Blood Flow Rates and Ultrafiltration Accuracy in a Manual Single Lumen Alternating Micro-Batch Dialysis Circuit

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Introduction

- Electrolyte derangements and volume overload remain life threatening emergencies in low resource settings.
- In 2020, a Single Lumen Alternating Micro-Batch (SLAMB) dialysis system was proposed as a means of performing blood clearance to patients with single small-bore vascular access for less invasive, portable treatment of acute kidney injury (AKI).[1]
- A manual form of the SLAMB (mSLAMB) dialysis system is now envisioned to treat severe AKI and its sequelae when a standard dialysis machine or peritoneal dialysis are not available.
- Blood is drawn in small batches from the patient into a sterile tubing circuit, and a hemofilter provides a diffusive surface for clearance, while syringes can pull fluid off for ultrafiltration.
- Through this closed loop system, we believe clearance and volume removal is not only possible, but that it will be efficient and volumetrically accurate.

Purpose

We sought to determine blood flow rates (Qb) and ultrafiltration accuracy using mSLAMB to dialyze human blood *in vitro*.

Methods

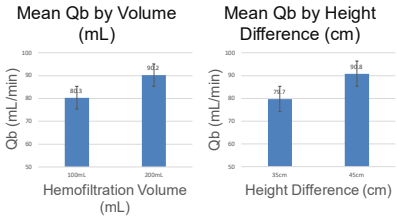
- The *in vitro* system was primed with crystalloid solution, then we connected the tubing to a bag filled with units of expired packed red blood cells to simulate the pediatric patient's blood volume.
- We diluted the blood with 0.9% NaCl to a final hematocrit of 30-35% and anticoagulated it with heparin.
- We timed the duration of each cycle to determine Qb.

$$Qb = \frac{\text{Hemofiltration volume (mL)}}{\text{Time for blood to pass through circuit (min)}}$$

- We used a 2x2 factorial design to assess the effect of the height difference between reservoirs and hemofiltration volume on Qb.
- 35cm vs 45cm height volumes were used.
- Aliquots of 50mL vs 150mL of crystalloid were added to 50mL of blood for total hemofiltration volumes of 100mL and 200mL.
- Effluent volumes were recorded after each run and compared to prescribed volume to assess ultrafiltration accuracy.
- Student's T-test was used to compare 2 groups, and a two-way ANOVA was performed to compare multiple groups.

Results

- Six runs of eight cycles each, were time recorded.
- Mean (SD) Qb of the 100mL vs. 200mL volume group was 80.3 (5.1) vs 90.2 (7.0) mL/min, p=0.03.
- Mean (SD) Qb of the 35cm vs. 45cm height difference was 79.7 (4.4) vs 90.8 (6.5) mL/min, p=0.01.



Figures 1 and 2. Mean Blood flow rates based on 1. hemofiltration volume and 2. height difference. Qb-blood flow rate.

- Together, higher volume and greater height difference was associated with increasing Qb, but this study was underpowered to show statistical difference.

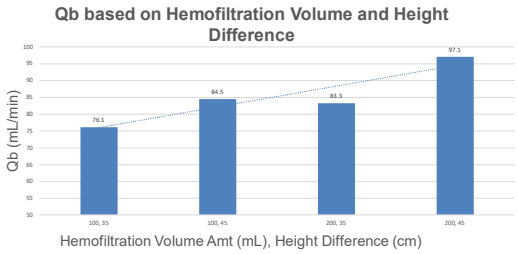


Figure 3. Blood flow rates based on hemofiltration volume and height difference, 2-way ANOVA, p=0.11. Qb-blood flow rate.

- Mean difference between volume prescribed and measured was 11.4mL for volumes of 800-2400mL.
- Percent absolute difference between volume prescribed and measured ranged from 0 to 2.4% and did not increase with increasing volumes.

Experiment	Volume Predicted (mL)	Volume measured (mL)	Volume difference (mL)	% difference
3	800	803	3	0.37
8	800	810	10	1.23
6	830	825	-5	-0.61
10	830	825	-5	-0.61
5	850	830	-20	-2.41
9	1600	1620	20	1.23
10	1600	1600	0	0.00
4	1630	1635	5	0.31
7	2400	2367	-33	-1.39

Table 1. Ultrafiltration Accuracy by Experiment.

Conclusions

- The mSLAMB achieved Qb comparable to an automated continuous dialysis machine consistently and precisely with accurate ultrafiltration volume.
- Increasing height between reservoirs and volume dialyzed improved Qb synergistically without sacrificing ultrafiltration accuracy.
- Next steps involve testing this system *in vivo* in large mammal animal models.

[1] Chawla, *Kidney 360*, 2020.