Best Practices in Hemodialysis Care

Access Patency • Dialysis Adequacy • Cardiac Function

The singular purpose of an AV vascular access is to serve as a conduit for sufficient blood flow to sustain hemodialysis delivery. Inadequate flow causes underdialysis; too much flow can lead to cardiac problems. Each has associated morbidities and can lead to serious complications that even include death.

Transonic's ultrasound dilution technology is the universally recognized gold standard for hemodialysis access flow measurements. The method uses Transonic Flow-QC® Hemodialysis Monitors and Flow/dilution Sensors to directly:

- Measure Dialysis Adequacy: (delivered blood flow and recirculation) for on-the-spot identification and correction of dose delivery problems in AV access and central venous catheters;

"Adequate blood flow in peripheral hemodialysis fistulae and grafts is vital to the success of hemodialysis and to the survival of the patient. Reduction in flow . . . presages failure of the access device itself. Access flow can therefore be considered a fundamental property of the access that should be monitored." Depner, TA *et al*

- Trend Vascular Access Flow to detect flow limiting problems wherever they occur in a vascular access. Flow-based trending alerts the patient care team to patients at risk for thrombotic events;

- Trend Cardiac Function: to measure ten non-invasive Cardiac Output parameters that can be used to identify patients at risk of increased cardiac related morbidity and mortality, manage fluid status and dry weight, evaluate for high flow cardiac output failure due to high flow AV access, and to help manage blood pressure/cardiac medications.

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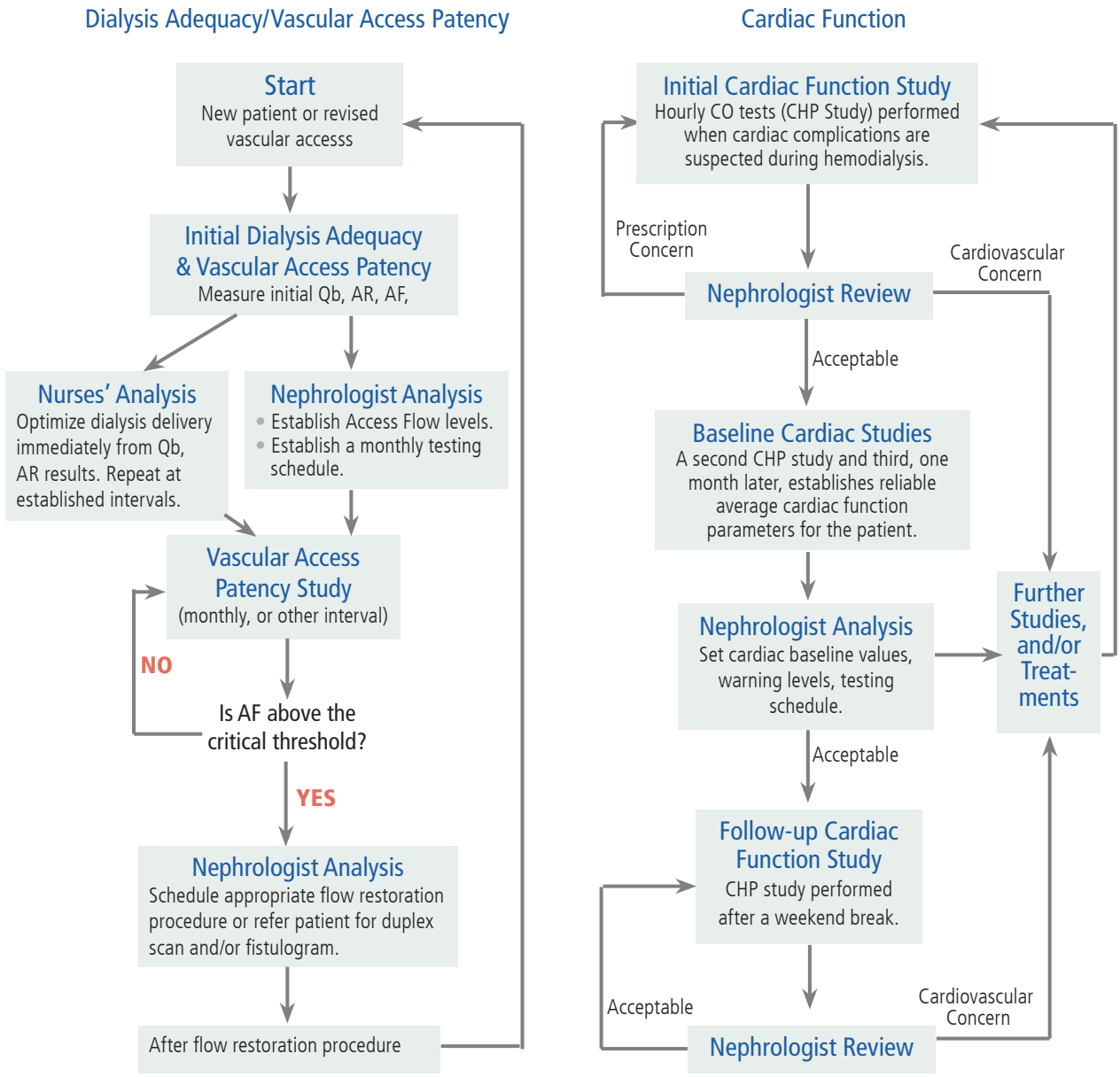
Flow-QC Protocol: AV Graft and Fistula Surveillance



A Flow-based Access Management Protocol includes an initial dialysis adequacy study, followed by periodic access patency assessment and a cardiac function assessment.

Dialysis Adequacy: Delivered Blood Flow; Recirculation

The Transonic Hemodialysis Monitor is used to optimize efficient dialysis delivery through measurement of delivered pump blood flow and recirculation in an AV access and central venous catheters. These measurements are used to:

- Verify true delivered blood flow;
- Test the calibration of the blood pump;
- Avoid underdialysis through inadvertent reversal of the dialysis lines;
- Detect and quantify access recirculation in an AV access, or central venous catheter;
- Help determine proper needle placement;
- Maximize catheter function;
- Identify sources of large negative arterial blood line pressure that causes underdialysis;
- Determine the most appropriate blood pump setting for a low flow access when access flow can't be increased.

Access Flow Thresholds in AV Fistulas and Grafts

CLINICAL INTERPRETATION KEY:

Probable risk for Hemodynamically Significant Stenosis/Recirculation as flow decreases (indicated by color progression from blue to purple)	**Expected Access Flow Range** Expected flow range is ideal. However, a sudden drop of 25% in this range may signal a potential onset of stenosis.	**Probable risk for Cardiac Failure as flow increases** (indicated by color progression from yellow to red)
Action: Consider Clinical Examination & Imaging	**Action: If Flow Is Steady, Continue Monitoring. If 25% Decrease Occurs, Consider Clinical Exam & Imaging**	**Action: Measure Cardiac Output Evaluate AF/CO% Ratio**

Lower Arm AVF (wrist and above)

200 400 600 800 1000 1200 1400 1600 1800 2000 2200 >

Upper Arm AVF (elbow and above)

200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 >

AV Graft (forearm loop graft)

200 400 600 800 1000 1200 1400 1600 1800 2000 >

Notes:

- The routine clinical examination (look, listen, feel, arm elevation and augmentation) should be used routinely as part of the pre-cannulation process.
- The Transonic Access Flow measurements are intended to be utilized in conjunction with the clinical examination to detect/confirm indications of access dysfunction.
- Snuffbox or Endovascular Fistulas may have a lower access flow range depending on the location of the anastomosis and the vessel's outflow configuration.
- Upper arm AV Fistula typically has a higher access flow range due to the larger artery size.

Flow-based Vascular Access Management

Trending Vascular Access Flow

Flow-based trending alerts a patient care team to patients at risk for underdialysis, thrombotic events and cardiac failure.

Dialysis Adequacy

Ensure adequate dose delivery by direct, accurate measurement of pump blood flow and access recirculation in AV accesses and catheters. Hemodialysis Adequacy optimization for Catheter Connection Configuration Algorithm using the Transonic Flow-QC® Hemodialysis Monitor can be used as an on-the -spot tool to optimize the dialysis session. Delivered Flow and Recirculation can be quickly measured before the implementation of any interventions to improve catheter dysfunction. The measurements are repeated to determine impact of any interventions including the use of any thrombolytic agents.

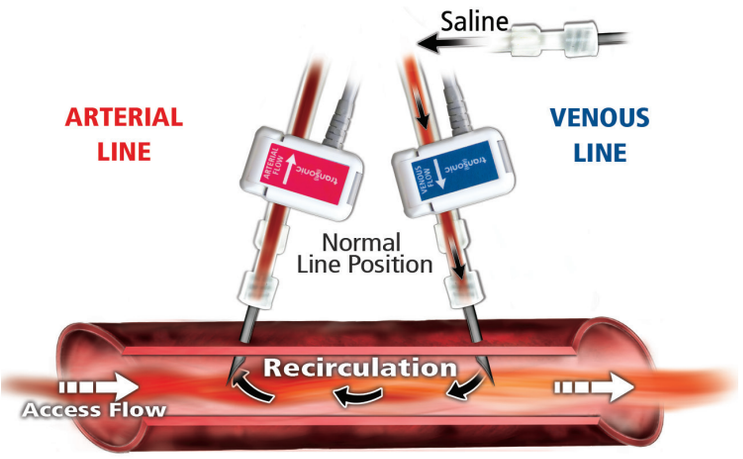
Cardiac Function

Transonic Flow-QC® Cardiac Function Assessment with ultrasound indicator dilution technology provides a way to integrate cardiac function studies into a hemodialysis clinic's treatment protocol in order to forestall the devastating consequences of CVD. Cardiac function measurements help diagnose cardiac overload in ESRD patients. When access flows measured during the dialysis session are unusually high (>2 L/min), cardiac overload can be suspected. A follow-up Flow-QC cardiac output measurement will verify whether the heart is stressed.

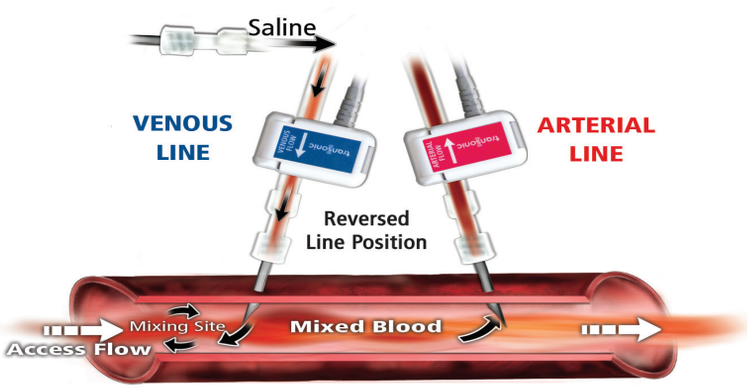
Cardiac output measurements during hemodialysis combined with access flow identify:

- Prolonged high access flow to cardiac output ratio that stresses the heart and can result in cardiomegaly and heart failure.
- Dangerously low cardiac index that places patients at high risk for cardiovascular complications and failure.
- Dramatic decreases of cardiac index during hemodialysis due to inaccurate dry weight estimation and/or inadequate medication.
- Dangerous decrease in central blood volume during hemodialysis that may portend hypotensive episodes.

ULTRASOUND DILUTION TECHNOLOGY



Recirculation Measurement: Saline is introduced into the venous sensor with the dialysis lines in normal position. Access recirculation (back flow) through the vascular access into the arterial needle is measured.



Krivitski Method® Access Flow Measurement: Dialysis lines are reversed at their needle connections to induce recirculation through the access. Vascular access flow can then be calculated from the change in blood concentration detected by the paired flow/dilution sensors. To measure recirculation, saline is introduced into the venous line with the dialysis lines in normal position. Recirculation is calculated from the change in blood concentration between the venous sensor and arterial sensor.

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Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells "gold standard" transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.

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