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Acute kidney injury
Renal replacement therapy

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Learning goals

- Student learns how to recognize and define acute kidney injury/failure.
- Student gains basic knowledge about the methods for renal functions replacement.

Lecture summary

- Definition and diagnostics of AKI
- Pathogenesis of AKI
- Treatment of AKI
- Methods of renal replacement therapy in AKI
- Vascular access
- Anticoagulation in CRRT

Definition and diagnostics of AKI

- abrupt/prompt deterioration of the glomerular filtration rate (GFR)
- several reasons (pre-renal, renal, post-renal)
- AKI (acute kidney injury)

- occurrence in 50-60% adult patients in critical care
- 5-10% in children
- confirmed independent factor of mortality – 50-60%
- approx. 70% of patients with AKI requires renal replacement therapy (RRT)

Definition and diagnostics of AKI

- ischemic injury
  - sepsis (most common reason for AKI onset)
  - pancreatitis
  - trauma
  - part of multiorgan dysfunction sydrome (MODS)
- toxic injury
  - exogenous
    - drugs (gentamicin, amphotericin, cisplatin, etc.)
    - toxins (heavy metals, plants, mushrooms, contrast media, etc.)
  - endogenous
    - hem pigments (rhabdomyolysis)
    - uric acid (tumor lysis syndrome)

Definition and diagnostics of AKI

- Clinical problems in AKI:

- Oliguria (<400 ml urine/day in adults, <0,5 ml/kg/h in children)
  - **fluid overload** and hypertension
  - complications with nutrition and drugs administration

- Reduced renal clearance
  - electrolyte imbalances (**hyperkalemia**)
  - **metabolic acidosis** with high anion gap (HAGMA)
  - azotemia (BUN and creatinine elevation)

Pathogenesis of AKI

- pathophysiology of AKI:
  - pre-renal
  - renal
  - post-renal

Pathogenesis of AKI

- Pre-renal reasons for AKI:
  - **hypovolemia** from bleeding (surgical intervention, trauma, GIT bleeding), gastrointestinal loses (diarrhea, vomiting), renal loses (diuretics, diabetes insipidus) or skin loses (burns)
  - **decrease in effective perfusion pressure** and/or effective circulating volume in heart failure, shock or liver cirrhosis
  - **combined pathology**, e.g. sepsis (hypovolemia + changes on cellular level + drug toxicity, e.g. antibiotics)

Pathogenesis of AKI

- Renal reasons for AKI:
  - **vascular** – thrombosis, HUS, vasculitis, malignant hypertension
  - **infection** – sepsis, glomerulonephritis
  - **tubular and interstitial pathology** – acute tubular necrosis, rhabdomyolysis, hemoglobinuria, sepsis, pancreatitis

Pathogenesis of AKI

- Post-renal reasons for AKI:
  - bilateral obstruction of urine passage
  - relative rare in children (posterior urethral valve)
  - other reasons may include **tumor**, **compression from outside** or **trauma**

Treatment of AKI

- basis common principles of AKI treatment:
  - restore/retain electrolyte homeostasis (Na, K, Ca, P) and fluid balance
    diuretics (furosemide) – only to solve fluid overload and hyperkalemia, not the treatment of AKI itself
  - proper nutritional support
  - prevention of life-threatening complications
  - elimination of endogenous and exogenous toxins as fast as possible
  - treatment of underlying illness
  - dose reduction of administered drugs (e.g. antibiotics)

Methods of renal replacement therapy in AKI

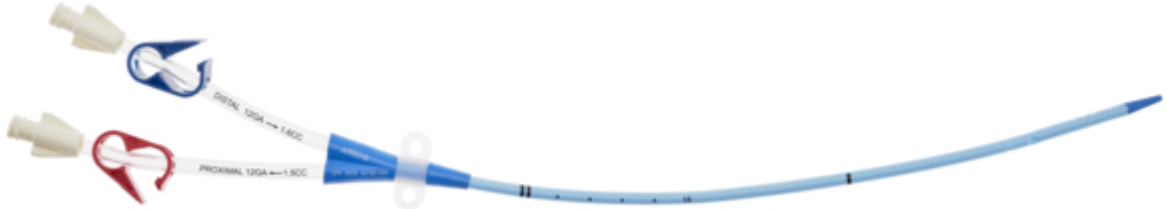
- **intracorporeal** – peritoneal dialysis (sometimes in children)
- **extracorporeal** – intermittent hemodialysis (iHD), continual elimination methods (CRRT, continual renal replacement therapy)

Methods of renal replacement therapy in AKI

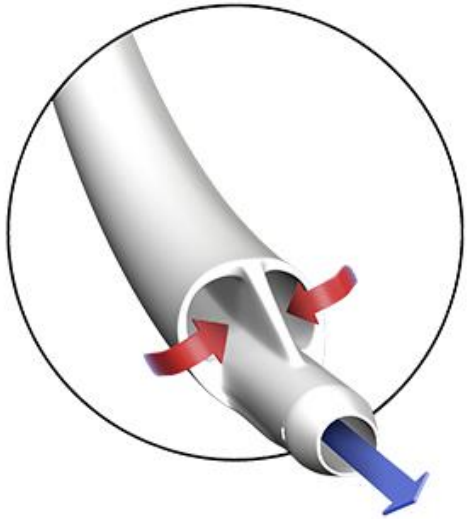
- **peritoneal dialysis**: sometimes used in children when CRRT not available, less effective in changing the ions concentration and body water volume, well tolerated in circulatory instability, simplest, serious risk of infection
- **iHD**: fastest changes in the ions concentration and body water removal compared to other methods, oldest, widely used, most effective, very complicated in critical care patients, mainly because of circulatory instability
- **CRRT**: several modalities (CVVD, CVVHD, CVVHDF), slow and continuous speed of ions and water removal, well tolerated in circulatory compromised patients

Vascular access

– vascular access



Source: https://www.teleflexvascular.com/products/cd-13902



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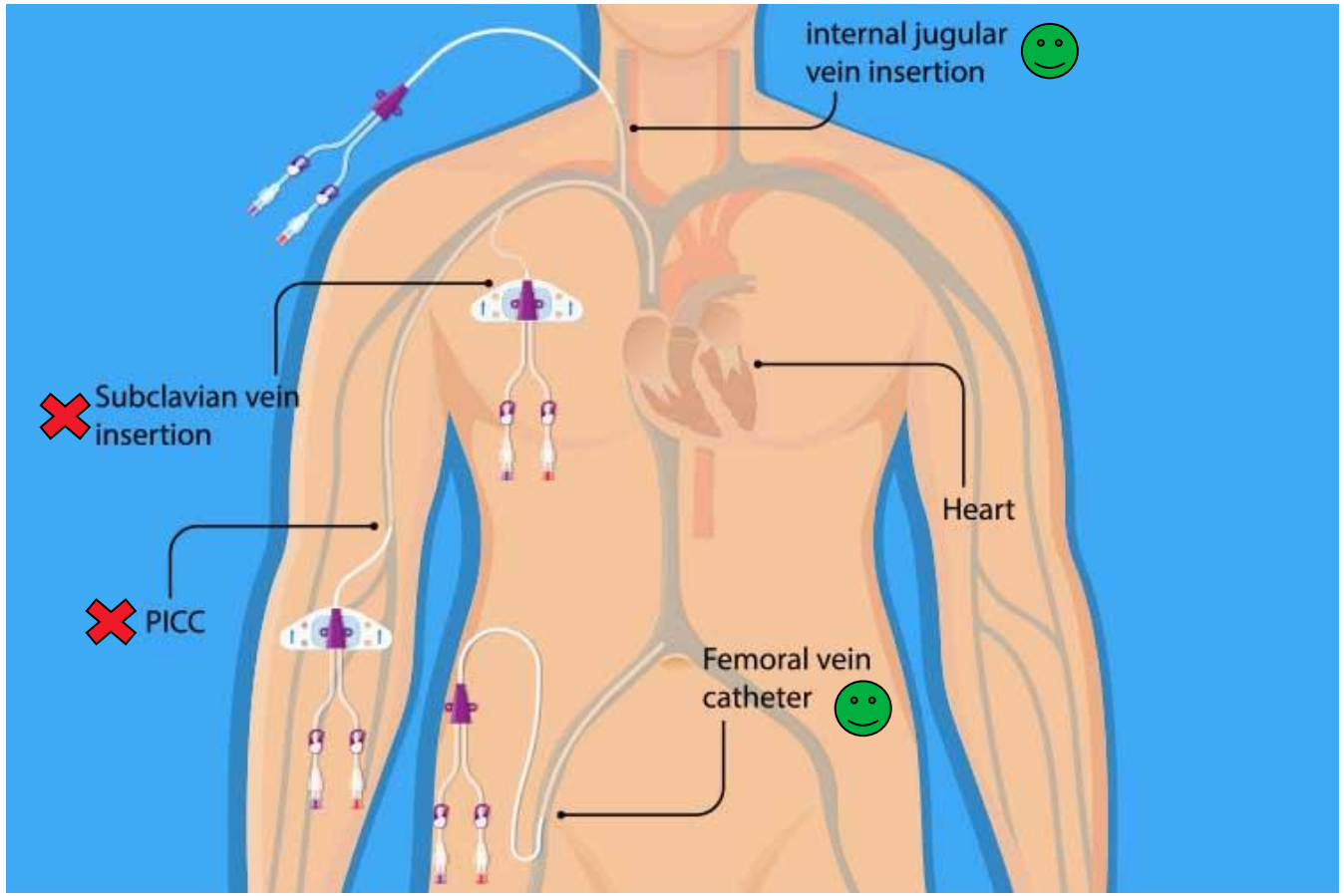
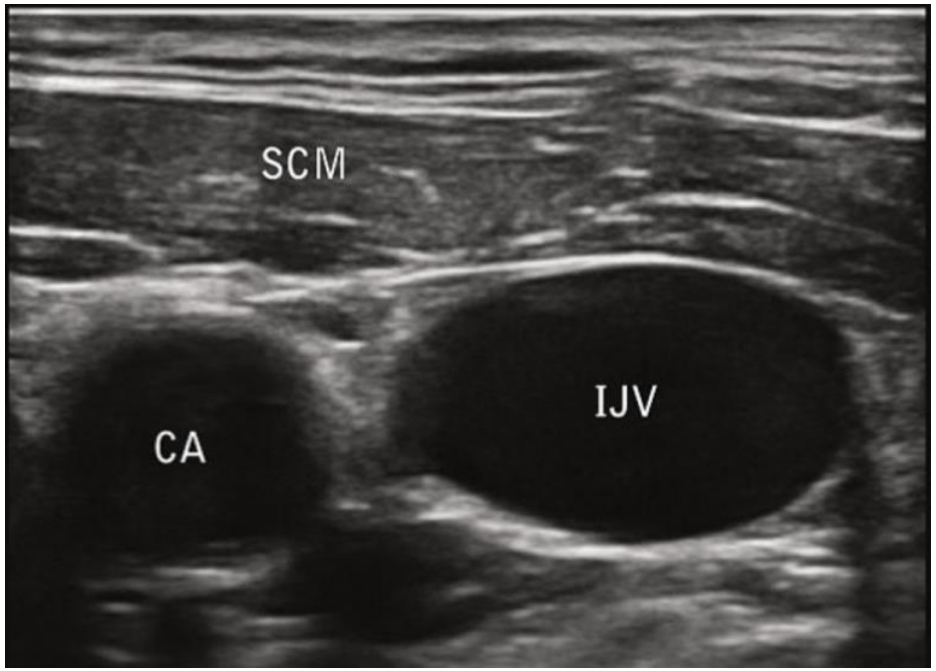
Vascular access





Source:
http://www.emdocs.net/unlocking-common-ed-procedures-never-let-go-a-review-of-central-venous-access-placement/
https://www.ausmed.com.au/cpd/articles/-central-venous-catheters

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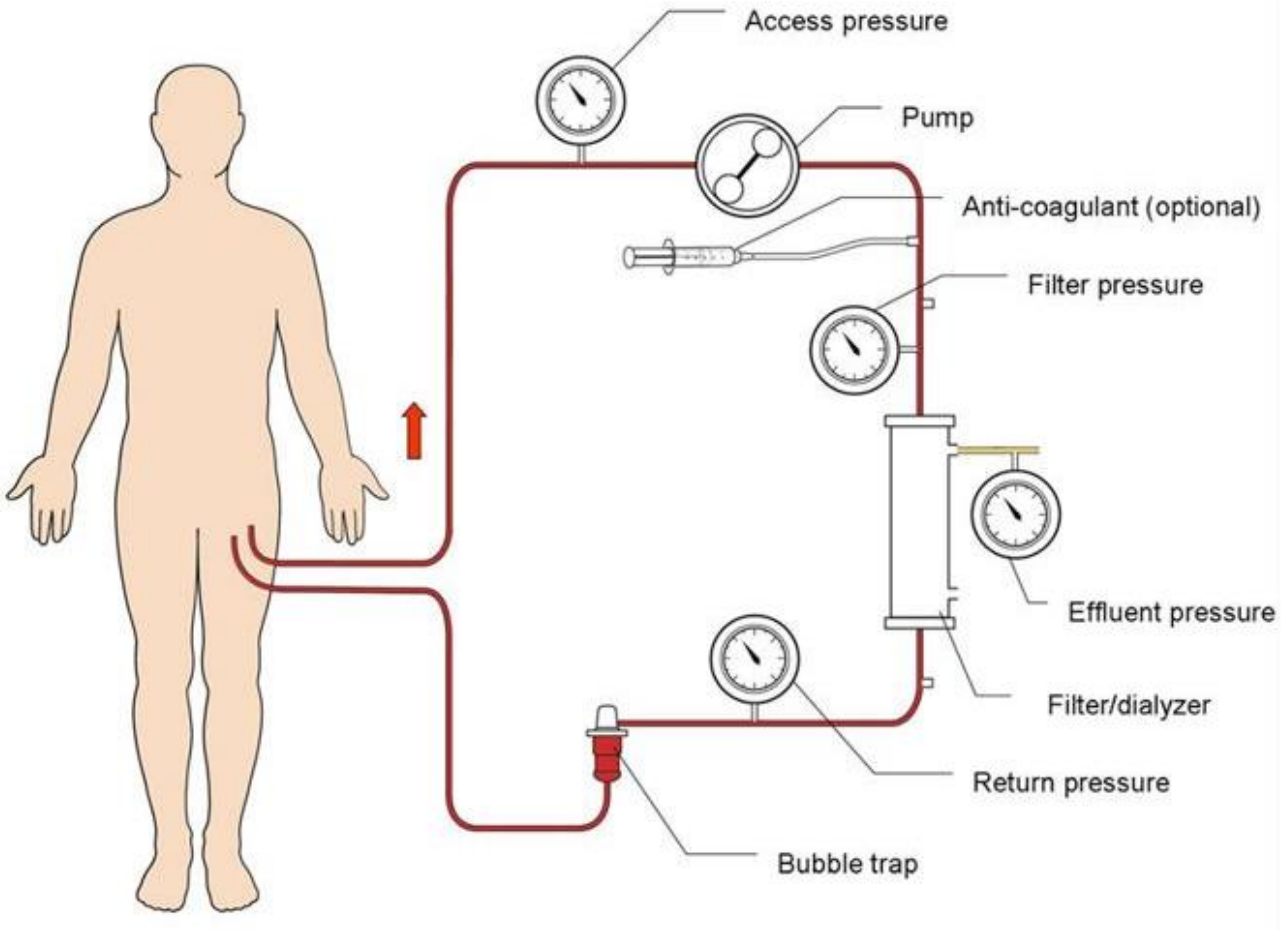
Design of RRT



Source: https://derangedphysiology.com/main/required-reading/renal-failure-and-dialysis/Chapter%203.1.6/cvvhf-circuit-diagram

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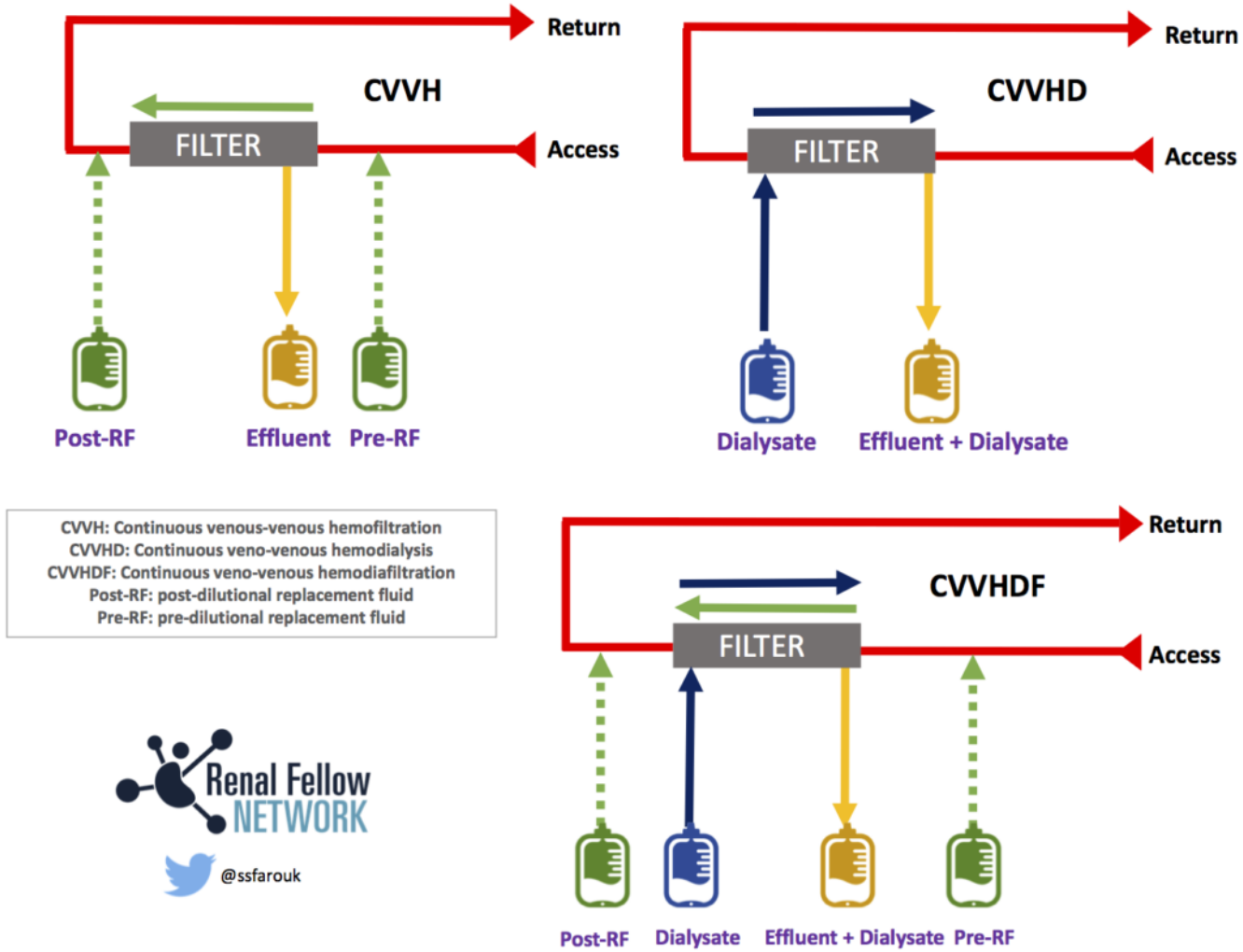
Design of RRT

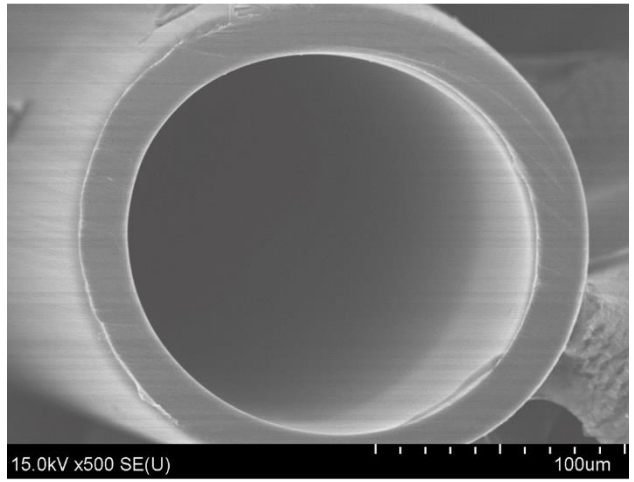


Source: https://www.renalfellow.org/2019/05/31/dosing-continuous-renal-replacement-therapies-crrt-what-is-enough/

Anticoagulation in CRRT

- blood of the patient comes in contact with the circuit tubing material – exogenous material, activation of coagulation

- possibilities:
  - no anticoagulation
  - heparin
  - citrate



Source:
https://www.freseniusmedicalcare.cz/cs/odborna-verejnost/akutni-terapie/filtry-pro-crrt-a-plazmaferezu/
https://www.intechopen.com/chapters/48020

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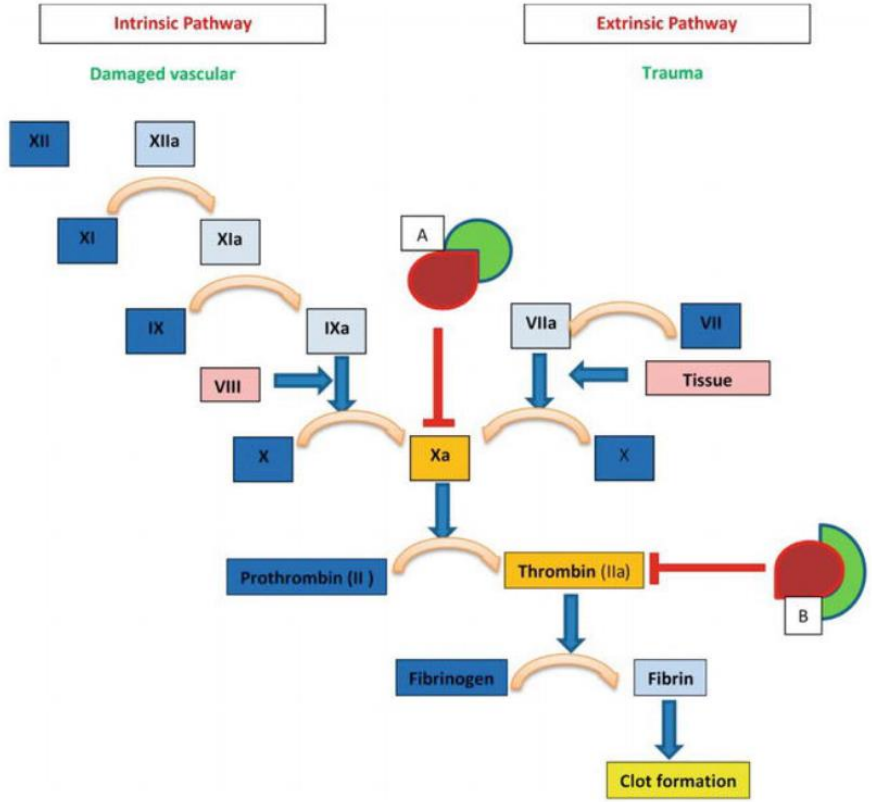
Anticoagulation in CRRT

- **Heparin**
- Advantages: used for the long time, extensive experience, well established protocols, intuitive usage, reliable function
- Disadvantages: systemic anticoagulation, needs frequent blood level monitoring, risk of bleeding, heparin-induced thrombocytopenia (HIT)



Source:
https://www.pfizerhospitalus.com/products/heparin-sodium-injection
https://www.intechopen.com/chapters/68788

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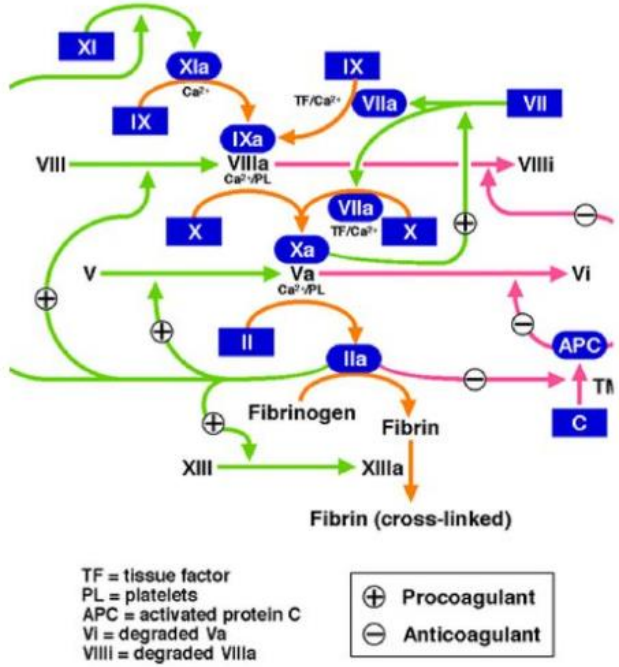
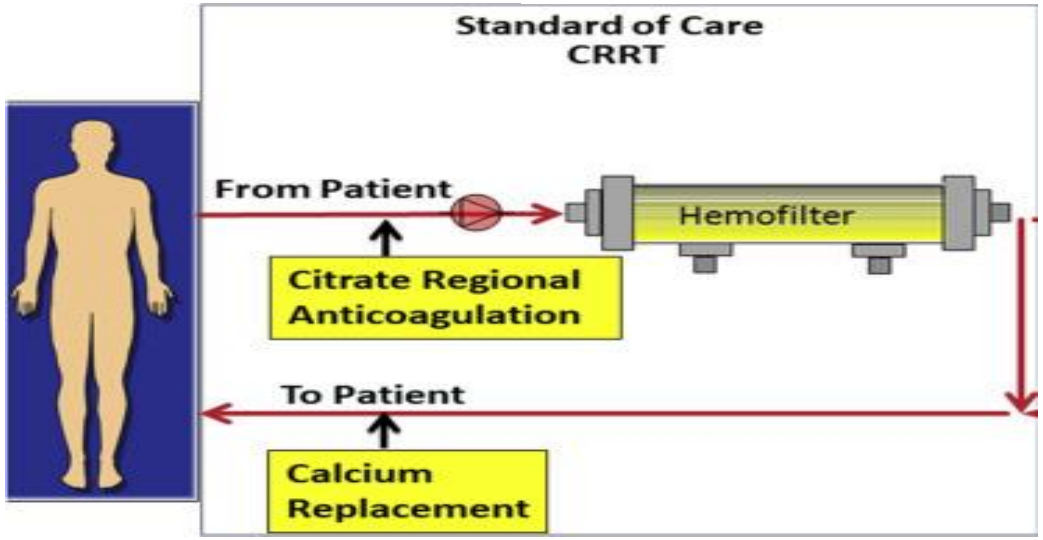
Anticoagulation in CRRT

- **Citrate**
- Advantages: very clever method when set correctly, method of the choice today, no systemic anticoagulation
- Disadvantages: risk of citrate accumulation when body metabolic capacity is exceeded, risk of hypernatremia (natrium citrate)





Source: https://www.kireports.org/article/S2468-0249(17)30295-4/fulltext

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Take home message

- acute renal injury/failure is relative common problem in critical care with high mortality
- accompanies most common ICU pathologies (e.g. sepsis)
- need to find out the reason of renal pathology (pre-renal, renal, post-renal)
- renal replacement therapy represents effective method of the treatment of AKI

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