Determining Filtration Fraction for CVVHF with Replacement Fluid Prefilter Dilution

Carl P. Walther*, Amber S. Podoll*, Kevin W. Finkel*
*The University of Texas Health Science Center at Houston

UTHealth
The University of Texas Health Science Center at Houston
Medical School

Background

Filter clotting is a common problem for continuous renal replacement (CRRT) therapies, and the risk of clotting increases with higher filtration fraction (FF). FF should not exceed 20 to 30% to prevent filter clotting. FF is easily calculated for continuous veno-venous hemodialysis, or continuous veno-venous hemofiltration (CVVHF) using post-filter replacement fluid (RF). However, prefilter RF is sometimes used in CVVHF to decrease FF and thus reduce filter clotting. However, this makes calculation of the FF more complex, and formulae for calculating FF in this setting have not been published to our knowledge.

Methods

FF is the ratio of the rate of fluid removal across a filter to the rate of fluid entering the filter. In RRT techniques without significant predilution rates, this is calculated as follows:

$$FF = \frac{Q_{uf}}{Q_p} \qquad \text{(Eq.1)}$$

FF, filtration fraction; Q_{uf}, ultrafitration rate
Q_p, plasma flow rate

Plasma flow rate is calculated as follows:

$$Q_p = Q_b \cdot \left(1 - \frac{Hct}{100}\right) \qquad \text{(Eq.2)}$$

Q_p, plasma flow rate; Q_b, blood flow rate; Hct, hematocrit

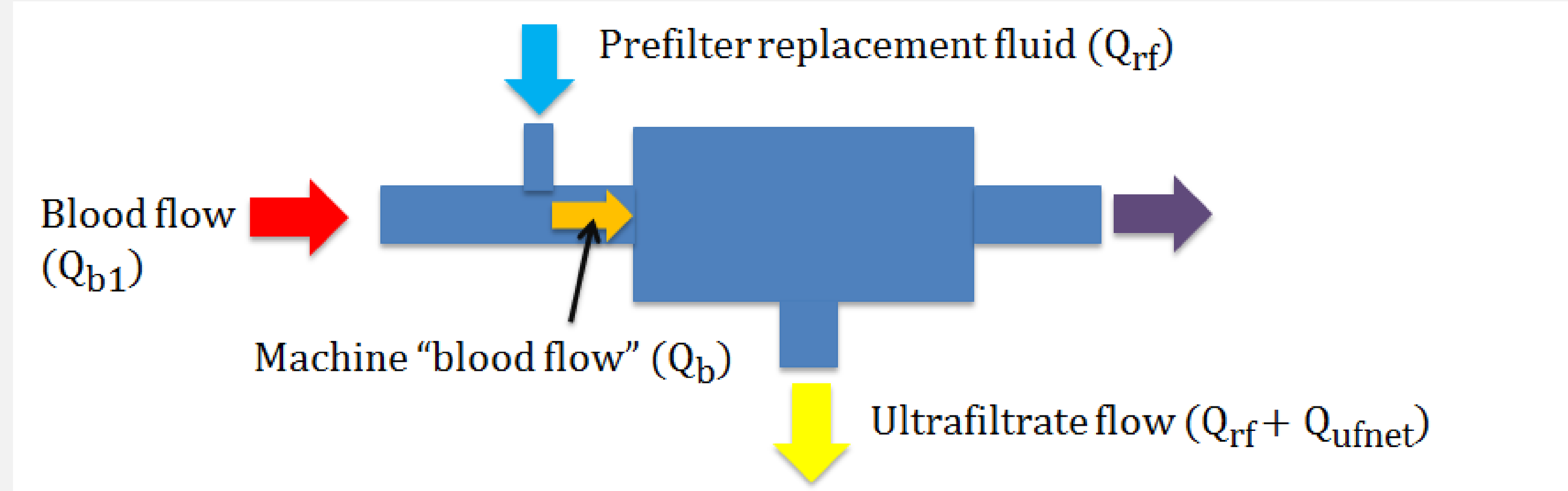
In CVVHF, the total "ultrafiltration" includes both rates of net volume removal (Q_{ufnet}) and replacement fluid (Q_{rf}), represented in equation form as follows:

$$Q_{uf} = Q_{ufnet} + Q_{rf} \qquad \text{(Eq.3)}$$

Q_{ufnet}, net rate of volume removal;
Q_{rf}, replacement fluid flow rate

In CVVHF with predilution with replacement fluid, the clinician sets the "blood flow rate," which is the rate of flow of the mixture of blood and replacement fluid, represented by Q_b in Figure 1.

Fig.1. Schematic of CVVHF with prefilter replacement fluid, with prefilter fluid entry point upstream to the blood pump (some devices differ).



Effective plasma flow rate can then be calculated using the following equations derived using the above schematic.
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$$Q_{b1} = Q_b - Q_{rf} \qquad \text{(Eq.4)}$$

$$Q_p = Q_{rf} + Q_{b1} \cdot \left(1 - \frac{Hct}{100}\right) \qquad \text{(Eq.5)}$$

Substituting Eq.4 into Eq.5 yields the following.

$$Q_p = Q_{rf} + (Q_b - Q_{rf}) \cdot \left(1 - \frac{Hct}{100}\right) \qquad \text{(Eq.6)}$$

By substituting for Q_{uf} (from Eq.3) and Q_p (from Eq.6) into Eq.1, we arrive at the following equation for filtration fraction:

$$FF = \frac{Q_{ufnet} + Q_{rf}}{Q_b \cdot \left(1 - \frac{Hct}{100}\right) + Q_{rf} \cdot \frac{Hct}{100}} \qquad \text{(Eq.7)}$$

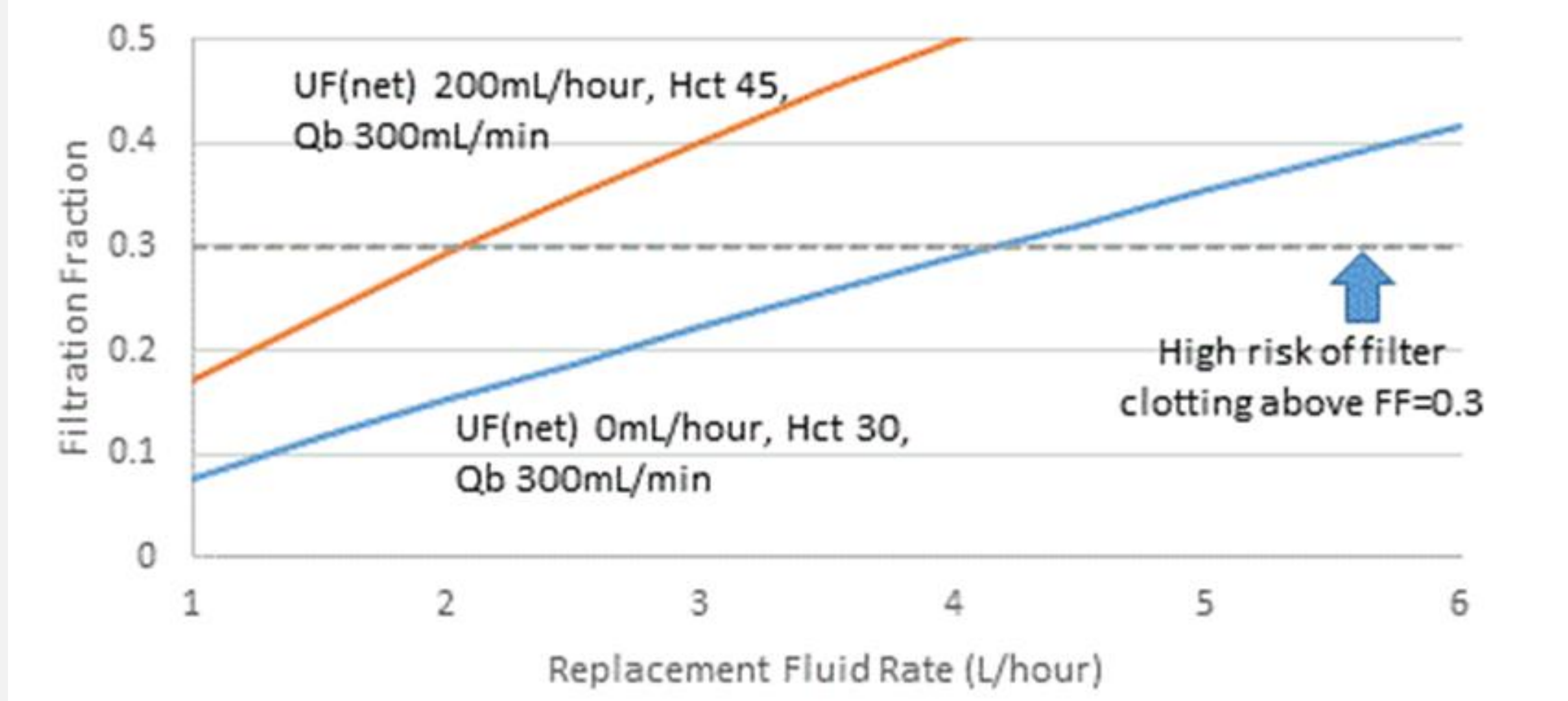
FF, filtration fraction; Q_b, blood flow rate
Q_{ufnet}, net rate of volume removal; Q_{rf}, replacement fluid flow rate
Hct, hematocrit

If the blood pump is placed upstream to the entry point for prefilter fluid, as in some devices, the denominator in Eq.7 simplifies to $Q_b \cdot \left(1 - \frac{Hct}{100}\right) + Q_{rf}$.

Results

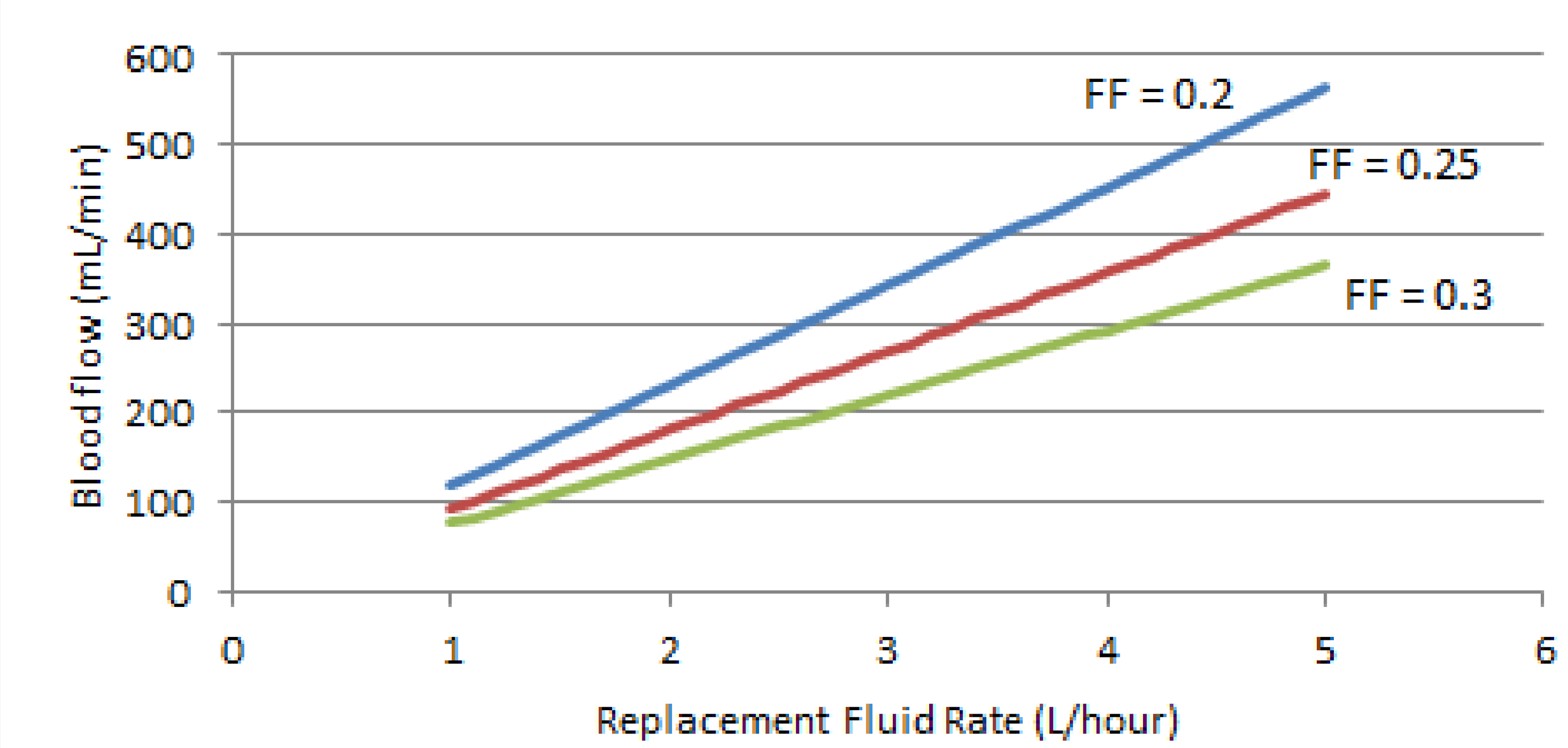
Fig. 2 shows filtration fraction versus replacement fluid rate for two example cases where Q_b is 300mL/min: in one case net UF is 0mL/hour and Hct 30, and in the other net UF is 200mL/hour and Hct 45.

Fig.2. Filtration fraction versus replacement fluid rate for CVVHF with prefilter replacement fluid



The equation can also be easily solved for blood flow, allowing the clinician to substitute desired values for Q_{rf}, Q_{ufnet}, and FF, and determine the required blood flow to achieve these values. Figure 3 shows blood flows required to maintain three different filtration fractions across a range of replacement fluid rates.

Fig. 3. Blood flow versus replacement fluid rate for different filtration fractions (Hct 30, 50mL/hour UF)



Conclusions

Prefilter dilution with replacement fluid is commonly used to reduce filter clotting in CVVHF. Risk of clotting increases for higher FF, but a method for calculation of FF in the setting of CVVHF with prefilter dilution with replacement fluid has not previously been published to our knowledge. The equation presented (Eq.7) may facilitate quantitative clinical decision making regarding CVVHF rate settings and decrease filter clotting.