HD02 Quick Reference Guide — Measurement Procedure

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STEP I: Laptop & Meter Setup

1) Plug-in the laptop computer & HD02 monitor.

↓

2) Boot-up computer.

↓

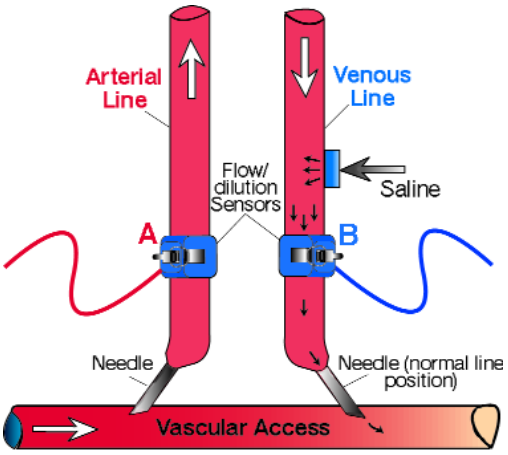
3) Once computer is running in MS-Windows, turn on the HD02 monitor

STEP 2: Flow/dilution Sensor Setup

1) Place a small amount of Vaseline in the groove of the arterial **(red label)** sensor and position it approximately 5-10 cm, (2-4 inches) from the needle connection on the arterial blood line **(A)**. The arrow on the sensor must point in the direction of flow.

↓

2) Place a small amount of Vaseline in the groove of the venous **(blue label)** sensor and position it approximately 5-10 cm, (2-4 inches) from the needle connection on the venous blood line **(B)**. The arrow on the sensor must point in the direction of flow.



Note: If you are using Flow-QC tubing, place the arterial sensor in the center of the arterial Flow-QC segment and the venous sensor in the center of the venous Flow-QC segment.

STEP 3: Software Program Operation

1) To start the HD02 program, double click on the **HD02 Dialysis System icon** on the computer screen.

↓

2) Click on the **Monitor icon.**

STEP 3a: Select or Add Patient

1) To select a patient, scroll and highlight a patient name or use the up and down arrow keys (the first letter of patient's last name will act as a short cut).

or

To add patient, click, **Add New Patient** or press **F1**. You will be prompted for new patient information.

↓

2) When the appropriate patient name is highlighted, click **Start Patient Session** or press the **Space Bar**.

STEP 3b: Select Tubing (F2)

1) Click on the tubing icon in the upper right-hand corner of the screen or press **F2.**

↓

2) Click the down arrow and scroll down or use the first letter of the tubing manufacturer as a shortcut to select the tubing being used for the patient.

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STEP 4: Delivered Blood Flow (F2)

To verify Delivered Blood Flow, compare the dialysis machine setting with the measured arterial delivered blood flow displayed on the front of the Transonic HD02 Hemodialysis Monitor. The discrepancy should be within 10% of the machine setting. See page 5, Troubleshooting Quick Reference Guide when discrepancy is >10%.

STEP 5: RECIRCULATION (F9)

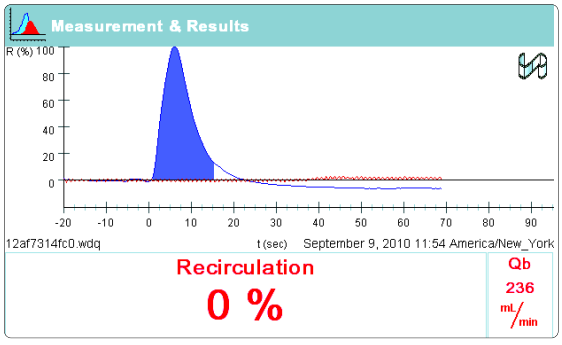
1) Click on the Recirculation icon in the lower right corner of screen or press **F9**.

2) Click on Start Protocol or press Space Bar.

3) When the traffic light turns green, open pressure limits on the dialysis machine and release saline from the saline bag for 5 to 6 seconds *or* inject 10 ml of saline into or before the venous bubble trap.

4) Once the timer has reached zero, a recirculation dilution curve (shown below) and a calculated % recirculation will be displayed on the screen.

5) If recirculation measurement is >0%, stop the pump, reverse the blood lines and repeat the recirculation test. If recirculation is 0%, the blood lines are inadvertently reversed.



STEP 6: Access Flow (F10)

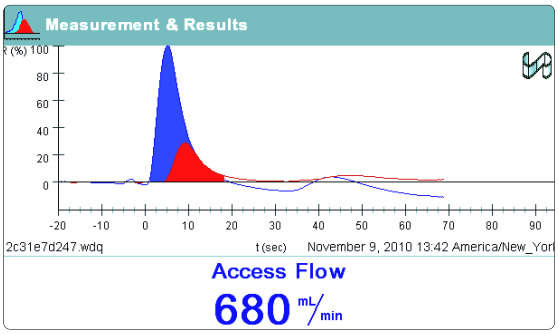
1) Click on the Access Flow icon in the lower right corner of the screen or press **F10**.

2) Click on Start Protocol or press Space Bar.

3) Stop the blood pump, reverse the blood lines and set the dialysis pump at 250-300 ml/min.

4) When the traffic light changes to green, open the pressure limits on the dialysis machine and release saline from the saline bag for 5 to 6 seconds. (If a pump flow of 200 ml/min can not be maintained, access flow can still be measured by injecting 10 ml of saline before or into the venous bubble trap.)

5) Once the timer has reached zero, an access flow dilution curve (shown below) and a calculated access flow will be displayed on the screen.



STEP 7: End of Patient Measurements (F1)

1) When measurements with patient are complete, click on the stop session icon in the upper left corner of the screen or press **F1.**

2) Move the system to the next patient *(do not turn off computer)*. Connect to power and repeat steps for new patient.

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HD02 Quick Reference Guide — Cardiac Output Procedure

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***Note:* Cardiac output cannot be measured in patients with a central venous catheter.**

STEP I: Prepare Saline

Prepare 30cc syringes for each patient with 30 ml of saline.

↓

Place syringes in Transonic Syringe Warmer.
Refer to the syringe warmer instructions for use.

STEP 2: Place Flow-QC Tubing & Sensors

The Flow-QC tubing segment is inserted into the hemodialysis circuit during priming of the dialysis lines.

Remove tubing segments from package.

↓

Remove caps from Flow-QC tubing segments. Attach the red banded end of arterial segment to male end of the arterial blood line (**a**). Likewise, attach blue-banded branch of Y end to male luer-lok connector on the venous blood line (**b**).

↓

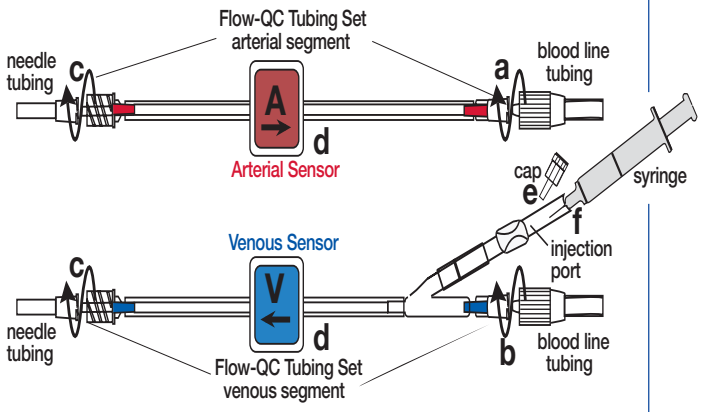
Prime Flow-QC tubing removing all air bubbles from tubing.

↓

Attach the arterial & venous Flow-QC set line to the needle tubing (**c**).

↓

Place sensors in middle of Flow-QC lines (**d**).
- Do not place sensors on needle tubing lines or blood lines.
- The arrows on sensors must point in the direction of flow.



STEP 3: Measure Cardiac Output

Select Transonic Flow-QC tubing **(F2).**

↓

Start CO measurement by clicking on the gold heart icon in the lower right corner of the Monitor Program screen, or press **F11**.

↓

Remove air bubbles from the syringe.

↓

Unscrew injection port cap (**e**) &Connect the syringe to injection port (**f**).

↓

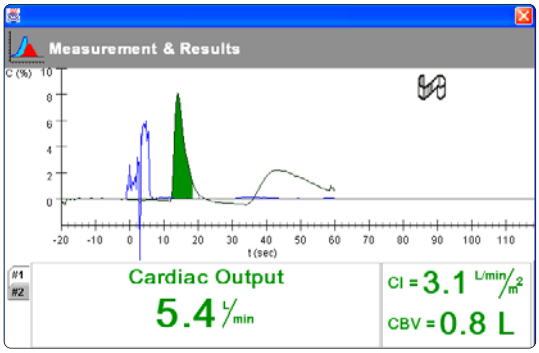
Open limits of venous pressure to avoid pump stoppage.

↓

When the traffic light on computer screen turns green, inject 30 ml of warmed saline within 6-7 seconds.
Note: if you cannot stop the pump or turn off the venous alarms, temporarily clamp off the line leading to the pressure transducer.

↓

A CO dilution curve, calculated CO, CI and CBV values will be displayed. To display Height, Weight, Heart Rate, Blood Pressure, Peripheral Resistance, Central Blood Volume Index, Systemic Cardiac Index and Stroke Volume, click on the small #2 icon next to the traffic light.



***Note:** If a REPEAT MEASUREMENT message is displayed, wait for the traffic light to turn green, and repeat injection. If the first two measurements are within 15% of each other, it is not necessary to make a third measurement.*

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Cardiac output and calculated parameters are related to age and gender, and depend on a patient's clinical status — such as the presence of diabetes or cardiac diseases. Measured parameters may change dramatically during a hemodialysis session.

Cardiac Output (CO)

Normal Range[1]: 5 - 8 L/min

Cardiac Output, the volume of blood in liters ejected from the heart within one minute, is a fundamental measure of human hemodynamic performance. Typical values for hemodialysis patients range from 4 to 8 L/min with the determination of "normal CO" depending on a patient's body size."

Cardiac Index (CI)

Normal Range[1]: 2.2 - 4.5 L/min/m^2

Cardiac Index is cardiac output divided by estimated Body Surface Area (BSA). A primary criterion of cardiac adequacy, CI is useful in comparing different sized patients.

Peripheral Resistance (PR)

Normal Range[1]:
9.6 - 18.8 mmHg x min/L (770 - 1500 dyne x sec/cm^5)

Total Peripheral Resistance is the average resistance to systemic blood flow and is approximated as Mean Arterial Pressure divided by Cardiac Output.

*Central Blood Volume (CBV)

Central Blood Volume is the volume of blood in the heart, lungs, and the great vessels. Normal values range from 0.8 - 1.6 L. CBVI is found by dividing CBV by the patient's weight (typical range, 11 - 17 ml/kg). Maintenance of CBV is thought to be a factor in blood pressure regulation. "CBV decreases during hemodialysis are similar to CO, and probably precede CO."When CBV is depleted, hypotensive episodes may occur.

Guidelines for CO Measurements (see Cardiac Function Handbook, pages 13-14.)

PARAMETER	TYPICAL RANGE	ABNORMAL RANGE	CLINICAL RELEVANCE	INTERPRETATION & RECOMMENDATIONS
Access Flow (AF)	**600 - 1600** ml/min	**> 1600 - 2000 ml/min for native fistula**	Heart adequately compensates: AF < 20% of CO CI > 6-8	Consider reducing AF by banding or other surgical procedure to avoid prolonged heart overload
			AF > 30% of CO CI < 2.2	Body tissues are not adequately perfused due to A-V fistulae stealing. Consider closure of fistula.
Cardiac Index (CI)	**2.5 - 4.2** L/min/m^2	**CI > 5**	Usually indicates heart overload due to high access flow (see above).	The reason for the increased CI should be identified and proper treatment implemented including: • A-V access intervention; • Change in dialysis prescription; • Change of erythropoietin prescription
			Significant volume of accumulated liquid between dialysis sessions.	
			May indicate low hematocrit levels.	
		CI < 2.0	Observed at the beginning of the HD session: indicates significant deterioration of CO function.	Refer to cardiologist for full study. Check for chronic hypoxia.
			Observed as a drop in CI during HD session: indicates potential cardiac conditions, inadequate dry weight estimation and/or medication prescription.	The dry weight and medications should be examined and/or changed and CHP measurements repeated.
Central Blood Volume Index (CBVI)	**11 - 17** ml/kg	< **10** ml/kg	Usually observed in obese patients where heart-lung system is relatively small compared to body weight.	Observation of CBVI decrease during or at the end of CHP may indicate patient is at risk for hypovolemic collapse. Dialysis prescription may be reconsidered
		>20 mg/kg	High CBVI usually (especially if maintained during CHP) indicates extra fluid in lung circulation or left ventricular dilation.	Perform follow-up studies.

* Parameters are given for research purposes. Some do not have well-established normal values.

[1]Darovic G.O.: Hemodynamic Monitoring *Invasive and Noninvasive Clinical Application*. WB Saunders Company, 1987.

HD02 Quick Reference Guide — Troubleshooting

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Incorrect Sensor Placement

PROBLEM: Ultrasound signal quality indicator is not full or there is a negative reading for pump blood flow on the HD02 monitor.

POSSIBLE SOLUTIONS

1) Check that sensors are on blood line tubing, not on needle tubing. If you're using Flow-QC tubing, sensors should be placed in the center of the Flow-QC segment.
2) Check that arterial sensor is on the arterial blood line and the venous sensor is on the venous blood line.
3) Check that arrows on the sensors are pointing in the direction of flow.
4) Apply a small amount of Vasoline™ in the sensing cavity of the sensors.

10% Difference between Dialysis Machine & HD02 Delivered Blood Flow

POSSIBLE CAUSES

1) Mis-calibration of dialysis machine and/or Transonic H4E Sensors.
2) Flow limited by needle size or needle placement.
3) Inadequate roller pump tubing segment occlusion or dialysis tubing kinked.

POSSIBLE SOLUTIONS

1) Check for occluded or kinked tubing.
2) Check that selected tubing in the software program matches tubing used on patient.
3) Set dialysis machine pump flow at 200 mL/min and compare it to delivered flow:
   - If difference is <6%, calibration of dialysis machine and sensors are OK.
     1) check that the tips of the needles are not pressed against the access wall.
     2) consider needle size.
   - If difference >6%, check calibration of dialysis machine and/or Transonic H4E Sensors.

> 0% Recirculation (REC)

If your initial recirculation value is >0%, please follow these steps:

1) Repeat Measurement.
2) If REC is >0%, stop dialysis pump, reverse blood lines &repeat the REC measurement.
   - If REC is 0% or REC is < initial values, blood lines are inadvertently reversed.
   - If REC > initial values, blood lines were in normal position at the initial REC measurement and REC is present. Proceed with access flow measurement.

Important On-Screen Messages

MESSAGE
Repeat: Noisy Baseline - This message may indicate that there is some question about the validity of the measurement.

SOLUTION Repeat Measurement.

MESSAGE
Communicating, Please Wait or No Meter - both messages indicate that a communication error has occurred between the laptop and monitor

SOLUTION

1) Make sure monitor is ON.
2) Turn monitor OFF and then back ON.
3) Check the connections of the 9-pin cable connecting the laptop to the monitor.

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Access Flow Interpretation

Important Tip: When reversing blood lines, make sure you reverse the lines at the needle tubing connection.

TYPE OF ACCESS	REFER PATIENT FOR FISTULUGRAM		POTENTIAL CARDIAC OVERLOAD[1]
AV Grafts	AF < 600 mL/min	AF < 1000 mL/min that has decreased more than 25% over 4 months	-
AV Fistulae	AF < 600 mL/min (Some clinicians suggest < 500 mL/min)	AF < 1000 mL/min that has decreased more than 25% over 4 months	AF > 2000 mL/min

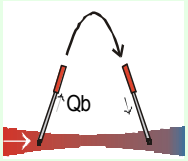
Repeat measurements to confirm & report results to physician.
[1]Cardiac Output measurement is recommended.

0% Recirculation When AF < Pump Flow?

QUESTION
"How can the HD-Monitor indicate 0% recirculation at a pump flow (Qb) of 400 ml/min when access flow (AF) is only 350 ml/min?"

ANSWER
Minor differences between measured AF and Qb with 0% recirculation have no clinical significance with two exceptions. These are when there is:

1) Significant Stenosis between The Needles
Pump flow (Qb) bypasses the stenosis and AF is significantly less (≤200 ml/min) then Qb at 0% recirculation.



2) Significant inflow and/or Outflow Stenosis
This condition presents when AF is slightly less (≤150 ml/min) then Qb at 0% recirculation.

See ***The Flow Connection*** 1998;1(1):2-3 for full explanation.

CONCLUSION
Trust AF measurements! Do not rely on 0% recirculation. A vascular access may be severely compromised even in the absence of recirculation.

AF Measurements in Native Fistula

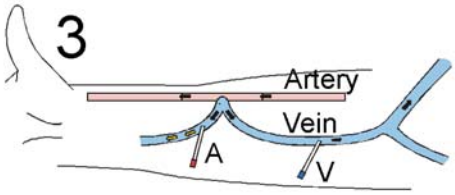
Tips for Adequate Mixing in Fistula
1. For pump flow between 200-300 ML/min, any needle orientation produces adequate missing for up to 2 liters of flow.
2. In fistulae with large aneurysms or upper arm fistula with 2 L /min of flow, place the arterial needle so that it faces the incoming access flow the next time you take a measurement.

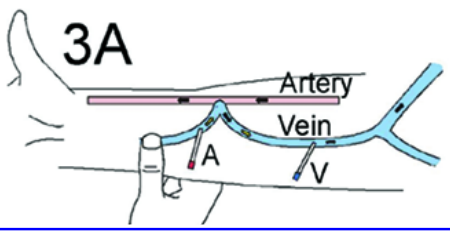
PROBLEM
After blood lines are reversed, the operator can not reach 250-300 mL/min because the dialysis machine pump stops.

SOLUTION
Set pump flow at 100-150 mL/min and inject a 10-ml bolus into the venous bubble trap.

PROBLEM
When measuring access flow with needle position in Figure 3 below, you may get the message **Check line reversal and needle placement.** This could indicate that the needles are in different branches of the fistula.

SOLUTION
Repeat measurement to confirm. If this message appears again, occlude the distal fistula branch downstream from the needle (Figure 3A) for 2-3 minutes and perform the access flow measurement again by injecting a 10-ml bolus into the venous bubble trap.





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