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CARDIOVASCULAR CONSEQUENCES OF HEMODIALYSIS VASCULAR ACCESSES

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1. The dialysis vascular access is considered the "Achilles Heel" of the dialysis patient, and it is absolutely necessary for the proper care of individuals with end-stage renal disease (ESRD). However, it is also the cause of significant morbidity and mortality in the ESRD patient.
2. The arteriovenous (AV) fistula is the preferred access of choice for long-term dialysis patients. After surgical creation, the fistula must "mature" for several weeks to months before it can survive the repeated cannulations needed for hemodialysis.
3. In some cases, the AV graft can be used for dialysis within just a few days or weeks after surgical creation, although AV grafts have shorter durations of patency and higher rates of infection and thrombosis compared to AV fistulas.
4. Both AV fistulas and AV grafts provide superior dialysis adequacy and lower rates of complications when compared to the various hemodialysis catheters.
5. For hemodialysis to provide adequate clearances (i.e., removal of uremic toxins), typically blood flows of 300 to 500 ml/min must be achieved through the dialysis circuit. To support such high flow demands and avoid vascular collapse and thrombosis during hemodialysis treatments, the vascular access should be able to support blood flows of 0.6 to 1.2 L/min.
6. The effect of shunting 0.6 to 1.2 liters of blood through hemodialysis AV accesses leads to several systemic cardiovascular effects, including:
   - an increase in cardiac output/demand,
   - a decrease in systemic peripheral resistance and increased stroke volume/heart rate, and
   - an increase in pulmonary vascular flows and pressures.
7. In patients with very advanced congestive heart failure or pulmonary hypertension, creation of an AV fistula or graft may worsen the patient's overall clinical condition.
8. The more proximal a hemodialysis vascular access is to the heart, the more severe the cardiovascular effects can be. For example, an AV fistula in the upper arm will generally have greater systemic cardiovascular effects than an AV fistula in the lower arm. However, proximal AV accesses also have higher rates of primary patency and generally achieve better clearances on dialysis.
9. "Shunting" can lead to vascular steal syndrome, especially in patients at risk of peripheral arterial disease (such as diabetics and the elderly). This can progress to ischemia, and even necrosis, of the extremity distal to the AV access.
10. If the blood flow in the AV access exceeds 1.8 L/min, the risk of high-output heart failure grows proportionately to the blood flow in the shunt.
11. Due to these complications, the preference is to place dialysis AV accesses in the nondominant arm; for example, in a right-handed individual, the preference would be to place a dialysis AV access in the left arm. This avoids potential debilitating loss of use of a primary arm.
12. Successful achievement of a functional AV access begins with preservation of the native vessels. Preservation measures include avoiding repeated phlebotomy for lab draws, placement of peripheral IVs, administration of caustic IV medications, or PICC line placement in the nondominant arm.
13. Use of central venous catheters (tunneled or nontunneled) for dialysis access should be avoided if possible. Dialysis catheters are associated with very high rates of complications, including infection, thrombosis, and central venous stenosis. Dialysis catheters also provide inferior blood flows relative to AV fistulas and grafts and are associated with higher rates of inadequate dialysis clearances.
14. The average rate of catheter-related bacteremia for a tunneled hemodialysis catheter is 0.9 to 2 episodes of bacteremia per catheter-year. These "line infections" can progress to catastrophic complications such as septic shock, endocarditis, osteomyelitis, vertebral abscess, and death.
15. Central venous dialysis catheters should be reserved only for those patients in need of emergent dialysis, those with contraindications to surgical creation of an AV fistula or graft, or those who have exhausted all other dialysis vascular access options.
16. The subclavian vein should generally be avoided as a site for placement of any hemodialysis catheter. A typical dialysis catheter is more rigid than a standard central line and cannot easily accommodate the curve from the brachiocephalic vein into the superior vena cava. Dialysis catheters placed in the subclavian vein have almost double the rate of thrombosis

and central venous stenosis compared with those placed in the internal jugular or common femoral veins.

17. To achieve adequate blood flows required for hemodialysis, dialysis catheters have large lumens. Due to fluid dynamics, these large lumens are much more prone to "backflow" of blood into the catheters when not in use, which can ultimately lead to thrombosis of the catheter.
18. To prevent thrombosis of the hemodialysis catheter when not in use, it is usually packed with a solution of heparinized saline (at a ratio of 1:100 or 1:1000 mL NS:units of heparin). Inevitably, some heparin will leak into the systemic circulation.
19. In patients with contraindications to systemic heparin, hemodialysis catheters can be packed with a citrate solution. However, citrate solutions are very difficult to obtain in the outpatient setting.
20. Thrombosis of dialysis catheters prevents adequate dialysis. Thrombi from the catheter can also embolize and lead to catastrophic complications such as pulmonary embolus, myocardial infarction, or stroke.
21. Both hemodialysis catheters and vascular accesses are associated with central venous stenosis. Depending upon the location of the stenosis, this can progress to massive swelling of an extremity or to superior vena cava syndrome.