Smaller Circuits for Smaller Patients: Improving Renal Support with the Aquadex™ Machine.

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UAB MEDICINE PEDIATRIC NEPHROLOGY

Children's of Alabama

BACKGROUND

- CRRT is used in very small critically ill children; however small children are dialyzed differently, experience more complications and have worse outcomes[1].
- Lower extracorporeal volumes are likely to decrease the potential risks, and improve outcomes in small children who require CRRT.
- Aquadex™ is designed to provide slow continuous ultrafiltration (SCUF)[2]
  - Max Ultrafilter rate is 500 ml / hr
  - Extracorporeal volume (ECV) = 33 ml (≈ 10% total blood volume (TBV) of 4 kg infants).
- Replacement fluid titrated via flow restrictors (commonly referred to as medication infusion pumps) can provide replacement fluids in small children on extra-corporeal membrane oxygenation (ECMO). However, these flow regulators are not designed for high pressure conditions, and may allow for inaccuracies[3]
- We adapted the Aquadex™ for CVVH using Alaris IV infusion systems

SPECIFIC AIMS

- We performed an In-Vitro experiment using the Aquadex™ machine adapted for CVVH to determine the effect of the replacement bag volume size, fluid rate, and access pressure on the % error of the fluid infused
- We performed a retrospective analysis of subjects who received SCUF or CVVH on Aquadex™ at Children's of Alabama from August 2013 through August 2014 to determine the feasibility and complication rates.

METHODS

IN VITRO Experimental methods

- We estimated actual fluid delivered based on the differences in the weight of the bag before and after 15 minutes of fluid infusion. Expected was determine based on fluid rate and time.
- % error was calculated as (actual – expected / expected) where:
  - Actual = difference between the weight of the bag before and after experiment- Weights were calculated with lab scale (precision of +/- 1 grams)
  - Expected = Prescribed amount of fluid.
- For rates of 100 ml/hr, we ran the machine for 1 hour, for rates of 300 ml/hr and 500 ml/hr, we ran the machine for 15 minutes.
- For each set of parameters, 3 experiments were conducted. The following parameters were tested in combination
  - Access pressures (P = -50, -125, and -200 mmHg)
  - Infused volume rate (V = 100 , 300 and 500 ml/hr)
  - Volume of replacement bag (B = 1L NS and 5 L Prismasol ™)

Retrospective analysis methods

- We conducted a retrospective analysis of subjects on Aquadex™ at Children's of Alabama from August 2013 through August 2014.
- Anticoagulation was done with heparin or no anti-coagulations
- The initial dose of replacement was 30 cc/kg of replacement fluid for CVVH mode and titrated.
- Permission to review cases was granted by local IRB.

References

1. Askenazi DJ, et al. Continuous renal replacement therapy for children </=10 kg: a report from the prospective pediatric CRRT registry. *The Journal of pediatrics.* Mar 2013;162(3):587-592
2. Jaski BE, et al. Peripherally inserted veno-venous ultrafiltration for rapid treatment of volume overloaded patients. *J Card Fail.* Jun 2003;9(3):227-231.
3. P. Sucosky LPD, et al. Development of a Novel Fluid Management System for Accurate Continuous Hemofiltration in Extracorporeal Membrane Oxygenation. *Journal of Medical Devices.* 2008;2.

RESULTS

Figure 1: Ultrafiltration

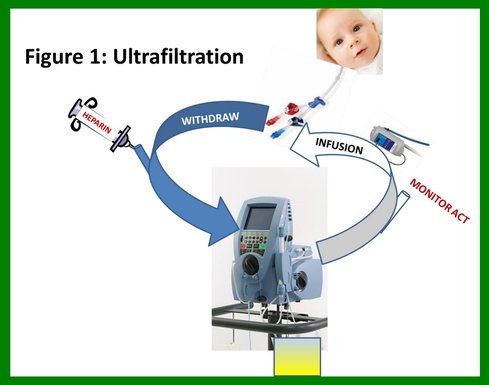
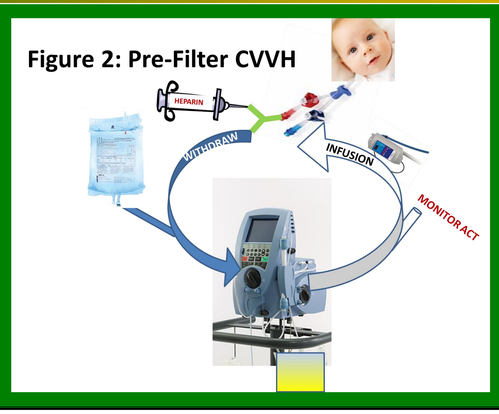


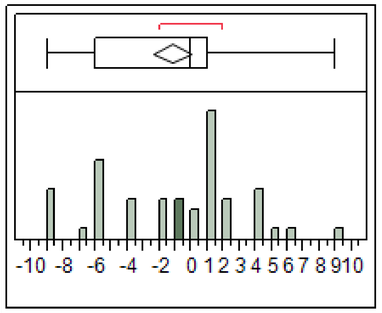
Figure 2: Pre-Filter CVVH



In Vitro Study

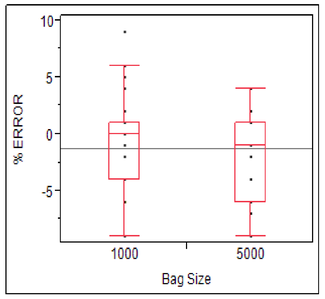
Overall Distribution (n = 54)

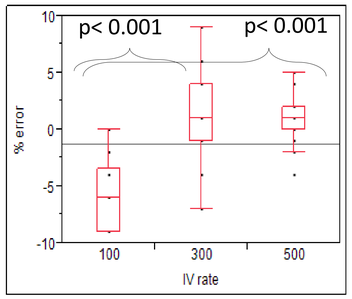
Median % error = 0% (IQR 1, -6)
Mean % error = -1.2% (SD = 4.3).
Max = 9% ; Min = -9%

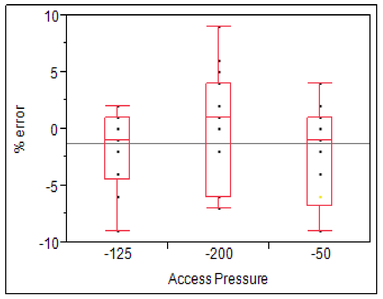


Effect of Bag Size, IV rate and Access Pressure on % error

There was no statistically significant difference in the % error by bag size and access pressure. The % error for the 100 ml/hr rate was significantly lower than the 300/hr and the 500 ml/hr rates (p value < 0.001 for each).







Retrospective Analysis

We identified 10 children (5 SCUF and 5 CVVH) on Aquadex™.

1. For SCUF, median age was 33.7 months (range 6.4-227) and median weight was 26.1 kg (range 6.3 – 33.6).
2. For CVVH, the median age at initiation was 13 days (range 4 – 25 days) and median weight was 3.9 kg (range 2.8-5.1).
3. Subjects were cared for in the CICU (3), PICU (3), NICU (3) and dialysis unit (1).
4. Heparin was used for 9/10 subjects. 1 subject received no anticoagulation.
5. In CVVH mode (see figure) Prismasol™ 2K/3.5 Ca with additives was infused pre-filter at 30 cc/kg/hr. This provided steady reduction in blood urea nitrogen and serum creatinine, an excellent control of electrolytes balance.
6. Complications were rare and mild and improved with interventions (hypothermia in 2, bleeding in 1, and hyponatremia in 1).

For the 10 children, 51 new circuits were used

1. When ECV was < 10% of TBV, circuits were primed with blood (n=10) or albumin (n=1), otherwise they were primed with saline (N=40).
2. Blood prime was performed using regional protocols in which sodium bicarbonate and calcium chloride are infused with blood prime.
3. Only 8/51 (15%) circuits were restarted for clotting, all others were either initial start, or maintenance restart after 72 hours.
4. Blood flow for all procedures was 40 ml/min.
5. No interventions were necessary to support vital function during initiation

CONCLUSIONS

A fluid regulator for Replacement fluid provides reasonable accuracy and is not affected significantly by access pressure or size of the fluid bag. The wide distribution of % error at 100 ml/hr is likely due to the methods of measurement as the actual measured volume is close to the detection error of the scale (further experiments will be needed to confirm). The Aquadex™ machine can provide renal support therapy in small children, allowing the clinician ability to control electrolytes, clear waste products and maintain fluid balance without hemodynamic instability, less blood exposure, and smaller vascular access.

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