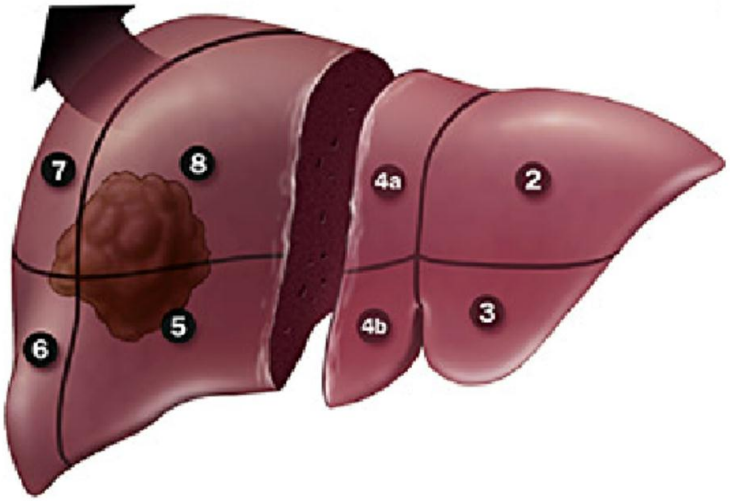
Khadzhynov D, et al J Crit Care (2014) 29: 265–271

Ricci D et al. Contrib Nephrol (2017) 190:19–30

However, there is increasing evidence that at least **impaired liver function need not be considered as an absolute contraindication** for RCA.

Several studies have reported that RCA can be safely used even in this population.





Fiaccadori E, et al. J Nephrol 2015; 28: 151–164.
Slowinski T, et al. Crit Care 2015; 19: 349.
Schultheiß C, et al. Crit Care 2012; 16:R162.
Kribben A, et al. 2012; 142: 782–789.e3.

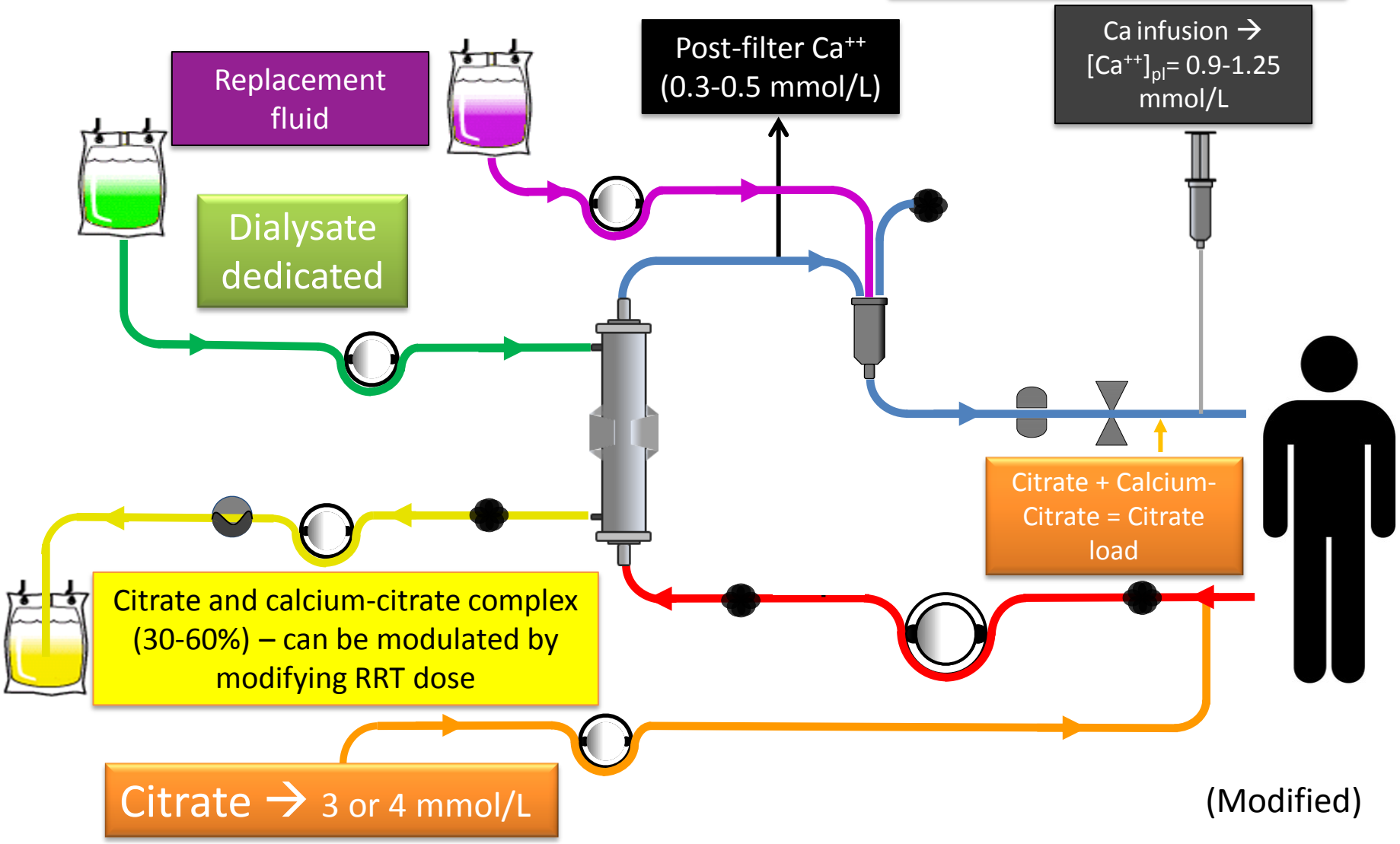
REGIONAL CITRATE

- A variety of protocols exist.

Kellum JA, Bellomo R, Ronco C - 2015

Regional citrate anticoagulation for renal replacement therapies in patients with acute kidney injury: a position statement of the Work Group "Renal Replacement Therapies in Critically Ill Patients" of the Italian Society of Nephrology

Enrico Fiaccadori · Valentina Pistolesi · Filippo Mariano · Elena Mancini · Giorgio Canepari · Paola Inguaggiato · Marco Pozzato · Santo Morabito



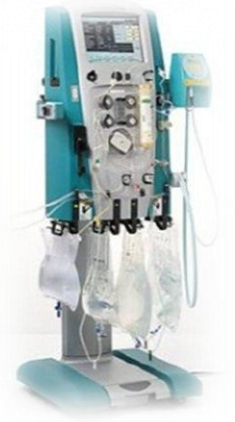
(Modified)

PrismOcal B22
5000 ml

Na^+ 140 mmol/L
K^+ 4 mmol/L
Mg^{++} 0.75 mmol/L
Cl^- 120 mmol/L
HCO_3^- 22 mmol/L
Lattato 3 mmol/L
Glucosio 6.1 mmol/L
Osm 294 mOsm/L

Calcium – Free
$NaHCO_3$ 22 mmol/l

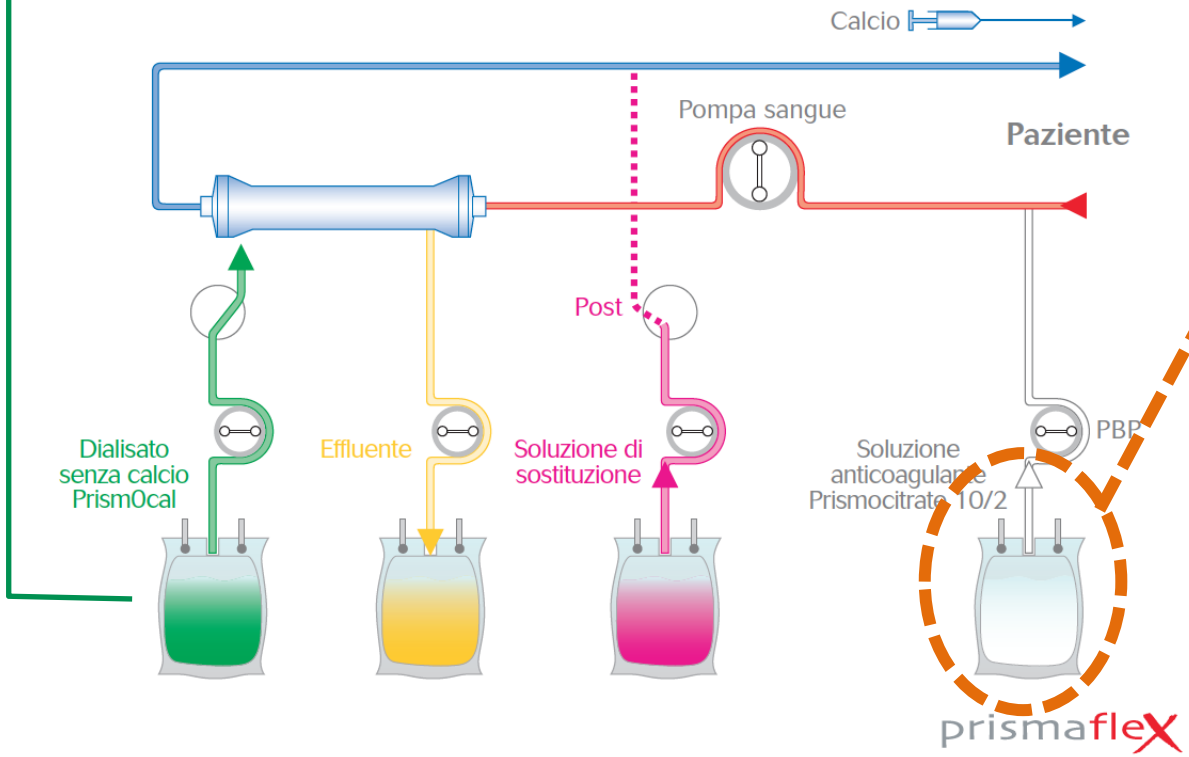
CVVHDF



Baxter

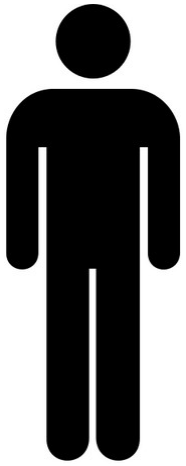
Prismocitrate 18/0
18 mmol/l
5000 ml

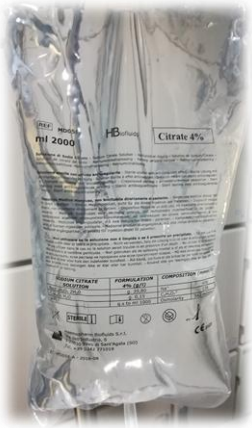
NaCl 5.03 g/L
Sodio citrate 5.29 g/L
Citrato 18 mmol/L
Na^+ 140 mmol/L
Osm 244 mOsm/L



Calcium – Free
K 4 mmol/l
$NaHCO_3$ 25 mmol/l
5000 ml

Na^+ 136 mmol/L
K^+ 4 mmol/L
Mg^{++} 0.75 mmol/L
Cl^- 116.5 mmol/L
HCO_3^- 25 mmol/L





HBiofluids

Citrate 4%
(136 mmol/l)
2000 ml

Sodio citrato 39.8 g/2000 mL
Ac.citrico 0.15 g/2000 mL
Citrato 136 mmol/L
Na^+ 406 mmol/L

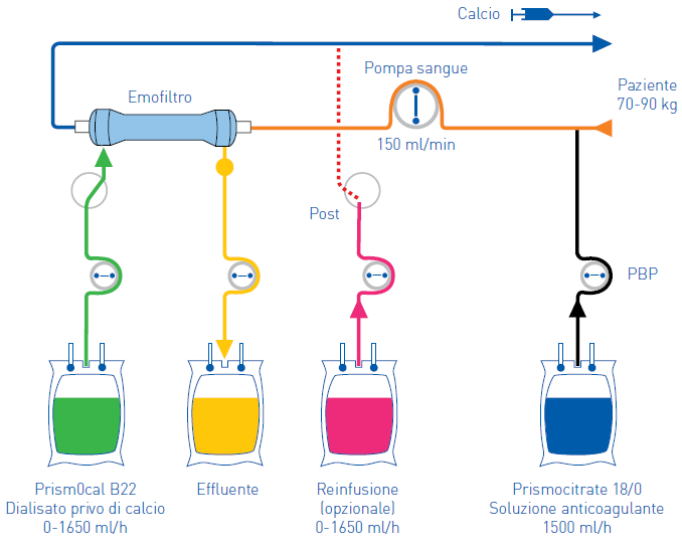
CVVHD

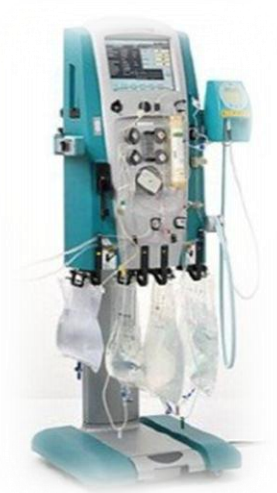
Protocollo CVVHDF con Citrato con Prismaflex

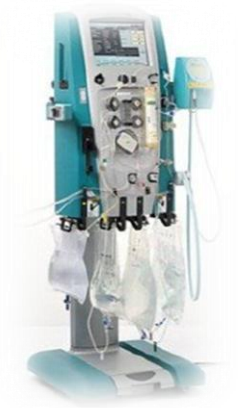
(con Prismocitrate® 18/0)

IMPOSTAZIONE FLUSSI	Peso Paziente [Kg]								
	50	60	70	80	90	100	110	120	130
FLUSSO SANGUE [ml/min]	100	110	120	130	140	150	160	170	180
Infusione PBP (pre diluizione) (1) Prismocitrate® 18/0 o Regiocit [ml/h]	1000	1100	1200	1300	1400	1500	1600	1700	1800
DIALISATO senza calcio Prism0cal® B22 o Biphozyl [ml/h]	1000	1100	1200	1300	1400	1500	1600	1700	1800
REINFUSIONE post diluizione (2) PRISMASOL 2 / 4 , Phoxilium® o Biphozyl [ml/h]	200	400	500	500	500	600	700	800	1000

IMPOSTAZIONE ANTICOAGULANTE	
Dose Citrato	3 mmol/L sangue
Compensazione Calcio (3)	100 %







Calcio ionizzato sistemico Range: 1,00 – 1,20 mmol/L o 4,00 – 4,80 mg/dL	Entro i primi 30 min	A 2 ore dalla partenza	Almeno ogni 6 ore (vedi schema)
Calcio ionizzato post filtro Range: 0,25 – 0,50 mmol/L o 1,00 – 2,00 mg/dL	Entro i primi 30 min		Almeno ogni 24 ore (vedi schema)

COMPENSAZIONE % DELLA CALCEMIA PAZIENTE TRAMITE SIRINGA PRISMAFLEX

Le variazioni si intendono rispetto al valore attualmente impostato

mg/dL	< 3,2	3,6	4,0		4,8	5,4	mg/dL
mmol/L	< 0,8	0,9	1,0		1,2	1,35	mmol/L
+ 30%	+ 20%	+ 10%	COMPENSAZIONE ADEGUATA NESSUNA MODIFICA			- 10%	- 20%
Prossimo controllo dopo 1 ora	Prossimo controllo dopo 2 ore	Prossimo controllo dopo 4 ore	Prossimo controllo dopo 6 ore			Prossimo controllo dopo 4 ore	Prossimo controllo dopo 2 ore

(dopo la seconda ora dall'inizio del trattamento o su richiesta del sistema Prismaflex)

In caso di grave Ipocalcemia si suggerisce di valutare un'ipotetica intolleranza mediante il rapporto Ca Tot. / Ca^{++}

AGGIUSTAMENTO DEL CALCIO IONIZZATO POST FILTRO

mg/dL	< 1,00	1,00 – 2,00	> 2,00	mg/dL
mmol/L	< 0,25	0,25 – 0,50	> 0,50	mmol/L
	Impostare Dose Citrato = 2,7 mmol/L	NESSUNA MODIFICA	Impostare Dose Citrato = 3,3 mmol/L (*)	
	Prossimo controllo dopo 6 ore	Prossimo controllo dopo 24 ore	Prossimo controllo dopo 6 ore	

(*) Da impostare solo se HCO_3^- < 28 mmol/L

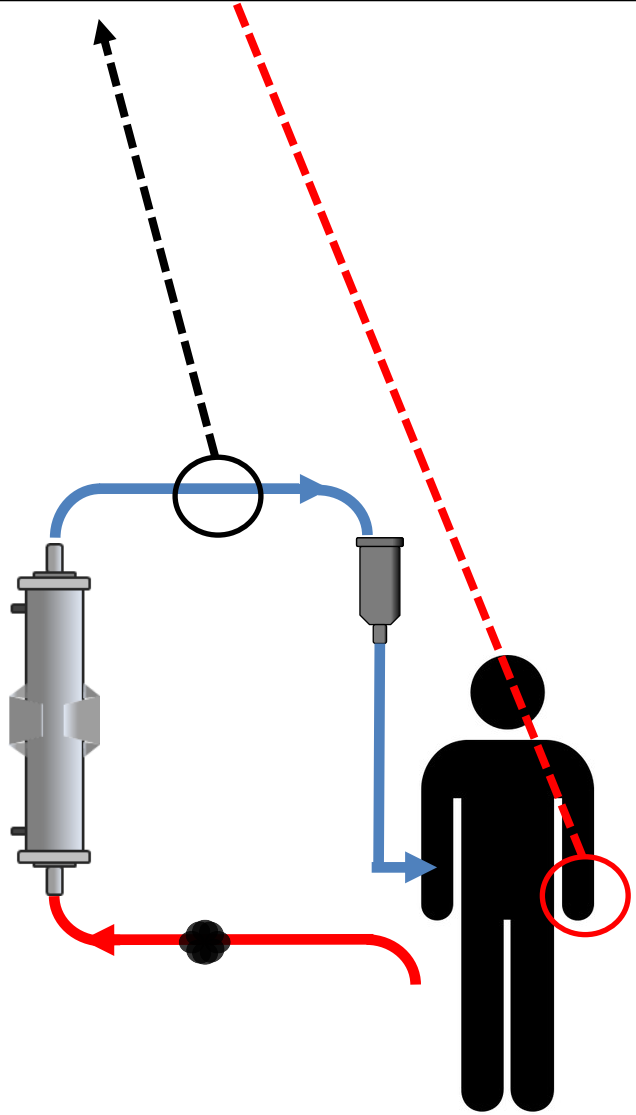
AGGIUSTAMENTO DELL'ACCUMULO DI CITRATO e/o BILANCIO BICARBONATI

(dopo 6 ore dalla partenza)

HCO_3^- mmol/L	22	28	mmol/L
DIALISATO: - 300 ml/h FLUSSO SANGUE: + 10 ml/min	NESSUNA MODIFICA	DIALISATO: + 300 ml/h FLUSSO SANGUE: - 10 ml/min	
Prossimo controllo dopo 6 ore	Prossimo controllo dopo 12 ore	Prossimo controllo dopo 6 ore	

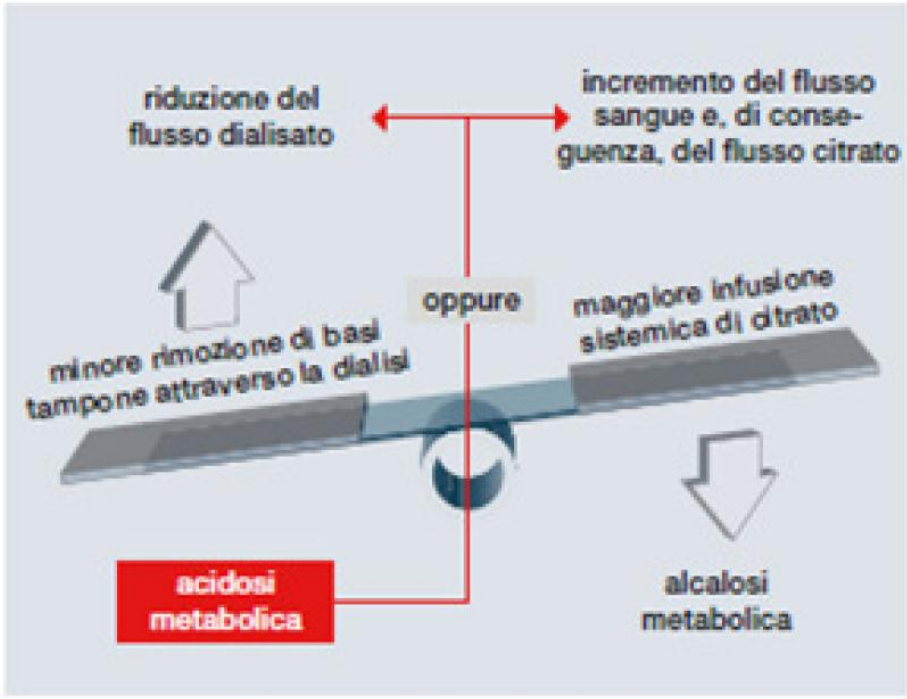
Range consigliati: DIALISATO (900 - 1800) mL/h – FLUSSO SANGUE (100 - 170) mL/min

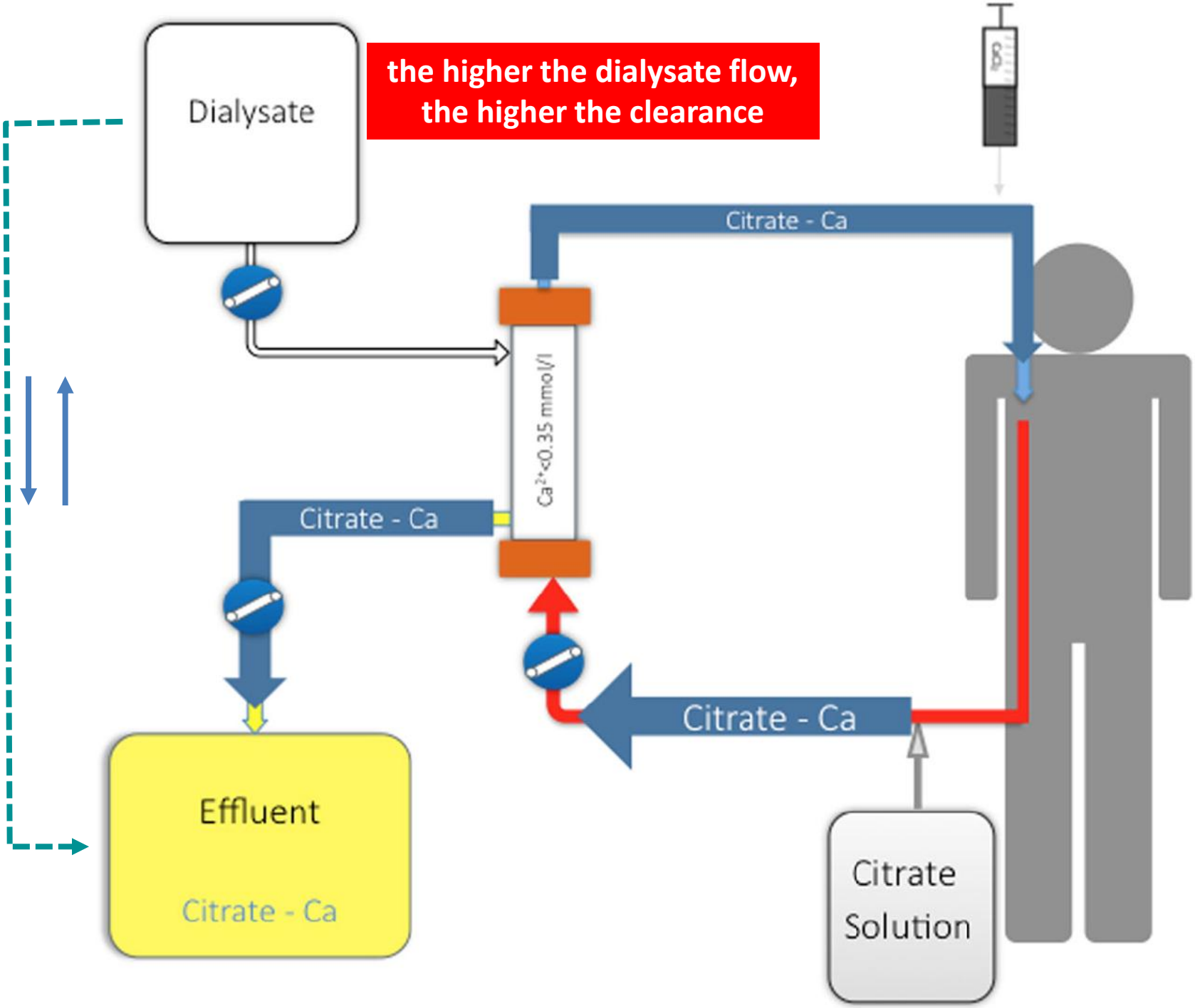
Applicare possibilmente entrambe le modifiche



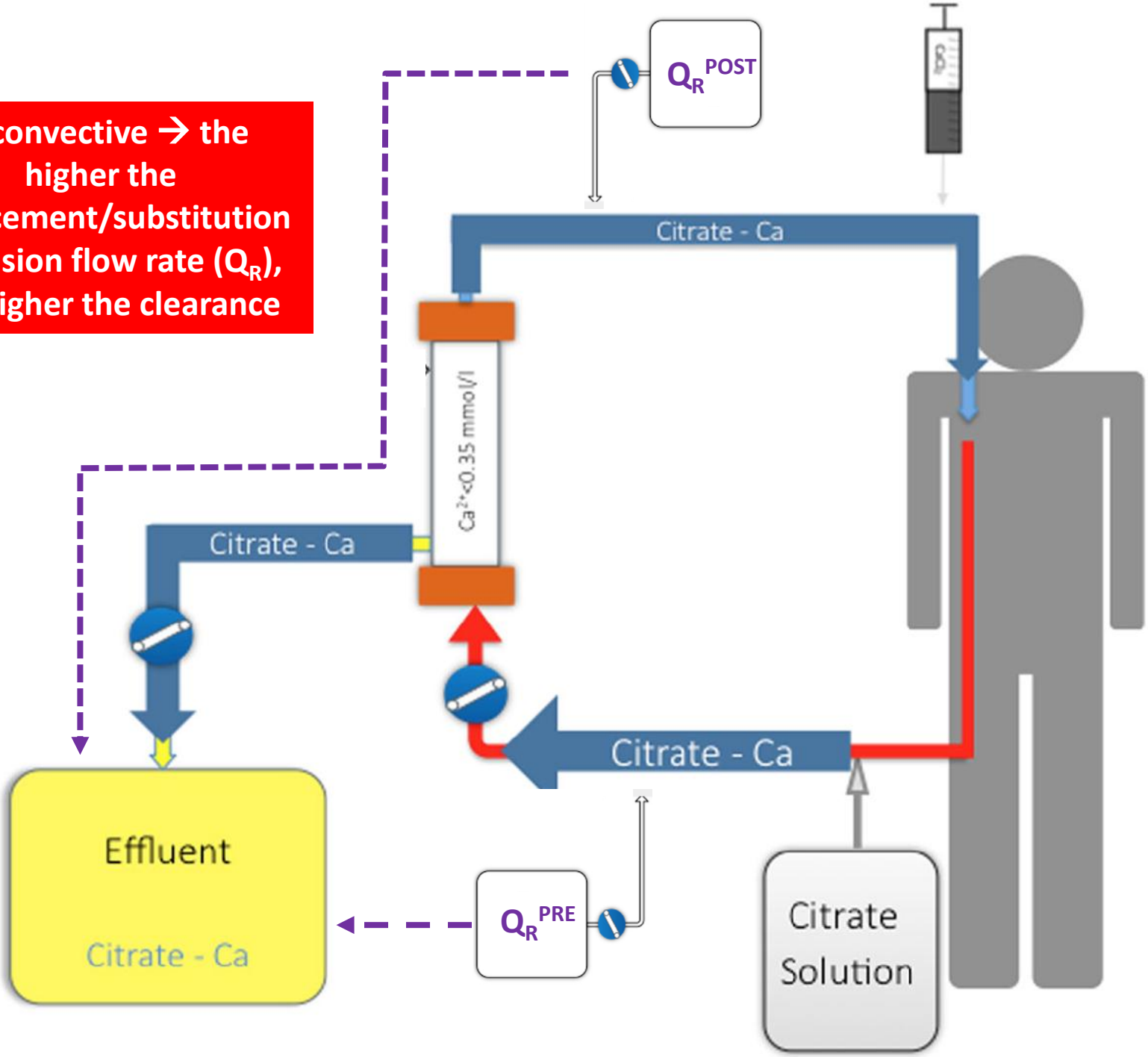
ALCALOSI METABOLICA

ACIDOSI METABOLICA




the higher the dialysate flow,
the higher the clearance
Dialysate
Citrate - Ca
Ca2+<0.35 mmol/l
Citrate - Ca
Citrate - Ca
Effluent
Citrate - Ca
Citrate
Solution

In convective → the higher the replacement/substitution / infusion flow rate (Q_R), the higher the clearance



OMNI – PROTOCOLLO CITRATO CVVHD (CHUV LOSANNA)

B|BRAUN
SHARING EXPERTISE

Peso paziente (Kg)	Flusso Dialisato (ml/h)	Flusso Sangue (ml/min)
60	1600	80
60 -79	2000	100
80 - 99	2600	130
100 - 119	3000	150
120 -149	3600	180

- Trisodio citrato **4%**
- Siringa B.Braun Omnifix da 50cc contenente:

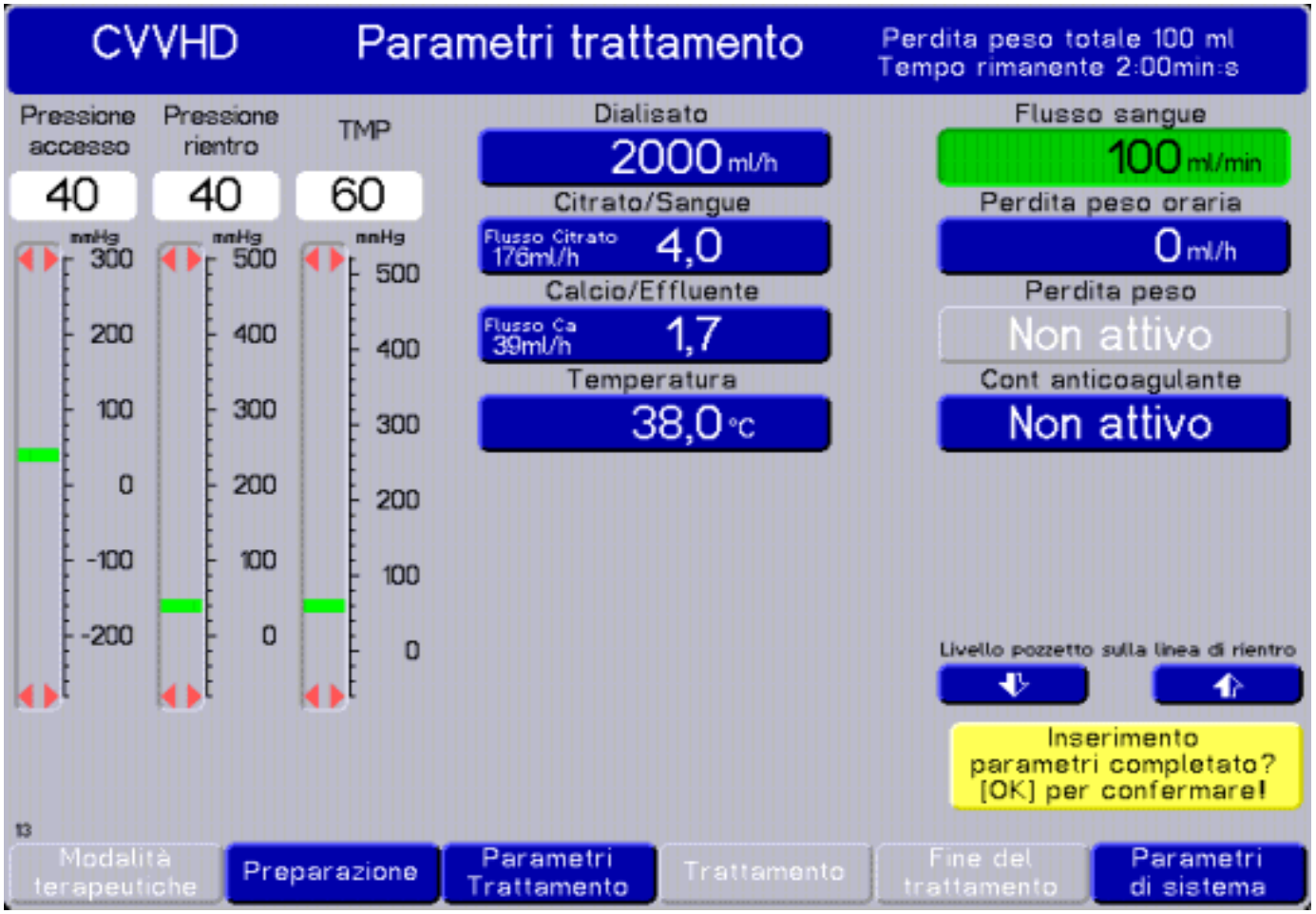
30 ml Calcio Cloruro 10% (680mmol/l) più **20 ml** di soluzione fisiologica => **408 mmol/l**

Rapporto Flusso Dialisato/Flusso sangue 20:1

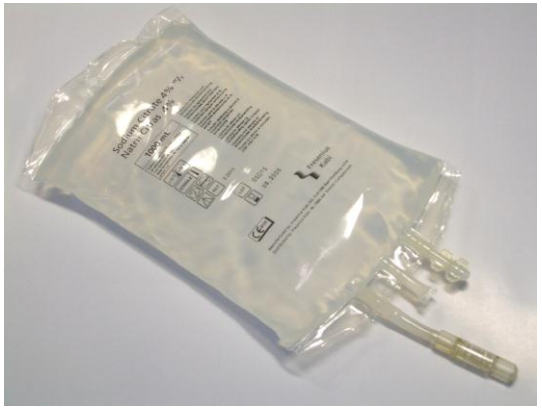
- Dialisato **senza calcio** a 4K+

Calcio ionizzato POST FILTRO (mmol/l)	Modifica dose CITRATO (Citrato/Sangue)
> 0,45	**Aumentare di 0,3 mmol/l e informare il medico**
0,41 – 0,45	Aumentare di 0,2 mmol/l
0,35 – 0,40	Aumentare di 0,1 mmol/l
0,25 – 0,34	**Nessuna modifica**
0,20 – 0,24	Ridurre di 0,1 mmol/l
0,15 – 0,19	Ridurre di 0,2 mmol/l
< 0,15	**Ridurre di 0,3 mmol/l**

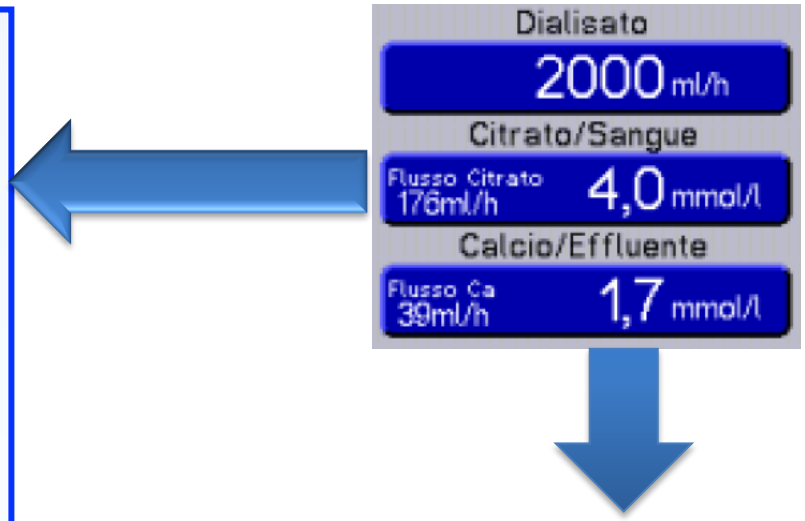
Calcio ionizzato SISTEMICO (mmol/l)	Modifica dose CALCIO (Calcio/Effluente)
> 1,45	**Diminuire di 0,6 mmol/l e informare il medico**
1,31 – 1,45	Diminuire di 0,4 mmol/l
1,21 – 1,30	Diminuire di 0,2 mmol/l
1,12 – 1,20	**Nessuna modifica**
1,05 – 1,11	Aumentare di 0,2 mmol/l
0,95 – 1,04	Aumentare di 0,4 mmol/l
< 0,95	**Aumentare di 0,6 mmol/l e informare il medico**



MultiFiltrate CVVHD



- 40 g/l Na_3Citrato
- pH regolato con acido citrico
- 136 mmol/l ioni citrato
- Sacca 1500 ml



Calcio ionizzato post-filtro (mmol/L)	Variazione della dose citrato (citrato/sangue)
> 0,45	Aumentare di 0,3 mmol/L e informare il medico
0,41 – 0,45	Aumentare di 0,2 mmol/L
0,35 – 0,40	Aumentare di 0,1 mmol/L
0,25 – 0,34	Nessun cambiamento
0,20 – 0,24	Diminuire di 0,1 mmol/L
0,15 – 0,19	Diminuire di 0,2 mmol/L
< 0,15	Diminuire di 0,3 mmol/L e informare il medico

Calcio sistemico ionizzato (mmol/L)	Variazione della dose calcio (calcio/filtrato)
> 1,45	Diminuire di 0,6 mmol/L e informare il medico
1,31 – 1,45	Diminuire di 0,4 mmol/L
1,21 – 1,30	Diminuire di 0,2 mmol/L
1,12 – 1,20	Nessun cambiamento
1,05 – 1,11	Aumentare di 0,2 mmol/L
0,95 – 1,04	Aumentare di 0,4 mmol/L
< 0,95	Aumentare di 0,6 mmol/L e informare il medico

SW Rel. 4.0.9 Rev. 00

CA++ IONIZZATO SISTEMICO - FLUSSO CALCIO

Ca ++ sistemico 1.40 mmol/L

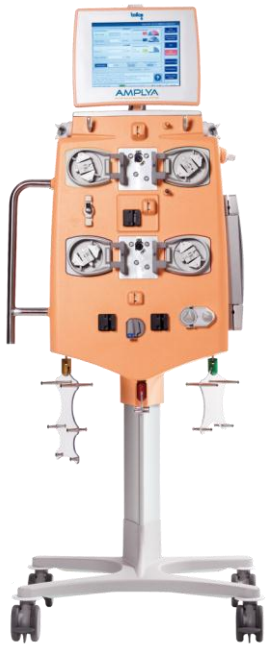
Conferma il nuovo valore di flusso della pompa calcio per rimanere nella modalità "Citrato Assistito".

Flusso Pompa Calcio 1.0 ml/h

REQ: mh 163 OPT: LOAD: minihelp/ita/mh 163.html

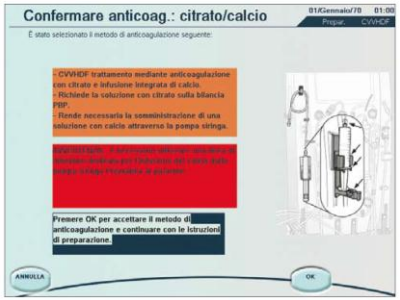
Premere spunta per confermare la quantità suggerita di calcio da infondere, oppure inserire la quantità di calcio da infondere.

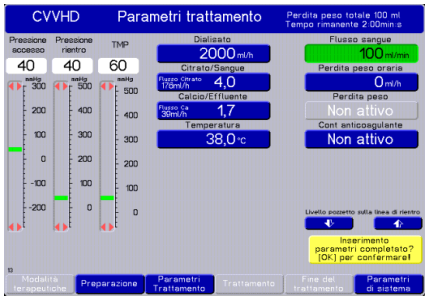
CPFA-ASSIST. 00m:00s -- 12 10



Medtronic

The **new software** is in fact able to adapt citrate infusion to blood flow changes, thus limiting the risk of an inappropriate citrate/blood flow ratio.





Moreover, with CRRT monitors the citrate dose **can be modified at any time during the treatment** in the event of a documented or suspected citrate overload.

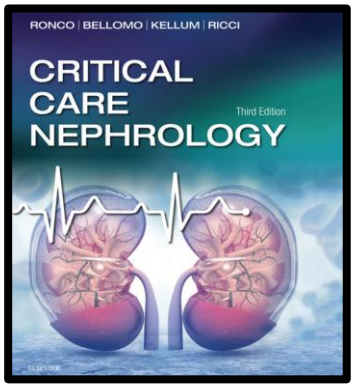
Last, **modulation of the convective and/or diffusive CRRT** dose may prevent the development of citrate accumulation, due to the substantial removal of citrate with the effluent fluid

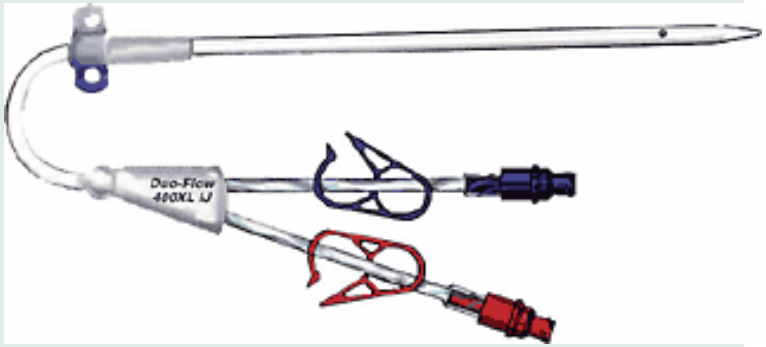
Citrate accumulation or overload

(management)

1) Decreasing Q_B (decreases intake) through blood flow–citrate coupling or
2) Increasing Q_D (CVVHD) or Q_R (CVVH) (increases removal), or
3) Decreasing the targeted citrate concentration within the filter.

Nonanticoagulant Measures Reducing Circuit and Access Clotting

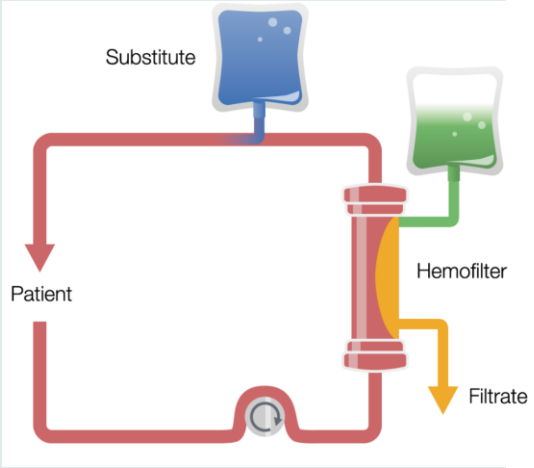




Catheter design
- Increase diameter
- High inner diameter (thin material)
- Avoid side holes
- Use short-gun tip

Catheter position
- Chose individually
- Chose position with lowest pressures
- Choose straight direction : right jugular, left or right femoral vein
- Prevent kinking
- Tip of jugular vein catheter in right atrium
- Tip of femoral vein catheter in inferior caval vein

CRRT mode
- Avoid or reduce hemoconcentration
  - Hemodialysis
  - Hemofiltration with low filtration fraction
  - Predilution hemofiltration



Circuit
- Avoid blood flows < 100mL/min

Venous access during CRRT interruptions
- Use a citrate lock

Ronco, Bellomo, Kellum, Ricci 2018

Final Thoughts

- RCA, compared to systemic anticoagulation
  - ✓ Per se is safe and effective
  - ✓ Prolongs filter running time
  - ✓ Decreases bleeding risk
  - ✓ Decreases workload & associated cost

- Patients at risk for citrate accumulation
  - ✓ Severe liver failure
  - ✓ Severe hypoxemia
  - ✓ Shock

- Take a look to … Magensium (Mg^{++})

CRRT nursing

X Edizione

Corso Teorico Pratico

grazie

Stefano Romagnoli

Another approach to achieve **regional anticoagulation is regional heparinization** combining a pre-filter dose of heparin, aiming at a prolongation of the extracorporeal aPTT, with post-filter neutralization with protamine, aiming at normalizing the systemic aPTT

It is cumbersome and difficult to titrate because heparin has a much longer half-life than protamine, inducing a risk of rebound. In addition, it exposes the patient to the side-effects of both heparin (mainly the risk of HIT) and protamine (mainly anaphylaxis, platelet dysfunction, hypotension, and pulmonary vasoconstriction with right ventricular failure) and is **therefore not recommended**.

LESS COMMON APPROACHES

HEPARIN DOSING GUIDE			
Drug	Infusion	Where?	Comments
Regional heparin/protamine	Protamine at 10 mg/h and heparin at 1000 U/h (1:100 ratio)	Heparin is administered pre-filter and protamine is administered post-filter into the venous chamber or directly into the return limb of the access .	Not with HIT. Check patient aPTT after 6 hours to ensure that heparin effect is reversed.
PGI2	Bolus (5 ng/Kg/min) over 15 minutes before commencement of CRRT via a CVC; infusion 4-8 ng/Kg/min	Circuit pre-filter	Hypotension, bleeding and/or abdominal cramps may occur with PGI2 therapy.
Danaparoid	Bolus of IU; 1-2 IU/h	Circuit pre-filter	Check daily anti-Xa level of 0.2-0.35 IU/mL.

Kellum JA, Bellomo R, Ronco C - 2015

LESS COMMON APPROACHES

Table 1 Alternative anticoagulation in heparin-induced thrombocytopenia [115-119]

	Danaparoid	Bivalirudin	Argatroban
Dosing	3,500 IU bolus, followed by 100 units/hour or 140 IU/hour without bolus	0.03-0.2 mg/kg per hour	Bolus 100 μg/kg followed by 0.1-0.5 μg/kg per minute
Monitoring	Anti-Xa activity 0.25-0.35 IU/mL (0.5-1.0 IU/mL[a])	Target aPTT ratio 1.5 (–2.5[a])	Target aPTT ratio 1.5 (–3.0[a])
Main adverse events	Cross-reactivity with HIT-ab	No data	Anemia; accumulation in liver failure

[a]If systemic anticoagulation is required. aPTT, activated partial thromboplastin time; HIT-ab, heparin-incuded thrombocytopenia antibody.

Ronco C et al. Critical Care (2015) 19:146

Managing an Alkalosis

- First review the patient, treat any underlying condition and ensure dialysate dose is appropriate
- Check that the dialysate and blood flow rates are set according to the protocol.

To correct an alkalosis *either:*

- Increase the dialysate flow (an increase of 20% will decrease the serum bicarbonate level by approximately 4mmol/L)

or

- Decrease the blood flow rate (a decrease of 20% to the blood flow rate will decrease the serum bicarbonate level by approximately 4mmol/L)