. . . Must come out

(Renal Replacement Therapy Update)

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No Disclosures / COIs
(except I'm not an anaesthetist!)

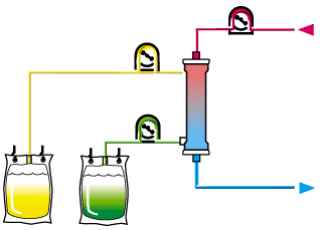
Learning Objectives

1. Understand the modalities of RRT available in ICU and factors which determine choice
2. Consider the advantages and disadvantages of options for anticoagulation in RRT
3. Discuss appropriate timing of RRT in ICU

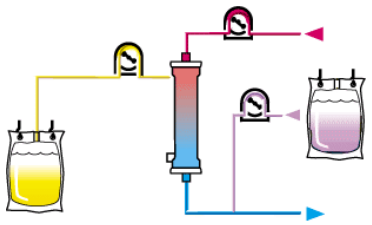
RRT modalities

Intermittent	**Continuous**
Haemodialysis	**Haemofiltration**
Hybrid systems	**Peritoneal Dialysis**

Haemodialysis



Haemofiltration



Comparison of HF and HD

Haemodialysis	Haemofiltration
Diffusion	Convection
Faster small molecule clearance	High flux (middle molecule clearance)
Counter current flow	Higher fluid replacement (labour intensive)
	Higher risk of clotting (reduced circuit life)
No difference in mortality	

Hybrid systems

- SLED (sustained low efficiency dialysis)
- CVVHDF (continuous veno-venous haemodiafiltration)

Table 22 | Theoretical advantages and disadvantages of CRRT, IHD, SLED, and PD

Modality	Potential setting in AKI	Advantages	Disadvantages
IHD	Hemodynamically stable	Rapid removal of toxins and low-molecular-weight substances Allows for "down time" for diagnostic and therapeutic procedures Reduced exposure to anticoagulation Lower costs than CRRT	Hypotension with rapid fluid removal Dialysis disequilibrium with risk of cerebral edema Technically more complex and demanding
CRRT	Hemodynamically unstable Patients at risk of increased intracranial pressure	Continuous removal of toxins Hemodynamic stability Easy control of fluid balance No treatment-induced increase of intracranial pressure User-friendly machines	Slower clearance of toxins Need for prolonged anticoagulation Patient immobilization Hypothermia Increased costs
SLED	Hemodynamically unstable	Slower volume and solute removal Hemodynamic stability Allows for "down time" for diagnostic and therapeutic procedures Reduced exposure to anticoagulation	Slower clearance of toxins Technically more complex and demanding
PD	Hemodynamically unstable Coagulopathy Difficult access Patients at risk of increased intracranial pressure Under-resourced region	Technically simple Hemodynamic stability No anticoagulation No need for vascular access Lower cost Gradual removal of toxins	Poor clearance in hypercatabolic patients Protein loss No control of rate of fluid removal Risk of peritonitis Hyperglycemia Requires intact peritoneal cavity Impairs diaphragmatic movement, potential for respiratory problems

CRRT, continuous renal replacement therapy; IHD, intermittent hemodialysis; PD, peritoneal dialysis; SLED, sustained low-efficiency dialysis.

RRT modalities

- Many modalities available
- No major clinical superiority of any 1 modality over another
- Choice is determined by local factors – expertise, cost, connectivity

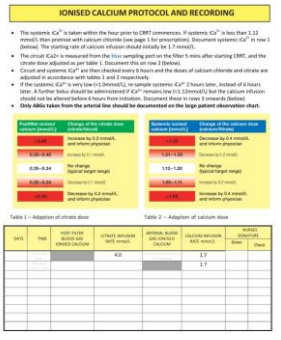
Anticoagulation for RRT

- None
- Unfractionated heparin
- Low molecular weight heparin
- Regional citrate
- Others

Regional citrate vs systemic heparin

Benefits of RCA	Limitations
Reduced risk of bleeding	Complicated
Improved patency of circuits	Risk of citrate accumulation
Increased delivered dose of RRT *	Strict protocols
More cost effective *	Monitoring of calcium levels to avoid hypocalcaemia

RCA Protocols


IONISED CALCIUM PROTOCOL AND RECORDING

- The systemic iCa^{2+} is taken within the hour prior to CRRT commences. If systemic iCa^{2+} is less than 1.12 mmol/L then pretreat with calcium chloride (see page 1 for prescription). Document systemic iCa^{2+} in row 1 (below). The starting rate of calcium infusion should initially be 1.7 mmol/L.
- The circuit iCa2+ is measured from the blue sampling port on the filter 5 mins after starting CRRT, and the citrate dose adjusted as per table 1. Document this on row 2 (below).
- Circuit and systemic iCa^{2+} are then checked every 6 hours and the doses of calcium chloride and citrate are adjusted in accordance with tables 1 and 2 respectively.
- If the systemic iCa^{2+} is very low (<0.9mmol/L), re-sample systemic iCa^{2+} 2 hours later, instead of 6 hours later. A further bolus should be administered if iCa^{2+} remains low (<1.12mmol/L) but the calcium infusion should not be altered before 6 hours from initiation. Document these in rows 3 onwards (below).
- **Only ABGs taken from the arterial line should be documented on the large patient observation chart.**

Post-filter ionised calcium (mmol/L)	Change of the citrate dose (ml/min/hour)
<0.25	Increase by 0.2 mmol/L and inform physician
0.25–0.34	Increase by 0.1 mmol/L
0.35–0.24	No change (typical target range)
0.25–0.24	Decrease by 0.1 mmol/L
>0.45	Decrease by 0.2 mmol/L and inform physician

Systemic ionised calcium (mmol/L)	Change of the calcium dose (ml/min/hour)
>1.30	Decrease by 0.4 mmol/L and inform physician
1.21–1.30	Decrease by 0.2 mmol/L
1.12–1.20	No change (typical target range)
1.00–1.11	Increase by 0.2 mmol/L
<1.00	Increase by 0.4 mmol/L and inform physician

Table 1 – Adaption of citrate dose

Table 2 – Adaption of calcium dose

DATE	TIME	POST-FILTER BLOOD GAS IONISED CALCIUM	CITRATE INFUSION RATE mmol/L	ARTERIAL BLOOD GAS / ON CLOT CALCIUM	CALCIUM INFUSION RATE mmol/L	NURSES SIGNATURE Given	Check
			4.0		1.7		
					1.7		

Timing of initiation of RRT

Table 2 | Benefits and drawbacks of earlier RRT in the absence of conventional indications among critically ill patients with AKI

Benefits	Drawbacks
Avoidance and/or early control of fluid accumulation and overload	Need for and complications associated with dialysis catheter insertion (i.e., bleeding, pneumothorax, bloodstream infection)
Avoidance and/or earlier control of acid-base derangement	Need for and complications associated with anticoagulation regimens
Avoidance and/or earlier control of electrolyte/metabolic derangement	Risk of iatrogenic episodes of hemodynamic instability that may exacerbate AKI and impede kidney repair/recovery
Avoidance and/or earlier control of complications of uremia	Risk of excess loss of unmeasured micronutrients and trace elements
Avoidance of unnecessary or excessive diuretic exposure	Risk of excess clearance or subtherapeutic levels of vital medications (i.e., antimicrobials, antiepileptics)
Immunomodulation and clearance of inflammatory mediators	Unnecessary exposure to RRT in patients who have a high likelihood of kidney recovery with conservative management
"Unloading" or "resting" stressed and/or damaged kidneys	Increased bedside workload for providers, resource use, and direct health costs

AKI, acute kidney injury; RRT, renal replacement therapy.

Comparison of RCTs in timing of RRT in ICU

	ELAIN	AKIKI	IDEAL-ICU	STARRT-AKI (pilot)
Setting	1 ICU in Germany	31 ICUs in France	24 ICUs in France	12 ICUs in Canada
No. of Participants	231	620	488	100
Population	95% surgical (cardiac 47%)	80% medical	Septic shock	Mixed medical/surgical
Intervention (early arm)	Within 8 hours of stage 2 AKI	Within 6 hours of stage 3 AKI	Within 12 hours of stage 3 AKI	Within 12 hours of stage 2 AKI (+NGAL)
Control (delayed arm)	Within 12 hours of stage 3 AKI	Specific criteria/emergent indications	48-60 hours of stage 3 AKI	Specific criteria/emergent indications
Received RRT in control arm	91%	51%	62%	75%
90 day mortality		(60 day mortality)		
Early	39.3%	48.5%	58%	38%
Control	54.7%	49.7%	54%	37%

Timing of AKI

- In patients with predictable natural history of AKI then early RRT may be beneficial
- In patients with multi-factorial AKI (most medical patients) there is no current proven benefit for early RRT compared to standard care
- START-AKI has finished recruiting 3000 patients so will hopefully give an answer

Learning Objectives

1. Understand the modalities of RRT available in ICU and factors which determine choice
   - There are many
   - Local factors determine choice
2. Consider the advantages and disadvantages of options for anticoagulation in RRT
   - RCA preferred but complex protocols and monitoring
3. Discuss appropriate timing of RRT in ICU
   - Not sure - ask me next year!

Questions

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References

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