



Transonic Technical Staff, updated October 2002

## I. Introduction

**Hemolysis** can result from an obstruction in a dialysis blood line circuit<sup>1-6</sup>. The *Transonic* Flow-QC® Hemodialysis Monitor and Clip-on Sensor measures **actual flow** in the dialysis tubing and can therefore identify such reductions in flow to provide early warning of conditions that could lead to hemolysis.

In contrast, the setting on the dialyzer pump sets the revolutions-per-minute (“RPM”) of the pump, or the flow that the pump is trying to generate. Comparison of the Flow-QC® dialysis blood flow measurement with the pump setting provides a sensitive indication of any tubing obstructions. When flow is restricted, actual flow drops substantially below the pump setting.

As the first step of Flow-QC® Hemodialysis Adequacy Protocol, this pump flow measurement is the initial check after a patient is connected to the Flow-QC® monitor. Whenever there is any significant discrepancy between the Flow-QC® measurement and the pump setting a flow restriction in the dialysis circuit should be suspected. When a flow restriction is identified or suspected in one patient, all dialysis stations should be checked for flow restriction using the Hemodialysis Pump Flow-Check Protocol outlined below. In one to two minutes per patient, a nurse can check that all dialysis pumps deliver the flow for which they are set. This provides early warning of adverse conditions that can cause hemolysis and/or under-delivery of dialysis.

## II. Hemodialysis Pump Flow-Check Protocol

### A. Measuring Delivered Blood (Pump) Flow.

- 1) Boot up the laptop computer. Once the computer is running in MS-Windows, turn on the HD02 Monitor.
- 2) Apply a small amount of Vaseline® to the tubing and position the arterial and the venous flow/dilution sensors on their respective sites.
- 3) On the computer screen, double click on the HD02 Dialysis System icon.
- 4) Click on the Monitor icon.
- 5) Select or add patient.
- 6) Select tubing.
- 7) Turn off ultrafiltration. After a 10-second settling period, verify that the flow indicated on the front panel of the monitor corresponds to the dialysis pump setting.

## II. Flow-Check Protocol *cont.*

### B. Is the Pump Flow Reading Acceptable?

It is normal for the pump to somewhat over estimate blood flow. The pump’s brand, its calibration and and tubing type all affect the pump’s RPM-to-flow conversion factor. The hemodialysis Pump Flow-Check Protocol scans for gross deviations. With practice, a trained Flow-QC® technician can judge a normal deviation from an abnormal one. Initially, the following guidelines are recommended:

- **20% Discrepancy Demands Immediate Attention:** If the *Transonic* flow measurement is  $\geq 20\%$  below the pump’s setting (i.e., Flow-QC measurement,  $< 280$  ml/min; pump setting, 350 ml/min), proceed immediately with the Flow Restriction Investigation Steps under Section III because of the potentially serious consequences of hemolysis.
- **10 - 20% Discrepancy, Moderate Concern:** A *Transonic* flow measurement 10% - 20% less than the pump setting (i.e., Flow-QC measurement, 280-315 ml/min; pump setting, 350 ml/min) can result from moderate flow resistance in the dialysis circuit, small needle diameter, incorrect needle placement, minor kink in the dialysis tubing or an access flow restriction. The patient may become uremic if the condition persists for several dialysis sessions. The cause of the low flow should be identified and corrected using the complete Hemodialysis Adequacy Flow Study<sup>7</sup> or the “Error Analysis Algorithm” of DOQI Guideline 12 of the Clinical Practice Guidelines for Dialysis Adequacy<sup>8</sup>.
- **10%, Normal Flow Range:** The *Transonic* flow indication is within 10% of the pump setting (i.e., Flow-QC measurement,  $\geq 315$  ml/min; pump setting, 350 ml/min). Such differences may well lie within the measurement tolerances of the two methods.

### C. Proceed to Next Patient & Repeat Step B & C.



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### III. Flow Restriction Investigation

Flow-QC indications are complemented by other immediate observations. Because of the serious consequences of hemolysis, we recommend the following:

- a) **Check pressure readings for any unusual signs.**  
An unusual arterial pressure reading indicates a source of obstruction located between the arterial patient connection and the pump inlet. An unusual venous pressure reading indicates an obstruction after the dialysis filter and the venous patient return. When both pressure readings are normal, the obstruction may be located in the part of the dialysis circuit located between the two pressure chambers.
- b) **Visually check for kinking of the tubing between arterial drip chamber and pump.** The tubing may have collapsed at the point where it enters the pump.
- c) **Check for ballooning of the tubing** between pump, dialyzer and venous drip chamber, either visually or by manual compression of the tubing. Because flow will pulsate sharply with the release of each pump roller, an obstruction between pump and dialyzer may create a "hammering" flow sound.
- d) **Immediately reduce the dialyzer pump setting to a level where pump setting and Flow-QC measurement agree to within 10%.** Discontinue dialysis with current equipment if the two readings cannot be brought within 10%.
- e) **Alert the nephrologist** to determine whether to proceed with an extended dialysis time to offset the lower pump flow setting, or to further examine the dialysis configuration to diagnose the cause(s) of flow obstruction.
- f) **Take a blood sample** to screen for hemolysis.

### IV. References

#### Flow Restrictions and Hemolysis

Manufacturing defects in the tubing may occur<sup>1</sup> but are rare. Kinking of the arterial line can occur with any tubing. Such kinking causes hemolysis<sup>2,3,4,5,6</sup>. Multiple hemolytic reactions may occur before the kink was detected<sup>3,6</sup>, and the location of the kink may not cause a pressure alarm<sup>6</sup>. These reports suggest that the flow restriction may easily go unrecognized. The incidence of hemolysis related to flow restriction could be higher than is clinically recognized.

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#### Pump Flow Monitoring using the Transonic Flow-QC Device

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