Publication Brief

The Clinical Relevance and Management of High-Flow Arteriovenous Access

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BACKGROUND:

An arteriovenous (AV) access for hemodialysis reduces risks of infections, hospitalizations, and need for interventions. However, it can cause or aggravate heart failure by increasing blood volume, cardiac contractility, and left ventricular end-diastolic volume in a non-physiologic fashion that can result in an overall increase in cardiac output, possibly leading to left ventricular hypertrophy, diastolic dysfunction, pulmonary hypertension, and high-output cardiac failure. AV accesses with blood flows greater than 1.5 L/min are of high risk. When access flow exceeds 25% to 30% of cardiac output (AF/CO ratio), the risk of developing high-output heart failure increases. Studies suggest that a blood flow AF/CO ratio greater than 0.3 be used to screen for further cardiac testing. Management of high flow accesses can range from a banding procedure (flow reduction) to the need for total abandonment of the AV access.

CONTENT:

- **High-flow AV Access Criteria: Qa >2 L/min, or Qa/CO: 30%, or Qa/Height > 603 mL/min/m**
  Four studies cited:
  1) (MacRae *et al,* 2004-2006) Blood flows >1.5 L/min; when Qa exceeds 25% of CO, the risk of developing high-output heart failure (HOCF) increases. A Qa/CO ratio of 0.30 should be used as a screening tool to perform further cardiac testing.
  2) (Basile *et al,* 2008) AV access flows >2.0 L/min result in high-output cardiac failure. Due to higher flows in this area, there is an association between upper arm AV fistula and the development of high output cardiac failure.
  3) (YE *et al,* 2013) "Cardiac adaptive changes after long-term arteriovenous fistula (AVF) include the enlargement of the left ventricle and thickening of the ventricular wall. The risk of cardiac failure significantly increases when the Qa of AVF is more than 2.0 L/min with much higher CO and lower peripheral resistance."
  4) (Zamboli *et al,* 2018) Indexation of blood flow for height gives a better diagnosis for HOCF.
- **High-flow AV Access Physiologic Basis:** Cardiac Output = Heart Rate X Stroke Volume (a function of peripheral vascular resistance). Peripheral vascular resistance drops with creation of an AV access, but blood volume, cardiac contractility, and left ventricular end-diastolic volume increase in a non-physiologic fashion that results in an overall increase in CO. When blood flows through an AV access, it bypasses the capillary beds to cause blood to return to the heart at non-physiologic pressures and velocities. The resultant higher filling pressures cause significant atrial stretch, which results in higher CO.
- **Modification of High-flow AV Access:** Multiple techniques are used to reduce Qa by increasing resistance at the inflow level. Banding, the simplest, most common flow-reducing procedure, requires achieving a fine balance between a band that is tight enough to be effective and not too tight to risk the patency of the access. Precision banding using intraoperative flow measurements support banding as an effective treatment with a low risk of access failure. Flow reduction revision using distal inflow involves ligation of the fistula at its origin followed by reestablishment of flow via a bypass from either the proximal radial or ulnar artery using a vein or graft as conduit.
- **How Common are Cardiac Complications Related to AV Access?** Limited data: Three studies cited:
  1) (Martínez-Gallardo R, *et al,* 2012) Spanish progressive study indicated that of chronic kidney disease patients, 17% developed at least one episode of pre-dialysis heart failure.
  2) (Schier T *et al,* 2013) Retrospective study: 7% of 113 transplant recipients previously on hemodialysis with an AV access required access ligation due to persistent symptoms of heart failure. The mean shunt flow of these patients was 2197 mL/min compared to 851 mL/ min among patients who did not undergo shunt closure.
  3) (Reddy YNV *et al,* 2017) Retrospective study: 137 CKD patients were followed up for a median of 2.6 years after AV access creation. 43% with no prior history developed incident heart failure. 75% percent of these cases had heart failure with preserved ejection fraction.

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- **Why Should Nephrologists Be Suspicious of High Flow AV Access?**
  CO and Cardiac Index drop during first 12 hours after dialysis. A high-flow fistula may steal blood away from an already compromised peripheral circulation, compromising end organ perfusion. Two studies cited:
  1) (Bleyer *et al 2006)* Study postulates that 35% of sudden deaths occur within the first 12 hour after dialysis. Critically low levels of cardiac index (>2 L/ min/m2) can occur during that time period and is aggravated as a high-flow fistula steals blood away from a suboptimal systemic circulation.
  2) (Tucker *et al 2002)* Study describes how the AF/CO ratio increases after dialysis, mainly driven by a decrease in CO. If an access is already in a "high flow state," this condition becomes exaggerated and can lead to precipitous decline in systemic perfusion, resulting in sudden death.

CLINICAL SUMMARY:

- High-output cardiac failure is a potential complication of arteriovenous (AV) access creation.
- AV accesses, especially upper arm, with blood flow >1.5 L/min are of high risk.
- Blood flow/Cardiac output ratio (AF/CO) of 0.30 is a valid screening tool to perform further cardiac testing.
- If no reversible cause for high-output heart failure is identified, a case can be made for flow reduction (banding) of the AV access.

CONCLUSIONS:

- High-flow AV access can have significant impact on the long-term outcomes of dialysis patient with other comorbidities.
- Complications associated with high-flow AV accesses are very often attributed to other etiologies or to patient related factors, eg, noncompliance.
- Nephrologists and vascular access experts should work together to mitigate the potential harm to patients on dialysis who are afflicted by this condition.

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