Protocol for sustained low-efficiency daily diafiltration (SLEDD-*f*) using Prismaflex machines and heparin anticoagulation

ICU USE ONLY

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Ratified By	
Authors	

INTRODUCTION

This protocol is intended for use in the event that CVVHD capacity is reached in an ICU setting.

Sustained low-efficiency daily diafiltration (SLEDD-f) is a renal replacement therapy for critically ill patients with AKI. SLEDD-f has evolved as a hybrid of continuous renal replacement therapy (CRRT) and intermittent haemodialysis (IHD), with therapeutic aims that combine the desirable properties of each. It is expected that a treatment cycle via this protocol will last approximately 8-12 hours.

It is essential that clinical and biochemical monitoring is performed both during and at the end of the session to ensure that the renal replacement therapy has achieved adequate acid base balance, biochemical correction and fluid balance.

We recommend heparin anticoagulation in this protocol as the higher flow rates will alter citrate clearance, resulting in increased potential for citrate accumulation.

Nursing set up guide (SLEDD-*f*)

Equipment needed

- 1 x Kit Prismaflex ST150 or M100
- 3 x bags Prismasol 4
- 1 x 1L 0.9% sodium chloride with 5000 units of heparin (priming solution)
- 1 x 1L 0.9% sodium chloride (to flush circuit after the priming solution)
- 1 x 20ml syringe made up to Heparin 1000 units/ml (20,000 units in 20ml)
- External syringe pump
- 1 x IV extension line

Setting up and priming circuit

Please setup the machine in CVVHDF mode as this allows the clinician to revert to standard CVVHDF in Heparin mode. If a change to citrate anticoagulation is required, re-priming a new set will be necessary.

1. Select New Patient
2. Input actual body weight
3. Choose CVVHDF
4. Choose no anticoagulation
5. Follow the installation steps on the screen:
   a. Install **Prismasol 4** on the white scale (PBP = pre blood pump)
   b. Install **Prismasol 4** on the green scale. (Dialysate)
   c. Install **Prismasol 4** on the purple scale (Replacement)

6. Connect heparin via external syringe driver (see protocol below). Connect to the access line after the blood pump and before the filter by the syringe pump (the line with the white clip).
7. Prime the circuit with 1L of 0.9% Sodium Chloride with 5000 units heparin.
8. Flush the circuit with 1L of 0.9% Sodium Chloride.

Please note Prism0cal and Prismacitrate should NOT be used, only Prismasol 4

Getting ready to start

Once the set has been primed it will ask you to check the circuit and then Prime Test.
Once the prime test has been completed, you **must** check the adequacy of the Access and Return ports of the vascath:

1. Withdraw 5mL blood from each port and discard. If any clots are visible, repeat the process until clot free.

2. On the Access line, ensure that you can draw back easily on the syringe and that the line is free flowing. This assessment is vital in understanding if a blood flow of 200 ml/minute can be achieved.
3. Repeat on the Return line.

Do not proceed with therapy in presence of poor access pressures, **it is sure to fail.**

INITIAL SETTINGS

Ideal body weight (kg)	50 and lower	60	70	80	90	100 and higher	Maximum Setting
Blood flow (ml/hr)	150	160	170	180	190	200	450
	Increase blood flows as tolerated, aim as high as possible without instability. Also increase other flows once stable towards "maximum" setting.						
Pre blood pump (pbp)	700	900	1000	1200	1400	1500	2000
Post Replace-ment (ml/hr)	1500	1800	2100	2400	2700	3000	4000
Dialysate flow ml/hr	2000	2400	2800	3200	3800	4000	8000

Fluid removal – as per clinician, start at 0. Bear in mind that with only 12hrs treatment, the fluid removal per day will be half of what would be expected.

If the starting prescription is tolerated well, the flow rates can be increased incrementally but not exceeding what is outlined in the maximum column. Blood flow rates are likely be the limiting factor, either through haemodynamic instability and / or access issues.

Because of the higher flow rates there may be more difficulty in maintaining haemodynamic stability particularly when aiming for a significant negative balance. If you experience problems with the patient tolerating these rates, consider

- Reducing flow rates (change settings to a lower weight / treatment bracket)
- Reducing fluid removal
- Returning back to the standard CRRT protocol (with heparin)
- Returning back to the standard CRRT protocol (with citrate – however If citrate anticoagulation is required then re-priming with a new set would be necessary
- Contact senior nursing and medical staff
- Contact renal team to consider intermittent haemodialysis

Monitoring

- Monitor APTT as per protocol (see below)
- Check biochemistry as per table below

Test	Reason	Frequency
U&Es	To assess solute clearance	At start and end of session
Glucose	Glucose level will generally fall when on this treatment	BM every 2-4 hours (and continue for at least 6 hours post treatment.)
FBC	Assess Hb / Haematocrit	Daily
Mg, PO4	Ensure stable plasma levels	Daily

Blood Gas / Acid Base Status

Aim for a pH between 7.35 and 7.45.
(Metabolic Acidosis; pH less than 7.35 (BXS worse than - 4mmol/l, HCO3 less than 22mmol/l)

HEPARIN PROTOCOL FOR CONTINUOUS VENO-VENOUS HAEMOFILTRATION USING SLEDD-f

Use actual bodyweight for dose calculations

1. Dilute 20,000 units of heparin in 0.9% NaCl to a final volume of 20mls (1000 IU/ml)
2. Connect to an external syringe driver. Connect to the access line after the blood pump and before the filter by the syringe pump (the line with the white clip)
3. Give bolus dose as prescribed via the pump (prescribing instructions overleaf)
4. Start the continuous infusion at 10 IU/kg/hour
5. Check APTT after 1 hour, then 4 hourly until stable, then twice daily at 06:00 and 18:00. Blood samples to be taken from post filter port on return line.
6. Target APTT is between 70 and 90 seconds. Adjust rate according to the table.

Adjusting the rate of heparin infusion according to the APTT

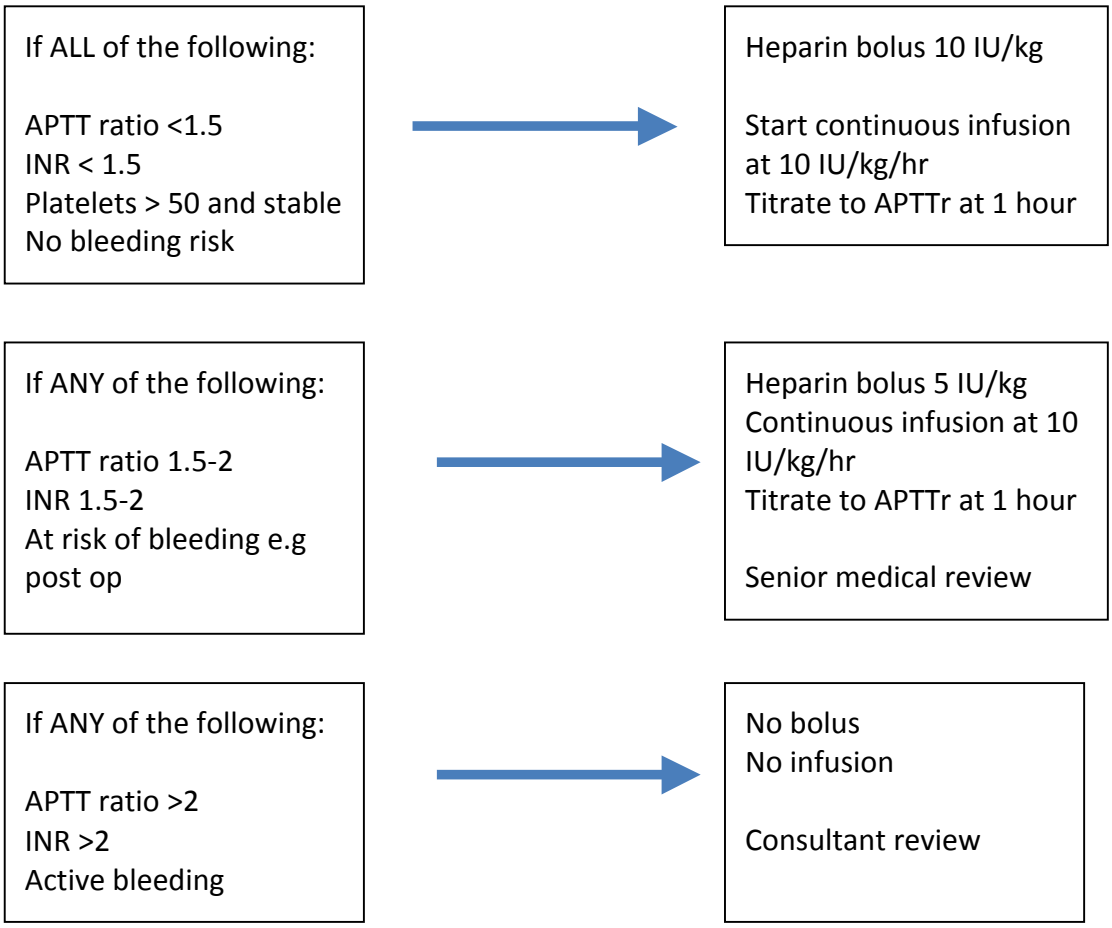
POST FILTER APTT (SECONDS)	HEPARIN BOLUS VIA PUMP	INFUSION RATE CHANGES
>150 seconds	NIL	Stop for 1 hour then repeat APTT. Medical review before restarting at 5-7units/kg/hr
120-150	NIL	Decrease infusion by 2 units/kg/hr
90-110	NIL	Decrease infusion by 1 unit/kg/hr
70-90	NIL	NO CHANGE-TARGET RANGE
55-70	NIL	Increase infusion by 1 unit/kg/hr
40-55	NIL	Increase infusion by 2 units/kg/hr
<40	7.5 IU/KG	Increase infusion by 3 units/kg/hr

URGENT SENIOR MEDICAL REVIEW IS REQUIRED IF TWO CONSECUTIVE RESULTS ARE BELOW 40 OR ABVE 150 SECONDS.

STOP heparin infusion if signs of bleeding are apparent. Inform medical staff immediately and send blood for urgent FBC and clotting screen.

GUIDANCE ON PRESCRIBING HEPARIN BOLUS DOSES AND CONTINUOUS INFUSION RATES

Check coagulation before prescribing
Prescribe bolus dose and 20'000 units of heparin in 20mls 0.9% NaCl (1000iu/ml) via EPR



Example bolus and starting doses. Use actual body weight.

Weight	10 IU/kg initial bolus	Reduced 5 IU/kg initial bolus	Starting infusion rate mls/hr (10 IU/kg/hr)
40	400 IU (0.4mls)	200 IU (0.2mls)	0.4
50	500 (0.5mls)	250 (0.25mls)	0.5
60	600 (0.6mls)	300 (0.3mls)	0.6
70	700 (0.7mls)	350 (0.35mls)	0.7
80	800 (0.8 mls)	400 (0.4mls)	0.8
90	900 (0.9mls)	450 (0.45mls)	0.9
100	1000 (1ml)	500 (0.5mls)	1
110	1100 (1.1ml)	550 (0.55mls)	1.1
120	1200 (1.2mls)	600 (0.6mls)	1.2
130	1300 (1.3mls	650 (0.65mls)	1.3
140	1400 (1.4mls)	700 (0.7mls)	1.4

(heparin IU x weight)/1000 = mls/hr

Supporting Information

This protocol is based on achieving a Kt/V of at least 1 which is assumed to be proportionate to 25ml/kg/hr. However the prescribed dose in the protocol below is 40 ml/kg/hr.

The formula used to transform ml/kg/hr for continuous technique to Kt/V based on urea clearance (and generally used in intermittent technique) assuming that 25 mL/kg/hr is 1 Kt/V, is as follows:

$$Kt/V = (1–[(1/24) \times (\text{downtime in hours})]) \times ([\text{effluent dose mL/kg/hr}]/25)$$

The treatment delivered will be CVVHD however the machine set up will be CVVHDF.

If the starting prescription is tolerated well, the flow rates can be increased and the duration of the treatment could be reduced down to 8 hours per day. The prismaflex machine will be able to increase dialysate flows to a maximum of 8L / h and the filter can tolerate a maximum blood flow of 450 ml/min. However blood flow rates are likely be the limiting factors though either haemodynamic instability and / or dialysis access. If the line tip is in the superior vena cava then the vessel wall will likely restrict flows and higher flow rates will only be achievable if the tip is placed just inside the right atrium.

Line Placement

As higher blood and dialysate flow rates are required in the 12-hour protocol, line placement is particularly important, and we would suggest aiming for placement of the distal catheter tip inside the superior vena cava at the junction with the right atrium or just inside the right atrium. Positioning the tip inside the right atrium will allow for higher flows while reducing haemofilter and extracorporeal circuit thrombosis. There is no evidence to suggest that it increases atrial or ventricular arrhythmias.

Anticoagulation

We recommend heparin anticoagulation in this protocol as the higher flow rates will alter citrate clearance. Therefore, a higher citrate concentration would be required, and it has not yet been tested sufficiently.

When using heparin anticoagulation please remember to use the trust heparin protocol

Given the Prismaflex machine pump settings require a 50ml syringe it will be easier to run a heparin infusion through a separate external infusion device but connect the external syringe driver onto the cassette.

Because of the higher flow rates we would expect that the circuit to remain patient through the full session. Lost or clotted circuits should be infrequent and where heparin is contraindicated it may be possible to run the circuit without anticoagulation. However a very high ul-

trafiltration rate (UF / fluid removal rates) will increase the risk of clotting -in the first instance we recommend heparinisation with monitoring of the APTT to maintain target range.

Filters

The above flow rates will be achievable on all sizes of ST and M filters. However please use the ST150 filter preferentially if available.

Blood flow on the 1.5 m2 membranes can tolerate up to 450 ml/min as the Trans Membrane Pressure (TMP) is limited at 450mmhg. As the TMP hits 300 mmHg then the efficiency of clearance may be reduced.

Ultrafiltration rate and fluid removal rates (effluent)

There is no evidence base currently for maximum ultrafiltration rates for SLEDD-f, however for continuous treatment there is suggestions that net ultrafiltration rates (NUF) greater than 1.75 mL/kg/hr compared with NUF rates less than 1.01 mL/kg/hr were associated with lower survival.

However for an 8 or 12 hour protocol the fluid removal rate may need to be increased above this however we would suggest start less than 1.75 mL/kg/hr and increase as tolerated.

Next dialysis session

The treatment is designed to be a daily treatment, however if there is recovery of renal function this may be spaced to alternate day treatment if felt to be appropriate.

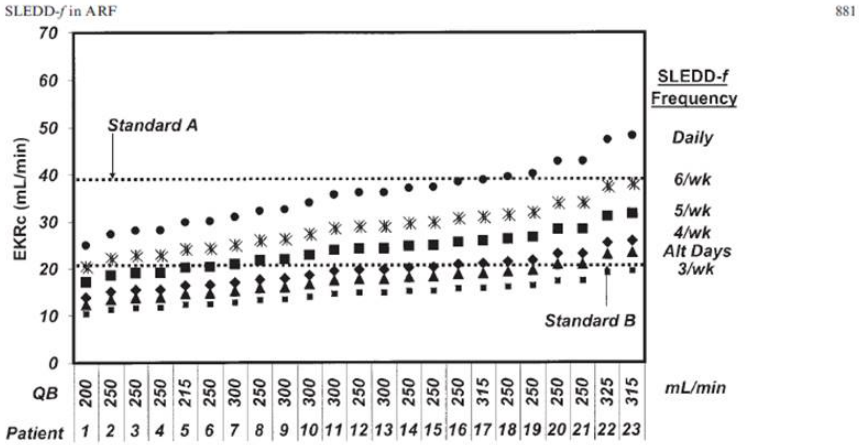


Fig. 1. EKRc for patients who had completed at least one SLEDD-*f* treatment. These are presented as a function of QB, and also modelled in each case to provide values for hypothetical SLEDD-*f* schedules that involve treatments being performed on less than a daily basis. The dotted lines indicate EKRc associated with superior outcomes in two recent studies (Standard A, CRRT delivering a clearance of 35 ml/kg/h [16]; Standard B, IHD delivering a single pool Kt/V of 0.92 per treatment at a frequency of 6.2 per week [15]).

Sustained low-efficiency daily diafiltration (SLEDD-f) for critically ill patients requiring renal replacement therapy: towards an adequate therapy. (2004) Marshall et al.

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