Impact of CRRT Circuit Design on Achievable Blood Flows in ARF Patients

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Introduction

Recent studies highlight the clinical benefits of high volume convective CRRT (>35 ml/kg/hr, or nearly 65 liters daily in a 75 kg patient) (Ronco et al. Lancet 2000). Other publications have advocated even higher doses of convective therapy for patients with sepsis (Honore et al. Crit Care Med 2000; Brendolan et al. ASN Abstract 2004). For predilution CVVH, widespread administration of doses described by these authors can only be attained at blood flow rates of 250 ml/min or more (Clark et al. Artif Organs 2003). Other studies indicate the importance of high blood flow rate in promoting circuit life (Holt et al. Anaesth Intensive Care 1996). Although blood flows between 200 and 300 mL/min are routinely achieved in ARF patients using conventional intermittent equipment (Teehan et al. J Intensive Care Med 2003), prevalent blood flows in CRRT are generally lower (180 ml/min or below).

Achievable blood flows are limited by venous access performance, but they are also influenced by extracorporeal circuit design. In particular, resistance in the arterial (or draw) line limits flow potential. Lower resistance leads to lower negative pressures at a given flow rate, and thus higher achievable blood flows from a given access.

The System One employs a unique circuit designed to minimize resistance and facilitate higher blood flows.

Objective

Compare the NxStage blood flow performance to prevalent CRRT equipment.

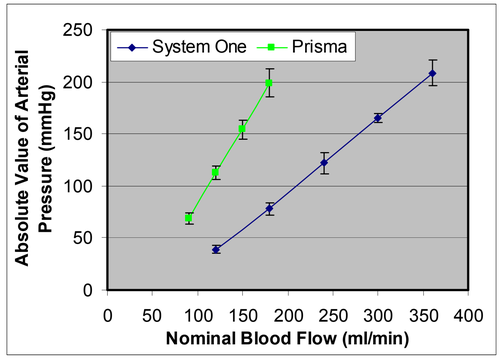
Methods

A 49% wt glycerin in water solution warmed to 37°C was recirculated by the System One (NxStage Medical) and the Prisma System (Gambro). The samples size was n = 3 for each system using the CAR-155 disposable set on the System One and the HF1000 disposable set on the Prisma System. 16 gauge fistula needles connected to the arterial and venous blood lines were used to simulate patient access. Flow rates were increased and the corresponding arterial pressure was measured for arterial pressures of up to -200 mmHg. Actual blood flow rates were measured using a transonic flow meter (Transonic Systems Inc.).

Results

The absolute value of the arterial pressure as a function of the nominal blood flow rate is shown in Figure 1 (average and standard deviation).

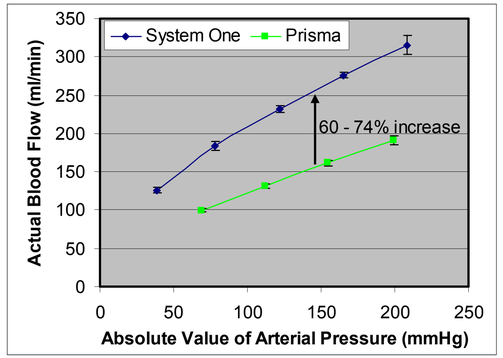
Figure 1: Arterial Pressure as Function of Nominal Blood Flow (N = 3; Average and StDev)



The arterial pressure increases with increasing blood flow rate. At the same nominal blood flow rates, the System One arterial pressures were significantly lower than those of the Prisma System (>60% lower, p<0.005) from identical vascular access.

The actual blood flow rate as a function of the absolute value of the arterial pressure is shown Figure 2. The lower arterial pressure for a given nominal blood flow rate translates into 60% - 74% higher actual blood flows for the System One at any given arterial pressure compared to the Prisma System.

Figure 2: Actual Blood Flow as Function of Arterial Pressure (N = 3; Average and StDev)

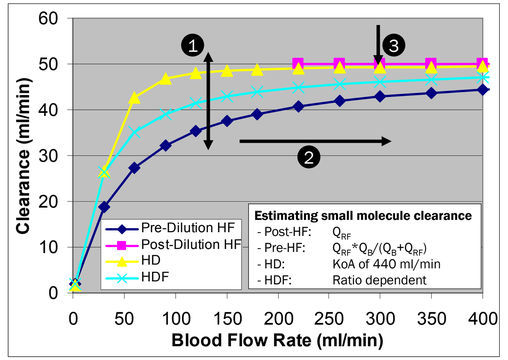


Discussion

Small molecule clearance can be improved by increasing the fluid flow rate (dialysate – Q_D or replacement fluid Q_{RF}) or the blood flow rate (Q_B). Blood flow implications on therapy efficiency are less obvious than the direct impact of replacement fluid or dialysate flows.

Figure 3 shows the impact of blood flow rate on therapy clearances for pre- and post-dilution HF, HD, and HDF.

Figure 3: Therapy Clearance as a Function of Blood Flow Rate 50 ml/min or 3 L/hr



1. Therapy efficiencies differ with post-HF > HD > HDF > pre-HF.
2. Efficiency increases and differences between therapies decrease as blood flow increases
3. Clearance levels of post-dilution HF are not achievable until a certain blood flow rate is reached due to hemoconcentration considerations.

Conclusion

The NxStage circuit design allows a higher blood flow from a given patient access. This capability may aid clinicians' efforts in achieving dosing targets proposed in recent literature and increase circuit life.