



Cardiovascular mortality in ESRD patients, depending on age, is 10 - 500 time greater than the general population.¹

¹Special Report from the NKF Task Force on Cardiovascular Disease, AJKD 1999; 32(5)Suppl 3

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in patients with End-Stage Renal Disease (ESRD). Transonic Flow-QC® Cardiac Function Monitoring provides a way to integrate cardiac function studies into a hemodialysis clinic's treatment protocol to forestall the devastating effects of CVD.

Flow-QC® Monitoring identifies:

- 1) Dangerously high and prolonged levels of access flow which stress on the heart and cause cardiomegaly and heart failure.
- 2) Dangerously low cardiac output which places patients at high risk for cardiovascular complications and failure.
- 3) Dramatic decreases of Cardiac Index during hemodialysis to dangerously low levels due to inaccurate dry weight estimation and/or inadequate medication.
- 4) Dangerous decrease in Central Blood Volume during dialysis that may portend hypotensive episodes.



**GOLD STANDARD
QUALITY CARE**

Transonic® proprietary ultrasound indicator dilution technology measures Cardiac Output.¹ Derived cardiac function parameters include:

- ✓ **Cardiac Output**
- ✓ **Cardiac Index**
- ✓ **Peripheral Resistance**
- ✓ **Central Blood Volume**
- ✓ **Central Blood Volume Index**

¹Protected under USA patents # 5,453,576; 5,595,182; 5,685,989, International patent #EP 0 781 161 B1.

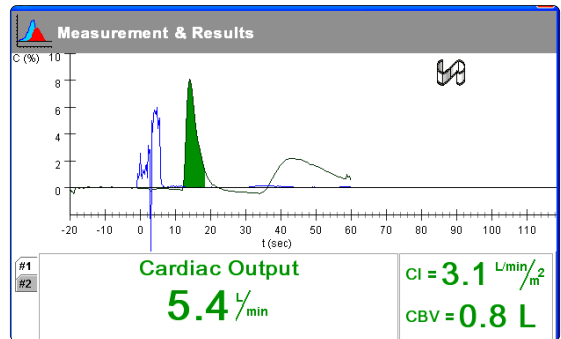


Fig. 1: Flow-QC screen reports Cardiac Output, Cardiac Index (CI) and Central Blood Volume (CBV). Software also displays Height, Weight, Heart Rate, Blood Pressure, Peripheral Resistance, Central Blood Volume Index, Systemic Cardiac Index and Stroke Volume.

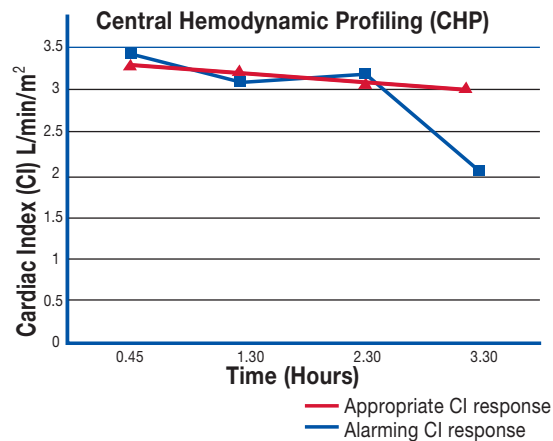


Fig. 2: Central Hemodynamic Profiling (CHP): four measurements taken during a single hemodialysis session shows Cardiac Index responses to the hemodialysis treatment. Acceptable CI results range between 2.5 - 4.2 L/min/m².

Courtesy of Dr. T. Tucker, Brunswick, GA



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

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 Range¹: 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 Range¹: 2.2 - 4.5 L/min/m²

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 Range¹:
9.6 - 18.8 mmHg x min/L (770 - 1500 dyne x sec/cm⁵)

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.

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