HD03 Quick Reference Guide — Measurement Procedure

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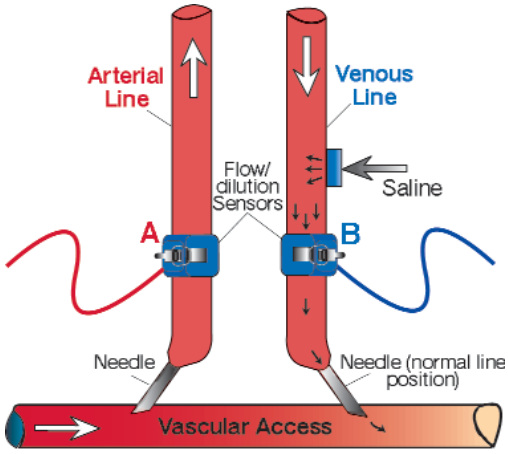
HD03 METER SETUP

Plug H4FX flow/dilution sensors into the connector on the back of the HD03 monitor. Turn on the power switch on the right rear side of the monitor.

FLOW/DILUTION SENSOR SETUP

1) Apply Vaseline® to the sensing cavity 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) Apply Vaseline® to the sensing cavity 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.

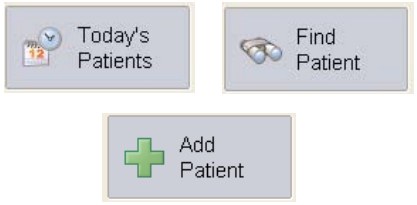
PROGRAM OPERATION

All monitor functions are accessed by touching the touch screen with your finger or a blunt stylus.

After intialization of the program, the Select Patient screen appears with the menu on the right hand side of the screen.

A: Select or Add Patient

Check **Today's Patients** or **Find, Select** or **Add** patient by pressing the respective menu button and following on-screen directions.



B: Measure Patient

To begin a measurement protocol, press the **Measure Patient** menu button.

1. Select Tubing

The **Select Tubing** screen will appear. Select tubing from options on the tubing screen. If you select from the **Tubing Library** option, you may use the first letter of the tubing manufacturer as a shortcut to select the tubing. Then press the OK button.

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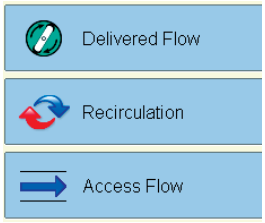
2. Choose Protocol

Choose **Delivered Blood Flow**, **Recirculation** or **Access Flow** protocol by pressing the respective menu button. Always wait 5 seconds after a measurement is saved before you power off the meter or remove the DTM.



2a. Delivered Blood Flow

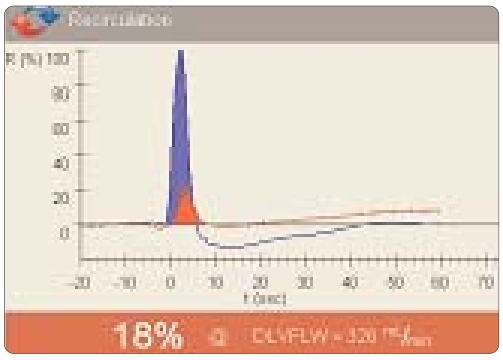
Enter dialysis pump setting using the keypad. Check dialysis machine setting with measured delivered blood flow on the computer screen. If the discrepancy is greater than 10% shown by a red bar at the bottom of the screen, check for correct tubing selection, sensor placement and/or kinking of lines.

2b. Optional / Required Parameters

When an Access Recirculation or Access Flow is selected, an optional parameter screen will appear. Entering values is optional unless you have selected a pediatric patient to be measured. Once values have been entered, press OK to proceed.

2c. Recirculation Measurement

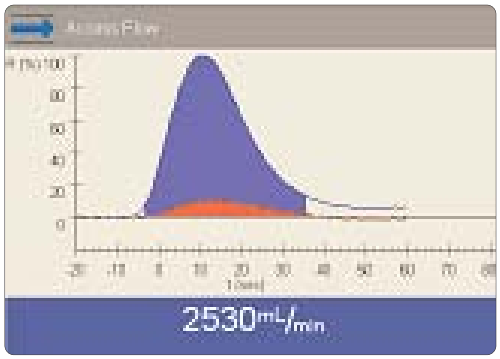
1) Press Recirculation on the "Choose Protocol" screen and follow directions.
2) When the measurement is completed, a recirculation dilution curve (shown at upper right of next column) and a calculated % recirculation will be displayed on the screen.
3) If recirculation measurement is >0%, stop the pump, reverse the blood lines and repeat the recirculation test. If recirculation is 0%, the blood lines were inadvertently reversed and are now in the correct position.



Sample display of HD03 vascular recirculation result and flow/dilution curve.

2d. Access Flow Measurement

1) Press Access Flow on the "Choose Protocol" screen and follow directions.
2) Stop the blood pump, reverse the blood lines and set the dialysis pump at 250-300 ml/min.
3) Follow on-screen directions
4) When measurement is completed, an access flow dilution curve (shown below) and a calculated access flow will be displayed on the screen.



Sample display of HD03 vascular access result and flow/dilution curve.

C. Measure Next Patient

Without turning the monitor off, move the system to the next patient and repeat the measurement steps for the next patient.

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HD03 Quick Reference Guide — Cardiac Output Procedure

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Note: For use only with HD03 units equipped with the CO Data Transfer Module (DTM-CO). Cardiac Output can only be measured in patients with access flow and no access recirculation. Cardiac Output cannot be measured in patients with a central venous catheter.

STEP I: Prepare Saline

Prepare 30 cc syringes for each patient with 30 ml of saline warmed to normal body temperature.

STEP 2: Place Flow-QC® Tubing

Insert Flow-QC® tubing segment into the hemodialysis circuit as described below.

Remove tubing segments from package.

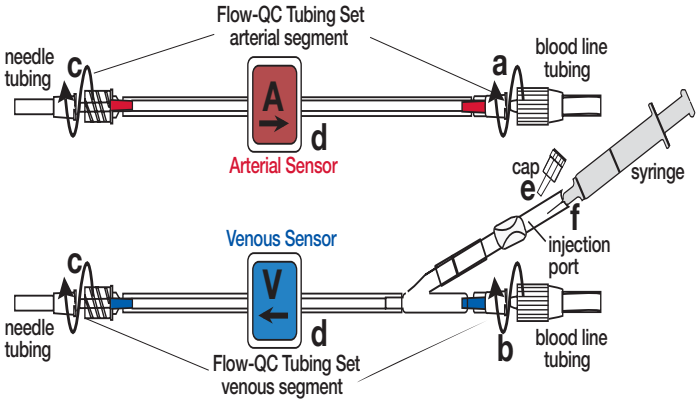
Remove caps from both sides of the arterial segment. Attach the red-banded end to the male end of the arterial bloodline.

Remove caps from both sides of the venous segment. Attach the blue-banded branch of the Y end to the male luer-lock connector on the venous bloodline.

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

Attach the arterial & venous Flow-QC® set lines to the needle tubing (**c**) in normal line position.

Note: Place sensors in the middle of the 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

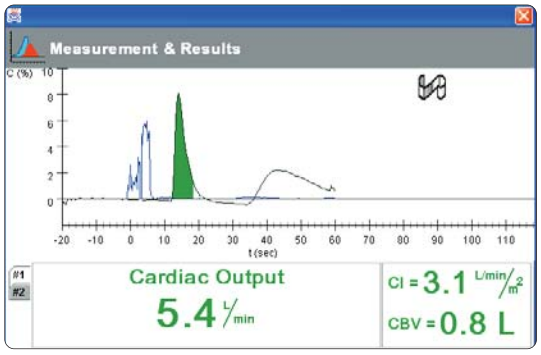
Press the Measure Patient icon.

On the Select Tubing screen, select the Flow-QC® Tubing icon

Press the Cardiac Output button to initiate a cardiac output protocol.

Enter parameters in the required fields and await activation of the cardiac output module.

Follow on-screen directions for injection of 30 ml of warmed saline over 6-7 seconds. A CO dilution curve, calculated CO, CI and CBV values will be displayed.



Note: If a REPEAT MEASUREMENT message is displayed, repeat injection. If the 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:	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. Repair or 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). Significant volume of accumulated liquid between dialysis sessions. May indicate low hematocrit levels.	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
		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.

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HD03 Quick Reference Guide — Troubleshooting

Ultrasound Signal Quality Indicator Not Full or Negative Pump Flow

PROBLEM: Incorrect sensor placement.

POSSIBLE SOLUTIONS

1) Check that sensors are on blood line tubing, not on needle tubing. If you are 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 Vaseline® in the sensing cavity of the sensors.

>10% Difference between Dialysis Machine & HD03 Delivered Blood Flow

POSSIBLE CAUSES

1) Mis-calibration of dialysis machine and/or Transonic H4FX 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 <10%, 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 >10%, check calibration of dialysis machine and/or Transonic H4FX 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.

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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 FISTULAGRAM		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

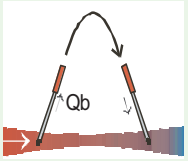
"How can the HD03 Monitor indicate 0% recirculation at a pump flow (Qb) of 400 ml/min when access flow (AF) is only 350 ml/min?"

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.

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 mixing 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

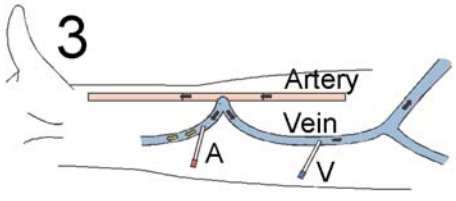
Set pump flow at 100-150 mL/min and inject a 10-ml bolus into the venous bubble trap to initiate an access flow measurement.

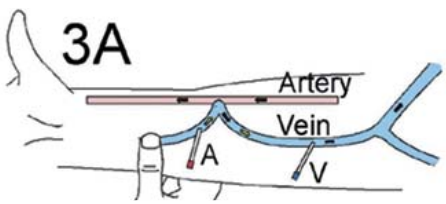
PROBLEM

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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