Renal Failure Unit

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Protocol: Regional Anticoagulation with Citrate (RCA) for Sustained Low-Efficiency Dialysis (SLED)

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Background and aims

The present protocol is aimed at describing the operational procedures for Regional Anticoagulation with Citrate during SLED, i.e. at explaining how to anticoagulate only the extracorporeal circulation of dialysis with citrate, leaving unchanged patient' hemostasis.

The protocol is based on the use of citrate. Citrate is an anticoagulant agent because it chelates ionized (i.e. free) calcium in the blood (Ca^{++}), thus reducing the availability of the most important co-factor activating the coagulation cascade.

Citrate is infused in the circuit as ACD-A solution (Anticoagulant Citrate Dextrose, citrate concentration 112.9 mmol/L) before the filter, in the predilution port of the circuit, in order to decoagulate the blood entering the circuit

When Ca^{++} levels (normal values 0.9-1.2 mmol/L) are reduced < 0.4 mmol/L the blood in the circuit is fully anticoagulated. Average citrate levels of 2-4 mmol/L in the circuit are needed in order to decrease Ca^{++} to 0.4 mmol/l or below, thus providing sufficient anticoagulation of the extracorporeal circuit.

The present protocol is aimed at obtaining an average citrate level of 3 mmol/L in the circuit segment before the blood pump and in the filter; this can be obtained with an ACD-A infusion rate of 300 ml/hour and a blood flow rate of 200 ml/min. Thus a fixed ratio of ACD-A to blood of 1.5:1 between absolute values of flows is to be employed (taking into account that citrate and blood flow rates are expressed respectively in ml/hour and ml/min).

For different combinations of ACD-A administration rates and blood flow, citrate levels in the whole treated blood can be approximately estimated by the following formula:

$$\textit{Whole Blood Citrate (mmol/L)} = (C_{ACD\text{-}A} \times Q_{ACD\text{-}A}) \div Q_{blood}$$

where $C_{ACD\text{-}A}$ is the citrate concentration in the ACD-A solution (mmol/L), $Q_{ACD\text{-}A}$ in the infusion rate of ACD-A solution (L/hr), and Q_{blood} is the blood flow into the circuit (L/hr).

Citrate levels progressively decrease in the filter, and thus in the segments of the circuit after the filter, because of the diffusion occurring with dialysis. Since citrate removal by the treatment itself can be predicted to be about 70%, no more than 30% of the infused citrate (about 10 mmoles/hour out of the 34 mmol/hour infused as ACD-A proximally in the circuit) will be returned to the patient. This amount is immediately diluted in the whole blood pool and rapidly metabolized by the liver and the skeletal muscle. Moreover, since SLED is by definition intermittent (8-12 hours a day), there is a time window of at least 12-16 hours without citrate administration between two consecutive sessions. Therefore, significant citrate accumulation is unlikely.

No systematic calcium infusion is routinely requested with the present protocol, since Ca^{++} levels in the blood returning to the patient are restored by backtransport of calcium from dialysis fluid containing calcium; in this case backtransport of calcium is mainly by diffusion, on the basis of a favourable gradient between the dialysis fluid and the blood in the filter. However, Ca^{++} levels are to be monitored in the patient especially in the first hour of the session, and calcium supplementation as calcium gluconate is to be started whenever iCa^{++} is < 0.90 mmol/L.

Warning: start 10% calcium gluconate infusion at SLED start if the patient has already Ca^{++} values < 0.90 mmol/L before the treatment.

Warning: We recommend to avoid RCA in patients with platelet count < 20000 mm^3. In patients with low platelet count and repeated problems in concluding SLED sessions in the prescribed time without RCA (for example, a cirrhotic patient with AKI), RCA at a reduced ACD-A dose (200 ml/hour) is suggested.

Fluids

Dialysis fluid (Gambro Diasol concentrate + Gambro Bicart): sodium 140 mmol/L, Potassium 3 or 4 mmol/L as per the attending nephrologist prescription, Chloride 110.5 mmol/L, Bicarbonate 34 mmol/L, Acetate 3 mmol/L, Calcium 1.25 mmol/L, Magnesium 0.5 mmol/L Dextrose 5.55%
ACD-A (500 ml bags): Trisodium citrate and Citric acid (total citrate concentration 112.9 mmol/L) in 2.5% dextrose
Calcium gluconate: 10 ml vials (0.24 mmol/ml), use undiluted

Extracorporeal circulation

Machine: Gambro AK 200S ultra type 1
Filter: Fresenius F8HPS, 1.8 m2, Kuf 18 ml/mmHg/hour
Blood flow rate: 200 ml/min
Dialysis fluid rate: 300 ml/min
Flow geometry: cocurrent
Citrate: ACD-A 300 ml/hour in the predilution port of the circuit
Dialysis fluid temperature: 35°

WARNING: Any change to the filter and/or the operational characteristics of the treatment (blood flow rate, flow geometry, dialysis flow rate etc.) could significantly change citrate levels in the blood returning to the patient. Therefore some of the recommendations detailed in the present protocol may no longer apply. The attending nephrologist must be aware of such changes beforehand, so he/she can adopt the required ACD-A dose adjustements and preventive measurements (e.g. additional measurements of Ca^{++}) to avoid possible adverse effects of the modified SLED treatment.

SLED start

- Priming: rinse the circuit with 2000 ml of normal saline in 15-20 min.
- Start dialysis with a blood flow of 50 ml/min, slowly increasing to 200 ml/min in 50 ml/min increments every 5 min, checking hemodynamic status
- Start ACD-A with a parenteral infusion pump at 300 ml/hour together with blood flow start, maintaining a ratio of 1.5:1 with respect to blood flow (ml/hour of ACD-A to ml/min of blood flow rate) when blood flow is at regimen (200 ml/min)
- When blood flow is 200 ml/min, access pressures should be less than -150 mmHg, with return pressures less than +200 mmHg
- Start ultrafiltration, is needed, after 30 min of SLED

Monitoring during SLED

Coagulation

- Check ACT (Hemochron) levels at baseline (SLED start) , at one hour and at the end of SLED in the blood of the patient taken form the circuit before the mixing point of blood with the infused ACD-A.
- No major changes in ACT levels during SLED (> than 1.25 of ACT ratio between actual ACT values and basal ACT values) should be accepted; in case consult the attending nephrologist to reduce ACD-A infusion rate by 50% (i.e. to 200 ml/hour)

Ionized calcium

- Check Ca++ in the patient blood and in the blood returning to the patient (after the filter) at baseline (SLED start), at one hour and at the end of SLED as routine, and everytime is needed.
- Start 10% Calcium gluconate infusion (no dilution) at 5 ml/hour by an infusion pump in a peripheral vein or a central vein (not in the dialysis CVC) whenever Ca++ is < 0.90 mmol/L in the blood from the patient, or <0.60 mmol/L in the blood returning to the patient. If Ca++ values are already low before SLED start, immediately start calcium gluconate infusion.
- Check Ca++ again after one hour, and increase Calcium gluconate infusion rate to 10 ml/hour if Ca++ values are not > 0.90 mmol/L in the patient blood or > 0.60 mmol/ in the blood returning to the patient.
- If Ca++ values were still low at the end of SLED, Calcium gluconate administration is to continued for one hour, rechecking the values.

Warning: The ACD-A infusion pump must be stopped every time blood pump is stopped